

MECHANIZATION IN THE LUMBER INDUSTRY

**WORK PROJECTS ADMINISTRATION
NATIONAL RESEARCH PROJECT**

WPA NATIONAL RESEARCH PROJECT

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FEDERAL WORKS AGENCY
WORK PROJECTS ADMINISTRATION

F. C. HARRINGTON
Commissioner

CORRINGTON GILL
Assistant Commissioner

NATIONAL RESEARCH PROJECT

ON

Reemployment Opportunities and Recent Changes
in Industrial Techniques

DAVID WEINTRAUB

Director

Studies in Equipment Changes and Industrial Techniques

George Perazich, Engineer in Charge



Farm Security Administration (*Rothstein*)

LOG MECHANICALLY CONVEYED FROM POND TO SAW

MECHANIZATION IN THE LUMBER INDUSTRY

*A Study of Technology in Relation to Resources
and Employment Opportunity*

by

Alfred J. Van Tassel
with the assistance of
David W. Bluestone

WORK PROJECTS ADMINISTRATION, NATIONAL RESEARCH PROJECT

Report No. M-5

Philadelphia, Pennsylvania

March 1940

**THE WPA NATIONAL RESEARCH PROJECT
ON REEMPLOYMENT OPPORTUNITIES AND RECENT CHANGES
IN INDUSTRIAL TECHNIQUES**

Under the authority granted by the President in the Executive Order which created the Works Progress Administration, Administrator *Harry L. Hopkins* authorized the establishment of a research program for the purpose of collecting and analyzing data bearing on problems of employment, unemployment, and relief. Accordingly, the National Research Program was established in October 1935 under the supervision of *Corrington Gill*, Assistant Administrator of the WPA, who appointed the directors of the individual studies or projects.

The Project on Reemployment Opportunities and Recent Changes in Industrial Techniques was organized in December 1935 to inquire, with the cooperation of industry, labor, and governmental and private agencies, into the extent of recent changes in industrial techniques and to evaluate the effects of these changes on the volume of employment and unemployment. *David Weintraub* and *Irving Kaplan*, members of the research staff of the Division of Research, Statistics, and Finance were appointed, respectively, Director and Associate Director of the Project. The task set for them was to assemble and organize the existing data which bear on the problem and to augment these data by field surveys and analyses.

To this end, many governmental agencies which are the collectors and repositories of pertinent information were invited to cooperate. The cooperating agencies of the United States Government include the Department of Agriculture, the Bureau of Mines of the Department of the Interior, the Bureau of Labor Statistics of the Department of Labor, the Railroad Retirement Board, the Social Security Board, the Bureau of Internal Revenue of the Department of the Treasury, the Department of Commerce, the Federal Trade Commission, and the Tariff Commission.

The following private agencies joined with the National Research Project in conducting special studies: the Industrial Research Department of the University of Pennsylvania, the National Bureau of Economic Research, Inc., the Employment Stabilization Research Institute of the University of Minnesota, and the Agricultural Economics Departments in the Agricultural Experiment Stations of California, Illinois, Iowa, and New York.

Since September 1, 1939, the Project has been sponsored by the National Resources Planning Board, Executive Office of the President, Washington, D. C.

FEDERAL WORKS AGENCY
WORK PROJECTS ADMINISTRATION

1734 NEW YORK AVENUE NW.

WASHINGTON, D. C.

F. C. HARRINGTON
COMMISSIONER OF WORK PROJECTS

March 14, 1940

Colonel F. C. Harrington
Commissioner of Work Projects

Sir:

In 1937 the lumber industry still ranked third among manufacturing industries as an employer of labor despite the fact that for three decades production and employment in this industry had been declining. The report transmitted herewith discusses technology, resource conditions, and labor productivity within this setting of generally declining employment opportunity.

Substitute products have taken over a great many of the functions of lumber in the construction and manufacturing industries. In the country as a whole, per-capita as well as total consumption has declined; rapidly declining production - 17 percent between 1909 and 1929 - was the principal cause of declining employment in the industry.

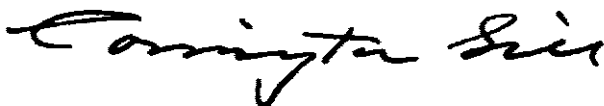
The economic dislocation which attended the decline of production has been intensified in particular regions by the depletion of the timber resources. The traditional clear-cutting policy resulted in the migration of the industry to fresh sources of supply, leaving abandoned cut-over areas in its wake. In the period of agricultural expansion the population of these areas frequently made a successful transition to agriculture; studies of our Division of Research have shown that in recent years such areas have become, for want of alternative employment opportunity, centers of particularly aggravated relief problems.

Timber depletion has taken its toll of lumber and related forest industries, particularly in the Northeastern, Lake, and Central States. Although the southern lumber regions as a whole are not now similarly threatened, particular localities have been

struck by the passing of the lumber industry. The United States Forest Service found that in 1934 there were over 18 thousand workers employed in southern logging and sawmilling operations of large mills whose owners expected to exhaust their local timber supplies by 1944. The expected increase in the number of small and medium-size mills is not likely to enhance the employment security of workers attached to such mills because of the prospective depletion of the timber supply within the working area of the mills. Although in the Pacific Coast States fewer localities are subject to the same imminent dangers, the potential economic dislocation due to timber depletion is much greater because of the strategic position occupied by the forest industries in the economy of the Northwest.

Certain of the types of logging equipment now available hold a promise that in the future the industry will be able to operate economically on a "cropping" instead of the traditional "mining" basis. Such agencies as the Forest Service of the United States Department of Agriculture and similar State-supported agencies are carrying on the major share of the work that is being done on reforestation, fire protection, and research in methods of forest management, use of forest products, and even logging and milling techniques. Sustained-yield logging, strongly advocated by these governmental forest agencies, combined with other features of progressive forest management, not only would assure for the future a continuous supply of high-grade lumber at reasonable prices but also would be an important factor in preserving the level of and stabilizing the location of employment opportunity.

Respectfully yours,

A handwritten signature in cursive script that reads "Corrington Gill". The signature is written in dark ink and is positioned centrally below the typed name.

Corrington Gill
Assistant Commissioner

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PREFACE

Prior to 1850 mechanization in the lumber industry was directed primarily toward securing building materials with the least possible effort from the abundant timber stands that were found almost everywhere more or less at hand. During the last half of the nineteenth century the Nation entered a period of rapid expansion; the nature of new developments and production techniques was dictated by the growth in demand for lumber and the consequent pressure to cut-out as rapidly as possible and to liquidate large forest holdings in order to be able to acquire other promising holdings. In recent years, with the demand for lumber declining and with the last great forest region the scene of the most active production, the objective of technological change has been shifted from high output and complete liquidation to the lowering of production costs in order to maintain competitive position.

In extractive industries technology is faced with continually increasing physical difficulties if operations are continued at one location. These difficulties must be overcome if the productivity of labor is to be maintained or increased. To the extent that the lumber industry has employed extractive techniques, it has faced obstacles to increased productivity analogous to those encountered by the mining industries. By and large the lumber industry has "mined" the timber in its path and has migrated to fresh sources of supply when the timber supply has been depleted. Production techniques have had to be altered in the course of the migration of the industry as well as in the course of operations within each region. The methods used were in each case conditioned by the characteristics of the resource. There are, therefore, profound regional differences in technology corresponding to regional differences in the characteristics of the timber stand and in the stage of development of the individual regions.

There have been two principal modes of adjustment to timber depletion. One method involved improvements in technique and machinery in order to accomplish the logging and milling of timber from less desirable stands with the same or a reduced expenditure of labor per unit of output. The other involved the shift of an increasing proportion of production to smaller mills operating closer to the timber stand, employing simpler and less extended production processes, and producing, in general, a somewhat cruder product. That is, the steady improvement in the machines and techniques available for use has not been accompanied by a consistent increase in the extent of their use.

The most striking technological development since 1920 has been the adaptation of tractors, trucks, and light cable yarders for logging operations. The use of this equipment has enabled the industry to undertake the logging of scattered stands which could not be profitably cut with the heavy steam cable yarders and forest railroads that had hitherto constituted the principal tools of mechanized logging. Within the sawmills cost reductions have been achieved through the more extensive use of mechanical handling equipment, through refinements in sawmill and planing-mill machinery which contributed to increased speed of operation, and through the shift to electric power which contributed to automatization of processes, increased speed of operation, and reduced power-generation and maintenance personnel. This mode of adjustment to less favorable stands of sparse or less accessible timber was characteristic primarily of the Pacific Coast region, and there the unit labor requirements of large operations appear to have declined throughout the period 1920-36.

The shift toward smaller mills, on the other hand, appears to have been typical of the southern lumber regions, and there such changes in technology as have been made barely served to offset the increasing natural difficulties. The small mill is able to operate closer to the timber and can draw on stands of smaller volume than are required for the successful operation of large, stationary mills. To do so, however, the small mill must move frequently; it attains the requisite mobility by sacrificing much of the labor-saving machinery of the large, stationary mills. The rise in the number of small sawmills represents, however, only a temporary adjustment to increased difficulties and, in any long view, must be regarded as a symptom rather than as a solution of the problems created by timber depletion.

Through technical advances and shifts of production to smaller mills the lumber industry has succeeded in maintaining production in the face of timber depletion. The lumber industry, however, bears the social responsibilities associated with operation on an exhaustible national resource; these responsibilities are not fully met so long as the industry's operation continues to be accompanied by a decline in the quality and availability of timber resources. The state of the forest resource has far-reaching implications for many phases of national life - in its relationship to other forest industries, soil erosion, flood control, and scenic and recreational values. Furthermore, although the industry as a whole has been able to adjust itself to declining timber resources, the workers and the communities that grew up around the camps and mills have not always been so successful. The migration of the industry has been

accompanied by the disruption of employment opportunities and the economic life of communities partly or wholly dependent upon the industry.

The most important factor affecting the level of employment opportunities during the past three decades has been the decline in the demand for lumber. This has been principally determined by factors beyond the industry's control. However, it should be noted that if there is to be an improvement in the position of lumber in its competition with other materials, the maintenance of high-quality timber resources is of paramount importance.

The problems of conservation of the forest resources differ fundamentally from those associated with the mineral resources. While some measure of depletion is an inevitable counterpart of the use of mineral resources, the forest can actually be made to yield an increasing raw-material return by the employment of appropriate forest-management techniques. The nature of recent technological developments in logging methods has been such as to encourage sustained-yield logging which, if widely adopted, would assure a basis for continued and stable operation in the industry. The effect of technical developments on future employment opportunities in the industry may well depend more on how the equipment is employed than on what particular equipment is developed and at what rate it is introduced.

The report was prepared by Alfred J. Van Tassel with the assistance of David W. Bluestone. It is one of the series of "Studies in Equipment Changes and Industrial Techniques" supervised by George Perazich. The manuscript was edited and prepared for publication under the direction of Edmund J. Stone.

Many of the data used in the report were derived from field surveys conducted by the National Research Project in cooperation with the National Bureau of Economic Research. A sample of lumber mills was covered in a cooperative study undertaken in 1936 as one in a series of "Studies of Productivity and Employment in Selected Industries" under the supervision of Harry Jerome and William A. Neiswanger. Tabulations developed for that study, which was conducted by Milton Gilbert, have been used extensively in this report, and many of the basic data are published in appendix A. Data on sales of various types of machinery and equipment to the lumber industry were also obtained in a field survey conducted in cooperation with the National Bureau of Economic Research. Harry Jerome participated in the planning of this survey of machinery manufacturers, and J. Van Horn Whipple organized the field work and supervised the editing of the materials collected.

The National Research Project is particularly indebted to the Forest Service of the United States Department of Agriculture, which cooperated in this study by furnishing statistical data and preparing special analyses. The Project is also indebted to the following individuals who reviewed the manuscript or furnished valuable suggestions or data: Axel J. F. Brandstrom, I. F. Eldredge, Herman M. Johnson, Burt P. Kirkland, R. E. Marsh, Raymond Miller, Richard W. Nelson, C. V. Sweet, C. J. Telford, George W. Trayer, and R. K. Winters, all of the Forest Service; Nelson C. Brown, professor, New York State College of Forestry at Syracuse University; and A. E. Hall, manager of the Milling Machinery Department of the Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin. The National Research Project is, of course, alone responsible for the content of the report and the conclusions reached.

DAVID WEINTRAUB

PHILADELPHIA

March 13, 1940

CHAPTER I

INTRODUCTION

In several respects the lumber industry occupies a position of outstanding importance in the national economy. It is one of the largest employers of labor, the source of one of the most important industrial raw materials, and an industry whose conduct has a vital effect on the basic land resource of the country in terms of such factors as soil erosion and flood control. Among manufacturing industries the lumber industry is third in importance as an employer of labor; it is estimated that in 1929 over 650,000¹ were dependent on lumber and timber production for employment.

PRODUCTION AND TIMBER DEPLETION

Production in the lumber industry grew steadily and rapidly throughout the nineteenth century. In 1799, the first year for which production estimates are available, 300 million board feet of lumber were produced from American forests. Throughout the ensuing century lumber production increased at an average rate of 61 percent per decade to 35,000 million board feet in 1899.² After 1909, when 45,000 million board feet were produced, lumber production ceased to expand, and during the 1920's the average annual production was little over 34,000 million board feet.³ A precipitous decline in lumber production took place after 1929, and annual production in 1932 was below the level of 1869. By 1938 production had recovered to 63 percent of the average of the 1920's.⁴

The production history of the industry is a composite of the histories of regional industries, each developing in its turn and declining when timber depletion took its toll. In its westward migration the industry has "mined" the timber in its path and marched on to fresh sources of supply, leaving abandoned, cut-over areas in its wake. It moved from the forests of New England and New York to the Middle Atlantic States and then to the Lake States, along with the movement of population. So rapid

Note.- The author wishes to acknowledge his indebtedness to Thomas G. Casey and Nathan Briskin, who collected material from secondary sources; Alice H. Bluestein, Harry Kavadio, Therese R. Levick, and Alexander M. Freund, who rendered valuable clerical assistance in computing and checking; and Henry W. Schultz and Elwood L. Peoples, who prepared the charts.

¹See table 23. This figure does not include an estimated number of 70,300 workers engaged in transportation of lumber.

²*The Lumber Industry* (U. S. Dept. Com., Bur. For. and Dom. Com., Marketing Research Division and Forest Products Division, Market Research Ser. No. 104, Dec. 1936), p. 20

³One board foot of lumber represents a board 12" x 12" x 1".

⁴See table 6.

was the development of white-pine operations in the Lake States that production in this region reached its peak in 1889, a decade after the region had attained production leadership. A single decade later, in 1899, production leadership passed from the Lake States to the South, but by 1909 the latter had also passed its peak of production. Since 1920 the South has shared leadership with the Pacific States. Today the Nation is faced with difficulties arising from the timber depletion which accompanied the migration of the industry. The most serious aspect of the situation relates to the supply of saw timber, i. e., timber of the size required by prevailing logging and milling practice for utilization by the lumber industry.

Of an estimated original forest area of 820 million acres, only 495 million acres are now available for commercial timber growing. The original forest growth on possibly 150 million acres was destroyed in clearing the land for agriculture. However, of an estimated original stand of 5,200 billion board feet, 1,650 billion board feet of old growth have been cut for lumber. There remain available for cutting only 1,346 billion board feet of original, old-growth stands, and only 1,668 billion board feet when second growth of saw-timber size is included. Since the most desirable and most easily available timber has been cut first, the portion of this 1,668 billion board feet which "can be cut profitably on the basis of the operating costs and mill lumber prices of recent years" has been placed by the best available estimates at little more than half.⁵

Production techniques have been successively altered in the course of the migration of the industry corresponding to the changing requirements in the development of a particular region. In the extractive industries technology is faced with continually increasing physical difficulties as operations are continued at the same location; these must be overcome if the productivity of labor is to be maintained or increased. To the extent that the lumber industry has employed an extractive technique, it has faced obstacles to increased productivity analogous to those encountered by the mining industries. If there is no accompanying change in the techniques employed, labor requirements are higher per thousand board feet of lumber realized in the logging and milling of smaller timber, and they are likewise increased as logging operations extend farther from the mill into less accessible territory or as the cutting of less

⁵U. S. Congress, Senate, *A National Plan for American Forestry*, S. Doc. No. 12, 73d Cong., 1st sess., 1933, I, 124, 174, 189. More recent estimates resulting from the Forest Survey are available, but they do not greatly alter these relationships. It is worth noting, however, that these estimates place the stand of old-growth timber at 1,287 billion board feet and the total saw-timber stand at 1,764 billion board feet (see *Lumber Industry Facts: 1939* [Washington, D. C.: National Lumber Manufacturers Association], p. 5).

dense stands of timber is undertaken. These difficulties are analogous to those of increasing depth or declining quality of ore faced by mining operations. The analogy ends here, however; the lumber industry, by employing the proper techniques, is capable of operating on a continually replenished stand of timber.

Production techniques have been conditioned at each stage of development by the nature and magnitude of the difficulties to be overcome. There are therefore profound regional differences in technology corresponding to regional differences in the characteristics of the timber stand and in the stage of development of the individual regions. The center of advance in production techniques has always been in those areas in which production was expanding and in which large mills were the characteristic centers of production. In spite of other regional differences, the ascendant policy has almost universally been to "cut out and get out", and production techniques have been designed for the rapid realization of immediate timber values without regard to future yield.

PURPOSE AND SCOPE OF THE STUDY

The purpose of this study is to analyze the relationship between recent developments in technology and employment opportunities in the lumber industry. Chapter II traces the development of the machines and techniques used by the industry, with some discussion of the economies attendant on the application of recent developments. Chapters III and IV consist of an examination of the application of these machines and techniques to the industry in the Pacific Coast and southern forest regions. This examination is directed toward an understanding of (1) the effects of changes in technology on the productivity of labor in particular sections of the industry and (2) the effects of types of mechanization and production techniques on the present and future economic availability of standing timber. Chapter V presents general statistics on production and employment which are analyzed with respect to factors affecting production, changes in labor productivity, and regional changes in the availability of standing timber, as well as a discussion of production, productivity, and the state of the forest resources in the Pacific Coast and southern forest regions as they relate to employment opportunities.

The industry with which this report is principally concerned is that designated by the *Census of Manufactures* as the "Lumber and timber products" industry. It is defined as follows:

Under the industry designation "Lumber and timber products" are classified logging camps; merchant sawmills; combined sawmills and planing mills, including those engaged in the manufacture of boxes; veneer mills; and cooperage-stock mills. . . .

The principal products of logging camps are saw logs; shingle, stave, and heading bolts; hewn and round poles; mine timbers; spars; piling; fence posts; railway ties; and wheel, handle, and excelsior stock. The products of sawmills include rough lumber, shingles, lath, sawed railway ties, and cooperage, spool, pencil, penholder, and veneer stock. The principal planing-mill products are dressed lumber, sash, doors, blinds, interior woodwork, and moldings.

.....
 The products of cooperage-stock mills are tight and slack staves, heading, and wooden hoops⁶

The industry embraces the manufacture of a wide range of heterogeneous products. The center of interest in this report is the lumber industry, which is that sector of the "Lumber and timber products" industry in which the logging camps are engaged in the production of saw logs and the sawmills and planing mills in the production of lumber. Lumber, as used here, may be defined as a product of saw and planing mills which is not further manufactured than by sawing, resawing, and passing lengthwise through a standard planing machine, or crosscut to length and matched. The product of even this narrower sector of the industry is a diversified one in that it includes many sizes⁷ and both rough and surfaced lumber.

The discussion of technological changes centers on the lumber industry as defined above; for the calculation of man-hour requirements, the industry is defined in this more precise sense. When the broader group of activities included in the census definition is referred to, the designation will be that employed by the census, viz, the "Lumber and timber products" industry.

SOURCES OF DATA

The basic data used in this report are from four principal sources: a field survey of logging camps and sawmills, a field survey of manufacturers of machinery used by the lumber industry, material made available through the cooperation of the United States Forest Service, and a directory of the Pacific Coast lumber industry.

In 1936 the National Research Project, in cooperation with the National Bureau of Economic Research, conducted a field survey of 64 Pacific Coast and southern sawmills and 22 of the logging camps supplying these sawmills. Thirty-six Pacific Coast sawmills had also been surveyed in 1928-29 by the NBER,⁸ which made available the records obtained in the earlier

⁶Fifteenth Census of the United States: 1930, "Manufactures: 1929" (U. S. Dept. Com., Bur. Census, 1933), II, 440.

⁷Strips, boards, dimensions, planks, scantlings, joists, and timbers.

⁸Of the 36, 19 were resurveyed in 1936. The remaining 17 were no longer operating or could not cooperate.

survey. These surveys are designated as the "NRP-NBER logging-camp and sawmill survey", and their findings constitute the principal source of data on labor productivity. Technical features of the data are discussed in some detail in appendix A.

Another cooperative field survey of the National Research Project and the National Bureau of Economic Research was conducted in 1936; this survey covered 14 manufacturers of lumber equipment and is designated as the "NRP machinery-manufacturers survey." It is the source of data on the value of sales of equipment used in the logging and manufacture of lumber. Appendix B describes the sample which constituted this survey.

Data on types of equipment used by Pacific Coast logging camps and sawmills were tabulated from material in the *Handbook and Directory of the Western Timber Industries* for 1933, 1935-36, and 1937. This directory is published periodically by the *West Coast Lumberman*, a trade publication of the Pacific Coast lumber industry. A description of the tabulations is presented in appendix C.

The Forest Service of the United States Department of Agriculture cooperated with the National Research Project in a number of ways. The Division of Research prepared a special report for the "Studies of Productivity and Employment in Selected Industries" section of the National Research Project. This report contained the results of a survey of a number of large logging operations and sawmills in the South, from which data on departmental man-hour requirements were obtained for 1929 and 1936. This report also contained the findings of the Southern Forest Survey on unit labor requirements at several hundred operations. The Southern Forest Experiment Station supplied tabulation sheets of the Southern Forest Survey from which information was obtained regarding types of equipment employed by operations of different size. The Southern Forest Experiment Station also supplied data on employment in 1934 at about 8,500 southern mills classified according to the operators' estimate of the length of life of the mills at their 1934 location. A detailed description of the Southern Forest Survey data is given in appendix D.

CHAPTER II

TECHNOLOGICAL DEVELOPMENTS

The development of lumber technology has been conditioned by two factors: (1) changes in the state of the resource (i. e., the magnitude, availability, and quality of the timber stand) with the passage of time and with the migration of the industry from one region to another and (2) the changes in economic conditions which determined what the industry did with the resource. The nature of the technological developments, determined in the first place by these factors, has had its effect, in turn, on the state of the forest resources and the economic objectives of the industry in relation to that resource. Finally, the rate and types of mechanization in the industry have been dependent in large measure on general developments in science and engineering.

The history of technological developments in the lumber industry as presented in this chapter has been written in the light of the conditioning factors noted above. The developments until about 1900 are presented sketchily, the principal aim being to indicate the manner in which mechanization of one phase of the process led to mechanization in another, with the consequent increase in the complexity of the process and in the amount of capital required for engaging in production. More recent developments are examined in greater detail for particular stages of the processes of logging and milling, the intention being to indicate more concretely the adjustment to changes in the state of the forest resource and in economic conditions and the effect of that adjustment on labor requirements in lumber production.

BASIC PROCESSES

Logging is the term for the series of processes involved in the harvesting of forest crops. Felling the standing timber, the first step in this process, is performed by "fallers" working in pairs with axe and saw. "Buckers" trim off the branches and cut the tree into convenient lengths for transporting and sawing. The logs are then assembled at a common point, an operation known variously as "bunching", "yarding", or "skidding." This is performed either by cable yarders, which haul in the logs by means of a cable wound onto a rotating drum, or by tractors or horses, which tow the logs over the ground. When the logs are assembled, they are loaded onto the means of transportation by mechanical loaders, animals, or manpower. Railroads, trucks, tractors, teams, and water

are some of the means of transportation used in the "long haul" to the mill over distances varying from less than a mile to 50 or even 100 miles. The logs are deposited in a log pond or other storage place adjacent to the mill.

At the mill the logs are hoisted, dragged, or conveyed to the log deck in the mill. From the deck the log is shifted onto a carriage which travels on rails and conveys the logs past the headsaw. The headsaw reduces the lumber to cants (large dimensions for later reduction by resaws or gang saws) or, by successive operations, to boards. The "sawyer", who is the key employee of the sawmill, stands beside the headsaw and directs the workers on the carriage in turning and setting the log for cutting. All boards from the headsaw, gang saw, or resaw which have not been cut to uniform width are passed through an edger where the bark is cut off and the width made standard. The boards then pass to trimmers where the ends are squared, inferior portions removed, and standard lengths made. After they have been trimmed, the boards are graded, sorted, and stacked. These stacks are either left in the yard for air drying or taken to dry kilns and dried by steam or heated air. After it has been dried, the lumber may be sold in its rough state or it may be surfaced or worked in the planing mill. The surfaced lumber is merely planed on one or more sides, while the worked lumber may be matched, shiplapped, or patterned. If this finished lumber is not loaded for immediate shipment, it must be stored in finishing sheds to keep it clean and dry.

EARLY DEVELOPMENTS

The mechanization of the lumber industry began with the sawing operation. Once the steam-powered mechanical saw and accessories were available, the need arose for the mechanization of transportation to supply the saw with logs and for machines to handle, season, and finish the larger output of the mechanical saws.

The Saw and Accessories

Mechanization of the sawing operation was foreshadowed by the development of the method known as pitsawing that came with the introduction of the cross-handled, two-man saw. Pitsawing effected a division of labor between the "top sawyer" who guided the saw and the "pitman" who acted as the prime mover and furnished the effective sawing energy by pulling the saw down. The same type of single-blade saw, pulled down by a wooden beam attached to the crank of a water wheel and pulled up by an overhead spring pole, constituted the first sawmills which prevailed

for the 200 years preceding the first half of the nineteenth century.¹ In the nineteenth century the quantitative addition of saw blades led to the gang saw; qualitative changes led to a faster, more powerful, single-blade saw, the mulay. With the introduction of the circular saw during the same period, the simple hand tool of the pitsawing period was transformed beyond recognition into a powerful machine.

In using mechanical saws the sawyer guided the log against the saw rather than the saw against the log. By 1850 a carriage for transporting the log past the saw had been developed to aid the sawyer in his work. At about the same time the edger for squaring the edges of the board and a mechanical planer for the finishing of lumber were introduced. Thus by 1850 all the mechanical prerequisites² existed for a greatly increased rate of production.

Steam Power

The strides in the speed of production represented by the transition from pitsawing to the mulay saw were small in absolute magnitude compared with the further increase possible through the application of steam power. This is indicated by the accompanying tabulation:³

Type of saw	Sawmill output per day (board feet)
Hand-powered pitsawing	100- 200
Water-powered single blade	500-3,000
Water-powered sash saw	2,000-3,000
Water-powered mulay saw	5,000-8,000
Water-powered circular saw (1820)	500-1,200
Steam-powered gang saw (1850)	40,000
Steam-powered circular saw (1863)	40,000

Steam power, the key to the realization of the potential capacity of the sawmill, was used occasionally during the first half of the nineteenth century.⁴ By 1850 the use of steam power was increasing rapidly, and in

¹William F. Fox, *A History of the Lumber Industry in the State of New York* (U. S. Dept. Agr., Bur. Forestry, Bull. No. 34, 1902), pp. 12-3. The connecting link between the crank and the beam was designated as the "pitman", and this term remained in use even when similar apparatus was powered by steam.

²Richard G. Wood, *A History of Lumbering in Maine, 1820-1861* (Orono, Maine: University Press, Univ. of Maine Studies, Sec. Ser., No. 33, 1935), pp. 162-3.

³Ralph C. Bryant, *Lumber: Its Manufacture and Distribution* (2d ed.; New York: John Wiley & Sons, Inc., 1938), p. 3; Wood, *op. cit.*, pp. 162-3; and James E. DeFebaugh, *History of the Lumber Industry of America* (Chicago, Ill.: *The American Lumberman*, 1907), Vol. 2, pp. 6, 58.

⁴The first steam sawmill, erected at New Orleans in 1811, was destroyed by the workers who were afraid of being thrown out of work by the steam-powered machine (Joseph S. Illick, *An Outline of General Forestry* [New York: Barnes & Noble, Inc., 1935], p. 51). The first steam-powered sawmill in Maine, the center of lumber production during this period, was installed in 1822 and was so successful that the mill stock increased in value from \$75 to \$125 per share (Wood, *op. cit.*, p. 167). Steam sawmills were reported at Detroit in 1829, at Pontiac in 1830, and at Black River in 1833. ("Michigan's Great Timber Wealth," *The Lumberman*, Vol. XXV, No. 8 [Aug. 20, 1898], p. 90).

1869, the first year for which data are available,⁵ steam power accounted for 51 percent of the mechanical power employed in the lumber industry; water wheels and turbines generated the other 49 percent. The displacement of water power by steam power proceeded rapidly in the following decades, and by 1904 over 90 percent of the horsepower in the lumber industry was provided by steam engines and turbines.⁶

Mechanical Logging Equipment

The application of steam power to the sawmill raised the problem of improved log transportation to assure an ample supply of raw material. In the period of the water-driven sash saw the forests immediately adjacent to the towns and cities supplied sufficient timber; with the advent of the water-driven mule and gang saws, short excursions into the woods near the sawmill became necessary; equipped with the powerful steam-driven circular saw, the lumber industry swept up the waterways of America and cleared the forests on and near their banks.

In the face of the steady depletion of the easily accessible timber, it became necessary to break the dependence of the lumber industry on water transportation; this dependence was virtually complete during the first half of the nineteenth century. The forest railroad provided the answer to this need. It assured a supply of logs which was not subject to the sharp seasonal and geographical limitations of water transportation. The first logging railroads were introduced after 1850, and after 1876 they were installed on a large scale in Michigan.⁷

An important effect of the introduction and adoption of the forest railroad was the freeing of the industry from one of its geographical limitations. The substitution of steam power for water power relieved the industry of the necessity of locating on the fall line of streams. The logging railroad opened up areas where water transportation was impossible, notably in the South, and made possible the logging of hardwoods which were floatable only with difficulty.

Toward the close of the nineteenth century the forest railroad was established as the most important means of log transportation. Logs were still driven and rafted down the rivers, but the period of the rivermen was nearing its close.

⁵*Fifth Census: 1870*, Vol. III, "The Statistics of the Wealth and Industry of the United States" (Under direction of Secretary of the Interior, 1872), p. 462.

⁶*Thirteenth Census of the United States: 1910*, Vol. X, "Manufactures: 1908" (U. S. Dept. Com., Bur. Census, 1913), p. 601.

⁷"Five years after the first logging railroad was completed in Michigan there were 71 logging railroads in operation in that State alone and five in Wisconsin." (Illick, *op. cit.*, p. 58.)

Although the railroad effected a vast extension of the scope of logging operations, toward the close of the nineteenth century it proved necessary to mechanize log yarding, the process whereby the logs are assembled, from the point of felling in the woods, at a common landing on the railroad or waterway for the "long haul" to the mill. In the period from about 1830 to 1870 logs had been skidded on crude sleds pulled directly to the landing upon the river or lake; as logging operations were extended farther from the river banks, a skid road of logs laid crosswise in a corduroy pattern somewhat facilitated skidding operations. As the timber line receded before the logger's axe, however, it became necessary to develop mechanical equipment to aid the logger in the short haul from the stump to the means of major transportation.

The donkey engines which found their way into logging camps in the 1880's and 1890's answered this need. The early donkey engine consisted simply of a cable on a single-drum hoist by means of which the logs were hauled in over the ground from the stump to the engine, or over skid roads and chutes. Steam equipment was especially necessary for handling the large logs of the Pacific Northwest. Accordingly, the earliest use of the steam donkey engine was reported on the Pacific Coast in 1885, and by 1895 the steam donkey was in widespread use in that region.⁸

Growth in Size of the Sawmill

The adoption of mechanical logging equipment, which followed from the application of steam power to the sawmill, also influenced the course of development of the sawmill. The introduction of steam engines made it possible to utilize larger, heavier, more expensive, and more productive machinery, for the larger investment entailed was profitable only if there was a large and assured volume of timber available for sawing. The result of these increases in the necessary investment for equipment was a widespread tendency toward consolidation⁹ and a growth in the size of mills.

Toward the close of the nineteenth century the production processes within the sawmill gradually assumed the characteristics of the processes of a mass-production industry. The headsaw which had changed but little since the invention of the circular saw was transformed again when the band saw achieved widespread application following the development, in 1869, of a steel blade of sufficient strength.¹⁰

⁸Joseph W. Gill, "Steam Logging," *Mechanical Engineering*, Vol. 47, No. 10 (Oct. 1925), p. 816; Norman Bruce, "Logging by Electricity Now Part of Big Business," *Forbes*, Vol. XXI, No. 5 (Mar. 1, 1928), p. 42.

⁹Bruce, *op. cit.*, pp. 40, 42.

¹⁰Bryant, *op. cit.*, p. 114.

The most pronounced changes occurred on the sawmill carriage which transports the log past the headsaw. By 1900 the logs were turned for cutting and set for the thickness of cut by steam-actuated mechanical devices. Mechanical conveyance of lumber was general throughout the more advanced mills at the close of the nineteenth century.¹¹

Other innovations during the nineteenth century, such as the edger for squaring the edges of boards, the trimmer for removing defective portions from the lumber, the artificial seasoning of lumber, and planers for finishing lumber, developed the processes of the industry by 1900 to approximately their present scope and degree of complexity.

Change in Economic Objectives

In the eighteenth century and for many years thereafter there were vast stands of choice timber readily accessible to all important centers of population. The problem faced by the industry was that of converting this easily available timber into useful products with the least possible effort. Accordingly, small trees which would have required excessive labor to log and mill were left standing and only the larger trees were selected for cutting. This left the forests in good condition for regeneration.

Steam-powered saws which accelerated timber depletion and the expansion of the frontier which opened markets for the products of new timber stands changed this situation. By 1900 the objectives of the logging operations of the lumber industry were considerably different from what they had been in the first half of the nineteenth century. In the period of rapid national expansion following the Civil War timber speculation became prevalent and large blocks of valuable forest lands passed rapidly into private control. The earlier objective of logging and milling to secure useful products with the least possible effort was overshadowed to an increasing extent by the effort to secure a complete liquidation of the value of the standing timber, which had increased during the period of speculative holding. With vast timberlands still available, the course of new developments in the industry was dictated by the intense competitive drive of individual operators for the rapid realization of timber values in order to be in a position to proceed successfully to the acquisition of other holdings.

Accordingly, the mechanical methods of logging developed during this period were best fitted for and were utilized in logging systems which involved virtually complete liquidation of the timber stand. The high

¹¹The New Sawyer-Goodman Mill, *The Fibreman*, Vol. XIV, No. 7 (Aug. 13, 1898), p. 20.

overhead costs involved in railroad logging encouraged the complete abandonment of a tract once logging became difficult; hence it appeared desirable to cut as cleanly as possible on the first logging. The methods of logging involving donkey engines for the short haul were likewise best adapted to clear-cut logging methods. The construction of larger mills made possible by steam power and railroad logging also stimulated cutting in excess of growth. The course of development of the technology of the lumber industry was definitely directed along lines favoring clear-cut logging, a factor responsible in large measure for the continued rapid depletion of timber resources in the period after 1900.

RECENT DEVELOPMENTS IN LOGGING EQUIPMENT

Felling, Bucking, and Yarding

The woods operations of felling and bucking, despite experimental installations of power-driven saws, have remained largely unmechanized. Extensive changes, however, have taken place in log yarding involving steam and, more recently, tractor logging equipment.

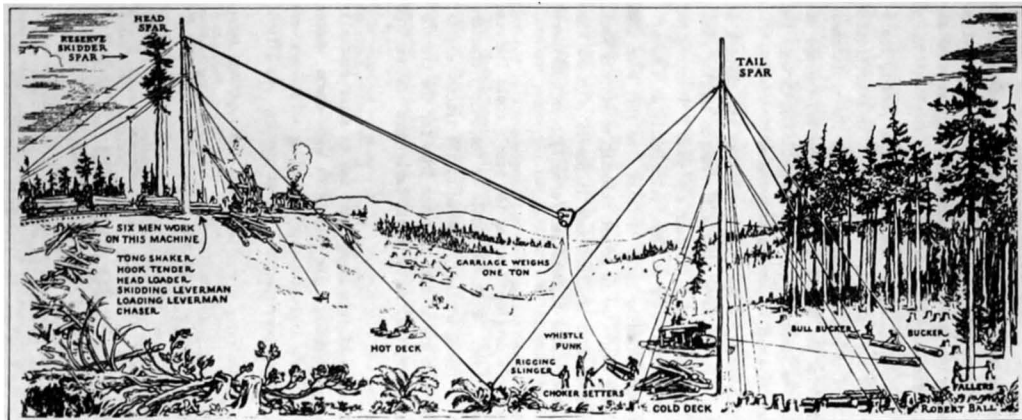
Steam Log-yarding Equipment.— The early donkey engines were used for skidding logs over the ground or over skid roads or chutes. High-lead logging, an alternative method, involved rigging the cables to a single spar tree in such a fashion as to lift one end of the log off the ground. A further advance was represented by sky-line yarding in which a cableway was attached between two spar trees giving a lifting effect sufficient to swing the log partially or fully clear of the ground (see figure 1). Both systems represented a marked advance over ground skidding in which time-consuming stoppages, caused by the catching of logs on stumps and other obstructions, restricted output. Yarding-cost reductions of as much as 13 percent were reported as a result of the shift to overhead logging.¹²

Overhead handling required more powerful, multidrum hoists and therefore stimulated the development of heavier and more complex engines utilizing higher boiler pressures.¹³ The weight of logging engines increased from about 20,000 pounds to between 31,000 and 36,000 pounds after 1900. By 1910 boiler pressures were employed which were double those in earlier engines.

Overhead logging demanded large outputs to justify the use of the heavy and expensive equipment associated with it, and it therefore found widest

¹²Ronald MacDonald, "High Lead and Ground Yarding Compared," *The Lumberman*, Vol. XVIII, No. 1 (Nov. 1916), p. 55.

¹³Gill, *op. cit.*, pp. 815-6.



Fortune (Robert Ball)

FIGURE 1.- LARGE-SCALE SKY-LINE LOGGING OPERATION

The sky-line yarding system shown is typical of the methods employed at many large-scale Pacific Coast operations. A bunch of logs near the tail spar have been attached to the sky line, which will swing them clear of the ground and transport them to the landing at the head spar. There the logs will be loaded onto flat cars by the mechanical loader shown just to the right of the head spar. To the right of the loader is a large cable yarder which drives the complicated cable system of the sky line. The sky line is yarding from

a cold deck, that is, a pile of logs collected earlier by other skidding methods for final yarding by the sky line. Between the spars is a hot deck, that is, a pile of logs which are yarded to the loader as fast as they are collected at this point. Behind the tail spar is another cable yarder, a donkey engine, being operated as a ground skidder. Sky-line yarders are heavy, complicated machines; their use involves large investment, moving, and rigging costs. Such methods have been associated with the clear-cutting of heavy timber stands.

use in the dense stands of the Pacific Coast. Introduced in 1906, high-lead yarding achieved popularity in that area about 1915.¹⁴ Sky-line yarding was introduced on the Pacific Coast at about the same time and achieved widespread use after 1915.¹⁵

During the 1920's the most significant changes in cable yarding equipment affected the type of fuel and power employed. The substitution of oil for wood as a fuel in steam donkey engines and the replacement of steam engines by gasoline and Diesel internal-combustion engines effected striking reductions in operating costs, especially through the elimination of the labor required to cut and gather wood.¹⁶

Tractor Log-yarding Equipment.— More important than the changes in cable yarding equipment were the developments in tractor logging which considerably widened the usefulness of tractor equipment. Tractors had been used in logging operations prior to 1920, principally as a substitute for animals in ground skidding logs. At that time they were used only on skid roads and log chutes or in ground skidding relatively small logs. The steady improvement of tractors made it possible to use them with larger logs for which cable yarders had formerly been considered necessary.

The more powerful tractors developed during the 1920's could likewise tow larger loads of small logs. About the middle of the 1920's tractors began to be equipped with towing winches, powered by the tractor engine, which made it unnecessary to use animals to bunch logs for the tractor. Equipped with a towing winch, the tractor could cable-yard its own logs within a short radius.

The first important effect of this improvement was to alter radically the technique of high-wheel yarding. For many years horse-drawn, wooden high wheels had been used to a limited extent in logging. The logs were bunched, the high wheel backed over them, one end of the logs was lifted,

¹⁴Jas. O'Hearne, "Description and Value of High Leads," *The Lumberman*, Vol. XVIII, No. 1 (Nov. 1918), pp. 56-7.

¹⁵Spencer Miller, "The Overhead-Cableway Method of Logging," *Mechanical Engineering*, Vol. 47, No. 7 (July 1925), p. 529; F. B. Mallory, "Modern Skyline Systems," *The Lumberman*, Vol. XVI, No. 11 (Sept. 1915), p. 45.

¹⁶A study of four operations indicated that operating costs were 61 percent higher for wood-burning steam engines than for oil-burning steam engines (W. D. Peaslee, "Electricity vs. Steam for Western Logging," *West Coast Lumberman*, Vol. 31, No. 362 [Nov. 1916], p. 26). Furthermore, it was found that merchantable timber rather than wood waste was frequently used as fuel, and the officials of one operation discovered that over 8 percent of the yearly output was consumed in logging engines (E. P. Whitney, "Electric Applications in the Logging Industry of the Northwest," *General Electric Review*, Vol. XXIV, No. 7 [July 1921], pp. 633-4). Fuel costs were reduced 96 percent in one instance and 87 percent in another through the substitution of Diesel engines for steam logging engines. Thirty-one percent of the reduction in fuel cost in the first instance and 41 percent in the second were due to the elimination of the labor necessary to cut and gather wood. (See "Diesel Logging on Oraya Harbor," *The Lumberman*, Vol. XXX, No. 8 [June 1920], p. 59; and John Schafer, "Diesel vs. Steam Yarder Costs," *The Lumberman*, Vol. XXXI, No. 1 [Nov. 1920], p. 132.)

and the load was towed to the mill or landing place. With the advent of the more powerful winch-equipped tractor it became possible to use steel wheels capable of towing heavier loads. A further evolution of this equipment led to the present logging arch. The arch aids in ground skidding logs over short distances and is capable of carrying much heavier loads than the early high wheels. Toward the end of the 1920's the tractor donkey, a double drum hoist attached to the tractor, was developed. This device could be used for high-lead logging, and its introduction converted the tractor into a light, mobile, multipurpose cable yarder.

The trend toward larger tractors which are better fitted for logging operations has continued in recent years. Since 1929, 75- to 80-horsepower Diesel tractors have been introduced and are tending to replace the smaller gasoline tractors, particularly in Pacific Coast operations. The larger Diesel tractor can be employed with greater efficiency in rough country and on steeper grades.¹⁷ In one test a 75-hp. Diesel tractor was able to haul 61 percent more footage per hour than the 60-hp. gasoline tractor; the fuel cost was 80 percent lower per thousand board feet logged.¹⁸ Diesel tractors have increased rapidly in importance in recent years.¹⁹ The tractor logging equipment of the leading manufacturer is now designed for use with a 75-hp. Diesel tractor.

The development of such logging auxiliaries as the towing winch, the tractor donkey, and the fair-lead arch, as well as the increase in the power of tractors, has placed tractors on a competitive level with cable yarders and animals in logging operations. The nature of the competition

¹⁷The relative advantages of the larger Diesel in rough country are shown by the following comparative performance figures:

Item	60-hp. gasoline tractor	75- to 80-hp. Diesel tractor
Maximum grade negotiable	30%	40%
Slope requiring least time for hauling and return	8%	16%
Grade on which round-trip speed is same as on the level	16%	26%
Average load (board feet)	2800	4330

In addition, slight adverse grades can be negotiated more easily by the Diesel tractor. The cost of operation is also lower, chiefly because of fuel economy. (Burt P. Kirkland and Axel J. F. Brandstrom, *Selective Timber Management in the Douglas Fir Region* [Forest Service of the U. S. Dept. Agr. and Charles Lathrop Pack Forestry Foundation, Jan. 1934], p. 18.)

¹⁸Nelson C. Brown, *Logging-Transportation: The Principles and Methods of Log Transportation in the United States and Canada* (New York: John Wiley & Sons, Inc., 1936), p. 65.

¹⁹One company which produces Diesel engines for tractors and incidental power units showed an extremely rapid increase in the production of Diesel engines between 1931 and 1934, as is indicated by these figures (*ibid.*, pp. 72-3):

Year	Total hp. of Diesel engines produced	Year	Total hp. of Diesel engines produced
1931	1,058	1933	107,833
1932	12,496	1934	237,314

between cable, tractor, and animal logging depends on the topography, the size of the timber, and the density of the stand.²⁰

The steam cable yarder weighs several tons, and unless it is employed at a point immediately adjacent to the forest railroad, it is usually quite cumbersome to move.²¹ When either the high-lead or sky-line system is employed, the rigging of the complicated system of cables adds further to the logging cost. Thus a large part of the total cost of operation is incurred in placing the machinery and rigging it up for operation before logging actually begins. Furthermore, the initial investment in this type of machinery has increased from a few thousand dollars for one of the early machines to as much as \$100,000 for a single unit.

If at each setting there is a sufficiently large stand of large trees available, the investment charges and moving and rigging costs may be distributed over a sufficiently large volume to reduce unit costs to a low level. On the other hand, if only sparse or scattered stands of timber are available for logging, these costs may constitute an important item. Furthermore, the cable yarder is poorly adapted to any system in which some trees in the stand are cut while the remaining timber is left for cutting at some future date.

Where the high-lead or sky-line system is employed, the clear-cutting of the stand is favored by the nature of the logging operation itself, for the logs are yarded along radial paths jutting out from the spar trees. Young trees which are left standing are frequently broken by the logs which are hauled in, and in the ground-skidding and high-lead system the forest covering, favorable to the sprouting of new trees, is torn up.

In contrast to the stationary cable yarder, the tractor is most frequently operated strictly as a mobile towing unit, traveling to and from the stump and the landing with each load. The fact that the tractor travels in and out with each load means that individual trees may be selected for logging from the forest. Stands too sparse or too scattered to justify the moving and rigging costs of the cable yarder may frequently be logged with profit by tractor because of its greater mobility. When a network of tractor roads is constructed, considerable selectivity may be exercised in choosing the economical sizes of trees to be cut. Thus clear-cutting may frequently be economically dispensed with when

²⁰The discussion of the relative merits of cable and tractor logging equipment is based largely on Brown (*op. cit.*, *passim*) and Axel J. F. Brandstrom, *Analysis of Logging Costs and Operating Methods in the Douglas Fir Region* (Forest Service of the U. S. Dept. Agr., West Coast Lumbermen's Association, and Charles Lathrop Pack Forestry Foundation, June 1933), *passim*.

²¹There is a wide variation in this respect between the relatively light and flexible wheel-mounted gasoline cable yarders, extensively employed in the South, and the large steam engines employed at Pacific Coast high-lead and sky-line operations.



Pacific Car and Foundry Co.

FIGURE 2.— SKIDDING WITH DIESEL TRACTOR AND FAIR-LEAD LOGGING ARCH

Logs are frequently skidded to a landing over inexpensively constructed tractor roads. They may be ground skidded over short distances and then lifted off the ground by means of a cable which is wound in by a winch mounted on the rear end of the tractor.

tractors are employed. Furthermore, tractors have been found to be considerably less destructive of growing timber than cable yarders.

For most southern operations the differences between cable yarding and tractor logging as described above are much less sharp. There ground-lead logging direct to the railroad track prevails; under this method, moving and rigging costs are not excessive and individual tree selection is possible when the logging is carefully managed.

In the South animal logging is more extensively employed than any mechanical method. Animal logging more nearly resembles tractor logging than any other method.

Sales of Cable and Tractor Log-yarding Equipment.— During the years 1909-18 over \$4,600,000 worth of heavy cable yarding equipment was sold by one Pacific Coast company which manufactured such equipment. This manufacturer reported that sales of this equipment reached a peak in 1923 and declined thereafter, the last power-yarding unit having been built in 1930. Sales of another important Pacific Coast manufacturer of this type of equipment were negligible after 1930.²² It appears from this that

²²HRP machinery-manufacturers survey. No manufacturers of the light gasoline yarders, which are widely used in the South, were surveyed.

between 1930 and 1936 there were few additions to the large number of heavy stationary yarders in use during the 1920's in the Pacific Coast States.

On the other hand, reports from manufacturers indicate a substantial volume of sales of tractor logging machinery after 1929. An index of the dollar volume of sales of two leading manufacturers of this equipment is given in table 1. Manufacture of this equipment as a regular production item began in 1927 and rose to a substantial volume by 1929, declining sharply thereafter. However, sales recovered rapidly after 1932. By 1935 sales of tractor hoists (single-drum towing winches and double-drum tractor donkeys) exceeded the 1930 level; in 1936 they rose to 32 percent above the previous peak of 1929. The recovery in the sales of logging arches was even more pronounced, reaching new highs in 1935 and 1936. In the latter year sales were roughly double those of 1929. The behavior of sales of tractor logging equipment is in sharp contrast to that of heavy cable yarding equipment and is indicative of a trend toward the former, which will be discussed in detail for the Pacific Coast and the South in later chapters.

**Table 1.- INDEXES OF VALUE OF SALES OF LOGGING ARCHES
AND TRACTOR HOISTS TO THE LUMBER INDUSTRY, 1929-36^a**
(1929=100)

Year	Logging arches	Tractor hoists	Year	Logging arches	Tractor hoists
1929	100.0	100.0	1933	24.7	18.8
1930	74.1	57.0	1934	71.8	40.8
1931	22.4	28.3	1935	127.1	79.4
1932	23.5	2.0	1936	198.8	131.8

^aBased on table B-6.

Major Transportation

Log-hauling Equipment.- The developments in the equipment and techniques of transporting logs from the landing to the mill parallel the changes in yarding logs from the stump to the landing. Railroad logging, which became the dominant method after 1900, has found its supremacy threatened by the increasing employment of trucks in the long haul. In recent years, trucks have been used to an increasing extent as a supplement to the rail haul, replacing spur-line rail transportation. The nature of the competition between these two most important means of major transportation is conditioned by their operating characteristics. The railroad has achieved and to a large extent has maintained a dominant position in logging operations because it has important advantages over

other forms of major transportation. It assures a continuous supply of logs for the mill, on the whole regardless of weather conditions, thus making year-round operations practicable. Furthermore, the railroad normally accomplishes this at a unit cost substantially below that of other methods. On the other hand, the initial investment in a short forest railroad is usually at least \$50,000; some single lines have cost more than \$1,000,000.

It is evident that continuous large-scale operation is necessary for profitable operation of a forest railroad in order that investment charges and operating costs may be distributed over a large output. This implies the existence of a stand having a volume at least sufficient to liquidate the investment in the area tapped by the railroad. It is also clear that density is another characteristic of the stand to be considered, because it will determine the amount of construction per unit of product.

The volume and density of the timber stand necessary for successful operation of the forest railroad depend largely on the length of haul and the relative expense associated with railroad construction and maintenance under varying conditions of terrain. In general, however, it may be said that small and scattered stands of old-growth timber (such as are left in the wake of clear-cut logging operations) or sparse stands of second-growth timber are frequently unsuitable for the profitable operation of a forest railroad.

The large initial investment required for the construction of the forest railroad has tended to encourage the clear-cutting of the area tapped by the railroad in order to achieve a rapid liquidation of the investment involved. The necessity for achieving large-scale continuous operation in order to realize the full efficiency of railroad logging has perhaps encouraged the cutting of timber in excess of current needs during periods of depression. Nevertheless the forest railroad is by no means necessarily linked to clear-cutting; it is frequently employed under a selection system of cutting, particularly for the main-line haul.

Trucks are valuable in logging scattered stands of timber for which the construction of railroad spurs would be prohibitively high. Thus, in one operation, truck-road construction cost about \$2,100 per mile in contrast to about \$10,200 per mile for railroad construction.²³ If road-amortization costs are disregarded, however, hauling costs for the railroad amount to one-half to one-fourth of the same costs when motor-trucks are used.²⁴

²³Brown, *op. cit.*, p. 102.

²⁴Brandstrom, *op. cit.*, p. 71.

Trucks can be used more profitably to tap new stands of timber, therefore, only through a sharp reduction in road-amortization and maintenance costs. This is frequently possible where public highways can be used for the major part of the haul, with temporary logging roads constructed at low cost for short distances only. Trucks are particularly well adapted to handling a low yield per acre and a low volume per day. This quality makes them useful in logging sparse stands or in selective cutting of a dense stand.²⁵

River driving is confined mostly to the Northeast and northern Rocky Mountains, but rafts and booms are employed to some extent in the Pacific Northwest and the South for the transportation of logs by water.²⁶ The use of chutes (principally in the northern Rocky Mountains and the Northeast), flumes (used occasionally in all sections but principally in northern Rocky Mountains), and other less commonly employed aids in log transportation have not been considered.

Log-loading Equipment.— The mechanization of yarding and hauling equipment could hardly have been accomplished without a corresponding mechanization of log-loading equipment. Several types of mechanical loaders, as well as a number of standard home-made devices powered by donkey engines, were available to the logging operator of the 1920's. Loading on railroads was almost universally accomplished with the aid of machines. The productivity of labor in log loading was much higher where mechanical devices were employed than in the considerable number of operations in which loading onto trucks or wagons was performed by animal power or manpower.

During the 1920's the locomotive crane, developed for general industrial use, was adapted to the lumber industry and was used both for log loading and for handling finished lumber in the sawmill yard.²⁷ During the 1930's a tractor-mounted mechanical loader was introduced which was suitable for use in loading trucks and wagons; its output compared favorably with that of the larger loaders used in loading railroad cars.

²⁵This is often done in conjunction with the use of horses for hauling logs on wagons (principally in the South and to lesser extent in the East, Northeast, and Lake States).

²⁶Brown, *op. cit.*, pp. 230-68.

²⁷A sample of sales of locomotive cranes believed to represent about 15 percent of the total sales of all locomotive cranes shows that 52 of these machines were sold to the lumber industry in the 5 years from 1920 to 1924. Compared with 21 units in the succeeding 5 years, sales after 1929 were negligible. The average size of the locomotive crane sold to the lumber industry tended to increase during this period, averaging 18 tons in weight each during the first 5 years and 22 tons in the next 5. The sizes of these cranes indicate that they were sold almost entirely to the larger lumber companies (NRP machinery-manufacturers survey; for a description of the sales sample of locomotive cranes and power shovels see appendix B).

