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FINANCIAL ASPECTS OF SELECTIVE CUTTING IN THE MANAGEMENT OF SECOND GROWTH
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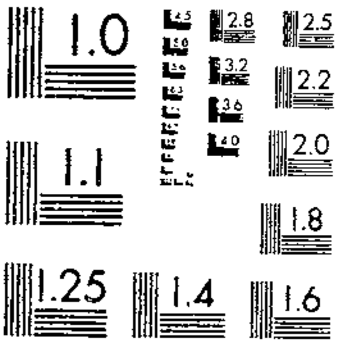


MICROCOPY RESOLUTION TEST CHART
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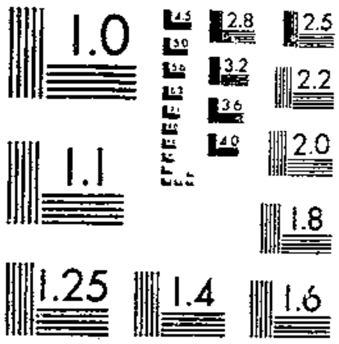


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# Financial Aspects of Selective Cutting in the Management of Second-Growth Pine-Hardwood Forests West of the Mississippi River[1]

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## INTRODUCTION

The shortleaf pine-loblolly pine-hardwood forests west of the Mississippi River typically are young second-growth forests. There is very little old-growth timber, and not much second growth large

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[2] The writers acknowledge their indebtedness to the Crossett Lumber Co., Crossett, Ark., which furnished all equipment and timberland for the study, and to the Charles Lathrop Pack Forestry Foundation, which awarded a fellowship to the senior author for 2 years as a help in financing the study. Credit is due the following members and former members of the Forest Service: A. E. Wackerman, formerly of the Southern Forest Experiment Station, who made many valuable suggestions as to methods and procedures for the study; R. A. Chapman, for assistance in analysis of field data; W. N. Sparhawk, for technical review of the manuscript; Ike Rawls; and C. C. Delavan. A group of CCC boys rendered invaluable assistance in the field work, and K. E. Thomson and her associates, in New Orleans, in the Work Projects Administration, assisted with the computations.

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enough for good sawlogs. In most stands, all of the merchantable trees have been cut at least once during the past 30 years, and the residual stands have been damaged by repeated fires. In consequence, practically all of the stands, except some of those that have come up on abandoned fields, are understocked. Small trees are too few and too unevenly distributed to make full stands, and the stocking of larger trees is still more inadequate. In the average stand, there are less than one-fourth as many trees more than 12 inches in diameter as there should be to utilize fully the productive capacity of the forest land. Many of the trees have crooked or limby stems and inadequate crowns, or are fire-scarred and partially decayed, or for other reasons are growing slowly and not likely to make good timber. The stands are generally uneven-aged, except those on old fields, and even those exhibit a considerable range of tree sizes. Whether the stands are dense or open, large and small trees are usually intermingled, singly and in groups.

The methods of exploitation that prevailed in the past are not well adapted to the understocked young stands of today. It is necessary to adopt new methods, which will yield a reasonable current income to landowners and operators, and at the same time enable the forest to build up a growing stock more in harmony with the productive capacity of the land. If production of sawlogs is to be permanent and profitable, cutting practices in the woods must be constantly studied and revised to assure greater and more valuable yields, and utilization standards and methods of transportation must be improved to increase the margin of income over cost. These are not impossible objectives; they do, however, demand a realistic view of the situation and intelligent planning. The time has come when the best brains of the forest-products industries must be applied to the woods' end of the operations and not confined to the manufacture and sale of lumber.

The development of modern motor trucks and trailers has made it possible to adopt methods of logging that would not have been practical a few years ago. With railroad logging, commonly employed in the larger operations in the South, there was little opportunity for adapting cutting operations to current market demands. If an area supporting low-grade timber was being logged, everything was satisfactory so long as the demand was for low-grade construction material; but if the demand shifted to high-grade material and the nearest stand of high-grade timber was 15 miles away from the railroad, it was practically impossible to pick up and move to that area. The mill could fill only those orders calling for the grade of material that was being cut at the time. In logging with trucks, on the other hand, it is entirely feasible to cut what the market demands. If an order calls for material of special size or grade, it is possible to cut the logs, deliver them to the mill, saw them up, and place the lumber in dry kilns within a day or two, and be ready to ship within a few days. Thus, the timber operator can take full advantage of market fluctuations, can salvage timber killed by fire, insects, or windstorms, and can make thinnings as and where they are needed. In this way, much material can be utilized that would be lost if its extraction depended upon reaching it by railroad.

This bulletin presents the results of a study of some of the economic aspects of timber management in the shortleaf pine-loblolly pine-hardwood type west of the Mississippi River. The purpose of this study was two-fold: First, to test on a commercial logging operation the financial feasibility of light cuts under the selective method; and, second, to show owners how to apply the results of the study in managing second-growth forests of this type so as to maintain profitable operations now and produce greater yields of better timber in the future.

The system of management that was investigated is frequently referred to in this report as "selective timber management." It is described in Part I. It was chosen for intensive study of its financial aspects because it appeared to be readily applicable to the mixed, uneven-aged, second-growth stands that generally occur in the region. Selective timber management has not been tested in this forest type by a long period of trial, and subsequent development of the stands under the treatment prescribed may indicate the need of modifications. So far, however, the system has proved satisfactory on the study area.

The permanent sample plots, near Crossett, Ark., that were provided by the Crossett Lumber Company for the field work of the studies discussed here were located in second-growth forests selected as typical of the region. The old-growth timber was cut about 1913; practically all the merchantable pine and most of the high-grade hardwood trees were removed. Before protective measures were adopted, in 1927, frequent fires destroyed many of the smaller trees and injured the larger ones. Even since 1927, there have been several destructive fires within the protected area. Consequently there is but little advance young growth, and many of the larger trees have defective butt logs. In the sample plots, pines and hardwoods each make up approximately 50 percent of the number of trees above 11 inches in diameter, but in the smaller diameters pines are about twice as numerous as hardwoods.[3]

Because of the many economic phases of these studies and the varied techniques necessary to deal with them, it has been convenient to arrange the subject matter of this bulletin in four parts.

Part I explains the major objectives of selective cutting in management of second-growth shortleaf pine-loblolly pine-hardwood forests and the problems involved in starting and carrying on a program of management for sustained yield. It contributes to an understanding of the nature of the forests, especially of the great range in values of the individual trees. It also aims to make clear the natural factors of forest production; the precautions needed to conserve them; and the need of cutting practices that will yield immediate income and at the same time lay foundations for larger future incomes.

Part II reports on thorough tests, in commercial logging operations, to determine the costs and the general feasibility of selective cutting of different volumes per acre, leaving specified volumes as the basis for future growth. These tests have proved that on the flat lands and gentle slopes characteristic of the region, if suitable logging equipment and methods are employed, the volume cut can be adjusted to the needs of sound forest management without any financial loss.

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[3] A list of the common and botanical names of the commercial tree species present is given in the appendix.

Part III describes techniques by which individual tree and log values can be determined with reasonable accuracy, and presents the results of applying them to the study data. These findings are directly applicable over a considerable area. The cost data are valid over a still wider territory. Of chief importance, however, is the showing that the second-growth pine-hardwood forests contain a wide range of values which owners can recover most profitably by cutting only the trees that will yield necessary immediate income and preserving those that will continue to grow at a profitable rate. The desirability of close study of each property by the owner, or by a competent technician in his behalf, is emphasized.

Part IV deals with the application to second-growth pine-hardwood stands of the selective-cutting methods developed in the studies. It sums up the results of the studies from the viewpoint of obtaining currently needed forest products, and income for the owner, the operator, and workers by operations conducted in such a manner that even better returns can be expected in the future.

## I. SELECTIVE CUTTING AND FOREST PROBLEMS INVOLVED IN MANAGEMENT FOR SUSTAINED YIELD

Large areas of land in Arkansas, Louisiana, Texas, and southeastern Oklahoma bear stands of shortleaf and loblolly pines, often containing substantial volumes of upland hardwoods. Surveys and studies have well established the fact that these forests are producing less than half as much timber as they are capable of producing. Undoubtedly, general application of sound principles of forest management could double the rate of production in 20 years or less.

### Sustained-Yield Management

A major objective of sound forest management is sustained yield. Sustained-yield forest management may be defined as management of a given forest tract under a systematic plan whereby it yields a substantially constant output of timber products.

In placing forests under sustained-yield management, the aim is not merely to maintain present output, but further than that, to build up the stands so that they will yield more and better timber. Forest owners should not be satisfied with the low yields from neglected and mismanaged forests. Mismanagement consists of premature cutting of trees and stands; removal of the better trees, leaving the poorer ones; failure to regulate density by thinning overstocked stands and filling blank spaces in understocked stands; lack of provision for regeneration; and absence of protection against fire and other sources of damage. Forests handled in this manner cannot produce more than a fraction of their potential yields, either in volume or in quality.

While sustained-yield management can be applied with various degrees of profit to most forest properties, many do not at present qualify. For example, on the large areas where all of the merchantable timber has been cut or will be cut within a few years, returns will not meet carrying charges for many years to come, no matter how well the land may be managed.

## Selective Timber Cutting

In understocked stands, which constitute more than 90 percent of the forests of this region, the aim of sustained-yield management is to build up the volume and quality of the merchantable timber. The volume can be increased by currently removing less volume than is added by growth, and the quality can be improved by removing trees of poor form and vigor and holding the better-formed and more vigorous trees until they are financially mature. These purposes can be accomplished by light and frequent selective cutting.

Forest management in general involves several different kinds of cutting, namely, release cutting, thinning, improvement cutting, and harvest cutting. Release cutting is done to free desirable sprouts, seedlings, and small saplings from harmful competition; thinning is to reduce density in stands of large saplings and poles; improvement cutting, sometimes including thinning, involves the removal of less desirable trees in stands of any size above saplings; and harvest cutting takes the mature trees of the main crop. Selection cutting is one of several harvest-cutting methods. In forests cut under the selection method, the operations may take place in sequence as stated above or, more generally, may be combined in one or more cuttings in which all of the purposes indicated are accomplished each time the area is cut over. The term "selective cutting" in this report connotes all these types of cutting.

The merchantable timber stand is never cut all at once but, instead, single trees, usually the largest, or small groups of trees are removed and reproduction is obtained under the remaining stand and in the openings. A growing stock including trees of all sizes, from seedlings to sawlog trees, is left. Under this system, timber can be harvested from the same stand continuously, without the long waiting periods that are required under other methods of cutting.

## Selective Timber Management

Selective cutting can be applied to one acre, one stand, or a whole forest property. When applied to an organized forest, it becomes more than a method of cutting; it becomes a system of forest management, inasmuch as it dictates the character of the protection system, the lay-out of roads, the method of logging, the organization of the forest into working units, the order of cutting operations, and the size and character of the sawmills and other processing plants. This system of management, built around the selection method of cutting, is designated as "selective timber management" throughout this report.

In an organized industrial forest, selective timber management contemplates cutting in most of the compartments or subdivisions at intervals of 3 to 12 years. Although cutting and logging are carried on periodically in each compartment, the operations are continuous in the forest as a whole. It is the aim to cut over as many compartments each year as will yield enough timber to meet the requirements of the owner, within limits set by the productive capacity of his forest, the manufacturing capacity of his mill, and his ability to market the product at a profit. The choice of the compartments to be cut each year is guided mainly by: (1) the relative ripeness of the stands for cultural and harvest cutting; and (2) the desirability of equalizing logging costs through balancing short against long hauls from stump to mill.

The data on costs and returns and the discussion of values derived from the tests made in this study apply directly to selective-cutting practices regardless of the particular over-all management system employed. In Part IV, the application of this material to selective management of an organized forest is indicated. However, a full treatment of this subject, which covers the procedures through which an industrial forest property becomes a going business, would require more space than can be given in this bulletin.

## Subdivision of Forest Property

Actual woods operations for sustained yield must be applied to definite units of area and specific growing-stock conditions. Before cutting is started, a forest should be subdivided into blocks and compartments for purposes of administration, control of logging, and record keeping. In large properties, blocks usually exceed 50,000 acres in area. Compartments are final units of management and on large properties usually include from 300 to 1,500 acres, bounded by a combination of roads, streams, and land lines. In a country covered by a public-land survey, sections of 640 acres or smaller are convenient units. All compartment boundaries should be plainly marked on the ground and accurately mapped.

It is advantageous to segregate hardwood bottom lands in separate compartments, but it is not necessary that pine stands be separated by stand conditions, for after some years of selective management all pine stands will tend to become fairly uniform as to stand condition. Compartments, being the units of record keeping and logging control, should be carefully laid out for permanence and with the definite purpose of establishing and maintaining an adequate but simple system of permanent records. It is obvious that a well-devised road system is necessary if the lowest costs possible are to be attained by motorized logging.

## Forest Protection

Forest protection is essential to sustained yield and should be initiated early in any management program.

### FIRE

Protection against fire involves the prevention of forest fires and their prompt detection and efficient suppression. For continued forest production in this forest type, a reasonable goal limits the average area burned annually to less than 1 percent of the area protected. State protection, as organized under the Clarke-McNary law of 1924, costs the private owner in this region between 2 cents and 4 cents an acre; however, emergency conditions may require additional expenditures by the owner.

Two conditions that characterize selectively cut shortleaf pine-loblolly pine-hardwood forests make fire protection relatively easy. The first is the small amount of fuel on the ground, which not only lessens the danger that fires will cause heavy damage to the living trees but also makes it possible to construct fire lines cheaply and expeditiously. The second is the density of the reserved stand, which reduces the velocity of the wind. It is common knowledge that in this region fires are far less difficult to control on timbered areas than in the open or in very light stands. The practice of cutting pulpwood from tops of felled sawlog trees further reduces the fire hazard and permits more efficient control of fires.

Selective timber management will be successful only if accidental fires are held to a minimum. Controlled burning to aid in the reduction of hardwood brush (*8*)[4] on some areas may have a place. As yet, the use of fire for this purpose is in the experimental stage, and a considerable amount of research is still needed before definite conclusions can be drawn.

### INSECTS

Observations made in selectively logged stands indicate that insects, particularly the engraver beetle (*Ips*) and to a less degree the southern pine beetle (*Dendroctonus frontalis*), have killed some timber. The volume of the trees killed, however, has generally been an insignificant proportion of the total volume of the stand. The little damage done has been in stands logged during the summer, particularly in those logged during a very dry period. Occasionally beetles are attracted to and infest trees that have been badly scarred in logging, more often those with wounds on the upper trunk than those with butt wounds. Control in most cases is quite easily accomplished by instructing saw crews to fell all trees that have been badly injured in the upper stems during an extremely dry period.

As is commonly known, there is always danger of some damage from insects during the dry summer months even though no cutting is in progress. This small loss, however, is not considered a serious deterrent to growing shortleaf and loblolly pine. Selective cutting, which removes the unthrifty and reserves the thrifty trees, should control rather than increase this damage.

### FUNGI OR DECAY

All timber stands contain some trees that have been attacked by rot-causing fungi. Unmanaged second-growth stands, particularly, in which all low-quality individuals were left from the first and later cuts contain relatively large numbers of infected trees, partly because of injuries from forest fires. Such trees should be removed from the stand as early as possible. With frequent light cuts the number of infected trees and the loss of volume can undoubtedly be reduced almost to the vanishing point within a relatively few years.

### DISTURBANCE OF GROWTH BY CUTTING OPERATIONS

When it is recognized that growing conditions approach the optimum in fully stocked stands and that such a stand consisting of useful species and trees of immediate or prospective value is laying on a

[4] Italic numbers in parentheses refer to Literature Cited, p. 103.

maximum of wood growth, it is obvious that ill-planned cutting operations may impair this maximum production. If too heavy cutting occurs, not only will an inadequate number of trees remain to lay on growth but those remaining may also be injured by excessive exposure to ice and wind. A program of light and frequent cutting is the simplest means of protecting second-growth stands against setbacks in growth. In shortleaf-loblolly pine stands, this means removing every 3 to 12 years from 50 to 100 percent of the periodic increase in volume, which is usually equivalent to 20 to 40 percent of the total merchantable volume. The shorter cutting intervals are suitable for small, closely supervised properties, and the longer for properties where cutting areas would be too extensive or stocking is too light to yield sufficient volume if cutting occurred every 3 to 7 years in each portion.

This light and frequent cutting procedure applies to virtually all species represented by merchantable-size classes. Although mature individual trees of all the species represented can usually be harvested in the same operations, in stands having many trees approaching maturity special cutting procedures may be necessary to avoid disproportionate regeneration of the less desired species.

Whenever for financial reasons more volume has to be removed than a uniform light cut will provide, the additional cutting should generally be made in the most mature groups, leaving as much of the stand fully stocked as possible. Otherwise, losses of production will be caused by diverting growth from merchantable timber to brush and regeneration.

Even light cutting involves some injury to the stand, the extent of which depends on the care exercised in felling and skidding. Determination of the desirable length of cutting cycle (period between successive cuttings) may be considerably influenced by observations on the relative number and persistence of injuries associated with different cutting intervals. With well-trained workmen, however, these injuries are negligible.

## The Significance of the Growing Stock

Selective timber management for sustained yield aims to improve the growing stock by light selective cuts at short intervals. Since an ample, vigorous, and high-quality growing stock is required for maximum yields and returns, the growing stock is defined, classified, and discussed here in some detail (*2*).

### CLASSIFICATION OF GROWING STOCK

The *total growing stock* on a given area consists of all trees growing thereon, of whatever age and species. It includes seedlings and saplings, as well as trees of pole and sawlog size, whether merchantable or unmerchantable. It may appropriately be thought of as a variable quantity to which nature is continually adding and from which, within conservative limits, any desired portion can be withdrawn. It is best evaluated in terms of the number of trees in each diameter class, as shown by figure 1, *A*, for a typical 40-acre second-growth stand in the Crossett Experimental Forest. It may also be measured in terms of basal area,[5] as shown in figure 1, *B*. Partial stem volume can be expressed in cubic measure, as in figure 1, *C*. All of these bases of evalu-

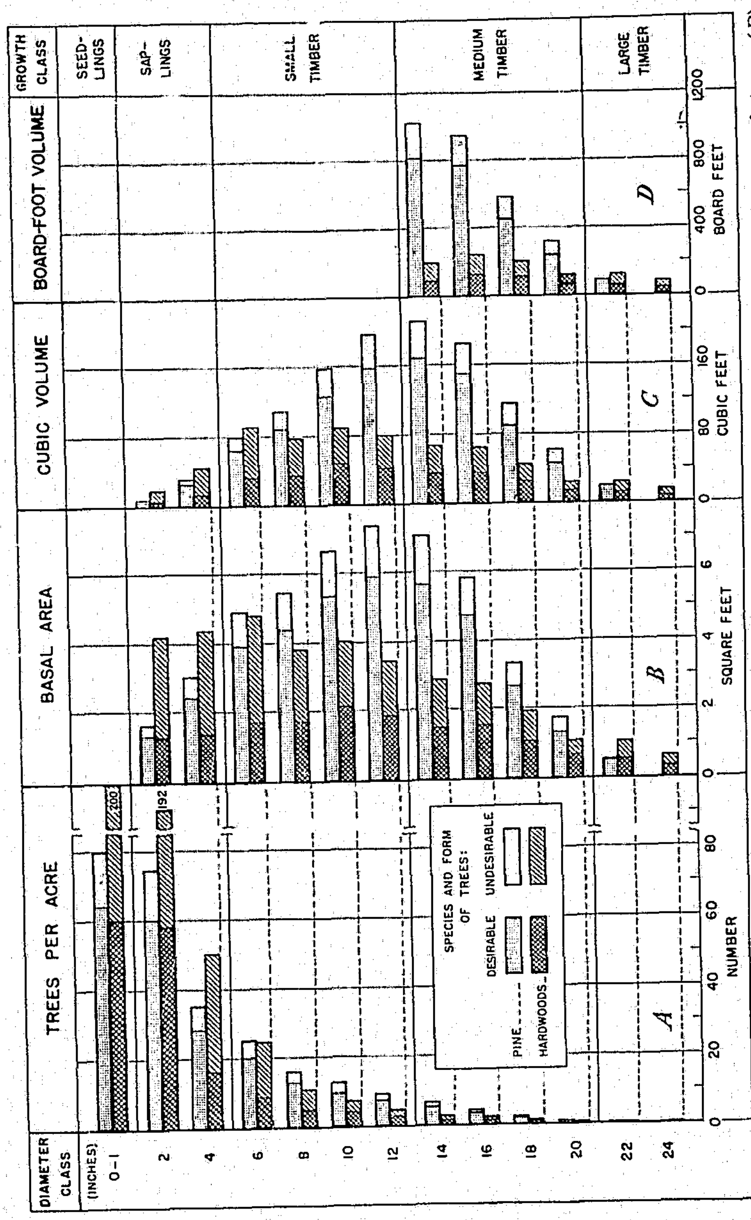


Figure 1.—Growing stock per acre of a fairly well-stocked area, expressed in terms of (*A*) number of trees (*B*) basal area, (*C*) volume in cubic feet, and (*D*) volume in board feet; defined in terms of combinations, by diameter class, of (1) significant growth classes, (2) pines and hardwoods, and (3) trees of desirable and undesirable form or species.

ation are given in table 1. In this table, the caption "undesirable" includes trees of low quality, such as extremely limby, crooked, badly suppressed, or otherwise defective trees.

[5] The basal area of a stand is the sum of the areas of the cross-sections of all trees in the stand, usually measured at breast height (4½ feet above the ground).

TABLE 1.—*Growing stock per acre of desirable and undesirable pine and hardwood species, by diameter (d. b. h.) class, in a typical second-growth stand*

| Diameter class (inches) | Pines | | | Hardwoods | | | All species |
|---|---|---|---|---|---|---|---|
| | Desirable | Undesirable | Total | Desirable | Undesirable | Total | |
| **NUMBER OF TREES** | | | | | | | |
| Seedling (0-1) | 64.0 | 16.0 | 80.0 | 60.0 | 140.0 | 200.0 | 280.0 |
| Saplings: | | | | | | | |
| 2 | 59.8 | 14.9 | 74.7 | 58.0 | 134.2 | 192.2 | 266.9 |
| 4 | 28.1 | 7.0 | 35.1 | 16.0 | 34.5 | 50.5 | 85.6 |
| Small timber: | | | | | | | |
| 6 | 20.1 | 5.0 | 25.1 | 8.7 | 16.0 | 24.7 | 49.8 |
| 8 | 12.6 | 3.1 | 15.7 | 4.9 | 6.0 | 10.9 | 26.6 |
| 10 | 9.8 | 2.4 | 12.2 | 4.0 | 3.4 | 7.4 | 19.6 |
| 12 | 7.5 | 1.9 | 9.4 | 2.4 | 2.0 | 4.4 | 13.8 |
| Medium timber: | | | | | | | |
| 14 | 5.3 | 1.3 | 6.6 | 1.4 | 1.3 | 2.7 | 9.3 |
| 16 | 3.4 | .8 | 4.2 | 1.1 | .9 | 2.0 | 6.2 |
| 18 | 1.5 | .4 | 1.9 | .6 | .5 | 1.1 | 3.0 |
| 20 | .6 | .2 | .8 | .3 | .2 | .5 | 1.3 |
| Large timber: | | | | | | | |
| 22 | .2 | | .2 | .2 | .2 | .4 | .6 |
| 24 | | | | .1 | .1 | .2 | .2 |
| Total | 212.9 | 53.0 | 265.9 | 157.7 | 339.3 | 497.0 | 762.9 |
| **BASAL AREA AT BREAST HEIGHT IN SQUARE FEET** | | | | | | | |
| Saplings: | | | | | | | |
| 2 | 1.31 | 0.33 | 1.64 | 1.28 | 2.95 | 4.23 | 5.87 |
| 4 | 2.44 | .61 | 3.05 | 1.30 | 3.09 | 4.39 | 7.44 |
| Small timber: | | | | | | | |
| 6 | 3.94 | .98 | 4.92 | 1.70 | 3.14 | 4.84 | 9.76 |
| 8 | 4.40 | 1.08 | 5.48 | 1.71 | 2.09 | 3.80 | 9.28 |
| 10 | 5.34 | 1.31 | 6.65 | 2.18 | 1.85 | 4.03 | 10.68 |
| 12 | 5.89 | 1.49 | 7.38 | 1.88 | 1.57 | 3.45 | 10.83 |
| Medium timber: | | | | | | | |
| 14 | 5.66 | 1.39 | 7.05 | 1.50 | 1.39 | 2.89 | 9.94 |
| 16 | 4.74 | 1.12 | 5.86 | 1.54 | 1.25 | 2.79 | 8.65 |
| 18 | 2.65 | .71 | 3.36 | 1.06 | .88 | 1.94 | 5.30 |
| 20 | 1.31 | .44 | 1.75 | .65 | .44 | 1.09 | 2.84 |
| Large timber: | | | | | | | |
| 22 | .53 | | .53 | .53 | .53 | 1.06 | 1.59 |
| 24 | | | | .31 | .32 | .63 | .63 |
| Total | 38.21 | 9.46 | 47.67 | 15.73 | 19.41 | 35.14 | 82.81 |
| **VOLUME IN CUBIC FEET** | | | | | | | |
| Saplings: | | | | | | | |
| 2 | 6.0 | 1.5 | 7.5 | 5.8 | 13.4 | 19.2 | 26.7 |
| 4 | 25.3 | 6.3 | 31.6 | 14.4 | 31.0 | 45.4 | 77.0 |
| Small timber: | | | | | | | |
| 6 | 64.3 | 16.0 | 80.3 | 32.2 | 59.2 | 91.4 | 171.7 |
| 8 | 88.2 | 21.7 | 109.9 | 35.8 | 43.8 | 79.6 | 189.5 |
| 10 | 127.4 | 31.2 | 158.6 | 48.8 | 41.5 | 90.3 | 248.9 |
| 12 | 157.5 | 39.9 | 197.4 | 43.9 | 36.6 | 80.5 | 277.9 |
| Medium timber: | | | | | | | |
| 14 | 169.6 | 41.6 | 211.2 | 35.1 | 32.6 | 67.7 | 278.9 |
| 16 | 149.6 | 35.2 | 184.8 | 35.4 | 29.0 | 64.4 | 249.2 |
| 18 | 90.0 | 24.0 | 114.0 | 24.3 | 20.3 | 44.6 | 158.6 |
| 20 | 46.2 | 15.4 | 61.6 | 15.1 | 10.0 | 25.1 | 86.7 |
| Large timber: | | | | | | | |
| 22 | 19.6 | | 19.6 | 12.4 | 12.3 | 24.7 | 44.3 |
| 24 | | | | 7.6 | 7.6 | 15.2 | 15.2 |
| Total | 943.7 | 232.8 | 1,176.5 | 310.8 | 337.3 | 648.1 | 1,824.6 |
| **VOLUME IN BOARD FEET** | | | | | | | |
| Medium timber: | | | | | | | |
| 14 | 816 | 200 | 1,016 | 104 | 96 | 200 | 1,216 |
| 16 | 772 | 181 | 953 | 134 | 110 | 244 | 1,197 |
| 18 | 462 | 123 | 585 | 111 | 92 | 203 | 788 |
| 20 | 243 | 81 | 324 | 77 | 52 | 129 | 453 |
| Large timber: | | | | | | | |
| 22 | 104 | | 104 | 68 | 68 | 136 | 240 |
| 24 | | | | 44 | 44 | 88 | 88 |
| Total | 2,397 | 585 | 2,982 | 538 | 462 | 1,000 | 3,982 |

Of more influence on immediate sustained yield than the total growing stock is that part of it that may be termed the *merchantable growing stock*—trees of such size and quality that they will yield salable raw material when cut and properly prepared. Very few merchantable products can be made from southern pine trees below the 6-inch diameter class (i. e., trees under 5.0 inches d. b. h.);[6] this, therefore, is ordinarily the smallest diameter class for which basal area or volume need be computed.