Construction Equipment.— The construction of logging railroads and, more recently, of truck roads is a considerable industry in itself, and large numbers of power shovels are employed by the lumber industry to grade railroad beds. The accumulation of this equipment took place most rapidly during the early 1920's.²⁸ More recently, since 1932, bulldozers have been introduced in road-grading operations. The use of bulldozers has been particularly associated with the construction of tractor trails and truck roads.

RECENT DEVELOPMENTS IN LUMBER-MANUFACTURING MACHINERY

Sawmill and Planing-Mill Machinery

During this recent period there were few fundamentally new developments in the sawmill. However, a number of refinements in the construction of band saws, edgers, resaws, and trimmers were made after 1920, and they had an important cumulative effect in improving these machines.

Typical of refinements employed to an increasing extent on post-1920 models were antifriction, ball, and roller bearings and higher quality alloy steels. The introduction of automatic networks and various air- and steam-powered log-handling devices on the sawmill carriage reduced the labor of the "doggers" and "setters" associated with that machine.

The newer machinery in the planing mill employed ball and roller bearings, direct-connected motors, and improved steels to an increasing extent. These changes, together with improvements in design, have made the newer machines capable of operating at speeds much higher than those of earlier years. The most modern surfacers in the period prior to 1920 were capable of operating at a feed speed of 200 to 250 lineal feet per minute,²⁹ although average speeds were much slower. The planer-matcher introduced since 1930 is capable of feed speeds as high as 500 lineal feet per minute, and speeds of over 300 feet per minute are quite ordinary.³⁰

However, the effect of these improvements in sawmill and planing-mill machinery has been limited in recent years by the relatively low volume of sawmill and planing-mill machinery sales. The cycle of lumber-production activity is reflected in the sales of sawmill equipment, for

²⁸NRP machinery-manufacturers survey. During the years from 1920 to 1924, 44 shovels were sold to the lumber industry by the firms included in the sample. During the years from 1925 to 1929, 37 were sold; during the following 7 years only 10 were sold. The dipper capacity of these shovels has increased from 1.13 for 1920-24 to 1.31 cubic yards for 1925-29 and 1.55 for 1930-36. These shovels are employed principally on the larger operations. For a description of the sales sample of locomotive cranes and power shovels see appendix B.

²⁹E. F. Whitney, "Electricity in the Lumber Industry," *Transactions of the American Institute of Electrical Engineers*, Vol. XXXIII (1914), pt. II, p. 1347.

³⁰Some mills report running dimension stock at feed speeds of 1,000 lineal feet per minute (Bryant, *op. cit.*, p. 259; Harry Morgan, "Report of Committee on Planing Mill Practice," *The Lumberman*, Vol. XXII, No. 5 [Mar. 1930], p. 62).

the construction and modernization of the larger mills takes place during periods of expanding production in a given area. The last phase of the expansion of Pacific Coast lumbering activity is indicated by the slight rise of machinery sales in the years preceding 1923. After 1924 the value of sales of both sawmill and planing-mill machinery showed a marked decline to a low point in 1932. The recovery in sawmill-machinery sales after 1932 was insufficient to restore sales to the volume of the 1920's. (See table 2.) However, the figures indicate that during the 1920's there were considerable purchases of new sawmill and planing-mill machinery. Sales during these years would probably have been larger had there not been an appreciable volume of second-hand machinery available from mills which were steadily cutting-out during this period.

Table 2.- INDEX OF VALUE OF SALES OF MACHINERY TO THE LUMBER AND WOODWORKING INDUSTRY, 1920-36^a
(1929=100)

Year	Sawmill	Planing mill (heavy finishing)
1920	216.3	198.0
1921	112.1	100.0
1922	123.5	127.6
1923	172.3	179.9
1924	171.1	172.1
1925	104.7	142.2
1926	134.9	136.9
1927	65.0	108.1
1928	76.4	94.5
1929	100.0	100.0
1930	59.6	66.9
1931	26.5	38.4
1932	10.3	11.3
1933	15.2	33.1
1934	20.7	31.1
1935	24.8	48.0
1936	51.4	59.0

^aBased on table B-1. Excludes lighter finishing and woodworking machinery which would usually be employed in independent woodworking establishments. The series for sawmill machinery is believed to represent 35 to 50 percent of the value of sales of all machinery equipment used exclusively in sawmills (table B-2).

Source of Power

The shift from water power to steam power was approaching completion in 1904 when the beginnings of a new shift from steam power to electric power became evident. Electricity is more economical to produce and transmit than steam power, and it is a prerequisite for the application of many refinements in machines. Nevertheless, its introduction

into the lumber industry has been relatively slow. Table 3 indicates that the percentage of the total horsepower in the industry furnished by electric motors rose slowly from 6.9 percent in 1914 to 11.9 percent in 1919. Thereafter the rate of increase was higher, and by 1929, 44.6 percent of the total horsepower was supplied by electric motors. The relatively slow increase is mainly attributable to the fact that the period of electrification following 1920 coincided with a period of declining total horsepower in the industry during which production was shifting to smaller mills. Generation of power at the mill involves a considerable investment, and the purchase of central-station power is frequently not feasible because lumber mills frequently operate in outlying regions.³¹

Table 3.- PERCENTAGE OF TOTAL RATED HORSEPOWER OF THE LUMBER AND TIMBER PRODUCTS INDUSTRY FURNISHED BY ELECTRIC MOTORS, 1914-29^a

Year	Total	Driven by energy generated in the plant	Driven by purchased electrical energy
1914	6.9	5.2	1.7
1919	11.9	8.3	3.6
1923	24.6	18.7	7.9
1925	36.2	27.8	8.4
1927	42.1	29.8	12.6
1929	44.6	30.4	14.2

^aData for 1923 from *Census of Manufactures: 1923* (U. S. Dept. Com., Bur. Census, 1926), p. 448; data for all other years from *Fifteenth Census of the United States: 1930, Manufactures: 1929* (U. S. Dept. Com., Bur. Census, 1935), II, 463.

The primary reasons for the electrification of the sawmill were the centralization of power generation and the operating economies attendant on the use of electric power. Centralization of power generation in one electric generator rather than in several steam engines, each with its full complement of firemen and tenders, reduced labor requirements in one instance from 70 to 19 men.³² The purchase of electric energy, of course, entirely eliminates power-house personnel in the sawmill.

The sharp increase in the average size of steam turbines as compared with the average size of steam engines (table 4) indicates the extent to which power generation was centralized by the shift to electric power,

³¹These factors restrict the use of electric power at small mills in particular. Thus, on the Pacific Coast more than three-fourths of the large mills (daily capacity of 100 thousand or more board feet) and less than one-fifth of the small mills (daily capacity of less than 50 thousand board feet) used electric or electric and steam power in 1936 (see table C-6).

³²C. B. Gorton and F. A. Innes, "One New Industrial Power Plant Replaces Seven," *Power Plant Engineering*, Vol. XIVIII, No. 15 (Aug. 1, 1924), p. 791.

since turbines are used almost entirely in electric-power generation whereas engines are frequently used for driving machinery without further power conversion. Having an average horsepower of 229 in 1919, steam turbines increased in size more than threefold to an average capacity of 844 horsepower in 1929; in general there was no correspondingly consistent increase in the size of steam engines during this period.

Table 4.- AVERAGE RATED HORSEPOWER OF STEAM ENGINES, STEAM TURBINES, AND ELECTRIC MOTORS IN THE LUMBER AND TIMBER PRODUCTS INDUSTRY, 1914-29^a

Year	Steam engines	Steam turbines	Electric motors
1914	n.a.	n.a.	24.5
1919	61.5	229.1	22.5
1923	89.9 ^b	598.9 ^b	22.0
1925	92.7	774.8	24.0
1927	91.9	875.7	18.8
1929	70.3	844.3	18.5

^aFor source see table 3, fn. a.

^bDerived by multiplying the average horsepower in 1923 of both steam engines and steam turbines by an estimated ratio of the average horsepower of each to the average horsepower of both. The estimated ratios for 1923 were obtained by straight-line interpolation between similar ratios for 1919 and 1925.

n.a. Data not available.

Another significant effect of electrification has been a considerable reduction in sawmill maintenance personnel. Associated with the steam engine was a relatively inefficient system of shafting and belting for power transmission which required a large amount of maintenance labor. The application of motors to individual machines and groups of machines eliminated labor for the maintenance of shafts, belts, and pulleys. The tendency to adopt this form of drive upon electrification is indicated by the decline in the average size of electric motors employed in the lumber industry and by a comparison of the average size of electric motors with that of steam engines. In 1914 the average size of electric motors in the lumber industry was 24.5 horsepower; by 1929 this figure was 18.5. In the latter year the average horsepower of steam engines was 70.3.

Savings in the cost of power generation are only one phase of the economies attendant upon the use of electric power. The most flexible and adaptable of all forms of power, electricity has increased the tempo of production throughout the sawmill. Electrical equipment, furthermore, is easily adaptable to automatic and semiautomatic control.

Important though not easily measurable savings have followed the greater flexibility of plant lay-out which becomes possible when electricity serves as the source of power. When electric power is employed, the mill

designer need not plan the lay-out with a rather clumsy mechanism of shafts and belting as the starting point. He can lay out the simplest arrangement of machines with the most direct and rugged drive for each machine and then select the most suitable motor. The cumulative effect of electrification plus the improvements in sawmill and planing-mill machinery already noted have been to increase production from 15 to 20 percent in reported instances without the addition of a single machine.⁵³

Seasoning Equipment

Developments in the artificial seasoning of lumber were stimulated during the 1920's by the rapid extension of its use. Kiln drying of softwoods was found to improve the wood, reduce the spoilage connected with air seasoning, cut the time of the process sharply, and lower the shipping weight of the material.⁵⁴

The smoke kiln, the earliest form adopted, has been replaced by moist-air kilns at all except small sawmills in the pine region of the South. The principal developments in recent years have been directed toward securing better air circulation within the kiln in order to secure more rapid and uniform seasoning. Forced-circulation kilns have largely replaced other kiln types since 1920.⁵⁵

The development of instruments for indicating and recording kiln temperature and humidity has facilitated their successful operation. Instruments were also developed for the full automatic control of temperature and humidity, and they were found to be capable of effecting marked savings in steam and operating-labor costs.⁵⁶

Handling Equipment

In the handling of lumber, semiautomatic and fully automatic lumber-sorting tables have found some use. The more popular type is the semi-automatic edge sorter, in which a workman turns the lumber on edge and

⁵³NRP-NBER logging-camp and sawmill survey. Also Allan E. Hall, "Electrically Driven Saw Mills," *Mechanical Engineering*, Vol. 43, No. 2 (Feb. 1921), pp. 65-7; Harry A. Mount, "In the Modern Sawmill," *Scientific American*, Vol. CXIII, No. 22 (Nov. 27, 1920), pp. 546-57.

⁵⁴As an indication of the extent to which kiln seasoning reduces drying time, southern yellow pine may be taken as an example. This material in 1-inch stock requires 45 to 60 days in the warm months and from 90 to 120 days during the winter for proper drying. Kiln seasoning, on the other hand, was found in a survey of 99 plants to require an average of 66 hours. (Bryant, *op. cit.* [1922 ed.], p. 244.)

⁵⁵Letter from the U. S. Department of Agriculture, Forest Service, Forest Products Laboratory, to the author, dated June 7, 1939.

⁵⁶In one case the installation of the automatic control system on 11 kilns increased the kilns' output by 23 percent and reduced the steam requirements of the kilns by 18 percent (L. A. Corwin, "Exhaust Steam Economy," *Power Plant Engineering*, Vol. XXXIV, No. 23 [Dec. 1, 1930], p. 1372). A test of two identical kilns at a Pacific Coast plant, the temperature of one regulated by hand and that of the other by an automatic regulator, indicated that the hand-regulated kiln used 45 percent more steam than the latter (*West Coast Lumberman*, Vol. 33, No. 394 [Mar. 1, 1918], p. 32).

drops it into the proper slot, after which live rollers convey it to the end of the sorter and drop it onto skids which carry it to storage platforms. The fully automatic types have not found common use because most of them separate lumber by length only, rather than by width or thickness. Another development of considerable importance in open-air drying or kiln seasoning of lumber was the introduction of mechanical stacking devices. The productivity of labor in stacking and unstacking kiln cars and in piling in the open yard was estimated to be 150 to 250 percent higher with these devices than without them.³⁷

Among the more striking changes in lumber manufacturing during the 1920's was the application of mechanical handling devices in the sawmill yard. Before 1920 lumber was hauled from the sorting chain or planing mill to the dry-storage sheds principally by means of lumber buggies pulled by horses. During the 1920's a number of devices were applied to reduce the labor in this process. One of the first stages in the mechanization of lumber handling was the substitution of tractors for horses in pulling lumber buggies. Horses could pull a maximum of about 1,500 board feet at a speed of $2\frac{1}{2}$ miles per hour; tractors could haul 3,000 board feet at 6 miles per hour.³⁸

Although it greatly increased the productivity of handling labor, the substitution of tractors for horses did not fundamentally change the handling system. Basic changes were effected, however, by the installation of monorail and crane systems and, particularly in later years, by relatively inexpensive self-powered straddle trucks or carriers.

The emphasis in the larger and more expensive items was on volume of lumber that could be moved. A monorail system, employing one operator, was capable of handling 100,000 board feet per day; a cantilever crane operated by two men was reported to have moved 492,000 board feet of lumber in 8 hours. Another type of crane had an estimated capacity of 150,000 board feet per day with two operators, and locomotive cranes were estimated to be capable of handling 90,000 to 125,000 board feet per day with two operators. In one case a particularly high output was reported for a gantry crane when 800,000 board feet of lumber was loaded on a vessel in 10 hours. These systems came into wide use wherever lumber was moved directly from the sawmill to ships. Their installation on docks in lumber-producing regions undoubtedly displaced a considerable amount of labor. Of these systems, the one employing the locomotive crane was perhaps the most flexible. The locomotive crane was capable

³⁷Based upon estimates of output by hand and by machine given in Bryant, *op. cit.* (1922 ed.), pp. 212, 241-3.

³⁸*Ibid.*, pp. 140-3.



Williamette-Hyster Co.

FIGURE 3.—STRADDLE-TRUCK LUMBER CARRIER

This highly adaptable and relatively inexpensive machine has found widespread use in transporting lumber, without rehandling, from the sorting table to piles in the yard and to planers. The lumber is carried in the space between the wheels; it is piled by means of a front-lift device.

of handling lumber in the yard, loading and unloading cars, spotting cars at the point of loading, and loading vessels. In one instance a locomotive crane loaded 170,000 board feet of lumber on a ship in 10 hours. However, all of these systems involved large investments; they were therefore largely limited to mills of high output.³⁹

For smaller plants and for large plants requiring flexibility in handling, carriers found great popularity. These mobile units are capable of handling 30,000 to 50,000 board feet per hour.⁴⁰

The period from 1921 to 1926 was one of rapidly increasing sales of carriers; after 1926 sales declined slowly and irregularly until 1929 and rapidly thereafter until 1932. The recovery after 1932 was even more rapid than the decline before 1932, and by 1936 the value of carrier sales had reached the highest level yet attained (see table 5). This

³⁹Ibid., pp. 147-52.

⁴⁰Dr. Brysson Cunningham, "American Method of Conveying Timber," *Cassier's Industrial Management and Mechanical Handling*, Vol. XV (new series), No. 2 (Feb. 1928), p. 48.

Table 5.- INDEX OF VALUE OF SALES OF LUMBER CARRIERS, 1920-36^a
(1929=100)

Year	Index	Year	Index
1920	46.6	1929	100.0
1921	21.5	1930	49.6
1922	59.1	1931	35.2
1923	116.4	1932	12.5
1924	88.3	1933	24.3
1925	86.4	1934	35.2
1926	109.7	1935	76.7
1927	77.7	1936	136.4
1928	81.0		

^aBased on table B-4.

striking recovery is in marked contrast to the behavior of the sales of sawmill equipment noted earlier.

SUMMARY

The machines and techniques of the lumber industry have been developed in response to changes in the economic objectives of the industry and in the state of the forest resource. The emergence of steam donkey engines and forest railroads associated with the clear-cutting technique and their subsequent partial replacement by trucks and tractors are indicative of this. Also illustrative is the emphasis in recent years on developments in sawmill and yard equipment designed to reduce costs or improve quality. The period of ample timber reserves and indifferent mechanical efficiency in which selective cutting was a prime necessity ended in the latter part of the past century; it gave way to a period in which emphasis was placed on the rapid liquidation of the timber resource. The effort to achieve cost reduction and quality improvement in recent years represents a trend of increasing importance.

The extent and mode of the application of the more recent machines and techniques depend upon the character of the forest resources in the several producing regions. The magnitude, availability, and quality of the forest resource in each region are determined in turn by the natural conditions, the length of time the region has been logged, and the types of technique employed in the past. There are accordingly marked differences in the extent of employment and rate of adoption of the machines and techniques which have been described. In the following chapters technological changes and their effect on labor productivity and the state of the forest resource are discussed in relation to the conditions peculiar to the two most important forest regions, the Pacific Coast and the South.

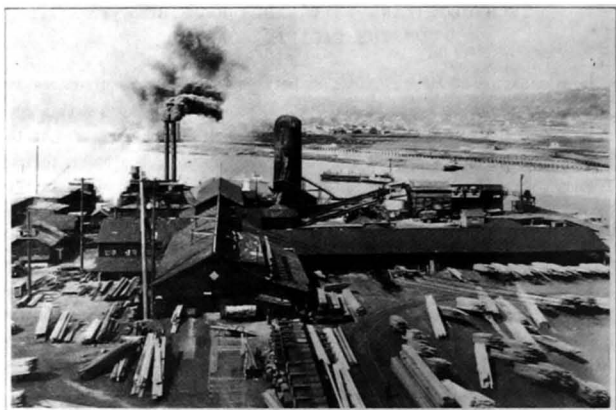
CHAPTER III

TECHNOLOGY AND UNIT LABOR REQUIREMENTS ON THE PACIFIC COAST

An examination of the relationship between unit labor requirements and technological developments in the lumber industry must begin with a recognition of two facts: (1) that unit labor requirements, measured by the number of man-hours required for the production of 1,000 board feet of lumber, increase with a decrease in the size, quality, and accessibility of the timber available for cutting and (2) that the lumber industry has operated for the most part on the principle of clear-cutting first the most accessible stands of large-size, high-quality timber, so that there has been a rather steady decrease in the accessibility of available timber, or in its size and quality, or in both as operations continued within a particular region. Because of these conditions, a constant process of adjustment has been necessary to accomplish a reduction or even the maintenance of the level of unit labor requirements.

One phase of this process of adjustment has been the advance of technology. There has been the steady improvement of machines, as noted in the preceding chapter, which has tended to reduce unit labor requirements. New machines and methods have been developed, particularly in logging, to meet the changes in conditions of accessibility and size of timber. Logging techniques have been developed to overcome to a considerable extent the difficulties of decreasing average size and to a lesser extent decreasing accessibility of selecting only the largest or most desirable trees for cutting. If practiced with an eye to the future yield of the stand, this process of selection is known as sustained-yield logging and may end almost entirely the increase in difficulties associated with the continuance of operations under the traditional clear-cutting system.

A second important mode of adjustment to depleted timber stands has been the abandonment of large stationary mills in favor of smaller and more mobile units. When timber becomes less accessible, it is thus frequently possible to move the mill closer to the timber instead of employing an increased amount of labor to bring the logs to the mill. Furthermore, stands are frequently available for cutting which are not of sufficient volume to justify the erection of a large and expensive stationary mill, but which can be profitably cut by small, temporary sawmills. The small mills attain the requisite mobility, however, by sacrificing much of the machinery of the large stationary mills; they frequently attain a competitive position in regard to labor requirements by manufacturing a cruder product.



United States Forest Service (E. S. Shipp)

FIGURE 4.- LARGE AND SMALL SAWMILLS

The Washington lumber mill shown at the top is typical of the large mills which produce the bulk of the Pacific Coast output. The portable sawmill shown below is one of more than 7,000 small sawmills in the South which accounted for nearly 40 percent of the southern production in 1934.

The relative importance of these two forms of adjustment to increasing difficulties varies regionally. The present discussion is limited to the Pacific Coast and the southern forest regions, areas which together accounted for over 80 percent of the total lumber production of the United States in 1935.

This and the following chapter are devoted to (1) an examination of the measures of adjustment to depleted timber reserves employed by the industry in these two regions and (2) an evaluation of the success of the adjustment made in particular sections of the industry in terms of the resulting level of unit labor requirements. Examination of the statistics on lumber production and timber depletion serves to indicate the magnitude of the adjustment necessary. Figures on the proportion of the total production in these two regions supplied by large and small mills at different points in time demonstrate whether or not the shift of production to smaller mills has been an important form of adjustment. A detailed analysis of technological changes with reference to their effect on labor productivity and the availability of timber defines the role of this form of adjustment to depleted timber reserves. Finally, the presentation of the available data on changes in the level of unit labor requirements, together with an analysis of the factors responsible for these changes, serves to summarize the effects of the shift in production and of technological changes.

On the Pacific Coast¹ are found the largest and densest remaining stands of old-growth timber in the United States. The Pacific Coast has 62 percent of the country's saw timber and 71 percent of the old-growth saw timber.² Most of this is in the dense stands on the moist western slopes of the Cascade Mountains where Douglas fir predominates; in the interior, the smaller ponderosa pine is the most important species. The old-growth stands are extremely dense and the individual trees are large. However, much of the remaining stand is not economically available at the present time because of the mountainous topography.

Production in this area began about 1845, but little lumber was cut until the completion of the Northern Pacific Railway in 1882. Production increased steadily after that time (table 6), with notable spurts after

¹Includes California, Oregon, and Washington.

²U. S. Congress, Senate, *A National Plan for American Forestry*, S. Doc. No. 12, 73d Cong., 1st sess., 1933, I, 176. More recent estimates indicate that these figures overstate slightly the importance of the Pacific Coast in terms of the Nation's timber reserves. The recent surveys by the United States Forest Service show that California and the Pacific Northwest (including Idaho and Montana) contain 62.1 percent of the Nation's saw timber and 75.4 percent of the old-growth saw timber (see *Lumber Industry Facts: 1939* [Washington, D. C.: National Lumber Manufacturers Association], p. 5).

MECHANIZATION IN THE LUMBER INDUSTRY

Table 8.- LUMBER PRODUCTION IN THE UNITED STATES
AND ON THE PACIFIC COAST, 1869-1938^a

(Millions of feet, b. m.)

Year	United States	Pacific Coast	Percent Pacific Coast is of United States	Year	United States	Pacific Coast	Percent Pacific Coast is of United States
1869	12,756	558	4.4	1920	29,878	10,323	34.6
1879	18,091	663	3.7	1921	26,961	7,215	26.8
1889	27,039	2,152	8.0	1922	31,569	10,581	33.5
1899	35,078	2,901	8.3	1923	37,166	12,762	34.3
1904	34,127	4,562	13.4	1924	35,931	11,929	33.2
1905	30,503	6,241	20.5	1925	36,339	13,287	34.7
1906	37,551	7,259	19.3	1926	36,936	14,189	38.4
1907	40,258	6,764	16.8	1927	34,532	13,390	38.8
1908	33,224	5,390	16.2	1928	34,142	13,630	39.9
1909	44,510	6,916	15.5	1929	36,886	14,149	38.4
1910	40,018	7,448	18.6	1930	26,051	10,670	41.0
1911	37,003	7,087	19.2	1931	16,523	7,494	45.4
1912	39,158	7,239	18.5	1932	10,151	4,545	44.8
1913	38,367	7,692	20.6	1933	13,961	6,147	44.0
1914	37,346	7,082	19.0	1934	15,494	6,459	41.7
1915	31,242	6,351	20.3	1935	19,539	7,953	40.7
1916	34,791	8,128	23.4	1936	24,355	10,297	42.3
1917	33,199	8,207	24.7	1937	25,997	10,840	41.7
1918	29,362	8,589	29.3	1938	21,646	8,601	39.7
1919	34,552	8,818	25.5				

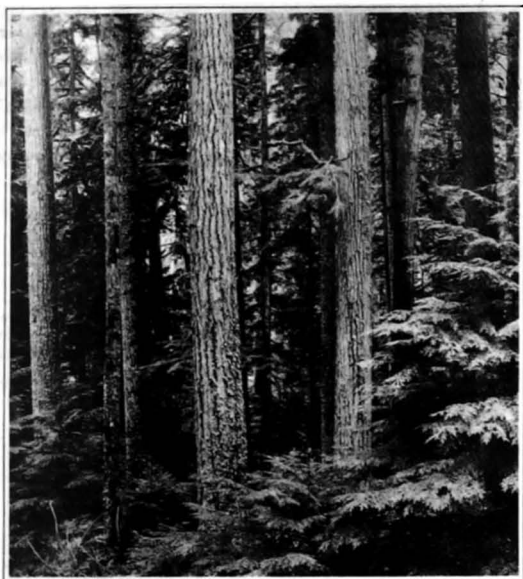
^aData for 1869-1934 from *Lumber Production: 1869-1934* (U. S. Dept. Agr., Forest Service, Div. Forest Econ., 1936), pp. 7-73; for 1935 from same, 1935 (1937); for 1936 from same, 1936 (1937); for 1937 from same, 1937 (rev. ed.; Apr. 4, 1939); for 1938 from same, 1938 (Nov. 1939). Figures for the Pacific Coast States (California, Oregon, and Washington) include data, usually not separable, for Nevada; however, the effect of the inclusion of Nevada is negligible (see table A-1, fn. c).

the opening of the Panama Canal in 1914 and in the post-war recovery of 1920. The production peak for this area occurred in 1926, but production was maintained at a uniformly high level throughout the years 1923-29.

In 1920 the United States Forest Service estimated that about 75 percent of the original 77,120,000 acres of forest land remained and that about 68 percent of this area was virgin stand.³ Between 1920 and 1935 the depletion of timber continued. The Forest Service estimates that the annual cut of saw timber in the years between 1925 and 1929 was 16,486,839 thousand board feet⁴ and that about 140 board feet of timber

³*Timber Depletion, Lumber Prices, Lumber Exports, and Concentration of Timber Ownership* (5d ed.; U. S. Dept. Agr., Forest Service, 1928), p. 32.

⁴*A National Plan for American Forestry*, I, 211.



United States Forest Service

FIGURE 5.—HEAVY STAND OF DOUGLAS FIR, WITH HEMLOCK UNDERGROWTH
Such dense stands of large, old-growth trees are typical of the Douglas-fir region of western Oregon and Washington.

per 1,000 board feet cut were destroyed by fire, insects, and other causes during each of these years.⁵ During these years the ratio of annual drain to annual growth was 10.5 to 1 for saw timber.⁶ The decline in lumber and timber-products production since 1929 has lowered considerably this rate of depletion. But in 1936 the current annual drain on the saw-timber resources of the Pacific Coast States, Idaho, and Montana was still over three times as great as the current annual growth.⁷

The depletion of the timber supply even on the Pacific Coast has made adjustments necessary to avoid rising logging costs. An examination of table 7 indicates that on the Pacific Coast this adjustment was not made

⁵The annual drain in timber cut and destroyed on the Pacific Coast was 3,444,011 thousand cubic feet (*ibid.*, p. 208) compared to 2,987,360 thousand cubic feet cut in each of these years (*ibid.*, p. 211).

⁶*ibid.*, p. 222.

⁷*Lumber Industry Facts: 1936*, p. 11.

through a shift of production to smaller mills during the 1920's. The percentage of the total production accounted for by the group of largest mills increased markedly, whereas that of all other groups declined.⁸ Since 1929 there have been indications of an increase in the importance of small mills. It is safe to say, however, that on the Pacific Coast the alteration and improvement of production techniques still constitute the most important of the two principal modes of adjustment to depleted timber supplies.

Table 7.- NUMBER AND ANNUAL PRODUCTION OF PACIFIC COAST SAWMILLS, BY VOLUME OF ANNUAL OUTPUT, 1919 AND 1929^a

Volume of annual output (thousands of feet, b. m.)	Mills		Production	
	Number	Percent of total	Thousands of feet, b. m.	Percent of total
1919, total ^b	1,217	100.0	6,796,504	100.0
50- 499	420	34.5	94,410	1.1
500- 999	165	13.5	116,837	1.3
1,000-4,999	305	25.1	659,253	7.5
5,000-9,999	85	7.0	602,479	6.8
10,000 or over	242	19.9	7,323,525	83.3
1929, total ^b	1,307	100.0	14,149,301	100.0
50- 499	469	35.9	110,447	0.8
500- 999	151	11.6	99,414	0.7
1,000-4,999	315	24.1	708,613	5.0
5,000-9,999	61	6.2	571,095	4.0
10,000 or over	291	22.2	12,659,732	89.5

^aData for 1919 from *Fourteenth Census of the United States: 1920*, Vol. X, *Manufactures: 1918* (U. S. Dept. Com., Bur. Census, 1923), p. 437; data for 1929 from *Fifteenth Census of the United States: 1930*, *Manufactures: 1929* (U. S. Dept. Com., Bur. Census, 1933), II, 448. Data are for California, Oregon, and Washington but include statistics for one mill in Nevada for 1929.

^bMills cutting less than 50 M ft. b. m. per year were excluded from the tabulation in 1919 because mills of this size were not reported in 1929 and it was desirable to have homogeneous groups for comparison. In 1919 there were 38 mills in this class (3 percent of the total of all mills on the Pacific Coast) cutting a total of 1,168 M ft. b. m. 6.01 percent of total lumber cut in this region). Because these mills are responsible for such a small percentage of the total production, their omission cannot affect the results appreciably.

TECHNICAL CHANGES AND UNIT LABOR REQUIREMENTS IN LOGGING CAMPS, 1920-35

Improvements in Machinery

The reduction of man-hour requirements on the Pacific Coast between 1920 and 1935 must be attributed in large measure to a process of steady

⁸There was a large increase in the volume of production between 1919 and 1929, and the increased utilization of capacity no doubt raised many mills from a lower to a higher size group. However, since 99.7 percent of the increase in production between 1919 and 1929 was accounted for by the increase in production of the group of largest mills, it is evident that the dominant tendency was to transfer a larger share of production to the large mills rather than to the small mills.

improvement in logging machinery. This was particularly true during the 1920's, when the powerful stationary cable yarders and forest railroads reached their peak of development.

The dense stands of old-growth timber on the Pacific Coast were particularly well adapted to logging by means of cable yarders, and the large size of individual timber holdings and the desire for their rapid liquidation favored the introduction of powerful equipment. Technical developments during the 1920's were therefore channeled to a considerable extent within the requirements of the large operations. The shift from ground skidding to high-lead and sky-line yarding likewise favored an increase in the size and complexity of logging engines.⁹ The central tendency in the development of the cable yarder was a steady increase in the size, power, and speed of logging engines; this culminated in the portable steel-spar skidders which found use at a number of large Pacific Coast operations during the 1920's. The usual sky-line system requires the rigging of two spar trees between which the cables of the sky line are strung. The portable steel-spar skidder of the middle 1920's employed a portable power plant mounted on a single railroad car with a 100-foot steel spar which could be raised and lowered. This tremendous machine could be run directly into the forest on a railroad spur line and quickly rigged at various points along the line to clear the forest. That it bore little resemblance to the early power skidders of 40 years earlier is indicated by the following tabulation:¹⁰

Item	First cableway skidder	Steel-spar skidder
Weight of power plant	15,000 lb.	300,000 lb.
Main cable	$\frac{3}{4}$ in.	$1\frac{3}{4}$ in.
Span	650 ft.	3,000 ft. ¹¹
Total amount of wire rope	3,000 ft.	32,000 ft.
Load carried	3 tons	25 tons
Daily maximum output	20,000 ft.	250,000 ft.

The large power skidders which reached their peak of development in the 1920's not only carried larger loads but transported them more rapidly. An average hauling speed of 250 to 450 feet per minute was increased, by

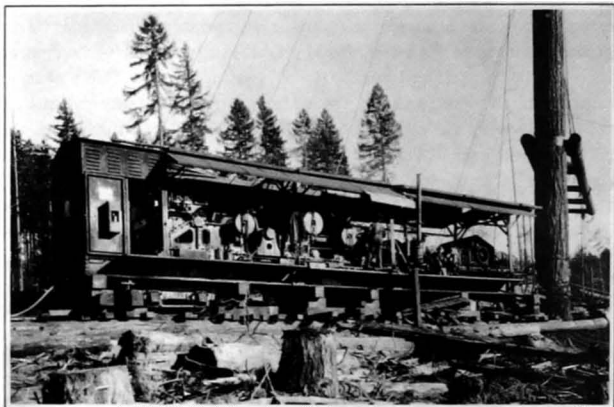
⁹High-lead and sky-line logging became general at logging operations in the Northwest after 1915. Introduced into California in 1917, high-lead logging was employed at 19 of 25 important operations by 1921. (S. B. Shaw and W. B. Greeley, *Timber Growing and Logging Practice in the California Pine Region* [U. S. Dept. Agr., Bull. No. 1402, May 1926], p. 29.)

¹⁰Adapted from Spencer Miller, "The Overhead-Cableway Method of Logging," *Mechanical Engineering*, Vol. 47, No. 7 (July 1925), p. 527.

¹¹Miller gave this figure as 5,000 feet, but since this clearly represents the extreme limits for operation of this equipment, it was felt desirable to substitute the more generally obtainable figure of 3,000 feet.

the middle of the 1920's, to 1,000 feet per minute, and in extreme instances to even higher speeds.¹²

The development of the forest railroad paralleled that of the cable yarders; there was a steady increase in the size and power of the locomotives and the strength and durability of the rolling stock employed.¹³ This meant an increase in the size of the load carried and in the speed of operation.



National Lumber Manufacturers Assoc.

FIGURE 6.- COMBINATION SKY-LINE YARDER AND LOADER

Such large machines as this electrically operated skidder-loader are capable of tremendous outputs in the dense stands of the Pacific Coast. They are, however, initially expensive, cumbersome to move and rig, and best suited to extensive clear-cut logging. Progressive timber depletion has increased the number of situations in which more flexible equipment is desirable.

Accompanying these changes in the size, speed, and power of logging machinery were the shifts from wood to oil as a fuel in steam engines and, in the case of yarding machinery, from steam to gasoline and Diesel engine power. This was productive principally of a reduction in the labor of attendance on these machines. These improvements in logging

¹²One important phase of technical progress which made possible these increases in the speed of operation and the size of the load carried was the constant improvement in the strength of the wire rope employed in the cable yarder (Shaw and Greeley, *op. cit.*, p. 27).

¹³Locomotives employed in western operations sometimes weighed 100 tons compared with 12 tons for earlier engines. The size of rails likewise increased from 12 pounds per yard on early lines to 60 and 70 pounds per yard on contemporary operations. (Nelson C. Brown, *Logging-Transportation: The Principles and Methods of Log Transportation in the United States and Canada* [New York: John Wiley & Sons, Inc., 1934], pp. 214-5.)

machinery - the increased size, speed, and power and the introduction of types of power and fuel requiring less labor - were probably the principal factors operating to reduce logging labor requirements during the 1920's. These improvements affected the larger operations particularly and were certainly the principal factor responsible for the reduction in unit labor requirements at the large camps during the 1920's.

The Shift to More Flexible Machinery.- In recent years the improvement of cable logging machinery and forest railroads has declined in importance as a factor influencing the Pacific Coast logging labor requirements. The increased utilization of more flexible types of logging machinery, such as the crawler tractor and the motortruck, has been the most important form of technological advance since 1929.

The development from ground skidding to high-lead and sky-line yarding resulted in a progressive increase in the weight, complexity, and size of the power unit. Thus the very steps which made the cable yarder a highly productive machine also contributed to its immobility. The system of clear-cutting timber (with which power yarders are associated and for which they are best fitted) leaves in its wake scattered stands of less accessible timber which are left precisely because they cannot be profitably logged by this method. The more intensively the equipment and methods of the clear-cutting system were developed and the more rapidly their use was extended, the more widespread became the necessity for a more flexible system capable of logging the scattered stands and the less accessible areas left by the cable yarder. The forest railroad, while not necessarily associated with the clear-cutting of the forest, was equally unsuitable for logging scattered stands.

The Shift From Cable to Tractor Logging.- In 1919, 2,987 cable yarders, some capable of reaching 3,000 feet into the forest, were in use in the three Pacific Coast States. There were 1,700 in Washington, 825 in Oregon, and 462 in California.¹⁴ It was noted earlier that sales of cable logging equipment appear to have declined after the middle 1920's, whereas sales of tractor logging equipment reached their highest point during the recovery years of 1935 and 1936. The beginning of the shift from cable to tractor logging became apparent during the latter 1920's and proceeded with particular rapidity during the period of recovery after 1932.

Data on the rate at which the shift took place following 1933 have been obtained from a directory of the western lumber industry. The results of

¹⁴"Magnitude of the Logging Industry of the West," *The Foreman*, Vol. XX, No. 5 (Mar. 1919), p. 36.

the tabulation are presented graphically in figure 7. Comparisons have been made of groups of identical camps classified according to estimated daily capacity in 1937, in terms of thousands of board feet.¹⁵ A definite increase between 1933 and 1937 in the percentage of camps employing tractors is shown for every size group. The greatest increase in the number of camps employing tractors occurred in the group of large camps cutting 100 to 249 thousand feet per day, and the shift to tractor logging proceeded furthest in the case of that group. Except for the two groups of small camps, however, there was no increase in the percentage of camps depending solely on tractors for yarding operations. The tendency during this period was to supplement cable yarders with tractors rather than to replace them entirely. Fifty percent or more of the camps in only one of the five size groups employed tractors in 1933; in 1937 over 50 percent of the camps in three of these groups employed tractors.

The same general trends are evident from the experience of 266 identical camps reporting in 1936 and 1937. This group is 75 percent larger than the group of camps identical for 1933 and 1937. In this group the increase in the number of camps employing tractors was greatest for the camps cutting 50 to 99 thousand feet per day; the increase in the number and percentage of camps depending entirely on tractors for yarding was greatest for the group cutting 100 to 249 thousand feet daily.

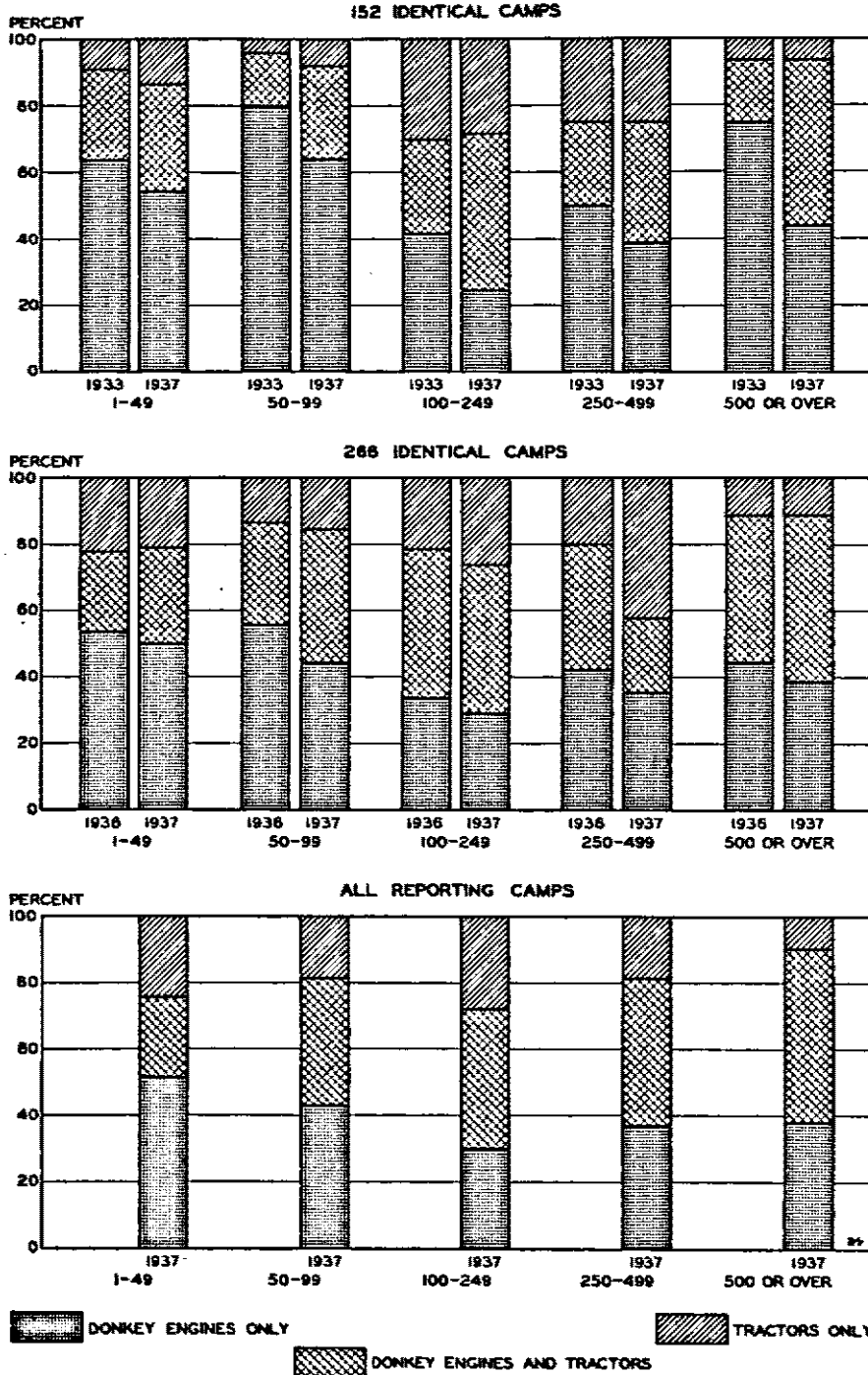
In 1937 about two-thirds of the large camps in the three size groups cutting more than 100 thousand feet per day employed tractors in logging. In general, however, there was little or no increase or an actual decrease (in the case of the group of largest camps and the group of smallest camps) in the number of camps depending exclusively on tractors for logging operations.

The two groups of camps considered thus far were limited in size by the requirement that identical camps for each of the years under consideration be examined. To give a more adequate picture of the present level of technique, a distribution was made according to method of the 409 camps reporting in 1937 (figure 7). This group is 54 percent larger than the group of camps identical for 1936 and 1937 and about 170 percent larger than the group of camps identical for 1933 and 1937. It is larger particularly for the small camps cutting less than 50 thousand feet, which are inadequately represented in the two groups discussed above.

An examination of this group shows that a majority of the camps in all except the smallest size categories now employ tractors at some point in the logging operation. Tractors are used by a greater percentage of the

¹⁵For a more detailed discussion of these data see appendix C.

Figure 7.- PERCENTAGE DISTRIBUTION OF PACIFIC COAST LOGGING CAMPS REPORTING SPECIFIED YARDING EQUIPMENT, BY DAILY CAPACITY, 1933, 1936, AND 1937
(Daily capacity in M ft. b. m.)



large camps (those cutting more than 100 thousand feet per day) than of the small and medium-size camps. The most popular practice at the larger camps is to combine cable and tractor logging.¹⁶

While the number of donkey engines employed at identical camps did not increase greatly between 1933 and 1937 and declined between 1936 and 1937, the number of tractors increased (table 8). However, the statistics on the number of donkey engines and tractors employed at all reporting camps in 1937 indicate that the donkey engine is still an extremely important factor in Pacific Coast logging.

**Table 8.- NUMBER OF TRACTORS AND DONKEY ENGINES REPORTED
BY PACIFIC COAST LOGGING CAMPS, 1933-37^a**

Year	Tractors	Donkey engines
108 identical camps		
1933	208	797
1937	244	868
1937 as percent of 1933	117.3	108.9
166 identical camps		
1936	331	1,172
1937	368	1,092
1937 as percent of 1936	111.2	93.2
All reporting camps		
1936 (387 camps ^b)	638	1,805
1937 (469 camps ^c)	724	1,848

^aData tabulated from *Handbook and Directory of the Western Timber Industries* (Seattle, Wash.: *West Coast Lumberman*), editions of 1933, 1935-36, and 1937. See appendix C.

^bOf this number, 201 reported tractors and 286 reported donkey engines.

^cOf this number, 259 reported tractors and 336 reported donkey engines.

There are important differences in the logging practices in Washington, Oregon, and California arising from differences in the principal types of timber cut. The two principal woods of Washington and Oregon are Douglas fir, which is the dominant species on the Pacific slope of the Cascade Mountains, and ponderosa pine, which is the most important species in the pine forests of the interior. In California ponderosa pine, with sugar pine found in the same forests, is the dominant species, and redwood is next in importance.

¹⁶It is interesting to note that the largest camps have the smallest percentage of camps employing tractors only, although they have a large percentage of camps employing tractors with cable yarders. On the other hand, the smallest camps have the smallest percentage of camps employing tractors but have a relatively large percentage of camps employing tractors only. The fact that the larger camps employ a greater number of machines, which in turn permit greater diversity in types of machines, is probably the explanation for this divergence. The small camps which employ tractors are likely to concentrate on them; on the other hand, the large number of small camps dependent on the second-hand machinery market would be likely to find cable yarders more easily available.

The shift to tractor logging is virtually complete in the ponderosa-pine forests. In the Douglas-fir region and in the redwood forests it is a comparatively recent development and has become important only since 1933.¹⁷ The shift to tractor logging proceeded rapidly in these areas between 1933 and 1937.

In Washington, Douglas fir accounts for almost four-fifths of the total production; ponderosa pine is relatively unimportant. Accordingly, in relation to its production Washington has a larger proportion of donkey engines and a smaller proportion of tractors than either of the other Pacific Coast States. A majority of the Washington logging operations depend entirely on donkey engines. On the other hand, the shift to tractor logging took place more rapidly between 1933 and 1937 in Washington than in either of the other States, because this development in Douglas-fir logging has been rapid.

In California the situation is just the opposite; pine production is dominant and Douglas fir is a relatively unimportant species. California, in relation to its production, therefore has a larger proportion of tractors and a smaller proportion of donkey engines than either of the other Pacific Coast States. A majority of the logging operations in California employ tractors only, and the number of operations dependent solely on donkey engines is small.¹⁸ Because the shift to tractor logging in pine is virtually complete, however, the rate of increase in the number of tractors is smaller in California than in the other States. The fact that the shift to tractor logging is less complete in redwood and was proceeding rapidly from 1933 to 1937 accounts for the considerable number of donkey engines employed in California and for whatever increase has taken place in the number of tractors.

In Oregon, Douglas-fir production is dominant, although ponderosa pine is a highly important species. Oregon accordingly occupies an intermediate position between California and Washington in respect to the relative popularity of the two methods of logging and the rate of increase of tractor logging.

Considered in relation to the period prior to 1933, the extent of the shift to tractor logging is even more pronounced. Tractors were a

¹⁷The chief engineer of a Pacific Coast firm engaged in the manufacture of tractor logging equipment estimated that, in 1936, 25 percent of the redwood was logged by tractors, whereas none had been so logged 3 years earlier. According to Axel J. F. Brandstrom of the United States Forest Service (special report of the U. S. Dept. Agr., Forest Service, Div. Res. [Nov. 1, 1936] for the "Studies of Productivity and Employment in Selected Industries" section of the National Research Project), by 1936 about 30 to 40 percent of the output of the Douglas-fir region had been shifted from cable logging to tractors, whereas "tractors were of very little importance until 1932"

¹⁸The percentages of camps using donkeys only are 4.5 for the smallest-output class and 0, 4.6, 11.1, and 0 for the successively larger classes (table C-2).

distinct rarity in western logging operations in 1920 and had begun to be a significant factor only toward the close of the 1920's. Single- and double-drum hoists were not introduced until 1925 and did not become an important production item until 1927. Similarly, the logging arch did not replace high wheels until the close of the 1920's. Nevertheless, by 1937 over 45 percent of the camps in all capacity groups were employing tractors and over 18 percent of the camps in four of the five groups used tractors without the aid of donkey engines.

The Shift From Railroad to Truck Logging.—Concomitant with the shift from cable to tractor logging has been a growth in the importance of truck logging, frequently at the expense of railroad logging. In the early 1920's the dominance of the railroad as a means of log transportation on the Pacific Coast was unquestioned. The scope and importance of logging railroads in the Pacific Coast States in 1919 are indicated by the fact that there were 3,665 miles of railroad employing 752 locomotives, distributed as follows:¹⁹

State	Mileage	Locomotives
Washington	2,000	430
California	840	160
Oregon	825	162
Total	3,665	752

Trucks were probably first used in the Northwest about 1913. During the 1920's truck logging gradually assumed an important position. By 1931 there were nearly 900 trucks hauling about 375 million board feet per year in Oregon and Washington. It was estimated that about 6 to 10 percent of the total cut of logs was hauled by trucks in these two States. Estimates placed the division between means of transportation in 1931 in the Puget Sound District of Washington as follows: Trucks, 6 percent; logging railroads, 58 percent; common-carrier railroad, 27 percent; and imports by water haul, 9 percent.²⁰

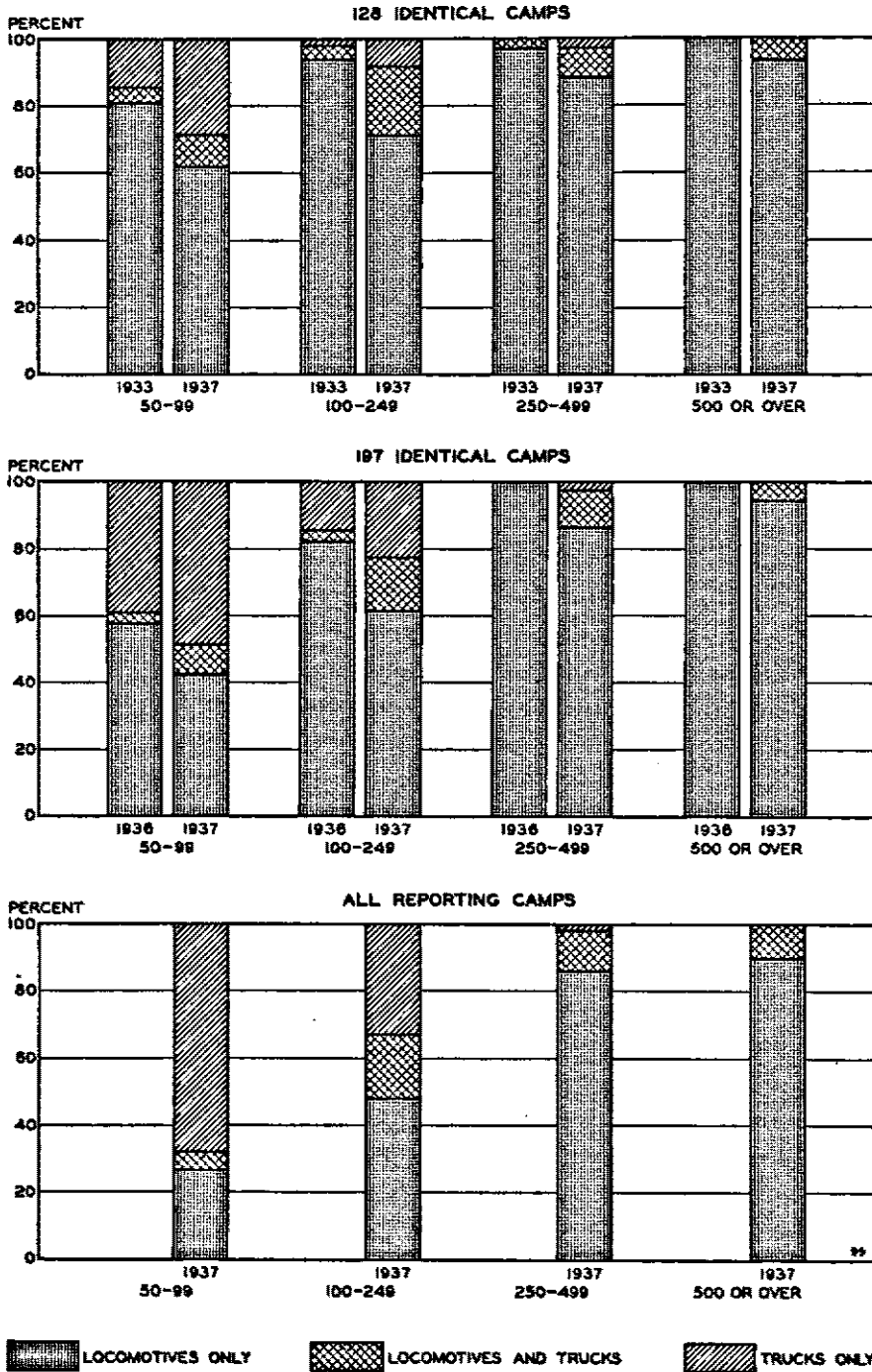
The indications are that since 1932 there has been a rapid increase in the extent and importance of truck logging. An examination of figure 8 indicates that a substantial majority of the small and medium camps, having a daily capacity less than 100 thousand feet, employ trucks as the sole means of major transportation. At 19 percent of the large operations, those cutting 100 to 249 thousand feet per day, trucks are employed in conjunction with railroads. A majority of the large camps in

¹⁹Magnitude of the Logging Industry of the West, loc. cit.

²⁰E. F. Rapaeger, "Motor Truck Log Hauling in Oregon and Washington," *The Lumberman*, Vol. LXXIV, No. 8 (June 1933), pp. 11-2. (For the remaining parts of this article see the following issues of the volume cited: No. 10 (Aug.), No. 11 (Sept.), and No. 12 (Oct.).)

Figure 8.- PERCENTAGE DISTRIBUTION OF PACIFIC COAST LOGGING CAMPS REPORTING SPECIFIED HAULING EQUIPMENT, BY DAILY CAPACITY, 1933, 1936, AND 1937

(Daily capacity in M ft. b. m.)



this group depend on trucks for at least part of the haul. The largest camps, cutting more than 250 thousand feet per day, are predominantly railroad operations; when trucks are employed, they are used as a supplement to the railroad. It is probable that camps which reported the use of both trucks and railroads employ trucks in many instances to replace railroad spur lines, thereby reducing the volume of railroad-construction and maintenance labor.²¹

It is evident that trucks have increased markedly in importance since 1932. One study stated that the number of logging trucks under permit from the State of Oregon doubled between 1932 and 1935.²² The data presented in this study indicate that a large proportion of the output was handled by truck in 1936.

However, there are difficulties in measuring the rate of change from railroad to truck logging. Trucks are employed because of their flexibility which makes it possible to log sparse or small, isolated stands profitably. Also, trucks are used chiefly on the smaller operations. Because of this, camps employing trucks tend to shift location more frequently. In the tabulation (table C-3) it proved impossible to trace operations which changed locations; hence the group of identical camps represents a more stable group of operations than the average, in terms of period of cutting at one location. Consequently any group of camps identical in general location as well as ownership over a period of years is likely to contain a higher-than-average percentage of railroad operations; a comparison of methods at identical plants in various years is likely to understate the extent of truck logging and the shift to that method.²³

With this qualification in mind, an examination of figure 8 demonstrates a remarkably rapid adoption of truck logging at the expense of railroad logging. In general, camps cutting less than 250 thousand board feet per day show a marked tendency to discard railroad logging entirely in favor of truck logging. The largest camps are more likely to supplement existing railroad facilities with truck haul, presumably for short distances only. The indications are that on the Pacific Coast truck logging is employed most in Oregon and least in Washington.

²¹For a discussion of these data see appendix C.

²²Ralph J. Staehli, "Today's Truck Logging," *The Timberman*, Vol. XXIV, No. 3 (Jan. 1935), p. 16.

²³On the other hand, a comparison of the methods employed at all reporting camps in two different years would in one sense overstate the change. Because the smaller operations working small and scattered stands are likely to increase in number with a recovery in production, there may be a greater apparent than actual shift to such a method as truck logging.

Table 9.- NUMBER OF TRUCKS AND MILES OF RAILROAD REPORTED BY PACIFIC COAST LOGGING CAMPS, 1933-37^a

Year	Trucks	Miles of railroad
100 identical camps		
1933	14	2,205
1937	101	2,405
1937 as percent of 1933	721.4	109.1
149 identical camps		
1936	67	3,087
1937	168	3,051
1937 as percent of 1936	250.7	99.5
All reporting camps		
1936 (367 camps ^b)	208	4,197
1937 (469 camps ^c)	701	4,091

^aData tabulated from *Handbook and Directory of the Western Lumber Industries* (Seattle, Wash.: *West Coast Lumberman*), editions of 1933, 1935-36, and 1937. See appendix C.

^bOf this number, 46 reported trucks and 194 reported railroad mileage.

^cOf this number, 148 reported trucks and 177 reported railroad mileage.

Effects of the Shift to More Flexible Equipment on Labor Requirements.-

The yarding operation, in which logs are hauled from the stump to the railroad or other means of major transportation, is a logging phase of decisive importance. The efficiency with which yarding is coordinated with loading and the long haul may determine the efficiency of these latter operations.

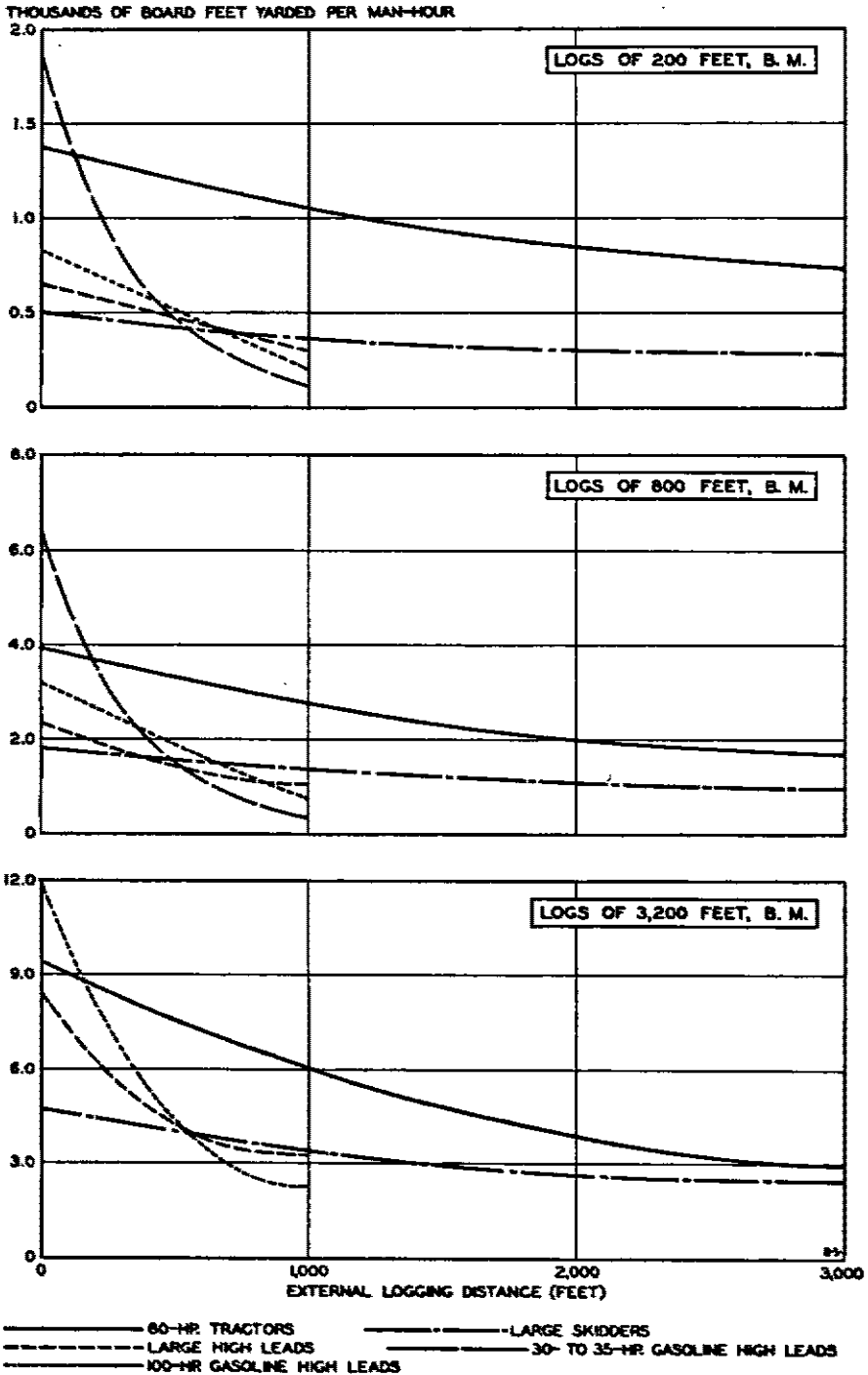
In a complete analysis of large-scale Douglas-fir logging operations the United States Forest Service has shown that the productivity of tractor yarding is greater than that of donkey-engine yarding. A comparison of man-hour requirements for gasoline and steam high leads, large skyline skidders, and tractors equipped with fair-lead arches, for logs of various sizes and for various yarding distances, is shown in figure 10.²⁴ Tractor logging with fair-lead arches shows decisively lower unit labor requirements at all except very short distances for all sizes of logs. Unit labor requirements with large skyline skidders approach the level

²⁴The curves in figure 10 are based on Axel J. F. Brandstrom, *Analysis of Logging Costs and Operating Methods in the Douglas Fir Region* (Forest Service of the U. S. Dept. Agr., West Coast Lumbermen's Association, and Charles Lathrop Pack Forestry Foundation, June 1933), pp. 19, 25-36.

The following method was employed in calculating the data: From the original tables, production per man-hour was computed for individual studies by dividing total production by the number of man-hours required; the resulting figures were then averaged, the number of studies represented being used as a weighting factor; curves of various types were fitted to these averages; and the final data, appearing in this table, were taken from the curves.

The external yarding distance is that from the landing to the outside boundary of the logging area.

**Figure 10.- YARDING PRODUCTIVITY IN DOUGLAS-FIR OPERATIONS,
BY TYPE OF EQUIPMENT, 1951**



of those with tractors only for very large logs and at considerable distances. Small gasoline high-lead yarders show a lower unit labor requirement than tractors at very short distances for small and medium-size logs. Unit labor requirements are lower with 100-hp. gasoline high leads than with tractors for large logs at very short distances. Otherwise these studies, the best available, demonstrate that tractor yarding has decisive advantages over other logging machinery in terms of unit labor requirements.²⁵

When it is necessary to extend yarding operations to distances beyond 3,000 feet, the advantage of tractor roading over sky-line swinging increases rapidly because of the fact that sky-line-swinging costs increase sharply as additional units become necessary.²⁶

The relatively slower increase in logging costs for tractor logging with an increase in distance has important implications for labor requirements and costs in related operations in railroad construction. Cable logging requires an extensive network of spur lines in logging a stand so that yarding distances are kept at a profitable maximum. When tractor logging is employed, it is possible to extend the yarding distance somewhat and thereby to reduce sharply the amount of spur-line construction. Thus tractor logging enables operators to achieve important reductions in construction-labor requirements.²⁷

An important aspect of the successful utilization of the new tractor equipment is the specialization of equipment for particular types of operations. The smaller operator who is limited in the number of machines which he can profitably employ will find it difficult to realize the full savings possible with the new machinery. This is true because it may be necessary to employ cable logging machinery in particular instances to overcome the difficulty associated with particularly rough topography. On the other hand the large number of uses to which both tractors and trucks may be put increases the degree of utilization of the capital investment of the small operator employing these machines.

²⁵It should be noted that the tractor can be equipped to serve as a small high-lead yarder by equipping it with a double-drum hoist or "tractor donkey."

²⁶Brandstrom, *op. cit.*, pp. 52-6.

²⁷Estimates for one operation placed construction costs as follows for the two methods (main-line railroad used in both methods): Using railroad and cable logging, 40 miles of spur lines cost \$355,850; using railroad, truck, and tractor logging, 1 mile of spur line cost \$10,000, 2.5 miles of truck road cost \$12,000, and 20 miles of main tractor roads cost \$18,000, or a total cost of \$40,000 (100-200 miles of branch tractor roads were charged directly to current operating costs) (Burt P. Kirkland and Axel J. F. Brandstrom, *Selective Timber Management in the Douglas Fir Region* [Forest Service of the U. S. Dept. Agr. and Charles Lathrop Pack Forestry Foundation, Jan. 1938], p. 27). For another operation road-construction costs for a large area were estimated as follows for the two methods of logging: Railroad-spur (50-60 miles) and donkey-engine logging, \$580,000; tractor logging (600 miles of road), \$319,000 (Brandstrom, *op. cit.*, pp. 104-5).

Truck logging has made headway in the West because of the need for equipment more flexible than the railroad in logging certain stands. However, Brandstrom concludes that "in spite of the rapid development of motor trucks, the typical logging railroad operation when operating at normal capacity is still far in the lead as far as actual hauling efficiency is concerned."²⁸ Truck logging, then, represents an adjustment in which current operating efficiency is sacrificed in favor of lower investment costs; if amortization costs are disregarded, truck-hauling costs are from two to four times as great as rail-hauling costs.²⁹



United States Forest Service

FIGURE 11.—TRUCK LOGGING IN THE PONDEROSA-PINE REGION
Logs are being loaded for the haul to the railroad several miles away.

On the other hand, truck hauling is much less expensive than tractor hauling, and frequently trucks may be employed profitably to replace long-distance tractor roading of logs. The disadvantage of this procedure is

²⁸Brandstrom, *op. cit.*, p. 71.

²⁹Costs of truck and railroad logging, in cents per mile per thousand board feet, for logs of 800-board-foot volume are as follows (*ibid.*, p. 82):

Motortrucks hauling on poor or steep roads; average hauling distance of 3 miles	40
Logging railroad-spur transportation (landing to make-up track); average hauling distance of 3 miles; 5-15 million feet of timber per mile of road; cost of construction per mile, \$8,000.	10
Motortruck hauling on good roads (public highways); average hauling distance of 10 miles	18
Logging main-line transportation; average hauling distance of 20 miles; 20-60 million feet of timber per mile of road; cost of construction per mile, \$12,000	4

the cost of loading logs on trucks, but this difficulty has been overcome to some extent by the introduction of small tractor-mounted loaders.

In spite of the greater operating costs of truck hauling compared with railroad hauling, truck transportation frequently constitutes the only possible method of logging small, scattered stands of timber having insufficient volume to justify railroad construction. Such operations are most practicable when public highways can be used for the major part of the haul. A rough calculation for 52 Oregon trucking operations studied in 1933 indicates that 86 percent of the total length of haul of these operations was made over public roads.³⁰ Even under favorable conditions, however, truck hauling on the whole probably requires more labor per unit of transportation service than most railroad operations. Nevertheless, by reducing the capital and labor requirements that would otherwise be necessary to log less favorable stands,³¹ truck hauling has made it possible to log such stands profitably and has thereby extended the limits of the economic availability of timber.

The shift from railroad logging to truck and tractor logging, particularly on the spur lines, has effected large reductions in construction costs in Pacific Coast logging. A considerable reduction in the cost of construction for railroad gradings, truck roads, and tractor roads and trails has been accomplished by the mechanization of construction activities.

The 1920's witnessed the introduction of power shovels principally for use on railroad gradings. It was noted that the sales of concerns manufacturing power shovels for the lumber industry declined sharply after 1929.³² The steady increase in the number of power shovels reported at Pacific Coast logging camps from 1933 to 1937 (table 10) is therefore

³⁰Rapraeger, *op. cit.*, Vol. XXXIV, No. 11 (Sept. 1933), p. 18. In his table Rapraeger gives the type of road employed for truck haul at 52 operations. Length of haul is given as 1 to 2 miles, 3 to 5 miles, etc.; by weighting the midpoints of these intervals by the number of operations, it was possible to estimate the number of miles hauled on the various types of road.

³¹Typical costs per mile in the redwood region for truck-road and railroad construction are as follows: Main truck roads, \$6,000 to \$10,000; branch roads, as little as \$1,500 graveled and \$750 ungraveled; main-line railroads, under comparable conditions, \$15,000 to \$20,000; and railroad spurs, \$10,000 (Emanuel Fritz, "Tractor Advantages in the Redwood Region," *Journal of Forestry*, Vol. 35, No. 10 [Oct. 1937], p. 922).

Rapraeger found that truck-road construction costs per mile for several operations were as follows: Earth - \$100, \$130, \$205, \$1,800 (hand labor, steep inclines, blasting), \$448, and \$193; gravel, 12-foot wide, 5 inches of gravel - \$1,313; plank - \$3,000 to \$5,000 (Rapraeger, *op. cit.*, Vol. XXXIV, No. 10 [Aug. 1933], pp. 16-7). Estimates for railroad-spur construction were placed at an average of about \$6,800 per mile at a Douglas-fir operation compared with \$4,600 for truck road (Kirkland and Brandstrom, *op. cit.*, p. 37). At a second-growth Douglas-fir operation truck-road construction cost was estimated at \$6,000 per mile (*ibid.*, p. 42).

³²See ch. II, fn. 28.

Table 10.- NUMBER OF POWER SHOVELS AND BULLDOZERS REPORTED BY PACIFIC COAST LOGGING CAMPS, 1933-37^a

Year	Power shovels	Bulldozers
111 identical camps		
1933	80	(b)
1937	131	(b)
1937 as percent of 1933	163.8	-
172 identical camps		
1936	160	51
1937	158	89
1937 as percent of 1936	98.8	174.5
All reporting camps		
1936 (387 camps ^c)	214	77
1937 (469 camps ^d)	232	168

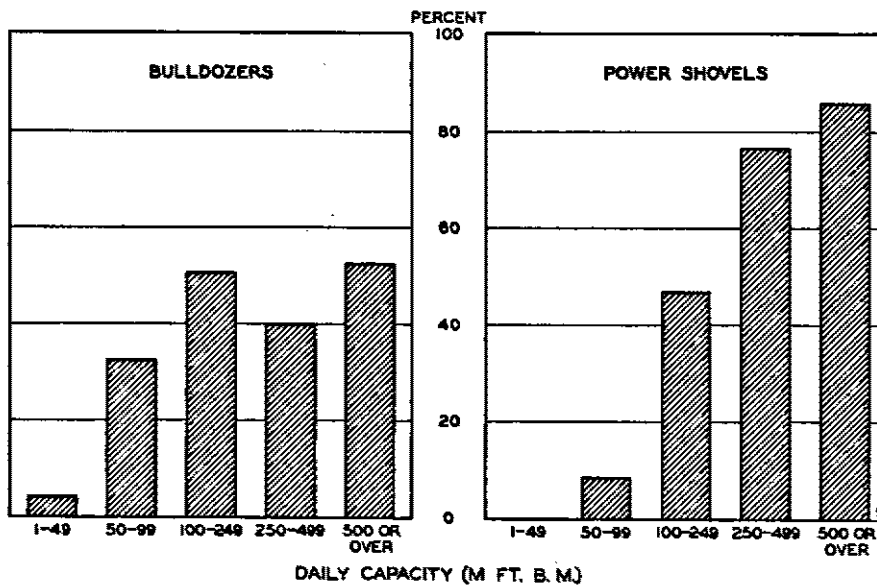
^aData tabulated from *Handbook and Directory of the Western Lumber Industries* (Seattle, Wash.: *West Coast Lumberman*), editions of 1933, 1935-36, and 1937. See appendix C.

^bInadequate sample.

^cOf this number, 120 reported power shovels and 61 reported bulldozers.

^dOf this number, 189 reported power shovels and 136 reported bulldozers.

Figure 12.- PERCENT OF PACIFIC COAST LOGGING CAMPS REPORTING BULLDOZERS AND POWER SHOVELS, BY DAILY CAPACITY, 1937





Caterpillar Tractor Co.

FIGURE 13.— BULLDOZER BUILDING A LOGGING ROAD

The blade of the bulldozer, seen at the left front corner of the tractor, is cutting a tractor road in the mountainside. The use of such equipment has radically reduced road-construction costs and has contributed to the development of truck and tractor logging.

the more noteworthy. Figure 12 shows that the reduction in labor requirements through the use of shovels was accomplished principally at the larger camps. Almost four-fifths of the larger camps, those cutting more than 250 thousand board feet per day, reported the use of power shovels, whereas only one-sixth of the smaller camps reported their use. Although these figures doubtlessly understate the extent of the use of power shovels at Pacific Coast logging camps, they probably reflect accurately the distribution of power shovels according to size of the camps.

An important recent development since 1932 has been the introduction of bulldozers into Pacific Coast camps, a development closely associated with the expansion of tractor logging. The rapid expansion in their use is indicated in table 10.

Bulldozers are more evenly divided among the camps of various sizes than power shovels, a fact which probably reflects the more general employment of tractors in logging operations. Power shovels are associated with railroad operations and are therefore concentrated in the larger

camps, whereas bulldozers are associated with tractor and truck operations and are therefore more widely employed (figure 12).

Effects of the Shift to More Flexible Equipment on Timber Resources.—The newer methods of logging, employing tractors and trucks, are notable principally for the fact that individual trees or scattered groups of trees may be selected for logging. The United States Forest Service has demonstrated that for a given type of timber there is a size limit below which the costs involved in logging and milling become excessive. The employment of the newer methods of logging, by making it possible to select only those individual trees larger than this economic lower limit, can reduce man-hour requirements in particular areas below levels attainable with the older equipment. Many operations have therefore doubtlessly lowered their unit labor requirements through the adoption of newer methods of logging.

Many of these operations, however, employ tractors to remove most of the merchantable stand, and they leave the land in a condition which is hardly more desirable from the standpoint of regeneration and fire protection than under the clear-cutting system of logging. Therefore the progressive increase in the difficulties of logging which was the feature of the clear-cutting system is also a characteristic of the newer systems of logging insofar as the newer "selective logging" involves the removal of all the timber which can be cut at a profit. Whether or not the newer methods of logging applied in this fashion will reduce unit labor requirements in logging for the Pacific Coast industry as a whole depends on how rapidly the difficulty of logging increases because of the essentially destructive nature of these methods and of the old clear-cutting system. In other words, the newer methods may merely perpetuate the race between improved technology and increasing extractive difficulties.

It seems likely that the short-time effect of the adoption of tractor logging has been to reduce unit labor requirements for the Pacific Coast industry as a whole. However, depletion of the forests continues. The obstacles to the reduction of unit labor requirements may increase too rapidly to be overcome by further advances in technology.

Tractors and trucks may nevertheless be profitably employed in logging the forest so as to obtain a sustained yield of large timber. This would mean that the newer methods of logging would be applied not merely to the cutting of all timber which can be cut at a profit but to the cutting of individual trees and groups of trees which had reached that point in their growth where the value of further growth is not sufficient to justify their further maintenance. Under selective logging of this type

a forest of large trees could be maintained and the natural growth of the trees accelerated through cyclical cuttings. Thus the progressive increase in logging difficulties could be largely ended and the capital values of the growing forest and of improvements in the land maintained. Although such a system would probably reduce unit labor requirements on particular tracts, its effect on employment opportunities in the industry would doubtlessly be beneficial. The relation between employment opportunities and the continued stable existence of forest resources, however, will be discussed in a later chapter.

Unit Labor Requirements at a Group of Large Operations

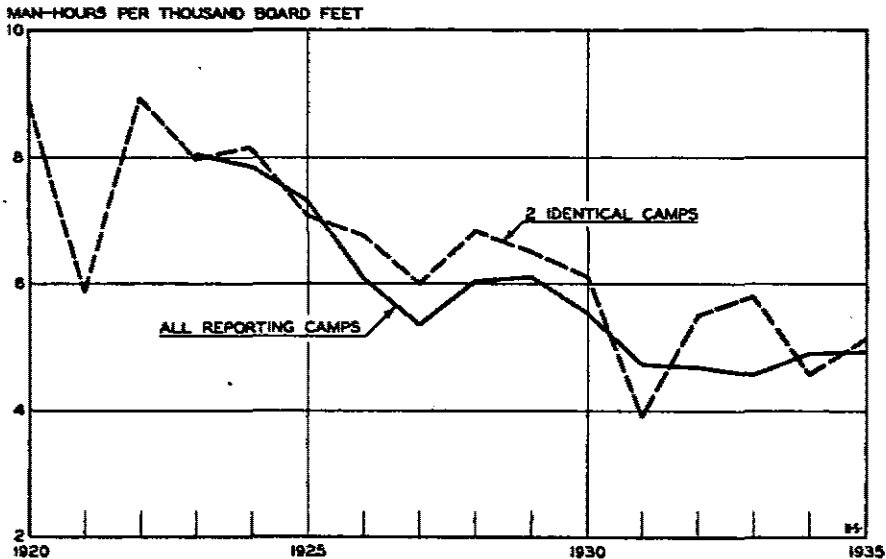
The National Research Project, in cooperation with the National Bureau of Economic Research, surveyed 17 logging camps in the Douglas-fir region and 3 ponderosa-pine operations in the Pacific Coast States. This survey is designated as the "NRP-NBER logging-camp and sawmill survey."

The production of these camps represented a small but generally increasing proportion of the Pacific Coast lumber production. Logging camps supplying mills which cut over 50 million board feet in 1929 are best represented in the sample, which is confined to logging camps supplying mills which cut over 25 million board feet in 1929. The findings therefore refer only to large logging camps; they are most representative of the experience of the largest logging camps. The sample is regarded as being reasonably adequate for the large logging camps after 1929. A more detailed analysis of the sample on which the following findings are based is presented in appendix A. The method of calculating logging production and a description of the operations included in the logging man-hour totals are also given in this appendix.

The production, man-hour, and unit-labor-requirement series obtained in the survey are presented in table A-3. In spite of somewhat erratic year-to-year fluctuations, a definite downward trend is evident in the labor-requirement ratio for this group of large camps. A comparison of the average unit labor requirements for 3-year periods indicates a steady decline in man-hour requirements averaging about 15 percent per period. The reduction of about 1 man-hour per thousand board feet between 1927-29 and 1933-35 indicates a consistent increase in labor productivity. Because of the steady increase in the size of the sample, comparisons of the man-hour ratio (man-hours per thousand board feet) for one period with that of another period are more hazardous for the earlier years. The available data indicate, however, that the 1920's represented a period of the most rapid decrease in the man-hour ratio.

The trend of the man-hour ratio for the two camps for which data are available over the entire period follows closely the trend for the sample as a whole (figure 14), but with more violent short-time fluctuations. The experience of one of these camps indicates that the explanation for the yearly variations lies in the concentration of construction activity in particular years.³⁵ When the area of operations must be extended and a new stand opened, a relatively large quantity of labor must be expended in tasks such as the construction of spur railroad lines, bridges, and roads which do not immediately result in increased production. In years when production is sharply curtailed, however, it may be possible to dispense with such construction labor almost entirely.

Figure 14.-- UNIT LABOR REQUIREMENTS IN LARGE PACIFIC COAST LOGGING CAMPS, 1920-35



BASED ON TABLE A-3

WRI-NATIONAL RESEARCH PROJECT

M-42

Factors Contributing to Increased Labor Productivity.— Insofar as the decrease in unit labor requirements shown by the sample was typical of large logging operations on the Pacific Coast during the 1920's, it must be attributed in large measure to the improvements in logging machinery made during that period. This period was marked by the peak in the development of cable logging machinery and forest railroads. The increases

³⁵At this camp construction activities at a new site began in 1923 so that production was curtailed and man-hours increased at the same time. As a result the man-hour ratio reached 49.6 in 1923 compared with 9.4 in 1922 and 10.1 in 1924. The estimated number of man-hours spent in construction activities at this camp in this year have been eliminated in the calculation of the man-hour ratio so as to avoid introducing a serious distortion of the trend.

in the size, speed, and power of cable logging engines and of logging locomotives were particularly typical of the larger operations. These improvements and the shift to types of power and fuel requiring less labor³⁴ were almost certainly the principal factors responsible for the observed reduction in unit labor requirements during the 1920's.

The improvement of cable logging machinery and forest railroads has declined in importance as a factor influencing Pacific Coast logging-labor requirements in recent years. The substitution of tractor logging for cable logging, a development which began in 1925 and proceeded with particular rapidity after 1932, has probably been the principal force operating to reduce unit labor requirements since 1929. In general this shift has taken the form of the abandonment of cable logging as the sole means of yarding in favor of a system combining tractor and cable. The United States Forest Service study of Douglas-fir logging costs indicates that the adoption of a system combining the use of cable logging engines and tractors affords opportunities for sharp reductions in unit labor requirements in yarding operations.³⁵ Nine of the 20 logging camps covered by the NRP-NBER survey employed tractors in yarding operations, and 2 camps depended solely on tractors for yarding.

Railroad logging was still the dominant means of major transportation in 1936 at the logging camps included in the NRP-NBER survey. Nineteen of the 20 operations used railroads exclusively; the other camp supplemented an extensive railroad system, employing 6 locomotives and 50 miles of track, with truck haul. These operations, then, were not forced to adopt truck logging in order to reach scattered stands of timber. Since the railroad, under favorable conditions, provides the means of transportation requiring the least labor per unit of output, the camps surveyed appear to occupy a favored position in this respect.

Another factor responsible for the reduction in unit labor requirements in large operations has been the mechanization of railroad grading and truck- and tractor-road construction. In 1936, 19 of the 20 logging operations surveyed used power shovels. A total of 26 shovels was reported. In recent years the adoption of bulldozers has been generally rapid and particularly characteristic of large operations; bulldozers were employed at 5 of the 20 operations under review in 1936.

³⁴In this connection, it is worth noting that the 20 logging operations on the West Coast which were surveyed had over 25 percent of the small number of Diesel logging engines reported by Pacific Coast logging camps in 1936. On the other hand they had a very small percentage of the gasoline donkeys, presumably because the light gasoline donkey engines are employed predominantly at the smaller operations not surveyed.

³⁵Brandstrom, *op. cit.*, *passim*.

Table 11.- LOGGING PRACTICES AT ALL REPORTING CAMPS
AND AT SAMPLE CAMPS ON THE PACIFIC COAST,
BY DAILY CAPACITY, 1936

Practice	All reporting camps ^a				NRP-NBER camps ^b	
	Daily capacity of 1-99 M ft. b. m.		Daily capacity of 100 M ft. b. m. or more			
	Number	Percent	Number	Percent	Number	Percent
Total number of camps reporting	225	-	156	-	19	-
Camps reporting specified yarding equipment, total	175	100.0	145	100.0	19	100.0
Donkey engines only	97	49.7	58	40.0	11	57.9
Donkey engines and tractors	54	30.8	59	40.7	8	31.6
Tractors only	34	19.4	28	18.3	2	10.5
Camps reporting specified long-haul equipment, total	100	100.0	142	100.0	19	100.0
Locomotives only	37	37.0	129	90.9	19	100.0
Locomotives and trucks	5	5.0	7	4.9	0	0
Trucks only	58	58.0	6	4.2	0	0
Camps reporting power shovels	19	5.8 ^c	101	64.7 ^c	19	100.0 ^c
Camps reporting bulldozers	9	4.0 ^c	43	27.6 ^c	5	25.3 ^c

^aData tabulated from *Handbook and Directory of the Western Timber Industries* (Seattle, Wash.: West Coast Lumbermen), 1935-36 edition. See appendix C.

^bAlthough 20 logging camps were included in the NRP-NBER logging-camp and sawmill survey, equipment information for only 19 could be found in the 1935-36 edition of the directory. In the textual discussion, however, information for the twentieth camp as obtained from the 1937 directory was assumed to hold true for 1936. Each of the 20 camps surveyed had a daily capacity of more than 100 thousand board feet according to the 1935-36 directory.

^cPercent of total number of camps reporting.

Table 11 presents data on the logging methods employed at camps covered in the NRP-NBER survey and at all Pacific Coast camps reporting on equipment. An examination of this table reveals that in 1935-36 the shift to tractors had not proceeded so far at NRP-NBER camps as at other Pacific Coast operations. Data presented earlier indicated that man-hour requirements for tractor logging operation were less than for cable logging. On the other hand, the adoption of tractors is frequently necessary because of the unfavorable stands of timber available for cutting. Thus the fact that camps included in the survey have been somewhat slower to adopt tractor logging may be a reflection of the fact that they are favored with more accessible stands than the average camp. It may also be a reflection of the fact that the sample is comprised largely of Douglas-fir operations, in which the adoption of tractors began at a late date (see page 41).

Logging practice in the long haul at NRP-NBER camps is very similar to that at other large Pacific Coast camps cutting over 100 thousand board feet per day. However, the methods used in the long haul at NRP-NBER

camps are strikingly different from those employed at small Pacific Coast camps, where truck haul is the favorite method. Since railroad haul generally involves less labor per unit of output, this difference probably means that labor requirements are lower for the same length of haul in this operation at the NRP-NBER plants than at smaller camps. On the other hand, the type of timber stand on which the small operations choose to employ trucks can probably be logged by that method with less labor per unit of output (including construction labor) than would be involved in railroad logging.

Road- and landing-construction activities at NRP-NBER camps are conducted on a somewhat more highly mechanized basis than in all large Pacific Coast camps and on a much more highly mechanized basis than in small Pacific Coast camps. This is indicated by the statistics on the proportion of camps employing shovels and bulldozers. It would appear from this that unit labor requirements for truck and railroad construction should be lower at NRP-NBER camps than at most Pacific Coast camps.

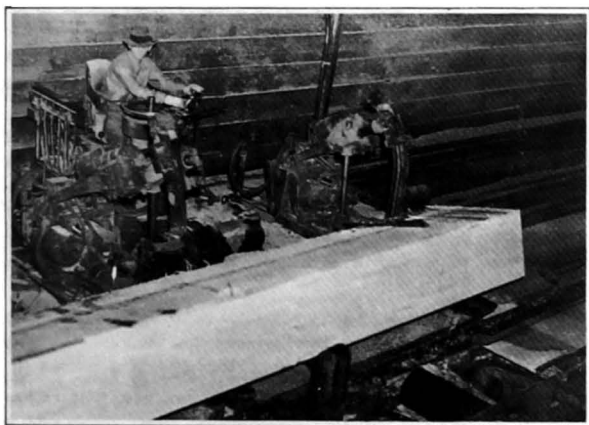
TECHNICAL CHANGES AND UNIT LABOR REQUIREMENTS IN SAWMILLS, 1920-36

In a certain sense, production techniques in the sawmill are less affected by the changes in the availability and size and quality of the timber resources than are logging methods. While the depletion of the most easily accessible stands of timber in the Pacific Coast area has given rise to striking changes in logging techniques, the technology of lumber milling since 1920 has developed in a more continuous and even fashion. Soon after production on the Pacific Coast attained sizable proportions, large mills became the characteristic production centers. During the 1920's the large mills strengthened their domination of Pacific Coast production, and it is only in recent years that small sawmills have attained any degree of importance in that region.

There are indications, however, that the reduction in the supply of the easily accessible high-quality timber has made the reduction of labor requirements at Pacific Coast mills a more difficult task. Reports from field agents of the NRP-NBER survey indicate a widespread belief that it has become progressively more difficult to secure an adequate supply of large-size, high-quality logs. Insofar as the depletion of easily available timber supply has been associated with a reduction in the size and quality of the logs supplied to the sawmill, it has meant an increase in the obstacles to increased labor productivity in the sawmill as well as in the logging camp.

Technical Developments

Since 1920 there have been no radical changes in the production techniques of Pacific Coast mills. However, this region has been the center of such technical advances as have been made because it was the only region in which there was an expansion in production and in the number of large mills during the 1920's. While there have been no outstanding changes, a large number of improvements in the manufacturing process have occurred which have had an important cumulative effect in reducing production costs. Within the milling department the most important factor tending to reduce unit labor requirements has been the increased speed and power of the headsaws, cut-off saws, trimmers, and edgers.



Farm Security Administration (Rothstein)

FIGURE 15.— SAWMILL CARRIAGE WITH AUTOMATIC NETWORKS

The sawmill carriage carries the log through and past the headsaw. The worker shown automatically adjusts the position of the log for the next cut according to the directions of the sawyer. The log may be turned or moved forward for a cut of any desired thickness by means of the automatic networks.

The increase in the speed and power of sawmill machinery has been made possible through improvements in the strength of materials, refinements in design, the application of antifriction bearings, and the electrification of the sawmill. The headsaw has been improved through the use of lighter-gage saws which reduce the waste in sawdust. The use of automatic networks and other devices on the carriage has tended to increase

labor productivity.³⁶ Electrification has speeded up production throughout the milling department, especially in the conveyance of the sawed lumber.

Electrification has been particularly widespread on the Pacific Coast because of the dominance of large mills. The substitution of electric for steam power reduces the number of men in the power division, reduces maintenance cost through the elimination of overhead pulleys and belting, increases the direct power, makes it more feasible to maintain constant speed of operation during sawing, and is subject to easier control.³⁷

Data on the equipment in use at Pacific Coast mills indicate that the large mills have been the principal beneficiaries of the improvements in machines and of the advances of electrification. This conclusion is indicated by the fact that the large mills are more frequently electrified than small mills, more generally employ the superior band saw in place of the circular saw, and are usually equipped with such special-purpose machines as gang saws.

An examination of figure 16 shows that an overwhelming majority of large mills with a daily capacity of over 100 thousand board feet employ band saws. On the other hand, from 80 to 90 percent of the small mills with a capacity of less than 50 thousand board feet per day use circular saws. Studies have shown that band saws cut almost 14 percent more lumber from logs of 13 to 20 inches inside diameter at the small end than circular saws.³⁸

Figure 16 also shows that a large proportion of the larger mills, those able to cut over 100 thousand board feet per day, use electric power, whereas roughly 80 percent of the smaller mills depend on steam power.

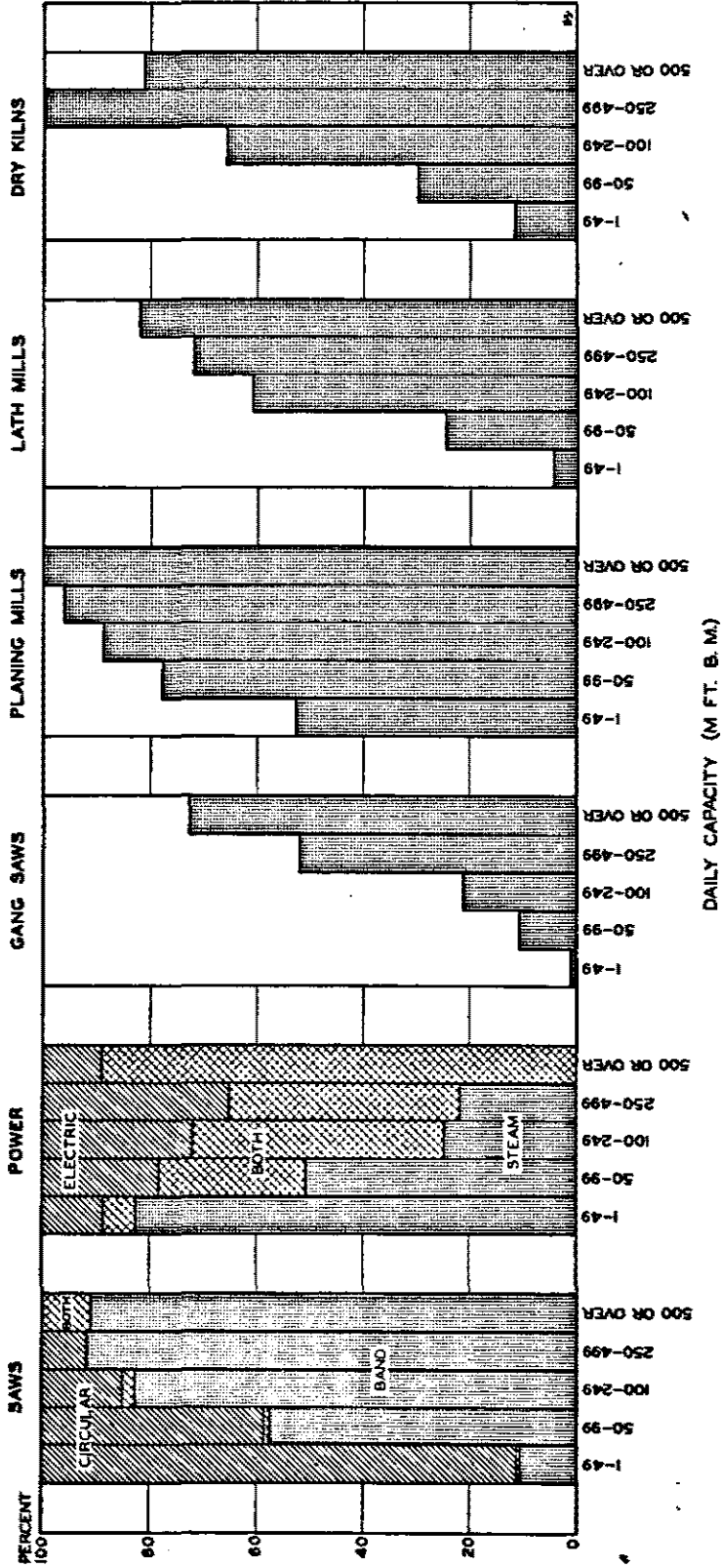
It is possible to increase the output per man-hour in sawing operations by employing a number of special-purpose machines to accomplish a major

³⁶The introduction of an air-dog carriage in 1927 at one of the mills in the NRP-NBER survey eliminated two men; in another, the introduction of a semiautomatic log carriage in 1930 reduced the labor force on the carriage from three men to one; at another mill the introduction of a log turner in 1926 increased the daily output by 5 to 10 thousand board feet.

³⁷Typical of the increase in productivity achieved through the more ready control of electric power is the introduction of the double-motor drive for the main head-saw at several large Pacific Coast plants. Because of the differences in hardness of logs, it is frequently necessary to slow down the saw speed from the usual 10,000 feet per minute to about 8,000 feet per minute to avoid making a wavy cut in the lumber. In the steam-driven mills this can be done only by shifting the belt driving the saw to a smaller pulley. With the double-motor drive it is possible for the sawyer to change the speed of the saw almost instantly by pushing a button. The installation of a double-motor drive at one Pacific plant saved \$1,000 monthly through an investment of \$3,000 by eliminating wavy cuts in lumber, speeding up production, and reducing planing cuts. ("Modernization Solves Industrial Problem," *Electrical West*, Vol. 68, No. 7 [June 1, 1932], pp. 573-4.)

³⁸Ralph C. Bryant, *Lumber: Its Manufacture and Distribution* (2d ed.; New York: John Wiley & Sons, Inc., 1936), p. 273.

Figure 16.- PERCENT OF PACIFIC COAST SAWMILLS REPORTING SPECIFIED EQUIPMENT, BY DAILY CAPACITY, 1986



BASED ON TABLES C-6 AND C-7

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part of the reduction of the timber to small dimensions. This is accomplished by cutting with the headsaw only to large dimensions, leaving the further sawing to such machines as horizontal and vertical resaws, and particularly gang saws. This procedure is even more important in reducing labor costs than labor time, since the sawyer who directs the cutting of the headsaw is one of the most highly skilled workers in the sawmill and receives a higher wage rate than operators of resaws and gang saws.

There is no indication of any marked increase from 1920 to 1936 in the amount of cutting done by gang saws and resaws. However, there are definite indications that the use of gang saws is characteristic of the mills which are able to cut over 250 thousand board feet per day. Figure 16 shows that more than two-thirds of the mills with a daily capacity of over 500 thousand board feet reported the use of gang saws and more than half of the mills with a daily capacity of 250 to 500 thousand board feet reported the employment of gang saws. On the other hand, only a negligible percentage of the small mills, those cutting less than 50 thousand board feet per day, reported gang saws.

Refinements in planing-mill machinery similar in character to those in sawmill machinery have resulted in even more pronounced increases in the speed of operation. Particularly important have been the improvements in the feeding tables which carry the lumber into the surfacing machines. As a result the feed speeds for planers and matchers have been increased from 200-250 lineal feet per minute for the best machines prior to 1920 to as much as 500 lineal feet per minute in the best machines of recent years. The output of such fast feed planers and matchers may be as high as 10 to 15 thousand board feet per hour.³⁹ Machines running at these speeds are employed almost exclusively in the large mills of the Pacific Coast.⁴⁰

The effect of the increase in the speed of operation in the planing mill on labor productivity has been offset to some extent by the effort to increase the production of high-quality lumber. In recent years sharp

³⁹E. F. Whitney, "Electricity in the Lumber Industry," *Transactions of the American Institute of Electrical Engineers*, Vol. XXIII (1914), pt. II, p. 1347; Bryant, *op. cit.*, p. 239. Some mills run dimensions at 1,000 lineal feet per minute.

⁴⁰A number of the mills surveyed reported the installation of faster planing machines since 1920. At one plant the application of an electric motor to the planers increased the output 60 percent per machine. At another, one fast feed planer replaced three dry machines in 1927. At a third, two new planers and matchers replaced four older machines in 1935; together with other improvements in the planing mill, this made it possible to increase the output of the department by 25 to 30 percent and to reduce the number of employees from 80 to about 50. In a fourth plant a dimension sizer with a feed speed of 360 lineal feet per minute replaced, in 1926, an older machine with a feed speed of 250 lineal feet per minute. It should be noted that in a number of instances the installation of faster machines during the 1920's, although doubtlessly increasing the productivity of labor, was associated with an increase in the total working force in the planing mill.

competition has made it necessary to increase the amount of finishing even on the lower grades of lumber, and a large number of lumber manufacturers now package and trade mark their product. Smooth trimmers, which finish the ends of the lumber and stamp the trade mark on each piece, are frequently found today in the larger planing mills. An examination of figure 16 reveals that over 85 percent of the mills cutting more than 50 thousand board feet per day had planing mills and that all of the very large mills had finishing plants. It is probable that the larger plants employ a greater number of special-purpose machines and produce a greater variety of finished products.

One phase of technical advance on the Pacific Coast which has not been productive of increased labor productivity (as measured in board feet of lumber) has been the application and improvement of methods of utilizing sawmill waste. Mills in the Douglas-fir region had a normal sawmill waste of about one-third of the total cubic volume of logs sawed at the mill. The waste from slabs, edgings, and trimmings averaged 19.3 percent, and the loss from sawdust accounted for 14.1 percent. It seems likely that prior to 1920 most of this waste was burned in large incinerators, with practically no labor expenditure. In 1931, however, about 44 percent of this waste was utilized for byproducts, about 29 percent was employed as fuel in the production of power, and less than 27 percent was burned in incinerators.⁴¹

The principal byproducts obtained from the solid sawmill waste are lath, box wood, hog fuel, and screen chips for pulpwood. The preparation and selection of sawmill waste suitable for utilization in byproducts add to the amount of direct labor in the sawmill and planing mill. Waste utilization also involves added labor for the operation of machines employed in the manufacture of byproducts. Figure 16 shows that a much larger proportion of the larger mills than of the smaller mills have lath mills attached to them.

The artificial seasoning of wood has developed with particular rapidity on the Pacific Coast, and because of the possibility of weight reduction through kiln drying, it was a particularly important aid to the Pacific Coast operators in improving their competitive position in the eastern markets by saving on freight rates.

This factor, together with the reduction in inventory, has resulted in the extension of kiln drying to over 70 percent of the plants cutting more than 100 thousand board feet per day (figure 16). A small proportion

⁴¹Allen H. Hodgson, "Present Utilization of Sawmill 'Waste' in the Douglas Fir Region," *The Finiserman*, Vol. XXII, Nos. 9-12 (July-Oct. 1931).

of the plants cutting less than 50 thousand board feet per day report the use of kilns.

The use of such labor-saving devices as electric transfer cars and automatic control devices for the regulation of temperature and humidity has been particularly widespread in the large mills of the Pacific Coast. Mechanical devices for the handling of lumber in the sawmill yard have received their most widespread adoption on the Pacific Coast. The installation of handling equipment has been responsible for the most striking instances of labor displacement during this period.

A study of 30 mills in the Pacific Northwest, made in 1915, showed that the handling systems in use at the time were favored approximately according to the following order: (1) Flat-wheel trucks and horses, (2) overhead monorail systems, (3) locomotive and traveling cranes, (4) revolving derrick arms, (5) rail trucks and horses or motors, and (6) miscellaneous methods.⁴² Of these, the most common device by far was the horse-drawn two-wheeled truck; hence the most important early development was the introduction of small tractors to replace horses in drawing these lumber buggies. A tractor is capable of performing the work of three to six animals.⁴³

Of the eight sawmills covered in the NRP-NBER survey which employed tractors for hauling lumber at some time during the period 1916-36, seven began to employ tractors between 1916 and 1922. In the five cases which reported fully, the tractors displaced horses in hauling lumber trucks. By 1929, five of the eight mills reported, the tractors and trucks had been replaced by straddle-truck lumber carriers. The straddle-truck carrier was introduced in 1916 and has had large sales to sawmills and lumber distributors since that time. Between 1916 and 1922, with a maximum of 29 companies reporting for any one year, 11 mills reported the initial purchase of carriers; between 1923 and 1929, 6 more mills reported the adoption of this equipment. Most of these carriers replaced horses and two-wheeled trucks, although in a number of cases tractors and lumber trucks were displaced.⁴⁴

Lumber carriers were capable of operating at higher speeds than tractors and eliminated a large part of the handling labor formerly necessary. The labor displacement accomplished through their use at those mills reporting this figure is indicated in table 12. Between 1915 and 1936, 16 of the mills surveyed purchased at least 65 lumber carriers.

⁴²J. S. Williams, "An Analysis of the Various Systems for Handling Lumber at the Mill," *West Coast Lumberman*, Vol. 27, No. 316 (Jan. 1, 1915), p. 42.

⁴³Bryant, *op. cit.*, p. 138.

⁴⁴NRP-NBER logging-camp and sawmill survey.

Table 12.- EXAMPLES OF LABOR DISPLACEMENT BY THE ADOPTION OF LUMBER CARRIERS AT PACIFIC COAST SAWMILLS^a

Year	Number of carriers adopted	Equipment replaced	Number of men required for operation per shift	
			Before	After
1922	2	5 tractors and trucks; 2 horses and trucks	8	2
1926	5	Tractors and trucks	12	5
1926	3	6 tractors and trucks	12	3
1931	1	5 teams and trucks	6	2
1934	1	10 teams and trucks	12	6
1935	2	5 tractors and trucks	5	2

^aNRP-NBER logging-camp and sawmill survey.

The installation of cranes and derricks in the yards of Pacific Coast mills was important during the period prior to 1929. The introduction of cranes of the overhead-monorail, traveling, and locomotive varieties was reported by 8 mills between 1916 and 1922 and by 11 mills between 1923 and 1929. In the five cases in which the types of displaced equipment were reported, the methods displaced were horses-and-trucks and tractors-and-trucks. A tramway system installed at one mill between 1919 and 1924 replaced gas tractors used in hauling lumber trucks and eliminated the need for 110 of 120 horses employed for the same purpose. At another mill the installation of an overhead monorail system displaced 20 men formerly employed in driving horses.

Unit Labor Requirements at a Group of Large Mills

The NRP-NBER logging-camp and sawmill survey covered 39 sawmills in the Douglas-fir region and 4 ponderosa-pine sawmills in the Pacific Coast States. The production of these sawmills represented about one-fifth of the Pacific Coast lumber production except for the period 1919-23, in which the coverage was considerably smaller. The coverage of the sample was best for mills which cut more than 50 million board feet per year. No mills cutting less than 15 million board feet were included in the 1929 sample. The findings of the survey therefore apply only to large mills and are most representative of the experience of the largest mills. A more detailed analysis of the sample on which the following findings are based is presented in appendix A.

In order to obtain comparable data for the mills surveyed, an effort was made to exclude from the production data the labor time of all workers not engaged directly or indirectly in the production of lumber. The output of byproducts, such as lath, or special products, such as shingles, was likewise excluded from the production data. To correct for differences between plants and over a period of time in the proportion of the lumber output surfaced in the planing mill, the output of the planing mill was converted to equivalent units of production of unsurfaced lumber and added to the unsurfaced sawmill production to secure for each plant its "equivalent production." The latter is plainly larger than actual production. The equivalent production represents the sum of the actual sawmill production of unsurfaced lumber and the additional production of unsurfaced lumber which would have been possible had the labor time in the planing mill been devoted to the production of additional unsurfaced lumber at the level of labor productivity prevailing in the plant's sawmill. The man-hour ratio was then computed from the total number of man-hours in the sawmill and planing mill and the total equivalent production.⁴⁵

A more detailed description of the methods employed in obtaining comparable units of production and labor time will be found in appendix A.

The movement of labor requirements per unit of equivalent production for the group of large Pacific Coast mills surveyed is shown in table 13. The index presented for all reporting companies was derived from chain indexes of man-hours and production (see table A-6). This type of index is believed to represent most accurately the relative changes which occur in a sample whose composition changes from year to year.

The index for mills in the Pacific Coast region shows a substantial decline in labor requirements from 123.6 in 1918 to 98.1 in 1935 with the base year taken as 1929, which represents a decrease of 21 percent over the period. The downward trend was concentrated in the years 1918-28. After 1928 there is no apparent trend in the sample plants.

Although the chain index provides a measure of the relative decline in unit labor requirements in the Pacific Coast mills surveyed, it does

⁴⁵In computing unit man-hour requirements at mills in the NRP-NBER survey, an effort was made to eliminate the effect on their magnitude of the degree of finishing and remanufacturing, waste utilization, byproduct manufacture, and the manufacture of other timber products such as shingles and boxes. On the whole, this effort was successful, and the effect of these factors on the time series of unit labor requirements was largely eliminated. Further analysis, however, indicates that the effect of these factors on the man-hour ratios of individual mills could not be entirely eliminated because it was not possible to exclude from the man-hour figures some of the labor indirectly employed in and ideally chargeable to waste utilization, byproduct manufacture, and the production of minor forest products. Furthermore, the method of adjustment did not take kiln drying into account; labor for this process was employed at some mills but not at others.

Table 13.- INDEX OF UNIT LABOR REQUIREMENTS IN LARGE PACIFIC COAST SAWMILLS, 1918-35^a

(1929=100)

Year	Index	Year	Index
1918	123.6	1927	100.5
1919	120.0	1928	97.7
1920	123.9	1929	100.0
1921	114.3	1930	101.2
1922	110.5	1931	97.5
1923	110.2	1932	107.0
1924	103.2	1933	96.4
1925	105.1	1934	100.2
1926	100.7	1935	98.1

^aTable A-8, col. (10).

not show the absolute decline. For this purpose the average unit labor requirements of a group of 11 mills on the Pacific Coast were computed (table A-8). The trend of labor requirements per unit of equivalent production in this group of mills is representative of the movement of the chain index.⁴⁶ This series is available as far back as 1920. In 1920 an average of 10.34 man-hours was required per thousand board feet of equivalent production, but by 1928 it had declined to 8.14 man-hours. Thus there was a saving, on the average, of 2.2 man-hours per thousand feet of equivalent output during this period. As in the case of the chain index for all reporting mills, there is no indication of a trend after 1928.

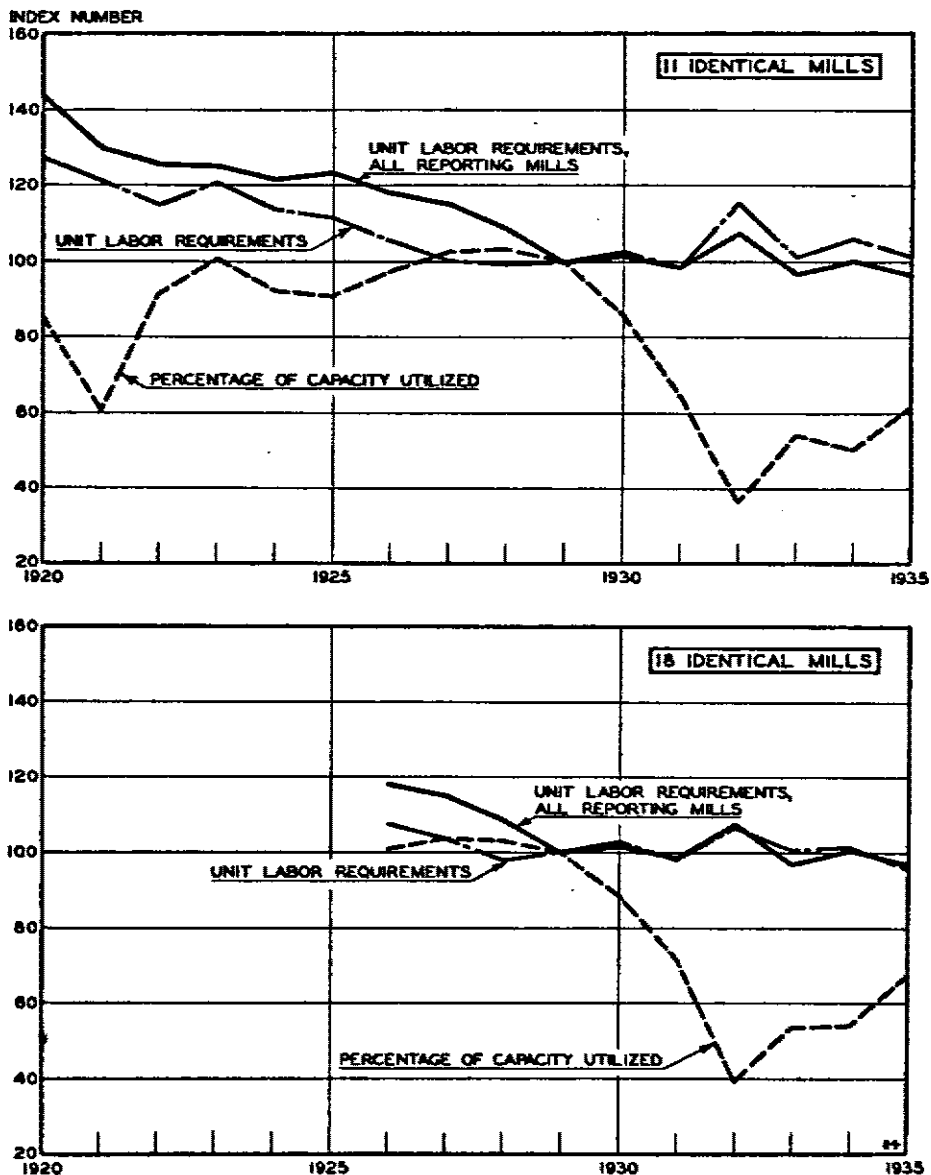
A sample of 18 identical plants for which data are available from 1926 to 1935 shows the same general trend after 1926 as that shown by the series of 11 identical plants (table A-8). The average of unit labor requirements for the 5-year period 1931-35 is slightly lower than for the 1926-30 period for the 18-mill series; the average for the later period is slightly higher for the 11-mill series.