Of still greater significance is the *sawlog growing stock*, or those trees of the salable species that are of a size and quality to make merchantable sawlogs. Sawlogs are frequently cut from smaller trees, but extensive studies, some as early as 1915 (*1*), have shown that the large commercial mills in the South can seldom make profitable use of sawlogs from trees under 13 inches d. b. h. Sawlog growing stock may be expressed in board-foot volume, as in figure 1, *D*.

The importance of producing high yields makes the protection and development of adequate forest growing stock the primary requirements of forest management.

In order to consider both the possible utilization of the present growing stock and its possible future development under various cutting practices, a useful procedure is to classify it into timber classes, that is, groups of diameter classes. Such classes are shown in table 1 and figure 1, in which the following groups are designated:

| | *Diameter classes (inches)* |
|---|---|
| Seedlings | Under 1.0. |
| Saplings | 2 and 4 (1.0 to 4.9). |
| Small timber or poles | 6, 8, 10, and 12-inch (5.0 to 12.9). |
| Medium timber | 14, 16, 18, and 20-inch (13.0 to 20.9). |
| Large timber | 22-inch and over (21.0 and over). |

A small portion of the small-timber or pole stand consists of trees sufficiently straight and clear to be valuable for posts and poles, but most of the trees in this stand can yield only pulpwood, fuel wood, and other cordwood.

In the medium-timber class, those trees (usually not over 20 percent of the stand) of a quality suitable for high-class poles and piling have a high stumpage value, but they are still only moderately valuable for saw timber. They constitute the base for current growth of high-value material.

The large-timber class, obviously, not only brings much greater stumpage returns (earnings on the investment in land and growing stock) but provides greater margins for operating risks and profit.

Distribution of growing stock, both on the average acre and over the entire forest property, has much bearing on management procedures, although less so on properties of which all parts are accessible to logging operations.

## Variety of Values To Be Dealt With

It should be clear from previous discussion that the practical aspects of continuous-yield forest management center around maintenance of a substantial growing stock suited to production of timber of the desired types. The decision on which trees to cut and which trees to leave to achieve this purpose requires a choice between

[6] d. b. h.=diameter at breast height, or 4.5 feet above ground surface.

elements of ever-changing value. Two kinds of value must be determined, either by the exercise of judgment based on experience or by appropriate investigations and computations: value for immediate cutting, and value for future cutting, after further gain in volume and quality. It would be possible to arrange all the trees on any area in a series, according to the value of each for immediate cutting. Or the same trees could be arranged in a parallel series according to their value for future growth. Each series would start with values well below zero and would range upward to positive values, generally of considerable magnitude. A few trees would have the same value in both series, but most would show marked differences. Economic considerations indicate immediate cutting of trees that show high positive values for immediate use, but cultural needs may require reserving some trees of this character.

In practice, these value determinations are made only for certain parts of the stand. Thus, they are not needed for individual trees in the seedling or sapling classes, beyond verifying that these premerchantable classes are present to replace merchantable trees that are to be removed. Where pole stands are clearly of unmerchantable character and thinnings are not contemplated, these also may be omitted from value determinations. Value determinations may begin with the 6-inch diameter class, however, where cordwood and saw timber are both marketable. Inasmuch as cordwood products are usually of lower value than saw timber, the cutting objective in the small-timber class (5 to 12.9 inches d.b.h.) is removal of surplus smaller trees so that the larger and better trees, which are more valuable for holding than for immediate utilization, will have sufficient growing space.

In the medium-timber class (13 to 20.9 inches), value determinations are based on saw timber, because of its higher value per cubic foot, with only occasional exceptions when poles and piling are the more valuable. Many trees in this class are still growing vigorously and the earnings they can make by further growth are often greater than those of any other part of the stand. Considering both volume and value growth, trees in this group may earn as much as 15 percent annually on their current investment value.

In the large-timber class (over 20.9 inches in diameter) more timber is approaching maturity and a smaller proportion of the stand is growing in value fast enough to warrant holding. The investment value per tree is large, and only the most vigorous trees commanding ample growing space should be retained.

Values differ among species, and especially between the pines and the hardwoods. The two major objectives always to be held in mind in cuttings are (1) to leave in the stand for future growth an ample supply of well-selected growing timber, in order to maximize productivity in volume and value, and (2) to withdraw from the forest each year mature, overmature, and surplus trees in such quantity and of such quality as to make the forest enterprise practical and economic.

Value determinations necessary to attain the objectives indicated in the discussion so far may be complicated. Techniques have been developed, however, which reduce these determinations to a practical basis. Parts II and III of this publication give practical examples of such techniques and indicate the probable costs of woods operations and the margins remaining for stumpage, profit, and risk for pines and hardwoods of various sizes.

# II. ECONOMIC FEASIBILITY OF LIGHT CUTTING

## Experimental Operation

The field work of the studies of costs of selective cutting discussed here [7] was begun at Crossett, Ark., in March 1935, and was for the most part completed during 1936. The methods subjected to cost analysis at that time have since been extensively employed by the Crossett Lumber Co. without discovery of any reasons for revising the initial findings. It is therefore possible to present these findings with full confidence in their reliability.

The cuttings were made on six experimental blocks, totaling 254 acres, and were so planned as to reveal the differences in costs and returns between light and heavy cutting and the minimum volume that it is economically feasible to cut. Volumes ranging from 636 to 4,192 board feet per acre were removed. The cost of logging and milling is generally greater for hardwoods than for pines, even if both have grown under the same conditions; the hardwoods are shorter and characteristically more crooked than the pines and, consequently, their yield per tree is less. For this reason, in order to determine the cost of logging pines alone and the cost of logging pines and hardwoods together, the cut was limited to pines on four of the six test blocks, containing 186 acres, and both pines and hardwoods were cut on two blocks, containing 68 acres.

On each of the test blocks the work began with a 100-percent inventory of the stand over 6 inches in diameter. A decision was then made as to the number of trees in each diameter class that should be removed in order to obtain the required volume of sawlogs and at the same time leave the stand in a good growing condition. After this the stands were retraversed and the trees to be cut were marked.

The costs of milling the logs and the sale value of the lumber were computed, and from these figures was derived for each method an estimate of the margin available for stumpage, profit, and uninsured risks. Because both labor costs and values of lumber and pulpwood have increased significantly since 1935, the results have been adjusted on the basis of 1940 wage rates and lumber values.

The cubic-foot and board-foot volumes per acre of the original stand, of the trees cut, and of the reserved stand on each test block are given in table 2. Figure 2 shows on a per-acre basis and by diameter class the number of trees before cutting and the number of trees cut on each test block. Although a relatively large percentage of the total merchantable volume of the stand was removed, very few trees were cut on an average acre. Because of heavier cutting in the larger diameter classes, volume per log and grade of average log were considerably higher than they would have been if all trees over 13 inches in diameter at breast height had been cut.

[7] Supplemental studies on log grades and costs of thinnings, improvement cuttings, logging, and milling are discussed later.

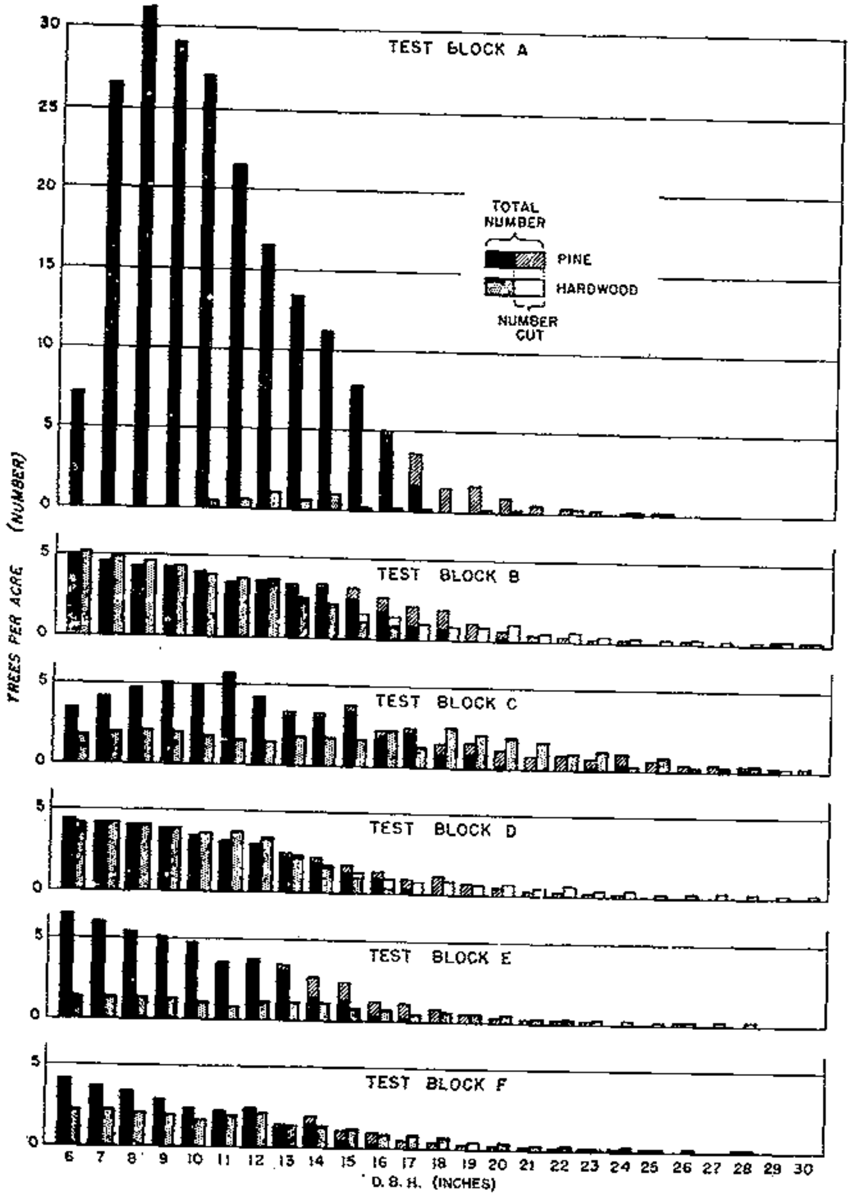


FIGURE 2.—Number of trees before cutting and number cut on each test block, by diameter class.

TABLE 2.—*Board-foot and cubic-foot volume per acre of original stand, of trees cut, and of reserved stand, by test block*

VOLUME IN BOARD FEET [1]

| Test block and number of acres | Original stand | | Trees cut | | Reserved stand | |
|---|---|---|---|---|---|---|
| | Pine | Hardwood | Pine | Hardwood | Pine | Hardwood |
| A (12) | 11,692 | 337 | 2,715 | | 8,977 | 337 |
| B (28) | 4,690 | 2,558 | 2,226 | 1,966 | 2,464 | 592 |
| C (14) | 8,118 | 4,264 | 4,112 | | 4,006 | 4,264 |
| D (40) | 2,790 | 2,668 | 1,286 | 2,064 | 1,504 | 604 |
| E (80) | 2,565 | 626 | 1,408 | | 1,157 | 626 |
| F (50) | 1,488 | 1,157 | 636 | | 852 | 1,157 |

VOLUME IN CUBIC FEET [2]

| Test block and number of acres | Original stand | | Trees cut | | Reserved stand | |
|---|---|---|---|---|---|---|
| | Pine | Hardwood | Pine | Hardwood | Pine | Hardwood |
| A (12) | 3,593 | 105 | 398 | | 3,195 | 105 |
| B (28) | 1,117 | 726 | 326 | 288 | 791 | 438 |
| C (14) | 1,612 | 860 | 581 | | 1,031 | 860 |
| D (40) | 719 | 660 | 189 | 303 | 530 | 357 |
| E (80) | 780 | 212 | 204 | | 576 | 212 |
| F (80) | 457 | 360 | 93 | | 364 | 360 |

[1] Merchantable volume, by International ¼-inch rule, of pine trees 10 inches d. b. h. and larger and hardwoods 12 inches and larger.
[2] Volume inside bark of pine and hardwood trees 6 inches d. b. h. and larger.

Relatively small merchantable trees were removed if they were defective or if certain portions of the stand were in need of thinning, and relatively large trees were reserved for additional growth if they were increasing in value at a satisfactory rate. It will be noted in figure 2 that on each test block except block A, which was cut to a d. b. h. limit of 17 inches, some trees were cut from every diameter class over 13 inches, and that some trees even as large as 20 inches d. b. h. were reserved. The aim was not only to obtain necessary logs for the sawmill but also to improve the growth rate of the trees in the stand and to build up the stand in volume and quality as rapidly as possible.

## HOW CUT PER ACRE AFFECTS COST OF FELLING AND BUCKING

In accordance with the usual practice of the Crossett Lumber Co., the trees cut were converted at the point where they were felled into the log lengths demanded by the mill or the market (fig. 3). Each tree was cut into logs from 12 to 20 feet long, the length in each case depending upon the quality of individual portions of the tree and the total merchantable length. The aim was to have each log include only one kind of material—clear high-grade, medium-grade, or rough. In all cases, the logs averaged close to 16 feet in length.

Two-man crews did the felling and bucking, and also the swamping and limbing. Altogether seven saw crews worked at one time or another during the study. The results obtained, therefore, are representative for reasonably efficient operations. Tree and log numbers were placed on each log, so that it could be identified in later parts of the study and no further measurement would be necessary. This made it possible theoretically to reconstruct the trees and to determine not only for each log but also for each tree the total costs of logging and milling, and the gross and net values. Two observers with stop watch, diameter tape, scale stick, and the necessary forms were assigned to each felling and bucking crew and obtained the following information for each tree felled: (1) Distance between trees,

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FIGURE 3.—Felling (*A*) and bucking (*B*) tree marked for cutting. Cost per unit volume of felling and bucking is *not substantially* greater under a light selective cutting system than in clear cutting or heavy selection cutting. The extra crew time spent in walking between trees on the lighter operation costs less than 3 cents an acre.

(2) walking time between trees, (3) species and diameter, (4) swamping and barking time, (5) felling time, (6) limbing time, (7) jump-butting time, (8) bucking time for each log and for all logs, (9) delay time, (10) length of each log by position in tree, (11) top diameter of each log inside and outside bark, (12) grade of each log, (13) Doyle-Scribner scale of each log, and (14) length of top not utilized for logs.

Saw crews in the South are usually employed on the piece-work or contract basis. In this study part of the cutting was done on a contract basis and part on a day basis, in order to compare the effectiveness of the two methods. In 1935 the cutters who worked on a contract basis were each paid 35 cents per M feet (Doyle-Scribner rule) of logs produced, and those who worked on the day basis were each paid 25 cents an hour. Although the contract method usually results in greater daily production and greater hourly wages to the cutters, in this study there was practically no difference. This can be attributed to close supervision of the work by the contractor and by the men collecting the data.

The 1940 wage rate, on the basis of which the data were adjusted, was 30 cents an hour. The average cost of operation per hour per saw crew, based on these wages, is given in table 3, which includes total hourly cost per man for comparison with costs of operations employing other than 2-man crews.

TABLE 3.—*Estimated hourly cost of felling and bucking per 2-man crew*

| Item | Rate per hour | Distribution |
|---|---|---|
| | *Dollars* | *Percent* |
| Current operating costs: | | |
| Direct labor cost: | | |
| Wages of 2 men | 0.600 | 85.0 |
| State and Federal social security costs | .024 | 3.4 |
| Total | .624 | 88.4 |
| Other direct cost: | | |
| Supplies (oil, wedges, etc.) | .026 | 3.7 |
| Maintenance | .004 | .6 |
| Supervision | .043 | 6.1 |
| Total | .073 | 10.4 |
| Ownership cost: | | |
| Depreciation | 0.008 | 1.1 |
| Interest, taxes, fire insurance | .001 | .1 |
| Total | .009 | 1.2 |
| Total cost | .706 | 100.0 |
| Man-hour cost | .353 | |

TABLE 4.—*Effective and ineffective time in felling and bucking*

| Test block and cut per acre (board feet)[1] | Effective time | Ineffective time | |
|---|---|---|---|
| | *Man-hours* | *Man-hours* | *Percent* |
| A (2,715) | 46.27 | 4.24 | 8.4 |
| B (4,192) | 260.77 | 24.56 | 8.6 |
| C (4,112) | 84.18 | 6.19 | 6.8 |
| D (3,350) | 303.17 | 36.15 | 10.7 |
| E (1,408) | 222.19 | 39.96 | 15.2 |
| F (630) | 118.04 | 17.41 | 12.9 |
| Total or average | 1,034.62 | 128.51 | 11.05 |

[1] International ¼-inch rule.

For comparison of the efficiency of one crew with another and of the present operation with those in other parts of the region, the ineffective time, or time each crew lost because of rest periods, filing axes and saws, and other miscellaneous delays, but not including the lunch period, was recorded along with the effective time for each of the test blocks (table 4). Apparently there is little correlation between cut per acre and total ineffective time. Ineffective time is determined by such factors as size of trees cut, percent of hardwoods, degree of limbiness, and amount of brush present.

The time data in table 4, used in connection with man-hour cost figures from table 3, give felling and bucking costs.

It has often been suggested that selective logging would considerably increase the cost of log production per M board feet from what it has been under the old clear-cutting method, because the cutters would spend a large amount of time in walking from one tree to another. If so, the cost of log production should be greater on a selective cutting where, instead of 50 percent of the merchantable stand volume, only 15 to 20 percent is cut. Table 5, giving number of trees cut per acre, volume per tree, average distance between trees, and time required and cost per tree for walking, felling, bucking, and other operations for each test block, shows that because of irregular distribution there is no exact relation between number of trees cut per acre and average distance between trees, or between average distance between trees and average walking time. The greatest average distance between trees cut on any test block was 121 feet and the least was 74 feet—a difference of 47 feet. The greatest average walking time between trees was 3.68 man-minutes and the least was 2.06 man-minutes—a difference of 1.62 man-minutes.

Man-hour requirements and costs per M board feet (International ¼-inch rule) and per 100 cubic feet of solid wood for each test block are given in table 6. Careful analysis of these data has led to the conclusion that the variation in costs per unit of volume among the several test blocks must have been caused largely by variation in the size and quality of the trees cut. At the rate of $0.0059 per man-minute, the cost of walking between trees averaged only $0.0096 more where the cut per acre was 636 board feet than where it was 4,112 board feet.

TABLE 5.—*Man-minute requirement [1] and cost [2] per tree for felling and bucking and associated operations, by test block*

| Test block and trees cut per acre (number) | Sawlog volume per tree [3] | | Average distance between trees | Walking between trees | | Swamping and barking | | Felling | |
|---|---|---|---|---|---|---|---|---|---|
| | *Board feet* | *Cubic feet* | *Feet* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* |
| A (7.5) | 362 | 53.11 | 74 | 2.28 | 0.013 | 1.26 | 0.007 | 14.44 | 0.085 |
| B (14.2) | 295 | 43.26 | 90 | 2.30 | .014 | 2.36 | .014 | 15.02 | .089 |
| C (7.3) | 563 | 79.64 | 81 | 2.06 | .012 | 2.02 | .012 | 16.30 | .096 |
| D (10.5) | 319 | 46.84 | 101 | 3.20 | .019 | .90 | .005 | 16.70 | .099 |
| E (5.9) | 239 | 34.62 | 70 | 3.01 | .018 | 1.08 | .006 | 10.12 | .060 |
| F (2.8) | 227 | 33.09 | 121 | 3.68 | .022 | .68 | .004 | 12.12 | .072 |

| Test block and trees cut per acre (number) | Limbing | | Jump-butting | | Bucking | | Total | |
|---|---|---|---|---|---|---|---|---|
| | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* |
| A (7.5) | 2.92 | 0.017 | | | 22.20 | 0.131 | 43.10 | 0.253 |
| B (14.2) | 4.88 | .029 | 0.48 | 0.003 | 19.22 | .113 | 44.26 | .262 |
| C (7.3) | 6.58 | .039 | .16 | .001 | 28.90 | .171 | 56.02 | .331 |
| D (10.5) | 5.68 | .034 | .54 | .003 | 21.36 | .126 | 48.38 | .286 |
| E (5.9) | 4.40 | .026 | .03 | (4) | 12.82 | .076 | 31.52 | .186 |
| F (2.8) | 4.90 | .029 | ... | ... | 14.32 | .084 | 35.70 | .211 |

1 Effective plus ineffective time.
2 Rate per man-minute=$0.0059.
3 Board-foot volume by International ¼-inch rule.
4 Negligible.

**TABLE 6.**—*Man-hour requirement and cost*[1] *per unit of volume for felling and bucking and associated operations, by test block*

| Test block | Cut per acre: Volume[2] | Cut per acre: Trees | Walking between trees: Man-hours | Walking between trees: Dollars | Swamping and barking: Man-hours | Swamping and barking: Dollars | Felling: Man-hours | Felling: Dollars | Limbing: Man-hours | Limbing: Dollars | Jump-butting: Man-hours | Jump-butting: Dollars | Bucking: Man-hours | Bucking: Dollars | Total: Man-hours | Total: Dollars |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PER M BOARD FEET[2] | | | | | | | | | | | | | | | | |
| | *Board feet* | *Number* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* |
| A | 2,715 | 7.5 | 0.105 | 0.04 | 0.058 | 0.02 | 0.665 | 0.23 | 0.134 | 0.05 | | | 1.022 | 0.36 | 1.984 | 0.70 |
| B | 4,192 | 14.2 | .130 | .04 | .133 | .05 | .849 | .30 | .276 | .10 | 0.027 | 0.01 | 1.086 | .38 | 2.501 | .88 |
| C | 4,112 | 7.3 | .061 | .03 | .060 | .02 | .483 | .17 | .195 | .07 | .005 | (3) | .856 | .30 | 1.660 | .59 |
| D | 3,350 | 10.5 | .167 | .06 | .047 | .02 | .873 | .31 | .297 | .10 | .028 | .01 | 1.116 | .39 | 2.528 | .89 |
| E | 1,406 | 5.9 | .212 | .07 | .075 | .03 | .706 | .25 | .307 | .11 | .004 | (3) | .894 | .32 | 2.198 | .78 |
| F | 636 | 2.8 | .270 | .10 | .050 | .02 | .890 | .31 | .360 | .13 | | | 1.051 | .37 | 2.621 | .93 |
| PER 100 CUBIC FEET[4] | | | | | | | | | | | | | | | | |
| | *Cubic feet* | | | | | | | | | | | | | | | |
| A | 308.32 | 7.5 | 0.072 | 0.03 | 0.040 | 0.01 | 0.453 | 0.16 | 0.092 | 0.03 | | | 0.697 | 0.25 | 1.354 | 0.48 |
| B | 614.29 | 14.2 | .089 | .03 | .091 | .03 | .579 | .20 | .188 | .07 | 0.018 | 0.01 | .740 | .26 | 1.705 | .60 |
| C | 581.37 | 7.3 | .042 | .02 | .042 | .01 | .341 | .12 | .138 | .05 | .003 | (3) | .605 | .21 | 1.171 | .41 |
| D | 491.82 | 10.5 | .114 | .04 | .032 | .01 | .594 | .21 | .202 | .07 | .019 | .01 | .760 | .27 | 1.721 | .61 |
| E | 204.26 | 5.9 | .146 | .05 | .052 | .02 | .487 | .17 | .212 | .08 | .003 | (3) | .617 | .22 | 1.517 | .54 |
| F | 92.65 | 2.8 | .185 | .06 | .034 | .01 | .610 | .22 | .247 | .09 | | | .721 | .25 | 1.797 | .63 |

[1] Rate per man-hour=$0.353.
[2] International 1/4-inch rule.
[3] Negligible.
[4] Solid wood (inside bark).

Because the cost of walking between trees is affected by factors other than distance, a purely theoretical case may show the effect of distance more strikingly than the actual field data have done. In an evenly spaced stand averaging 4 trees to the acre, with a total volume of 800 board feet per acre, the trees would be about 104 feet apart, and in one averaging 25 trees to the acre, with a total volume of 5,000 board feet, they would be about 42 feet apart. The walking distances per M board feet would be 520 feet and 210 feet, respectively. If the average rate of walking is 0.015 minute per foot and the average cost $0.0059 per man-minute, the cost per M board feet for walking between trees where 4 per acre were cut would be $0.0451 and where 25 per acre were cut it would be $0.0181. The extra cost per M board feet for walking where cutting removed 800 board feet per acre as against 5,000 board feet per acre would be only $0.0270.

Analysis of data obtained in the studies has led to the conclusion that the felling and bucking cost per unit volume is not appreciably greater under light selective cutting than under heavy selective cutting or clear cutting. In any event, the cost differential is too small to be determinative in choice of a cutting policy.

## How Cut Per Acre Affects Costs of Skidding and Loading

All logs cut in the study were skidded and loaded by animal power. A teamster and a team of two horses or mules made up a skidding and loading unit. Because of the relatively short truck haul (3.3 to 5.5 miles), a unit was usually assigned to each truck. Each teamster was expected to do all the work for his truck, including swamping, road building, skidding and bunching of logs for each load, loading, and assisting in pulling the truck through muddy spots.

Each teamster selected places where the logs could be bunched and the trucks loaded quickly and effectively (fig. 4). He sorted and bunched the logs by size, so that the largest possible load could be

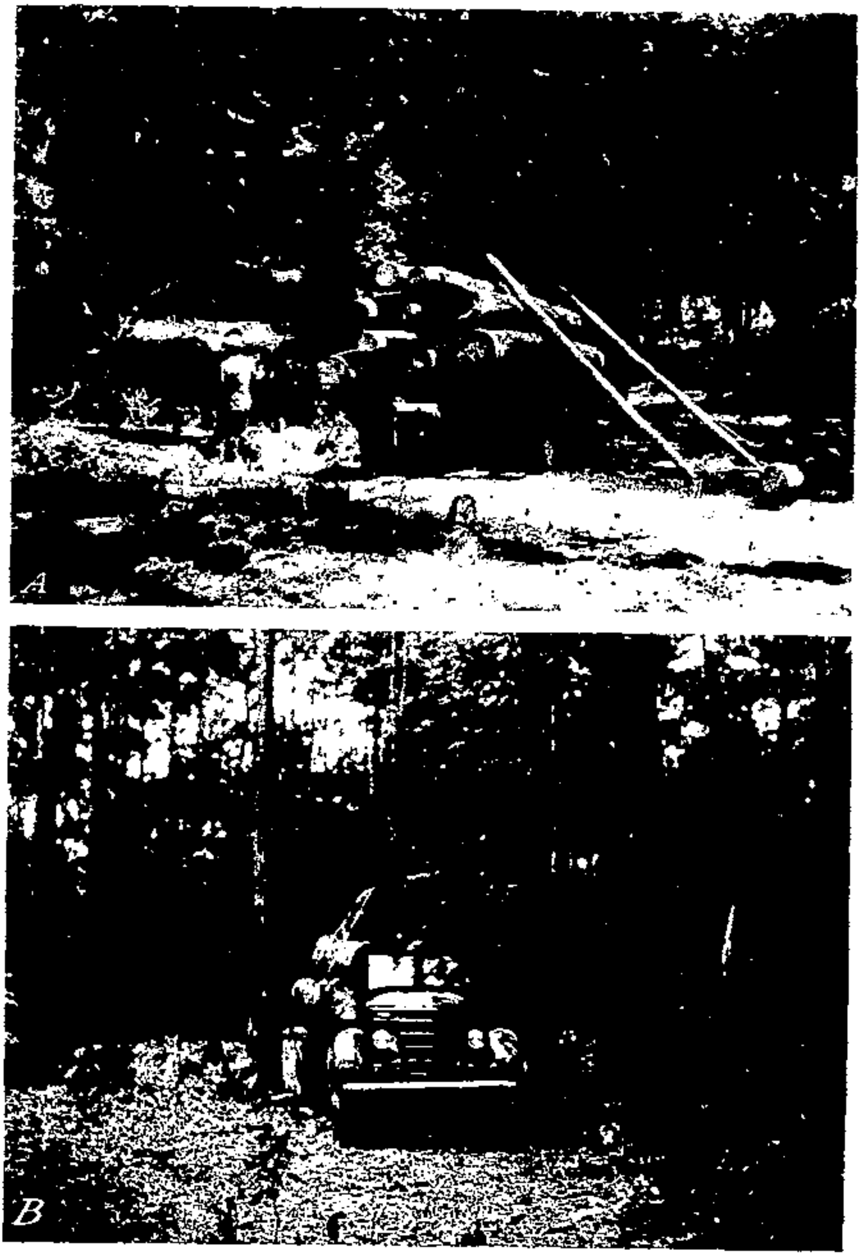

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FIGURE 4.—*A*, Teamster loading truck by common cross-haul system. Increases in cost due to the somewhat greater skidding distances involved in very light selective cutting are negligible. Costs may be raised much more by other factors, such as irregular tree distribution, or underbrush so dense as to require much swamping. *B*, Truck loaded with logs leaving woods. Cost of hauling depends much more on log size, load carried, and road condition than on volume of cut per acre.

made at each point. Usually the larger logs were placed so that they could be loaded first, without additional skidding. The smaller logs were placed close to the loading point, so that very little further skidding was necessary. While the truck was at the landing, he did all the necessary swamping out of the logs and of the various loading sites or "sets" and, if necessary, cleared out and worked on the woods roads. The truck driver was usually in direct charge of loading. He determined the order in which the logs concentrated at any one set should be loaded and helped the teamster do the actual loading. He also unloaded at the landing. When the truck returned to the woods the teamster directed it to the next loading point and, with the team, often helped to drag the trailer into position to be loaded.

Logs were loaded by the common cross-haul method; that is, they were pulled and rolled up two wooden skid poles onto the truck by means of a chain. After the loading was completed the chain was used to bind the load. Although this method of loading may take longer than other methods, it should not be condemned as inefficient on that score. It is simple, does not require skilled and highly paid workers, and does not require a large investment in high-priced and complicated machinery. Also, if logging is temporarily halted, the team can be used to good advantage on other work.

In order to determine the hourly cost of skidding and loading, daily records were kept of (1) the actual expenses for feed, labor, and repairs to harness, grabs, etc.; and (2) the time in crew-hours spent on the job. Allowance was made for depreciation of team and equipment, interest on the investment, personal property taxes, supervision, and overhead. Hourly cost per crew was determined by adding all the costs together for the period of the study and dividing the total by the number of hours worked. The resulting figures, as presented in table 7, may be used in comparing this operation with others in the region, and may easily be adjusted in the future for increase or decrease in costs of specific items.

TABLE 7.—*Estimated hourly cost of skidding and loading per teamster with 2-horse or 2-mule team*

| Item | Rate per hour | Distribution | Item | Rate per hour | Distribution |
|---|---|---|---|---|---|
| Current operating costs: | | | Ownership cost: | | |
| Direct labor cost: | *Dollars* | *Percent* | Depreciation of team and equipment | *Dollars* 0.041 | *Percent* 6.6 |
| Wages of teamster | 0.300 | 48.6 | Interest on investment, taxes, etc | .009 | 1.5 |
| State and Federal social security costs | .012 | 1.9 | Total | .050 | 8.1 |
| Total | .312 | 50.5 | Total cost | .617 | 100.0 |
| Other direct cost: | | | Man-hour cost | .617 | |
| Feed | .187 | 30.3 | | | |
| Upkeep of harness and other equipment | .025 | 4.1 | | | |
| Supervision | .043 | 7.0 | | | |
| Total | .255 | 41.4 | | | |

An observer with a stop watch obtained the following information for each log: (1) Log and tree identification number, (2) skidding distance, (3) skidding time, (4) loading time, (5) swamping time, (6) road-building time, and (7) ineffective time. Necessary rest periods for the team were considered ineffective time unless the teamster was performing some operation, such as swamping, building a road, or locating a loading site. From this information the average time and cost per tree and per unit of volume for skidding, for loading, and for the associated operations combined were computed for each test block.

Ineffective time made up a large part of the total, ranging from 29.0 to 41.2 percent on the different test blocks (table 8). This indicates that the skidding and loading operations were not perfectly integrated with the hauling. Team rest periods accounted somewhat for the large proportion of ineffective time. Another reason was the fact that, because the time required by the trucks to make a round trip to the landing was unpredictable, the teamster was inclined to bunch the next load as quickly as possible so as to avoid holding up the truck.

To determine whether skidding and loading cost is influenced by volume cut per acre, the information obtained in this portion of the study was summarized (table 9) on a per-tree basis, a per-M-board-foot basis, and a per-100-cubic-foot basis.

TABLE 8.—*Effective and ineffective time in skidding and loading*

| Test block and cut [1] per acre (board feet) | Effective time | Ineffective time | |
|---|---|---|---|
| | *Man-hours* | *Man-hours* | *Percent* |
| A (2,715) | 15.20 | 8.82 | 36.7 |
| B (4,192) | 107.45 | 60.90 | 36.2 |
| C (4,112) | 38.42 | 18.72 | 32.8 |
| D (3,350) | 117.85 | 82.60 | 41.2 |
| E (1,408) | 86.48 | 35.28 | 29.0 |
| F (636) | 43.63 | 18.12 | 29.3 |

[1] International ¼-inch rule.

TABLE 9.—*Time requirement (man-minutes or man-hours) and cost* [1] *for skidding, loading, and associated operations, by test block*

PER TREE

| Test block | Cut per acre | | Sawlog volume [2] per tree | | Skidding | | Loading | | Associated operations [3] | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Volume [2] | Trees | | | | | | | | | | |
| | *Board feet* | *Number* | *Board feet* | *Cubic feet* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* |
| A | 2,715 | 7.5 | 362 | 53.11 | 8.83 | 0.091 | 3.48 | 0.036 | 3.15 | 0.033 | 15.49 | 0.160 |
| B | 4,192 | 14.2 | 295 | 43.26 | 11.37 | .117 | 3.85 | .040 | 8.95 | .092 | 24.17 | .249 |
| C | 4,112 | 7.3 | 563 | 79.64 | 17.14 | .177 | 5.37 | .055 | 9.18 | .095 | 31.69 | .327 |
| D | 3,350 | 10.5 | 319 | 46.84 | 16.40 | .170 | 9.07 | .093 | 6.22 | .064 | 31.75 | .327 |
| E | 1,408 | 5.9 | 239 | 34.62 | 10.71 | .110 | 4.54 | .047 | 2.93 | .030 | 18.18 | .187 |
| F | 636 | 2.8 | 227 | 33.09 | 9.79 | .101 | 4.32 | .044 | 2.88 | .030 | 16.99 | .175 |

PER M BOARD FEET

| Test block | Volume | Trees | Board feet | Cubic feet | Skidding *Man-hours* | Skidding dollars | Loading *Man-hours* | Loading dollars | Associated *Man-hours* | Associated dollars | Total *Man-hours* | Total dollars |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 2,715 | 7.5 | 362 | | 0.407 | 0.25 | 0.160 | 0.10 | 0.146 | 0.09 | 0.713 | 0.44 |
| B | 4,192 | 14.2 | 205 | | .642 | .40 | .218 | .13 | .506 | .31 | 1.366 | .84 |
| C | 4,112 | 7.3 | 563 | | .507 | .31 | .159 | .10 | .272 | .17 | .938 | .58 |
| D | 3,350 | 10.5 | 319 | | .860 | .53 | .474 | .29 | .325 | .20 | 1.659 | 1.02 |
| E | 1,408 | 5.9 | 239 | | .747 | .46 | .317 | .19 | .204 | .13 | 1.268 | .78 |
| F | 636 | 2.8 | 227 | | .719 | .44 | .317 | .20 | .211 | .13 | 1.247 | .77 |

PER 100 CUBIC FEET [4]

| Test block | Volume *Cubic feet* | Trees | *Cubic feet* | | Skidding | | Loading | | Associated | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 398.32 | 7.5 | 53.11 | ----- | 0.277 | 0.17 | 0.109 | 0.07 | 0.100 | 0.06 | 0.486 | 0.30 |
| B | 614.29 | 14.2 | 43.26 | ----- | .438 | .27 | .148 | .09 | .345 | .21 | .931 | .57 |
| C | 581.37 | 7.3 | 70.64 | ----- | .359 | .22 | .112 | .07 | .192 | .12 | .663 | .41 |
| D | 491.82 | 10.5 | 46.84 | ----- | .586 | .36 | .323 | .20 | .221 | .14 | 1.130 | .70 |
| E | 201.26 | 5.9 | 34.62 | | .516 | .32 | .219 | .13 | .141 | .09 | .876 | .53 |
| F | 92.65 | 2.8 | 33.09 | | .493 | .30 | .218 | .13 | .145 | .09 | .856 | .53 |

[1] Rate per man-hour, $0.617; per man-minute, $0.0103.
[2] International ¼-inch rule.
[3] Swamping, road building, moving set, etc.
[4] Solid wood (inside bark).

Variations in tree and log size and other factors make it difficult to judge the influence of any single factor. Moreover skidding, being dependent on the rate at which trucks removed logs, could not be pushed ahead as if it were an independent operation. To eliminate the effect of log size, table 10 was prepared, giving average skidding distance per log and cost per M feet for 14-inch logs. This table shows about the same relative costs as if logs were of the same average size on each block. It shows that cost per M feet increases with average skidding distance. It shows also that because of tree distribution or other factors the skidding distance per log and the skidding cost per unit volume may be relatively greater for areas such as test block C, on which a heavy cut of 4,112 feet per acre was made, than for areas such as test block F, on which only 636 feet per acre was cut. Furthermore, when the effect of log size is eliminated the cost of skidding on block F is only 10 cents more per M feet than on block D, where 3,350 feet per acre was cut.

TABLE 10.—*Co. per M board feet of skidding 14-inch logs the average distance for each test block*

| Test block and average skidding distance per log (feet) | Trees cut per acre | Cost per M board feet [1] | Test block and average skidding distance per log (feet) | Trees cut per acre | Cost per M board feet [1] |
|---|---|---|---|---|---|
| | *Number* | *Dollars* | | *Number* | *Dollars* |
| A (89) | 7.5 | 0.26 | E (132) | 5.9 | 0.38 |
| D (101) | 10.5 | .29 | F (136) | 2.8 | .39 |
| B (113) | 14.2 | .32 | C (184) | 7.3 | .54 |

[1] International ¼-inch rule.

To summarize, the data show that skidding and loading costs may be higher than average (1) when very light selective cuts are made, resulting in long average skidding distances; (2) when tree distribution is irregular, so that even heavy cutting results in long average skidding distances; (3) when logs are above the maximum size that can be handled effectively with teams; (4) when hardwood logs, which are heavier and more difficult to handle than pine, make up a large proportion of the cut; (5) when logs are relatively small; and (6) when underbrush is so dense that swamping is necessary for nearly every log. They show, however, that any cost increase resulting from limiting the cut to 600 board feet (International ¼-inch rule) per acre is negligible in comparison with total logging costs, and can be avoided by proper marking of groups of trees to make up load lots. Light selective cuts are financially feasible so far as skidding and loading costs are concerned. In fact, the team method of skidding and loading, combined with truck transportation, makes light harvest cuttings—and improvement cuttings—economically possible in understocked stands that, if subjected to heavy cutting, would be wrecked for production during the next 15 to 30 years.

## HOW CUT PER ACRE AFFECTS COST OF TRUCK HAULING

The equipment used for truck logging in the shortleaf-loblolly pine-hardwood region is fairly well standardized at the present time. Some 80 percent or more of the operators use a standard 1½-ton short-wheel-base truck with dual wheels at the rear and a dual-wheel trailer, which is attached by means of a coupling pole and which works on a fifth wheel. The tires on the truck and trailer are usually 32 by 6 inches or larger, and interchangeable. The truck and trailer equipment used in the selective logging study was of this description except that one trailer had single wheels.

The experience gained in this study proved quite conclusively that it was cheaper to load at a different set each time than to skid logs to a central loading point. In most cases no attempt was made to skid large logs. It was usually cheaper and easier to drive the truck to the logs. Enough smaller logs were skidded to the larger ones to complete a load.

Most contractors pay their truck drivers on the per diem basis but expect a fixed number of loads per day. In the experimental operation the truck drivers were not required to take a given number of loads per day, but were expected to make as many trips as possible during a working day of a definite number of hours.

For each truckload or trip, a record was made of (1) time spent locating set, (2) time spent loading, (3) time spent binding load, (4) time spent on trip to landing, (5) time spent unloading, (6) time spent returning to woods, (7) delay time for each of these operations, (8) number of logs carried per load, (9) identification number of each log, and (10) distance hauled.

The same observer who recorded the time spent in skidding and loading logs recorded also the truck time spent on the various operations in the woods. He recorded the time the loaded truck left the woods for the landing and the time the empty truck arrived at the next loading point. An observer at the landing recorded the time when each truck arrived, the time spent in unloading, and the time when each truck started the return trip. In case of breakdown or other delay between the woods and the landing, the driver kept the amount of lost time and reported it to the observer in the woods. He also reported the distance of each haul. The fact that each log had been numbered and measured made it possible to record the volume of each load.

To determine the cost of operating the trucks and trailers, a daily record of gasoline and oil used, and cost of repair parts and labor, greasing, etc., was kept for each. Other costs, such as depreciation, taxes, and license, were determined by averaging records of several truck owners in the locality. Because cost of repairs averaged considerably lower than for other operators, the average cost of repairs per truck with trailer has been adjusted for the purpose of this report on the basis of other operators' experience, and is set at $112.50 for a year of 225 10-hour days.

In use of working time the log hauling was the most efficient of all the woods operations; ineffective time amounted to but 6.71 percent of the total time on the job. Approximately half this lost time was chargeable to tire and engine trouble, and the remainder to delays in loading caused by breaking of the cross-haul chain or harness. This does not mean that the loading and hauling were entirely efficient. A considerable amount of wasted effort, as in rolling a log over the load in loading or skidding the wrong log into position for loading, could perhaps have been avoided. The time required for such operations was recorded as effective; also that required to adjust the logs on the trucks in loading, since such adjustments were necessary to build loads of effective size.

The adjusted hourly cost of operating a 1½-ton truck and trailer is given in table 11.

TABLE 11.—*Estimated hourly cost* [1] *of operating a 1½-ton truck with trailer*

| Item | Rate per hour | Distribution |
|---|---|---|
| | *Dollars* | *Percent* |
| Current operating costs: | | |
| Direct labor cost: | | |
| Wages of driver | 0.300 | 29.2 |
| State and Federal social security costs | .012 | 1.2 |
| Total | .312 | 30.4 |
| Other direct cost: | | |
| Fuel (0.89 gallons gasoline at $0.18) | .160 | 15.6 |
| Oil and grease | .027 | 2.6 |
| Repair labor | .025 | 2.4 |
| Repair supplies | .025 | 2.4 |
| Supervision | .043 | 4.2 |
| Total | .280 | 27.2 |
| Ownership cost: [1] | | |
| Depreciation | 0.328 | 31.9 |
| Interest on investment at 6 percent | .033 | 3.2 |
| License and taxes | .023 | 2.2 |
| Uninsured risks ($117) | .052 | 5.1 |
| Total | .436 | 42.4 |
| Total cost | 1.028 | 100.0 |
| Cost per man-hour | 1.028 | |

[1] For the benefit of those planning a logging operation or wishing to check present operations, bases of estimating truck-operating costs are given, as follows:

| Item | Truck only | Trailer only | Tires | Total |
|---|---|---|---|---|
| | *Dollars* | *Dollars* | *Dollars* | *Dollars* |
| Original cost | 650.00 | 250.00 | 500.00 | 1,400.00 |
| Trade-in value | 200.00 | 100.00 | 0 | 300.00 |
| Annual depreciation | 337.50 | 56.25 | 344.32 | 738.07 |
| Average investment | 593.75 | 203.12 | 422.16 | 1,219.03 |

Annual depreciation is figured on the following estimated life of equipment: Truck, 300 operating days; trailer, 600 days; tires, 15,000 miles (10,340 miles per year of 225 operating days). Cost of tires per mile, $0.0333.

To compare hauling costs involved in a heavy selection cut with those in a light or very light selection cut, the time and cost records for all parts of the hauling operation have been summarized in table 12.

TABLE 12.—*Man-minute requirement and cost* [1] *per load for loading, truck hauling, and associated operations, by test block*

| Test block | Basis, loads | Average load: Logs | Average load: Volume [2] | Average log volume [2] | Locating set | | Loading | | Binding | | Hauling [3] | | Unloading | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Number* | *Number* | *Board feet* | *Board feet* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* |
| A | 36 | 13.1 | 1,503 | 115 | 3.60 | 0.062 | 33.32 | 0.570 | 5.99 | 0.102 | 15.40 | 0.263 | 15.99 | 0.273 | 74.30 | 1.270 |
| B | 115 | 11.2 | 1,390 | 124 | 3.39 | .058 | 32.96 | .564 | 4.81 | .082 | 16.38 | .280 | 15.99 | .273 | 73.53 | 1.257 |
| C | 66 | 10.3 | 1,634 | 159 | 2.60 | .044 | 27.64 | .473 | 4.90 | .084 | 14.24 | .244 | 15.99 | .273 | 65.37 | 1.118 |
| D | 121 | 11.9 | 1,971 | 166 | 5.80 | .099 | 56.47 | .966 | 7.50 | .128 | 15.57 | .266 | 15.99 | .273 | 101.33 | 1.732 |
| E | 82 | 20.1 | 1,887 | 94 | 4.61 | .079 | 49.62 | .849 | 6.04 | .103 | 16.37 | .280 | 15.99 | .273 | 92.63 | 1.584 |
| F | 46 | 18.3 | 1,937 | 106 | 4.48 | .077 | 49.22 | .842 | 6.76 | .116 | 16.95 | .290 | 15.99 | .273 | 93.40 | 1.598 |

[1] Rate per man-minute=$0.0171.
[2] International ¼-inch rule.
[3] Time and cost figures for all test blocks based on 1-mile haul from woods to landing loaded, and return empty.

The average time per load given for each element includes both effective and ineffective time. In order that the results for the various blocks may be directly comparable, the hauling time is given in number of minutes required for a round trip on a 1-mile haul. Time required and costs per M board feet (International ¼-inch rule) and per 100 cubic feet, computed from table 12 and the average volume per load, are given in table 13.

TABLE 13.—*Man-hour requirement and cost [1] per unit of volume for loading, truck-hauling, and associated operations, by test block*

PER M BOARD FEET [2]

| Test block | Cut per acre: Volume [2] | Cut per acre: Trees | Average log volume [2] | Locating set: Man-hours | Locating set: Dollars | Loading: Man-hours | Loading: Dollars | Binding: Man-hours | Binding: Dollars | Hauling [3]: Man-hours | Hauling [3]: Dollars | Unloading: Man-hours | Unloading: Dollars | Total: Man-hours | Total: Dollars |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Board feet* | *Number* | *Board feet* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* |
| A | 2,715 | 7.5 | 115 | 0.040 | 0.04 | 0.369 | 0.38 | 0.066 | 0.07 | 0.171 | 0.18 | 0.177 | 0.18 | 0.823 | 0.85 |
| B | 4,102 | 14.2 | 124 | .041 | .04 | .395 | .41 | .058 | .06 | .196 | .20 | .192 | .20 | .882 | .91 |
| C | 4,112 | 7.3 | 159 | .027 | .03 | .282 | .29 | .050 | .05 | .145 | .15 | .163 | .17 | .667 | .69 |
| D | 3,350 | 10.5 | 166 | .049 | .05 | .478 | .49 | .063 | .06 | .132 | .14 | .135 | .14 | .857 | .88 |
| E | 1,408 | 5.9 | 94 | .041 | .04 | .438 | .45 | .053 | .05 | .145 | .15 | .141 | .15 | .818 | .84 |
| F | 636 | 2.8 | 106 | .039 | .04 | .424 | .44 | .058 | .06 | .146 | .15 | .138 | .14 | .805 | .83 |

PER 100 CUBIC FEET

| Test block | Cut per acre: Volume | Cut per acre: Trees | Average log volume | Locating set: Man-hours | Locating set: Dollars | Loading: Man-hours | Loading: Dollars | Binding: Man-hours | Binding: Dollars | Hauling: Man-hours | Hauling: Dollars | Unloading: Man-hours | Unloading: Dollars | Total: Man-hours | Total: Dollars |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Cubic feet* | | *Cubic feet* | | | | | | | | | | | | |
| A | 398.32 | 7.5 | 16.7 | 0.027 | 0.03 | 0.254 | 0.26 | 0.046 | 0.05 | 0.117 | 0.12 | 0.122 | 0.12 | 0.566 | 0.58 |
| B | 614.20 | 14.2 | 17.8 | .026 | .03 | .276 | .28 | .040 | .04 | .137 | .14 | .134 | .14 | .615 | .63 |
| C | 581.37 | 7.3 | 22.2 | .019 | .02 | .201 | .20 | .036 | .04 | .104 | .11 | .117 | .12 | .477 | .49 |
| D | 491.82 | 10.5 | 23.1 | .035 | .03 | .342 | .35 | .045 | .05 | .094 | .10 | .097 | .10 | .613 | .63 |
| E | 204.26 | 5.9 | 13.8 | .028 | .03 | .298 | .30 | .036 | .04 | .098 | .10 | .096 | .10 | .556 | .57 |
| F | 92.65 | 2.8 | 15.4 | .026 | .03 | .291 | .30 | .040 | .04 | .100 | .10 | .095 | .10 | .552 | .57 |

[1] Rate per man-hour=$1.028.
[2] International ¼-inch rule.
[3] Time and cost figures for all test blocks based on 1-mile haul from woods to landing loaded, and return empty.