A substantial part of the explanation for this is afforded by a comparison of the percentages of capacity utilized by the two groups of plants. The series for 11 plants shows a noticeably sharper decline in the percentage of capacity utilized after 1929 than does the series of 18 plants (figure 17). The drop in percentage of capacity utilized is appreciable in either case, and it is doubtlessly one of the factors principally responsible for the failure of man-hour requirements to decline after 1928.

⁴⁶That is, the percentage decline from 1920 to 1928 is almost the same for the two series. However, there are year-to-year differences which have no explanation other than the erratic fluctuations of individual plants, which have more effect on the series with the smaller number of plants.

Another factor responsible for the failure of unit labor requirements to continue to decline during the 1930's was the decline in new-equipment purchases after 1929. The 11 identical mills increased their aggregate capacity rapidly and steadily until 1929, but there was no increase thereafter (table A-8). Similarly, there was some increase in aggregate

Figure 17.-- INDEXES OF UNIT LABOR REQUIREMENTS AND PERCENTAGE OF CAPACITY UTILIZED IN IDENTICAL LARGE PACIFIC COAST SAWMILLS, 1920-35
(1929=100)



capacity for the 18 identical plants from 1926 to 1929, whereas the level of aggregate capacity was actually lower during the 1930's.

The expansion in capacity noted for this sample of large mills during the 1920's was generally associated with the installation of new and more efficient machinery. The failure of capacity to expand after 1929 meant a drastic reduction in new-equipment purchases. This is reflected in the much lower level of sawmill-machinery purchases after 1929, as noted in chapter II. Such purchases as were made apparently were for replacement purposes.

Another rough indication of the extent of the decline in equipment purchases is obtained from reports on Pacific Coast sawmills in the NRP-NBER survey. An examination of the reports reveals that the number of all kinds of installations per company year of reporting were 45 percent lower for the period 1930-35 than for 1920-29.⁴⁷

The decline in unit labor requirements was associated with the period of high production levels when many plants were expanding their capacity and additions or replacements of equipment were frequent. The types of equipment changes associated with the decline in unit labor requirements have been indicated earlier in the discussion; they include the electrification of mills, which resulted in some reduction in the indirect labor of the power-house and the maintenance department, increased speed and power of machinery throughout the mill, and more extensive use of handling equipment, particularly in the yard.

An examination of the types of installations made at the Pacific Coast mills in the NRP-NBER survey indicates the nature of the changes which predominated in various periods. Between 1916 and 1922 the installations of handling equipment, particularly of carriers and yard tractors, accounted for half of the total changes. Between 1923 and 1929 installations of handling equipment declined in proportion to the total, and the

⁴⁷In the course of the survey field agents gathered, when possible, material on the installation of equipment at sawmills. From 1920 to 1929 the number of sawmills reporting on equipment changes or additions varied from 20 to 35, and the total number of company years of reporting (the sum of the yearly figures on number of companies for which data were obtained) was 300. Between 1930 and 1935 the number varied from 15 to 19, and the total number of company years of reporting was 92. The total number of equipment changes was 195 for 1920-29 and 33 for 1930-35. Equipment changes were counted individually regardless of the number of units involved and included changes or additions to machinery, power equipment, handling equipment, and such structures as kilns, dry sheds, and storage or shipping facilities. For the most part, the equipment changes recorded represented important replacements, alterations, or additions to plant facilities. The plant reports on which these data are based may be incomplete over a period of time or for any reported year. Furthermore, the reports used covered, in several instances, initial equipment of sawmills established after 1920.

The figure quoted in the text understates the extent of the decline in equipment purchases inasmuch as reporting was presumably less complete in earlier years and individual installations involved a larger average capital investment before 1929 than after. Major changes were largely limited to the earlier years.

emphasis appeared to be on the purchase of large and expensive units, such as monorail systems, locomotive cranes, and gantry cranes. Carrier purchases remained at the same level of relative importance. Installations in the power-house and the construction of yard structures accounted for almost one-third of the total number of equipment changes reported in the 1923-29 period. After 1930 there was, as has been noted earlier, a sharp decline in equipment purchases. About half of the changes made were in the sawmill and planing mill. Planing-mill installations were almost double in relative importance, but power-house installations and the erection of yard structures declined sharply in relative frequency. The reports indicated no further installations of heavy handling equipment, such as monorail systems and cranes, or of the outmoded yard tractors, but installations of carriers continued.

Field agents' reports indicate that the productivity of labor was increased during the 1920's through the extensive installation of handling equipment, the speeding up of production by the use of faster machines, and the electrification of the sawmill and planing mill. Since 1930 purchases have been restricted more to essential replacements. It seems reasonable to believe that the declining rate of mechanization was one of the factors principally responsible for the failure of sawmill unit labor requirements to decline after 1928.

The reports of the NRP-NBER field agents indicate that even the maintenance of unit labor requirements at the same level from 1928 to 1935 represented something of an achievement, for a number of factors tending to increase unit labor requirements were operative during this period. The low rate of operation in relation to capacity was one such factor. Logs received by the sawmill became poorer and smaller, and this had a consequent adverse effect on labor productivity. Unit labor requirements were also increased through efforts to achieve truer size and better inspection of grades in order to improve the grade of lumber obtained from a log of given quality and to meet changes in consumer buying habits. Demand for large-dimension lumber and timber, which require relatively less labor than small dimensions, has declined. The effort of lumber dealers to reduce inventories under conditions of depressed demand has led in recent years to an increase in the importance of mixed-lot orders relative to carload-lot orders. Mixed cars require more man-hours not only in loading and tallying but also in making up the orders from stock.

The type of equipment used by the sample of mills in the NRP-NBER survey corresponds fairly closely with that of mills having a daily capacity of 100 thousand board feet or more (table 14). Such differences as do exist indicate that the NRP-NBER mills are more generally equipped with

Table 14.- SAWMILL PRACTICES AT ALL REPORTING MILLS AND AT SAMPLE MILLS ON THE PACIFIC COAST, BY DAILY CAPACITY, 1936

Practice	All reporting mills ^a						NRP-NBER mills ^b	
	Daily capacity of 1-49 M ft. b. m.		Daily capacity of 50-99 M ft. b. m.		Daily capacity of 100 M ft. b. m. or more		Number	Percent of total
	Number	Percent of total	Number	Percent of total	Number	Percent of total		
Camps reporting on power, total	209	100.0	89	100.0	150	100.0	38	100.0
Steam power only	178	85.2	35	50.7	34	22.7	5	13.0
Steam and electric power	13	6.2	19	21.5	74	49.3	23	60.3
Electric power only	24	11.5	15	16.7	42	28.0	8	20.7
Camps reporting on handsaw, total	280	100.0	87	100.0	168	100.0	41	100.0
Circular saw only	246	87.9	36	41.4	21	12.5	4	9.8
Circular and band saws	4	1.4	1	1.1	4	2.3	1	2.4
Band saw only	30	10.7	50	57.5	137	81.2	36	87.8
Camps reporting on specified equipment, total	229	-	94	-	169	-	41	-
Gang saw	8	1.0	10	10.6	49	29.0	19	46.3
Planing mill	127	55.5	79	77.7	159	93.5	39	95.1
Lath mill	12	4.3	23	24.5	106	62.8	31	75.6
Dry kiln	25	11.7	28	29.8	122	72.2	33	80.5
Shingle mill	19	8.4	5	5.3	23	13.6	8	19.5
Box factory	11	5.7	9	9.5	22	13.0	6	14.6
Machine shop	15	5.0	24	26.5	86	50.9	25	61.4

^aData tabulated from *Handbook and Directory of the Western Lumber Industries* (Seattle, Wash.: West Coast Lumbermen, 1935-36 edition, see appendix C).
^bNRP-NBER logging-camp and sawmill survey. All mills surveyed had a daily capacity of more than 70 thousand board feet, according to the *Handbook and Directory of the Western Lumber Industries* for 1935-36.

the specified items of equipment. The differences in equipment between the NRP-NBER mills and the mills in the two smaller size classes are much more pronounced.

The difference in equipment used by mills of different sizes, as indicated in table 14, raise the question of the effect of the use of more advanced and special equipment on the man-hour ratio. Unfortunately, adequate data for a thorough analysis are not available. It was possible, however, to analyze data for 37 of the NRP-NBER mills, all having a daily capacity exceeding 70 thousand board feet (details of the analysis may be found in appendix E).

The average unit labor requirements for the 19 larger mills (daily capacity of at least 250 thousand board feet) were 15 percent higher than those for the 18 other mills (daily capacity of 70 to 249 thousand board feet). Further analysis revealed, however, that factors other than relative efficiency in the utilization of labor could account for the disparity in the man-hour ratios. The 19 larger mills were more generally equipped with dry kilns, lath mills, shingle mills, box factories, and machine shops, which involve the employment of additional workers without a corresponding increase in the footage of lumber output.⁴⁶ When

⁴⁶Direct labor involved in lath mills, shingle mills, and box factories attached to sawmills was largely excluded from the man-hour figures, but indirect labor required to supply materials for and to handle the product of such activities, as well as dry-kiln and maintenance labor, was included.

similarly equipped mills in the two size groups were compared, it was found that the man-hour ratios of the larger mills were slightly lower than those of the smaller mills.

It appears, therefore, that such factors as the extent of artificial seasoning, waste utilization, manufacture of products other than lumber, and maintenance work at machine shops attached to the sawmill exert influences which tend to raise unit labor requirements at large mills. The end product of the sawmill proper is green lumber. Further finishing operations (such as surfacing and kiln drying), remanufacturing, and the production of byproducts increase the labor involved without equivalently increasing the number of board feet produced. Similarly, in their efforts to offset high freight costs in shipping to eastern markets, some large Pacific Coast mills produce end-matched, trade-marked lumber which is frequently packaged for shipment. The more fully equipped mills may in this manner obtain advantages over smaller competitors. These advantages must often be obtained at the expense of greater unit labor requirements, but these do not necessarily reflect a lower degree of efficiency in the utilization of labor.

SUMMARY

Lumber production in the Pacific Coast States increased by more than 60 percent between 1919 and 1929 (table 15). This increase represented the continuation of a regular rise during the preceding two decades.

Table 15.- INDEXES OF PRODUCTION AND EMPLOYMENT IN THE
PACIFIC COAST LUMBER INDUSTRY, 1899-1937^a
(1929=100)

Year	Production of lumber	Number of wage earners in the lumber and timber products industry	Year	Production of lumber	Number of wage earners in the lumber and timber products industry
1899	20	31	1925	94 ^b	101
1904	32	42	1927	95 ^b	98
1909	49	61	1929	100 ^b	100
1914	50	58	1931	59	52
1919	62	81	1933	49	52
1921	51	65	1935	56 ^b	67
1923	90 ^b	108	1937	77	89

^aBased on data from *Census of Manufactures*.

^bIncludes data for Nevada in addition to data for California, Oregon, and Washington; however, the effect of the inclusion of Nevada is negligible (see table A-1, fn. c).

However, employment in the lumber and timber products industry declined between 1923 and 1929 in spite of the continued rise in production. Prior to 1923 the increase in employment in the lumber and timber products industry did not keep pace with the production rise. Although the indexes presented do not refer to strictly comparable universes, the available data on unit labor requirements tend to substantiate the conclusion that the disparity between the courses of production and employment prior to 1929 is attributable to an actual change in unit labor requirements in lumber production.

The available data on logging labor requirements indicate that there was a steady decrease in the man-hours per thousand board feet between 1920 and 1929 for the most important section of the industry consisting of the large camps. While the sample of camps surveyed was not large enough to yield conclusive results, the survey showed that the decrease in the man-hour ratio over the decade may have amounted to as much as 30 percent. The data on sawmill labor requirements, also representing the experience of large operations, showed a downward trend in the man-hour ratio between 1920 and 1929; the reduction amounted, perhaps, to 20 percent.

Between 1931 and 1933 the index of the average number of wage earners employed in the lumber and timber products industry failed to decline in spite of a sharp drop in lumber production, and between 1933 and 1935 the index of average number employed in the lumber and timber products industry rose more rapidly than did production. Since 1929, however, the regular workweek in the Pacific Coast lumber industry has been shortened in many instances from 48 to 40 hours.⁴⁹ The available information indicates that the rise in employment in the lumber and timber products industry from 1931 to 1935 relative to the index of production was not due to any rise in the man-hour ratio in those years.

Unit labor requirements at the larger logging camps appear to have continued to decline after 1929, although at a reduced rate. The man-hour ratio for the large sawmills remained practically unchanged between 1929 and 1935 except for year-to-year fluctuations. As far as the experience of the large operations which were sampled is concerned, it seems likely that there was, if anything, some decrease between 1929 and 1935 in the number of man-hours required to produce a thousand feet of lumber from standing timber.

The developments in logging machinery which contributed to the reduction in man-hour requirements during the 1920's were associated with

⁴⁹*West Coast Lumber Facts* (Seattle, Wash.: West Coast Lumbermen's Association, Jan. 1, 1937), p. 16.

increases in size, speed, and power, particularly of cable logging machinery. The mechanization of logging construction activities was another notable feature of the period. The intensive development up to the middle 1920's of powerful cable logging machinery and of the clear-cut logging techniques associated with it led to the necessity, in an increasing number of instances, of employing more flexible logging equipment, notably tractors and trucks. The utilization of tractors has been a feature of the period since 1929 and has probably contributed more than any other single factor to whatever reduction has occurred in the man-hour ratio since 1929. However, the principal role of logging technology in recent years has probably been the extension of operations to areas formerly regarded as unprofitable logging "chances" because of the inaccessibility or insufficient density of the stands. Trucks have played a particularly important part in extending the scope of logging operations since 1929.

The developments in the sawmill which contributed most to the reduction of the man-hour ratio involved considerable capital expenditures. The introduction of faster machinery, particularly in the planing mill, the introduction of handling and conveying devices in the sawmill and in the yard, and the centralization of power generation and elimination of some maintenance work through electrification constituted the outstanding changes during the 1920's. Equipment changes since 1929 have been limited largely to essential replacements or to the addition of relatively inexpensive, cost-reducing equipment such as carriers.

The increase in labor productivity during the 1920's to which technological advance contributed is not likely to continue at the same rate in the future. To an increasing extent technological advance will be devoted to extending operations to areas not now economically available and to the reduction in the production costs for lumber from trees of a given size and quality in order to maintain over-all production costs at the same level.

In logging operations the large and powerful cable logging machinery associated with clear-cut logging is giving way to tractor logging. Tractors may be employed in a sort of selective cutting which removes most of the merchantable stands and leaves only the timber too small to be removed profitably from the forest. This method, however, does not improve the forests; it leaves an unprotected stand of small trees which is subject to excessive loss through windfall and which constitutes a greater fire hazard than a clear-cut patch.⁵⁰ Both clear-cut cable logging and "zero margin" selection mean a continued increase in the obstacles to be

⁵⁰Kirkland and Brandstrom, *op. cit.*, p. 88.

overcome in achieving logging production at the same level of man-hour requirements. Employed within the framework of this type of logging system, the use of tractors and the logging techniques associated with them may serve, as they have in recent years, to make economically available timber which could not be profitably logged with older techniques. The replacement of railroads by trucks has likewise extended operations to areas considered poor logging "chances" in the past, and it will probably continue to do so. However, unless the newer techniques are employed in a system designed to assure a sustained yield of timber of approximately the present size and quality, the progressive cumulation of obstacles to increased labor productivity will continue.

The obstacles to increased labor productivity under a system of rapid liquidation of timber resources are perhaps less pronounced in the sawmill than in logging. If the depletion of the timber reserve forces the shift of an increasing proportion of the production to small mills, however, the indications are that some of the progress made in waste utilization, quality improvement, and the level of mechanization will be forfeited. If the size and quality of available logs decline, improved technology in the sawmill may be necessary to maintain labor productivity at present levels.

CHAPTER IV

TECHNOLOGY AND UNIT LABOR REQUIREMENTS IN THE SOUTH

The South¹ contains about 200 million acres of commercial forest land, about 44 percent of the Nation's total.² The volume of lumber production from this vast stand increased rapidly after the introduction of railroad logging in the 1870's. Southern lumber production increased by 763 percent from 1869 to 1899 (table 16) and at the end of this period displaced the Lake States region from production leadership. In the decade after 1899 lumber production in the South increased by 80 percent; by 1909 southern lumber production was at the highest point in its history, amounting to 19,973 million board feet. Production declined somewhat after 1909, but in the 20 succeeding years it averaged almost 80 percent of the 1909 peak.

During the period of rising production the drain on the forest resources of the South far exceeded the annual growth. During the 1920's the annual drain on southern timber was estimated to be about 1.5 times as great as the annual growth; the ratio for saw timber was about 3.9.³ The latest available estimates indicate that an approximate balance was achieved between growth and drain in 1936, although the situation was less satisfactory with respect to quality.⁴ The excess of annual drain over annual growth which obtained until recent years, although due in part to natural causes, was largely due to destructive methods of logging at an excessive rate without regard for the future yield of the forest. The cutting of the vast virgin forest areas of the South was conducted under the traditional clear-cutting policy of the industry. By 1936 only about 12 percent of the commercial forest area was in land bearing old-growth timber of saw-timber size, and only 48 percent was in land bearing both old and second-growth saw timber. Because of destructive methods of cutting, over 14 percent of the commercial forest land of the South was in poor to non-restocking condition by 1936.⁵ In that year the South had about 14 percent of the Nation's stand of softwood of saw-timber size and nearly 64 percent of the hardwood of this size.⁶

¹Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Texas, and Virginia.

²*Lumber Industry Facts: 1939* (Washington, D. C.: National Lumber Manufacturers Association), p. 4.

³U. S. Congress, Senate, *A National Plan for American Forestry*, S. Doc. No. 12, 73d Cong., 1st sess., 1933, I, 222.

⁴*Lumber Industry Facts: 1939*, p. 11.

⁵*Ibid.*, p. 4. The terms "poor" and "non-restocking" refer to areas characterized by 10 to 39 percent, and less than 10 percent, respectively, of normal stocking with trees for the most part below cordwood size.

⁶*Ibid.*, p. 5.

Table 16.- LUMBER PRODUCTION IN THE UNITED STATES
AND THE SOUTH, 1869-1936^a
(Millions of feet, b. m.)

Year	United States	South	Percent South is of United States
1869	12,758	1,288	10.1
1879	18,091	2,499	13.8
1889	27,039	5,082	18.8
1899	35,078	11,116	31.7
1904	34,127	13,377	39.2
1905	20,503	10,500	51.2
1906	37,551	13,849	36.9
1907	40,256	18,026	44.8
1908	39,224	19,607	49.9
1909	44,510	19,973	44.9
1910	40,018	17,432	43.6
1911	37,003	15,965	43.1
1912	39,158	18,118	46.3
1913	38,387	18,312	47.7
1914	37,346	17,801	47.7
1915	31,242	14,890	47.7
1916	34,791	16,573	47.6
1917	33,193	15,634	47.1
1918	29,362	12,440	42.4
1919	34,552	16,078	46.5
1920	29,878	11,491	38.5
1921	26,961	13,530	50.2
1922	31,569	14,383	45.6
1923	37,166	16,461	44.3
1924	35,931	16,239	45.2
1925	38,339	17,146	44.7
1926	36,936	15,571	42.2
1927	34,532	14,478	41.9
1928	34,142	13,978	40.9
1929	36,886	15,462	41.9
1930	26,051	10,158	39.0
1931	16,523	5,984	36.2
1932	10,151	3,936	38.8
1933	18,961	5,765	41.3
1934	15,494	5,910	38.1
1935	19,539	7,829	40.1
1936	24,355	9,528	39.1
1937	25,997	10,293	39.6
1938	21,646	9,359	43.2

^aData for 1869-1904 from *Lumber Production: 1869-1934* (U. S. Dept. Agr., Forest Service, Div. Forest Econ., 1936), pp. 7-75; for 1905 from same, 1935 (1937); for 1936 from same, 1936 (1937); for 1937 from same, 1937 (rev. ed.; Apr. 4, 1939); for 1938 from same, 1938 (Nov. 1939). The South includes Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Texas, and Virginia.

In spite of the serious reduction in the timber reserve of the South, that region has succeeded in maintaining a leading position in production. The southern States as a region maintained production leadership continuously from 1899 until 1929, after which the volume of production on the Pacific Coast exceeded that of the South. This has been possible because of a number of circumstances favoring the South. Although southern stands are sparse compared with those on the Pacific Coast and frequently



United States Forest Service

FIGURE 18.— VIRGIN STAND OF SOUTHERN PINE

The open stands and level topography of southern forests offer few obstacles to logging. It is possible, however, to achieve higher levels of labor productivity in the denser stands of the Douglas-fir region.

yield only low-grade timber, these disadvantages are largely balanced by the fact that except for limited areas there are few natural obstacles to overcome in logging.⁷ Practically all of the softwood saw timber, including second-growth timber, can be classed as economically available; this is also true of the bulk of the hardwood of saw-timber size. Furthermore, growth is fast in most southern forests, and second-growth stands rapidly attain saw-timber size. Finally, proximity to the principal consuming centers is another favorable factor.

The reduction of the southern timber resources has nevertheless made the maintenance of the region's share in the total lumber production more difficult. The large stands of old-growth timber, on which the large mills depend to a great extent for their log supply, have been particularly reduced. To an increasing extent southern mills have been forced to depend on second-growth stands or on scattered stands of old-growth timber. Southern production has been maintained principally by the rise in the number of small mills capable of operating on sparse and scattered stands of timber; most of them operate close to the timber supply and move frequently.

⁷Timber stands in the South average only about 3,600 board feet per acre in saw-timber stands as compared to about 19,000 board feet on similar stands in the Pacific Coast and North Rocky Mountain States. (*Ibid.*, pp. 4, 5.)

Census data on this point are somewhat inconclusive, but other sources indicate a pronounced shift to small mills, particularly in the production of southern pine. The results of three surveys of southern-pine production by the Southern Pine Association, presented in table 17, show a marked increase during the period 1919-29 in the relative importance of small mills cutting less than 6 million board feet per year.

Table 17.- SOUTHERN-PINE PRODUCTION IN LARGE AND SMALL MILLS, 1919, 1924, AND 1929^a

Year and size of mill	Amount cut (millions of feet, b. m.)	Percent of total
1919		
Large	10,609	67
Small	5,150	33
1924		
Large	9,287	57
Small	7,089	43
1929		
Large	6,179	47
Small	6,987	53

^a*Economic Conditions in Southern Pine Industry* (Southern Pine Association, July 1, 1931), p. 43. Data exclude production of States which were responsible for a total pine output of 123 million feet in 1919 and 102 million feet in 1924, for which no data were available in 1929. In this table a large mill is one producing 6 million board feet or more per year.

The most accurate information is available for 1934 for a somewhat more limited section of the South as covered in the Southern Forest Survey. These data (table 18) show that about 47 percent of the pine production, 21 percent of the hardwood production, and 40 percent of all production is accounted for by the 7,709 mills having a daily capacity of less than 20 thousand board feet. Small and medium-size mills, having respective daily capacities of 1 to 19 and 20 to 39 thousand board feet, produced over half of the pine and hardwood lumber in the region covered by the Southern Forest Survey in 1934.

These surveys are sufficient to substantiate the general belief in the importance and magnitude of the shift to small mills since 1920. Small mills are dominant today in the North Carolina pine region and nearly equal in importance to the medium and large mills in the southern-pine region.^b The few technological developments which have taken place in

^bSpecial report of the U. S. Dept. Agr., Forest Service, Div. Res. (Nov. 1, 1936), for the "Studies of Productivity and Employment in Selected Industries" section of the National Research Project.

Table 18.- PERCENTAGE DISTRIBUTION OF LUMBER PRODUCTION IN THE SOUTH, BY SPECIES OF LUMBER AND DAILY CAPACITY, 1934^a

Capacity (M ft. b. m. per 10-hour day)	Number of mills	Percent of 1934 production (dry-lumber tally)			
		Total	Pine	Hardwood	Cypress
Total	8,894	100.0	100.0	100.0	100.0
1- 4	1,408	2.3	2.0	3.2	0.7
5- 9	3,060	11.3	13.2	7.2	1.6
10-19	3,243	26.0	32.2	10.4	10.9
20-39	715	20.4	18.8	29.8	21.4
40-79	166	15.7	6.8	37.9	32.8
80 or over	104	24.3	29.0	11.5	32.6

^aAdapted from special report of the U. S. Dept. Agr., Forest Service, Div. Res. (Nov. 1, 1936), for the "Studies of Productivity and Employment in Selected Industries" section of the National Research Project.

the southern lumber industry since 1920 have been unspectacular in relation to advances made during the same period at Pacific Coast operations. However, the introduction of more flexible logging equipment in the South has been an important factor in the rise in importance of the small mill. At the larger operations technological adjustments in logging methods have enabled many companies to maintain themselves in the face of increasingly difficult conditions.

TECHNICAL CHANGES AND UNIT LABOR REQUIREMENTS IN LOGGING CAMPS, 1920-35

Changes at Large and Medium-Size Operations

The period of rapid increase in the use of forest railroads in logging operations, from the 1870's to 1900, was also the period of the most rapid expansion in the southern lumber industry. Thus, from the beginning the forest railroad with its extensive network of spur lines was the backbone of the logging system employed at large operations in the South. Steam cable yarders, also a product of the last decades of the nineteenth century, were used to ground skid logs in the system of clear-cut logging employed at the large southern operations during the peak of production in the early 1900's. Animals supplemented cable yarders in yarding, principally for bunching logs within a small radius preparatory to cable yarding and for logging difficult corners of the operation. The methods and equipment used at many of the large operations during the 1900-1910 period were substantially the same as those employed today at a few operations with a daily capacity of more than 40 thousand board feet. Since then high-lead and sky-line yarding have been employed to a limited extent on the larger operations, particularly in logging out of swamps.

A track-laying machine which reduces the crew on this work by about half has found some use in Alabama, Florida, Louisiana, North Carolina, and Texas.⁹ Gasoline cable yarders, which are lighter and therefore more easily transported than steam skidders, have been introduced in recent years and have found extensive use. Since 1920 the principal advances in steam cable logging machinery have been made in response to the requirements of the Pacific Coast logging camps and have led to larger and more powerful machines which were neither necessary nor desirable in the smaller timber and under the less strenuous logging conditions of the South. Changes in the equipment of railroad and cable logging have not been of major importance as a factor affecting the level of unit labor requirements or the economic availability of the timber stand since 1920.

The major development at the large operations during this period has been the introduction of trucks, particularly in the long haul. The open timber stands and flat topography of much of the South make railroad construction simple, for it is frequently possible to lay ties and rails for spur lines on ungraded ground. While this makes it profitable to log stands of lower density than those on the Pacific Coast, it is nevertheless necessary that the railroad tap a total stand of timber of sufficient volume to serve as the basis for the amortization of construction costs. Since 1920 an increasing number of timber stands have been encountered which were either too sparse or of insufficient total volume to be economically available to railroad logging - at least to the logging system employing extensive spur-line construction.

Formerly the only alternative to the railroad, aside from water transportation which was only occasionally feasible, was animal-hauled carts and "bummers." In recent years truck logging has replaced spur-line haul at many operations supplying mills with a daily capacity of more than 40 thousand board feet and has replaced railroad haul entirely at most pine camps cutting from 20 to 39 thousand board feet daily. Truck-road construction is less expensive in the South than on the Pacific Coast for the same reasons that railroad construction is less expensive, and it is sometimes possible to run trucks directly into the woods without preliminary grading. By permitting the logging of some stands for which spur-line construction costs were prohibitive and for which wagon haul involved excessive current operating costs, the introduction of the truck has been an important factor in increasing the timber volume economically available to the larger mill.

⁹Nelson C. Brown, *Logging-Transportation: The Principles and Methods of Log Transportation in the United States and Canada* (New York: John Wiley & Sons, Inc., 1936), p. 222.

In log-yarding operations at camps supplying mills with a daily capacity of 40 thousand or more board feet, the principal development since 1920 has been the introduction of tractors. More mobile than steam skidders and permitting a higher labor productivity than animals, tractors have increased rapidly in importance in recent years. Trucks have also found use at large operations since 1920 in the short haul as well as the long haul.

Changes at Small Operations

The same circumstances which have led to the abandonment of railroad logging at many large operations have likewise favored the development of small operations (daily capacity of less than 20 thousand board feet) which are close to the timber supply and capable of moving frequently. At the small operations the one development of overwhelming importance since 1920 has been the increased use of trucks in the long haul. The old-growth timber stands left by the large mills and the second-growth stands allowed to reproduce without further cutting by the large mills were available to the small mills for cutting precisely because they could not be logged profitably by railroad. Prior to the advent of truck logging, the only available method in most cases was animal haul. The introduction of truck logging has presumably either increased the amount of timber economically available to the small mills or has reduced the labor requirements for logging stands economically available by animal haul. The extension of the highway system since 1920 has brought much of the southern forest within easy reach of public roads, so that truck-road construction is greatly reduced and in certain areas is virtually unnecessary. In the logging system which is coming into increasing use at small operations, animals are used for bunching the logs within a radius of about 200 feet and for loading the truck, and the loaded truck is run directly from the woods to the mill. At a number of small operations trucks are being employed in the haul directly from the stump. Otherwise there are no indications of any important progress in the mechanization of bunching or short-haul methods at the small operations.

Recent Practices in the Lower South

The best available data on logging methods in the southern lumber industry are presented in tables D-1 and D-2. These data represent the results of a survey of several hundred mills conducted by the United States Forest Service in 1934 and 1935. The mills were classified according to approximate size on the basis of the operator's estimate of capacity, and they were designated as pine, hardwood, or cypress mills according to

the species constituting over 50 percent of the cut in the year of the survey, 1934.

The survey territory includes the most important forest regions of the southern States but excludes most of South Carolina and all of North Carolina and Virginia, three States included among those comprising the "South" as defined in this report.¹⁰ For the sake of brevity, group numbers have been assigned to the various size classes as follows: Group 1 consists of operations having a daily capacity of 1 to 9 thousand board feet; Group 2, 10 to 19 thousand feet; Group 3, 20 to 39 thousand feet; Group 4, 40 to 79 thousand feet; and Group 5, 80 thousand or more feet. Operations in Group 1 and Group 2 are referred to as small operations; those in Group 3 as medium-size operations; and those in Group 4 and Group 5, as large operations. The capacity assigned to the logging operation is the same as that of the mill to which the operation was attached.

Short Haul - Pine.— Within the Southern Forest Survey territory there were 839 operations which reported on the type of equipment employed in the short haul (see table D-1). This number included 60 percent of the large and almost 35 percent of the medium mills in the territory. The 427 small mills which reported on short-haul equipment constituted only 6 percent of the small mills in 1934. However, the sample may be regarded as adequately representative within the size classifications.

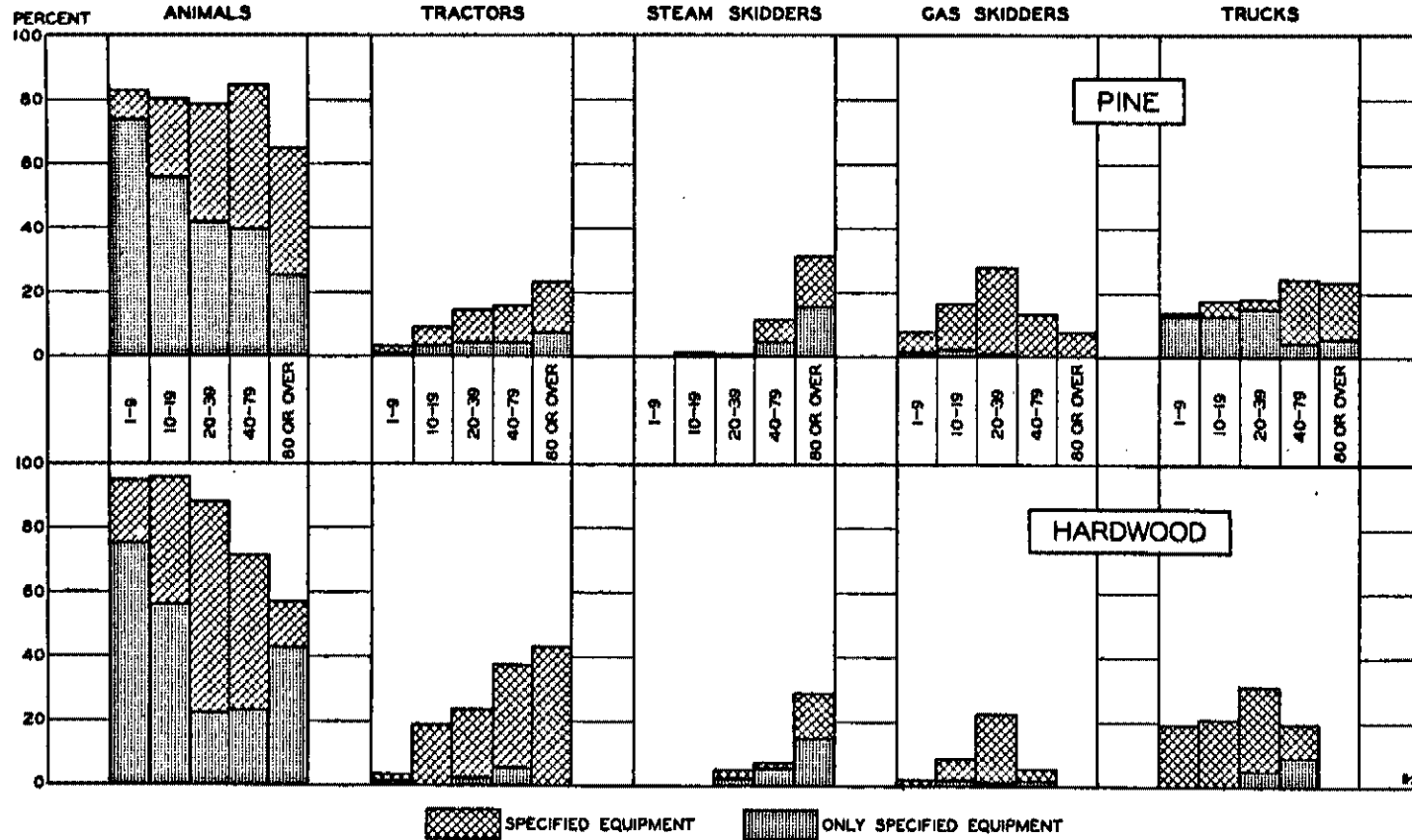
An examination of figure 19 indicates that animals are still employed extensively in hauling logs from the stump to the means of major transportation. Animals are employed at some point in the yarding operation at about 80 percent of all small and medium operations and at the large operations in Group 4. Animals are employed to the exclusion of mechanical equipment at a substantial majority of all small operations and at 40 percent of the remainder, with the exception of the large operations in Group 5.

The principal mechanical devices employed in yarding are tractors, steam skidders, and gas skidders. Mechanical yarding equipment is usually employed in combination, animals being most frequently employed as a supplement to these devices. Steam skidders are employed at about one-third of the large operations in Group 5, but they are virtually unknown at small and medium operations. Tractors are used at almost one-fourth of the operations in Group 5 and at over 9 percent of the operations in Groups 2, 3, and 4. Gas skidders are the most popular item of mechanical

¹⁰The area covered by the survey includes all of Alabama, Florida, Georgia, Louisiana, and Mississippi and the important forest regions of Arkansas, Oklahoma, and Texas. In addition, the survey included small sections of Tennessee and Missouri, two States not included in the "South" as defined in this report. For a more detailed description of the Southern Forest Survey see appendix D.

Figure 19.- PERCENT OF SOUTHERN MILLS REPORTING SPECIFIED SHORT-HAUL EQUIPMENT,
BY SPECIES OF LUMBER AND DAILY MILL CAPACITY, 1934

(Daily capacity in M ft. b. m. per 10-hr. day)



BASED ON TABLE D-1

logging equipment at medium-size mills. Trucks are used at a substantial proportion of the mills in all size groups and at about 15 percent of all small and medium operations, the haul being made directly from the stump by truck without preliminary bunching.

Short Haul - Hardwood.- Logging methods vary more widely at hardwood operations of different sizes than at pine mills. About 95 percent of the small mills employ animals in the short haul, and at 75 percent of the operations in Group 1 animals constitute the sole means of bunching logs. On the other hand, less than one-fourth of the operations in Groups 3 and 4 use animals alone in the short haul.

Three of the seven largest hardwood operations employ tractors in logging and two employ steam skidders. Almost two-fifths of the 56 operations in Group 4 and about one-fifth of those in Groups 2 and 3 employ tractors. Gas skidders are employed in considerable numbers only at the medium-size operations. Trucks are employed at more than one-fifth of the hardwood operations in all groups except Group 5. Truck logging of hardwood in the short haul is almost always supplemented by animal bunching.

At the few cypress operations tractors, steam skidders, and water haul predominate at the large and medium operations, with animal haul of first importance only at the camps in Group 1.

From an examination of the data it is evident that in recent years mobile logging equipment such as tractors and trucks was preferred to cable logging equipment, whether powered by steam or gasoline engines. At the large operations steam skidders are often used, but at the medium-size camps the lighter gasoline skidder is more desirable. It seems evident that the steam skidder has declined in importance in southern logging with the decline in importance of the large mills.

The widespread use of animals even at the larger operations reflects their greater efficiency under conditions of small timber, flat topography, and short yarding distances such as prevail in the South. Although the replacement of animals in yarding offers the greatest opportunity for mechanization in southern operations, it is not certain that mechanical yarding is more efficient than animal yarding when yarding distances are small. It seems likely that because of the increase in the relative importance of the small mills a greater percentage of the log output of the South is yarded by animals today than in 1920.

Long Haul - Pine.- The 862 mills in the Southern Forest Survey territory which reported on the type of equipment employed in the long haul included 60 percent of the large mills and 35 percent of the medium-size



United States Forest Service

FIGURE 20.— ANIMAL LOGGING IN THE SOUTH, 1939

Animals still play an important part in the short haul at the smallest southern logging operations, which account for a considerable proportion of the southern production. However, truck logging in the long haul has almost entirely displaced animal logging at all except the smallest operations.

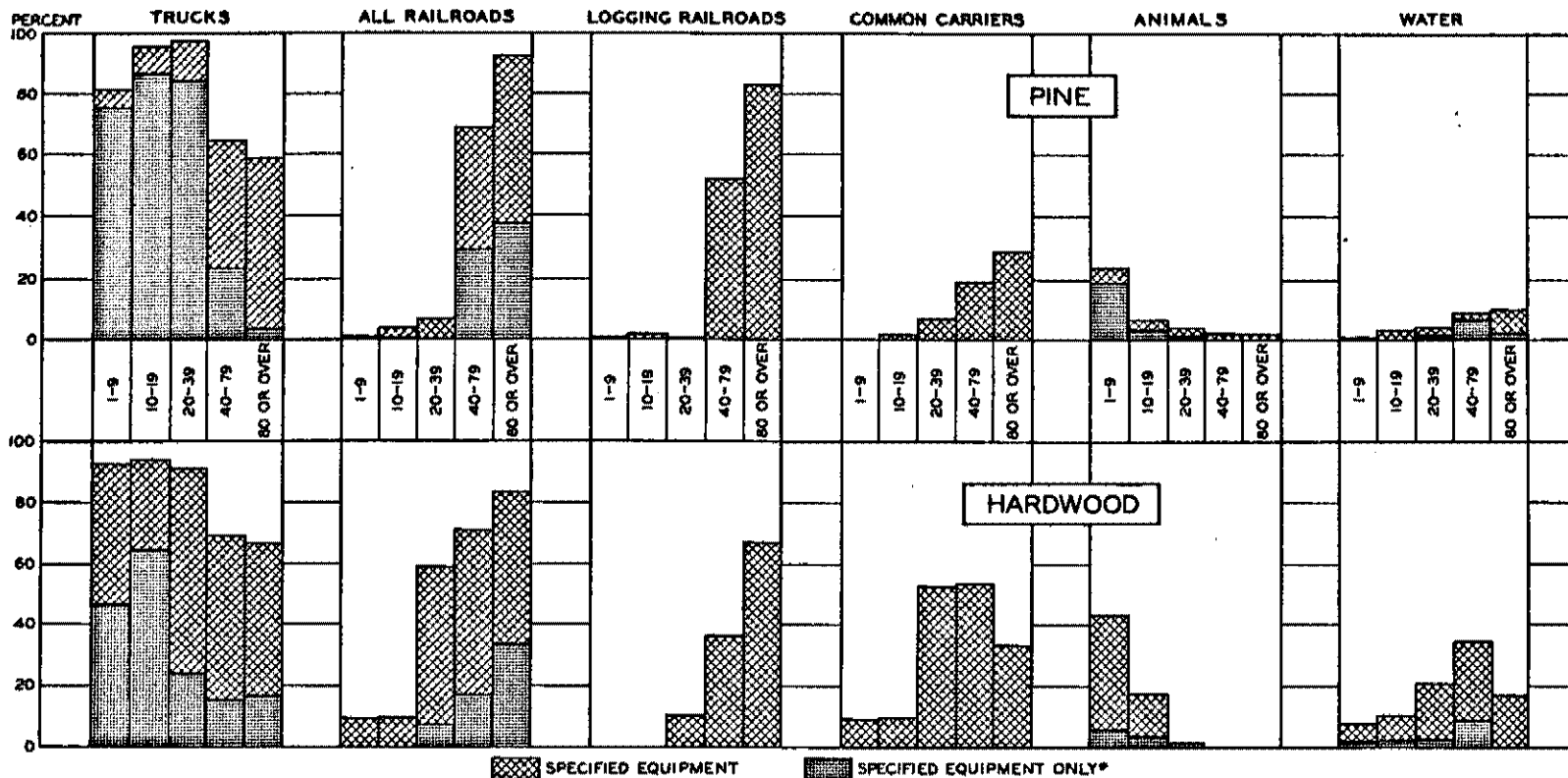
mills in the area. The 440 small mills which reported constituted 5.7 percent of the small mills in 1934. Variations in the completeness of reporting account for the differences in the samples for the long and short hauls.

The most striking changes in logging methods since 1920 have affected the long haul. The introduction of trucks into operations of all sizes has doubtlessly had a greater effect on unit labor requirements in southern lumber production than any other single technical change. Data supplied by the Forest Service indicate that in 1934 a majority of all size groups of pine and hardwood operations in the Southern Forest Survey territory employed trucks at some stage in the long haul.

Figure 21 indicates that at the large pine operations the railroad was still the dominant means of major transportation in 1934. Railroad haul is employed for part of the distance at 92.5 percent of the operations in Group 5 and at 68.7 percent of those in Group 4. At the smaller operations railroad haul is unimportant. But even at the large operations railroad transportation has been supplemented by truck haul for part

Figure 21.- PERCENT OF SOUTHERN MILLS REPORTING SPECIFIED LONG-HAUL EQUIPMENT, BY SPECIES OF LUMBER AND DAILY MILL CAPACITY, 1954

(Daily capacity in M ft. b. m. per 10-hr. day)



* NOT AVAILABLE FOR LOGGING RAILROADS AND COMMON-CARRIER RAILROADS.
 BASED ON TABLE D-2

of the distance in a majority of the camps. Over one-sixth of the operations in Groups 4 and 5 utilize common carriers for part of the haul, a development which represents another phase of the loggers' efforts to avoid part of the costs associated with the maintenance of a logging railroad.

Trucks are employed at 97.4 percent of the medium-size operations, at 95.9 percent of the operations in Group 2, and at 81.3 percent of those in Group 1; they are practically the sole mechanical means of major transportation at these operations. Though trucks predominate at the smallest operations, animal haul is used as the sole means of major transportation in nearly one-fifth of the cases.

Long Haul - Hardwood.— Truck haul is employed at two-thirds of the large and at over 90 percent of the medium and small hardwood operations. Water, usually supplemented by railroad or truck, is the medium of transportation at almost one-third of the large and at about 20 percent of the medium operations. Railroad haul is employed at over 70 percent of the large and at almost three-fifths of the medium operations, but a majority of the operations in Groups 3 and 4 employ the facilities of common carrier lines. Truck haul to a common carrier is the combination most frequently employed by Groups 3 and 4.

Trucks are the sole mechanical equipment employed at over 55 percent of the small operations. However, animals are employed in the long haul to supplement trucks at about 35 percent of the operations in Group 1.

These data indicate clearly the pronounced changes in southern-pine and hardwood logging methods produced by the introduction of trucks, principally since 1920 and with particular rapidity since 1929. The extensive use of trucks as a supplement to the railroad at large pine and hardwood operations suggests that their introduction has been responsible for a sharp reduction in the volume of spur-line construction and the labor associated with it. The use of trucks at small operations has almost eliminated animal haul as the sole means of major transportation except at about one-fifth of the pine operations in Group 1. The use of animals in the long haul even as a supplement to trucks is important only at small hardwood operations. It seems reasonable to assume that their use there is associated primarily with the logging of hardwood from wet sections.

Logging Methods and Unit Labor Requirements at a Group of Large Operations

The significance of changes in the operating methods of large operations in the short and long hauls can be seen from an examination of

data for five mills surveyed by the United States Forest Service for the National Research Project. The man-hour requirements by operation were obtained for 1929 and 1936.

Four of the five mills cut both pine and hardwood and one mill cut only pine. Four of the five mills experienced some increase in the difficulties of cutting and logging pine between 1929 and 1936 because of the decrease in the size of logs available for cutting. Most of the mills are cutting second-growth pine, and the average diameter of the logs cut decreased from 13.0 inches to 11.8 inches, or by 9.2 percent. These mills were nevertheless able to reduce their logging labor requirements between 1929 and 1936 from an average of 11.9 to 10.8 man-hours per thousand board feet, or by 9.2 percent. This was accomplished principally through the introduction of trucks into the logging operations.

Table 19 presents the average unit man-hour requirements, by operation, of these five mills. Man-hours required for felling and bucking trees increased, presumably because of the decrease in the average size of logs cut.¹¹ Man-hours per unit of output in the short haul increased only slightly in spite of the fact that the hauling distance was increased in three of the five cases. In these three cases, however, trucks were substituted entirely or in part for wagons; this lessened the increase in unit man-hour requirements in two cases and reduced them in the third.

At four of the operations loading on railroads by means of McGiffert or American mechanical loaders did not change between 1929 and 1936, although the average for the five mills increased markedly. This was due to the fact that between 1929 and 1936 one operation began loading trucks for truck haul directly to the mill, and loading man-hours were increased as a result.

The principal factor responsible for the reduction in the average logging unit labor requirements at these camps was the introduction of trucks to supplement the railroad in the long haul. This resulted in a sharp reduction in the amount of spur-line construction at the four operations where this change was made, with a corresponding reduction of more than 50 percent in the man-hours allocated to railroad construction and maintenance. This was the only department in which a reduction in man-hour requirements occurred, and the reduction attained in this department offset the increases in other departments sufficiently to reduce total logging unit man-hour requirements. Railroad-operating labor was likewise

¹¹At one operation logmaking man-hours were reduced from 2.5 to 1.8 per thousand board feet through a shift from a daily rate of pay to the piece-rate system employed at the other four camps studied. At this camp the reduction in short-haul man-hours per thousand board feet from 3.0 to 2.2 without a change of equipment was attributed to the increased speed of work of the fallers and buckers as a result of this change in the system of pay.

Table 19.- LOGGING UNIT LABOR REQUIREMENTS OF FIVE LARGE SOUTHERN OPERATIONS, BY OPERATION, 1929 AND 1936^a

Operation	Number of man-hours		Change in number of man-hours	
	1929	1936	Number	Percent
Total, excluding purchased logs ^b	11.9	10.8	-1.1	-9.2
Cutting	2.2	2.4	+0.2	+9.1
Yarding ^c	3.3	3.4	+0.1	+3.0
Loading				
Five mills	0.8	1.5	+0.7	+87.5
Four mills ^d	0.7	0.7	0	0
Railroad construction and maintenance				
Five mills	4.2	2.3	-1.9	-45.2
Four mills ^e	4.4	2.0	-2.4	-54.5
Long-haul operating labor	0.9	1.0	+0.1	+11.1
Railroad haul only	0.9	0.7	-0.2	-22.2
Supervision and miscellaneous	0.4	0.4	0	0
Total, including purchased logs ^f	11.8	10.3	-1.5	-12.7

^aSpecial report of the U. S. Dept. Agr.; Forest Service, Div. Res. (Nov. 1, 1936), for the "Studies of Productivity and Employment in Selected Industries" section of the National Research Project. Man-hour ratios are unweighted averages.

^bFigures represent unweighted averages of the sums for five mills. The sums of the figures below are 11.8 for 1929 and 11.0 for 1936, but these differences are due to rounding off the unweighted averages for the specified operations.

^cIncludes man-hours required in loading trucks and wagons in the woods.

^dExcludes camp which began loading trucks for truck haul directly to the mill between 1929 and 1936.

^eIncludes camps which introduced trucks to supplement railroad haul.

^fLogs were purchased in appreciable quantities by three mills. The man-hours expended by the contractors supplying the purchased logs are included.

reduced, although all operating labor in the long haul increased because one of the operations initiated truck haul directly to the mill.

In recent years some of the large southern mills have supplemented cuttings from their own holdings and by their own crews with logs purchased from independent operators cutting small bodies of timber. They also purchase from small sawmills green lumber which they season, finish, and market. Two of the five mills surveyed purchased logs from independent operators, and one mill bought green lumber. In 1936, 9.5 man-hours were required per thousand board feet of logs produced on the operations of these three mills; the number of logging man-hours per thousand board feet of purchased wood was 6.9, or 27 percent less. If data for logging

man-hours expended on wood purchased by these three mills are included, the logging man-hour ratio for the five mills drops from 11.8 in 1929 to 10.3 in 1936, or by 12.7 percent.

The experience of these five large logging operations, which reduced their logging unit labor requirements by 9 percent between 1929 and 1936, is paralleled by that of two large southern camps included in the NRP-NBER survey. The average man-hour ratio of these two camps for the period 1933-35 was 12 percent lower than that for the period 1927-29.¹²

The five cases for which departmental man-hour requirements were available illustrate the importance of the introduction of trucks at large logging operations as a form of adjustment to a less favorable timber stand. The data noted earlier, which indicated an extensive employment of trucks in the short and long hauls as a supplement to the forest railroad at large operations, indicate that the type of change noted at these operations was characteristic of many large operations. It seems reasonable to assume that the introduction of trucks, particularly as a supplement to railroads in the long haul, has been the principal means of maintaining or increasing the productivity of labor at the large southern operations.

Unit Labor Requirements at Logging Operations in the Lower South

Of great significance to the trend of unit labor requirements of the southern industry are the differences in the relative man-hour ratios of logging operations attached to small and large mills. A wide difference would have a profound effect on the ratio for the southern industry as a whole because of the increase in the relative importance of the small mills. Data alluded to earlier indicated that the production of small mills increased from one-third of the total southern-pine production in 1919 to over one-half in 1929, and the survey undertaken by the United States Forest Service indicated that this was also occurring in hardwood production.

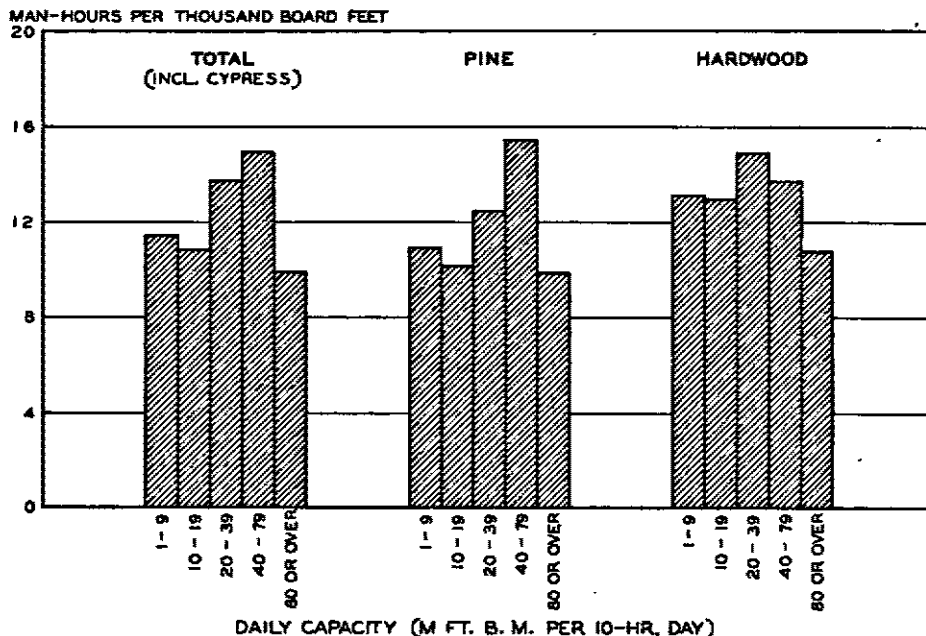
The Forest Service obtained information on the output, number of men employed, and hours of work when in full operation from 651 operations in the Southern Forest Survey territory.¹³ These data were based either on the operator's knowledge of his organization or on actual records.