Analysis has shown that except for block C the total loading and hauling cost varied among the blocks by only $0.06 per 100 cubic feet and $0.08 per M board feet of logs handled. For block C the cost was exceptionally low owing to the fact that only rather large pine logs were cut there. It is apparent that, although such factors as log size, load carried, and condition of roads may affect materially the unit cost of truck hauling, the cut per acre has no significant effect upon this cost. The differences in unit cost are too small to have much influence on selective-cutting policy.

## MEASURES FOR REDUCING TRANSPORTATION COSTS

The costs of truck hauling in the experimental operation are mainly for hauling over ungraded or very low-class woods or country roads and may correctly be applied to similar logging chances. Trucks have proved efficient for hauling logs in dry weather even where there are no roads whatsoever. Nevertheless, lumber companies and logging contractors who haul all or some of their logs with trucks realize the necessity of building good, well-graded dirt or gravel roads in order that the trucks can maintain good speeds. They know that in general the cost of producing logs varies inversely with the quality of the roads available and that over a period of years good roads will pay dividends in the form of cheaper logs, even to companies that contract all their logging. For these reasons most of them have already built or are building relatively high-class truck roads. In the future most truck transportation of logs and other forest products will be over roads of this description.

Many dry-weather roads can be converted into all-weather roads by draining them properly and applying gravel in some places. If properly located, an all-weather secondary road can be built in most cases for $50 to $300 a mile, which is considerably below the cost of preparing a railroad right-of-way and laying the ties and steel. The road can be used continuously for an indefinite length of time for transporting forest products harvested selectively, whereas the railroad would be removed after one heavy cut had depleted the timber.

Figures on costs of hauling for various lengths of haul over such roads are presented in table 14. They were computed in the following manner:

TABLE 14.—*Cost of hauling per unit of volume, by length of haul, in dry weather on well-graded dirt or gravel roads*

| Length of haul (miles) | Time per load (fixed preparation time, 63.94 minutes) | | Average trips per 10-hour day | Cost per load [1] | | | Total cost per— | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Actual hauling (round trip) | Total | | Fixed [2] | Variable with distance hauled [3] | Total | M feet Doyle-Scribner rule | M feet International ¼-inch rule | M feet Scribner rule | 100 cubic feet |
| | *Minutes* | *Minutes* | *Number* | *Dollars* | *Dollars* | *Dollars* | *Dollars* | *Dollars* | *Dollars* | *Dollars* |
| 0 | 0 | 63.94 | 0 | 0.71 | 0 | 0.71 | 0.57 | 0.41 | 0.46 | 0.29 |
| 1.0 | 9.00 | 72.94 | 8.2 | .71 | .13 | .84 | .67 | .49 | .54 | .35 |
| 1.5 | 13.50 | 77.44 | 7.7 | .76 | .20 | .96 | .77 | .56 | .62 | .40 |
| 2.0 | 18.00 | 81.94 | 7.3 | .80 | .27 | 1.07 | .86 | .62 | .69 | .44 |
| 2.5 | 22.50 | 86.44 | 6.9 | .84 | .34 | 1.18 | .94 | .69 | .76 | .49 |
| 3.0 | 27.00 | 90.94 | 6.6 | .89 | .40 | 1.29 | 1.03 | .75 | .83 | .53 |
| 3.5 | 31.50 | 95.44 | 6.3 | .93 | .47 | 1.40 | 1.12 | .82 | .91 | .58 |
| 4.0 | 36.00 | 99.94 | 6.0 | .97 | .54 | 1.51 | 1.21 | .88 | .98 | .62 |
| 4.5 | 40.50 | 104.44 | 5.7 | 1.02 | .60 | 1.62 | 1.30 | .95 | 1.05 | .67 |
| 5.0 | 45.00 | 108.94 | 5.5 | 1.06 | .67 | 1.73 | 1.38 | 1.01 | 1.12 | .71 |
| 5.5 | 49.50 | 113.44 | 5.3 | 1.11 | .74 | 1.85 | 1.48 | 1.08 | 1.20 | .76 |
| 6.0 | 54.00 | 117.94 | 5.1 | 1.15 | .80 | 1.95 | 1.56 | 1.14 | 1.26 | .81 |
| 6.5 | 58.50 | 122.44 | 4.9 | 1.19 | .87 | 2.06 | 1.65 | 1.20 | 1.33 | .85 |
| 7.0 | 63.00 | 126.94 | 4.7 | 1.24 | .94 | 2.18 | 1.74 | 1.27 | 1.41 | .90 |
| 7.5 | 67.50 | 131.44 | 4.6 | 1.28 | 1.00 | 2.28 | 1.82 | 1.33 | 1.47 | .94 |
| 8.0 | 72.00 | 135.94 | 4.4 | 1.33 | 1.07 | 2.40 | 1.92 | 1.40 | 1.55 | .99 |
| 8.5 | 76.50 | 140.44 | 4.3 | 1.37 | 1.14 | 2.51 | 2.01 | 1.46 | 1.62 | 1.04 |
| 9.0 | 81.00 | 144.94 | 4.1 | 1.41 | 1.21 | 2.62 | 2.10 | 1.53 | 1.69 | 1.08 |
| 9.5 | 85.50 | 149.44 | 4.0 | 1.46 | 1.27 | 2.73 | 2.18 | 1.59 | 1.77 | 1.13 |
| 10.0 | 90.00 | 153.94 | 3.9 | 1.50 | 1.34 | 2.84 | 2.27 | 1.66 | 1.84 | 1.17 |
| 11.0 | 99.00 | 162.94 | 3.7 | 1.59 | 1.47 | 3.06 | 2.45 | 1.79 | 1.98 | 1.26 |
| 12.0 | 108.00 | 171.94 | 3.5 | 1.68 | 1.61 | 3.29 | 2.63 | 1.92 | 2.13 | 1.36 |
| 13.0 | 117.00 | 180.94 | 3.3 | 1.76 | 1.74 | 3.50 | 2.80 | 2.04 | 2.26 | 1.45 |
| 14.0 | 126.00 | 189.94 | 3.2 | 1.85 | 1.88 | 3.73 | 2.98 | 2.18 | 2.41 | 1.54 |
| 15.0 | 135.00 | 198.94 | 3.0 | 1.94 | 2.01 | 3.95 | 3.16 | 2.30 | 2.55 | 1.63 |
| 16.0 | 144.00 | 207.94 | 2.9 | 2.03 | 2.14 | 4.17 | 3.34 | 2.43 | 2.70 | 1.72 |
| 17.0 | 153.00 | 216.94 | 2.8 | 2.12 | 2.28 | 4.40 | 3.52 | 2.57 | 2.85 | 1.82 |
| 18.0 | 162.00 | 225.94 | 2.7 | 2.20 | 2.41 | 4.61 | 3.69 | 2.69 | 2.98 | 1.90 |
| 19.0 | 171.00 | 234.94 | 2.6 | 2.29 | 2.55 | 4.84 | 3.87 | 2.82 | 3.13 | 2.00 |
| 20.0 | 180.00 | 243.94 | 2.5 | 2.38 | 2.68 | 5.06 | 4.05 | 2.95 | 3.27 | 2.09 |

[1] Average load=1,250 board feet Doyle-Scribner rule, or 1,714 board feet International ¼-inch rule, or 1,546 board feet Scribner rule, or 242 cubic feet.

[2] Fixed cost per hour=$0.585, including labor $0.312, supervision $0.045, and ownership (of truck and trailer without tires) $0.228.

[3] Cost per mile=$0.067, including tires $0.033, gasoline $0.025, oil and greasing $0.003, and repairs $0.006.

1. From table 12 the total time per load required for locating the set, loading, and binding the load was determined, for all the 466 loads hauled from the study area, to average 63.94 minutes. This time is the same regardless of distance of haul or type of roads over which the hauling is done.

2. Through supplemental studies of hauling time and truck speeds for well-graded dirt and gravel roads, the average round-trip time required per mile of one-way distance on such roads was determined as 9 minutes.

3. The total time required for any length of haul equals the product of the actual round trip time (including delay time) per mile of haul and the distance factor plus the fixed preparation time.

4. The number of loads hauled per day for any given length of haul was determined by dividing minutes in a 10-hour day by minutes per load.

5. The fixed costs per load, including $0.312 for labor, $0.045 for supervision, and $0.228 for depreciation of truck and trailer (without tires) and other ownership costs, were found to total $0.585 per hour or $5.85 per 10-hour day. Dividing this fixed daily cost by the number of loads hauled per day gave the fixed cost per load. The costs per mile that are dependent upon distance traveled were determined as follows: $0.033 for tires, $0.025 for gasoline, $0.003 for oil and greasing, and $0.006 for repairs, or a total of $0.067. Multiplying the cost per mile by the number of miles of round-trip distance gave the cost per load for various lengths of haul. With better roads the depreciation, gasoline, oil, and repair costs are less than with ungraded roads.

6. From the total cost per load and the volume of the average load the cost per 100 cubic feet and the cost per M board feet by the International ¼-inch, Doyle-Scribner, and Scribner rules were computed for each length of haul.

In using the figures given in table 14 it should be remembered that they will need to be adjusted for other operations if items of operating cost or size of load are different from those of this study. With the detailed information that is given, this can be done easily. Cost figures will need adjusting, too, if the average size of log differs from what it was in the study. It should be remembered that these costs are based on dry-weather conditions and on hauling over well-graded dirt or gravel roads. The cost per unit volume may be different for paved, blacktop, or low-class dirt roads, or for hilly country. Furthermore, the figures include only the actual cost of hauling; nothing has been included for the operator's or contractor's profit and risk.

The winter or rainy season in the South, extending from about the middle of December to about the first of April, presents a serious problem in selective logging. During this time it is extremely difficult to drive a truck into the woods and some roads become almost impassable. Logging during this period is expensive, even in old-growth timber under the railroad method.

One way of meeting this problem is to reserve for cutting during this period any timber within 300 feet of all-weather roads and along main-line railroads. Another solution, more commonly used at present, is log storage (fig. 5, *A*). Beginning the latter part of October, or as soon as cool weather arrives, all available logging equipment and manpower are directed toward getting out logs. Logs not needed by

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FIGURE 5.—*A*, Trucked logs stored along railroad track for immediate or future use—one solution of the problem of supplying logs to the mill in winter. *B*, Loading logs on railroad cars. The car-top loader here shown can load about 6 cars an hour and usually can be moved to the next car as the engine pulls the log train 1 car forward.

the mill for the next 2 months are banked on all-weather roads, on main-line railroads, or at the mill, to supply the mill over the worst of the rainy season. If warm weather occurs during the latter part of the storage season, blue-stain fungi may attack and discolor the logs, and so reduce the value of the lumber produced from them; but this loss can be kept very low by spraying the ends of the freshly cut logs with well-known chemicals.

## SUMMARY OF OPERATING COSTS FROM STUMP TO RAILROAD

Large areas of timberland in the South, in tracts of various sizes, are owned separately from sawmills or other manufacturing plants. The owner of an area of 500 acres or more can engage in selling logs, pulpwood, and other forest raw materials, independently of manufacturing. It is common practice, also, for manufacturing concerns owning timber to contract the logging. It should be of interest to many, therefore, to summarize at this point the average logging costs for each of the six test blocks. This is done in table 15, on the basis of the International ¼-inch kerf rule, Doyle rule, and cubic-foot scale. The averages show that properly planned and supervised light selective cuttings can be carried on at moderate costs per unit of volume, where timber of suitable size and quality is available.

TABLE 15.—*Man-hour requirement and cost of logging operations from stump to railroad or local mill*

| Test block | Cut per acre | Felling and bucking | | Skidding and loading | | Truck haul | | Total | | Net cost plus allowance for profit and risk |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Board feet* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Dollars* |
| PER 1,000 BOARD FEET, INTERNATIONAL ¼-INCH RULE | | | | | | | | | | |
| A | 2,715 | 1.984 | 0.70 | 0.713 | 0.44 | 1.336 | 1.37 | 4.033 | 2.51 | 3.26 |
| B | 4,192 | 2.501 | .88 | 1.366 | .84 | 1.470 | 1.51 | 5.337 | 3.23 | 4.20 |
| C | 4,112 | 1.660 | .59 | .938 | .58 | 1.103 | 1.13 | 3.701 | 2.30 | 2.99 |
| D | 3,350 | 2.528 | .89 | 1.659 | 1.02 | 1.252 | 1.29 | 5.439 | 3.20 | 4.16 |
| E | 1,408 | 2.198 | .78 | 1.268 | .78 | 1.252 | 1.29 | 4.718 | 2.85 | 3.71 |
| F | 636 | 2.621 | .93 | 1.247 | .77 | 1.241 | 1.28 | 5.109 | 2.98 | 3.87 |
| Weighted average | 1,988 | 2.323 | .82 | 1.319 | .81 | 1.290 | 1.33 | 4.932 | 2.96 | 3.85 |
| PER 100 CUBIC FEET | | | | | | | | | | |
| A | 398 | 1.354 | 0.48 | 0.486 | 0.30 | 0.920 | 0.95 | 2.760 | 1.73 | 2.25 |
| B | 614 | 1.705 | .60 | .931 | .57 | 1.028 | 1.06 | 3.664 | 2.23 | 2.90 |
| C | 581 | 1.172 | .41 | .663 | .41 | .788 | .81 | 2.623 | 1.63 | 2.12 |
| D | 492 | 1.721 | .61 | 1.130 | .70 | .898 | .92 | 3.749 | 2.23 | 2.90 |
| E | 204 | 1.517 | .54 | .876 | .54 | .954 | .88 | 3.247 | 1.96 | 2.55 |
| F | 93 | 1.707 | .63 | .850 | .53 | .854 | .88 | 3.507 | 2.04 | 2.65 |
| Weighted average | 290 | 1.595 | .56 | .906 | .56 | .903 | .93 | 3.404 | 2.05 | 2.67 |
| PER 1,000 BOARD FEET, DOYLE-SCRIBNER RULE | | | | | | | | | | |
| A | 1,942 | 2.837 | 0.99 | 1.012 | 0.62 | 1.879 | 1.95 | 5.726 | 3.56 | 4.63 |
| B | 3,012 | 3.481 | 1.23 | 1.901 | 1.17 | 2.046 | 2.10 | 7.428 | 4.50 | 5.85 |
| C | 3,176 | 2.149 | .76 | 1.214 | .75 | 1.428 | 1.47 | 4.791 | 2.98 | 3.87 |
| D | 2,608 | 3.247 | 1.15 | 2.131 | 1.31 | 1.608 | 1.65 | 6.986 | 4.11 | 5.34 |
| E | 918 | 3.371 | 1.19 | 1.945 | 1.20 | 1.920 | 1.97 | 7.236 | 4.36 | 5.67 |
| F | 432 | 3.859 | 1.36 | 1.836 | 1.13 | 1.827 | 1.88 | 7.522 | 4.37 | 5.68 |
| Weighted average | 1,453 | 3.223 | 1.14 | 1.830 | 1.13 | 1.789 | 1.83 | 6.842 | 4.10 | 5.33 |

In short, carefully planned and supervised motor truck transportation, together with careful selection of trees to be cut and simple skidding and loading methods, makes it possible to realize the objectives of forest management discussed in Part I of this report. Simply stated, the solution consists in selecting each year and transporting to the sawmill or other primary manufacturing plant such mature trees, surplus trees from dense groups, and other trees in need of removal as can be handled at a profit or at least without loss.

## III. INDIVIDUAL LOG AND TREE VALUES—ECONOMIC BASIS OF TREE SELECTION AND CURRENT FOREST INCOME

During the earlier part of the three centuries of forest exploitation in North America, it was recognized by nearly all forest users that certain tree species and certain individual trees served their purposes better than others. Timber cutting, except for land-clearing operations, was highly selective. Later, in the great expansion of the lumber industry into the rather uniform virgin forests of Pennsylvania, the Lake States, and the South, increasing lumber values and mass-production methods brought an era of wholesale cutting that almost destroyed some forest types, such as the Lake States white pine. This indiscriminate cutting undoubtedly caused enormous losses to the industry as a whole, although it brought wealth to a small percent of the operators. Fortunately for the South, nature has been generous and on many cut-over areas has presented another opportunity for sound forest management.

Even when timber utilization has passed from a purely exploitative stage to one characterized by methods designed to perpetuate productivity, forest managers have often attempted to grow uniform stands that could be cut all at once. Since the early 1930's, however, forest-management experience and research results have increasingly supported the principle of continuing care and opportune utilization of the individual tree as the foundation of a sound management program. It has already been noted in Part I that the care and timely utilization of individual trees is properly based on individual tree values; and that, with few exceptions, each tree has two definite values—value to hold for future growth in volume and quality, and volume value for immediate cutting. Part III deals with values of the latter class. It is based on further analysis of the study data used, as described in Part II, to test the economy of light selective cutting, on studies of costs for loading on cars, for railroad haul, and for milling, and on a study of lumber-value recoveries. It gives logging, railroad-haul, and milling costs of individual logs and trees; value recoveries determined for each log size and grade by subtracting costs from gross lumber-value recoveries; and corresponding values obtained for trees by combining the data for logs making up the trees in each size class. In the analysis for individual log and tree values, the techniques of which are described, the data from all the test blocks were combined.

Cost of production for each part of the logging and milling operation is given in man-hours as well as in dollars, to permit easy application in operations in which unit costs differ from those of the experimental operation, and also to facilitate revision of figures on costs and returns as changes take place in conditions affecting costs. The costs quoted are based on the Doyle-Scribner, International ¼-inch, Scribner, and cubic-foot scales. These cost figures are considered applicable only to stands under selective management. Details of costs are shown in tables in the appendix.

Of all the items of expense included in the cost of finished lumber, manufacturing is by far the largest. This is the one part of the whole lumber production operation that can make or break a company, with or without good practice in the woods. It is at the mill, also, that the kinds of logs that are profitable, and those that are unprofitable, can most easily be checked. Three men in 2 days' time, at a total cost of not more than $30, can make a simple study in the mill that will determine roughly which logs are being cut and milled at a loss. It is then a simple matter to prevent the cutting of unprofitable logs in the woods.

Costs of lumber manufacture vary greatly with type, size, and efficiency of mills. Operating costs differ between mills of the same size class in the same region, owing to differences in operating conditions and efficiency of mill and management. Even for an individual mill, costs vary considerably from year to year according to total number of hours of operation and volume of lumber produced. The figures on cost of lumber manufacture per M feet found in this study may not be applicable to any other operation, and each operator is strongly advised to calculate his own costs. Of much greater significance are the relative time requirement and cost of milling by log-size class, since these vary but little from year to year for a given operation and are more likely to be consistent for different mills of the same size class.

The Crossett mills (fig. 6) are quite typical of the large older mills in the South that contain two or more head saws and cut from 60 M to 90 M feet per saw each 8-hour shift. They operate three band head saws and a Swedish gang saw and, except for the large shotgun feeds, are entirely electrified. The carriages are large and heavy and at the time of the study were manually operated, three men to the carriage. The mills have a large dry-kiln capacity, and when they are being operated on the customary one shift per day all the pine is kiln-dried. The company has complete remanufacturing facilities—a flooring plant, a box factory, and a gluing plant—all run in direct connection with the sawmill. The plants are so integrated that the lumber cut on the head rig can all be handled currently through the edgers, trimmers, green chain, dry kilns, remanufacturing plants, shipping department, and sales organization.

The mill at which the pine and hardwood logs included in the study were cut was equipped with band head saw, edger, and trimmer for rough lumber manufacture. It was therefore relatively simple to measure the time required by the sawyer to cut each log into lumber and to grade and tally the lumber that was produced from each log, and later to reconstruct from the tree and log identification numbers on each log the trees represented. One man stationed at the head saw with a stop watch recorded the field log and tree numbers, the time required to saw each log, and the amount of delay time—the time the mill was not in operation because of the changing of saws or mechanical trouble. A second man marked each board from each log so that an expert grader and his assistant at the green chain could identify and tally for each log the size and grade of all lumber produced.

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FIGURE 6.—Typical large southern sawmill, with trainload of logs and loader in foreground. Such a mill usually has two or more head saws, each cutting 60 to 90 M board feet per 8-hour shift.

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The mill study proceeded only so far as rough lumber manufacture, including pond, head saw, edgers, trimmers, and green chain.

## How Log Size Affects Cost of Selective Logging

Costs and returns for individual logs not only enter into determination of individual tree values but also indicate what kinds of logs can be used profitably for lumber and what kinds should be diverted, if possible, to other uses.

Because of the very large number of logs produced in the experimental operation, not all logs cut and measured in the woods were included in the computation of costs of logging by log size; but all the very large and all the very small logs were included, in order to obtain sound results covering the whole range of sizes. The average cost per M feet computed for all logs, therefore, does not always check exactly with the average cost per M feet for all trees or for the trees on individual test blocks.

Since the logs cut varied in length from 12 feet to 20 feet, averaging close to 16 feet, weighted averages presented for diameter classes represent logs of the average woods-run length.

### FELLING AND BUCKING

In order to determine the cost per log of felling and bucking by log diameter, it has been necessary to prorate the cost of walking from one tree to another, the swamping cost, and the actual felling cost among the logs produced from each tree. These costs have been divided in direct proportion to the cubic volumes of the individual logs. Thus, if the second log of a given tree contained 30 percent of the cubic volume of all logs in the tree, 30 percent of these costs plus the bucking cost of the second log were charged to this log. After the prorating of time and cost the total felling and bucking time, in man-minutes, and cost per log were summarized by log-diameter class. The summary for pine is presented in appendix table 54, and that for hardwoods in appendix table 57. Time in man-hours and costs per unit of volume for the three scale rules and for cubic measure were computed and are given for pine logs in appendix tables 55 and 56 and for hardwood logs in tables 58 and 59. These cost data, illustrated for pine in figure 7, show, as do the tables for all species, a strong trend of increase in cost as log size decreases.

### SKIDDING AND LOADING

The field records of time required for the skidding and loading on trucks of the pine and hardwood logs were compiled by log size (appendix tables 54 and 57). Costs per log are uniform for pine logs up to 15 inches top diameter, but increase rapidly with increase beyond that point in log size. In team skidding and loading, usually only one log is handled at a time, and the team moves at a uniform rate except when the log is large and the animals become winded and require rest periods. Figure 3 and tables 55 to 59 in the appendix show the trends of the skidding and loading costs on M-board-foot and 100-cubic-foot bases. Regardless of type of cutting, there are always some small logs that are relatively costly per unit of volume; but selective management, allowing individual trees to reach full development before they are cut, will reduce the number of these and lower considerably the skidding and loading as well as all other costs per

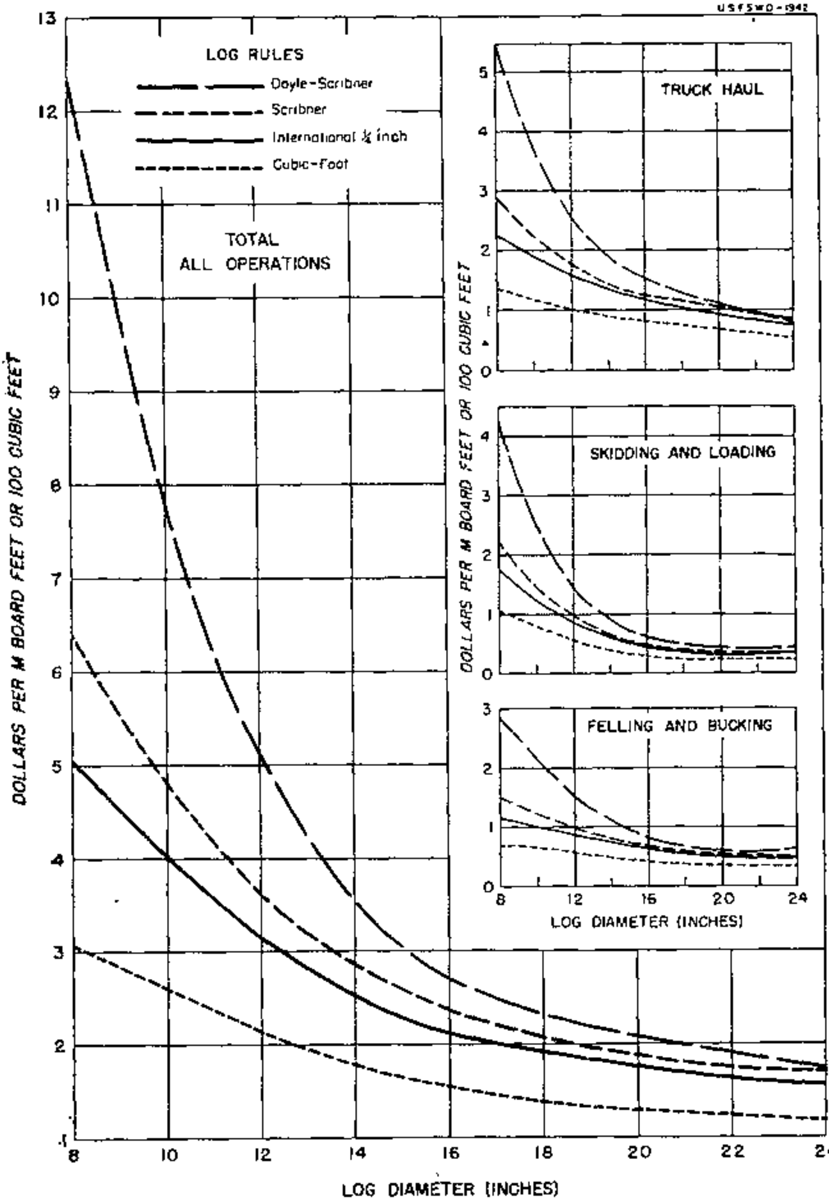


FIGURE 7.- Costs, by log size, of logging shortleaf and loblolly pine.

unit volume, as compared with costs in clear cutting. For instance, an increase in the diameter-inside-bark average for pine logs from 10 inches to 14 inches would reduce both the skidding and the loading cost per M feet (Doyle-Scribner rule) by about one-third.