These data are presented in figure 22 for pine-logging and hardwood-logging operations and for all operations including the 14 cutting cypress. This survey covered a larger number of operations than any other

¹²The man-hour ratios for these two camps for 1927-35 are presented in table A-14.

¹³Of the 651 operations in the Southern Forest Survey territory, 448 cut pine principally, 189 cut hardwood principally, and 14 cut cypress principally.

Figure 22.- UNIT LABOR REQUIREMENTS OF SOUTHERN LOGGING CAMPS, BY SPECIES OF LUMBER AND DAILY MILL CAPACITY, 1934



BASED ON TABLE D-4

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undertaken to date and included a large sample of small operations. The data are, unavoidably, somewhat crude insofar as they are based in instances on the opinion of the operator; nevertheless, the size of the sample is such that these data may be employed to indicate the relative man-hour ratios for operations of different size.

Pine.— The most striking feature of the man-hour ratios for pine operations is the regular increase in the magnitude of the ratios as the operations increase in size from Group 2 to Group 4. This probably reflects the longer haul necessary to the stationary mills supplied by the large logging operations in Group 4 compared with that necessary at the smaller operations in Group 2.

The fact that the man-hour ratio is lowest for the largest operations, in Group 5, suggests that the increase in labor requirements associated with the longer hauls which are generally necessary to stationary mills can be offset by superior mechanical equipment. Under favorable conditions the railroad offers the means of transportation requiring the least labor, and the use of railroads at over 90 percent of the operations in Group 5 is one of the factors responsible for their low unit labor requirements. On the other hand, when railroad-construction and -operating labor are chargeable to a small volume of traffic, unit labor requirements may be high.

The logging operations in Group 2 have lower unit labor requirements than those in Group 1. This is probably attributable to the fact that the percentage of operations employing animals in the long haul in Group 1 is three and one-half times as great as that in Group 2. Furthermore, mechanical yarding equipment is employed at a larger percentage of the operations in Group 2 than in Group 1.

Hardwood.- There is less variation in the man-hour ratios of size groups in the case of hardwood operations. The considerations which guided the analysis of the differences in the level of unit labor requirements of pine operations of various sizes probably apply as well to hardwood operations. Unit labor requirements are highest for the medium-size operations. Presumably, the haul is somewhat longer than to smaller portable mills, which might account for the lower unit labor requirements at the operations in Groups 2 and 1. The fact that unit labor requirements are much lower for the five largest operations, in Group 5, than for any other group may indicate advantages in terms of labor productivity of the types of mechanization at the largest operations.

The smallest operations had slightly higher unit labor requirements than had the operations in Group 2. Here also this may reflect the more widespread use of animals in Group 1.

The figures for average labor requirements for all operations, including the 14 engaged principally in cutting cypress, are heavily weighted by the large number of pine mills, so that the unit labor requirements by size groups are similar to those of the pine operations.

TECHNICAL CHANGES AND UNIT LABOR REQUIREMENTS IN SAWMILLS, 1920-35

The advances in design and construction of sawmill machinery during 1920-35 had from all indications little effect on the technique and methods employed in southern sawmills. The large mills, which were the characteristic production centers during the boom period in southern lumber production, have declined in importance since 1920. During this period many of the large mills have been faced with the prospect of cutting-out the timber stand from which they received their log supply. There has therefore been little incentive for extensive replacement of standard machines or for considerable investments in the newer mechanical handling equipment.

The principal changes during the years 1920-35 at the medium and large southern mills have been the introduction of electric power and improvements in and extension of the techniques of kiln drying.

Equipment Changes and Unit Labor Requirements
at a Group of Large Mills

The experience of the six mills studied for the National Research Project by the United States Forest Service¹⁴ is perhaps indicative of the lack of change at large southern mills since 1929. The five mills which reported on handling methods employed mechanical handling equipment on the log deck and from the headsaw to the sorting table. The six mills had a total of 16 band mills, and the carriages were in every instance powered by steam piston feeds. One of the mills used electric networks on the carriages; the others used the less advanced cable networks. Eleven of the 16 headsaw carriages were equipped with air dogs; the others were operated with the less advanced lever dogs. Each of the six mills had edgers and trimmers, two of the trimmers being operated by compressed air. The others were operated by lever. In the yard, stacking was performed with the aid of machines at two of the six mills. All but one of the six employed the usual lumber buggies or tramtrucks for the conveyance of lumber in the yard, and one mill was equipped with an electric monorail system. Each of the six had planing mills attached.

The only changes at these mills during the period 1929-36 were the addition of a vertical resaw and an air-dog carriage and the discontinuance of a horizontal resaw. There were opportunities for improvement through the introduction of steam or electric networks at 5 of the 6 mills, the replacement of lever dogs by air dogs on 5 of the 16 sawmill carriages, and the replacement of lever-operated trimmers by air-operated trimmers at 4 mills. More important, perhaps, were the opportunities for mechanization of yard handling operations at almost all the mills.

It will be recalled that at five of the six mills the average size of pine logs decreased by 9.2 percent between 1929 and 1936.¹⁵ The adjustments in logging technique which made it possible to reduce unit labor requirements in that operation in spite of the increased difficulties were not paralleled in the sawmill, where there were only negligible changes in methods or equipment. It is not surprising, then, that the average man-hour ratio for these five mills, the five which reported on unit labor requirements for 1929 and 1936, increased from 21.9 to 23.4 man-hours per thousand board feet, an increase of 6.8 percent. The experience of the group of large southern mills covered in the NRP-NBER logging-camp and sawmill survey suggests that this failure to reduce unit labor requirements was characteristic of this sector of the industry.

¹⁴Includes the five mills discussed earlier (pp. 88 ff.).

¹⁵See p. 89.



United States Forest Service

FIGURE 23.— LUMBER HANDLING AT A SOUTHERN MILL

Lumber dollies or buggies at the right receive lumber from the sorting table. The dollies are then moved by horse or tractor, as shown at left, to dry kiln, planing mill, or storage. This method of handling, largely replaced at large Pacific Coast mills by crane systems and straddle-truck carriers, still prevails in the South.

The National Research Project in cooperation with the National Bureau of Economic Research surveyed 28 mills in Alabama, Louisiana, Mississippi, South Carolina, and Texas. Because of the inadequacy of available records it proved impossible to sample small mills adequately. Accordingly, the sample is limited to large mills having a daily capacity of 40 thousand or more board feet; smaller mills were eliminated from the computations.¹⁶ About half of the mills retained in the sample had a daily capacity of at least 80 thousand board feet.

Since small mills are important in the South, the sample of large mills covered by the survey accounts for only a small proportion of total southern production. The percentages of the total southern production accounted for by sample mills amount to from 3.8 to 7.0 percent in the census years 1927-35.

With one exception, the NRP-NBER mills actually cut over 10 million board feet in 1929; more than half of them cut over 25 million board feet. In 1929 these size classes accounted for less than 3 percent and less than 1 percent, respectively, of the total number of southern mills. For the group of larger mills, those which cut more than 25 million board

¹⁶See appendix A, pp. 145-6, particularly fn. 7.

feet in 1929, the sample was reasonably adequate. NRP-NBER mills accounted for 19.8 percent of the production of mills which cut more than 50 million board feet and 12.6 percent of the production of mills which cut 25 to 50 million feet in 1929.¹⁷

In table 20 is presented an index of unit man-hour requirements for the group of large southern mills covered in the NRP-NBER survey. This index, based on "equivalent" production, is of the type presented for Pacific Coast sawmills.¹⁸ An examination of this table reveals that between 1926 and 1935 there was neither an increase nor a significant decrease in unit labor requirements at these mills. The average of the year-to-year changes in unit labor requirements in the second half of the period is slightly higher than that in the first half, but the difference is too small to be characterized as an upward trend, particularly in view of the sharp drop in the equivalent-production index after 1930.

Table 20.- INDEX OF UNIT LABOR REQUIREMENTS IN LARGE SOUTHERN SAWMILLS, 1926-35^a
(1926=100)

Year	Index	Year	Index
1926	98.0	1931	101.4
1927	96.1	1932	101.7
1928	102.3	1933	96.1
1929	100.0	1934	102.9
1930	94.4	1935	96.8

^aTable A-11, col. (10).

Since the chain index reveals only relative levels of the man-hour ratios, a series for 12 identical mills was computed. For 1926-35 the latter corresponds with the chain index with reasonable consistency (figure 24).

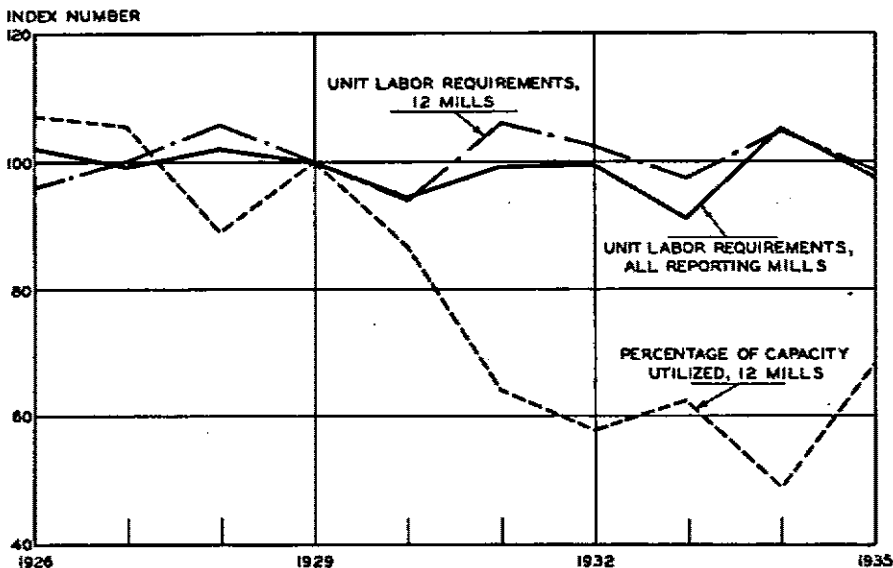
The average man-hour ratio of the 12 mills is 16.1¹⁸ for the period 1926-35. There was no significant upward or downward movement in the level of unit labor requirements for these 12 mills during the period 1926-35. Their aggregate annual capacity declined from 459 million board feet in 1926 and 1927 to 449 million board feet in subsequent years. The percentage of capacity utilized by these mills declined sharply after 1929 (figure 24).

¹⁷Figures represent actual rather than "equivalent" production. For a more detailed description of the NRP-NBER logging-camp and sawmill survey see appendix A.

¹⁸See p. 66 and table 13.

¹⁹In comparing this ratio with that for the five mills studied by the U. S. Forest Service, it is important to recall that in computing the man-hour ratios for the NRP-NBER survey the man-hours in the planing mill were excluded.

Figure 24.- INDEXES OF UNIT LABOR REQUIREMENTS AND PERCENTAGE OF CAPACITY UTILIZED IN LARGE SOUTHERN SAWMILLS, 1926-35 (1929=100)



BASED ON TABLES A-12 AND A-13

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On the basis of the available data there appears to be no evidence of any marked change since the middle 1920's in unit labor requirements at southern mills of the size covered in the NRP-NBER survey. No data are available to show whether or not this relative consistency of the man-hour ratio obtained in the years 1920-26.

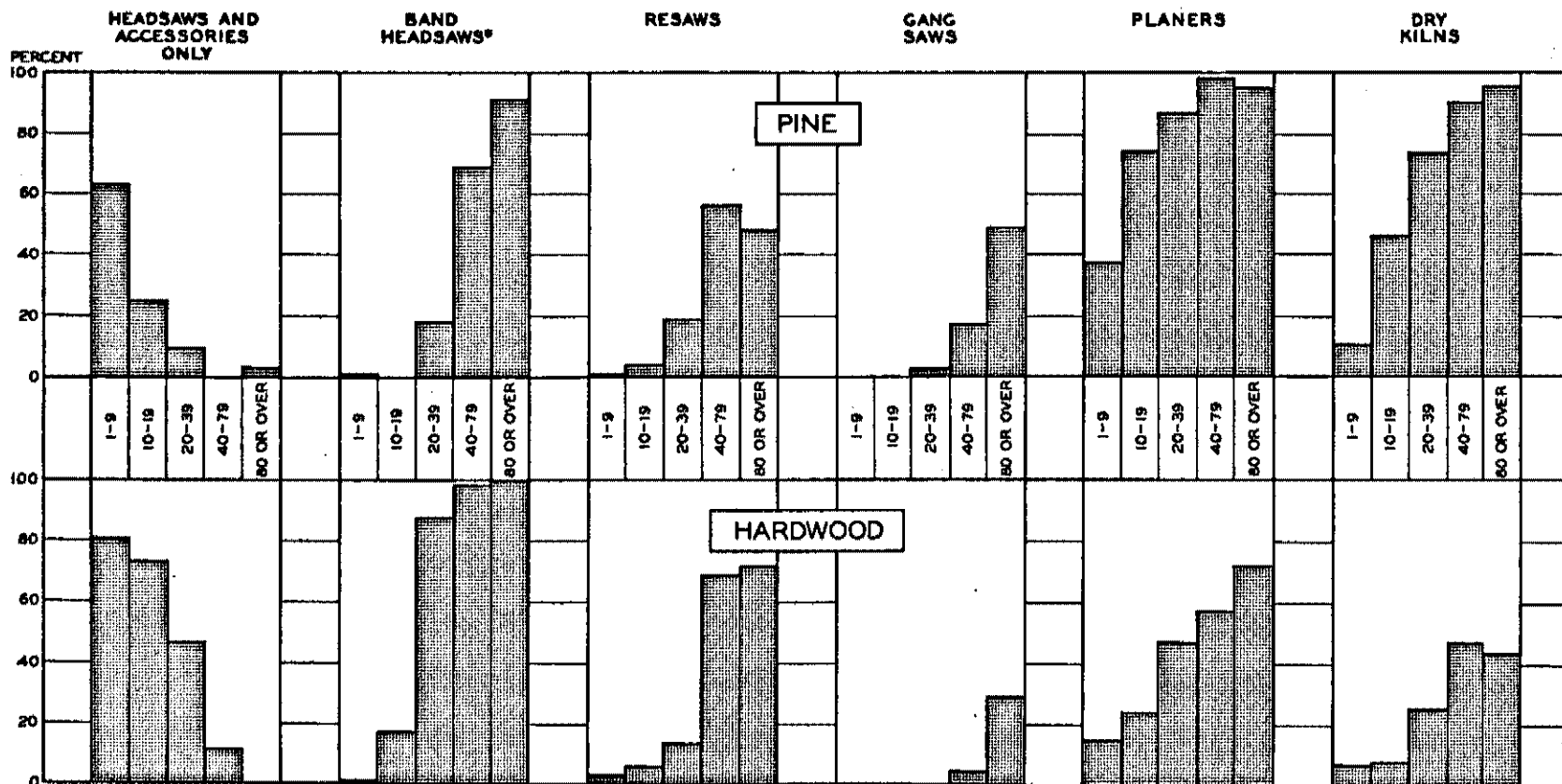
Differences in Equipment and Unit Labor Requirements by Size of Mill

A comparison of the type of equipment employed by mills of various sizes indicates that mills of the size of those included in the NRP-NBER survey are more extensively equipped than the smaller mills. This is shown in figure 25 for the mills in the Southern Forest Survey territory.

A substantial majority of the large pine mills are equipped with band saws, whereas the small mills use circular saws almost exclusively. Since band saws produce approximately 10 to 15 percent less kerf than circular saws, it is possible to achieve with band saws a considerably higher board-foot production from a log of given size. Thus at the large mills equipped with band saws less log handling is required to achieve the same board-foot production from logs of the same size. A majority of the large and medium hardwood mills and almost one-fifth of the mills in Group 2 used band saws.

Figure 25.- PERCENT OF SOUTHERN MILLS REPORTING SPECIFIED SAWMILL EQUIPMENT, BY SPECIES OF LUMBER AND DAILY MILL CAPACITY, 1934

(Daily capacity in M ft. b. m. per 10-hr. day)



* MILLS NOT EQUIPPED WITH BAND HEADSAWS USE CIRCULAR HEADSAWS.

BASED ON TABLE D-3

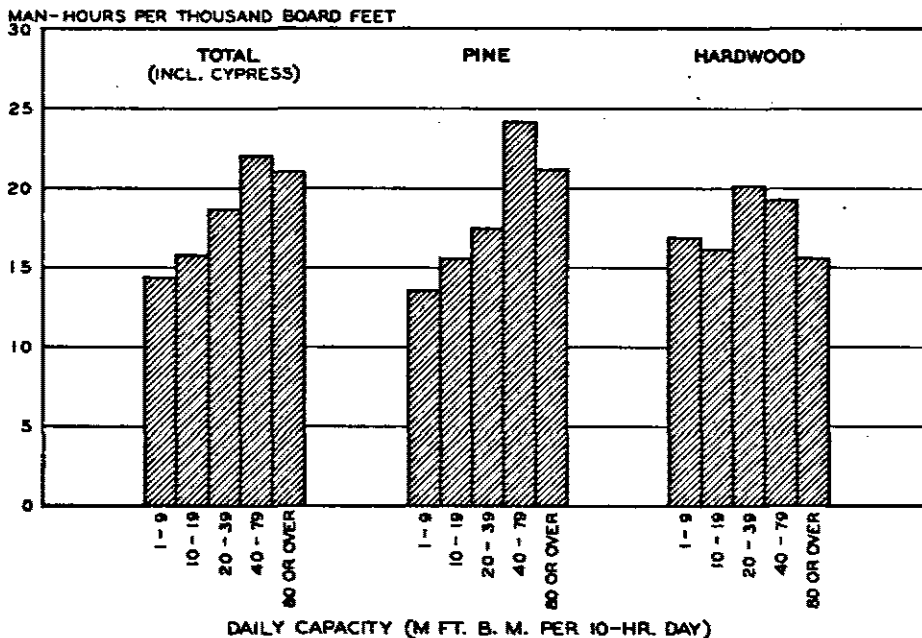
About half of the large pine mills use resaws for the further reduction of lumber produced on the headsaw. Almost half of the pine mills in Group 5 also employ gang saws, and about 17 percent of the pine mills in Group 4 are also so equipped. About 70 percent of the large hardwood mills employ resaws, and about one-fourth of the mills in Group 5 employ gang saws. The use of resaws and gang saws by the large pine and hardwood mills probably means a reduction in the amount of work which would otherwise be required on the headsaw in order to reduce logs to given dimensions. Thus the more extensive use of superior headsaw equipment and labor-saving gang saws and resaws apparently provides a basis for a higher productivity of labor at the large mills, of the size covered in the NRP-NBER survey, than at the smaller ones.

There are important differences in the character of the product of the large and small mills which are likely to offset some of the advantages resulting from the better equipment of the large mills. About 25 percent of the pine mills in Group 2 and about 63 percent of those in Group 1 are equipped only with the headsaw and such accessories as the cut-off saw and edger. In many of the smallest mills there is no edger, and in some instances not even a cut-off saw. About one-fourth of the mills in Groups 1 and 2 employed planers as the sole item of equipment in addition to the headsaw and accessories. The percentage of hardwood mills which are equipped only with headsaws and accessories is much larger; about half of the medium-size mills and over three-quarters of the small mills have no other equipment. Another 10 percent of the mills in Group 1, 16 percent of the mills in Group 2, and 18 percent of the mills in Group 3 employed planers only in addition to the headsaw and accessories. The small pine and hardwood mills, equipped with such simple machinery, bear little relation, in terms of number of operations and type of product, to the large mills which employ a variety of special-purpose machines and produce seasoned and finished lumber. The more extensive use of planers and dry kilns at the large mills means that a larger amount of labor is required for the operation of these additional items of equipment; this is not reflected in increased production. The large percentage of the small hardwood mills which are equipped only with headsaw and accessories may be attributed in part to the fact that these mills often manufacture, as their principal products, sawn railroad ties and planking, which are in common local use for bridge timbers.

The equipment data reflect the difference in the degree of refinement of the product of the large and small mills. The latter produce for the most part only rough green lumber, whereas the large mills produce a variety of seasoned dimensions and finished planing-mill products. Topkis

showed that in southern-pine sawmills yard lumber required about 55 percent more man-hours per thousand board feet than timbers, whereas planing-mill lumber required almost 112 percent more labor than timbers.²⁰ The large mills, according to the equipment data, would be likely to produce a high percentage of planing-mill lumber and the small mills a high percentage of timbers.

Figure 26.- UNIT LABOR REQUIREMENTS OF SOUTHERN SAWMILLS, BY SPECIES OF LUMBER AND DAILY MILL CAPACITY, 1934



BASED ON TABLE D-4

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Data on the average sawmill labor requirements of southern mills in 1934, secured by the United States Forest Service, are presented in figure 26.²¹ The average labor requirements at pine mills, it may be seen, increased with an increase in the size of mill under consideration. Thus, the pine mills in Group 4 required about 80 percent more man-hours per thousand board feet of lumber sawed than the mills in Group 1. These differences are traceable very largely to differences in the degree of refinement of the product. The data on equipment indicated that about the same proportion of the mills in Groups 4 and 5 employed planers and dry kilns, and it seems likely that, on the average, these mills manufacture products approximately similar in size, diversity, and degree of

²⁰Bernard H. Topkis, "Labor Requirements in Lumber Production," *Monthly Labor Review*, Vol. 44, No. 5 (May 1927), p. 1145.

²¹See p. 61.

refinement. It is therefore probable that the fact that the man-hour ratio of the mills in Group 5 was approximately 12 percent lower than that of the mills in Group 4 reflects a real change in the efficiency of utilization of labor.

In the case of the hardwood mills there is not the same degree of uniformity in the relationship between size and unit labor requirements. The mills in Groups 3 and 4 have higher unit labor requirements than the small mills, but the mills in Group 1 have higher unit labor requirements than the mills in Group 2. The large mills have lower unit labor requirements than the medium-size mills; the largest mills have the lowest unit labor requirements.

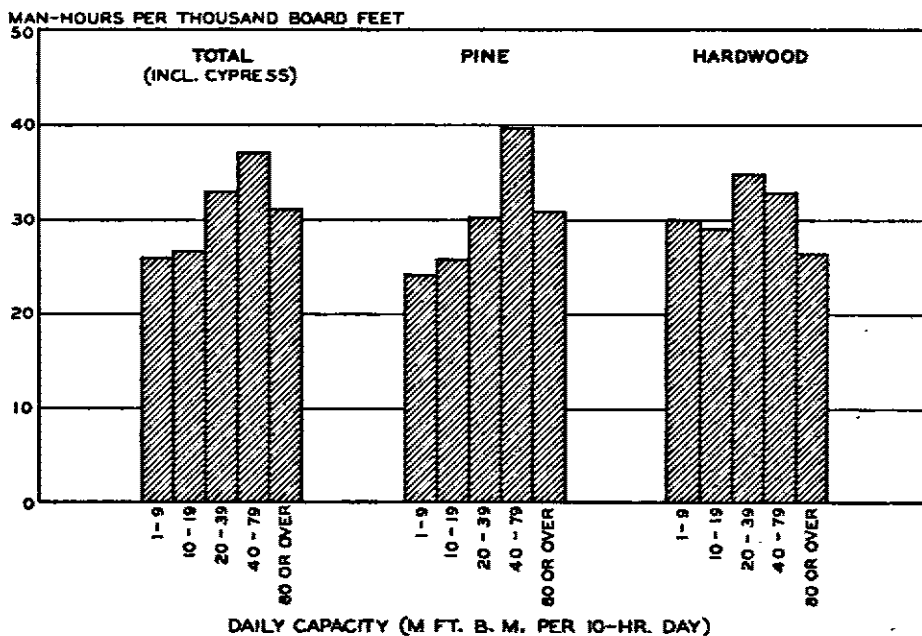
The data on equipment at hardwood mills indicate that the degree of refinement of the product increases with an increase in the size of the mill. However, the facts that a substantial percentage of the large hardwood mills do not have planing equipment and that over half of these mills do not have dry kilns may indicate that differences in degree of refinement of the product between large and small mills are not so pronounced in hardwood as in pine. It appears that the greater labor productivity of the large hardwood mills is sufficient to offset much of the increase in unit labor requirements necessary to carry manufacture further.

LOGGING AND SAWMILL UNIT LABOR REQUIREMENTS, BY SIZE OF SAWMILL

The discussion of unit labor requirements at the southern logging operations and sawmills has shown that in general the small mills have lower unit labor requirements than the mills of medium size and those in Group 4. This is reflected in the logging and sawmill unit labor requirements as presented in figure 27. These differences have been explained primarily through the conclusion that the small mills were located closer to the timber supply and that they manufactured a considerably cruder product than the large mills.

The products of large and small mills are not, in general, of comparable quality, and conversion of the product of the small mill to the same degree of manufacture as the product of the large mill requires further finishing at another plant. The small southern-pine mills are known to market their product primarily through concentration yards which season and finish the output of these mills. Dimension mills bear somewhat the same relationship to small hardwood mills. In any attempt to determine whether the lower man-hour ratios of the small mills actually constitute

Figure 27.— UNIT LABOR REQUIREMENTS OF SOUTHERN LOGGING CAMPS AND SAWMILLS, BY SPECIES OF LUMBER AND DAILY MILL CAPACITY, 1934



BASED ON TABLE D-4

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a competitive advantage, it would be necessary to add to the amount of labor employed at the small mills the man-hours utilized in transporting the green lumber to the concentration yard and in seasoning and finishing this lumber.

In table 21 data are presented for the purpose of indicating the importance of such activities in determining the total number of man-hours required to carry the product of the small mill through the seasoning and finishing operations. In this table a comparison is made of the unit labor requirements in the production of finished lumber of 11 mills cutting less than 15 thousand board feet daily and those of larger mills. These mills were surveyed by the United States Forest Service in different years over the period 1926-35. The data cannot be used to establish the absolute or relative man-hour ratios of large and small mills, but they are adequate for the purpose indicated above.

The labor requirements for the two groups are approximately equal, and in this respect the data for the mills chosen for comparison do not seem to be typical. The unit labor requirements in the sawmill and in the yard are about 5 percent lower at the larger mills, and the amount of labor required per unit in remanufacturing and shipping is somewhat less in the case of the smaller mills.

Table 21.- UNIT LABOR REQUIREMENTS OF SOME SOUTHERN MILLS,
BY SIZE OF MILL AND OPERATION^a

Operation	Number of man-hours per thousand board feet	
	Large mills ^b	Small mills ^c
Total	33.6	32.9
Woods and haul	8.7	8.7
Cutting	2.6	3.5
Yarding	3.5	5.2 ^d
Railroad loading	0.6	-
Transportation	1.8	-
Mill	24.9	24.2
Milling	6.3	7.9
Stacking	2.4	1.9
Mill moving and miscellaneous	-	2.1
Transportation to concentration yard	-	3.0 ^e
Remanufacturing and shipping	6.7	7.7
Office and supervision	1.1	1.6
Plant erection and maintenance	6.4	0.6

^aSpecial report of the U. S. Dept. Agr., Forest Service, Div. Res. (Nov. 1, 1936), for the "Studies of Productivity and Employment in Selected Industries" section of the National Research Project. Mills classified as "small" for purposes of this table have a daily capacity of less than 15 thousand board feet.

The figures presented are based on data for 11 small and 11 large mills. In some cases mills did not report unit man-hour requirements for each operation separately; man-hours expended in the unreported operation were included with man-hours reported for other operations. Averages, however, were computed by dividing the sums of the figures for each operation by 11.

^bIncludes data for six mills surveyed in 1929, one in 1931, two in 1932, one in 1933, and one in 1934. The average diameter of logs for seven pine mills was 13.0 inches; for seven hardwood mills, 17.4 inches.

^cIncludes data for five mills surveyed in 1926, one in 1928, one in 1930, and four in 1935. The average diameter of logs for 10 pine mills was 11.5 inches; for 1 hardwood mill, 17.7 inches.

^dThe average distance from stump to mill was one-half mile.

^eThe average distance from mill to concentration yard for 10 mills was 16.7 miles.

The man-hour requirements for plant erection and maintenance are more than 10 times as great at the larger mills as at the smaller ones. This, however, is largely balanced by the labor required at the smaller mills for moving the mill and for transporting green lumber to the concentration yard. To prepare a thousand board feet of lumber at the smaller mills for transportation to the concentration yard required 22.2 man-hours; a thousand board feet of lumber shipped by the larger mills required 33.6 man-hours of labor. However, when the labor involved in the transportation to the concentration yard and in remanufacturing and shipping is added to the number of man-hours required at the smaller mills,

the average unit labor requirements for these mills are seen to have been only 2 percent lower than for the larger mills. The experience of these mills indicates that for comparable products the man-hour ratios of mills of varying sizes are approximately equal. It is evident, then, that the man-hour ratios presented earlier for mills of various sizes do not accurately reflect the competitive position of the different size groups in relation to unit labor requirements for lumber of a specified degree of finishing.

SUMMARY

At the beginning of the period 1920-35 the southern lumber industry had already passed its peak. Estimates placed the remainder of the virgin yellow-pine timber in 1920 at about one-fifth of the original stand.²² Similar estimates placed the remaining virgin stand of southern Appalachian hardwoods at about one-third of the original stand.²³ Only the hardwood stands in the lower Mississippi Valley remained comparatively unexploited.²⁴ Thus throughout the period since 1920 the southern lumber industry has had to adjust itself constantly to poorer stands of timber in order to continue in operation. This has been accomplished primarily through the shift of production to smaller mills and secondarily through the adoption of more flexible logging equipment, notably trucks. The success of the southern lumber industry in maintaining its relative importance must be attributed in large measure to the exceptionally favorable natural conditions for timber growth.

From 1909 to 1929 the southern States accounted for almost half of the total national employment and over 40 percent of the total lumber production of the lumber and timber products industry. Although the comparison must be made with caution, it is interesting to note that the index of employment in the lumber and timber products industry of the South and that of southern lumber production have been in general agreement since 1899 (table 22). The decline in employment opportunities in the southern lumber industry must be attributed almost entirely to the decline in demand for the lumber and timber products of the South.

The data available on the course of unit labor requirements for sawmill production indicate that at least for the large mills there has been no apparent trend since 1928. The more limited group of large mills reporting on logging operations was able to effect some reduction in unit labor

²² *Timber Depletion, Lumber Prices, Lumber Exports, and Concentration of Timber Ownership* (3d ed.; U. S. Dept. Agr., Forest Service, 1928), p. 20.

²³ *Ibid.*, p. 25.

²⁴ *Ibid.*, p. 26.

Table 22.- INDEXES OF PRODUCTION AND EMPLOYMENT IN THE
SOUTHERN LUMBER INDUSTRY, 1899-1937^a
(1929=100)

Year	Production of lumber	Number of wage earners in the lumber and timber products industry
1899	72	70
1904	87	79
1909	129	130
1914	115	116
1919	104	116
1921	88	91
1923	106	121
1925	111	112
1927	94	99
1929	100	100
1931	39	45
1933	37	45
1935	51	59
1937	67	74

^aBased on data from *Census of Manufactures*.

requirements in the woods in spite of increased difficulties. This was accomplished principally through an extension in the use of trucks; the data on equipment in use show a widespread adoption of trucks at operations of all sizes. Although the evidence scarcely justifies the conclusion that logging labor requirements have been reduced generally through the adoption of trucks, it does suggest that this type of mechanization has been an important factor in maintaining the level of labor productivity in the face of increasing difficulties.

The decline in employment opportunities in the southern lumber and timber products industry can scarcely be traced to technological developments. On the contrary, it appears that the only extensive technological changes, those in logging, had the effect of extending logging operations to stands which would not have been economically available otherwise. In most instances, therefore, the effect of the introduction of mobile and flexible logging equipment, such as tractors, trucks, and gasoline skidders, has been to preserve employment opportunities for the time being by making it possible to obtain the timber necessary for mills from stands that could not have been logged profitably with the equipment previously employed.

The advance of technology has, then, been one of the ways in which the lumber industry of the South has adjusted itself to depleted timber

reserves. The rise of small mills in areas abandoned by large mills has been the other important method of adjustment. The operation of small mills on timber from second-growth stands or scattered old-growth stands has been made more profitable by the adoption of flexible mechanical logging equipment, particularly trucks. The operating economics of the small mill often do not permit the use of railroad logging. Before the introduction of trucks and tractors the only alternative to railroad haul was, in most instances, animal haul. It is safe to say that the increase in the number of small mills would not have been so great if trucks had not been introduced into logging operations.

In the South, as on the Pacific Coast, the nature of recent technological developments has favored the adoption of better forest-management practices. The use of trucks as a substitute for or as a supplement to railroads and the use of tractors and gasoline donkeys in place of heavy steam cable yarders have increased the chances for profitable operation of a system of selective logging. Animal logging is also well adapted to tree selection, although it is generally less efficient than the mechanical methods.

In the immediate future it is unlikely that increased mechanization will by itself produce a significant change in unit labor requirements. The future level of unit labor requirements will depend in large measure upon the extent to which the new technology is applied within a logging system designed to assure a sustained yield.

If the further depletion of the forests is not halted, the man-hour ratio for southern lumber will probably be determined by the interplay of opposing forces: a decrease in the size, quality, and accessibility of standing timber on the one hand and a decline in the quality of the product and the amount of refabricating on the other hand. The progressive decrease in the size of individual trees and in the density of the stands will probably continue; the proportion of southern lumber produced by small mills is likely to continue to increase.

If the quality of the pine-forest resource is allowed to continue to decline, the quality of southern-pine lumber will probably become perceptibly lower. It is also probable that there will be a decline in the amount of refabricating of pine lumber into moldings, ceiling, handles, sash, door stock, siding, etc. This will probably not be carried on so extensively as it is now carried on in large mills because the requisite high-grade lumber will not be so plentiful as at present and the small sawmills are not generally equipped with the necessary machinery. It

seems likely that man-hour requirements (including the labor involved in transportation to and manufacture at the concentration yard) may increase slightly per thousand board feet of pine lumber of specified size and degree of finishing. On the other hand, it is likely that slightly less labor will be spent per board foot of pine lumber produced because of the decline in the degree of finishing.²⁵

If the operating practices in vogue in hardwood production are continued, a situation similar to that which obtains in pine-lumber production is likely to prevail. In hardwood-lumber production it is likely that the replacement of large mills which are cut out by small mills will not be so complete as in pine-lumber production. The small mills will probably devote themselves principally to the production of structural materials for railroad and local use. Those small mills which do serve as successors to the large industrial-hardwood mills will probably engage in the cutting of blanks for handles, athletic goods, vehicle stock, and specialties.²⁶ In the main, however, the southern industrial-hardwood supply now manufactured principally in large mills is likely to be produced in mills of medium size.

Since the differences in the degree of finishing of large and small mills are less pronounced in hardwood than in pine production, the influence of the increase in difficulties is likely to have a more pronounced effect on the level of unit labor requirements than the decline in the degree of finishing which is associated with the shift of production to smaller mills. The average amount of labor spent per board foot of lumber leaving the hardwood mills is therefore likely to be about the same or to increase somewhat.²⁷

The widespread adoption of forest-management practices leading to a sustained yield from southern forests would undoubtedly alter radically the outlook for the future. The adoption of sustained-yield practices would probably mean an increase in the size of trees cut for saw logs and a gradual improvement in the quality of the forest resource. The timber supply available to individual mills would be stabilized and the closing of mills due to timber depletion reduced.

An improvement in the size and quality of timber available for cutting would make it possible to carry finishing and remanufacturing operations

²⁵Based on a special report of the U. S. Dept. Agr., Forest Service, Div. Res. (Nov. 1, 1936), for the "Studies of Productivity and Employment in Selected Industries" section of the National Research Project.

²⁶Ibid.

²⁷Ibid.

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further and hence would increase the total amount of labor employed in such operations per unit of lumber production. Unit labor requirements for lumber of a specified size and degree of finishing would nevertheless be reduced. Furthermore, sustained-yield logging would probably pave the way for the adoption of machines and techniques whose use in the South is not profitable at the present time.

CHAPTER V

TECHNOLOGY, RESOURCES, AND EMPLOYMENT OPPORTUNITIES

In 1929 the lumber and timber products industry, one of the most important sources of manufacturing employment, provided jobs for 419,000 wage earners and over 21,000 salaried employees.¹ The further manufacture of lumber into planing-mill products and the distribution and marketing of lumber and planing-mill products gave employment to over 350,000 more persons. Thus a rough estimate places the 1929 employment afforded by the lumber and closely allied industries at close to 800,000 wage earners and salaried employees. About 55 percent of those employed were engaged in cutting and sawing and about 13 percent in planing, or a total of about 69 percent occupied in the various stages of production. It was estimated that 9 percent were railroad employees transporting lumber to the wholesale and retail dealers, who comprised 22 percent of the total. (See table 23.)

Certain groups of workers for whom no data were available were excluded from this estimate. It did not prove practicable to estimate the employment afforded by the manufacture of equipment used in the lumber and timber products industry. The manufacture of sawmill machinery provided employment for roughly 1,000 workers in 1929, but this represented only a fraction of the workers engaged in the production of all equipment.²

Also excluded were the employees of mills sawing lumber on a contract basis; workers engaged in manufacturing locomotives, tractors, trucks, logging equipment, stackers, mill structures, etc.; and longshoremen, sailors, and others carrying lumber by sea or inland waterways. The course of total employment in the lumber and timber products industry (logging camps, sawmills, and combined sawmills and planing mills) is shown in table 24 for the period 1899-1937. At the turn of the last

¹Logging accounted for 35 to 40 percent of the wage-earner employment of the industry in years for which separate data are available (1909, 1919, and 1923; see *Thirteenth Census of the United States: 1910*, Vol. X, "Manufactures: 1909" [U. S. Dept. Com., Bur. Census, 1913], pp. 496-7; *Fourteenth Census: 1920*, Vol. X, "Manufactures: 1919" [1923], pp. 424-5; *Census of Manufactures: 1923* [U. S. Bur. Census, 1926], pp. 442, 444).

²This estimate is for the labor employed in the manufacture of sawmill machinery and straddle-truck lumber carriers. The figure was obtained by multiplying the estimated value of sawmill-machinery and lumber-carrier sales by the number of man-hours of labor required to produce a dollar's worth of sawmill machinery and lumber carriers, and then dividing the result by 2,400 in order to convert to man-years of employment. The estimated value of sawmill-machinery and lumber-carrier sales was computed by inflating figures secured in the NRP machinery-manufacturers survey by their coverage during the NRA period. The labor required to produce a dollar's worth of sawmill machinery and lumber carriers was computed from data obtained in the same survey. Data on the number of workers engaged in producing other machinery used in lumber manufacture are not available.

Table 23.- EMPLOYMENT IN LUMBER PRODUCTION
AND RELATED ACTIVITIES, 1929^a

Industry	Total	Wage earners	Salaried workers.
Total	795,491	-	-
Lumber and timber products ^b	440,798	419,084	21,714
Planing-mill products ^c	107,101	90,134	16,967
Railroad transportation of lumber ^d	70,300	n. a.	n. a.
Wholesale lumber dealers ^e	24,874	24,874	n. a.
Retail lumber dealers ^f	152,418	139,009	13,409

^aDoes not include water transportation, for which no data are available.

^bFifteenth Census of the United States: 1930, "Manufactures: 1929" (U. S. Dept. Com., Bur. Census, 1933), II, 443. Includes workers of lumber camps, sawmills, and planing mills operated in conjunction with sawmills. Excludes a small number of workers engaged in contract work and many workers attached to portable mills.

^cIbid., p. 465. Includes workers of planing mills operated independently of sawmills.

^dEstimated by multiplying the number employed in freight transportation by Class I railroads by the ratio of ton-miles of lumber hauled to ton-miles of all freight hauled (Interstate Commerce Commission, Bur. Statistics, *Freight Commodity Statistics of Class I Steam Railways in the United States: 1929* [1930]). Freight employment of Class I railroads was derived by adding to the workers classified by the Interstate Commerce Commission as freight employees a portion of the workers classified as both freight and passenger employees. Apportionment of the latter classification was done on the basis of revenue received for the freight and passenger services (Interstate Commerce Commission, Bur. Statistics, *Forty-sixth Annual Report on the Statistics of Railways in the United States: 1932* [1934]; *Forty-ninth Annual Report on the Statistics of Railways in the United States: 1935* [1937]).

^eFifteenth Census, Vol. II, "Wholesale Distribution" (1933), p. 76.

^fFifteenth Census, Vol. I, "Retail Distribution" (1934), pt. I, p. 48. Includes "lumber and building-material dealers" and "lumber and hardware dealers."

n. a. Data not available.

Table 24.- NUMBER OF WAGE EARNERS IN THE LUMBER
AND TIMBER PRODUCTS INDUSTRY, 1899-1937^a

Year	Number	Year	Number
1899	419,257	1925	467,090
1904	404,563	1927	413,948
1909	547,178	1929	419,084
1914	479,786	1931	196,647
1919	480,945	1933	189,367
1921	364,247	1935	255,230
1923	495,992	1937	323,928

^aData for 1899-1929 from *Fifteenth Census of the United States: 1930, "Manufactures: 1929"* (U. S. Dept. Com., Bur. Census, 1933), II, 442; data for 1931-35 from *Census of Manufactures: 1935* (U. S. Dept. Com., Bur. Census, 1936), p. 469; and data for 1937 from same, 1937 (1939), p. 501.

For 1919 and earlier years the census data included all establishments whose products were valued at \$500 or more per year; for 1921 and subsequent years data included only establishments whose products were valued at \$5,000 or more. In 1914 the number of wage earners in establishments whose production was valued at less than \$5,000 but more than \$500 was 36,868; in 1919 the number was 11,848 (*Fourteenth Census of the United States: 1920, Vol. X, "Manufactures: 1919"* [1923], p. 429).

century employment in this industry was still rising, and by 1909 over 547,000 workers were employed. Thereafter there was a gradual downward trend until 1929, when about 419,000 workers were employed. Thus between 1909 and 1929 employment declined by over 125,000, or nearly a fourth. More than half of this decline occurred between 1909 and 1914. From 1914 to 1923 there was no further sustained decline, but between 1923 and 1929 employment dropped markedly and between 1929 and 1931 was more than halved. A continuing decline was noted in 1933, after which there was a pronounced recovery; the 1937 figure, however, was still 23 percent below that of 1929. (See table 24.)

FACTORS AFFECTING TOTAL EMPLOYMENT

Demand for Lumber and Timber Products

The decline in the demand for lumber was the principal factor responsible for the decline in employment; the volume of exports and imports has been a small fraction of production, and the general trend of internal consumption coincides rather closely with the production trend. This decline was of such overwhelming importance as to obscure the effect of the operation of other forces. Between 1909 and 1929 production of lumber decreased by more than 7,600 million board feet, or by almost 20 percent (table 6); production of other timber products was similarly affected. The dominant importance of lumber production in the level of employment

Table 25.-- VALUE OF LUMBER AS PERCENTAGE OF VALUE
OF ALL PRODUCTS OF THE LUMBER AND TIMBER
PRODUCTS INDUSTRY, 1919-37^a

Year	Percent	Year	Percent
1919	75.2	1929	78.0
1921	70.1	1931	69.1
1923	79.0	1933	73.9
1925	75.6	1935	72.4
1927	73.3	1937	74.3

^aData for 1919-31 from *Census of Manufactures: 1931* (U. S. Dept. Com., Bur. Census, 1935), pp. 425, 429, 438; data for 1933 and 1935 from same, 1935 (1936), pp. 473, 476; and data for 1937 from same, 1937 (1939), pp. 506, 507. To find total value of lumber, lumber production was multiplied by average mill value.

in the lumber and timber products industry is suggested by table 25, which shows that the value of lumber constituted between 69 and 79 percent of the value of all products of the lumber and timber products industry throughout the period 1919-37.

The key to the sharp decline in lumber production and employment lies in the steady fall of per-capita consumption since the 1900's, a striking

indication of how extensively new commodities have supplanted lumber in the economic life of the Nation.

The lumber industry was one of the pioneer industries of America. The frontier marched westward on wood. The railroads, the frontier towns and cities, and the farms used wood for ties, railroad cars, houses and buildings, sidewalks, roads, fences, wagons and buggies, barrels and boxes, furniture, and agricultural implements. It is estimated that prior to 1910 "there was a prospective market for $4\frac{1}{2}$ billion feet of lumber annually for 90,000 new farms" alone.³

By the end of the 1900's it was apparent that demand was slowing down. Per-capita consumption, which had increased by over 80 percent from 1849 to 1889, increased by only 20 percent between 1889 and 1906. Wood was being crowded out of construction, particularly urban construction, by brick, cement, iron, and steel; the last two also replaced it for many uses in the manufacturing industries.⁴

Prior to 1906-7 the per-capita consumption of lumber was steadily increasing, but since then the demand for lumber has declined both absolutely and per capita. The factors behind the decline in lumber consumption are revealed in table 26, which presents the results of surveys by the United States Forest Service on the quantity of lumber consumed in

Table 26.- DISTRIBUTION OF LUMBER CONSUMPTION,
BY PRINCIPAL USE, 1912 AND 1926^a

Use	1912		1926		Change, 1912-26	
	Millions of board feet	Percent of total	Millions of board feet	Percent of total	Millions of board feet	Percent
Total	43,000	100	36,500	100	-6,500	-15
Factory	11,200	26	10,300	28	-900	-8
Construction						
Sash, door, and millwork	2,500	6	3,300	9	+800	+32
Direct construction	29,300	68	22,900	63	-6,400	-22
Rural	15,000	35	5,500	15	-9,500	-63
Urban residential	9,000	21	12,000	33	+3,000	+33
Urban nonresidential	5,300	12	5,400	15	+100	+2

^aAdapted from U. S. Congress, Senate, *A National Plan for American Forestry*, S. Doc. No. 12, 73d Cong., 1st sess., 1933, I, 249.

³U. S. Congress, Senate, *A National Plan for American Forestry*, S. Doc. No. 12, 73d Cong., 1st sess., 1933, I, 249.

⁴The replacement of lumber sidewalks by brick and cement paving eliminated the potential demand for 900 million feet of lumber a year (Rolf Thelen, *The Substitution of Other Materials for Wood* [U. S. Dept. Agr., Report No. 117, 1917], p. 33). The tonnage of wooden ships built in private shipyards fell from about 470 thousand in 1879 to 220 thousand in 1909, whereas iron and steel ship construction increased from 30 thousand tons in 1879 to 325 thousand in 1904 (*ibid.*, p. 51). The substitution of barbed and woven wire for wood in farm fencing amounted to an estimated 1 billion board feet per year by 1917 (*ibid.*, p. 32).

1912 and 1928 by the principal users. The major factor is evidently the declining demand for lumber in agricultural areas, stemming from the termination of the period of rapid agricultural expansion, the population movement away from the farm, and the agricultural depression which enforced curtailment of normal repairs. For the past two decades the number of farms in the United States has remained almost stationary, and the agricultural depression of the 1920's eliminated the demand for about half of an estimated 11 billion board feet required annually for normal repair and replacement of rural farm buildings.⁵

Another factor important in the declining demand for lumber is the growing urbanization of the population which is accompanied by the development of multifamily dwellings requiring less floor space; these utilize building materials other than lumber to a greater extent than do single-family urban dwellings. This condition, together with the displacement of lumber in other urban residential construction, resulted in a 25-percent reduction in demand for lumber per family unit of urban residential construction between 1912 and 1928. In urban nonresidential construction the consumption of lumber relative to that of other materials was probably reduced by fully one-half.⁶ The consumption of lumber for construction purposes since 1928 has been at an extremely low ebb. In 1932 lumber consumption for such purposes was only about $6\frac{1}{2}$ billion board feet, a decline of 64 percent from the 1929 level. In 1936 lumber consumption for construction was 80 percent of the 1929 level; in 1939 this figure had risen to 98 percent.⁷

The widespread substitution of other materials for wood in factory products was a third factor of major importance in accounting for the decline in demand. The lumber consumed in wood-using industries, ranging from one-fourth to one-third of the total lumber consumption, declined by less than 8 percent between 1912 and 1928. Fiber was substituted for wood in boxes and crates and metal for wood in railroad-car construction and in nonhousehold furniture. The drop in consumption was pronounced in the case of almost all other factory uses of wood, indicating a rapid process of substitution of other materials for lumber. The dramatic strides in this respect in automobile construction have doubtlessly brought about a sharp reduction in the use of wood in automobiles in recent years, although it increased by 410 percent between 1912 and 1928.⁸ The secular

⁵*A National Plan for American Forestry*, I, 248-50.

⁶*Ibid.*, pp. 252-3.

⁷W. LeRoy Neubrech, "Present Position of the Lumber Industry," *Survey of Current Business*, Vol. 20, No. 1 (Jan. 1940), p. 15.

⁸*A National Plan for American Forestry*, I, 253-5.

decline in the consumption of wood for industrial purposes which was evident during the twenties has continued. In 1939, with consumption of lumber for construction purposes at approximately the 1929 level, consumption of lumber for boxes and crating was 66 percent, industrial consumption of lumber was 39 percent, and railroad purchases were 60 percent of the 1929 levels.⁹

Although lumber exports accounted for an average of only 7 percent of the total production during the 1920's,¹⁰ the export market has nevertheless constituted an important source of demand. Fluctuations in the volume of exports have been slight. Generally speaking, and apart from the competition between American and Canadian Douglas fir, there is a marked difference between the quality and types of lumber imported for domestic use and lumber purchased internally, so that imports probably have little direct effect upon the demand for domestic lumber. Exports declined sharply from 1929 to 1933 under the impact of such factors as the war in the Orient and the British imperial-preference policy; they have not recovered since. Exports in 1939 were 35 percent of the 1929 volume.¹¹

The demand for other products of the lumber and timber products industry has probably been of secondary importance in terms of total employment in the industry. It appears that there was a slight downward trend in the demand for railroad ties from 1906 to 1929 because of a slowing down in the amount of new railroad construction and the reduction in the demand for ties for renewals per mile of track.¹² As may be noted in table 26, the demand for planing-mill products, such as dressed lumber, sash, and doors, has increased relative to that for lumber. Shingle production dropped by almost 50 percent from 1910 to 1920 but was stable during the 1920's.¹³

The production of veneer as measured by the wood consumed in its manufacture almost doubled from 1919 to 1929 and has increased in importance relative to total lumber production since that time.¹⁴ Particularly notable was the steady increase in Douglas-fir plywood production, which more than tripled from 1925 to 1935.¹⁵

⁹Neubrech, loc. cit.

¹⁰Adapted from *A National Plan for American Forestry*, I, 246. Total exports during the 1920's in round figures were 2,602 million board feet; total production during the 1920's in round figures was 37,139 million board feet.

¹¹Neubrech, loc. cit.

¹²*A National Plan for American Forestry*, I, 270-1.

¹³*Ibid.*, p. 276.

¹⁴*Statistical Abstract of the United States: 1937* (U. S. Dept. Com., Bur. For. and Dom. Com., 1936), pp. 663, 665.

¹⁵Special report of the U. S. Dept. Agr., Forest Service, Div. Res. (Nov. 1, 1936), for the "Studies of Productivity and Employment in Selected Industries" section of the National Research Project.

Unit Labor Requirements

For a given volume of production, the volume of employment is determined by the amount of labor required per unit of product. Although the decline in demand was responsible for most of the decrease in employment in the lumber and timber products industry, indications are that since 1919 man-hours of employment have declined more rapidly than has production. This is shown by the indexes of output per wage earner and per man-hour in the lumber and timber products industry given in table 27. Several factors suggest themselves as possible explanations of the relatively more rapid decline in man-hours than in production. First, the composition of the total product has shifted from 1920 to 1936. Table 28 gives the percentage distribution of the total lumber production by important types (the less important associated species are included with each type). The same table gives relative man-hour requirements per unit of output, also by important types of timber cut.

Table 27.- INDEXES OF OUTPUT PER WAGE EARNER AND PER MAN-HOUR IN THE LUMBER AND TIMBER PRODUCTS INDUSTRY, 1919-36^a

(1929=100)

Period	Output per wage earner	Output per man-hour
1919-24	86.1	91.1
1925-30	95.4	95.9
1931-36	86.7	111.6

^aHarry Magdoff, Irving H. Siegel, and Milton B. Davis, *Production, Employment, and Productivity in 59 Manufacturing Industries, 1919-36* (WPA National Research Project, Report No. S-1, May 1939), Part Two, p. 126. The 6-year averages presented above represent unweighted averages of the yearly index numbers.

It will be noted that Douglas fir and western pine, which are reduced to lumber with the least amount of labor, have increased in relative importance since 1919-24. Unit man-hour requirements for the manufacture of southern-pine lumber are from 80 to 100 percent higher than those for Douglas fir and associated species, and southern-pine production has declined markedly in relative importance since 1919-24. Southern hardwood, which has a much higher man-hour ratio than the average for Douglas fir and associated species, has declined slightly in relative importance since 1925-30. Among the western lumbers only redwood products have high unit man-hour requirements, and redwood-lumber production has been a consistently unimportant part of total western production. Lumber production from all other forest regions, including the Lake States and the Northeast in particular, has also declined noticeably in relative importance. Unit labor requirements are considerably higher in the Lake States than in the

South (table D-5). It is likely that lumber production in the Northeast also requires more labor per unit than in the South. It therefore seems reasonable to assume that the man-hour ratio for the production included in "All other" lumber in table 28 is higher than for that of other types.

Table 28.- RELATIVE PRODUCTION OF LUMBER AND RELATIVE UNIT LABOR REQUIREMENTS, BY SPECIES OF LUMBER, 1919-36

Producing area	Percentage distribution of production ^a			Relative unit labor requirements, 1935 ^b (Douglas fir=100)		
	1919-24	1925-30	1931-36	Timbers	Yard lumber	Planing-mill lumber
Total lumber	100.0	100.0	100.0	-	-	-
Douglas fir	22.7	28.0	29.0	100	100	100
Western pine	12.5	14.1	17.7	(c)	125	103
Redwood	1.8	1.4	1.5	(c)	189	155
Southern pine	36.0	31.7	29.5	199	201	181
Southern hardwood	9.5	10.2	9.3	302	262	224
All other	17.7	14.6	13.0	-	-	-

^aBased on Harry Magdoff, Irving H. Siegel, and Milton B. Davis, *Production, Employment, and Productivity in 59 Manufacturing Industries, 1919-36* (WPA National Research Project, Report No. 8-1, May 1939), Part Three, p. 84.

^bBased on Bernard H. Topkis, "Labor Requirements in Lumber Production," *Monthly Labor Review*, Vol. 44, No. 5 (May 1937), p. 1148.

^cRelatively few timbers are produced in this area.

Thus changes in the composition of lumber production have been uniformly such as to favor a reduced man-hour ratio for the total production. Furthermore, the production of lath and shingles, which require more man-hours per unit of equivalent production than does lumber, has declined in importance relative to lumber.¹⁶ This too has been a factor favoring a more rapid decline in man-hours of employment than in production.