In order to determine the cost influence of skidding distance for pine logs of various sizes, the costs per log and per unit of volume for skidding 100 feet were computed from the study data (table 16). These figures include hooking and unhooking time, prorated delay time, and time spent in maneuvering the logs into position for immediate or later loading on trucks, and represent average costs for dry-weather skidding on a typical truck-logging job. Except in extremely wet weather, log trucks are usually driven to all points in the woods, so that in most instances logs are skidded a distance of less than 200 feet and only a few are moved so far as 1,000 feet.

TABLE 16.—*Man-minute requirement*[1] *and cost per log and per unit of volume for skidding*[2] *shortleaf-loblolly pine logs of various sizes*

| Diameter inside bark (inches) | Volume per log | | | | Time per log per 100 feet | Cost[3] per 100 feet of distance | | | | | Basis, logs |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Doyle-Scribner rule | International rule | Scribner rule | Cubic-foot rule | | Per log | Per M feet of volume | | | Per 100 cubic feet | |
| | | | | | | | Doyle-Scribner rule | International rule | Scribner rule | | |
| | *Board feet* | *Board feet* | *Board feet* | *Cubic feet* | *Man-minutes* | *Dollars* | *Dollars* | *Dollars* | *Dollars* | *Dollars* | *Number* |
| 8 | 15 | 37 | 29 | 6.1 | 2.88 | 0.030 | 2.00 | 0.81 | 1.03 | 0.49 | 50 |
| 9 | 20 | 45 | 36 | 7.4 | 2.98 | .031 | 1.55 | .69 | .86 | .44 | 160 |
| 10 | 27 | 54 | 45 | 8.3 | 3.09 | .032 | 1.19 | .59 | .71 | .39 | 322 |
| 11 | 36 | 65 | 55 | 9.8 | 3.20 | .033 | .92 | .51 | .60 | .34 | 434 |
| 12 | 49 | 80 | 69 | 11.8 | 3.41 | .035 | .71 | .44 | .51 | .30 | 489 |
| 13 | 64 | 97 | 86 | 14.2 | 3.52 | .036 | .56 | .37 | .42 | .25 | 438 |
| 14 | 83 | 117 | 106 | 16.9 | 3.62 | .037 | .45 | .32 | .35 | .22 | 431 |
| 15 | 103 | 139 | 126 | 19.6 | 3.73 | .038 | .37 | .27 | .30 | .19 | 303 |
| 16 | 126 | 162 | 149 | 22.6 | 3.84 | .040 | .32 | .25 | .27 | .18 | 212 |
| 17 | 149 | 186 | 171 | 25.7 | 3.94 | .041 | .28 | .22 | .24 | .16 | 115 |
| 18 | 175 | 211 | 196 | 29.2 | 4.05 | .042 | .24 | .20 | .21 | .14 | 72 |
| 19 | 201 | 237 | 221 | 32.7 | 4.16 | .043 | .21 | .18 | .19 | .13 | 41 |
| 20 | 229 | 264 | 247 | 36.3 | 4.26 | .044 | .19 | .17 | .18 | .12 | 27 |
| 21 | 258 | 292 | 274 | 40.1 | 4.37 | .045 | .17 | .15 | .16 | .11 | 21 |
| 22 | 289 | 321 | 302 | 43.8 | 4.48 | .046 | .16 | .14 | .15 | .11 | 16 |
| 23 | 320 | 350 | 330 | 47.3 | 4.69 | .048 | .15 | .14 | .15 | .10 | 5 |

[1] Including delays.
[2] Including hooking, skidding, and unhooking.
[3] Rate per man-minute=$0.0103.

## TRUCK HAUL

The time required for the 4-mile truck haul was computed in man-minutes per log for the various diameters (appendix tables 54 and 57). Similar information on a unit-volume basis is given in figure 3 and appendix tables 55 and 56 for pine and in tables 58 and 59 for hardwood. The hauling cost per M feet (Doyle-Scribner rule) is more than twice as great for 10-inch pine logs as for 14-inch, indicating the great reductions possible through a cutting practice that will increase average log size.

The widespread adoption in the South of truck transportation for logs has led to repeated requests for information on costs for various lengths of haul and for logs of various average volumes. In order to furnish this information, separate compilations have been made of the trucking data in actual time per load and cost per M board feet by the different rules for logs of various volumes (International) on a 4-mile haul (appendix table 60). Table 61 gives the corresponding cost per additional one-half mile. It should be remembered that these costs do not include contractor's profit or skidding and loading cost, are based on hauling over ordinary dirt roads, and must be adjusted to fit individual wage rates and local conditions, such as different truck-operating costs. Once the cost per minute for any given set of conditions has been computed, the cost per unit of volume for hauling any given number of miles can be determined quickly by multiplying the minute rate by the number of minutes required to haul loads of logs of various sizes, and dividing by the average number of units of volume per load. The costs per additional one-half mile given here can be corrected on the basis of the difference in percent between the new rate per minute and the rate ($0.0171) used in the study.

## How Log Size Affects Cost of Railroad Transportation

The use of railroads for transporting logs part of the way to the mill is justified from a cost standpoint if the volume to be hauled by rail is large and the maximum hauling distance is 25 miles or more. Because of the high cost involved, however, an operator should make a very detailed cost study before deciding to use railroads in places where the entire hauling job could be done with trucks.

### LOADING ON CARS

After all the logs produced in the experimental operation were delivered to the landing, they were loaded on standard-gage railroad log cars for transportation to the mill. The loading was done with a car-top loader, operated in conjunction with a small rod locomotive (fig. 5, *B*). This loader is very efficient; it can load a string of 25 log cars in about 4 hours. As each load is completed the loader moves over to the next car and loads the car just vacated. The move from one car to another requires but 12.5 percent of the total loading time, and is usually accomplished as the engine pulls the loader and cars abreast of the logs on the landing.

In loading the logs cut in the experimental operation, the engine and loader crew worked on a contract basis of 25 cars per day; that is, when 25 loads were completed and delivered at the mill the crew was through for the day and drew a full day's pay, regardless of actual number of hours worked. Since the number of cars loaded per day usually varies, according to length of train haul, the man-hour operating cost for the loader and locomotive were determined on the basis of an 8-hour day. The cost per hour of actual loading time (table 17) was determined by dividing the total cost per 8-hour day by the average actual number of hours of loading time in such a day. The total cost of the loading crew and equipment per day amounted to $31.040, and the average effective loading time per 25-car trainload of logs was 3.833 hours. The loading cost per effective hour of operation was, therefore, $8.098. With a loading crew of 5⅔ men (including one-third of the locomotive engineer's and one-third of the fireman's time) the cost per effective man-hour was $1.429 and the cost per effective man-minute was $0.0238.

A stop-watch time study was made of the loading operation, and the actual effective time required to load each log was obtained. This information was sorted on the basis of size of log, and the man-minutes required for logs of each size class were computed. The cost per log was then determined by multiplying the number of man-minutes by $0.0238, the rate per effective minute. The data are shown for pine and hardwood in appendix tables 62 and 65. The man-hours and costs per unit of volume by log size have also been computed and are given in appendix tables 63 and 64 for pine and tables 66 and 67 for hardwood.

TABLE 17.—*Estimated average operating cost for car-top loader* [1] *and locomotive* [2] *per hour of actual loading time*

| Item | Rate per hour | Distribution |
|---|---|---|
| Current operating costs: | | |
| Direct labor costs: [3] | *Dollars* | *Percent* |
| 1 loaderman, at $0.60 | 0.600 | 17.8 |
| 1 top loader, at $0.425 | .425 | 10.9 |
| 3 tong hookers, at $0.425 each | 1.275 | 32.9 |
| ⅓ locomotive engineer, at $0.59 | .197 | 5.1 |
| ⅓ locomotive fireman, at $0.49 | .163 | 4.2 |
| State and Federal social-security costs (4 percent of above) | .110 | 2.8 |
| Total | 2.860 | 73.7 |
| Other direct costs: | | |
| Fuel and oil for loader: | | |
| Fuel oil, 6 gallons, at $0.024 | .144 | 3.7 |
| Oils and waste | (4) | |
| Fuel and oil for locomotive: | | |
| Fuel oil, ⅓ of 40 gallons, at $0.024 | .320 | 8.2 |
| Oils and waste | (4) | |
| Current operating costs—Con. | | |
| Other direct cost.—Con. | *Dollars* | *Percent* |
| Loading line | 0.080 | 2.1 |
| Supervision | .050 | 1.3 |
| Repairs (labor and supplies) | .182 | 4.7 |
| Total | .776 | 20.0 |
| Ownership costs: | | |
| Depreciation | .100 | 2.6 |
| Interest (6 percent of average investment) | .105 | 2.7 |
| Fire insurance and taxes (2¼ percent of average investment) | .039 | 1.0 |
| Total ownership cost | .244 | 6.3 |
| Total cost | 3.880 | 100.0 |
| Man-hour cost (5⅔-man crew) | .685 | |

[1] Present value of loader, $3,500.
[2] Present value of locomotive, $2,500.
[3] Includes service labor (greasing, fueling, and firing up).
[4] Negligible.

## TRAIN HAUL

After being loaded, the train of 25 cars was pulled by a rod locomotive about 20 miles to the mill. The costs of the haul are shown in table 18. Only two-thirds of the costs of the train and crew are included because one-third was charged against loading. Cost per day of 8 hours was $27.944 and cost per car was $1.118. Man-hours required averaged 10.667 per day and 0.427 (25.60 man-minutes) per car.

In order to determine the man-minute requirement and cost per log the following calculations were made:

1. Average size of log was determined for each car, and carloads were grouped accordingly.

2. Average number of logs per load for each log diameter group was determined, and man-minute requirement and cost per log were obtained by dividing the totals per car by this number.

Labor time and cost of train haul per log and per unit of volume are given for pine and hardwoods in appendix tables 62–67, which include car-loading data.

TABLE 18.—*Estimated average operating cost for locomotive*[1] *and 25 log cars,*[2] *per hour of running time to and from woods, and switching*

| Item | Rate per hour | Distribution |
|---|---|---|
| | *Dollars* | *Percent* |
| Current operating costs: | | |
| Direct labor costs: | | |
| ⅔ locomotive engineer at $0.59 | 0.393 | 11.3 |
| ⅔ locomotive fireman at $0.49 | .327 | 9.4 |
| State and Federal social security costs (4 percent of above) | .029 | .8 |
| Total | .749 | 21.5 |
| Other direct costs: | | |
| Fuel oil, ⅔ of 40 gallons at $0.024 | .640 | 18.3 |
| Oils and waste | (3) | |
| Repairs (labor and supplies) for engine and cars | .991 | 28.4 |
| Current operating costs—Con. | | |
| Other direct costs—Con. | | |
| Supervision | 0.050 | 1.4 |
| Total | 1.681 | 48.1 |
| Ownership costs: | | |
| Depreciation of engine and cars | .290 | 8.3 |
| Interest (6 percent of average investment) | .562 | 16.1 |
| Fire insurance and taxes (2½ percent of average investment) | .211 | 6.0 |
| Total ownership cost | 1.063 | 30.4 |
| Total cost | 3.493 | 100.0 |
| Man-hour cost (1⅓-man crew) | 2.620 | ---- |

[1] Present value of locomotive, $2,500.
[2] Present value of each log car, $500.
[3] Negligible.

### MAIN-LINE TRACK

In addition to the actual cost of the train haul there is a cost of main-line track, including maintenance, depreciation, interest on the investment, and taxes. This cost, obtained from company records, amounts to $0.679 per M feet Doyle-Scribner scale, or $0.544 per M feet International (¼-inch) scale. From the company's records of men employed in maintaining the track and the total of timber hauled, it was found that 1.595 man-hours were required per M feet Doyle-Scribner scale, or 1.276 man-hours by International scale. Maintenance and depreciation, making up the greater part of the costs of the track, are directly proportional to the number of loaded log cars that are hauled over it. By dividing the total man-hours required and the total costs of the track by the total number of loads of logs hauled, the man-hours per car were found to be 3.611 and the cost per car $1.538. With these figures available, the main-line track costs per log and per unit of volume by log size were determined by the same method used to determine the effect of log size upon costs of train haul. The results are given in appendix tables 62–67.

## HOW LOG SIZE AFFECTS COST OF LUMBER MANUFACTURE

Two types of costs were recognized in determining the total cost of manufacturing lumber from logs of various sizes and grades—(1) those varying with log size, and (2) those fixed at a constant amount per M feet of lumber. The first included the cost per minute or per hour for cutting each log on the headrig and for edging and trimming the boards and handling them on the green chain. The second was an average cost per M feet for handling the lumber through the dry kiln and the remanufacturing plants, and for shipping and selling and overhead expenses. Costs were determined separately for pine and for hardwood and were figured on the headrig doing the sawing and on that proportion of the plant and sales organization handling the lumber from that particular headrig.

Costs and man-hour requirements were calculated on the basis of the company's 1940 production cost figures (table 19), the total running time (effective plus ineffective) in hours, and the number of men

TABLE 19.—*Costs per M board feet (green-chain tally) of manufacturing pine and hardwood lumber in a large mill, 1940*

| Item | Pine | | | Hardwood | | |
|---|---|---|---|---|---|---|
| | Costs affected by log size | Other costs | Total | Costs affected by log size | Other costs | Total |
| | *Dollars* | *Dollars* | *Dollars* | *Dollars* | *Dollars* | *Dollars* |
| Sawmill costs (labor and supplies): | | | | | | |
| Pond | 0.21 | | 0.21 | 0.21 | | 0.21 |
| Sawmill | 1.87 | | 1.87 | 2.57 | | 2.57 |
| Green chain | .40 | | .40 | .40 | | .40 |
| Dry kilns | | 2.02 | 2.02 | | | |
| Green yard | | 1.17 | 1.17 | | 2.33 | 2.33 |
| Transportation | | .29 | .29 | | .29 | .29 |
| Dry skids | | .68 | .08 | | | |
| Send in | | .50 | .50 | | .50 | .50 |
| Planing | | 2.03 | .203 | | .64 | .64 |
| Loading | | .58 | .58 | | 1.17 | 1.17 |
| Dipping | | | | | .39 | .30 |
| Selling costs | | 3.25 | 3.25 | | 3.14 | 3.14 |
| Overhead costs (depreciation, insurance, taxes, association dues, office salaries and expenses, legal fees, audits and appraisals, and fire protection) | | 5.60 | 5.60 | | 5.71 | 5.71 |
| Total | 2.48 | 16.12 | 18.60 | 3.18 | 14.17 | 17.35 |

employed on each phase of the work. For pine-lumber manufacture the costs were $0.820 per man-hour for the 18 men in rough-lumber manufacture and $0.463 per man-hour for the 207 men in the remainder of the plant; for hardwoods the costs were $1.07 per man-hour for the 15 men engaged in rough-lumber manufacturing and $0.4555 per man-hour for the 157 men in the remainder of the plant. The difference in total costs was chiefly due to the fact that the hardwood lumber was air-dried and the pine lumber was kiln-dried.

The rough-lumber production time in minutes for each log as recorded from a stop watch was increased by a proportionate amount of delay as ineffective time (equivalent to 6.76 percent) and then converted to man-hours. This figure was multiplied by the rough-lumber production rate per man-hour to get the rough-lumber cost per log. To obtain the per-log cost for the remainder of the milling operation (lumber handling, kiln drying, planing, shipping, and selling), the green-chain volume per log was multiplied by the constant cost per M feet as given in table 19. The total cost of lumber manufacture per log was computed by adding together the rough-lumber costs affected by log size and the other cost.

The time requirement and the cost per log and per unit of volume of cutting logs of various sizes into lumber at the headsaw and of performing all other mill operations involved in producing and selling dried and finished pine and hardwood lumber are given by log size in table 20.

TABLE 20.—*Man-hour requirement and cost*[1] *per log and per unit of volume for sawmilling*[2] *logs of various sizes*

| Diameter inside bark (inches) | Per log | | | | | | Per M board feet by designated log rule— | | | | | | Per 100 cubic feet | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Time | | | Cost[3] | | | Doyle-Scribner | | International | | Scribner | | | |
| | Fixed | Variable | Total | Fixed | Variable | Total | | | | | | | | |
| | *Man-hours* | *Man-hours* | *Man-hours* | *Dollars* | *Dollars* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* |
| PINE | | | | | | | | | | | | | | |
| 8 | 1.531 | 0.201 | 1.732 | 0.709 | 0.165 | 0.874 | 115.467 | 58.27 | 46.811 | 23.62 | 59.724 | 30.14 | 28.393 | 14.33 |
| 9 | 1.706 | .207 | 1.913 | .790 | .170 | .960 | 95.650 | 48.00 | 42.511 | 21.33 | 53.139 | 26.67 | 26.944 | 13.52 |
| 10 | 1.916 | .220 | 2.136 | .887 | .180 | 1.067 | 79.111 | 39.52 | 39.556 | 19.76 | 47.467 | 23.71 | 25.735 | 12.86 |
| 11 | 2.194 | .237 | 2.431 | 1.016 | .194 | 1.210 | 67.528 | 33.61 | 37.400 | 18.62 | 44.200 | 22.00 | 24.806 | 12.35 |
| 12 | 2.542 | .261 | 2.803 | 1.177 | .214 | 1.391 | 57.204 | 28.39 | 35.038 | 17.39 | 40.623 | 20.16 | 23.754 | 11.79 |
| 13 | 2.994 | .291 | 3.285 | 1.386 | .239 | 1.625 | 51.328 | 25.30 | 33.866 | 16.75 | 38.198 | 18.90 | 23.134 | 11.44 |
| 14 | 3.551 | .327 | 3.878 | 1.644 | .268 | 1.912 | 46.723 | 23.04 | 33.145 | 16.34 | 36.585 | 18.04 | 22.047 | 11.31 |
| 15 | 4.177 | .368 | 4.545 | 1.934 | .302 | 2.236 | 44.126 | 21.71 | 32.608 | 16.09 | 36.071 | 17.75 | 23.180 | 11.41 |
| 16 | 4.875 | .417 | 5.292 | 2.257 | .342 | 2.599 | 42.000 | 20.63 | 32.667 | 16.04 | 35.517 | 17.44 | 23.416 | 11.50 |
| 17 | 5.639 | .468 | 6.107 | 2.611 | .384 | 2.995 | 40.987 | 20.10 | 32.833 | 16.10 | 35.713 | 17.51 | 23.763 | 11.65 |
| 18 | 6.441 | .522 | 6.963 | 2.982 | .428 | 3.410 | 39.759 | 19.49 | 33.000 | 16.16 | 35.526 | 17.40 | 23.840 | 11.68 |
| 19 | 7.276 | .579 | 7.855 | 3.369 | .475 | 3.844 | 39.080 | 19.12 | 33.143 | 16.22 | 35.543 | 17.39 | 24.021 | 11.76 |
| 20 | 8.147 | .639 | 8.786 | 3.772 | .524 | 4.296 | 38.367 | 18.76 | 33.280 | 16.27 | 35.571 | 17.39 | 24.204 | 11.83 |
| 21 | 9.052 | .701 | 9.753 | 4.191 | .575 | 4.766 | 37.802 | 18.47 | 33.401 | 16.32 | 35.595 | 17.39 | 24.322 | 11.89 |
| 22 | 9.957 | .768 | 10.725 | 4.610 | .630 | 5.240 | 37.111 | 18.13 | 33.411 | 16.32 | 35.513 | 17.35 | 24.486 | 11.96 |
| 23 | 10.862 | .837 | 11.699 | 5.029 | .686 | 5.715 | 36.559 | 17.86 | 33.426 | 16.33 | 35.452 | 17.35 | 24.734 | 12.08 |
| 24 | 11.769 | .909 | 12.678 | 5.449 | .745 | 6.194 | 36.327 | 17.75 | 33.540 | 16.39 | 35.413 | 17.30 | 25.055 | 12.24 |
| HARDWOOD | | | | | | | | | | | | | | |
| 9 | 2.053 | 0.327 | 2.380 | 0.935 | 0.350 | 1.285 | 82.069 | 44.31 | 56.638 | 27.34 | 62.632 | 33.82 | 22.885 | 12.36 |
| 10 | 2.239 | .329 | 2.568 | 1.020 | .352 | 1.372 | 69.405 | 37.08 | 45.053 | 24.07 | 54.636 | 29.19 | 23.778 | 12.70 |
| 11 | 2.520 | .332 | 2.852 | 1.148 | .355 | 1.503 | 60.681 | 31.98 | 41.333 | 21.78 | 49.172 | 25.91 | 23.960 | 12.63 |
| 12 | 2.894 | .342 | 3.236 | 1.318 | .366 | 1.684 | 54.847 | 28.54 | 38.088 | 20.29 | 44.944 | 23.39 | 23.794 | 12.38 |
| 13 | 3.328 | .359 | 3.687 | 1.516 | .384 | 1.900 | 49.824 | 25.68 | 36.870 | 19.00 | 41.427 | 21.35 | 23.335 | 12.03 |
| 14 | 3.827 | .392 | 4.219 | 1.743 | .419 | 2.162 | 45.859 | 23.50 | 35.158 | 18.02 | 39.065 | 20.02 | 22.683 | 11.62 |
| 15 | 4.386 | .429 | 4.815 | 1.998 | .459 | 2.457 | 42.091 | 21.94 | 33.908 | 17.30 | 37.326 | 19.05 | 22.169 | 11.32 |
| 16 | 4.977 | .474 | 5.451 | 2.267 | .507 | 2.774 | 40.679 | 20.70 | 33.036 | 16.81 | 35.862 | 18.25 | 21.804 | 11.10 |
| 17 | 5.600 | .524 | 6.124 | 2.551 | .561 | 3.112 | 38.759 | 19.70 | 32.402 | 16.47 | 34.795 | 17.69 | 21.338 | 10.84 |
| 18 | 6.252 | .579 | 6.831 | 2.848 | .620 | 3.468 | 37.328 | 18.95 | 31.921 | 16.20 | 33.985 | 17.25 | 20.954 | 10.63 |
| 19 | 6.937 | .636 | 7.573 | 3.160 | .681 | 3.841 | 36.234 | 18.38 | 31.554 | 16.00 | 33.361 | 16.92 | 20.691 | 10.49 |
| 20 | 7.653 | .686 | 8.340 | 3.486 | .745 | 4.231 | 35.377 | 17.93 | 31.270 | 15.85 | 32.870 | 16.66 | 20.514 | 10.40 |
| 21 | 8.369 | .759 | 9.126 | 3.812 | .812 | 4.624 | 34.576 | 17.52 | 30.942 | 15.67 | 32.369 | 16.40 | 20.284 | 10.28 |
| 22 | 9.085 | .821 | 9.906 | 4.138 | .878 | 5.016 | 33.694 | 17.06 | 30.574 | 15.48 | 31.852 | 16.13 | 20.012 | 10.13 |
| 23 | 9.800 | .883 | 10.683 | 4.464 | .945 | 5.409 | 32.871 | 16.64 | 30.178 | 15.28 | 31.328 | 15.86 | 19.820 | 10.04 |
| 24 | 10.514 | .949 | 11.463 | 4.789 | 1.015 | 5.804 | 32.109 | 16.26 | 29.774 | 15.08 | 30.815 | 15.60 | 19.662 | 9.96 |
| 25 | 11.229 | 1.016 | 12.245 | 5.115 | 1.087 | 6.202 | 31.397 | 15.90 | 29.364 | 14.87 | 30.309 | 15.35 | 19.498 | 9.88 |

[1] Rate per man-hour for pine: Pond, sawmill, green-chain, $0.820; remainder of mill, $0.463. Rate per man-hour for hardwood: Pond, sawmill, green-chain, $1.070; remainder of mill, $0.4555.

[2] Including milling, shipping, and selling.

[3] See table 19 for classification of fixed and variable costs.

## HOW LOG SIZE AFFECTS TOTAL COST PER UNIT OF MILL CUT FOR LOGGING, RAILROAD TRANSPORTATION, AND MANUFACTURE

In order to compare logging and milling cost with the value of the lumber produced from both pine and hardwood logs of various sizes, it is necessary that overrun and underrun be taken into consideration and that both sets of figures be based on lumber tally at the mill.

The overrun and underrun of mill tally with respect to log scale for pine and hardwood logs of various sizes are given in table 21. It

TABLE 21.—*Overrun or underrun of mill tally with respect to log scale, for logs of various sizes*

PINE

| Diameter inside bark (inches) | Mill tally | Log scale volume: Doyle-Scribner | Log scale volume: International | Log scale volume: Scribner | Log scale volume: Cubic foot | Overrun (+) or underrun (−) by designated log rule: Doyle-Scribner | International | Scribner | Cubic foot | Doyle-Scribner | International | Scribner | Cubic foot | Basis, logs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Board feet* | *Board feet* | *Board feet* | *Board feet* | *Cubic feet* | *Board feet* | *Board feet* | *Board feet* | *Cubic feet* | *Percent* | *Percent* | *Percent* | *Percent* | *Number* |
| 8 | 44 | 15 | 37 | 29 | 6.1 | +29 | +7 | +15 | −2.4 | +193 | +19 | +52 | −39 | .... |
| 9 | 49 | 20 | 45 | 36 | 7.1 | +29 | +4 | +13 | −3.0 | +145 | +9 | +36 | −42 | 11 |
| 10 | 55 | 27 | 54 | 45 | 8.3 | +28 | +1 | +10 | −3.7 | +104 | +2 | +22 | −45 | 41 |
| 11 | 63 | 36 | 65 | 55 | 9.8 | +27 | −2 | +8 | −4.6 | +75 | −3 | +15 | −47 | 79 |
| 12 | 73 | 49 | 80 | 69 | 11.8 | +24 | −7 | +4 | −5.7 | +49 | −9 | +6 | −48 | 127 |
| 13 | 86 | 64 | 97 | 86 | 14.2 | +22 | −11 | ---- | −7.0 | +34 | −11 | ---- | −49 | 125 |
| 14 | 102 | 83 | 117 | 106 | 16.9 | +19 | −15 | −4 | −8.4 | +23 | −13 | −4 | −50 | 144 |
| 15 | 120 | 103 | 139 | 126 | 19.6 | +17 | −19 | −6 | −9.6 | +17 | −14 | −5 | −49 | 122 |
| 16 | 140 | 126 | 162 | 149 | 22.6 | +14 | −22 | −9 | −10.9 | +11 | −14 | −6 | −48 | 102 |
| 17 | 162 | 149 | 186 | 171 | 25.7 | +13 | −24 | −9 | −12.2 | +9 | −13 | −5 | −47 | 50 |
| 18 | 185 | 175 | 211 | 196 | 29.2 | +10 | −26 | −11 | −13.8 | +6 | −12 | −6 | −47 | 46 |
| 19 | 209 | 201 | 237 | 221 | 32.7 | +8 | −28 | −12 | −15.3 | +4 | −12 | −5 | −47 | 28 |
| 20 | 234 | 229 | 264 | 247 | 36.3 | +5 | −30 | −13 | −16.8 | +2 | −11 | −5 | −46 | 24 |
| 21 | 260 | 258 | 292 | 274 | 40.1 | +2 | −32 | −14 | −18.4 | +1 | −11 | −5 | −46 | 12 |
| 22 | 286 | 289 | 321 | 302 | 43.8 | −3 | −35 | −16 | −20.0 | −1 | −11 | −5 | −46 | 10 |
| 23 | 312 | 320 | 350 | 330 | 47.3 | −8 | −38 | −18 | −21.3 | −2 | −11 | −5 | −45 | 3 |
| 24 | 338 | 349 | 378 | 358 | 50.6 | −11 | −40 | −20 | −22.4 | −3 | −11 | −6 | −44 | 1 |
| Weighted average or total | 115 | 97 | 130 | 118 | 18.5 | +18 | −15 | −3 | −8.9 | +19 | −12 | −3 | −48 | 925 |

HARDWOOD

| Diameter inside bark (inches) | Mill tally | Log scale volume: Doyle-Scribner | Log scale volume: International | Log scale volume: Scribner | Log scale volume: Cubic foot | Overrun (+) or underrun (−) by designated log rule: Doyle-Scribner | International | Scribner | Cubic foot | Doyle-Scribner | International | Scribner | Cubic foot | Basis, logs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Board feet* | *Board feet* | *Board feet* | *Board feet* | *Cubic feet* | *Board feet* | *Board feet* | *Board feet* | *Cubic feet* | *Percent* | *Percent* | *Percent* | *Percent* | *Number* |
| 9 | 66 | 29 | 47 | 38 | 10.4 | +37 | +19 | +28 | −4.9 | +128 | +40 | +74 | −47 | 5 |
| 10 | 72 | 37 | 57 | 47 | 10.8 | +35 | +15 | +25 | −4.8 | +95 | +26 | +53 | −44 | 21 |
| 11 | 81 | 47 | 69 | 58 | 11.9 | +34 | +12 | +23 | −5.1 | +72 | +17 | +40 | −43 | 38 |
| 12 | 93 | 59 | 83 | 72 | 13.6 | +34 | +10 | +21 | −5.8 | +58 | +12 | +29 | −43 | 58 |
| 13 | 107 | 74 | 100 | 89 | 15.8 | +33 | +7 | +18 | −6.9 | +45 | +7 | +20 | −44 | 47 |
| 14 | 123 | 92 | 120 | 108 | 18.6 | +31 | +3 | +15 | −8.4 | +34 | +2 | +14 | −45 | 62 |
| 15 | 141 | 112 | 142 | 129 | 21.7 | +29 | −1 | +12 | −9.9 | +26 | −1 | +9 | −46 | 34 |
| 16 | 160 | 134 | 165 | 152 | 25.0 | +26 | −5 | +8 | −11.7 | +19 | −3 | +5 | −47 | 32 |
| 17 | 180 | 158 | 189 | 176 | 28.7 | +22 | −9 | +4 | −13.7 | +14 | −5 | +2 | −48 | 19 |
| 18 | 201 | 183 | 214 | 201 | 32.6 | +18 | −13 | ---- | −15.8 | +10 | −6 | ---- | −48 | 18 |
| 19 | 223 | 209 | 240 | 227 | 36.6 | +14 | −17 | −4 | −18.0 | +7 | −7 | −2 | −49 | 9 |
| 20 | 246 | 236 | 267 | 254 | 40.7 | +10 | −21 | −8 | −20.2 | +4 | −8 | −3 | −50 | 6 |
| 21 | 269 | 264 | 295 | 282 | 45.0 | +5 | −26 | −13 | −22.6 | +2 | −9 | −5 | −50 | 6 |
| 22 | 292 | 294 | 324 | 311 | 49.5 | −2 | −32 | −19 | −25.2 | −1 | −10 | −6 | −51 | 3 |
| 23 | 315 | 325 | 354 | 341 | 53.9 | −10 | −39 | −26 | −27.7 | −3 | −11 | −8 | −51 | 3 |
| 24 | 338 | 357 | 385 | 372 | 58.3 | −19 | −47 | −34 | −30.1 | −5 | −12 | −9 | −52 | 2 |
| 25 | 361 | 390 | 417 | 404 | 62.8 | −29 | −56 | −43 | −32.7 | −7 | −13 | −11 | −52 | .... |
| Weighted average or total | 131 | 102 | 129 | 117 | 20.3 | +29 | +2 | +14 | −9.3 | +28 | +2 | +12 | −46 | 363 |

is important to remember that, in scaling, no deductions were made for crook or hidden defect, as lumber companies buying on Doyle or Doyle-Scribner scale generally do not make these deductions. This explains why in this study the International (¼-inch) rule, which for straight and sound logs approximates very closely the mill cut, overruns the mill cut. Furthermore, these overrun figures are based on the material removed in the first cut in selectively logged stands, which included the defective, crooked, and otherwise least desirable trees. Second and later cuts to be made in the same stands should and undoubtedly will produce a much greater percent of straight and sound logs.

Costs of logging, railroad transportation, and manufacture per M board feet of mill lumber tally were computed by log size for both pine and hardwood by dividing the mill lumber tally per log into the total cost of production per log, and then multiplying by 1,000. The

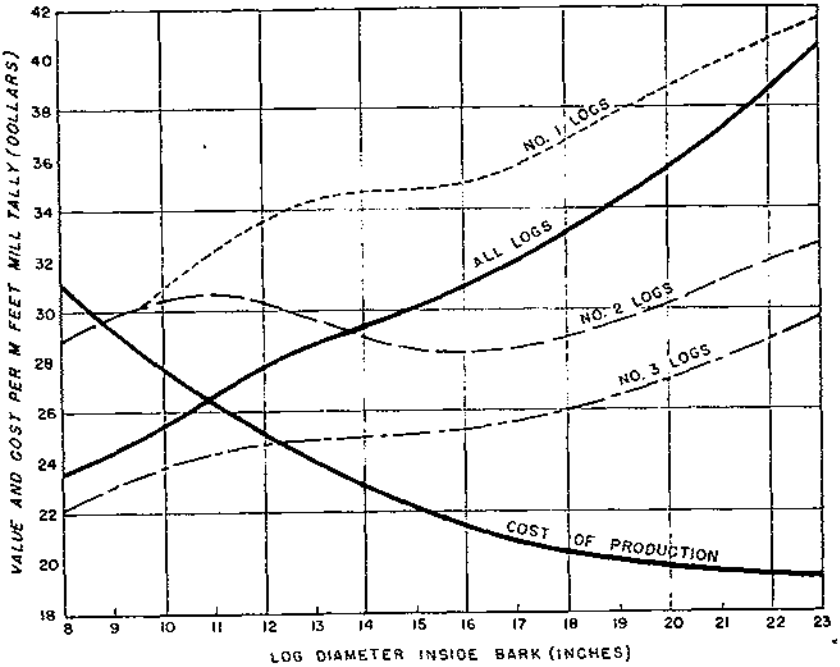


FIGURE 8.—Value of lumber produced from shortleaf and loblolly pine logs of grades 1, 2, and 3, and total cost of production.

results are given for pine in figure 8 and for pine and hardwood in appendix table 68.

## How Grade and Size of Log Affect Grade and Value of Lumber Produced

In determining profitable and unprofitable sawmill logs, the factor of log grade must be considered. For example, a relatively small clear log may yield better grades and more valuable lumber than a large rough log and may therefore be more profitable.

### LOG GRADES RECOGNIZED

In order to arrive at definite figures on the effect of log grade as well as log size upon grades and values of lumber produced, the data from all logs in the study were sorted by log grade and then by log size for each log grade. The following four grades of logs were recognized:

No. 1. Surface-clear logs 10 inches d. i. b. or over, and logs over 16 inches d. i. b. with not more than three 2- to 4-inch knots; length 10 feet or over.

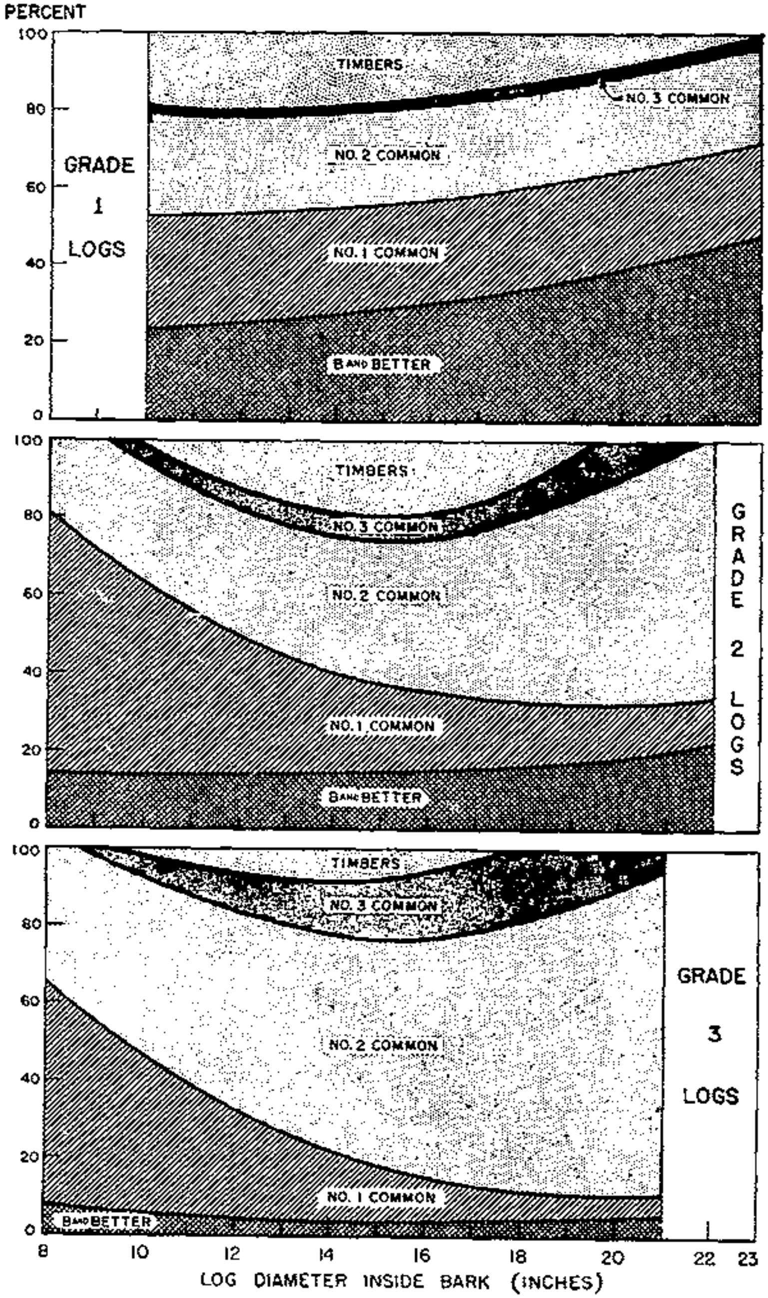


FIGURE 9.—Grades of green lumber produced from shortleaf and loblolly pine logs of grades 1, 2, and 3.

No. 2. Logs 8 inches d. i. b. or over containing numerous small knots; or logs more than 14 inches d. i. b. containing four to six 2- to 4-inch knots; length, 10 feet or over.

No. 3. Knotty or crooked merchantable logs 8 inches d. i. b. or over that do not fall in either No. 1 or No. 2 grade; length 10 feet or over.

No. 4. Logs that are extremely crooked, or less than one-third sound.

These are very simple log grades; in applying them a considerable amount of judgment is required of the log grader. If log grading can be proved to be desirable, however, everyone connected with log production, including the men who cut the logs, must be able to understand these grades and to apply them. A set of grades inclusive enough to require little or no judgment in applying it would have to be so involved that only an expert could use it.

## GRADES OF LUMBER PRODUCED FROM LOGS OF VARIOUS GRADES AND SIZES

The percent of B and Better and No. 1, No. 2, and No. 3 Common lumber graded on the green chain from pine logs of various sizes for grades No. 1, No. 2, and No. 3 is shown in figure 9 and in appendix table 69. There were not enough grade No. 4 logs to work out lumber grades by log size.

It was found that large No. 1 logs yielded 25 to 40 percent B and Better lumber, a uniformly high percent of No. 1 Common, and a moderate percent of No. 2 Common and timbers. This is consistent with the findings from many other mill studies on southern pine. No. 2 logs yielded 15 to 20 percent B and Better, a large percent of No. 1 Common from 8- to 16-inch logs and little from larger logs, and a large percent of lower-grade lumber, especially from larger logs.

As might be expected, the percent of high-grade lumber produced from No. 3 logs is very small, and that of the lower grades correspondingly large. These logs are usually produced either from the upper portions of good-quality trees or from any position in limby, very fast growing "wolf" trees. Lumber produced from trees of this class is very likely to warp and twist badly and has often caused purchasers to assume that all shortleaf and loblolly pine is of very poor quality.

Since No. 4 logs are extremely crooked, or rough, or less than one-third sound, it is not surprising that the average log of about 10 inches yielded only 1 percent B and Better lumber. It is very doubtful if any of these logs could be cut into lumber at a profit except under very favorable market conditions.

Appendix table 70 gives the grades of lumber produced from hardwood logs of various grades. The number of logs produced, however, was insufficient to permit a valid comparison of lumber-grade yields by diameter class for each grade of log. Table 70 indicates that there are very few high-grade hardwood logs and that No. 1 logs are but little better than No. 3 logs in yield by lumber grade.

## LUMBER VALUE PER M BOARD FEET BY GRADE

Since the mill-scale study was not carried beyond the green chain, it did not cover reductions in the green lumber tally to account for loss due to drying, dressing, and remanufacture. Failing the very complicated and difficult study necessary to determine these losses by size and grade for each log, reference was made to a similar study (4) completed a few years previous at the mill at Fordyce, Ark., by the Forest Products Laboratory of the Forest Service. From the report of this study, losses were compiled for different grades of pine lumber in percent of volume of green lumber (appendix table 71), allowance being made for increase in the upper grades and loss in lower grades due to remanufacturing of boards of a given grade to a higher grade, as well as for drying and trimming losses. When the prices of dried and dressed lumber are reduced by these percents, values are obtained that can be applied directly to lumber on the green chain, giving the value of this same lumber dried, dressed, and remanufactured. These values based on pine-lumber prices for the first 8 months of 1940 were computed and are given in appendix table 72.

The unreduced 1940 pine values by lumber grade are compared with 1935 values in table 22. The prices for 1940 are based on the average for the first 8 months, to avoid unusually high prices due to the defense program.

TABLE 22.—*Values of finished pine lumber per M feet board in 1935*[1] *and in 1940*[2]

| Lumber grade | 1935 | 1940 | Increase | |
|---|---|---|---|---|
| | *Dollars* | *Dollars* | *Dollars* | *Percent* |
| B and better | 40.30 | 50.75 | 10.36 | 25.6 |
| No. 1 Common | 27.28 | 32.68 | 5.40 | 19.8 |
| No. 2 Common | 17.20 | 24.24 | 7.04 | 40.9 |
| No. 3 Common | 14.71 | 20.61 | 5.90 | 40.1 |
| Timbers | 22.70 | 30.00 | 7.30 | 32.2 |

[1] Average for 12 months.
[2] Average for 8 months (January through August).

Table 23 gives for hardwoods the average price of finished lumber for the first 8 months of 1940, the loss percent of green-lumber volume due to drying, dressing, and remanufacture, and reduced lumber values which, when applied to the green-chain tally, will give values of the finished lumber to be expected from such processing. These losses from drying and dressing are based not on any given study but on the experience of the company at whose mill the study was made.

TABLE 23.—*Values of finished hardwood lumber per M board feet, and corresponding values*[1] *applicable to green-chain lumber tally*

| Lumber grade and species | Finished-lumber value | Loss in drying and remanufacture | Green-lumber value |
|---|---|---|---|
| | *Dollars* | *Percent* | *Dollars* |
| 4/4 Firsts and Seconds: | | | |
| White oak | 64.55 | 20 | 51.64 |
| Red oak | 53.79 | 20 | 43.03 |
| 4/4 No. 1 Common: | | | |
| White oak | 37.06 | 20 | 29.65 |
| Red oak | 34.67 | 20 | 27.74 |
| 4/4 No. 2 Common: | | | |
| White oak | 28.69 | 20 | 22.95 |
| Red oak | 27.40 | 20 | 21.99 |
| 4/4 No. 3 Common and 3A: | | | |
| White oak | 16.74 | 0 | 16.74 |
| Red oak | 16.74 | 0 | 16.74 |
| 4/4 Sound wormy: | | | |
| White oak | 28.69 | 0 | 28.69 |
| Red oak | 22.71 | 0 | 22.71 |
| 8/4 *Firsts and Seconds:* | | | |
| White oak | 95.63 | 20 | 76.50 |
| Red oak | 83.68 | 20 | 66.94 |
| 12/4 Decking, white oak | 14.34 | 0 | 14.34 |
| 8/4 Decking, white oak | 14.34 | 0 | 14.34 |
| Car stock, white oak | 29.88 | 25 | 22.41 |
| Bridge plank, white oak | 29.88 | 0 | 29.88 |
| Ties | 29.88 | 0 | 29.88 |

[1] Values of finished lumber for the first 8 months of 1940 have been reduced by the percents of volume loss due to drying, dressing, and remanufacture so that the value of finished lumber can be obtained directly by applying the reduced values to the green-chain tally.

## VALUE OF DRIED AND DRESSED LUMBER PRODUCED FROM LOGS OF VARIOUS GRADES AND SIZES

In order to compare the logging and milling cost with the value of the lumber produced from pine logs of various grades and sizes, a separate compilation has been made (table 24, fig. 8) of the value per log and per M feet of the lumber produced from each size of No. 1, No. 2, and No. 3 logs, by multiplying the 1940 values given in appendix table 72 by the respective volumes of each grade of lumber in each log. There were not enough No. 4 logs to separate them by sizes, but the average value per M feet, mill tally, was $26.55. Average values per log and per M feet by log size without consideration of log grade are given in table 25. A comparison of the values in these two tables illustrates strikingly the importance of considering grade as well as size in separating profitable from unprofitable logs.

TABLE 24.—*Value per log and per M board feet of dried and dressed lumber produced from pine logs of various grades and sizes*

| Diameter inside bark (inches) | Volume per log[1] | | | Value per log | | | Value per M feet | | |
|---|---|---|---|---|---|---|---|---|---|
| | No. 1 | No. 2 | No. 3 | No. 1 | No. 2 | No. 3 | No. 1 | No. 2 | No. 3 |
| | *Board feet* | *Board feet* | *Board feet* | *Dollars* | *Dollars* | *Dollars* | *Dollars* | *Dollars* | *Dollars* |
| 8 | | 45 | 44 | | 1.30 | 0.98 | | 28.89 | 22.27 |
| 9 | | 50 | 49 | | 1.49 | 1.13 | | 29.80 | 23.06 |
| 10 | 58 | 57 | 55 | 1.79 | 1.72 | 1.31 | 30.86 | 30.18 | 23.82 |
| 11 | 68 | 65 | 63 | 2.19 | 1.99 | 1.54 | 32.21 | 30.62 | 24.44 |
| 12 | 79 | 76 | 72 | 2.65 | 2.30 | 1.78 | 33.54 | 30.26 | 24.72 |
| 13 | 92 | 89 | 83 | 3.18 | 2.64 | 2.06 | 34.57 | 29.66 | 24.82 |
| 14 | 109 | 104 | 95 | 3.78 | 3.02 | 2.39 | 34.68 | 29.04 | 25.16 |
| 15 | 125 | 121 | 110 | 4.46 | 3.46 | 2.78 | 34.84 | 28.60 | 25.27 |
| 16 | 149 | 140 | 128 | 5.23 | 3.97 | 3.24 | 35.10 | 28.36 | 25.31 |
| 17 | 171 | 160 | 147 | 6.10 | 4.57 | 3.77 | 35.67 | 28.56 | 25.65 |
| 18 | 193 | 182 | 167 | 7.10 | 5.27 | 4.37 | 36.79 | 28.96 | 26.17 |
| 19 | 216 | 205 | 188 | 8.18 | 6.06 | 5.03 | 37.87 | 29.56 | 26.76 |
| 20 | 240 | 229 | 210 | 9.33 | 6.93 | 5.75 | 38.88 | 30.26 | 27.38 |
| 21 | 265 | 253 | 232 | 10.54 | 7.87 | 6.53 | 39.77 | 31.11 | 28.15 |
| 22 | 290 | 278 | 255 | 11.80 | 8.87 | 7.37 | 40.69 | 31.91 | 28.90 |
| 23 | 315 | 304 | 278 | 13.10 | 9.92 | 8.27 | 41.59 | 32.63 | 29.75 |

[1] Green-chain tally.

TABLE 25.—*Value of finished lumber produced from pine and hardwood logs of various sizes, per log and per M board feet*[1]

| Diameter inside bark (inches) | Pine | | | | Hardwood | | | |
|---|---|---|---|---|---|---|---|---|
| | Volume per log | Value per log | Value per M feet | Basis, logs | Volume per log | Value per log | Value per M feet | Basis, logs |
| | *Board feet* | *Dollars* | *Dollars* | *Number* | *Board feet* | *Dollars* | *Dollars* | *Number* |
| 8 | 44 | 1.045 | 23.75 | | | | | |
| 9 | 49 | 1.195 | 24.39 | 11 | 66 | 1.993 | 30.20 | 5 |
| 10 | 55 | 1.405 | 25.54 | 41 | 72 | 2.036 | 28.28 | 21 |
| 11 | 63 | 1.685 | 26.75 | 79 | 81 | 2.268 | 28.00 | 38 |
| 12 | 73 | 2.040 | 27.94 | 127 | 93 | 2.556 | 27.50 | 58 |
| 13 | 86 | 2.475 | 28.78 | 125 | 107 | 2.932 | 27.40 | 47 |
| 14 | 102 | 3.000 | 29.41 | 144 | 123 | 3.394 | 27.59 | 62 |
| 15 | 120 | 3.620 | 30.17 | 122 | 141 | 3.880 | 27.52 | 34 |
| 16 | 140 | 4.340 | 31.00 | 102 | 160 | 4.429 | 27.68 | 32 |
| 17 | 162 | 5.170 | 31.91 | 50 | 180 | 5.015 | 27.86 | 19 |
| 18 | 185 | 6.115 | 33.05 | 46 | 201 | 5.618 | 27.95 | 18 |
| 19 | 209 | 7.180 | 34.35 | 28 | 223 | 6.264 | 28.09 | 9 |
| 20 | 234 | 8.365 | 35.75 | 24 | 246 | 6.931 | 28.18 | 6 |
| 21 | 260 | 9.670 | 37.19 | 12 | 269 | 7.610 | 28.29 | 6 |
| 22 | 286 | 11.095 | 38.79 | 10 | 292 | 8.318 | 28.49 | 3 |
| 23 | 312 | 12.640 | 40.51 | 3 | 315 | 9.028 | 28.66 | 3 |
| 24 | 338 | 14.305 | 42.32 | 1 | 338 | 9.740 | 28.82 | 2 |

[1] Green-chain tally.