A second factor responsible for the more rapid decline in man-hours than in production was the decline in unit labor requirements for the production of Douglas fir and western pine at the large Pacific Coast mills. The available data indicate a reduction of about one-third in the man-hour ratio for logging between 1925 and 1935 and a reduction of 6.7 percent in sawmill unit labor requirements.¹⁷ Although the survey covered only the larger mills, operations of the size most adequately represented accounted for the bulk of the Pacific Coast production.

¹⁶Harry Magdoff, Irving H. Siegel, and Milton B. Davis, *Production, Employment, and Productivity in 59 Manufacturing Industries, 1919-36* (WPA National Research Project, Report No. 8-1, May 1939), Part Three, p. 83.

¹⁷NRP-NBER logging-camp and sawmill survey. See tables A-5 and A-6.

EFFECTS OF THE STATE OF FOREST RESOURCES
ON EMPLOYMENT AND UNEMPLOYMENT

Insofar as the magnitude, availability, and quality of timber resources influence lumber production and unit labor requirements, they represent important elements in the determination of employment levels. As used here, the magnitude of the timber resource refers to the volume of the stand regardless of its quality or availability; availability, to the topographical obstacles to be overcome, the density of the stand, and the distance to markets; and quality, to the size of the trees composing the stand and the quality of the wood.

The magnitude of timber reserves has never imposed a direct limitation on the volume of employment opportunities for the Nation as a whole. In spite of tremendous depletion of timber resources, there is no likelihood of a general shortage of timber for some time to come. It seems likely, however, that the decline in the availability and quality of the timber resources has had an adverse effect on the domestic utilization of lumber, although the importance of this effect is difficult to evaluate.

Whatever the influence of the magnitude, availability, and quality of the timber resources on the volume of employment opportunities for the industry as a whole may have been, the state of the forest resource has frequently constituted the decisive factor governing the volume and stability of employment in particular regions and localities.

In the course of the migration of the lumber industry, production has shifted from one region to another as timber stands have been depleted. To a considerable extent the decline in production due to timber depletion in one region has been offset by a rise in production in other regions.¹⁸ However, the decline in production accompanying timber depletion in particular regions and localities has been the cause of severe regional economic dislocation, unemployment, and aggravated relief problems. Since improved forest-management practices can largely eliminate violent regional fluctuations in the volume of production attributable to timber depletion, and since the technological developments of recent years have increased the possibility of a general adoption of such practices, the state of the forest resource is highly significant in a consideration of the employment problems of the lumber and timber products industry.

¹⁸This must be qualified to the extent that consumption drops because the area of adequate timber reserves may not be able to supply the market formerly served by the area of depleted timber reserves with lumber of the same type or at the same price. Also, if production is shifted from areas of relatively high labor requirements to areas of low labor requirements, the increase in employment in the area of rising production will not be equal to the decline in employment in the area of declining production.

The ensuing discussion will be concerned with employment fluctuations and the relief problem in the several forest regions in relation to the state of the forest resources. These will be followed by a discussion of sustained-yield logging as a means of reducing or ending timber depletion and of technological developments as an element favoring the adoption of better forest-management practices.

Regional Employment Fluctuations

Table 29 indicates the shifts in regional employment which have occurred since 1899. The Pacific Coast and the Rocky Mountain States have increased their share of the national employment almost steadily since 1899. On the other hand, there has been a slight decline in the percentage of total employment accounted for by the South. The rise in employment in the western States was made chiefly at the expense of the Northwestern, Lake, Central, and the other less important areas.

Table 29.—EMPLOYMENT IN THE LUMBER AND TIMBER PRODUCTS INDUSTRY, BY REGION, 1899-1937^a

Year	Total	Pacific States	Rocky Mountain States	Southern States	Lake States	Central States	North-eastern States	Other States
1899	413,257	36,045	8,012	142,578	94,000	66,119	64,758	3,745
1904	404,563	48,468	8,636	160,007	72,791	61,998	52,108	2,530
1909	547,175 ^b	70,847	12,541	262,473	69,420	73,297	57,342	1,255
1914	479,786	64,377	12,240	235,050	63,243	59,070	45,352	454
1919	480,945	93,234	15,507	238,053	49,320	47,197	35,598	2,036
1921	364,247	75,161	11,735	183,242	35,872	30,296	27,256	683
1923	495,632	122,452	19,658	244,015	44,740	36,067	25,661	1,099
1925	467,090	115,904	20,601	227,588	45,503	34,420	21,931	1,149
1927	413,946	110,976	18,120	201,153	35,375	30,166	16,303	1,204
1929	419,084	115,224	20,443	202,324	30,539	32,858	16,177	1,519
1931	196,647	60,295	9,180	91,085	14,423	18,174	7,759	731
1933	189,369	60,014	8,811	90,035	11,693	13,081	7,344	381
1935	255,230	77,724	11,391	119,440	18,101	19,343	9,512	719
1937	323,828	102,632	15,973	148,850	20,130	22,806	12,833	702
Percent								
1899	100.0	8.7	1.5	34.5	22.7	16.0	15.7	0.9
1909	100.0	12.9	2.3	48.0	12.7	13.4	10.5	0.2
1919	100.0	19.4	3.2	49.5	10.3	9.8	7.4	0.4
1929	100.0	27.5	4.9	48.3	7.3	7.8	3.9	0.3
1937	100.0	31.7	4.9	46.0	6.2	7.0	4.0	0.2

^aBased on Census of Manufactures. See table 24, fn. a. State groupings referred to are those of the Census of Manufactures.

^bA revised figure of 547,178 was published in the 1929 Census of Manufactures (see table 24); the figure shown in this table was obtained from the Census of Manufactures for 1909, which presented the regional distribution of employment.

During the 1920's, when demand was still at a relatively high level, the quality of the forest resource was doubtlessly the decisive factor affecting the volume of employment opportunities in the forest regions of the Northeastern, Lake, and Central States. Between 1909 and 1929

employment in the lumber and timber products industry as a whole declined by 23 percent. During the same period employment in the Northeastern States decreased by 72 percent; in the Lake States, by 56 percent; and in the Central States, by 55 percent. The total decline in employment between 1909 and 1929 in these three regions was over 120,000, or 94 percent of the drop in the industry as a whole. Comparisons with years other than 1909, a peak year for employment in the industry, indicate even more clearly the loss of employment in these areas, which was due to the exhaustion of the timber supply.

No such striking loss in the proportion of total employment has as yet affected the South, which has long been able to maintain a leading position in lumber production.

Remarkably favorable natural conditions, which make the South one of the fastest-growing timber regions in the world, have enabled the South to stave off the disastrous decline in the forest industries that has stricken other forest regions. The high rate of growth has tended to offset much of the timber depletion, and the annual drain of all species and sizes exceeds the annual growth by only about 3 percent. The situation with respect to saw timber (sizes suitable for use in lumber production) is less favorable, however, there being a net annual drain of over 3 billion board feet.¹⁹ The balance between growth and drain is generally less favorable in terms of quality than quantity. There is a heavier annual net drain on saw timber than on cordwood sizes and on larger saw-timber sizes than on small ones. Furthermore, the drain may far exceed the growth within the working area of any given mill.

Forest resources do not impose limitations on the employment opportunities for the southern forest region as a whole. However, the stability of employment in particular localities and at particular mills is and has been threatened by timber exhaustion. Data collected by the United States Forest Service in the course of the Southern Forest Survey show clearly the high degree of insecurity of employment associated with the depletion of the timber supply of particular mills. Table 30 presents data on the number of persons employed in 1934 by mills in the Southern Forest Survey territory, classified by daily capacity and by the operator's estimate of the length of time his mill would continue to cut in the immediate vicinity of the 1934 location. It should be noted that these data cannot be taken as estimates of the future employment or unemployment in the Southern Forest Survey territory. They are based on the answers of individual operators to a questionnaire, and the answers represent in all cases only

¹⁹Lumber Industry Facts: 1939 (Washington, D. C.: National Lumber Manufacturers Association), p. 11. The data cited are for 1936.

the operator's best opinion. Furthermore, the operator's estimate was usually made on the basis of the continued employment of the techniques in use at the time. In general, the estimates are probably more accurate for large mills and particularly for those cutting virgin timber from their own lands.

Table 30.— LIFE EXPECTANCY OF SOUTHERN MILLS,
BY DAILY MILL CAPACITY, 1934^a

Daily capacity and estimated year of termination	Mills		Persons employed ^b	
	Number	Cumulated number	Number	Cumulated number
1-19 M ft. b. m.				
1935-39	2,508	-	12,051	-
1940-44	1,169	3,677	4,656	16,707
1945-49	1,432	5,109	5,003	21,710
1950-59	307	5,416	1,101	22,811
Permanent	2,106	7,522	9,597	32,408
20-39 M ft. b. m.				
1935-39	219	-	5,884	-
1940-44	138	357	3,826	9,710
1945-49	99	456	2,681	12,391
1950-59	33	489	789	13,180
Permanent	202	691	5,688	18,868
40 M ft. b. m.				
1935-39	65	-	9,142	-
1940-44	60	125	9,282	18,424
1945-49	65	190	9,180	27,604
1950-59	6	196	932	28,536
Permanent	75	273	10,370	38,908

^aSpecial report by I. F. Eldredge and R. K. Winters of the U. S. Dept. Agr., Forest Service, Div. Res. (Dec. 2, 1936), for the "Studies of Productivity and Employment in Selected Industries" section of the National Research Project. Data refer to the Southern Forest Survey territory. See appendix D.

^bIncludes woods, sawmill, and office workers.

The logging operations, sawmills, and offices of the 273 large mills in the region surveyed employed about 39,000 persons in 1934, or 43 percent of the total employed in the mills surveyed. Only about 27 percent of the employees of large mills were attached to mills which anticipated permanent operation in the immediate vicinity of the 1934 mill site; an additional $2\frac{1}{2}$ percent were attached to mills which may be regarded as semipermanent, for in 1934 they had an anticipated life of more than 15 years in their vicinity. The operators of mills employing over 9,000 persons, or 23 percent of the employees of the large mills, expected to

exhaust the timber supply in their 1934 vicinity before 1939; the operators of two other groups of mills, each employing approximately the same number of persons, expected to cut-out by 1944 and 1949, respectively.

The medium-size mills employed 18,868 persons in woods, mills, and offices in 1934, and only about 30 percent of this number were at mills regarded by their owners as permanent. At mills accounting for over half of the total employment in this size class the operators expected to exhaust the timber supply at their 1934 location before 1945. More than 12,000 workers were employed in 1934 at mills whose owners expected to cut-out by 1949.

Although the data for large and medium mills may not be sufficiently reliable to be used as a basis for estimates of job separations due to timber exhaustion, they are nevertheless indicative of a high degree of employment instability. Probably most of the owners who expected in 1934 to cut-out by a certain date made their estimates on a sound basis, and many of these mills will exhaust their timber supply at approximately the indicated date.

The interpretation of the data for small mills is much more difficult than in the case of larger mills, because the owners' estimates of the length of life at the 1934 location for the small mills are probably much less reliable than estimates for larger mills and because the number of small mills in the South is increasing and is likely to increase in the future. The majority of these small mills will continue to operate almost indefinitely.²⁰ Even if an allowance is made for a considerable underestimation of the timber supply available to the small mills within a small radius of the 1934 location and even if it is assumed that all the mills will continue to operate elsewhere, it is evident that the small southern mills constitute an unstable source of employment to that portion of their labor supply which has firm attachments to particular localities.

In general, the data in table 30 indicate that the statistics on employment in the South, which show only a slight decline in that region's share of total employment, tend to obscure the considerable disruption of employment opportunities, attributable to timber depletion, in particular southern localities.

Employment in the Pacific Coast forest region has constituted an increasing percentage of employment provided by the lumber and timber

²⁰In the case of the small mills the owner's estimate of the life expectancy of the operation in the immediate vicinity of the 1934 location is at best a rough guess, for many of these mills are portable; they operate at each new location on stands of small volume and compete with other mills for the cutting of such low-volume stands.

products industry as a whole. In no other area is the industry a more decisive factor in the regional economy than in Washington and Oregon, which together accounted for 83 percent of the Pacific Coast lumber production in 1935. It has been estimated that over 40 percent of the population of Oregon and Washington are dependent, directly or indirectly, on incomes from the forest industries.²¹

It is fortunate, then, that the Pacific Coast still has vast stands of old-growth forests despite the liquidation of forest capital that has taken place. For several decades, at least, the size of the timber reserve need not in itself become a factor which will limit employment opportunities for the Pacific Coast region as a whole.

The situation is much less favorable for particular localities. Several important lumber-producing centers in the Pacific Coast States are threatened with economic dislocation because of timber shortage. The fact that the forest industries constitute the major part of the economy of many of these localities makes this threat all the more serious.

Regional Relief Needs

The preceding discussion has shown how employment has declined in several forest regions and is threatened in others because of timber depletion. Unemployment problems associated with economic dislocation occasioned by timber depletion may frequently lead directly to intensified public-relief problems.

The American lumber industry has traditionally left cut-over areas in its wake. During the years in which the frontier was pressing westward, it was frequently possible for the communities of the cut-over areas to make successful transitions to other forms of sustaining activity, generally agriculture. The ghost town was probably less a feature of the pioneer lumber industry than of the mineral industries which also participated in the exploitation of the Nation's natural resources. In many localities the passing of the lumber industry occasioned only temporary hardships. The termination of the expanding period of American agriculture has, however, made the adjustment to depleted timber resources more difficult.

The community decadence associated with cut-over areas is familiar. Abandoned towns and railroads are the more dramatic aspects of this phenomenon. These features, however, tend to divert attention from the existence of a considerable residual population which has attempted to make

²¹Burt P. Kirkland and Axel J. F. Brandstrom, *Selective Timber Management in the Douglas Fir Region* (Forest Service of the U. S. Dept. Agr. and Charles Lathrop Pack Forestry Foundation, Jan. 1936), p. 1.



Farm Security Administration (Lee)

FIGURE 28.— CUT-OVER LAND IN NORTHERN MICHIGAN

Forest land is frequently unsuitable for agriculture. It is therefore difficult for the population which is left behind after the forest has been cut to make a successful transition to agriculture. When the lumber industry cuts-out, the agriculture which existed while the timber was being cut is jeopardized because of the lack of opportunities for supplementary work for the farmers, the loss of local markets for farm produce, and the dismantling of railroads following cessation of timber traffic.

a transition from lumbering to some other means of livelihood and has failed. As a result, such areas frequently present particularly acute relief problems. Superficially the relief problem in such areas appears to be an agricultural one, but closer study reveals that it is frequently traceable in large measure to loss of income from the lumber industry.

In 1935 the Federal Emergency Relief Administration conducted studies in sample counties of six rural areas having high relief loads. These areas contained 36 percent of the Nation's rural population and approximately one-half of the rural families receiving direct or work relief from governmental sources. The Appalachian-Ozark and Lake States cut-over regions, which represented two of the six problem areas, contain much cut-over forest land. Thirty-two percent of the families in the counties surveyed in the Lake States cut-over area received relief in June 1934; the corresponding figure for the Appalachian-Ozark region was 22 percent. The average rate for the United States at that time was about 15 percent. In the Appalachian-Ozark region 39 percent and in the Lake States cut-over area 78 percent of the heads of families who were receiving relief were usually engaged in nonagricultural occupations. Many of those who considered their usual occupation to be farming were

receiving relief because of the loss of supplementary employment. The need for relief arose in the Lake States cut-over area mainly because of the loss of employment in mining and lumbering, which was accompanied by the development of small-scale farming on submarginal land. The relief households in the Appalachian-Ozark area had depended largely on subsistence farming with supplementary employment for cash income. Loss of supplementary employment in the lumber industry was one of the major reasons for relief in this region.²² A later study of these same two areas likewise concluded that the loss of supplementary employment in industry, particularly lumbering and mining, was the fundamental cause of what appeared to be an agricultural relief problem.²³

A study of four Appalachian counties²⁴ indicates the course which is likely to be followed by the population remaining in a timber-exhausted area. Marketable timber was the greatest natural resource of these four counties until the well-established lumber industry had exhausted most of the timber supply by the early 1930's. Between 1930 and 1935 the percentage increase in the farm population of these four counties varied from 14 to 49 percent without a proportional increase in farm acreage, indicating that many of the workers released by the lumber industry had turned to farming. The inadequacy of farm income in these counties is shown by the fact that in 1934 from 23 to 41 percent of the farm operators in each of these counties worked for pay at occupations not connected with their farms. With the onslaught of the depression, income from farming and from what was left of the lumber industry soon collapsed and relief rates soared. At various times between April 1933 and December 1935 the following percentages of the populations in four counties were receiving relief: 86 percent, 63 percent, 15 percent, and 32 percent.

These studies and others indicate the relationship between the manner of utilization of the forest resource and the relief problem. When the bulk of the timber in a locality is cut-out, the inhabitants who remain turn to agriculture. The land in such areas is frequently submarginal for agriculture, and additional means of support are necessary. These are obtained from a failing source - marginal lumbering operations which

²²G. Beck and M. C. Forster, *Six Rural Problem Areas, Relief - Resources - Rehabilitation* (Federal Emergency Relief Administration, Division of Research, Statistics, and Finance, Research Section, Research Monograph No. 1, 1935), pp. 1, 2, 27, 120.

²³Berta Asch and A. R. Mangus, *Farmers on Relief and Rehabilitation* (Works Progress Administration, Division of Social Research, Research Monograph No. VIII, 1937), pp. 54-5.

²⁴L. S. Dodson, *Living Conditions and Population Migration in Four Appalachian Counties* (U. S. Dept. Agr., Farm Security Administration in cooperation with Bur. Agr. Econ., Social Research Report No. III, Oct. 1937), pp. 1, 3, 146.

cut scattered stands of old-growth timber or cull second-growth stands. When depression strikes, both agriculture and the industry are quick to succumb.

The relief problems characteristic of cut-over areas in the badly depleted forest regions of the Lake and Central States are not found in such striking form in the South. There is every indication, however, that timber depletion in the South has created in particular localities the preconditions for relief problems similar to those which have afflicted regions characterized by more general depletion.

The large mills having a daily capacity of more than 40 thousand board feet are disappearing from the South. The shift of southern production to small mills proceeded throughout the 1920's, and the outlook in 1934 was for a continued abandonment of the large mills. In 1934 owners of large mills employing almost half the total personnel of mills in that size class expected to exhaust the timber supply within the working circle of their 1934 location by 1944.

The adoption of improved forestry practices, a reduction in the rate of cutting, and the underestimation in 1934 of the timber supply are possibilities which could alter the estimated number of workers actually affected by the closing of large mills. There can be no doubt, however, that timber depletion constitutes a real threat to the employment security of the employees of many large southern mills.

Such mills constitute an established part of the economy of their localities. They are large enough to form the nucleus of a lumber town or to be an important source of employment in any town having a population of less than 5,000.²⁵ It is probable that the labor reserve for most southern operations is drawn from the villages and farms in the immediate vicinity.²⁶

The economic dislocation resulting from the passing of these large mills is therefore likely to be out of proportion to the actual number of employees affected. The experience of other regions indicates the course

²⁵Ninety-nine mills with an estimated daily capacity of at least 80 thousand board feet, each employing an average of 237 persons in 1934, accounted in that year for 61 percent of the total employment of large mills. These 99 mills would have employed from 250 to 650 persons each if they had been operating at capacity. The remaining 174 large mills, with a daily capacity of 40 to 79 thousand board feet and an average employment of 89 persons in 1934, accounted for the remaining 39 percent of the 1934 employment of large mills. These mills, had they been operating at capacity, would have employed from 150 to 250 persons each. (Based on a special report by I. F. Eldredge and R. K. Winters of the U. S. Dept. Agr., Forest Service, Div. Res. [Dec. 2, 1936], for the "Studies of Productivity and Employment in Selected Industries" section of the National Research Project. Data refer to the Southern Forest Survey territory.)

²⁶The southern lumber industry has not, according to Vance, employed migratory labor extensively; on the contrary, it has drawn on the stable native labor supply (Rupert B. Vance, *Human Geography of the South* [Chapel Hill, N. C.: The University of North Carolina Press, 1932], p. 130).

frequently followed by a community and by the workers dependent on a mill when the mill ceases operations. The population of the lumber town declines and commercial establishments close their doors. The number of persons attempting to live by combining agriculture with part-time employment increases most rapidly at the time when opportunities for supplementary employment are declining. Studies of areas in which this course was followed indicate that the result was an aggravation of the rural relief problem.

Smaller lumber mills or other forest industries offer possible sources of reemployment for workers released by large mills. It should be noted, however, that when a particular community is struck by the closing of a large mill the rise of new employment opportunities in sufficient numbers and in ample time to avoid the ill effects of economic dislocation is largely a matter of chance.

Data presented earlier (table 30) indicated that the anticipated rate of exhaustion of timber resources within the working radius of the 1934 location of medium-size southern mills was approximately the same as that for large mills.²⁷

Medium-size mills are of two types: stationary mills similar to the large mills and semiportable mills capable of moving to fresh supplies of timber if necessary. The effect of the closing of a stationary mill differs only in degree from the effect of the closing of a large one. The semiportable mills which exhaust the timber supplies at their 1934 location are not likely to close; they may be expected to move to new locations. Many of the medium-size mills whose owners expected in 1934 to cut-out at a definite date may achieve permanency by the adoption of better forest-management practices. The chances of making the transition to sustained-yield operation are much greater for the medium-size than for the large mills. If this is not achieved, the closing of medium-size mills is likely to add to local relief problems even though other mills may spring up elsewhere to replace them.

The small southern mills surveyed in 1934 expected to shift location even more frequently than did the large and medium-size mills. These small mills are increasing in number and importance, and it is probable that most of their owners who expected to cut-out will continue to operate elsewhere. It should be noted, however, that a large portion of the employees of small mills are part-time workers attached to farms. The migration of these mills from particular localities on the scale indicated

²⁷The medium-size mills employed an average of 27 workers in 1934 and would have employed from 65 to 160 workers had they been operating at their stated capacity.

by the data in table 30 may produce serious problems for individual workers who have firm attachments to particular localities and who are unable to travel the distance necessary to secure the part-time employment to which they have been accustomed. The probability that employment in small mills will show a relative increase does not lessen the seriousness of the situation for individual workers.

There is no indication that timber exhaustion has been a significant factor in increasing the relief load in any considerable number of localities in the Pacific Coast States. There is no section of the country in which the forest industries play a more decisive economic role than in Washington, Oregon, and northern California. In those localities of the Northwest which have neared the exhaustion of the timber resources the impact on the economy has been particularly severe and the effect on the relief load especially noticeable.

The recent history of three counties of the Inland Empire in eastern Washington and northern Idaho illustrates the drastic results of depletion. The forest industries of these three counties, Boundary and Bonner Counties in Idaho and Pend Oreille County in Washington, entered a period of rapid expansion in 1900 which reached a peak in 1910. Sixty-six percent of their 1920 population of 24,000 were dependent on forest industries. During the period 1911-20, 12 of the 20 mills which had sprung up during 1900-10 had cut-out, and 4 other mills followed between 1921 and 1930. Between 1930 and 1934 three more large mills, faced with imminent timber exhaustion and beset by financial reverses, ceased operations. The number of workers employed in the forest industries near one town, regarded as typical, declined from 3,500 in 1924 to 100 in 1934. The present timber supply is adequate to maintain operations at only 1 large or 2 small mills, instead of at 20 mills. In 1934 more than 3,500 people in these three counties were supported by employment in Civilian Conservation Corps camps and in the regular and emergency work conducted by the United States Forest Service.²⁸

Other localities in the Pacific Coast States are in danger of following in the path of these three counties. Because of the vastness of the forests and favorable natural conditions for timber growth, this danger can probably be averted in most instances by proper management. It is significant to note in this connection that the Forest Service has estimated that if the timber stand in the three counties mentioned above had been managed on a sustained-yield basis and protected from fire it could have

²⁸Letter from R. D. Garver of the U. S. Dept. Agr., Forest Service, Div. Forest Econ., to the National Research Project, dated April 28, 1937.

yielded continuously the largest cut and afforded continuously the largest employment ever achieved in these counties.

NATURE AND IMPORTANCE OF FOREST MANAGEMENT

Proper management of the forest resource requires, foremost, a balance between drain and growth. The measures necessary to achieve this balance include improvement of the rate and quality of growth and protection of the stand against fire, insects, and destructive cutting.

Improved productivity of the forest can be accomplished most rapidly in timber stands which are being logged, provided that cuttings are so conducted as to be balanced by timber growth. Such sustained-yield logging involves the selection for cutting of individual trees or groups of trees that are no longer rapidly increasing in value. A considerable percentage of good-sized trees should be retained in the forest after each cut; a continuing basis for industries requiring saw-timber sizes would thereby be assured. Over a considerable area the drain from such selective cuttings and other causes would be roughly balanced by timber growth. If the area is large enough, this need not mean a reduction in the volume of cut, for growth is stimulated by the removal of mature trees in selective cuttings and defective and small trees in occasional thinnings. The possible increase in the rate of growth is especially great



United States Forest Service

FIGURE 29.— SELECTIVE LOGGING IN A WYOMING NATIONAL FOREST
Supervised selective cutting for mine props has left an ample stand of medium-size trees for future harvesting.

in the Pacific Coast forests, because the high percentage of overmature trees now standing in the old-growth forests of that region inhibits the growth of smaller trees.

Sustained-yield logging practices would largely eliminate periodic disruptions of employment opportunities in particular regions and localities. The decline of the forest industries in the depleted regions of the Northeastern, Lake, and Central States, attended by intensified relief problems in those areas, can be avoided on the Pacific Coast and in the South by instituting sustained-yield operation. In the South many of those large and medium-size mills whose owners expected in 1934 to cut-out within 10 years might be maintained. Furthermore, a better adjustment of mill capacity to growth capacity may be necessary to preserve employment opportunities at many of the large mills regarded by their owners as permanent.

The need for applying sustained-yield methods is no less immediate in the case of individual localities in the Pacific Coast States. In Bend, a town of about 9,000 population in the interior of Oregon, an investigation by the local chamber of commerce disclosed a striking lack of balance between the timber cut by local mills and timber growth in the vicinity. The committee reported:

Unless operations in the timber tributary to the Bend mills are placed on a sustained-yield basis, the future of the community dependent on those mills is uncertain * * * [and this will cause] * * * great suffering and financial loss * * * among all classes of the local population.²⁹

Bend is not an isolated case. In the region west of the Cascades the local situation is becoming serious in the 6 most populous and highly industrialized of the 11 survey units.³⁰

The quality as well as the magnitude and availability of the forest resource may be improved by employing the techniques of sustained-yield logging. This fact also has important implications for the employment problem. It may be noted first that the lumber from large, high-quality logs is likely to be taken through more stages of finishing and refabrication than lumber from small, poor-quality logs. In southern States the transition to sustained-yield logging, combined with other improvements in forest management, is likely to increase the quality of the forest resource. With larger and higher quality timber to be drawn upon, it is

²⁹Quoted in *Report of the Chief of the Forest Service: 1938* (U. S. Dept. Agr., Forest Service, 1939), p. 11.

³⁰*Ibid.*, p. 9.

likely that the amount of employment afforded per unit of timber removed from southern forests will tend to increase.³¹

The most pressing problem on the Pacific Coast is that of preserving the existing high-quality stands. In the case of the important Douglas-fir region the prosperity of the industry is dependent on the sale of the products of high-quality timber in the eastern domestic and foreign markets. Kirkland and Brandstrom, of the United States Forest Service, conclude:

If the supply of high-quality timber is allowed to diminish there is no escaping the conclusion that a large proportion of the foreign markets and most of the remote domestic markets will be lost. The lower grades of lumber cannot stand on their own feet for distant shipments. In particular, the large eastern domestic markets for these grades of west coast woods are sure to dwindle, because it has been amply demonstrated that the southern pine region with its 200 million acres of forest lands can produce them at lower cost and with a large freight differential in its favor.³²

A continuous supply of large, high-quality logs has been shown by Forest Service studies to be feasible if the remaining large areas covered with many aged stands capable of supplying such timber are placed on a sustained-yield basis of operation.

A correlation can be found between the level of incomes derived from employment in the lumber industry and the quality of the forest resource. Available data indicate that hourly wage rates at large mills in the southern lumber industry are about half of those in the Pacific Coast industry. In nearly all years from 1926 to 1935, however, unit labor costs at a group of large southern mills covered by the NRP-NBER survey were slightly higher than at another survey group of large Pacific Coast mills, because of the much higher unit labor requirements of the southern mills. This is shown in table 31. Data from other sources indicate that the relationship shown in table 31 between unit labor requirements, average hourly earnings, and unit labor costs is fairly typical for other operations in these two regions.

A marked reduction in the disparity between hourly earnings on the Pacific Coast and in the South without compensating movements in labor productivity would, of course, alter the relationship of unit labor costs. Since the southern industry holds a favored position in regard to proximity to many of the major consuming centers and since it is well

³¹On the other hand it should be noted that the unit labor requirements for lumber of a specified size and degree of finishing will tend to decline when larger and higher quality timber is cut.

³²Kirkland and Brandstrom, *op. cit.*, p. 120.

Table 31.- AVERAGE HOURLY EARNINGS, UNIT LABOR REQUIREMENTS, AND UNIT LABOR COSTS OF SEVEN PACIFIC COAST AND NINE SOUTHERN SAWMILLS, 1926-35^a

Year	Seven Pacific Coast sawmills			Nine southern sawmills		
	Average hourly earnings	Number of man-hours per thousand board feet of equivalent production	Labor cost per thousand board feet of equivalent production	Average hourly earnings	Number of man-hours per thousand board feet of equivalent production	Labor cost per thousand board feet of equivalent production
1926	\$0.565	8.28	\$4.87	\$0.302	15.77	\$4.77
1927	.561	8.39	4.71	.289	16.30	4.72
1928	.576	8.19	4.72	.292	16.42	5.39
1929	.584	7.99	4.87	.285	16.70	4.76
1930	.563	8.21	4.82	.275	15.38	4.23
1931	.476	8.15	3.89	.204	17.40	3.55
1932	.398	8.34 ^b	3.35 ^b	.163	16.58	2.71
1933	.392	7.76	3.04	.199	16.33	3.25
1934	.528	7.89	4.17	.291	17.22	5.01
1935	.566	8.05	4.56	.275	16.74	4.61

^aNRP-NBER logging-camp and sawmill survey. Figures are weighted averages of figures for the individual sawmills. Labor time and wages expended in new construction, in the production of byproducts and special products, in delivery, etc., were not included in the calculations. Similarly, hours and salaries of salaried officials were excluded.

The 1929 practically obtainable capacities of the Pacific Coast mills ranged from 22.4 to 226.4 million board feet per year, the median being 61.5 million; similar capacities of the southern mills ranged from 11.8 to 91.5 million board feet per year, the median being 40.2 million.

^bBased on data for only five operations.

established in certain markets, there is presumably some room for movement in relative unit labor costs before the competitive relationship between the two regions will be affected. However, any pronounced alteration of existing relations between unit labor costs in the two regions which would affect the southern industry adversely would probably create a pressure for increased labor productivity in southern operations.

Forest Service studies indicate that at southern operations the improvements in technique which are necessary to establish a sound foundation for increases in labor productivity are those which would contribute to the rate and quality of timber growth rather than to further mechanization. Kirkland, who has observed production techniques in both regions, concluded that "the difference in outputs [of labor] arises directly from differences in condition of the resource [size of trees, stand density, etc.], and indirectly from greater mechanization thereby made possible for handling large Pacific Coast timber."³³ Another Forest Service study

³³Burt P. Kirkland, "Potentialities of the Forest Resource and Forest Industries of the South" (U. S. Dept. Agr., Forest Service, Div. Forest Econ., typewritten report, 1936), p. 9.

found that "if Pacific Coast wage rates were applied in these [southern-pine] operations, trees under about 20 inches in diameter and forests lacking a considerable volume of larger trees could not profitably be cut for saw-timber unless price levels should greatly increase."³⁴ Today trees of considerably smaller diameters are being logged and sawed at southern operations.

An improvement in the condition of the forest resource should therefore furnish a sounder basis for increased incomes from employment in the southern lumber industry by making it possible to restrict cuttings to large trees. Likewise, the preservation of the quality of the timber stand on the Pacific Coast is one of the important conditions for the maintenance of the relatively favorable wage rates in that region.

Without accompanying improvements in the state of the forest resource, mechanization of the southern lumber operations is not likely to effect a considerable reduction in unit labor requirements and is therefore not likely, by itself, to provide a basis for higher wage rates. The larger southern mills, which might utilize the more advanced equipment in use on the Pacific Coast, are giving way to small mills, and it has been shown that the owners of almost half of the large mills expected to exhaust their timber supply before 1945 (see table 30). Under such circumstances it appears unlikely that the owners of these mills would be willing to undertake extensive modernization. The possibilities for mechanization in the small southern sawmills are especially limited, for the installation of the labor-saving handling machinery and special-purpose machines employed in the large mills on the Pacific Coast would destroy the mobility which is the basis for the existence of the small mills.

Significance of Sustained-Yield Logging for Other Forest Industries

The maintenance of local and national timber supplies would have a favorable effect on other forest industries. The expansion of these industries offers the principal hope for the reemployment of those who have become or are likely to become unemployed because of timber depletion or because of the secular decline in lumber consumption.

In the South it is probable that, at a given level of national demand for lumber, the employment afforded by the production of lumber itself will decline.³⁵ The loss in employment occasioned by the passing of the

³⁴Burt P. Kirkland, "Higher Economic and Social Returns From Forest Management," *Journal of Forestry*, Vol. 36, No. 9 (Sept. 1938), p. 894.

³⁵Special report of the U. S. Dept. Agr., Forest Service, Div. Res. (Nov. 1, 1938), for the "Studies of Productivity and Employment in Selected Industries" section of the National Research Project.

large mills will probably not be entirely offset by the increase in employment at small mills. It seems reasonable to assume, however, that this decline will be almost entirely offset by an increase in employment in other forest industries. It is doubtful that there will be any substantial decline in the forest industries as a whole, except for changes associated with the fluctuations in the general level of business activity. The most important of the expanding fields for employment is pulp production. It is also likely that there will be some increase in package-veneer production, in pole and piling production, in cutting and creosoting pine, and in the manufacture of small-dimension hardwood.

The establishment of 15 new pulp mills in the South from 1935 to 1938 increased the number of southern pulp mills from 30 to 45.³⁶ Employment in the woods increased by about 4,000 man-years of 200 days each between 1935 and 1937 because of the manufacture of pulp products from southern pine. In the same period the estimated increase in employment in mills and factories producing pulp products from southern pine was about 6,500 man-years. The total employment in woods and in manufacturing establishments involved in the production of southern-pine pulp products increased from an estimated 21,400 in 1935 to 31,900 in 1937, an increase of about 50 percent.³⁷ During the same period the consumption of all domestic and imported pulpwood increased by only 36 percent.³⁸ Thus the growth of the pulpwood industry in the South has prospects of compensating, in large measure, for any decline in employment in the lumber industry as a result of the cutting-out of the large mills.

If the pulpwood industry is to fulfill the promise which it holds for the South, however, improvements will have to be made in the care of the forest. The pulpwood industries are able to employ material from the small and poorly formed trees which must be removed from the forest at frequent intervals in the process of growing high-quality trees of saw-timber size. If pulpwood is secured as an inexpensive byproduct of the growth of high-quality timber under an extensive sustained-yield program, the expansion of the pulpwood industry could be further stimulated. On the other hand, if timber depletion continues and the pulpwood industries become dependent on forests yielding and devoted to growing cordwood sizes

³⁶ *Report of the Chief of the Forest Service: 1938*, p. 13.

³⁷ The consumption of southern pine for domestic pulpwood consumption increased from 1,785,228 cords in 1935 to 2,858,949 cords in 1937 (see *Lumber Industry Facts: 1939*, p. 45). The U. S. Forest Service estimates that 0.9 man-day in the woods and 1.5 man-days in the manufacturing plants are required for each cord of southern pulpwood (see Kirkland, "Potentialities of the Forest Resource and Forest Industries of the South").

The man-year figures cited above were computed from the foregoing figures and the arbitrary assumption of a 200-day year.

³⁸ *Lumber Industry Facts: 1939*, p. 45.

only, pulpwood production costs are likely to be increased and the present expansion is likely to be foreshortened.³⁹

In the Pacific Coast States, also, the conduct of the lumber industry can have a decisive influence on other forest industries. One of the industries most immediately affected is the Douglas-fir plywood industry, which requires the large, old-growth, high-quality logs which are so essential to the prosperity of the lumber industry itself. The production of plywood has increased almost steadily over the period since 1925 for which data are available. The 1937 production of plywood was roughly double that of 1929 and nearly five times as great as that of 1925.⁴⁰ Employment in the plywood industry increased from about 2,300 workers in 1925 to about 5,000 in 1935.⁴¹ The Douglas-fir plywood industry at the present time depends on logs suitable for peeling into plywood stock and obtained principally from log producers who also supply lumber mills. Although the supply of standing timber of "peeler" size and quality is adequate, the reliance of plywood operators on logs from lumber operations has created in the lumber industry a dearth of large logs yielding a high percentage of the valuable "clears." The competition for peeler logs is so keen that there is a constant interchange of such logs between producing centers several hundred miles apart.⁴² These facts emphasize the possibility of a shortage of high-quality logs on the Pacific Coast.⁴³ The preservation of forests with an adequate representation of trees of 40 or more inches in diameter is vital to both the lumber and plywood industries of this region.

The operation of Pacific Coast forests on a sustained-yield basis should encourage the use of sawmill waste and the cordwood-size byproducts of selective logging by pulp mills and thereby stimulate the growth of pulp-products industries. During the 1920's there was a pronounced growth in the proportion of pulp-mill raw-material requirements supplied from sawmill waste,⁴⁴ and byproducts of logging operations offer another source of supply for pulp mills. Further progress along this line should be

³⁹Kirkland, "Potentialities of the Forest Resource and Forest Industries of the South," p. 12.

⁴⁰*Lumber Industry Facts: 1938*, p. 44.

⁴¹Special report of the U. S. Dept. Agr., Forest Service, Div. Res. (Nov. 1, 1936), for the "Studies of Productivity and Employment in Selected Industries" section of the National Research Project.

⁴²*Ibid.*

⁴³The ready adaptability of plywood to unit construction methods and prefabrication emphasizes the importance of providing a sound basis for the plywood industry. Plywood, because of its adaptability to newer construction methods, might regain for wood some of the ground lost to competitive building materials (see *A National Plan for American Forestry*, II, 1367).

⁴⁴Letter from Herman M. Johnson of the U. S. Dept. Agr., Forest Service, Pacific Northwest Forest and Range Experiment Station, to the author, dated June 5, 1939.

stimulated by the assurance of a stable supply of such byproduct materials from operations producing on a sustained-yield basis.

In general, it may be noted that the labor employed per cubic foot of wood withdrawn from the forest may be profitably increased if the forest industries which use different portions of the tree are integrated. Under a program of joint utilization of the forest resource by such industries as lumber, pulp and paper, fuel wood, wood distillation, and wood specialties, the raw materials for each can be secured at a lower cost than would otherwise be necessary. A number of noteworthy examples of communities in which diversified industries complement one another in the use of the forest resource are to be found both in the South and on the Pacific Coast. The capital investments involved in creating such diversified forest industrial communities could be greatly stimulated by assuring a sustained yield from the local forests.

SUMMARY

The history of technical development in the industry shows that the type of mechanization has been determined by the economic objectives of the industry and by the conditions of the forest resource. Thus, at one stage, the emphasis was on reducing the production cost; at another, on logging and sawmill equipment capable of effecting rapid and complete liquidation of forest resources; and, in recent stages, on the application of flexible logging equipment and cost-reducing improvements in the sawmill. The rate and type of change in technique have also been conditioned in each stage by developments in science and technology generally.

The mechanization of the lumber industry was motivated until about 1850 by the need for converting with the least possible effort the timber which was found more or less at hand, in every important center, into useful building materials. During the last half of the nineteenth century the United States entered a period of rapid expansion, and vast timberlands were opened to easy acquisition. Timber speculation became prevalent and large blocks of valuable forest land rapidly passed into private control. The nature of new developments in production techniques was dictated by the intense-competitive drive for the rapid realization of timber values in order to proceed successfully to the acquisition of other holdings. Powerful donkey engines, extensive logging railroads, and large sawmills were products of this period.

With the rapid expansion of Pacific Coast lumbering activities after 1910, the industry reached the last frontier; further migration of the industry as an answer to timber depletion was barred. Since then the

industry has been forced to penetrate ever farther into the forests and to overcome ever greater obstacles in its search for suitable raw materials. The objective of technological change has been shifting from high output and complete liquidation to lowered production costs. This tendency has been noticeable since 1920 and particularly since 1929.

Changes in the sawmill since 1920 have been directed primarily toward the reduction of costs. Handling equipment capable of sharply improving labor productivity has been widely introduced, especially in Pacific Coast mills. There are indications that in an increasing number of cases reduction of handling-labor requirements in the period since 1929 has been accomplished through the adoption of such equipment as straddle-truck carriers, which are relatively less expensive than the more elaborate handling equipment which was popular during the twenties. Other changes included refinements in saws and planing-mill machinery, which contributed to increased speed of operation, and the shift to electric power, which contributed to the automatization of processes, increased speed of operation, and reduced power-generation and maintenance personnel.

The most important improvements in technique in recent years have taken place in logging, and the most important feature of these changes is that they permit a greater degree of selectivity in cutting. The lumber industry has been forced to turn, to an increasing extent, to less favorable stands of sparse or scattered timber, and this has encouraged the use and development of tractors, trucks, and light cable yarders. The same qualities of flexibility and mobility which make the new logging equipment preferable to heavy steam cable yarders and forest railroads also make its use preferable in logging systems involving the selective cutting of individual trees and groups of trees. Such selective logging is a prerequisite for the application of sustained-yield logging.

In the Pacific Coast States the substitution of tractors for cable yarders represents the most important of the technical steps leading to sustained-yield logging. Heavy steam cable logging equipment is poorly adapted to selective logging. The magnitude of investment charges for a single unit and the cost of moving and rigging at each location are such as to encourage a large output at each setting. The nature of the logging operation in sky-line and high-lead logging makes individual tree selection virtually impossible and group tree selection extremely difficult. Furthermore cable yarding, particularly high-lead and sky-line yarding, is generally more destructive of young growth and of the forest covering than any other system.

Tractors, equipped with logging arches and single-drum towing winches, are ideally adapted to either individual or group tree selection. United

States Forest Service studies in the Douglas-fir region indicated that logging with a modified individual and group tree-selection system employing tractors involved lower unit costs than did the traditional clear-cutting system employing cable yarders.⁴⁶

Trucks also play an important part in selective logging, serving as a supplement to the railroad and replacing much of the expensive spur-line construction formerly considered necessary. This reduces the magnitude of that portion of the investment which is to be liquidated immediately, and it thereby reduces the pressure for heavy initial cuts of the timber stand.

The application of the techniques of selective cutting is a necessary but not a sufficient condition for the realization of sustained-yield logging. To attain continuous production it is necessary that selection in cutting be made so as to maintain continuous replacements of the timber cut. Tractors are frequently employed in Pacific Coast Forests to remove almost all of the timber stand capable of yielding a profit, a procedure which leaves the forests in an unsatisfactory state. The full long-run value of the new logging techniques to the Pacific Coast forest industries can only be realized if those techniques are employed within the framework of a sustained-yield system designed to perpetuate the timber resources at their present level of magnitude, availability, and quality.

In the South the most important phase of recent technological advance is the introduction of trucks into the loading operations. Also important is the adoption of tractors and light, flexible, gasoline-powered cable yarders in bunching operations, although animals are principally employed in that phase of logging.

The importance of the adoption of trucks in southern logging operations is traceable to the fact that the southern industry is now operating on comparatively sparse stands. Railroad-construction costs are likely to be prohibitively high per unit of production in the logging of the relatively sparse second-growth stands, which constitute the bulk of the southern timber resource today, and in the logging of scattered stands. Trucks can be used profitably in making light cuts. The substitution of truck for railroad logging would frequently represent an essential step in the process of building up the forest resource by periodic selective cuttings of a small part of the stand. The substitution of tractors and light gasoline yarders for the heavy steam yarders formerly employed on the larger operations would also contribute to the efficiency

⁴⁶Axel J. F. Brandstrom, *Analysis of Logging Costs and Operating Methods in the Douglas Fir Region* (Forest Service of the U. S. Dept. Agr., West Coast Lumbermen's Association, and Charles Lathrop Pack Forestry Foundation, June 1933).

of sustained-yield logging. Thus the nature of recent technical developments in the South, as on the Pacific Coast, has been such as to stimulate the adoption of sustained-yield methods.

Whether or not timber depletion will continue at the same rate as in the past will depend largely on the extent to which the recently developed logging equipment is employed within the framework of an improved forest management. Historically, it is safe to say that profits in the lumber industry were made principally through speculation in timber resources. The emphasis in technological developments was accordingly placed on those machines and techniques which enabled the operator to achieve a rapid liquidation of timber resources. In terms of these objectives, clear-cut logging was naturally most desirable, for it effected in one cutting virtually a complete liquidation of the resource; when mechanized logging was developed, the machines were designed for clear-cutting. The cable logging engines, which reached their peak of development in the 1920's, were in their most advanced form suitable only for extensive clear-cut logging.

Recent developments in logging equipment have come in response to two factors: the decline in availability of timber and the decline in demand for timber products. These have made the rapid liquidation of timber resources a less desirable objective. The use of tractors and trucks in logging operations has come in response to the need for reducing costs or maintaining them at the same level in the face of greater obstacles. This reflects an increase in relative importance of operating efficiency compared with the volume of output. The history of the timber resource has been one of steadily declining reserves; its future will depend on the extent to which the new machines are employed in sustained-yield logging, to which they are well adapted.

If tractors and trucks are employed with the sole objective of lowering present operating costs, without regard for the future yields from the timber stand, the progressive depletion will continue. To the extent that the demand for timber continues to show a secular decline, timber depletion may be slowed down. Insofar as declining availability and quality of timber depress the demand for timber products, the slowing-down process might be accelerated. However, if tractors and trucks are applied to a system of sustained-yield logging, further timber depletion could be halted and some improvement made in the state of the forest resources. This would end periodic disruptions of employment opportunities due to timber depletion, open the way for reducing operating costs, help maintain a market for wood products by preserving quality, and have an important favorable effect on employment in other forest industries.

The state of the forest resource is one of a group of factors which include the level of labor productivity and the volume of demand; these factors are affected by technological developments and in turn determine the volume and stability of employment opportunities.

The available data indicate that labor productivity in the lumber and timber products industry tended to increase throughout the period 1919-36. The index of output per man-hour for the industry was 23 percent higher in the period 1931-36 than in the period 1919-24 (see table 27). This increase in the output per man-hour is ascribable primarily to the shift of an increasing proportion of the production to regions of relatively higher labor productivity and secondarily to increased output per man-hour in logging and milling in the Pacific Coast States.

If timber depletion is allowed to continue, the available evidence indicates that changes in the number of man-hours required to produce a thousand board feet of lumber of specified size and degree of finishing will not be an important factor in determining the volume of employment. On the one hand, large reductions in unit labor requirements through advances in mechanization will be rendered more difficult by the progressive increase in the obstacles to be overcome. On the other hand, an increase in unit labor requirements for rough lumber because of declining quality of available timber would not necessarily mean an increase in the amount of employment afforded by a given volume of production, for less finishing and refabricating labor would be used on lower-quality lumber.

The principal factor responsible for the secular decline in employment opportunities in the lumber industry has been the decline in the demand for its products. In large measure this has been due to changes outside the control of the industry, such as the use of competitive materials and the declining importance of agriculture in the economy.

On the other hand, it should be noted that the position of lumber in its competition with other materials was not improved by the depletion of the timber resources of some of the major consuming areas, a factor over which the individual operators in the industry might have exercised some measure of control.

Furthermore, while new manufacturing techniques and new uses resulting from industrial research have been steadily improving the position of materials competing with wood, the lumber industry has left the support of such research activity almost entirely to public bodies. The only forest industry in which research has received any significant amount of support from industry has been the pulp-products industry, which represents one of the few expanding uses for wood.

The central question regarding the relation of recent technological developments to the future of employment opportunities concerns the rate at which the techniques of improved forest management, directed toward assuring a continuing basis for the industry, are adopted. Unless technical developments take an unexpected turn, the particular types of machines developed in the near future and the rate at which they are introduced will be less significant for the level of employment opportunities than the extent to which machines of existing types are applied within the scope of a program designed to insure an uninterrupted flow of timber from highly productive forests.

Encouraging beginnings have been made in the adoption of sustained-yield forestry both on the Pacific Coast and in the South. However, the great majority of operators still follow a policy of rapid liquidation of the forest resource. Measures to stimulate the more rapid adoption of better forest-management practices appear to be of first importance in any effort to preserve and stabilize employment opportunities in the lumber and related forest industries.

APPENDIXES

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APPENDIX A

DESCRIPTION OF DATA FROM NRP-NBER LOGGING-CAMP AND SAWMILL SURVEY¹

In order to obtain data for a study of changes in the labor productivity of the lumber industry, the National Research Project, in cooperation with the National Bureau of Economic Research, made a field study in 1936 of 64 Pacific Coast and southern sawmills and 22 of the logging camps supplying these sawmills. In the case of each operation an attempt was made to secure year-by-year data on capacity, production, and the number of man-hours of employment. Where a break-down was possible, the man-hour data were obtained for separate departments. In addition, detailed information on changes in production techniques was obtained for a smaller number of plants, including data on the nature and the amount of equipment purchased, replaced, and retired and the effect of these changes on the absorption or displacement of labor.

The numbers of operations used in the various statistical analyses were smaller than the total number of plants surveyed because most records did not provide complete information over the period 1920-36, either because the operations were not working in all years or because their records were incomplete.

PACIFIC COAST LOGGING CAMPS

The 1936 survey covered 20 Pacific Coast logging camps. Seventeen of the camps were engaged principally in logging Douglas fir, usually together with hemlock and frequently with cedar and spruce. Three were engaged in logging ponderosa pine, and two of the three cut some other species. Thirteen of the 20 estimated their daily capacity at between 100 and 249 thousand board feet; 4, between 250 and 499 thousand board feet; and 3, at over 500 thousand board feet. Eleven of the camps were located in Washington, seven were in Oregon, one was in California, and

Note.- The appendixes were prepared by the author in collaboration with Julius H. Balick and William R. Gray.

¹Except as specified, the data included in this appendix were collected in a field survey conducted by the National Research Project in cooperation with the National Bureau of Economic Research as one in a series of "Studies of Productivity and Employment in Selected Industries" directed by Harry Jerome and William A. Neiswanger. For this study data were also available from a field survey conducted in 1928-29 by the National Bureau of Economic Research (see Harry Jerome, *Mechanization in Industry* [New York: National Bureau of Economic Research, 1934], p. 15). The basic statistical techniques employed in handling these field data were developed in the "Studies of Productivity and Employment in Selected Industries" section of the Project. Milton Gilbert conducted the study of the lumber industry.

one was in Montana.² All 20 supplied sawmills included in the Pacific Coast sawmill sample.

Table A-1 shows the percentage of the total lumber cut in the Pacific Coast States which was obtained from logs supplied by the 20 camps covered in the survey. The incompleteness of records, particularly in earlier years, made it impossible to include all camps in each year. Accordingly there is a steady growth in the percentage of total Pacific Coast production accounted for by these operations. As may be observed from an examination of table A-2, the sample was considerably more representative of the camps supplying the larger mills. In 1929 all of the camps surveyed were attached to mills which cut at least 25 million board feet in that year; 82.6 percent of the production of the camps surveyed was accounted for by camps attached to the largest mills, those which cut at least 50 million board feet. After 1929, therefore, the sample is reasonably adequate for the camps supplying large mills and particularly for the camps supplying the largest mills, which accounted for over half of the 1929 Pacific Coast lumber production.

In order that accurate figures for the logging operation might be obtained, the NRP-NBER data were collected in the form of logging man-hours and logging production in log-scale measure. Thus the fact that a company may sell some of its logs to other sawmills or purchase some of the logs used in its sawmill does not introduce any error into the logging-camp figures. Logging-camp production in log scale was converted to board measure (lumber scale) by the year-by-year overrun experience of the mills which the NRP-NBER camps supplied with logs. The overrun for a mill constitutes the difference, within a given time period, between the number of feet, log scale, supplied to the mill in log form and the output in feet, board measure, actually achieved. The higher the overrun of a given mill, the more lumber that mill is obtaining from the logs which it receives. The overrun varies with the precision of manufacture and the size of logs sawed. For camps for which the overrun experience was not available, the average of the overrun ratios for other camps was used.

All the labor time spent in the camp or in transporting logs to the mill has been included in the man-hour totals. These man-hours include such operations as felling and bucking, skidding, yarding, and loading, as well as transportation of logs to mill or tidewater and construction

²The Montana operation surveyed cut ponderosa pine and operated under conditions and with methods characteristic of the operations of the ponderosa-pine regions of Oregon and California. The Montana operation was therefore included in the sample and was treated as if it were located in one of the three Pacific Coast States.

and maintenance of logging roads or railroads. In short, all the labor time which appears on the logging pay-roll records is included. However, it was not possible to obtain a figure for all the transportation man-hours in cases where some of the work was done by independent booming companies or common carriers.

Table A-3 presents production, man-hours, and unit labor requirements for all camps for which data were available in each year of the 1920-35 period; data for two camps for which data are available in each year of the period are also given.

PACIFIC COAST SAWMILLS

The NRP-NBER survey covered 36 Pacific Coast sawmills in 1936. Nineteen of these mills and 17 others had been surveyed in 1928 and 1929 by the NBER.³ It proved impossible to obtain an adequate sample of small mills, and the surveys were accordingly limited to a sample of 53 large mills, each of which cut more than 15 million board feet in one of the years for which data for the respective mills were obtained. Data for 2 of the 53 mills were not adequate, and these mills were not included in the analyses.

Of the 51 mills in the sample, 47 were engaged principally in cutting Douglas fir and associated species; the other 4 produced lumber from ponderosa pine and associated species. Thirty-three of the mills were located in Washington, 15 in Oregon, 2 in California, and 1 in Montana.⁴

The sample shows a steady growth in coverage, from 9.5 percent of the total Pacific Coast production in 1919 to 27.4 percent in 1927. From 1927 to 1929 the coverage of the sample declined sharply because a large number of the mills included in the sample for 1927 were surveyed by the NBER in 1928 and at the time of the resurvey (in 1936) 17 of the mills were out of existence or could not cooperate. The coverage since 1929 is relatively stable at a 20-percent level (table A-4).

The analysis of the change in unit labor requirements is confined to the experience of the large mills, and for this group of mills the sample is considerably more adequate than figures on the percentage of total production would indicate. This is shown in table A-5 by an analysis of census data for 1929, the only year in the period covered for which

³An effort was made to resurvey all 36 sawmills surveyed in 1928-29, but 17 of the mills were no longer operating or could not cooperate. The combination of mills covered in the two surveys into one sample did not have a distorting effect, however, for the 19 mills covered in both surveys and the 17 covered in the second survey showed similar movements of unit labor requirements (see table A-6, fn. d).

⁴See fn. 2 of this appendix.

production figures are available classified according to the size of the reporting mill.

In 1929 the sample included only 2.5 percent of the total number of mills in the Pacific Coast States. However, the production of mills included in the survey represented 17.2 percent of the total production of the Pacific Coast States. About 27 percent of the total production of mills which cut over 50 million board feet in 1929 was accounted for by the mills included in the sample; about 20 percent of the production of Pacific Coast mills which cut over 15 million board feet in 1929 was cut by sample mills. None of the 1,061 Pacific Coast mills which cut less than 15 million board feet in 1929 were surveyed. The sample, then, is reasonably adequate for mills which cut more than 15 million board feet, but it is most representative of the largest mills. Sample mills in the latter group produced 84 percent of the lumber sawed by sample mills.

Table A-6 presents chain indexes of man-hours, equivalent production,⁵ and man-hour requirements per unit of equivalent production for sample mills. The man-hour and equivalent-production indexes were computed on the basis of percentage changes from year to year of aggregates for all mills which reported in each of two consecutive years. The unit-labor-requirement index was computed from the man-hour and equivalent-production indexes. The figures are for 1918-35.

Table A-7 presents two additional indexes of labor requirements per unit of equivalent production. One represents a weighted average for all mills for which data were available for the respective years. The other represents an index of the medians of the ratios for individual sample mills. The table shows, in addition, the lowest and highest individual mill ratios for each of the years. The period covered is 1918-35.

Unit labor requirements, percentages of capacity utilized, and aggregate capacities⁶ are presented in table A-8 for two groups of identical mills. The figures for a group of 11 mills cover the period 1920-35; the figures for a group of 18 mills (including the 11 mills in the first group) cover the period 1926-35.

SOUTHERN SAWMILLS

The NRP-NBER survey covered 28 mills in Alabama, Louisiana, Mississippi, South Carolina, and Texas. Because of the inadequacy of available records, it proved impossible to sample small mills adequately. The sample

⁵For method of computing equivalent production see pp. 146-9.

⁶See table A-8, ftms. a and b.

was accordingly limited to large mills believed to have a daily capacity of more than 40 thousand board feet; the four smaller mills were eliminated from the analysis, as was another mill for which data were inadequate.⁷

The percentage of the total southern production accounted for by sample mills is shown in table A-9. Coverage ranges from 3.8 to 7.0 percent in the census years from 1927 to 1935. Small mills are quite important in the South, and the sample covers a much greater proportion of the production of large southern mills, for which the sample is reasonably adequate.

Table A-10 shows the relation between the production of sample mills and total southern production, by size groups. With one exception the sample mills cut more than 10 million board feet in 1929; over half of the sample mills cut more than 25 million board feet in that year. These size classes contained less than 3 percent and less than 1 percent, respectively, of the total number of southern mills in 1929. The sample was reasonably adequate, however, for the group of mills which cut more than 25 million board feet in 1929. NRP-NBER mills accounted for 19.8 percent of the production of mills which cut at least 50 million board feet and 12.6 percent of the production of mills which cut 25 to 50 million board feet in 1929. The entire NRP-NBER sample accounted for 8.6 percent of the production of all southern mills which cut more than 10 million board feet in that year.

Table A-11 presents chain indexes, derived as in the case of the Pacific Coast sample, of man-hours, equivalent production, and man-hour requirements per unit of equivalent production for the period 1926-35. Table A-12 presents an index of weighted average labor requirements per unit of equivalent production for all sample mills for which data were available in the respective years, an index of the medians of the ratios for individual mills, and the range of the ratios for each year. The period covered by this table is 1926-35. Unit labor requirements, percentages of capacity utilized, aggregate capacities, and aggregate equivalent production are presented in table A-13 for a group of 12 mills for 1926-35.

Data on production, man-hours, and unit labor requirements were obtained for 1927-35 for two logging camps supplying two of the southern sawmills included in the sample. These data are presented in table A-14.

⁷Of the 23 mills retained in the sample, 20 had a practicably obtainable capacity of at least 12 million board feet; the other 3 had capacities which were in excess of 11.6 million board feet. On the basis of 300 working days per year, these yearly figures can be reduced to daily figures of at least 59 thousand board feet. It is believed that daily capacity figures obtained in this fashion are considerably lower than figures for daily rated capacity; mills included in the NRP-NBER survey are therefore considered to fall within the category of mills having a daily rated capacity of more than 40 thousand board feet. Twelve of the 23 mills [Con.]

BASIS OF SELECTION OF MILLS FOR STUDY

Sawmills and attached planing mills commonly manufacture a variety of products, such as timbers,⁸ rough lumber, surfaced lumber, doors, sashes, molding, lath, boxes, and shingles. These products require a varying quantity of labor time for their manufacture, and it was believed that differences in the relative output of such products might impair comparisons between mills and between years. Accordingly, mills included in the field survey were those which manufactured a relatively small variety of products.

In a further effort to obtain a fairly uniform sample, only sawmills which had planing mills attached were surveyed.⁹

Sizes of lumber may also vary considerably, and each size requires a different amount of labor per board foot. Thus the mills studied were those which produced the general run of sizes common to the industry of the particular section of the country. Because it is possible to cut a greater proportion of timbers from the large trees on the Pacific Coast than from the smaller logs available to southern mills, there is an important difference in lumber sizes produced by sample mills of the two areas.

COMPOSITION OF PRODUCTION AND MAN-HOUR DATA

A number of the mills studied produced byproducts (such as hogged fuel, briquets, and sawdust) and special products (such as lath, shingles, and boxes). Such products and the labor time expended in their production were, on the whole, excluded from the production and man-hour data presented in this report. Man-hours expended in auxiliary services not common to all mills, such as new construction, company stores, retailing, and local delivery by truck, were also excluded. It was not possible in every case, however, to separate and exclude completely the various by-product, special-product, and auxiliary-service items; this is especially true of indirect labor, such as handling, which could not be allocated to production and surfacing of lumber on the one hand and to waste utilization, byproduct manufacture, and the production of minor forest products on the other. Kiln-drying labor, used in some mills but not in others, was included in the data presented.

⁷[Com.] had practicably obtainable annual capacities of more than 24 million board feet. The largest mill included in the sample had a daily practicably obtainable capacity of 305 thousand board feet. (For method of determining practicably obtainable capacity of sample mills see pp. 149-50.)

⁸Timbers are lengths of wood whose smallest diameter is at least 5 inches.

⁹One of the Pacific Coast mills studied did some surfacing but did not have a complete planing mill attached.

Unadjusted production figures represent aggregates of surfaced and un-surfaced lumber produced. The man-hour figures are aggregates of the labor time expended in the pond, the sawmill, the dry kiln, the yard, the planing mill, shipping, power production, maintenance, and other work directly or indirectly connected with lumber production, rough and surfaced.

DERIVATION OF EQUIVALENT PRODUCTION

The operation of a planing mill increases labor requirements without increasing footage produced. Although only sawmills with attached planing mills were surveyed, changes in unit labor requirements of an individual mill or a group of mills may reflect changes in the proportion of the output which is surfaced as well as changing efficiency in the utilization of labor. Differences in unit labor requirements may similarly reflect differences in the proportion of the output which is surfaced.

Unfortunately the data were not sufficiently adequate to permit presentation of separate unit-labor-requirement series for the manufacture of rough and surfaced lumber. An effort was therefore made to adjust the production series in such a fashion that, when divided into the man-hour series, it would yield a series of man-hour ratios which would not be appreciably influenced by shifts or differences in percentage of total output surfaced. The adjusted production is referred to as "equivalent" production.

Planing-mill outputs in each year were multiplied by average ratios of unit labor requirements in planing mills to unit labor requirements in sawmills. The resulting figures (representing theoretically the amount of additional lumber which would have been cut had man-hours expended in the planing mill been expended instead in the sawmill) were added to the sawmill production of the respective mills in order to obtain each mill's equivalent production. Thus the equivalent-production figures exceed the figures for actual production; they represent both rough and surfaced output in terms of rough output.

Ratios used to convert surfaced production to rough production are presented in table A-15. They were computed from reports for mills for which separate planing-mill and sawmill data were available. Separate ratios were computed for Pacific Coast mills, southern pine mills, and southern hardwood mills. Except for the latter group of mills, each of which had a practicably obtainable capacity of less than 50 million board feet, separate ratios were also computed for mills whose practicably obtainable annual capacity was under or over 50 million board feet. Thus

ratios were computed for five distinct groups of mills. For each group ratios were computed for the period preceding 1930 and for the period 1930-35. Each of the ratios shown in table A-15 represents an average of selected ratios for individual mills and years.¹⁰

Examination of table A-15 reveals that the ratios for each area are, in general, similar. For three of the five groups of mills the ratios for 1929 and earlier years were identical with those for 1930-35. In the remaining two cases the proportion of surfaced production added to total rough production rose from 20 to 25 and from 23 to 30 percent. In view of the facts (1) that the production of not all mills in either area was adjusted by ratios which changed over time and (2) that only part of the rough production of the mills was surfaced, the distorting influences on equivalent production exerted by changes in the ratios are believed to be negligible.

DERIVATION OF PRACTICABLY OBTAINABLE CAPACITY

Practicably obtainable capacity was computed for individual logging camps and sawmills on the basis of attained production peaks and normal interruptions of production. The production peak attained for any 3-month period was quadrupled to yield hypothetical annual obtainable capacity under conditions of continuous peak production. This estimate was then adjusted downward in order to take into account necessary shut-downs occasioned by weather or repairs. The adjustment was based on the season during which the 3-month peak occurred and on information obtained from officials and engineers of the operations surveyed.

Where only annual production figures were available, the highest annual figure was inflated to yield practicably obtainable capacity. Annual peaks were multiplied by the median ratio, as observed for operations in the same area for which monthly production data were available, of practicably obtainable capacity to peak annual production.

In some cases further adjustment was made necessary because of known changes in the length of the working day, in the number of shifts per day, and in major equipment items. In other cases further adjustment was made to take into account several discernible production peaks or definite trends in production, either of which might indicate changes in obtainable capacity.

¹⁰Ratios were computed annually for individual mills in each of the five groups of mills. These ratios were then separated according to the period to which they referred. The ratios in each of the 10 groups of ratios were arrayed in order of magnitude, and those occupying a central position in each array were combined into an unweighted average (these averages are shown in table A-15). The number of ratios selected for use in computing the average varied from 3 to 8, depending upon the total number of ratios in the group.

It should be noted that factors other than size of operation may lead to differences in practicably obtainable capacity. For instance, different mills may have working days of different duration, and this would be reflected in the annual practicably obtainable capacities. Particularly, the working day in the South was normally somewhat longer than that on the Pacific Coast.

Table A-1.- TOTAL AND SAMPLE PRODUCTION OF PACIFIC COAST LOGGING CAMPS, 1925-35

Year	Thousands of board feet		Sample as percent of total Pacific Coast
	Total Pacific Coast ^a	Sample ^b	
1925	13,286,699 ^c	417,175	3.1
1927	13,389,525 ^c	684,759	5.1
1929	14,149,301 ^c	1,181,015	8.3
1931	7,493,772	882,731	11.8
1933	6,146,749	958,447	15.6
1935	7,953,477 ^c	887,290	11.2

^aData for 1925-29 from *Fifteenth Census of the United States: 1930, "Manufactures: 1929"* (U. S. Dept. Com., Bur. Census, 1933), II, 447; data for 1931 from *Census of Manufactures: 1931* (U. S. Dept. Com., Bur. Census, 1935), p. 429; data for 1933-35 from same, 1935 (1936), p. 474. Data are for California, Oregon, and Washington, and include only mills producing 50 M ft. b. m. or more.

^bConverted from log scale to board measure. See p. 143.

^cIncludes data for Nevada because output for California and Nevada was reported together. The effect of the inclusion of Nevada is negligible, however, for in 1919, the only year for which separate production data were reported for Nevada, the output of Nevada was only 0.2 percent of the total output of California, Oregon, and Washington.

Table A-2.- TOTAL AND SAMPLE PRODUCTION OF PACIFIC COAST LOGGING CAMPS, BY VOLUME OF PRODUCTION, 1929

Volume of production ^a (M ft. b. m.)	Total Pacific Coast ^b		Sample	
	Production (M ft. b. m.)	Percent	Production (M ft. b. m.)	Percent of total Pacific Coast
Total	14,149,301	100.0	1,181,015	8.3
50-24,999	3,230,747	22.8	0	0
25,000-49,999	3,378,738	23.9	205,688	6.1
50,000 or over	7,539,816	53.3	975,347	12.9

^aOutput of the sawmill to which the logging camp is attached.

^bData from *Fifteenth Census of the United States: 1930, "Manufactures: 1929"* (U. S. Dept. Com., Bur. Census, 1933), II, 448. Data are for California, Nevada, Oregon, and Washington. See table A-1, fn. c.

Table A-3.- PRODUCTION, MAN-HOURS, AND UNIT LABOR REQUIREMENT RATIOS IN SAMPLE PACIFIC COAST LOGGING CAMPS, 1920-35^a

Period	All reporting camps				Two identical camps		
	Number of camps	Production (M ft. b. m., lumber scale)	Man-hours		Production (M ft. b. m., lumber scale)	Man-hours	
			Number	Per M ft. b. m.		Number	Per M ft. b. m.
1920	2	131,113	1,165,448	8.89	131,113	1,165,448	8.89
1921	2	30,353	176,554	5.88	30,353	176,554	5.88
1922	2	122,973	1,097,710	8.93	122,973	1,097,710	8.93
1923	3	117,037	940,538 ^a	8.04 ^a	87,872	699,434 ^a	7.96 ^a
1924	3	179,823	1,412,734	7.86	153,146	1,246,849	8.14
1925	8	417,176	3,046,533	7.30	158,146	1,118,413	7.07
1926	9	504,670	3,063,142	6.07	147,226	996,576	6.77
1927	10	684,759	3,664,650	5.35	153,292	919,756	6.00
1928	13	893,818	5,386,358	6.03	163,034	1,115,384	6.84
1929	16	1,181,016	7,221,313	6.11	161,649	1,052,662	6.51
1930	18	1,267,466	7,019,603	5.54	112,227	686,196	6.11
1931	18	882,731	4,166,374	4.72	53,235	208,299	3.91
1932	15	560,255	2,627,298	4.69	36,084	198,340	5.50
1933	17	956,447	4,376,115	4.58	90,622	527,399	5.82
1934	16	902,592	4,430,051	4.91	76,427	349,023	4.57
1935	15	887,290	4,385,924	4.94	116,012	594,623	5.13
1920-23	-	401,476	3,382,260	8.42	372,311	3,141,146	8.44
1924-26	-	1,101,668	7,522,409	6.83	458,518	3,361,838	7.33
1927-29	-	2,759,592	16,274,321	5.90	477,975	3,087,802	6.46
1930-32	-	2,710,462	13,812,275	5.10	201,546	1,092,835	5.42
1933-35	-	2,746,329	13,194,090	4.80	283,061	1,471,044	5.20
Percentage decrease							
1920-23 to 1924-26	-	-	-	18.9	-	-	13.2
1924-26 to 1927-29	-	-	-	13.6	-	-	11.9
1927-29 to 1930-32	-	-	-	13.6	-	-	16.1
1930-32 to 1933-35	-	-	-	5.9	-	-	4.1

^aAt one of the camps a large proportion of the working time was spent in new construction. Since this would seriously distort the trend of man-hours and unit labor

requirements, the number of man-hours spent in construction at this camp was estimated and subtracted from the total number of man-hours. See ch. III, fn. 23.

Table A-4.- TOTAL AND SAMPLE PRODUCTION OF PACIFIC COAST
SAWMILLS, 1919-35

Year	Thousands of board feet		Sample as percent of total Pacific Coast
	Total Pacific Coast ^a	Sample	
1919	8,796,504	832,295	9.5
1921	7,204,457	988,074	13.7
1923	12,761,833 ^b	2,083,015	16.3
1925	13,286,899 ^b	2,726,757	20.5
1927	13,389,525 ^b	3,668,710	27.4
1929	14,149,301 ^b	2,435,426	17.2
1931	7,493,772	1,583,979	21.1
1933	6,146,749	1,337,719	21.8
1935	7,953,477 ^b	1,543,791	19.4

^aData for 1919 from *Fourteenth Census of the United States: 1920*, Vol. X, "Manufactures: 1919" (U. S. Dept. Com., Bur. Census, 1923), p. 437; data for 1921-23 from *Census of Manufactures: 1923* (U. S. Dept. Com., Bur. Census, 1926), p. 449; for source of data for 1925-35 see table A-1, ft. a. Data are for California, Oregon, and Washington, and except for 1921 include only mills producing 50 M ft. b. m. or more.

^bSee table A-1, ft. c.

**Table A-5.- TOTAL AND SAMPLE NUMBER OF PACIFIC COAST SAWMILLS AND THEIR PRODUCTION,
BY VOLUME OF PRODUCTION, 1929**

Volume of production (M ft. b. m.)	Total Pacific Coast ^a				Sample					
	Mills		Production		Mills			Production		
	Number	Percent	M ft. b. m.	Percent	Number	Percent	Percent of total Pacific Coast	M ft. b. m.	Percent	Percent of total Pacific Coast
Total	1,307	100.0	14,149,301	100.0	33	100.0	2.5	2,435,428	100.0	17.2
50-14,999	1,061	81.2	2,031,951	14.3	0	0	0	0	0	0
15,000-24,999	61	4.7	1,198,798	8.5	4	12.1	6.6	82,826	3.4	6.9
25,000-49,999	93	7.1	3,378,738	23.9	8	24.3	8.6	299,471	12.3	8.9
50,000 or over	92	7.0	7,539,816	53.3	21	63.6	22.9	2,053,129	84.3	27.2
50-14,999	1,061	81.2	2,031,951	14.3	0	0	0	0	0	0
15,000 or over	246	18.8	12,117,350	85.7	33	100.0	13.4	2,435,428	100.0	20.1

^aSee table A-2, fn. b.

Table A-6.- CHAIN AGGREGATIVE INDEXES OF MAN-HOURS, EQUIVALENT PRODUCTION, AND UNIT LABOR REQUIREMENTS
IN SAMPLE PACIFIC COAST SAWMILLS, 1917-35

Year	Number of mills	Given year		Preceding year		Link relative ^a		Chain index (1929=100)		
		Man-hours	Equivalent production (millions of board feet)	Man-hours	Equivalent production (millions of board feet)	Man-hours	Equivalent production	Man-hours ^b	Equivalent production ^c	Unit labor requirements ^d
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1917	-	-	-	-	-	-	-	80.8	55.3	108.9
1918	7	4,221,110	356.0	4,580,294	434.4	0.922	0.820	56.0	45.3	123.6
1919	12	7,945,333	725.9	6,675,623	592.5	1.190	1.225	66.7	55.6	120.0
1920	15	9,880,900	904.2	9,754,204	923.1	1.019	0.980	87.5	54.5	123.9
1921	21	10,292,860	1,012.0	14,279,861	1,292.2	0.721	0.783	48.7	42.6	114.3
1922	24	16,005,799	1,656.6	11,092,835	1,110.2	1.443	1.492	70.3	63.6	110.5
1923	29	21,201,061	2,203.3	16,804,851	1,950.3	1.127	1.130	79.2	71.9	110.2
1924	33	22,620,932	2,511.7	22,371,266	2,326.6	1.011	1.079	80.1	77.6	103.2
1925	37	29,054,235	3,053.6	24,885,614	2,665.5	1.167	1.146	93.4	88.9	105.1
1926	39	31,707,480	3,486.6	29,409,345	3,097.9	1.078	1.125	100.7	100.0	100.7
1927	40	33,399,645	3,695.3	32,806,957	3,619.4	1.018	1.021	102.6	102.1	100.5
1928	42	32,312,898	3,660.6	33,853,231	3,876.9	0.969	0.998	99.4	101.7	97.7
1929	29	19,140,215	2,421.9	19,026,931	2,463.8	1.006	0.933	100.0	100.0	100.0
1930	33	19,609,893	2,516.7	21,369,201	2,773.6	0.918	0.907	91.8	90.7	101.2
1931	33	14,497,108	1,911.9	19,687,126	2,506.7	0.736	0.763	87.5	69.2	97.5
1932	27	9,310,760	1,124.4	13,675,976	1,809.7	0.691	0.621	46.0	43.0	107.0
1933	27	11,478,468	1,538.1	9,310,760	1,124.4	1.233	1.368	56.7	58.6	96.4
1934	31	12,294,650	1,598.6	11,978,678	1,607.6	1.026	0.988	58.2	58.1	100.2
1935	29	13,708,938	1,844.4	11,642,502	1,535.1	1.177	1.201	66.4	69.7	98.1

^aCols. (2) and (3) respectively divided by cols. (4) and (5).

^bComputed from col. (6).

^cComputed from col. (7).

^dCol. (8) divided by col. (9), and multiplied by 100. Similar indexes for 1928-35 for the group of 19 mills included in both surveys and the group of

17 mills included only in the 1936 survey are as follows (1929=100):

Year	All mills	19 mills	17 mills	Year	All mills	19 mills	17 mills
1928	87.7	97.9	97.6	1932	107.0	107.1	106.7
1929	100.0	100.0	100.0	1933	98.4	99.8	93.8
1930	101.2	103.8	98.1	1934	100.2	102.3	98.1
1931	97.5	97.8	97.9	1935	98.1	94.3	102.6

Table A-7.- INDEXES OF AVERAGE AND MEDIAN UNIT LABOR REQUIREMENTS IN SAMPLE PACIFIC COAST SAWMILLS, 1918-35

Year	Number of mills	Number of man-hours	Equivalent production (millions of board feet)	Man-hours required per thousand board feet of equivalent production			Indexes of unit labor requirements (1929=100)	
				All mills, weighted mean ^a	Individual mills		Weighted mean ^b	Median ^c
					Range	Median		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
1918	13	7,424,679	670.2	11.08	7.21-19.74	9.62	143.9	125.6
1919	15	9,754,204	923.1	10.57	6.29-21.07	9.66	137.3	126.1
1920	21	14,279,661	1,292.2	11.05	6.28-16.69	10.38	143.5	135.5
1921	24	11,092,835	1,110.2	9.99	5.35-24.66	9.59	129.7	125.2
1922	29	16,804,651	1,950.3	9.64	5.67-13.35	9.40	125.2	122.7
1923	33	22,371,266	2,326.8	9.61	5.54-16.53	10.33	124.8	134.9
1924	37	24,866,614	2,665.5	9.34	4.21-23.97	8.86	121.3	115.7
1925	39	29,409,345	3,097.9	9.49	4.02-19.99	8.47	123.2	110.6
1926	41	33,175,262	3,655.4	9.08	4.59-15.12	7.99	117.9	104.3
1927	44	36,795,105	4,159.2	8.85	4.62-14.75	7.40	114.9	96.6
1928	44	33,003,962	3,957.5	8.34	3.58-14.94	6.81	108.3	88.9
1929	33	21,369,201	2,773.6	7.70	4.48-13.15	7.66	100.0	100.0
1930	35	20,023,445	2,560.3	7.82	4.48-12.06	6.00	101.6	104.4
1931	33	14,497,108	1,911.9	7.58	4.50-11.93	7.98	98.4	104.2
1932	27	9,310,760	1,124.4	8.28	3.90-16.39	7.87	107.5	102.7
1933	31	11,978,678	1,607.8	7.45	3.90-13.54	7.39	96.8	95.5
1934	32	12,561,715	1,626.6	7.72	3.89-12.11	7.55	100.3	98.6
1935	29	13,708,938	1,844.4	7.43	3.85-16.84	6.97	95.5	89.7

^aNumber of man-hours divided by equivalent production.

^bComputed from col. (4).

^cComputed from col. (6).

Table A-8.- UNIT LABOR REQUIREMENTS, PERCENTAGES OF CAPACITY UTILIZED, AND AGGREGATE CAPACITY OF IDENTICAL SAMPLE PACIFIC COAST SAWMILLS, 1920-35

Year	Weighted average of man-hours required per M ft. b. m.		Percentage of capacity utilized ^a		Aggregate annual capacity ^b (millions of feet, b. m.)	
	11 plants	18 plants	11 plants	18 plants	11 plants	18 plants
1920	10.34	n. a.	64.5	n. a.	808	n. a.
1921	9.87	n. a.	46.0	n. a.	828	n. a.
1922	9.95	n. a.	69.3	n. a.	916	n. a.
1923	9.85	n. a.	76.3	n. a.	937	n. a.
1924	9.27	n. a.	70.1	n. a.	977	n. a.
1925	9.09	n. a.	68.8	n. a.	991	n. a.
1926	8.57	8.52	74.1	79.9	1,005	1,711
1927	8.18	8.21	78.0	82.2	1,017	1,725
1928	8.14	7.77	78.7	81.7	1,030	1,739
1929	8.16	7.93	76.1	79.4	1,043	1,753
1930	8.35	8.14	65.3	70.3	1,043	1,693
1931	8.04	7.78	48.6	56.7	1,043	1,693
1932	9.41	8.45	27.3	31.2	1,043	1,697
1933	8.24	7.99	41.1	42.6	1,043	1,697
1934	8.64	8.04	38.2	42.9	1,043	1,697
1935	8.24	7.60	46.9	53.2	1,043	1,697

^aBased on equivalent production and aggregate capacity. See pp. 148-9 and pp. 149-50.

^bPractically obtainable capacity. See pp. 148-9.

n. a. Data not available.

Table A-9.- TOTAL AND SAMPLE PRODUCTION OF SOUTHERN SAWMILLS, 1927-35

Year	Thousands of board feet		Sample as percent of total South
	Total South ^a	Sample	
1927	14,475,897	547,559	3.8
1929	15,462,485	628,637	4.1
1931	5,983,762	421,547	7.0
1933	5,765,491	363,606	6.3
1935	7,828,572	417,910	5.3

^aData for 1927-29 from *Fifteenth Census of the United States: 1930, Manufactures: 1929* (U. S. Dept. Com., Bur. Census, 1933), II, 447; data for 1931 from *Census of Manufactures: 1931* (U. S. Dept. Com., Bur. Census, 1935), p. 429; data for 1933-35 from same, 1935 (1938), p. 474. Data are for Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Texas, and Virginia, and include only mills producing 50 M ft. b. m. or more.

Table A-10.- TOTAL AND SAMPLE NUMBER OF SOUTHERN SAWMILLS AND THEIR PRODUCTION, BY VOLUME OF PRODUCTION, 1929

Volume of production (M ft. b. m.)	Total South ^a				Sample					
	Mills		Production		Mills			Production		
	Number	Percent	M ft. b. m.	Percent	Number	Percent	Percent of total South	M ft. b. m.	Percent	Percent of total South
Total	11,046	100.0	15,482,485	100.0	22	100.0	0.2	828,637	100.0	4.1
50- 9,999	10,728	97.1	8,178,974 ^b	52.9	0	0	0	0	0	0
10,000-14,999 ^c	118 ^b	1.1	1,442,083 ^d	9.3	7	31.8	6.0	77,897	12.4	5.4
15,000-24,999	102 ^d	0.9	2,110,165 ^e	13.6	3	13.7	2.9	52,246	8.3	2.5
25,000-49,999	90 ^e	0.8	3,331,845 ^f	21.6	11	50.0	12.2	419,802	66.7	12.6
50,000 or over	10 ^f	0.1	399,418	2.6	1	4.5	10.0	79,092	12.6	19.8
50- 9,999	10,728	97.1	8,178,974	52.9	0	0	0	0	0	0
10,000 or over	318	2.9	7,283,511	47.1	22	100.0	6.9	828,637	100.0	6.6

^aData from *Fifteenth Census of the United States: 1930, "Manufactures: 1929"* (U. S. Dept. Com., Bur. Census, 1933), II, 448. For States included see Table A-9, fn. a.

^bProduction data for 1 of the 118 mills producing 10,000-14,999 M ft. b. m. are included with production data for mills producing 50-9,999 M ft. b. m.

^cSample data include one mill with an output of 9,500-10,000 M ft. b. m.

^dProduction data for 2 of the 102 mills producing 15,000-24,999

M ft. b. m. are included with production data for mills producing 10,000-14,999 M ft. b. m.

^eProduction data for 5 of the 90 mills producing 25,000-49,999 M ft. b. m. are included with production data for mills producing 15,000-24,999 M ft. b. m.

^fProduction data for 4 of the 10 mills producing 50,000 M ft. b. m. or over are included with production data for mills producing 25,000-49,999 M ft. b. m.

Table A-11.-- CHAIN AGGREGATIVE INDEXES OF MAN-HOURS, EQUIVALENT PRODUCTION, AND UNIT LABOR REQUIREMENTS
IN SAMPLE SOUTHERN SAWMILLS, 1925-35^a

Year	Number of mills	Given year		Preceding year		Link relative ^b		Chain index (1929=100)		
		Man-hours	Equivalent production (millions of board feet)	Man-hours	Equivalent production (millions of board feet)	Man-hours	Equivalent production	Man-hours ^c	Equivalent production ^d	Unit labor requirements ^e
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1925	-	-	-	-	-	-	-	97.4	100.6	96.8
1926	10	7,039,129	452.7	6,979,318	454.6	1.009	0.998	98.2	100.2	98.0
1927	14	9,335,825	572.1	8,934,570	536.9	1.045	1.066	102.6	106.8	96.1
1928	17	10,202,213	592.2	10,583,951	654.5	0.964	0.905	98.9	96.7	102.3
1929	21	12,012,694	740.1	11,894,654	715.8	1.011	1.034	100.0	100.0	100.0
1930	22	10,399,636	677.0	12,461,294	765.1	0.835	0.985	83.5	88.5	94.4
1931	22	8,238,180	499.2	10,399,636	677.0	0.792	0.737	66.2	65.3	101.4
1932	23	6,743,470	415.3	8,430,446	520.8	0.800	0.798	53.0	52.1	101.7
1933	22	6,681,144	449.8	6,166,694	393.2	1.083	1.144	57.4	59.7	96.1
1934	22	5,800,104	364.9	6,691,144	449.8	0.869	0.811	49.8	48.4	102.9
1935	21	6,450,106	530.4	6,291,264	371.6	1.343	1.427	65.8	69.0	96.8

^aOne of the mills covered in this table cut 9,500-10,000 M ft. b. m. in 1929; the others cut at least 10,000 M ft. b. m. in that year.

^bCols. (2) and (3) respectively divided by cols. (4) and (5).

^cComputed from col. (6).

^dComputed from col. (7).

^eCol. (8) divided by col. (9), and multiplied by 100.

Table A-12.- INDEXES OF AVERAGE AND MEDIAN UNIT LABOR REQUIREMENTS IN SAMPLE SOUTHERN SAWMILLS,
1926-35

Year	Number of mills	Number of man-hours	Equivalent production (millions of board feet)	Man-hours required per thousand board feet of equivalent production			Indexes of unit labor requirements (1929=100)	
				All mills, weighted mean ^a	Individual mills		Weighted mean ^b	Median ^c
					Range	Median		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1926	14	8,934,570	536.9	16.84	12.85-54.40	16.27	102.1	104.5
1927	17	10,583,951	654.5	16.17	12.78-22.59	16.87	99.3	108.3
1928	21	11,884,654	715.8	16.80	10.40-29.77	14.73	101.9	94.8
1929	22	12,461,294	765.1	16.29	11.46-28.19	15.57	100.0	100.0
1930	22	10,399,636	677.0	15.36	12.54-22.68	15.63	94.3	100.4
1931	23	8,430,446	520.3	16.20	9.11-24.95	16.52	99.4	106.1
1932	23	6,743,470	415.3	16.24	9.82-37.95	17.95	99.7	115.3
1933	22	6,681,144	449.8	14.85	7.73-23.45	16.48	91.2	105.8
1934	23	6,647,283	387.8	17.14	7.89-36.99	17.64	105.2	113.3
1935	21	8,450,106	530.4	15.93	7.65-29.04	16.01	97.6	102.8

^aNumber of man-hours divided by equivalent production.

^bComputed from col. (4).

^cComputed from col. (6).

Table A-13.- UNIT LABOR REQUIREMENTS, PERCENTAGE OF CAPACITY UTILIZED, AGGREGATE CAPACITY, AND AGGREGATE PRODUCTION OF 12 SAMPLE SOUTHERN SAWMILLS, 1926-35

Year	Weighted average of man-hours required per M ft. b. m.	Percentage of capacity utilized ^a	Aggregate annual capacity ^b (millions of feet, b. m.)	Aggregate annual equivalent production ^c (millions of feet, b. m.)
1926	15.34	87.4	459	401
1927	16.00	86.1	459	395
1928	16.84	72.8	449	327
1929	15.99	81.5	449	366
1930	15.02	71.0	449	319
1931	16.97	52.1	449	234
1932	16.35	47.0	449	211
1933	15.59	50.8	449	228
1934	16.71	39.9	449	179
1935	15.73	55.5	449	249

^aBased on equivalent production and aggregate capacity. See pp. 148-9 and 149-50.

^bPractically obtainable capacity. See pp. 149-50.

^cSee pp. 148-9.

Table A-14.- PRODUCTION, MAN-HOURS, AND UNIT LABOR REQUIREMENTS OF TWO SAMPLE SOUTHERN LOGGING CAMPS, 1927-35^a

Period	Production (M ft. b. m., lumber scale)	Man-hours	
		Number	Per M ft. b. m.
1927	27,445	394,176	14.36
1928	24,428	364,816	14.93
1929	22,217	370,026	16.66
1930	23,658	315,152	13.32
1931	20,977	267,456	12.75
1932	16,418	265,393	14.41
1933	17,523	248,861	14.20
1934	11,824	149,891	12.69
1935	20,068	261,614	13.04
1927-29	74,090	1,129,020	15.24
1930-32	69,053	848,001	13.45
1933-35	49,415	660,366	13.36
Percentage decrease			
1927-29 to 1930-32	-	-	11.7
1930-32 to 1933-35	-	-	0.7
1927-29 to 1933-35	-	-	12.3

^aOne of these camps supplied a mill whose practically obtainable capacity was 12 million board feet per year; the other, a mill whose practically obtainable capacity was 21 million board feet per year. Both camps cut yellow pine principally.

Table A-15.- RATIO OF PLANING-MILL TO SAWMILL UNIT LABOR REQUIREMENTS OF SAMPLE SAWMILLS, BY REGION, MILL CAPACITY, AND PERIOD^a

Period	Pacific Coast mills		Southern pine mills		Southern hardwood mills, less than 50 million board feet
	Less than 50 million board feet	50 million or more board feet	Less than 50 million board feet	50 million or more board feet	
Number of mills	2	5	5	3	3
Ratio					
Before 1930	0.19	0.20	0.32	0.23	0.37
1930-35	0.19	0.25	0.32	0.30	0.37

^aFor method of computing ratios see pp. 148-9. Mill-capacity figures refer to practicably obtainable annual capacity (for method of determining practicably obtainable capacity see pp. 149-50).

APPENDIX B.

DESCRIPTION OF DATA FROM NRP MACHINERY-MANUFACTURERS SURVEY¹

Data were obtained in a field survey covering 14 equipment-manufacturing companies conducted by the National Research Project in cooperation with the National Bureau of Economic Research. From these companies was obtained the value of sales (and in some instances the number of units sold), chiefly for the period 1920-36, of equipment used in the manufacture of lumber. Of these companies, seven produced sawmill or other woodworking equipment, three produced lumber carriers, two produced tractor logging equipment, and three produced excavating equipment.²

SAWMILL AND OTHER WOODWORKING EQUIPMENT

The woodworking-machinery sales data include equipment employed in sawmills and in planing mills attached to sawmills and, in addition, a wide variety of equipment used in other woodworking industries. The sales of companies covered in the survey have accordingly been divided into the following three categories:

1. Sawmill machinery. This category includes large band mills, portable circular sawmills, steam feeds, carriages, edgers, trimmers, gang saws, large vertical resaws, large horizontal resaws, cut-off saws, and circular rip-saws.

2. Heavy planing-mill machinery used in planing mills attached to sawmills, and including only machines that would be used for the surfacing and finishing of lumber as discussed in this report. This category includes planers, planer-matchers, planer-matcher-molders, planer-matcher-floorers, band resaws, vertical resaws, rip-saws, surfacers, and molders.

3. Light woodworking machinery. This category contains items of machinery used to some extent in planing mills attached to sawmills, but the sales represent mainly equipment used in furniture factories and other woodworking establishments which are not attached to the lumber industry as defined in this report. It includes small planers, gang planers, cabinet planers, small planer-matchers, hand planers-and-jointers,

¹Except as specified, the data included in this appendix were collected in a field survey conducted by the National Research Project in cooperation with the National Bureau of Economic Research. Harry Jerome participated in the planning of the survey and J. Van Horn Whipple organized the field work and supervised the editing of the materials collected.

²One of the companies produced equipment in two of the indicated categories.

small surfacers, small cut-off saws, scroll saws, shapers, small molders, woodworkers, sanders, wood lathes, tenon machines, mortisers-and-tenoners, hand jointers, sash and door stickers, and band, siding, and circular resaws.

Data obtained from three of the companies were for sales of sawmill and heavy planing-mill machinery only. The remaining four produced equipment falling in two or more of the three categories, and the allocation of sales to these categories was made on the basis of the sales of individual new machines.

The data obtained for two of the seven companies represented inseparable totals for sales of new machines, repairs, and parts. Sales of repairs and parts were separated and eliminated in the case of the other five companies.

The value of sales of woodworking machinery by these seven manufacturers is presented in table B-1 according to the three categories noted above. Sales of some of the companies were not available for a few years of the period 1920-36. For such years sales of the companies for which data were lacking were estimated on the basis of the average proportions that the sales of these companies comprised of the sales of other companies manufacturing similar products. The proportions were computed for years for which the sales of all companies were available. One of the companies required such estimates for the period 1920-27. It was necessary in the case of two companies to divide estimated total sales of woodworking equipment into sales of sawmill and planing-mill equipment. This was done on the basis of the percentage of all sales of the individual companies accounted for by sales of sawmill and planing-mill equipment. In one instance estimates for the last 2 months of 1936 were made on the basis of the average for the first 10 months.

Table B-2 presents a comparison of the value of sales of sawmill and heavy planing-mill machinery by the seven companies and the value of sawmill machinery as estimated by the code application division of the National Recovery Administration.

Of the 39 subdivisions of the machinery and allied products industry specified by the NRA, 1 manufactured woodworking machinery with the exception of sawmill machinery and 1 manufactured sawmill machinery, defined as equipment "for use in sawmills for converting saw logs or timbers into lumber and other timber products."³ Since it is not certain whether planing-mill machinery, even of the limited types contained in

³National Recovery Administration, *Codes of Fair Competition*, Nos. 330-373 (Approved Code No. 347, Mar. 17, 1934), VIII, 242, 245.

the sample, is included in sawmill machinery as defined by the NRA, the comparisons in table B-2 are made on the basis of two sample totals, one including and one excluding sales of heavy planing-mill machinery.

Examination of table B-2 reveals that the volume of sales obtained in the survey fluctuates closely with the values reported to NRA. The percentage which the sample series including sawmill and heavy planing-mill machinery comprises of the NRA series varies between 51 and 63; the percentage which the sample series including only sawmill machinery comprises of the NRA series varies between 38 and 48.

The NRA registered 17 manufacturers of sawmill machinery, and it was estimated that 7 of these concerns accounted for 75 percent of the sales.⁴ The NRP machinery-manufacturers survey included five producers of sawmill machinery and two producers of planing-mill machinery. Three of the five producers of sawmill machinery also manufactured planing-mill machinery.

The biennial *Census of Manufactures* has reported the value of production of woodworking machinery; since 1927 it has also reported on woodworking power-saw blades. Table B-3 presents a comparison between the value of total sales of the seven manufacturers included in the survey and the value of production of all woodworking machinery as reported by the *Census of Manufactures*.

The percentage which the value of sample sales comprises of the value of total production declines steadily from 1925 to 1935. It seems reasonable to assume that sales of sawmill and heavy planing-mill machinery may have declined proportionately more than the sales of other woodworking machinery. If this were so, it would account in part, at least, for the decline in the percentage of the value of total production represented by the sales sample.

LUMBER CARRIERS

Data obtained for three of the companies surveyed refer principally to the value of sales of the straddle-truck type of lumber carrier. These data included the sales values of a small front-lift truck used for piling lumber (this machine embodies the operating principles of the front-lift device which constitutes a special feature of one of the straddle-truck carriers). In the case of two of the three companies, only total sales of all equipment were available for a few years of the period 1920-36, and it was necessary to estimate the value of their sales of lumber carriers for these years. The estimates were made on the basis

⁴W. H. Dillingham, Report on NRA Pre-Code Labor and Production Statistics (National Research Project memorandum, 1936, based on NRA file materials).

of the average of the ratios in surrounding years of the value of sales of lumber carriers to total value of sales of the company in question. One company began manufacturing carriers in 1927, and sales for 1927 and 1928 were estimated by straight-line interpolation between 1929 and the known zero in 1926. For two of the companies 1936 data were available only for the first 9 months; sales for the last 3 months were estimated from the 9-month average.

The three carrier-manufacturing companies surveyed are the only producers of lumber carriers at the present time; other producers have never been important. The sample of sales shown in table B-4 is therefore believed to represent practically all of the sales of lumber carriers during the period 1920-36.

The sales data for these machines do not represent sales made only to the lumber industry. Sales of carriers of the type discussed here to industries engaged in activities other than the fabrication and distribution of lumber products have been small in volume; on the other hand, many carriers are employed in the wholesale and retail distribution of lumber.

TRACTOR LOGGING EQUIPMENT

Data for two of the companies surveyed cover the value of sales of tractor hoists and logging arches. Only total sales of all equipment were available for 1932 and 1933 for one of these companies, and it was necessary to estimate the value of sales of tractor logging equipment for these years. The estimates were made on the basis of the average of the 1931 and 1934 ratios of the company's sales of tractor logging equipment to its total sales. Data for one of the two companies were available only through the first 9 months of 1936; sales for the last 3 months were estimated from the 9-month average.

There are no comparable data with which to compare sample sales of tractor logging equipment. An examination of trade journals indicates that the two companies surveyed are among the leading advertisers of this equipment. It seems likely that the sample of sales shown in table B-5 reflects the course of the sales of this equipment with reasonable accuracy.

EXCAVATING EQUIPMENT

Each of the three excavating-equipment companies surveyed manufactured power shovels, and one also produced locomotive cranes.

The sales of power shovels and locomotive cranes to the lumber industry account for only a small proportion of the total sales of excavating equipment of the three companies. Their total sales, however, comprise a large portion of the total production of this type of equipment. They represent between 33 and 61 percent of the total volume of production of power shovels and locomotive cranes (see table B-6).

Repairs and resales make up a considerable portion of the sales of two of these companies; for the third, available data cover only new units. The *Census of Manufactures* normally includes in its detailed production tables only new units and parts, listing receipts for repair work separately. It is therefore likely that the percentages shown in table B-6 are inflated.

The total-sales series was partly estimated. For one company the 1936 data were obtained for only 9 months; figures for the last 3 months were estimated on the basis of the monthly average for the first 9 months. For another company the figures for 1920 and 1936 were estimated on the basis of the ratios in 1921 and 1935, respectively, of the sales of this company to the sales of the other two.

**Table B-1.- VALUE OF SALES OF WOODWORKING MACHINERY
BY SEVEN COMPANIES, BY TYPE OF EQUIPMENT, 1920-36^a**

(Thousands of dollars)

Year	Total	Sawmill	Planing-mill (heavy finishing)	Planing and woodworking
1920	3,893	2,843	681	569
1921	2,089	1,370	344	375
1922	2,454	1,509	439	506
1923	3,316	2,108	619	591
1924	3,301	2,091	592	618
1925	2,387	1,280	489	618
1926	2,653	1,648	471	534
1927	1,865	1,039	372	454
1928	1,587	933	325	329
1929	1,956	1,222	344	390
1930	1,161	731	230	200
1931	555	324	115	116
1932	230	126	39	65
1933	338	198	114	38
1934	401	253	107	41
1935	516	303	165	48
1936	907	628	203	76

^a For definition of specified types of machinery see pp. 162-3.

**Table B-2.-- VALUE OF TOTAL SALES AND SAMPLE SALES
OF WOODWORKING MACHINERY, 1928-32**

Year	Total sales ^a (thousands of dollars)	Sales of seven companies ^b (thousands of dollars)		Percent of total sales accounted for by sample sales of -	
		Sawmill machinery	Planing-mill (heavy finishing) machinery	Sawmill machinery ^c	Sawmill and planing-mill (heavy finishing) machinery ^c
1928	2,440	939	325	38.2	51.6
1929	2,540	1,222	344	48.1	61.7
1930	1,608	731	230	45.5	59.8
1931	780	324	115	42.8	57.8
1932	261	128	39	48.3	63.2

^aW. H. Dillingham, Report on NRA Pre-Code Labor and Production Statistics (National Research Project memorandum, 1936, based on NRA file materials).

^bTable B-1.

^cThe series presented may not be strictly comparable. It is not known whether the NRA figures include sales of parts and repairs; except for two of the seven companies, such sales are not included in the sample series. The percentages may therefore understate or overstate the coverage of the sample.

**Table B-3.-- VALUE OF TOTAL PRODUCTION AND SAMPLE SALES
OF WOODWORKING MACHINERY, 1925-35**

Year	Value (thousands of dollars) of -		Percent 7-company sales are of total production ^c
	Total production ^a	Total sales of seven companies ^b	
1920	n. a.	6,508	-
1921	(d)	3,518	-
1922	n. a.	4,064	-
1923	(d)	5,394	-
1924	n. a.	5,103	-
1925	49,861 ^e	4,112	8.2
1926	n. a.	4,320	-
1927	37,213	3,054	8.2
1928	n. a.	2,769	-
1929	41,827	3,322	7.9
1930	n. a.	2,185	-
1931	13,968	1,090	7.8
1932	n. a.	471	-
1933	6,717	599	6.6
1934	n. a.	784	-
1935	15,683	843	5.4
1936	n. a.	1,708	-

^aIncludes woodworking machinery and woodworking power-saw blades. Data for 1925-29 from *Fifteenth Census of the United States: 1930, "Manufactures: 1929"* (U. S. Dept. Com., Bur. Census, 1933), II, 979, 1102; data for 1931 from *Census of Manufactures: 1931* (U. S. Dept. Com., Bur. Census, 1935), pp. 820, 938; data for 1933 and 1935 from same, 1935 (1938), pp. 911, 1056.

^bRepresents gross sales.

^cThe *Census of Manufactures* production figures normally refer to new units and parts; receipts for repair work are listed separately. The 7-company series represents gross sales and includes inseparable items for parts and repairs. Although receipts from repairs comprised a small but indeterminate proportion of the total for repairs and parts, it is likely that the percentages are somewhat inflated.

^dFigures for woodworking machinery only are \$25,482,000 for 1921 and \$44,447,000 for 1923. No effort was made to extrapolate figures for woodworking power-saw blades as was done in the case of 1925.

^eData for woodworking power-saw blades were not reported for 1925. The value was estimated by multiplying the value of woodworking machinery in 1925 by the 1927 ratio of the value of woodworking power-saw blades to the value of woodworking machinery.

n. a. Data not available.

Table B-4.- VALUE OF SALES OF LUMBER CARRIERS, 1920-36^a

Year	Thousands of dollars	Year	Thousands of dollars
1920	236	1929	506
1921	109	1930	251
1922	299	1931	178
1923	589	1932	63
1924	447	1933	123
1925	437	1934	178
1926	555	1935	388
1927	393	1936	690
1928	410		

^aData refer to sales by the only three manufacturers of this equipment at the time of the survey. Sales to retail and wholesale distributors of lumber are included, as is the small volume of sales to other industries.

Table B-5.- VALUE OF SALES OF LOGGING ARCHES AND TRACTOR HOISTS BY TWO COMPANIES, 1929-36

(Thousands of dollars)

Year	Logging arches	Tractor hoists	Year	Logging arches	Tractor hoists
1929	85	456	1933	21	85
1930	63	280	1934	61	186
1931	19	129	1935	108	362
1932	20	9	1936	169	601

Table B-6.- VALUE OF TOTAL PRODUCTION AND SALES
BY THREE COMPANIES OF POWER SHOVELS
AND LOCOMOTIVE CRANES, 1919-36

Year	Value of total production ^a (thousands of dollars)	Value of sales by three companies			
		Total ^b		To lumber industry ^c	
		Thousands of dollars	Percent of value of total production	Thousands of dollars	Index (1925=100)
1919	15,368 ^d	n. a.	-	n. a.	-
1920	n. a.	14,478 ^e	-	245	121.9
1921	15,867 ^d	5,422	34.2	97	48.3
1922	n. a.	9,074	-	218	108.5
1923	29,226 ^d	14,112	48.3	450	223.9
1924	n. a.	11,648	-	187	93.0
1925	32,835 ^f	12,547	38.2	201	100.0
1926	n. a.	13,005	-	158	78.6
1927	36,494 ^f	12,742	33.1	142	70.6
1928	n. a.	14,878	-	196	97.5
1929	49,301	16,952	34.4	111	55.2
1930	n. a.	9,941	-	89	34.3
1931	20,442	8,183	40.0	25	12.4
1932	n. a.	3,507	-	15	7.5
1933	5,095	3,108	61.0	0	0
1934	n. a.	4,568	-	24	11.9
1935	13,295	6,282	47.3	0	0
1936	n. a.	8,218 ^e	-	66	32.8

^aBased on *Census of Manufactures: 1925* (U. S. Dept. Com., Bur. Census, 1928), p. 1031; *1929* (1933), II, 1099; and *1935* (1936), p. 1076.

^bData are from NRP machinery-manufacturers survey and cover two companies manufacturing power shovels and one company manufacturing both power shovels and locomotive cranes. Data for the latter company are for new units only (no repairs or rebuilt equipment). Data for the former companies include repairs and resales. In the case of one, about 70 percent of the sales represented sales of new units, about 20 percent represented resales, and about 10 percent represented parts. In the case of the other, about one-third represented repairs.

^cIncludes complete units only. Some rebuilt units may be included. The company manufacturing both power shovels and locomotive cranes sold only the latter to the lumber industry.

^dData for locomotive cranes were not reported for 1919, 1921, and 1923. Values were estimated by multiplying the value of power shovels in these years by the 1925 ratio of the value of locomotive cranes (see fn. f) to the value of power shovels.

^ePartly estimated.

^fCrawler and locomotive cranes were reported in combination in 1925 and 1927. The value of locomotive cranes only was estimated on the basis of the 1929 proportions.

n. a. Data not available.

APPENDIX C

DESCRIPTION OF DATA FROM WEST COAST DIRECTORY

The *West Coast Lumberman*, a trade publication of the Pacific Coast lumber industries, has published periodically its *Handbook and Directory of the Western Timber Industries*. The sections on the lumber industry contained information for concerns operating logging camps and sawmills in each of the various localities.¹

NATURE OF THE DATA

Many of the concerns listed reported their approximate daily capacity and the nature of their principal items of equipment. In a considerable number of instances the number of items of equipment was also reported.

A particular virtue of the directories as a source for equipment data is that they cover a large number of operations. The 1935-36 directory, for instance, listed 1,477 Pacific Coast operations.² The number of Pacific Coast mills reported by the *Census of Manufactures* for 1935 was only 1,090.³ This difference may be explained only in part by the fact that the census figure does not include establishments whose products for 1935 were valued at less than \$5,000.

The 1933, 1935-36, and 1937 editions of the directories were used as the basis for tabulations designed to indicate techniques utilized by Pacific Coast logging camps and sawmills. According to the publishers of the directory, the material in the 1933 and 1937 directories was collected during the early months of the date year and the late months of the preceding year. The publishers did not specifically state the period during which materials for the 1935-36 directory were collected, and it was assumed that this material was collected late in 1935 and early in 1936. The data from these directories were therefore considered to refer to the years 1933, 1936, and 1937.

Unfortunately, reports for many of the operations did not contain information on equipment. Since there is evidence to indicate that reports for smaller operations were considerably more deficient in this respect

¹Some concerns had establishments in several localities and were accordingly listed in each. In such cases the various establishments were considered to be separate operations and were so treated in tabulations based on the directories.

²Logging camps and sawmills were counted as separate operations unless they were operated by the same concern in the same locality, in which case the sawmill and its logging camp were counted as a single operation.

³*Census of Manufactures: 1935* (U. S. Dept. Com., Bur. Census, 1936), p. 476.

than reports for larger operations,⁴ equipment data for operations of all sizes would therefore be of doubtful significance. In individual size groups, however, this source of distortion is minimized. Because many reports also failed to indicate the capacity of the operation, a large proportion of the operations had to be excluded from the tabulations.⁵ Another reason for the exclusion of a number of operations from the tabulations was that reports in earlier directories were less detailed than those for 1937; this could be offset only by including in time comparisons those operations for which adequate reports were available for 1933 and 1937 and for 1936 and 1937.

DESCRIPTION OF THE TABULATIONS

Logging Camps

In order to determine changes over time and differences between camps of different size with respect to log-yarding equipment of Pacific Coast camps, a tabulation was made of operations reporting such equipment. Because operating conditions differ according to size, camps included in the tabulations were separated into five size groups, which are based on reported daily capacity.⁶ Comparisons were made for each size group between 1933 and 1937 and between 1936 and 1937. In order that distortion due to incomplete reporting might be avoided, the only camps included in the 1933-37 comparisons were those which reported for both years the type of log-yarding equipment in use. Camps which failed to report on the number of units in use were included, for the tabulation was intended to indicate, for each of the two years, how many camps used donkey engines only, tractors only, or both. The size group to which a camp was assigned was determined by the daily capacity reported for 1937. Where the 1937 estimate was not available, the 1933 estimate was used. Where neither was available, the camp was not included in the tabulation. The procedure followed for the 1933-37 comparisons was also followed for the 1936-37 comparisons. Because a number of the camps for which adequate 1937 reports were available could not be included in the 1933-37 or 1936-37 comparisons, a separate distribution by size of camp

⁴See p. 175.