Figure 8 shows that from 12 or 13 inches up to 16 or 17 inches in diameter, all grades of logs decrease in value or remain nearly stationary. This is most pronounced for No. 2 logs, 16-inch logs having the lowest value. This tendency is explained by the removal in the selective cutting (1) of many 14- to 20-inch pines which because they were rough, defective, or otherwise unsuitable for further growth yielded logs below average values; (2) of small clear-stemmed trees severely suppressed by an overstory, yielding logs above average values; and (3) of large mature trees, producing large logs and relatively high-grade lumber. In future selective cuts, however, 12- to 17-inch logs should be of higher value, and no doubt the sag in the curves of values will be straightened out.

The hardwood logs were too few to permit a determination of lumber value by size classes for each log grade; consequently, the value per M feet has been computed only by log grade for red and white oak and for post oak. The results are given in table 26. Values per log and per M feet by log size without consideration of log grade are given in table 25. The value of the lumber produced from No. 1 logs of red and white oak is but $2.20 greater than for No. 2 logs, and for post oak only $0.62 greater. Likewise, No. 2 logs of all species are not on the average worth very much more than No. 3 logs. Because of the relatively low grade of all post oak, this situation would undoubtedly hold true regardless of whether the hardwood portion of the stand were clear cut or selectively cut, or whether the stands were even-aged or all-aged. But on the other hand, the main reason for the small difference in the value of the red and white oak logs is the fact that only low-grade defective trees were removed in the selective cutting. Undoubtedly the value of the logs of these two species that will be removed in the second selective cut from the same areas will show a much higher value and a much greater difference in value between log grades.

TABLE 26.—*Value per M board feet of lumber produced from oak logs, by log grade*

| Species | No. 1 | No. 2 | No. 3 | No. 4 |
|---|---|---|---|---|
| | *Dollars* | *Dollars* | *Dollars* | *Dollars* |
| Red and white oak | 31.37 | 29.17 | 28.24 | 24.05 |
| Post oak | 28.04 | 27.42 | 27.30 | 27.24 |

## EFFECT OF GRADE AND SIZE OF LOG ON REALIZATION VALUE

### REALIZATION VALUE OF PINE LOGS

Realization value is the difference between the lumber sales value and the total costs of logging, transportation, and milling, and includes stumpage, profit, and uninsured risks. Table 27 gives the realization value of pine per M board feet lumber tally by size for each log grade. Table 28 gives realization values by log size without consideration of log grade. Value trends are readily understandable without further discussion.

It should be remembered that the lumber prices on which the data given in this section are based are for 1940 and may be expected to vary. Furthermore, the milling costs may not apply at other mills. In using these figures one should, therefore, adjust them to present-day lumber prices and to milling costs at the mill in question. Except in unusual cases, however, all No. 1 logs will prove to be profitable sawmill logs. Furthermore, No. 2 logs 12 inches and over and No. 3 logs 18 inches and over usually will show a positive realization value. The marginal logs, those that may or may not be profitable, are therefore No. 2 logs 9 to 11 inches in size and No. 3 logs 13 to 17 inches in size. Only with very favorable prices for low-grade lumber, or very low milling costs, can most mills avoid severe loss of net income from cutting this class of log. It is, therefore, decidedly important for both the forest owner and the mill owner to determine how many of the marginal logs will prove profitable. It is equally important to determine what effect each change in market price for lumber will have, and to adapt utilization practices accordingly.

TABLE 27.—*Realization values*[1] *per log and per M board feet lumber tally*[2] *for pine logs of various grades and diameters*

| Diameter inside bark (inches) | Value per log | | | Value per M feet | | |
|---|---|---|---|---|---|---|
| | No. 1 | No. 2 | No. 3 | No. 1 | No. 2 | No. 3 |
| | *Dollars* | *Dollars* | *Dollars* | *Dollars* | *Dollars* | *Dollars* |
| 8 | | +0.11 | −0.21 | | 2.44 | −4.77 |
| 9 | | .19 | −.17 | | 3.80 | −3.47 |
| 10 | 0.37 | .30 | −.11 | 6.38 | 5.26 | −2.00 |
| 11 | .61 | .41 | −.04 | 8.97 | 6.31 | −.63 |
| 12 | .87 | .52 | .00 | 11.61 | 6.84 | .00 |
| 13 | 1.14 | .60 | .02 | 12.39 | 6.74 | .24 |
| 14 | 1.43 | .67 | .04 | 13.12 | 6.44 | .42 |
| 15 | 1.75 | .75 | .07 | 13.67 | 6.29 | .64 |
| 16 | 2.13 | .87 | .14 | 14.30 | 6.21 | 1.09 |
| 17 | 2.56 | 1.03 | .23 | 14.97 | 6.44 | 1.56 |
| 18 | 3.10 | 1.27 | .37 | 16.06 | 6.98 | 2.22 |
| 19 | 3.71 | 1.59 | .56 | 17.18 | 7.76 | 2.98 |
| 20 | 4.37 | 1.97 | .79 | 18.21 | 8.60 | 3.76 |
| 21 | 5.06 | 2.39 | 1.05 | 19.09 | 9.45 | 4.53 |
| 22 | 5.79 | 2.86 | 1.36 | 19.97 | 10.29 | 5.33 |
| 23 | 6.56 | 3.38 | 1.73 | 20.83 | 11.12 | 6.22 |

[1] Realization values are the difference between the lumber sales value and total logging, transportation, and milling costs, and include stumpage, profit, and uninsured risks.
[2] Green-chain tally.

TABLE 28.—*Realization values per M board feet lumber tally*[1] *for pine and hardwood logs of various diameters*

| Diameter inside bark (inches) | Pine | | | | Hardwood | | | |
|---|---|---|---|---|---|---|---|---|
| | Lumber tally per log | Value per M board feet | Cost per M board feet | Realization value | Lumber tally per log | Value per M board feet | Cost per M board feet | Realization value |
| | *Board feet* | *Dollars* | *Dollars* | *Dollars* | *Board feet* | *Dollars* | *Dollars* | *Dollars* |
| 8 | 44 | 23.75 | 27.13 | −3.38 | | | | |
| 9 | 49 | 24.39 | 26.42 | −2.03 | 66 | 30.20 | 25.97 | 4.23 |
| 10 | 55 | 25.54 | 25.80 | −.26 | 72 | 28.28 | 25.01 | 3.27 |
| 11 | 63 | 26.75 | 25.09 | 1.66 | 81 | 28.00 | 23.94 | 4.06 |
| 12 | 73 | 27.94 | 24.39 | 3.55 | 93 | 27.50 | 22.94 | 4.56 |
| 13 | 86 | 28.78 | 23.72 | 5.06 | 107 | 27.40 | 22.17 | 5.23 |
| 14 | 102 | 29.41 | 23.04 | 6.37 | 123 | 27.59 | 21.64 | 5.95 |
| 15 | 120 | 30.17 | 22.55 | 7.02 | 141 | 27.52 | 21.26 | 6.26 |
| 16 | 140 | 31.00 | 22.17 | 8.83 | 160 | 27.68 | 21.01 | 6.67 |
| 17 | 162 | 31.91 | 21.85 | 10.06 | 180 | 27.86 | 20.82 | 7.04 |
| 18 | 185 | 33.05 | 21.60 | 11.45 | 201 | 27.95 | 20.71 | 7.24 |
| 19 | 209 | 34.35 | 21.40 | 12.95 | 223 | 28.09 | 20.64 | 7.45 |
| 20 | 234 | 35.75 | 21.22 | 14.53 | 246 | 28.18 | 20.57 | 7.61 |
| 21 | 260 | 37.19 | 21.08 | 16.11 | 269 | 28.29 | 20.55 | 7.74 |
| 22 | 286 | 38.79 | 21.01 | 17.78 | 292 | 28.49 | 20.55 | 7.94 |
| 23 | 312 | 40.51 | 20.97 | 19.54 | 315 | 28.66 | 20.58 | 8.08 |
| 24 | 338 | 42.31 | 20.96 | 21.35 | 338 | 28.82 | 20.63 | 8.19 |

[1] Green-chain tally.

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It is advantageous to divert the material from unprofitable logs into pulpwood or into some other product. If logs are not profitable for any product it is better to leave them in the woods, and so to avoid further deductions from the returns obtained from the high-quality and high-value material.

## REALIZATION VALUE OF HARDWOOD LOGS

The average realization values per M board feet for the various grades of hardwood logs produced are given in table 29. The realization values by log size without reference to log grade have already been given in table 28.

TABLE 29.—*Realization values per M board feet lumber tally for hardwood logs, by log grade*

| Species | No. 1 | No. 2 | No. 3 | No. 4 |
|---|---|---|---|---|
| | *Dollars* | *Dollars* | *Dollars* | *Dollars* |
| Red oak and forked-leaf white oak | 9.61 | 7.44 | 6.51 | 3.22 |
| Post oak | 6.91 | 5.60 | 5.57 | 5.51 |

## REALIZATION VALUE OF PINE LOGS WHEN UTILIZED FOR PULPWOOD

The recent rapid expansion of the pulp mills in the South has opened up a market for pine pulpwood throughout much of the shortleaf-loblolly pine region. The owners of sawmills, therefore, usually have a ready market for practically all material that is unprofitable as sawlogs or for other products.

In order to compare the realization values of the material in marginal logs when utilized for pulpwood and for sawlogs, the values of pulpwood per log and per M feet of logs were computed for logs of various sizes, assuming realization values of $0.50 and $1 per standard cord. A converting factor of 84 cubic feet of solid wood inside bark per cord was used. The value of pulpwood contained in 1 M feet of logs was determined by multiplying the value per log by the number of logs required to produce 1 M feet of lumber. The results are given in table 30.

TABLE 30.—*Realization value per cord and per M board feet of pine logs of various diameters when utilized for pulpwood*

| Diameter inside bark inches | Cubic foot volume per log [1] | Value per log at rate per standard cord [2] of— $0.50 | Value per log at rate per standard cord [2] of— $1.00 | Value per M feet of logs [3] at rate per standard cord of— $0.50 | Value per M feet of logs [3] at rate per standard cord of— $1.00 | Diameter inside bark inches | Cubic foot volume per log [1] | Value per log at rate per standard cord [2] of— $0.50 | Value per log at rate per standard cord [2] of— $1.00 | Value per M feet of logs [3] at rate per standard cord of— $0.50 | Value per M feet of logs [3] at rate per standard cord of— $1.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 6.1 | 0.036 | 0.073 | 0.82 | 1.65 | 17 | 25.7 | 0.153 | 0.306 | 0.94 | 1.89 |
| 9 | 7.1 | .042 | .085 | .86 | 1.72 | 18 | 29.2 | .174 | .348 | .94 | 1.88 |
| 10 | 8.3 | .049 | .099 | .90 | 1.80 | 19 | 32.7 | .195 | .389 | .93 | 1.86 |
| 11 | 9.8 | .058 | .117 | .93 | 1.85 | 20 | 36.3 | .216 | .432 | .92 | 1.85 |
| 12 | 11.8 | .070 | .140 | .96 | 1.92 | 21 | 40.1 | .239 | .477 | .92 | 1.84 |
| 13 | 14.2 | .085 | .169 | .98 | 1.97 | 22 | 43.8 | .261 | .521 | .92 | 1.82 |
| 14 | 16.9 | .101 | .201 | .99 | 1.97 | 23 | 47.3 | .282 | .563 | .90 | 1.80 |
| 15 | 19.6 | .117 | .233 | .97 | 1.94 | 24 | 50.6 | .301 | .602 | .89 | 1.78 |
| 16 | 22.6 | .135 | .269 | .96 | 1.92 | | | | | | |

[1] Solid wood inside bark.
[2] Containing 84 cubic feet of solid wood inside bark.
[3] Based on mill tally.

It should be noted that with lumber prices and operating costs similar to those used in this report and no more than a $0.50 value for pulpwood a company would realize a greater net return in pulpwood than in lumber from material that would cut to 15-inch No. 3 logs, or to No. 4 logs that could be split or from which the unsound portion could be removed without too much cost. These low-grade logs would net $0.82 to $0.99 per M feet as pulpwood not a large amount, but considerably better than a loss of a few cents, or possibly of nearly $5, per M feet at the sawmill.

### PURCHASING LOGS BY SIZE AND GRADE

Most lumber companies in the South purchase from farmers and other timberland owners at least a small part and in many cases a large share of the logs they mill, customarily at a given price per M board feet Doyle-Scribner rule, regardless of size or grade of the logs. Sometimes the logs are small and mostly of No. 2 and No. 3 grade, offering little chance of profitable manufacture into lumber, and in such cases the companies often pay too much for them. On other purchases, of large, high-grade logs, the companies rarely pay the landowners the real value of the logs. The one fair way for both parties is to buy and sell on size and grade of log. This is not only fair to both purchaser and seller, but it also encourages landowners to produce relatively large and high-grade logs.

In order to show the possibilities of this system, the realization values per M board feet (Doyle-Scribner rule) of pine logs of various sizes and grades are given in table 31. These figures for the difference between lumber sale value and total costs of logging and milling represent the margin for stumpage, profit, and uninsured risks.

TABLE 31.—*Realization value per M board feet (Doyle-Scribner rule) for pine logs, by log grade and diameter*

| Diameter inside bark (inches) | No. 1 logs | No. 2 logs | No. 3 logs | Diameter inside bark (inches | No. 1 logs | No. 2 logs | No. 3 logs |
|---|---|---|---|---|---|---|---|
| 8 | | $7.14 | −$14.00 | 16 | $15.87 | $6.90 | $1.21 |
| 9 | | 9.31 | −8.50 | 17 | 16.32 | 7.02 | 1.70 |
| 10 | $13.03 | 10.75 | −4.07 | 18 | 17.02 | 7.40 | 2.35 |
| 11 | 15.08 | 11.05 | −1.11 | 19 | 17.86 | 8.07 | 3.10 |
| 12 | 16.42 | 10.20 | .00 | 20 | 18.57 | 8.78 | 3.84 |
| 13 | 16.59 | 9.01 | .32 | 21 | 19.28 | 9.54 | 4.57 |
| 14 | 16.14 | 7.92 | .52 | 22 | 19.77 | 10.19 | 5.28 |
| 15 | 16.00 | 7.25 | .74 | 23 | 20.41 | 10.90 | 6.10 |

The figures in table 31 show that a company would make a greater profit ($1) by paying $15 per M feet for 15-inch No. 1 logs than it would make ($0.74) on 15-inch No. 3 logs, even though the No. 3 logs were given to the company without cost. A careful analysis of these realization values for pine logs of various grades and sizes should convince any mill operator that buying timber at a set price per M feet regardless of size or grade is very unbusinesslike, and that grading logs proves advantageous to both buyer and seller.

## HOW TREE SIZE AFFECTS LOGGING COST

To determine effects of tree size on cost, time and cost data recorded on felling and bucking have been recombined with similar data computed for each log size. In this computation each diameter class contains an average number of logs, each of which in turn contains an average volume. To assemble the time and cost data for an average tree of any diameter class requires only selecting and adding together the data for the log sizes in that diameter class. This is true for each stage of utilization from the stump to finished lumber.

Data in each case have been computed and tabulated for the four more or less common methods of measuring tree volume—Doyle-Scribner, International ¼-inch kerf, and Scribner log rules and cubic-foot volume. It is well known that the International rule usually comes nearest to actual mill-tally yield of logs. For reasons discussed later under overrun, this was not the case in the present study. Cubic-foot volume is given because it is the most accurate gage of actual log volume and weight. Tables in terms of Doyle-Scribner and International ¼-inch scale are presented in the text, the others in the appendix.

### FELLING AND BUCKING

The costs per tree of felling and bucking, expressed both in time and in dollars by 1-inch size classes, have been determined for pines and hardwoods as given in appendix tables 73 and 76. Time includes walking between trees, felling, limbing, and bucking the tree into logs. Cost per tree was obtained by multiplying the time by the rate per man-minute (table 5) of the men doing the work. In table 32 and figure 10, respectively, the man-hours required and the cost per M board feet for felling and bucking shortleaf and loblolly pines of various sizes are given. Additional data for pines and hardwoods are given in appendix tables 74–78.

The evidence is conclusive that the cost of felling and bucking per unit of volume decreases considerably with increase of tree size; for example, the cost per M board feet (Doyle-Scribner rule) for pine trees 12 inches d. b. h. is about twice as great as that for 17-inch pines and about three times as great as that for 24-inch pines.

### SKIDDING AND LOADING

The time and cost per tree of skidding and loading the logs from pine and hardwood trees of various sizes are also summarized by diameter class in appendix tables 73 and 76. The cost per tree was obtained by multiplying the skidding and loading time per tree by the rate per man-minute (table 7). The costs per M board feet (table 32) and per 100 cubic feet were determined upon the basis of costs per tree and the volume of sawlogs per tree, for various tree sizes. See also figure 10 and appendix tables 74, 75, 77, and 78.

Cost per M board feet for skidding and loading, like that for felling and bucking, decreases with increase of size of tree for both pines and hardwoods. By the Doyle-Scribner rule, this cost for pine logs from 12-inch trees is almost 2½ times as great as that for logs from 17-inch pines, and about 5 times as great as for 24-inch pines. For hardwoods the difference in cost between small and large trees is less pronounced, probably because large and small hardwoods differ less in total merchantable length than do large and small pines. For trees of a given diameter the skidding and loading cost is greater for hardwoods than for pines.

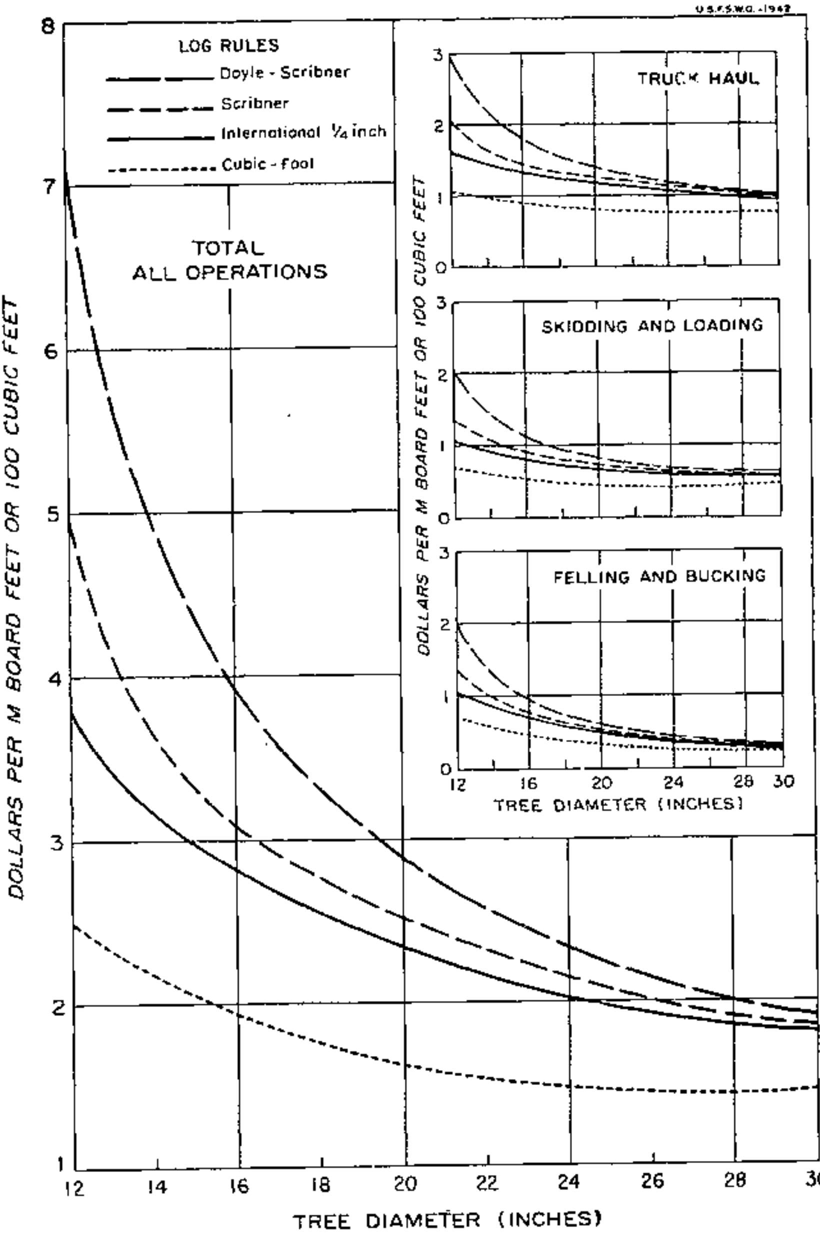


FIGURE 10.—Costs, by tree size, of the several operations in logging shortleaf and loblolly pine.

TABLE 32.—*Man-hour requirement and cost*[1] *per M board feet for logging pines, by process and tree diameter*

DOYLE-SCRIBNER RULE

| Diameter breast high (inches) | Volume per tree | Felling and bucking | | Skidding and loading | | Truck haul[2] | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| | *Board feet* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* |
| 12 | 58 | 5.741 | 2.03 | 3.281 | 2.02 | 2.917 | 3.00 | 11.930 | 7.05 |
| 13 | 81 | 4.732 | 1.67 | 2.570 | 1.59 | 2.405 | 2.53 | 9.767 | 5.79 |
| 14 | 108 | 4.032 | 1.42 | 2.102 | 1.30 | 2.148 | 2.21 | 8.282 | 4.93 |
| 15 | 141 | 3.472 | 1.23 | 1.750 | 1.08 | 1.890 | 1.94 | 7.112 | 4.25 |
| 16 | 176 | 3.110 | 1.10 | 1.517 | .93 | 1.740 | 1.79 | 6.367 | 3.82 |
| 17 | 213 | 2.861 | 1.02 | 1.349 | .83 | 1.638 | 1.68 | 5.848 | 3.53 |
| 18 | 252 | 2.672 | .94 | 1.222 | .75 | 1.564 | 1.61 | 5.458 | 3.30 |
| 19 | 297 | 2.501 | .88 | 1.106 | .68 | 1.488 | 1.53 | 5.095 | 3.09 |
| 20 | 344 | 2.381 | .84 | 1.014 | .63 | 1.433 | 1.47 | 4.828 | 2.94 |
| 21 | 400 | 2.250 | .80 | .925 | .57 | 1.366 | 1.40 | 4.541 | 2.77 |
| 22 | 465 | 2.122 | .75 | .841 | .52 | 1.295 | 1.33 | 4.258 | 2.60 |
| 23 | 541 | 1.996 | .71 | .761 | .47 | 1.218 | 1.25 | 3.975 | 2.43 |
| 24 | 621 | 1.905 | .67 | .697 | .43 | 1.156 | 1.19 | 3.758 | 2.29 |
| 25 | 705 | 1.838 | .65 | .643 | .40 | 1.103 | 1.13 | 3.584 | 2.18 |
| 26 | 790 | 1.793 | .63 | .599 | .37 | 1.064 | 1.09 | 3.456 | 2.10 |
| 27 | 876 | 1.758 | .62 | .561 | .35 | 1.035 | 1.06 | 3.354 | 2.03 |
| 28 | 963 | 1.744 | .61 | .529 | .33 | 1.012 | 1.04 | 3.285 | 1.98 |
| 29 | 1,050 | 1.744 | .62 | .502 | .31 | .997 | 1.02 | 3.243 | 1.95 |
| 30 | 1,140 | 1.754 | .62 | .475 | .29 | .984 | 1.01 | 3.213 | 1.92 |

INTERNATIONAL ¼-INCH RULE

| Diameter breast high (inches) | Volume per tree | Felling and bucking | | Skidding and loading | | Truck haul[2] | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| | *Board feet* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* |
| 12 | 107 | 3.112 | 1.10 | 1.779 | 1.10 | 1.581 | 1.62 | 6.472 | 3.82 |
| 13 | 137 | 2.798 | .99 | 1.520 | .94 | 1.457 | 1.49 | 5.775 | 3.42 |
| 14 | 168 | 2.592 | .92 | 1.351 | .83 | 1.381 | 1.42 | 5.324 | 3.17 |
| 15 | 202 | 2.423 | .85 | 1.222 | .75 | 1.319 | 1.36 | 4.964 | 2.96 |
| 16 | 239 | 2.290 | .81 | 1.117 | .69 | 1.281 | 1.31 | 4.688 | 2.81 |
| 17 | 280 | 2.176 | .77 | 1.026 | .63 | 1.246 | 1.28 | 4.448 | 2.68 |
| 18 | 325 | 2.072 | .73 | .948 | .58 | 1.213 | 1.25 | 4.233 | 2.56 |
| 19 | 375 | 1.981 | .70 | .876 | .54 | 1.179 | 1.21 | 4.036 | 2.45 |
| 20 | 431 | 1.901 | .67 | .809 | .50 | 1.144 | 1.18 | 3.854 | 2.35 |
| 21 | 492 | 1.829 | .65 | .752 | .46 | 1.111 | 1.14 | 3.692 | 2.25 |
| 22 | 561 | 1.759 | .62 | .697 | .43 | 1.073 | 1.10 | 3.529 | 2.15 |
| 23 | 631 | 1.711 | .61 | .652 | .40 | 1.044 | 1.07 | 3.407 | 2.08 |
| 24 | 706 | 1.676 | .59 | .613 | .38 | 1.017 | 1.05 | 3.306 | 2.02 |
| 25 | 785 | 1.651 | .58 | .577 | .36 | .990 | 1.02 | 3.218 | 1.96 |
| 26 | 867 | 1.634 | .58 | .546 | .34 | .969 | .99 | 3.149 | 1.91 |
| 27 | 950 | 1.621 | .57 | .518 | .32 | .954 | .98 | 3.093 | 1.87 |
| 28 | 1,033 | 1.626 | .58 | .493 | .30 | .944 | .97 | 3.063 | 1.85 |
| 29 | 1,116 | 1.641 | .58 | .472 | .29 | .936 | .96 | 3.051 | 1.83 |
| 30 | 1,200 | 1.667 | .59 | .451 | .28 | .935 | .96 | 3.053 | 1.83 |

[1] Man-hour rates: Felling and bucking, $0.353; skidding and loading, $0.617; truck haul, $1.028.
[2] Distance, 4 miles.