⁵The various tabulations are described in the following section.

⁶The reported size of an operation is based on the owner's estimate of the daily capacity of his operation. Since differing criteria may have been used by the various owners, the meaning and comparability of these estimates are open to some question. A number of the operations were covered in the NRP-NBER logging-camp and sawmill survey, and estimated daily capacities as reported to NRP-NBER field agents are quite similar to those published in the directories. The similarity suggests that the estimates in the directories are carefully considered ones. In any event, the figures as published are probably sufficiently accurate to show generally the differences in equipment associated with differences in size of operations.

and type of log-yarding equipment was made for all camps whose 1937 reports were sufficiently detailed to permit this. The results of the log-yarding tabulation are presented in table C-1. State break-downs of the 1937 distribution are shown in table C-2.

A tabulation similar to that for log-yarding equipment was made for log-hauling equipment (locomotives and trucks). The results are presented in tables C-3 and C-4.

A construction-equipment (bulldozers and power shovels) tabulation, shown in table C-5, was also made. In this tabulation, however, no effort was made to make comparisons over time, and the data refer to 1937 only. Furthermore, the basis for selection of camps to be included in the tabulation differed. It was believed that all camps required log-yarding and log-hauling equipment, and therefore differences in techniques could be indicated by differences in the types of equipment in use. Not all camps, however, have need for construction equipment of their own, and a different criterion was sought for inclusion of camps in the construction-equipment tabulation. The criterion selected was completeness of reporting; the test for this was: did the camp report adequately on the type of log-yarding or log-hauling equipment used? Thus the "Number of camps reporting" in table C-5 includes all camps included in the distributions of "All camps reporting in 1937" as shown in tables C-1 and C-3.

It should be noted that the changes over time shown by this series of tabulations, based as they are on groups of identical companies, may be somewhat biased. It was not possible to trace changes in ownership of the camps, nor was it feasible to trace changes in location. Thus the groups of camps are identical with respect to ownership and location as well as completeness of reporting. Such camps are likely to be more stable than the average in terms of the length of the period of cutting at a single location and are therefore likely to employ methods which are somewhat different from those employed by camps which move frequently. This applies particularly to the methods used for hauling logs.

It should be recognized, furthermore, that changes in techniques over a period of time for the Pacific Coast as a whole are likely to be minimized by a consideration of data for identical camps, for new camps are likely to employ new techniques.

Another series of tabulations was made. This series is concerned with the number of units of particular types of equipment in use rather than with the number of camps using them. There are three tabulations in the

series dealing, respectively, with log-yarding, log-hauling, and construction equipment. No distinction is made between units used in small and large camps. In this series, as in the preceding one, data for 1933 and for 1936 are separately compared with data for 1937.

In the tabulation dealing with log-yarding equipment the number of donkey engines and the number of tractors used by a group of camps in 1933 are compared with the number of each used by the same camps in 1937. Data used in the tabulation are for those camps which reported on the number of units of log-yarding equipment and on type of log-hauling equipment in both years.⁷ Failure to report on daily capacity did not constitute grounds for exclusion. The description of the 1933-37 comparisons also applies to the 1936-37 comparisons. In addition to these comparisons over time for groups of identical camps, the number of donkey engines and the number of tractors used by all camps which had sufficiently detailed reports were counted for 1936 and 1937. The results of this tabulation are presented in table 8.

Similar tabulations were made for log-hauling equipment (number of trucks and railroad mileage) and construction equipment (number of power shovels and number of bulldozers); these are shown in tables 9 and 10. Because of the fact that bulldozers were not introduced in Pacific Coast logging camps until 1932, adequate data for 1933 could not be obtained; the 1933-37 comparison for bulldozers is accordingly omitted from table 10. The criteria used for selecting camps to be included in the log-yarding tabulation were used in the case of the log-hauling tabulation. In the case of the construction-equipment tabulation, however, some modification was necessary because of the fact that not all camps needed construction equipment of their own. Camps included in the construction tabulation were those which reported the types of log-yarding or log-hauling equipment in use in both years; thus the camps included in the construction tabulation (table 10) include all camps included in either the log-yarding or log-hauling tabulations (tables 8 and 9).

The changes over time indicated by this second series of tabulations for logging camps, being based on the experience of identical camps, are subject to the kind of bias discussed in connection with the first series. Unlike the first series, which deals separately with camps of different size, these tabulations are subject to bias introduced by the relative overrepresentation of the larger camps.

⁷Such camps are believed to have reported fully on type of equipment. Accordingly, a camp which did not report at all on a given type of yarding equipment for one of the two years was assumed to have used no units of that type of yarding equipment in that year, and data for the camp were included in the tabulation. However, a camp that reported the use of a given type of yarding equipment without specifying the number of units in use was not included.

Sawmills

Information appearing in the 1935-36 edition of the directory was used in order to distribute sawmills by type of headsaw used (band saws only, circular saws only, or both) and by type of power used (steam only, electric only, or both).⁸ These distributions were made separately for each of the five size groups.⁹ All mills which indicated the type of headsaw used were included in the type-of-headsaw tabulation provided that they reported also their daily capacity. Similar criteria were used for the inclusion of mills in the type-of-power tabulation. The results of these tabulations are presented in table C-6.

Table C-7 presents the results of a third tabulation of sawmill equipment. This tabulation was made by counting the number of mills which reported using specified types of equipment. As in the case of the other two tabulations, the mills were assigned to their appropriate size class; where this could not be done, the mills were not counted. The first line of figures of table C-7 indicates the total number of mills reporting on any type of sawmill equipment in use and on daily capacity.

COVERAGE OF THE TABULATIONS

Indications of the extent of the coverage of the tabulations of logging camps according to types of equipment in use are given in table C-8. In table C-9 are given similar figures for the tabulations on number of units of such equipment. Table C-10 gives the coverage of the type-of-headsaw and type-of-power tabulations for sawmills. The measure of coverage used is the percentage that the number of logging camps or sawmills used in a given tabulation for a given year is of the total number of logging camps or sawmills listed in the directory for that year.

With respect to the tabulations of logging camps reporting type of equipment in use, 31 to 37 percent of the camps in the 1933 directory were included in the tabulation. Of the camps listed in the 1935-36 directory, 29 to 39 percent were included in the tabulation. Of the camps in the 1937 directory, 43 to 56 percent of the camps reported in sufficient detail to permit their inclusion in the distribution made for 1937.

Corresponding percentages for the tabulations dealing with the number of logging-camp equipment units in use are as follows: 24 to 27 for 1933, 22 to 25 for 1935-36, and 58 for 1937.

⁸An examination of data for other years indicated that changes in sawmill equipment over the period of time covered by the available directories (1933-37) were not of sufficient magnitude to warrant separate tabulations for each year.

⁹See fn. 8 of this appendix.

The type-of-headsaw tabulation for sawmills covered 46 percent of the sawmills listed in the 1935-36 directory; the type-of-power tabulation covered 38 percent.

The State distributions of the logging camps and sawmills included in the various tabulations were reasonably similar to the distributions of all listed logging camps and sawmills. This may be seen in tables C-8 to C-10, which present also the State coverages of the various tabulations. It will be noted that California logging camps are relatively overrepresented in most of the tabulations; Washington logging camps, on the other hand, are least adequately represented. This situation is reversed in the case of the sawmill tabulation.

In order that the characteristics of operations which reported might be compared with those of operations which did not report, special enumerations were made of operations listed in the 1935-36 directory. Operations were separated into two classes: those which reported on capacity and on some types of equipment and those which failed to report on one or both of these items. The first class includes operations eligible for inclusion in one or more of the tabulations; the second includes operations which could not have been included. The two classes were subdivided according to type of ownership - company, partnership, or individual. The numbers of operations in each class and subdivision are given in table C-11.

Table C-12 presents a distribution of those operations owned individually or in partnership which were eligible for inclusion in at least one of the tabulations. An examination of this table shows that an overwhelming majority of the operations having such ownership are in the smallest size class (daily capacity of 1 to 49 thousand board feet) and are concentrated in the lower half of that size class. With but few exceptions, none of the operations distributed in table C-12 had a daily capacity exceeding 100 thousand board feet.

An examination of data in table C-11 in the light of the data in table C-12 suggests that a majority of those operations which could not be included in any of the tabulations were in the smaller size groups. Whereas only 21 percent of the operations eligible for inclusion in the various tabulations were owned individually or in partnership, 58 percent of the ineligible operations had such ownership. It therefore appears likely that the tabulations are appreciably more representative of the larger operations.

Table C-1.- NUMBER OF PACIFIC COAST LOGGING CAMPS REPORTING ON LOG-YARDING EQUIPMENT, BY DAILY CAPACITY AND TYPE OF EQUIPMENT, 1933, 1936, AND 1937

Years and type of equipment	Daily capacity (M ft. b. m.) ^a									
	1-49		50-99		100-249		250-499		500 or over	
	Earlier year	1937	Earlier year	1937	Earlier year	1937	Earlier year	1937	Earlier year	1937
152 camps reporting in 1933 and 1937	22	22	25	25	53	53	36	36	18	18
Number employing -										
Donkey engines only	14	12	20	16	22	13	18	14	12	7
Donkey engines and tractors	6	7	4	7	15	25	9	13	3	8
Tractors only	2	3	1	2	16	15	9	9	1	1
266 camps reporting in 1936 and 1937	86	86	52	52	65	65	45	45	18	18
Number employing -										
Donkey engines only	46	43	29	23	22	19	19	16	8	7
Donkey engines and tractors	21	25	16	21	29	29	17	19	8	9
Tractors only	19	18	7	8	14	17	9	10	2	2
All camps (409) reporting in 1937	-	136	-	91	-	107	-	54	-	21
Number employing -										
Donkey engines only	-	70	-	39	-	32	-	20	-	8
Donkey engines and tractors	-	33	-	35	-	45	-	24	-	11
Tractors only	-	33	-	17	-	30	-	10	-	2

^aCapacity in 1937. Where this was not available, capacity in the "earlier year" was used.

**Table C-2.- NUMBER OF PACIFIC COAST LOGGING CAMPS REPORTING
ON LOG-YARDING EQUIPMENT, BY DAILY CAPACITY, STATE,
AND TYPE OF EQUIPMENT, 1937**

State and type of equipment	Daily capacity in 1937 (M ft. b. m.)				
	1-49	50-99	100-249	250-499	500 or over
California camps (64) reporting	22	9	22	9	2
Number employing -					
Donkey engines only	1	0	1	1	0
Donkey engines and tractors	6	4	10	6	0
Tractors only	15	5	11	2	2
Oregon camps (201) reporting	67	55	54	24	1
Number employing -					
Donkey engines only	46	24	12	6	1
Donkey engines and tractors	10	23	29	11	0
Tractors only	11	8	13	7	0
Washington camps (144) reporting	47	27	31	21	18
Number employing -					
Donkey engines only	23	15	19	13	7
Donkey engines and tractors	17	8	6	7	11
Tractors only	7	4	6	1	0

Table C-2.- NUMBER OF PACIFIC COAST LOGGING CAMPS REPORTING ON LOG-HAULING EQUIPMENT, BY DAILY CAPACITY AND TYPE OF EQUIPMENT, 1933, 1936, AND 1937

Years and type of equipment	Daily capacity (M ft. b. m.) ^a									
	1-49		50-99		100-249		250-499		500 or over	
	Earlier year	1937	Earlier year	1937	Earlier year	1937	Earlier year	1937	Earlier year	1937
128 camps reporting in 1933 and 1937	9	9	21	21	49	49	34	34	15	15
Number employing -										
Locomotives only	5	5	17	13	46	35	33	30	15	14
Locomotives and trucks	0	1	1	2	2	10	1	3	0	1
Trucks only	4	3	3	6	1	4	0	1	0	0
197 camps reporting in 1936 and 1937	40	40	33	33	62	62	44	44	18	18
Number employing -										
Locomotives only	8	8	19	14	51	38	44	36	18	17
Locomotives and trucks	3	1	1	3	2	10	0	5	0	1
Trucks only	29	31	13	16	9	14	0	1	0	0
All camps (349) reporting in 1937	-	102	-	75	-	102	-	50	-	20
Number employing -										
Locomotives only	-	7	-	20	-	49	-	43	-	16
Locomotives and trucks	-	2	-	4	-	19	-	6	-	2
Trucks only	-	93	-	51	-	34	-	1	-	0

^aSee table C-1, fn. a.

Table C-4.- NUMBER OF PACIFIC COAST LOGGING CAMPS REPORTING ON LOG-HAULING EQUIPMENT, BY DAILY CAPACITY, STATE, AND TYPE OF EQUIPMENT, 1937

State and type of equipment	Daily capacity in 1937 (M ft. b. m.)				
	1-49	50-99	100-249	250-499	500 or over
California camps (56) reporting	16	8	21	9	2
Number employing -					
Locomotives only	0	1	12	7	1
Locomotives and trucks	2	0	2	2	1
Trucks only	16	7	7	0	0
Oregon camps (169) reporting	51	44	52	21	1
Number employing -					
Locomotives only	2	12	23	16	1
Locomotives and trucks	0	2	11	4	0
Trucks only	49	30	18	1	0
Washington camps (122) reporting	33	23	29	20	17
Number employing -					
Locomotives only	5	7	14	20	16
Locomotives and trucks	0	2	6	0	1
Trucks only	28	14	9	0	0

Table C-5.- NUMBER OF PACIFIC COAST LOGGING CAMPS REPORTING CONSTRUCTION EQUIPMENT, BY DAILY CAPACITY, 1937

Type of equipment	Daily capacity in 1937 (M ft. b. m.)				
	1-49	50-99	100-249	250-499	500 or over
Number of camps reporting	187	95	109	55	21
Number of camps reporting bulldozers	7	31	55	22	11
Percent of total number of camps	4.2	32.6	50.5	40.0	52.4
Number of bulldozers reported ^a	7	31	64	29	24
Average number of units per camp reporting bulldozers	1.0	1.0	1.2	1.3	2.2
Number of camps reporting power shovels	0	6	51	42	18
Percent of total number of camps	0	6.4	46.8	76.4	85.7
Number of shovels reported ^a	-	9	69	76	64
Average number of units per camp reporting shovels	-	1.1	1.4	1.8	3.6

^aDiffers from data in table 10 (p. 51) in that equipment used by camps which did not report daily capacity is not included in this table.

Table C-6.- NUMBER OF PACIFIC COAST SAWMILLS REPORTING ON TYPE OF HEADSAW AND TYPE OF POWER, BY DAILY CAPACITY AND TYPE OF EQUIPMENT, 1936

Type of headsaw or type of power	Daily capacity in 1936 (M ft. b. m.)				
	1-49	50-99	100-249	250-499	500 or over
Mills reporting on type of headsaw	280	87	127	24	11
Number employing -					
Band saws only	30	50	105	22	10
Band and circular saws	4	1	3	0	1
Circular saws only	246	36	19	2	0
Mills reporting on type of power	209	69	116	23	9
Number employing -					
Steam power only	172	35	29	5	0
Steam and electric power	13	19	56	10	8
Electric power only	24	15	33	8	1

Table C-7.- NUMBER OF PACIFIC COAST SAWMILLS REPORTING SPECIFIED TYPE OF EQUIPMENT, BY DAILY CAPACITY, 1936

Type of equipment	Daily capacity in 1936 (M ft. b. m.)				
	1-49	50-99	100-249	250-499	500 or over
Number of mills reporting on equipment ^a	299	94	133	25	11
Number employing -					
Gang saws	3	10	28	13	8
Planing mills	157	73	118	24	11
Lath mills	13	23	81	18	9
Dry kilns	35	28	97	25	10
Shingle mills	19	5	13	4	6
Box factories	11	9	18	3	1
Machine shops	15	24	62	14	10

^aIncludes mills included elsewhere in this table or in table C-6.

**Table C-8.-- COVERAGE OF PACIFIC COAST LOGGING-CAMP TABULATIONS
REFERRING TO TYPES OF EQUIPMENT IN USE, 1933, 1936, AND 1937^a**

Year and State	Total number of camps ^b	Number of camps in tabulation ^c			Camps in tabulation as percent of total		
		Log yarding	Log hauling	Construc- tion	Log yarding	Log hauling	Construc- tion
1933, total	413	152	128	(d)	36.8	31.0	-
California	73	31	27	(d)	42.5	37.0	-
Oregon	182	65	48	(d)	35.7	26.4	-
Washington	158	56	53	(d)	35.4	33.5	-
1936, total	690	266	197	(d)	39.1	29.0	-
California	87	46	35	(d)	52.9	40.2	-
Oregon	272	121	88	(d)	44.5	32.4	-
Washington	321	99	74	(d)	30.8	23.1	-
1937, total	805	409	349	447	50.8	43.4	55.5
California	103	64	58	70	62.1	56.3	68.0
Oregon	374	201	169	216	53.7	45.2	57.9
Washington	328	144	122	161	43.9	37.2	49.1

^aFigures are for all camps, whether reported as operated separately or in conjunction with sawmills.

^bAll camps listed in the respective directories.

^cThe 1933 figures include only camps that reported adequately on the specified types of equipment for 1937 as well as 1936 and on daily capacity for 1933 or 1937; the 1936 figures include only camps which reported in a similarly adequate fashion for 1936 and 1937. The 1937 figures, however, include all camps which reported adequately for 1937.

^dTabulation not made for this year.

**Table C-9.-- COVERAGE OF PACIFIC COAST LOGGING-CAMP TABULATIONS
REFERRING TO NUMBER OF EQUIPMENT UNITS IN USE,
1933, 1936, AND 1937^a**

Year and State	Total number of camps ^b	Number of camps in tabulation ^c			Camps in tabulation as percent of total		
		Log yarding	Log hauling	Construc- tion	Log yarding	Log hauling	Construc- tion
1933, total	413	106	100	111	25.7	24.2	26.9
California	73	22	20	23	30.1	27.4	31.5
Oregon	182	40	37	41	22.0	20.3	22.5
Washington	158	44	43	47	27.8	27.2	29.7
1936, total	680	166	149	172	24.4	21.9	25.3
California	87	35	31	35	40.2	35.6	40.2
Oregon	272	66	58	71	25.0	21.3	26.1
Washington	321	63	60	66	19.6	18.7	20.6
1937, total	805	469	439	489	58.3	56.3	58.3
California	103	77	77	77	74.6	74.6	74.6
Oregon	374	227	227	227	60.7	60.7	60.7
Washington	328	165	165	165	50.3	50.3	50.3

^aFigures are for all camps, whether reported separately or in conjunction with sawmills.

^bAll camps listed in the respective directories.

^cThe 1933 figures include only camps that reported adequately on the number of units of the specified types of equipment for 1937 as well as 1936; the 1936 figures include only camps which reported in a similarly adequate fashion for 1936 and 1937. The 1937 figures, however, include all camps which reported adequately for 1937.

Table C-10.- COVERAGE OF PACIFIC COAST SAWMILL TABULATIONS
REFERRING TO TYPES OF EQUIPMENT IN USE, 1936^a

State	Total number of mills ^b	Number of mills in tabulation ^c		Mills in tabulation as percent of total	
		Type of headsaw	Type of power	Type of headsaw	Type of power
Total	1,139	529	428	46.4	37.6
California	233	92	78	39.5	33.5
Oregon	492	217	168	44.1	34.1
Washington	414	220	162	53.1	44.0

^aFigures are for all mills, whether reported as operated separately or in conjunction with logging camps.

^bAll mills listed in the 1935-36 directory.

^cAll mills reporting adequately on type of headsaw or power used in 1936 and on daily capacity in 1936.

Table C-11.- DISTRIBUTION OF REPORTING AND NONREPORTING
PACIFIC COAST OPERATIONS, BY TYPE OF OWNERSHIP, 1936^a

Type of ownership	Reporting		Nonreporting	
	Number	Percent	Number	Percent
All operations ^b				
Total	694	100	783	100
Company	546	79	391	42
Partnership	65	9	144	19
Individual	83	12	308	39
Logging camps				
Total	442	100	236	100
Company	339	77	110	46
Partnership	50	11	43	18
Individual	53	12	85	36
Sawmills				
Total	587	100	552	100
Company	464	79	226	41
Partnership	55	9	101	18
Individual	68	12	225	41

^aA "reporting" operation is one which reported on capacity and on some items of equipment; a "nonreporting" operation is one which failed to report on one or both of these items.

^bLogging camps and sawmills operated in conjunction with each other are considered a single operation for purposes of this table. Of the reporting logging camps, 835 were operated in conjunction with sawmills; of the logging camps for which there were no reports, 7 were operated in conjunction with sawmills.

Table C-12.- DISTRIBUTION OF REPORTING PACIFIC COAST OPERATIONS OWNED INDIVIDUALLY AND IN PARTNERSHIP, BY DAILY CAPACITY, 1936^a

Type of ownership and daily capacity (M ft. b. m.)	All operations ^b		Logging camps		Sawmills	
	Number	Percent	Number	Percent	Number	Percent
Individual	63	100	53	100	68	100
1- 24	50	60	26	49	44	65
25- 49	26	31	21	40	21	31
50- 74	3	4	3	5	1	1
75-100	3	4	2	4	2	3
Over 100	1	1	1	2	0	0
Partnership	65	100	50	100	55	100
1- 24	33	51	25	50	31	56
25- 49	20	31	13	26	19	35
50- 74	9	14	9	18	3	5
75-100	3	4	3	6	2	4

^aSee table C-11, ftm. a.

^bSee table C-11, ftm. b.

APPENDIX D

DESCRIPTION OF DATA FROM SOUTHERN FOREST SURVEY

The McSweeney-McNary Forest Research Act of 1928 authorized the United States Forest Service to conduct a Nation-wide survey of forest resources. The findings of the Southern Forest Survey, which was conducted pursuant to this act, represent the most complete and detailed body of data available regarding the southern lumber industry. Through a cooperative arrangement the Forest Service made some of these data, collected in 1934, available to the "Studies of Productivity and Employment in Selected Industries" section of the National Research Project. The data were supplied in the form of a special, unpublished report dated November 1, 1936. Later the Southern Forest Experiment Station supplied tabulation sheets of the Southern Forest Survey on types of equipment employed.

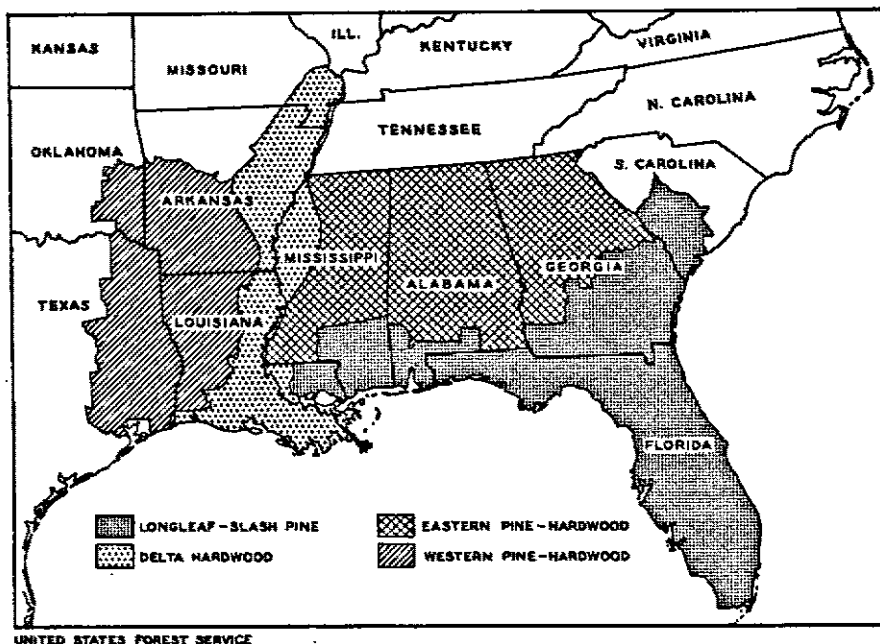
The territory covered by the survey is shown in figure D-1. It includes the Gulf States (Alabama, Florida, Louisiana, and Mississippi); Georgia; the most important pine-forest regions of Arkansas, Oklahoma, and Texas; and the Delta hardwood-forest regions of Arkansas, Kentucky, Missouri, and Tennessee. A small section of South Carolina is also included.

Operations of different sizes employ different techniques. For instance, about half of the mills having a daily capacity of 20 to 39 thousand board feet and practically all mills having a lower daily capacity may be considered to be portable mills. However, some of the very small sawmills are permanent neighborhood mills attached to plantations or doing local custom sawing. On the other hand, all of the largest sawmills, those with a daily capacity of 40 thousand or more board feet, may be considered stationary. The mills surveyed were broken down into five size groups, and separate data are presented for mills in each group.¹

In addition to break-downs by size, break-downs were also made according to the species of lumber constituting 50 percent or more of the production of the particular mills in 1934, the year of the survey. This latter break-down consists of three categories: pine, hardwood, and cypress.

¹Size classifications are based on rated capacity in thousands of board feet per 10-hour day. The capacities reported for each mill were frequently based on an arbitrary estimate made by the sawmill operator. These estimates may be subject to considerable error and may, furthermore, be based on differing criteria. Thus some operators underestimated capacity by quoting the cut under 1934 conditions, whereas others overestimated capacity by reporting the capacity which the operations might have had formerly when a favorable timber supply existed. Although the division of the mills into the specified size group may not be altogether accurate, it is nevertheless sufficient to differentiate in a general fashion between the practices and experiences of operations of different sizes.

Figure D-1.- SOUTHERN FOREST SURVEY TERRITORY



The Southern Forest Survey material has been used in this report in order to obtain information for southern operations on equipment in use, unit labor requirements, and life expectancy of mills.

DATA ON EQUIPMENT IN USE

A sample of 839 operations was used by the Southern Forest Survey in order to determine the short-haul equipment in use in southern operations. The operations were asked to supply information regarding the means of transportation used to move logs from the stump to the beginning of the long haul. The replies are summarized, by size of mill and predominating species cut, in table D-1.

Information on equipment used in the long haul was also obtained in the survey, in this instance from a sample of 862 operations. The sample operations were asked to check blanks provided for the following items: Team, truck, tractor, logging railroad, common-carrier railroad, barge, and raft. They were also asked to specify and describe briefly any other equipment in use. The reports obtained on long-haul equipment are summarized in table D-2.

The survey likewise sought information regarding equipment in use in sawmills. A total of 901 southern mills checked one or more of the following items: Band saw, circular saw, gang saw, resaw, planer, and dry kiln. The replies to this query are presented in table D-3.

Data presented in tables D-1 to D-3 were obtained from the tabulation sheets supplied by the Southern Forest Experiment Station.

DATA ON UNIT LABOR REQUIREMENTS

Logging and sawing unit labor requirements of 651 southern operations are presented in table D-4. Data are presented separately for mills cutting pine predominantly, for mills cutting hardwood predominantly, and for all mills regardless of species cut. As in the case of equipment data, separate figures are shown for mills falling into one or another of the different size groups.

Average unit labor requirements were calculated from information obtained from responses to several questions. Operators were asked to indicate the number of persons employed, either by the operator or his contractors or jobbers, in the wood, in the mill and yard, and in office or sales work. The operators were also requested to supply information on the number of hours worked in the woods and in the mill. In addition, information on daily cutting capacity was requested. These queries were to be answered on the basis of full-capacity rather than 1934 operation. Large mills were known to surface a much larger proportion of their product than the small mills. Although labor employed in surfacing was included in the reported totals, operators were asked to supply information on the proportion of the product surfaced. Responses to this last question indicated that about 80 percent of the output of the largest pine mills - those which cut 40 thousand or more board feet per day - was surfaced; a much smaller proportion of the output of small pine mills and of all hardwood mills was surfaced.

Concentration yards (mills that finish and market unsurfaced and frequently unseasoned lumber cut by a number of small operations) were not included in the survey.

Information on unit labor requirements was contained in the special cooperative report supplied to the National Research Project by the United States Forest Service. This report also contained information on unit labor requirements in 58 operations in the Lake States. This information is summarized in table D-5 in comparison with data for the Southern Forest Survey territory.

DATA ON LIFE EXPECTANCY OF MILLS

The information on life expectancy of mills presented in table 30² was obtained from 8,486 operations. These operations were asked how long a

²See p. 120.

lifetime they anticipated in the immediate vicinity of their 1934 location. Information on 1934 output, rated daily capacity, number of persons employed when operating at capacity, and number of hours worked when operating at capacity provided the basis for determining the 1934 "employment" of individual mills. These "employment" figures represent the number of man-years of employment required to produce the 1934 output. A man-year was arbitrarily assumed to be made up of 200 10-hour working days.

Replies to the question on life expectancy represented, of course, the operators' best opinions. In the case of a number of the largest mills which were cutting virgin timber from their own lands the answers were definite and probably rather accurate. Answers from mills cutting remnant old-growth stands, second-growth timber, and purchased timber were often indefinite and at best were good guesses. Answers from portable mills, which operate at each new location on small stands and which frequently compete with other mills in cutting these stands, are probably rough guesses. The United States Forest Service has found that operators are more likely to err in the direction of underestimating the future timber supply. On the other hand, the Forest Service has estimated that southern mills were in general operating at about a third of capacity in 1934; operators may have based their estimates of anticipated lifetime in the 1934 vicinity on an assumed future extent of capacity utilization varying from the proportion of capacity utilized in 1934 to full capacity utilization.

The data in table 30, therefore, can be used only to indicate the impact of timber depletion on the security of job tenure of workers attached to southern mills. They cannot be used as a basis for determining employment opportunities to be afforded by southern mills or unemployment resulting from the cutting-out of mills.

The source of the data on life expectancy was a United States Forest Service memorandum to I. F. Eldredge, who directed the Southern Forest Survey. A copy of this memorandum, dated December 2, 1936, was made available to the National Research Project by the Forest Service.

ANALYSIS OF THE SAMPLES

Number of Mills

Table D-6 presents, for the southern forest territory as a whole, the proportion of the mills in each size class covered by the various samples. The equipment samples included roughly 10 percent of all mills. In each of these samples, however, a much greater proportion of the large than of

the small mills was covered. The samples of mills having a daily capacity of at least 40 thousand board feet were quite large, constituting more than 60 percent of all mills of that size. An adequate sample of about 35 percent of the medium-size mills (those having a daily capacity of 20 to 39 thousand board feet) was obtained. The number of smaller mills covered is large although the percentages which the samples comprise of the totals are small. About 8 percent of the mills having a daily capacity of 10 to 19 thousand board feet are included in the equipment samples; the percentages for mills having a daily capacity of less than 10 thousand board feet are about half this magnitude. The very small mills which serve neighborhood markets are inadequately represented in the samples; however, the large numerical representation of small mills tends to compensate this inadequacy.

The sample used for data on unit labor requirements is somewhat smaller than the equipment samples. Of the 8,702 mills in the territory, 651, or $7\frac{1}{2}$ percent, were included in the sample. In terms of size groups, 45 percent of the large, 23 percent of the medium, and 4 to 5 percent of the small mills were covered.

The life-expectancy sample covers $97\frac{1}{2}$ percent of the mills. Coverage of each size group exceeds 95 percent and in one case (mills with a daily capacity of 40 to 79 thousand board feet) is as high as 100 percent.

Geographic Distribution

An analysis was also made in order to determine the geographic representativeness of the equipment and unit-labor-requirement samples (table D-7). The Southern Forest Survey territory is divided into four regions (see figure D-1). The longleaf-slash pine region includes the area bordering on the Gulf coast and Florida and constitutes the core of the naval-stores industry. The eastern pine-hardwood region encompasses the northern portions of Alabama, Georgia, and Mississippi; it contains over half the mills in the territory, but about 99 percent of its mills have a daily capacity of less than 40 thousand board feet. The western pine-hardwood region (western portions of Arkansas and Louisiana and eastern portions of Oklahoma and Texas) contains, on the other hand, nearly three-fifths of the mills having a daily capacity of at least 80 thousand board feet. The Delta hardwood region (eastern Arkansas and Louisiana, southeastern Missouri, and western Mississippi) has a larger than average proportion of mills with a daily capacity of 40 to 79 thousand board feet but only one mill in the largest size group.

Only 8,112 of the 8,702 mills in the Southern Forest Survey territory could be distributed by region, but it is believed that these 8,112 mills

truly represent the existing distributions. For purposes of table D-7, therefore, the regional distribution of 8,112 mills was assumed to represent the distribution of all mills in the territory.

Examination of table D-7 reveals that the regional distributions of the four samples are approximately the same within each size group. In general the regional distributions of all mills and of sample mills are roughly similar. Pronounced differences in the regional distributions occur primarily in size classes containing large numbers of mills. Conversely, total and sample distributions agree rather closely in the large-size groups which contain comparatively small numbers of mills. It may also be recalled that coverage was greatest for large mills.

Because the eastern pine-hardwood region contains the largest proportion of small mills, it is not surprising to find that this region is relatively underrepresented in the samples. On the other hand the Delta hardwood region, which has a comparatively small proportion of small mills, is relatively overrepresented in the samples.

Of the four samples, the regional distributions of the unit-labor-requirement sample compare least favorably with the distributions for all mills, regardless of size group. In this respect it may be recalled that the coverage of this sample was less complete than that of the others.

Species Cut

Sample mills in the various size groups were distributed according to the species of lumber dominating the mills' output (table D-8). Similar distributions were made for 8,112 mills in the territory.³ Comparisons revealed that the distributions agreed closely and that on the whole the various species predominated in the output of sample mills to the same degree as in the output of all mills in the territory. To some extent, however, among mills having a daily capacity of less than 40 thousand board feet, mills cutting pine were relatively underrepresented and those cutting hardwood were relatively overrepresented.

³See pp. 188-9.

Table D-1.- NUMBER OF OPERATIONS IN SOUTHERN FOREST SURVEY TERRITORY REPORTING SPECIFIED SHORT-HAUL EQUIPMENT, BY SPECIES OF LUMBER CUT AND DAILY MILL CAPACITY, 1934

Equipment	Species of lumber cut and daily capacity (M. ft. b. m. per 10-hr. day)														
	Pine					Hardwood					Cypress				
	1-9	10-19	20-39	40-79	80 or over	1-9	10-19	20-39	40-79	80 or over	1-9	10-19	20-39	40-79	80 or over
Total number of operations reporting	116	189	154	45	51	57	48	84	55	7	9	8	8	4	3
Number reporting -															
Animals	96	152	121	38	33	54	46	74	40	4	6	9	1	1	0
Animals only	86	108	65	18	13	43	27	19	13	3	5	2	0	0	0
Tractors	4	17	22	7	12	2	9	20	21	3	1	0	2	1	2
Tractors only	1	7	7	2	4	1	0	2	3	0	1	0	1	0	0
Steam skidders	0	2	1	5	16	0	0	4	4	2	0	1	2	3	3
Steam skidders only	0	0	0	2	8	0	0	2	3	1	0	0	1	1	0
Gas skidders	9	31	43	6	4	1	4	19	3	0	1	4	2	2	0
Gas skidders only	2	5	2	0	0	0	1	1	1	0	1	3	1	0	0
Trucks	16	33	28	11	12	11	10	26	11	0	1	1	1	0	0
Trucks only	15	24	23	2	3	0	0	4	5	0	0	0	0	0	0
Pullboats	0	0	0	0	0	0	0	1	6	0	0	1	2	0	1
Pullboats only	0	0	0	0	0	0	0	0	3	0	0	1	1	0	0
Floats or water	0	1	0	1	0	1	2	4	1	1	1	0	0	1	0
Hand logging	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Animals and mechanical equipment	10	46	56	20	20	11	13	54	26	1	1	1	1	1	0
Combinations of mechanical equipment	0	0	2	0	3	1	1	1	1	1	0	1	3	1	3

Table D-2.- NUMBER OF OPERATIONS IN SOUTHERN FOREST SURVEY TERRITORY REPORTING SPECIFIED LONG-HAUL EQUIPMENT, BY SPECIES OF LUMBER CUT AND DAILY MILL CAPACITY, 1934

Equipment	Species of lumber cut and daily capacity (M ft. b. m. per 10-hr. day)														
	Pine					Hardwood					Cypress				
	1-9	10-19	20-39	40-79	80 or over	1-9	10-19	20-39	40-79	80 or over	1-9	10-19	20-39	40-79	80 or over
Total number of operations reporting	123	194	155	48	53	54	51	88	58	6	9	9	7	4	3
Number reporting -															
Trucks	100	188	151	31	31	50	48	80	40	4	6	6	2	1	1
Trucks only	93	169	131	11	2	25	33	21	9	1	4	4	1	1	0
Railroads	1	7	11	33	49	5	5	52	41	5	0	2	4	2	3
Common carriers	0	3	10	9	15	5	5	46	31	2	0	1	2	0	2
Logging	1	4	1	25	44	0	0	9	21	4	0	1	3	2	3
Railroads only	0	1	0	14	20	0	0	6	10	2	0	1	3	2	2
Animals	29	13	6	1	1	23	9	1	0	0	4	1	0	0	0
Animals only	23	7	2	0	0	3	2	0	0	0	2	0	0	0	0
Water	1	6	6	4	5	4	5	18	20	1	2	3	3	1	0
Water only	0	0	2	3	1	1	1	2	5	0	1	2	2	1	0
Tractors	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
Railroads and trucks	1	6	11	19	29	5	5	48	28	3	0	1	1	0	1
Trucks and animals	5	6	4	1	0	20	7	1	0	0	2	1	0	0	0
Water, and trucks or railroads	1	6	4	1	4	3	4	18	15	1	1	1	1	0	0

APPENDIX D

Table D-3.- NUMBER OF OPERATIONS IN SOUTHERN FOREST SURVEY TERRITORY REPORTING SPECIFIED SAWMILL EQUIPMENT,
BY SPECIES OF LUMBER CUT AND DAILY MILL CAPACITY, 1934

Equipment	Species of lumber cut and daily capacity (M ft. b. m. per 10-hr. day)														
	Pine					Hardwood					Cypress				
	1-9	10-19	20-39	40-79	80 or over	1-9	10-19	20-39	40-79	80 or over	1-9	10-19	20-39	40-79	80 or over
Total number of operations reporting	125	201	162	48	56	63	51	95	60	7	9	10	7	4	3
Number reporting -															
Saws and accessories only	79	49	15	0	2	51	37	44	7	0	9	7	4	0	0
Resaws	1	8	31	27	27	2	3	13	41	5	0	0	0	2	1
Resaws only ^a	0	1	1	1	0	2	0	4	11	1	0	0	0	0	0
Gang saws	0	0	5	8	27	0	0	0	3	2	0	1	0	2	3
Gang saws only ^a	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0
Planers	46	148	140	47	53	9	12	44	34	5	0	2	3	4	2
Planers only ^a	32	58	22	1	0	6	8	17	3	1	0	2	2	0	0
Dry kilns	13	91	118	43	53	4	4	24	28	3	0	0	1	2	2
Dry kilns only ^a	0	2	5	0	0	1	2	3	3	0	0	0	0	0	0
Hand saws	2	1	30	33	51	1	9	23	59	7	0	1	6	4	3
Circular saws	123	200	132	15	5	62	42	12	1	0	9	9	1	0	0

^aIn addition to saws and accessories.

**Table D-4.-- LOGGING AND SAWMILL UNIT LABOR REQUIREMENTS
OF OPERATIONS IN SOUTHERN FOREST SURVEY TERRITORY,
BY SPECIES OF LUMBER CUT AND DAILY
MILL CAPACITY, 1934**

Species of lumber cut and daily capacity (M ft. b. m. per 10-hr. day)	Number of mills	Number of man-hours per thousand board feet		
		Total	Logging	Sawmill
Total, including cypress				
1- 9	169	26.0	11.5	14.5
10-19	173	26.6	10.8	15.8
20-39	164	32.5	13.8	18.7
40-79	60	37.0	14.9	22.1
80 or over	45	31.0	9.9	21.1
Pine				
1- 9	136	24.5	10.9	13.6
10-19	142	25.8	10.2	15.6
20-39	92	30.3	12.8	17.5
40-79	39	39.7	15.5	24.2
80 or over	37	31.1	9.9	21.2
Hardwood				
1- 9	49	30.1	13.1	17.0
10-19	29	29.2	13.0	16.2
20-39	67	35.1	14.9	20.2
40-79	39	32.9	13.6	19.3
80 or over	5	26.4	10.8	15.6

**Table D-5.-- UNIT LABOR REQUIREMENTS OF OPERATIONS IN SOUTHERN
FOREST SURVEY TERRITORY AND IN THE LAKE STATES,
BY DAILY MILL CAPACITY, 1934^a**

Daily capacity (M ft. b. m. per 10-hr. day)	Southern Forest Survey territory		Lake States	
	Number of operations	Man-hours per M ft. b. m. ^b	Number of operations	Man-hours per M ft. b. m.
1-19	362	26	44	34
20-39	164	32	9	59
40 or over	125	35	5	44

^aData cover both logging and sawmill activities of each of the operations.

^bFigures represent weighted averages of those for more detailed size classifications in table D-4, the numbers of mills being used as weights.

Table D-6.- DISTRIBUTION OF ALL AND OF SAMPLE OPERATIONS IN SOUTHERN FOREST SURVEY TERRITORY,
BY DAILY MILL CAPACITY, 1934

Daily capacity (M ft. b. m. per 10-hr. day)	Total number of oper- ations	Number of operations in sample					Sample operations as percent of all operations				
		Short- haul equip- ment	Long- haul equip- ment	Sawmill equip- ment	Unit labor require- ments	Length of life	Short- haul equip- ment	Long- haul equip- ment	Sawmill equip- ment	Unit labor require- ments	Length of life
Total	8,702	839	862	901	651	8,486	9.6	9.9	10.4	7.5	97.5
1- 9	4,468	182	186	197	189	4,372	4.1	4.2	4.4	4.2	97.9
10-19	3,243	245	254	262	173	3,150	7.6	7.8	8.1	5.3	97.1
20-39	715	246	250	264	164	691	34.4	35.0	36.9	22.9	96.6
40-79	174	105	110	112	80	174	60.9	63.2	64.4	46.0	100.0
80 or over	104	61	62	66	45	99	58.7	59.6	63.5	43.3	95.2

Table D-7.- DISTRIBUTION OF ALL AND OF SAMPLE OPERATIONS IN SOUTHERN FOREST SURVEY TERRITORY,
BY DAILY MILL CAPACITY AND REGION, 1934

Daily capacity (M ft. b. m. per 10-hr. day) and region	Number of operations					Percent of group total				
	All operations ^a	Sample operations				All operations	Sample operations			
		Short- haul equip- ment	Long- haul equip- ment	Sawmill equip- ment	Unit labor require- ments		Short- haul equip- ment	Long- haul equip- ment	Sawmill equip- ment	Unit labor require- ments
1-19	7,309	427	440	459	362	100	100	100	100	100
Longleaf-slash pine	1,347	112	120	122	129	18	26	27	27	36
Pine hardwood, east	4,213	162	166	170	114	58	38	38	37	31
Delta hardwood	517	82	83	89	62	7	19	19	19	17
Pine hardwood, west	1,232	71	71	78	57	17	17	18	17	18
20-39	561	246	250	264	164	100	100	100	100	100
Longleaf-slash pine	121	72	71	75	57	22	29	29	29	36
Pine hardwood, east	207	88	88	93	33	37	36	35	35	20
Delta hardwood	47	27	30	35	30	8	11	12	13	18
Pine hardwood, west	186	59	61	61	44	33	24	24	23	27
40-79	153	105	110	112	80	100	100	100	100	100
Longleaf-slash pine	43	28	29	28	21	28	26	26	25	26
Pine hardwood, east	30	15	16	15	9	20	14	15	13	11
Delta hardwood	38	31	31	32	29	25	30	28	29	37
Pine hardwood, west	42	31	34	37	21	27	30	31	33	26
80 or over	89	61	62	66	45	100	100	100	100	100
Longleaf-slash pine	25	22	23	23	15	28	36	37	35	33
Pine hardwood, east	12	9	9	9	6	14	15	14	14	13
Delta hardwood	1	1	1	1	3	1	2	2	1	7
Pine hardwood, west	51	29	29	33	21	57	47	47	50	47

^aSee pp. 188-9.

Table D-8.- DISTRIBUTION OF ALL AND OF SAMPLE OPERATIONS IN SOUTHERN FOREST SURVEY TERRITORY,
BY DAILY MILL CAPACITY AND SPECIES OF LUMBER CUT, 1934

Daily capacity (M ft. b. m. per 10-hr. day) and species of lumber cut	Number of operations					Percent of group total				
	All oper- ations ^a	Sample operations				All oper- ations	Sample operations			
		Short- haul equip- ment	Long- haul equip- ment	Sawmill equip- ment	Unit labor require- ments		Short- haul equip- ment	Long- haul equip- ment	Sawmill equip- ment	Unit labor require- ments
1-19	7,309	427	440	459	362	100	100	100	100	100
Pine	6,158	305	317	326	280	84	71	72	71	77
Hardwood	1,127	105	105	114	78	16	25	24	25	22
Cypress	24	17	18	19	4	*	4	4	4	1
20-39	561	246	250	264	164	100	100	100	100	100
Pine	413	154	155	162	92	74	63	62	61	58
Hardwood	135	84	88	95	67	24	34	35	36	41
Cypress	13	8	7	7	5	2	3	3	3	3
40-79	153	105	110	112	80	100	100	100	100	100
Pine	66	45	48	48	39	43	43	44	43	49
Hardwood	80	56	58	60	39	52	53	53	54	49
Cypress	7	4	4	4	2	5	4	3	3	2
80 or over	89	61	62	66	45	100	100	100	100	100
Pine	76	51	53	56	37	86	84	85	85	82
Hardwood	10	7	6	7	5	11	11	10	11	11
Cypress	3	3	3	3	3	3	5	5	4	7

^aSee p. 189.

*Less than 0.5 percent.

APPENDIX E

RELATION OF SIZE TO UNIT LABOR REQUIREMENTS OF PACIFIC COAST SAWMILLS

The determination of the relationship between labor productivity and size of mill is complicated by differences in the character of product and the conduct of auxiliary activities. Thus relatively high unit labor requirements in larger mills may reflect a greater degree of finishing and byproduct production rather than less efficient utilization of labor.

Closer examination of the size-productivity relationship was possible for 37 of the large Pacific Coast sawmills covered in the NRP-NBER logging-camp and sawmill survey.¹ The man-hour ratios used for these mills are standard man-hour ratios based on equivalent production and were obtained from survey data.² The 1935-36 edition of the *Handbook and Directory of the Western Lumber Industries* was used to determine daily capacity and equipment of each of the mills.³

Table E-1 shows the average standard sawmill man-hour ratios for 18 mills having a daily capacity of 70 to 249 thousand board feet and for 19 mills having a daily capacity of 250 thousand board feet or more. From this table it appears that when differences in equipment are disregarded the average ratio for the larger mills is about 15 percent higher than that for the smaller ones. This is consistent with the findings of a 1929 study of Pacific Coast mills conducted by the United States Bureau of Labor Statistics.⁴ In the latter study it was found that man-hour productivity decreases with size of plant as measured by number of wage earners employed. This relationship held especially for mills which produced their own logs; man-hours spent in logging were included in the totals for those mills. In the case of the southern mills, also, as shown by data presented in chapter IV, labor productivity tended to decrease with an increase in the size of mill, although labor productivity was high in the group of largest mills.

It seems possible, however, that in the lumber industry the man-hour ratio for a mill is an inadequate measure of the efficiency of utilization of labor in that mill. It was pointed out in chapter III that differences in the degree of manufacture, waste utilization, manufacture of timber products other than lumber, and the extent to which maintenance

¹No small mills were covered in this survey. For a description of the survey see appendix A.

²For a description of the "standard" man-hour ratio see table E-1, fn. b.

³For a description of the data from the West Coast directories see appendix C.

⁴"Man-Hour Productivity in the Lumber Industry in the Pacific Coast States in 1929," *Monthly Labor Review*, Vol. 35, No. 4 (Oct. 1932), pp. 818-25.

work is done by the mill's own employees may affect the mill's man-hour ratio.

In the NRP-NBER logging-camp and sawmill survey the effect of variations in the proportion of lumber surfaced was largely eliminated by computing man-hour ratios on the basis of equivalent production. An effort was also made to exclude man-hours expended in the production of byproducts and special products, but it was not possible to separate and exclude such labor time completely. (See appendix A.) Since the larger mills carry on such auxiliary activities to a greater extent than the smaller ones, it seems likely that factors other than relative efficiency in the utilization of labor could account, at least in part, for the difference in average unit labor requirements observed in table E-1.

The existence of differences between size groups in the degree of finishing, extent of manufacture of byproducts and special products, and the volume of activity auxiliary to the production of lumber may be indicated in a rough fashion by differences in the kinds of equipment used. Table E-2 indicates the nature of some of these differences in 1936. There are no pronounced differences in the type of power and type of headsaw employed at the two groups of mills. However, the proportion of the mills having a daily capacity of at least 250 thousand board feet that used the labor-saving gang saw was much greater than the corresponding proportion for the smaller mills. This is the only difference in equipment which would indicate a basis for higher output per man-hour in the larger mills.

On the other hand, the fact that relatively more of the larger mills had planing mills and dry kilns indicates that a larger portion of the lumber produced by this group was seasoned and finished. Lath mills were more generally employed at the larger mills, suggesting that the utilization of waste through the manufacture of byproducts was more widespread. Few of the smaller mills had shingle mills or box factories, whereas a considerable fraction of the large mills did have them. A much greater percentage of the larger mills than of the smaller ones had their own machine shops, perhaps indicating that more of the maintenance and repair work was carried on by the mill itself in the case of the larger mills.

The presence or absence of these items of special equipment may be taken as a general indicator of the degree of manufacture and integration of activities at the sawmill. Table E-3 presents average standard unit labor requirements of the 37 mills grouped according to the number of items of special equipment employed.⁵ The data in this table suggest,

⁵Gang saws and planing mills were not taken into account in this and the following table. Mills reporting the use of each of the special-equipment items reported the use of the following five items: Box factory, dry kiln, lath mill, machine shop, and shingle mill.

though by no means conclusively, that these factors, rather than size as such, are responsible for the differences in average labor requirements.

This conclusion is strengthened by an examination of table E-4. Thus, when a comparison is made of the standard average unit labor requirements of mills in the two size groups on the basis of the number of different items of special equipment reported, it appears that the larger mills have somewhat lower average unit labor requirements.

Of the 37 mills considered in this appendix, 7 did not report the use of dry kilns in 1936 (each of the 7 also did not report the use of at least one of the four other items of special equipment used in tables E-3 and E-4).⁶ These seven mills had an average standard man-hour ratio of 5.25, a figure strikingly lower than the average of 7.91 for all 37 mills. This suggests that mills which use dry kilns and thereby, presumably, accomplish a reduction in time-in-process, an improvement in quality, and a reduction in shipping weights do so at the expense of labor productivity.

Whether or not the higher labor productivity apparently associated with the smaller mills employing fewer items of special equipment compensates for the loss of the advantages associated with the use of such equipment probably depends on the character of the market which these mills seek to enter. Thus the materially lower man-hour ratios of the mills employing less special equipment need not reflect more efficient use of labor despite the fact that these mills have a greater volume of output per unit of labor time expended.

Table E-1.- UNIT LABOR REQUIREMENTS OF 37 LARGE PACIFIC COAST SAWMILLS, BY DAILY CAPACITY, 1936^a

Daily capacity (M ft. b. m.)	Number of plants	Standard man-hour ratio ^b
Total	37	7.91
70-249	18	7.34
250 or over	19	8.45

^aIn this and subsequent tables the man-hour ratios of the mills are based upon the NRP-NBER logging-camp and sawmill survey (see appendix A); the capacity and equipment data for the mills were obtained from the 1935-36 edition of the *Handbook and Directory of the Western Lumber Industries* (see appendix C).

^bRatios shown are unweighted averages of standard ratios for individual mills. Standard ratios for each mill were calculated by computing the weighted average of the mill's man-hour ratios for those years during the period 1928-30 in which the percentage of capacity utilized by the mill was between 70 and 89. Thus the effects on unit labor requirements of differences in capacity utilization and of random year-to-year fluctuations were minimized.

^cOf the seven, three had a daily capacity of at least 250 thousand board feet; the other four were in the smaller-size group.

Table E-2.- DISTRIBUTION OF 37 LARGE PACIFIC COAST SAWMILLS, BY DAILY CAPACITY AND TYPE OF EQUIPMENT REPORTED, 1936^a

Type of equipment reported	Daily capacity (M ft. b. m.)			
	70-249		250 or over	
	Number of mills	Percent of total	Number of mills	Percent of total
Type of power	16	100.0	16	100.0
Steam power	2	12.5	2	12.5
Electric power	4	25.0	2	12.5
Steam and electric power	10	62.5	12	75.0
Type of headsaw	16	100.0	19	100.0
Band saw	16	88.9	17	89.5
Circular saw	2	11.1	0	0
Band and circular saws	0	0	2	10.5
Special equipment	16	-	19	-
Box factory	2	11.1	4	21.1
Dry kiln	14	77.8	16	84.2
Gang saw	5	27.8	13	68.4
Lath mill	11	61.1	17	89.5
Machine shop	8	44.4	15	78.9
Planing mill	17 ^b	94.4 ^b	19	100.0
Shingle mill	0	0	8	42.1

^aSee table E-1, fn. a.

^bAlthough each of the NRP-NBER mills engaged in surfacing, one of the mills did not have a complete planing mill attached.

Table E-3.- UNIT LABOR REQUIREMENTS OF 37 LARGE PACIFIC COAST SAWMILLS, BY NUMBER OF TYPES OF SPECIAL EQUIPMENT REPORTED, 1936^a

Number of types of special equipment reported ^b	Number of mills	Standard man-hour ratio
All five reported	10	10.21
Four reported	8	7.72
Three reported	12	7.10
Two or less reported	7	6.26

^aSee table E-1, fnns. a and b.

^bThe five types of special equipment considered in this table are box factories, dry kilns, lath mills, machine shops, and shingle mills.

Table E-4.- UNIT LABOR REQUIREMENTS OF 37 LARGE PACIFIC COAST SAWMILLS, BY NUMBER OF TYPES OF SPECIAL EQUIPMENT REPORTED AND DAILY CAPACITY, 1936^a

Number of types of special equipment reported ^b and daily capacity	Number of mills	Standard man-hour ratio
Five or less reported (all 37 mills)		
70-249	18	7.34
250 or over	19	8.45
Four or less reported		
70-249	17	7.29
250 or over	10	6.88
Three or less reported		
70-249	13	7.29
250 or over	6	5.70

^aSee table E-1, ftms. a and b.

^bSee table E-8, ftm. b.

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