## TRUCK HAULING

The truck hauling time and cost per M board feet and per 100 cubic feet for trees of various sizes for a 4-mile haul (including ½ mile woods road, 2 miles graded dirt, and 1½ miles gravel) are given in table 32 and in appendix tables 74, 75, 77, and 78. They are shown graphically in figure 7.

Data on hauling time and cost were computed on the basis of average size of logs produced. No properly conducted selective-logging operation produces logs of one size only from any cutting area, and logs are never hauled in loads of uniform log diameter. All contracts for cutting and hauling, therefore, are based on an average of different log sizes. The reason loads as actually built up invariably include logs of different sizes may be explained as follows: Assume log bunks of such size that when extended to the maximum width they will barely accommodate three logs of 28-inch diameter on the bed, or a total of 6 logs of this size to the load. It is apparent that no more than two 29-inch logs will be accommodated on these bunks, or three 29-inch logs to the load, and that the cost per M board feet of hauling a load of three 29-inch logs only will be considerably higher than that of hauling six 28-inch logs. It is possible, however, to load two 29-inch logs plus one 26-inch log on the bunks and three 29-inch logs above, and thus to haul at less expense than if the load contained 29-inch logs only.

In the case of hauling, also, the cost per unit of volume decreases rapidly with increase in diameter of the trees. For example, the cost per M feet (Doyle-Scribner rule) for 12-inch pine trees is 1.8 times that for 17-inch pines and 2.5 times that for 24-inch pines.

#### TOTAL LOGGING COST TO RAILROAD OR MILL

Total logging cost per unit of volume decreases rapidly as larger trees are selected (fig. 10 and table 32 and appendix tables 73–78). The rapidity of growth of southern pine, particularly in the small and medium timber classes, is well enough known to make it very obvious that holding vigorous individual trees for 10 to 20 years not only will permit each tree to double in volume but also will bring greatly reduced logging costs per unit of volume. These savings in utilization costs far exceed the cost of holding these tree sizes for a few more years. Implications of increased net returns resulting from intelligent timing of cutting are clear.

It should not be overlooked that the margin of value between the costs, as shown in figure 10, and values of the logs f. o. b. railroad or mill has to cover stumpage, profit, and uninsured risks. Where cutting operations liquidate successive tracts, as is still common practice, stumpage value will probably average no more than half of this margin. In continuous operations resulting from utilizing efficiently the productive capacity of the forest, risks gradually decrease and a greater part of the margin above costs may accrue to stumpage. The cost trends shown by these tables and graphs deserve careful study and should not be overlooked by forest owners and managers seeking the best financial results.

### How Tree Size Affects Total Cost Per Unit of Mill Cut

In addition to the data given thus far on logging costs on tree and log-scale bases, it is desirable to determine for trees of various sizes the total cost of production from stump to finished product per M board feet lumber tally.

#### OVERRUN OR UNDERRUN OF MILL TALLY WITH RESPECT TO LOG SCALE

The percent overrun and underrun of mill tally with respect to log scale for pine and hardwood trees of various sizes is given for pine and hardwood in table 33.

It should be pointed out that deductions in the log scale have been made for major defects but not for minor or hidden defects or for crook or sweep, in conformity with the common scaling practice in the region. The underrun of the International rule in this study shows the seriousness of sweep and minor and hidden defects in the first cutting in selectively logged timber, occurring chiefly in the smaller pine trees that were removed because of suppression, crook, rot, or other defect, and in the larger overmature hardwoods. The removal of these trees insures, however, that this large defect will not recur at the time of the next cut. It should be noted also that the hardwoods in the smaller diameters were of much better form and quality than the small pines and that the large hardwoods were of poorer quality than the large pines.

**TABLE 33.**—*Overrun or underrun of mill tally with respect to log scale, for trees of various diameters*

SECOND-GROWTH SHORTLEAF-LOBLOLLY PINE

| Diameter breast high (inches) | Mill tally | Log-scale volume | | | | Overrun (+) or underrun (—), by log rule | | | | | | | | Basis, trees |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Doyle-Scribner | International | Scribner | Cubic-foot | Doyle-Scribner | International | Scribner | Cubic-foot | Doyle-Scribner | International | Scribner | Cubic-foot | |
| | *Bd. ft.* | *Bd. ft.* | *Bd. ft.* | *Bd. ft.* | *Cu. ft.* | *Bd. ft.* | *Bd. ft.* | *Bd. ft.* | *Cu. ft.* | *Pct.* | *Pct.* | *Pct.* | *Pct.* | *No.* |
| 12 | 77 | 58 | 107 | 82 | 17.0 | +19 | −30 | −5 | −10.6 | +33 | −28 | −6 | −62 | 16 |
| 13 | 99 | 81 | 137 | 113 | 20.1 | +18 | −38 | −14 | −11.9 | +22 | −28 | −12 | −59 | 63 |
| 14 | 127 | 108 | 168 | 146 | 24.1 | +19 | −41 | −19 | −13.5 | +18 | −24 | −13 | −56 | 156 |
| 15 | 161 | 141 | 202 | 182 | 29.3 | +20 | −41 | −21 | −15.9 | +14 | −20 | −12 | −51 | 162 |
| 16 | 201 | 176 | 239 | 219 | 34.9 | +25 | −38 | −18 | −18.1 | +14 | −16 | −8 | −52 | 160 |
| 17 | 248 | 213 | 280 | 257 | 41.0 | +35 | −32 | −9 | −20.3 | +16 | −11 | −4 | −50 | 160 |
| 18 | 298 | 252 | 325 | 298 | 47.7 | +46 | −27 | ----- | −22.0 | +18 | −8 | ----- | −48 | 166 |
| 19 | 352 | 297 | 375 | 342 | 55.1 | +55 | −23 | +10 | −25.8 | +19 | −6 | +3 | −47 | 120 |
| 20 | 410 | 344 | 431 | 392 | 62.7 | +66 | −21 | +18 | −28.5 | +19 | −5 | +5 | −45 | 73 |
| 21 | 470 | 400 | 492 | 449 | 70.8 | +70 | −22 | +21 | −31.6 | +18 | −4 | +5 | −45 | 46 |
| 22 | 533 | 465 | 561 | 513 | 79.3 | +68 | −28 | +20 | −34.0 | +15 | −5 | +4 | −44 | 24 |
| 23 | 598 | 541 | 631 | 585 | 88.1 | +57 | −33 | +13 | −38.3 | +11 | −5 | +2 | −43 | 13 |
| 24 | 665 | 621 | 706 | 662 | 97.0 | +44 | −41 | +3 | −41.6 | +7 | −6 | (1) | −43 | 14 |
| 25 | 734 | 705 | 785 | 743 | 105.9 | +29 | −51 | −9 | −44.7 | +4 | −6 | −1 | −42 | 9 |
| 26 | 805 | 790 | 867 | 827 | 114.9 | +15 | −62 | −22 | −47.8 | +2 | −7 | −3 | −42 | 7 |
| 27 | 877 | 870 | 950 | 913 | 124.0 | +1 | −73 | −36 | −50.0 | (1) | −8 | −4 | −41 | 3 |
| 28 | 949 | 963 | 1,033 | 1,000 | 133.0 | −14 | −84 | −51 | −53.9 | −1 | −8 | −5 | −41 | 6 |
| 29 | 1,021 | 1,050 | 1,116 | 1,090 | 142.0 | −29 | −95 | −69 | −56.9 | −3 | −9 | −6 | −40 | ----- |
| 30 | 1,093 | 1,140 | 1,200 | 1,182 | 151.0 | −47 | −107 | −89 | −59.9 | −4 | −9 | −8 | −40 | 3 |

HARDWOOD

| Diameter breast high (inches) | Mill tally | Doyle-Scribner | International | Scribner | Cubic-foot | Doyle-Scribner | International | Scribner | Cubic-foot | Doyle-Scribner | International | Scribner | Cubic-foot | Basis, trees |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 76 | 31 | 68 | 62 | 10.4 | +45 | +8 | +14 | −4.1 | +145 | +12 | +23 | −30 | ----- |
| 13 | 98 | 43 | 80 | 75 | 13.1 | +55 | +18 | +23 | −4.9 | +128 | +22 | +31 | −37 | ----- |
| 14 | 119 | 57 | 94 | 90 | 16.0 | +62 | +25 | +29 | −6.1 | +109 | +27 | +32 | −38 | ----- |
| 15 | 141 | 73 | 112 | 107 | 19.1 | +68 | +29 | +34 | −7.3 | +93 | +26 | +32 | −38 | ----- |
| 16 | 162 | 92 | 134 | 126 | 22.4 | +70 | +28 | +36 | −8.9 | +76 | +21 | +29 | −40 | ----- |
| 17 | 184 | 113 | 158 | 147 | 25.9 | +71 | +26 | +37 | −10.6 | +63 | +16 | +25 | −41 | ----- |
| 18 | 205 | 136 | 184 | 169 | 29.6 | +69 | +21 | +36 | −12.5 | +51 | +11 | +21 | −42 | ----- |
| 19 | 227 | 160 | 212 | 192 | 33.5 | +67 | +15 | +35 | −14.6 | +42 | +7 | +18 | −44 | ----- |
| 20 | 251 | 185 | 242 | 217 | 37.7 | +66 | +9 | +34 | −16.8 | +36 | +4 | +16 | −45 | ----- |
| 21 | 273 | 211 | 274 | 245 | 42.1 | +62 | −1 | +28 | −19.3 | +29 | (1) | +11 | −46 | ----- |
| 22 | 295 | 239 | 307 | 275 | 46.8 | +56 | −12 | +20 | −22.2 | +23 | −4 | +7 | −47 | ----- |
| 23 | 319 | 270 | 342 | 308 | 51.8 | +49 | −23 | +11 | −25.2 | +18 | −7 | +4 | −49 | ----- |
| 24 | 344 | 303 | 379 | 343 | 57.0 | +41 | −35 | +1 | −26.3 | +14 | −9 | (1) | −50 | ----- |
| 25 | 371 | 338 | 417 | 380 | 62.5 | +33 | −46 | −9 | −31.6 | +10 | −11 | −2 | −51 | ----- |
| 26 | 400 | 374 | 457 | 419 | 68.2 | +26 | −57 | −19 | −34.9 | +7 | −12 | −5 | −51 | ----- |
| 27 | 432 | 411 | 499 | 460 | 74.4 | +21 | −67 | −28 | −38.4 | +5 | −13 | −6 | −52 | ----- |
| 28 | 467 | 450 | 543 | 503 | 80.9 | +17 | −76 | −36 | −42.0 | +4 | −14 | −7 | −52 | ----- |
| 29 | 503 | 491 | 590 | 548 | 87.8 | +12 | −87 | −45 | −45.9 | +2 | −15 | −8 | −52 | ----- |
| 30 | 540 | 534 | 639 | 595 | 95.1 | +6 | −99 | −55 | −50.1 | +1 | −15 | −9 | −53 | ----- |

[1] Negligible.

For all pine trees studied, the mill cut overran the Doyle-Scribner rule by 15 percent, but underran the International rule 11 percent and the Scribner rule 3 percent. Lumber by the cubic-measure rule was from 38 to 60 percent of cubic volume. If deductions for crook and minor defects had been made in the woods scale, undoubtedly the mill cut would have approximated more closely the International rule, would have overrun the Scribner rule, and would have overrun to a greater extent the Doyle-Scribner rule. For all hardwoods, the mill tally overran the three log rules by 32, 2, and 11 percent, respectively, and yielded rough green lumber amounting to 54 percent of cubic-foot volume of wood in logs.

### COSTS OF LOGGING, RAILROAD TRANSPORTATION, AND MANUFACTURE PER M BOARD FEET OF MILL LUMBER TALLY BY TREE SIZE

Costs of logging, railroad transportation, and manufacture per M

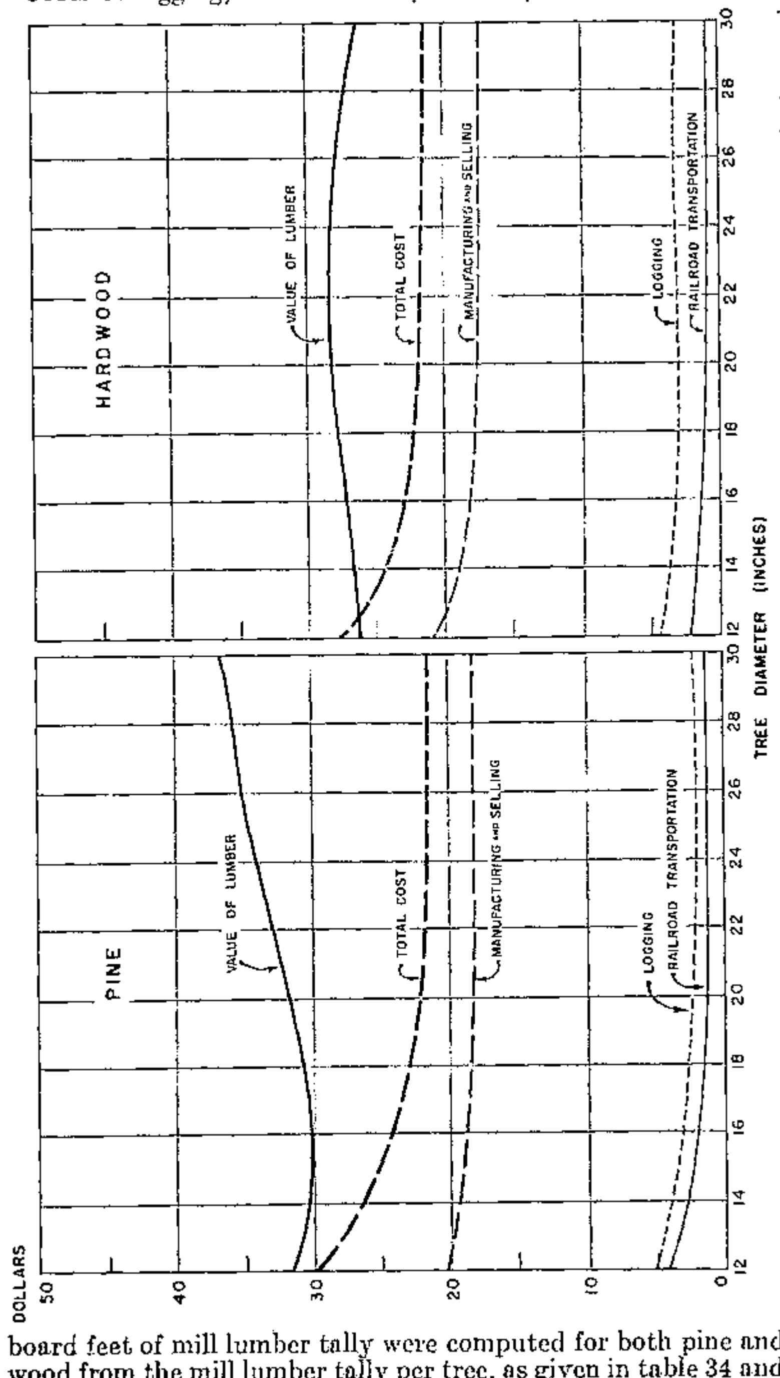


FIGURE 11.—Costs, by tree size, of logging shortleaf and loblolly pine trees and hardwood trees, transporting the logs, and manufacturing lumber from them, and value of the lumber produced.

board feet of mill lumber tally were computed for both pine and hardwood from the mill lumber tally per tree, as given in table 34 and figure 11. As will be noted, they decrease rapidly from 12-inch to 20-inch

**TABLE 34.**—*Total time (man-hours) and costs per M board feet, lumber tally, of logging, railroad transportation, and manufacturing, for trees of various sizes*

PINE

| Diameter breast high (inches) | Trees in study | Volume per tree, lumber tally | Total volume in study | Felling and bucking | | Team skidding and truck loading | | Truck hauling | | Railroad log transportation | | Rough lumber manufacturing | | Lumber handling, kiln drying, planing, shipping, selling, etc. | | Total time and cost—stump to cars | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Time | Cost | Time | Cost | Time | Cost | Time | Cost | Time | Cost | Time | Cost | Time | Cost |
| | *Number* | *Board feet* | *Board feet* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* |
| 12 | 16 | 77 | 1,230 | 4.32 | 1.53 | 2.47 | 1.53 | 2.20 | 2.25 | 5.58 | 4.40 | 4.99 | 4.09 | 34.82 | 16.12 | 54.38 | 29.92 |
| 13 | 63 | 99 | 6,240 | 3.87 | 1.37 | 2.10 | 1.30 | 2.02 | 2.07 | 4.55 | 3.60 | 4.57 | 3.75 | 34.82 | 16.12 | 51.93 | 28.21 |
| 14 | 156 | 127 | 19,810 | 3.43 | 1.21 | 1.79 | 1.10 | 1.83 | 1.87 | 3.72 | 2.98 | 4.11 | 3.37 | 34.82 | 16.12 | 49.70 | 26.65 |
| Total or weighted average | | | 27,280 | 3.57 | 1.26 | 1.89 | 1.17 | 1.89 | 1.94 | 4.00 | 3.20 | 4.25 | 3.40 | 34.82 | 16.12 | 50.42 | 27.15 |
| 15 | 162 | 161 | 26,080 | 3.04 | 1.07 | 1.53 | .95 | 1.66 | 1.69 | 3.13 | 2.47 | 3.68 | 3.02 | 34.82 | 16.12 | 47.86 | 25.32 |
| 16 | 160 | 201 | 32,160 | 2.72 | .96 | 1.33 | [illegible] | 1.52 | 1.56 | 2.65 | 2.10 | 3.34 | 2.74 | 34.82 | 16.12 | 46.38 | 24.30 |
| 17 | 160 | 248 | 39,680 | 2.46 | .87 | 1.16 | [illegible] | 1.41 | 1.44 | 2.28 | 1.82 | 3.06 | 2.51 | 34.82 | 16.12 | 45.19 | 23.48 |
| 18 | 166 | 298 | 49,470 | 2.26 | .80 | 1.03 | .68 | 1.32 | 1.36 | 2.06 | 1.62 | 2.80 | 2.37 | 34.82 | 16.12 | 44.38 | 22.91 |
| 19 | 120 | 352 | 42,240 | 2.11 | .75 | .93 | .58 | 1.26 | 1.29 | 1.88 | 1.48 | 2.77 | 2.27 | 34.82 | 16.12 | 43.77 | 22.49 |
| 20 | 73 | 410 | 29,930 | 2.00 | .71 | .85 | .53 | 1.20 | 1.23 | 1.78 | 1.30 | 2.68 | 2.20 | 34.82 | 16.12 | 43.33 | 22.18 |
| 21 | 46 | 470 | 21,620 | 1.91 | .68 | .79 | .49 | 1.16 | 1.19 | 1.50 | 1.32 | 2.66 | 2.18 | 34.82 | 16.12 | 43.03 | 21.98 |
| 22 | 24 | 533 | 12,790 | 1.85 | .65 | .73 | .45 | 1.13 | 1.16 | 1.67 | 1.28 | 2.65 | 2.17 | 34.82 | 16.12 | 42.85 | 21.83 |
| 23 | 13 | 598 | 7,770 | 1.81 | .64 | .69 | .43 | 1.10 | 1.13 | 1.62 | 1.26 | 2.67 | 2.19 | 34.82 | 16.12 | 42.71 | 21.77 |
| 24 | 14 | 665 | 9,310 | 1.78 | .63 | .65 | .40 | 1.08 | 1.11 | 1.65 | 1.24 | 2.67 | 2.19 | 34.82 | 16.12 | 42.65 | 21.69 |
| 25 | 9 | 734 | 6,610 | 1.77 | .63 | .62 | .38 | 1.06 | 1.09 | 1.63 | 1.23 | 2.67 | 2.19 | 34.82 | 16.12 | 42.57 | 21.64 |
| 26 | 7 | 805 | 5,640 | 1.76 | .62 | .59 | .36 | 1.04 | 1.07 | 1.63 | 1.22 | 2.67 | 2.19 | 34.82 | 16.12 | 42.51 | 21.58 |
| 27 | 3 | 877 | 2,630 | 1.76 | .62 | .56 | .35 | 1.03 | 1.06 | 1.63 | 1.21 | 2.67 | 2.19 | 34.82 | 16.12 | 42.47 | 21.55 |
| 28 | 6 | 949 | 5,690 | 1.77 | .63 | .54 | .33 | 1.03 | 1.05 | 1.63 | 1.20 | 2.66 | 2.18 | 34.82 | 16.12 | 42.45 | 21.51 |
| 29 | 0 | 1,021 | 0 | 1.79 | .63 | .52 | .32 | 1.02 | 1.05 | 1.63 | 1.19 | 2.66 | 2.18 | 34.82 | 16.12 | 42.44 | 21.49 |
| 30 | 3 | 1,093 | 3,280 | 1.83 | .65 | .50 | .31 | 1.03 | 1.05 | 1.62 | 1.20 | 2.66 | 2.18 | 34.82 | 16.12 | 42.46 | 21.51 |
| Total or weighted average | | | 294,900 | 2.25 | .80 | 1.00 | .62 | 1.31 | 1.34 | 2.09 | 1.64 | 2.94 | 2.41 | 34.82 | 16.12 | 44.41 | 22.93 |
| Total or weighted average, all trees | | | 322,180 | 2.30 | .84 | 1.08 | .67 | 1.36 | 1.39 | 2.25 | 1.77 | 3.05 | 2.50 | 34.82 | 16.12 | 44.92 | 23.29 |

HARDWOOD

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 1 | 76 | 76 | 2.81 | 0.99 | 1.56 | 0.96 | 2.63 | 2.70 | 2.54 | 2.30 | 6.23 | 6.67 | 31.11 | 14.17 | 46.88 | 27.79 |
| 13 | 0 | 98 | 0 | 2.78 | .98 | 1.46 | .90 | 2.09 | 2.15 | 2.17 | 1.94 | 5.09 | 5.45 | 31.11 | 14.17 | 44.70 | 25.59 |
| 14 | 5 | 119 | 595 | 2.80 | .99 | 1.40 | .86 | 1.80 | 1.85 | 1.92 | 1.68 | 4.44 | 4.76 | 31.11 | 14.17 | 43.47 | 24.31 |
| Total or weighted average | | | 671 | 2.80 | .99 | 1.42 | .87 | 1.89 | 1.95 | 1.99 | 1.75 | 4.64 | 4.98 | 31.11 | 14.17 | 43.86 | 24.70 |
| 15 | 13 | 141 | 1,833 | 2.81 | 1.00 | 1.35 | .83 | 1.62 | 1.66 | 1.75 | 1.51 | 4.00 | 4.28 | 31.11 | 14.17 | 42.64 | 23.45 |
| 16 | 15 | 162 | 2,430 | 2.84 | 1.00 | 1.32 | .81 | 1.51 | 1.55 | 1.60 | 1.37 | 3.73 | 3.99 | 31.11 | 14.17 | 42.11 | 22.89 |
| 17 | 26 | 184 | 4,784 | 2.82 | 1.00 | 1.29 | .79 | 1.43 | 1.47 | 1.47 | 1.24 | 3.52 | 3.77 | 31.11 | 14.17 | 41.64 | 22.44 |
| 18 | 25 | 205 | 5,125 | 2.81 | 1.00 | 1.27 | .78 | 1.40 | 1.43 | 1.41 | 1.18 | 3.39 | 3.63 | 31.11 | 14.17 | 41.39 | 22.19 |
| 19 | 19 | 227 | 4,313 | 2.81 | .99 | 1.25 | .77 | 1.38 | 1.42 | 1.33 | 1.11 | 3.29 | 3.52 | 31.11 | 14.17 | 41.17 | 21.98 |
| 20 | 31 | 251 | 7,781 | 2.78 | .98 | 1.22 | .75 | 1.37 | 1.40 | 1.26 | 1.04 | 3.19 | 3.41 | 31.11 | 14.17 | 40.93 | 21.75 |
| 21 | 12 | 273 | 3,276 | 2.77 | .98 | 1.21 | .75 | 1.39 | 1.42 | 1.23 | 1.01 | 3.14 | 3.36 | 31.11 | 14.17 | 40.85 | 21.69 |
| 22 | 18 | 295 | 5,310 | 2.77 | .98 | 1.20 | .74 | 1.41 | 1.45 | 1.22 | .99 | 3.11 | 3.33 | 31.11 | 14.17 | 40.82 | 21.66 |
| 23 | 10 | 319 | 3,190 | 2.75 | .97 | 1.18 | .73 | 1.44 | 1.48 | 1.18 | .95 | 3.08 | 3.30 | 31.11 | 14.17 | 40.74 | 21.60 |
| 24 | 6 | 344 | 2,064 | 2.73 | .97 | 1.16 | .72 | 1.47 | 1.51 | 1.18 | .94 | 3.07 | 3.28 | 31.11 | 14.17 | 40.72 | 21.59 |
| 25 | 7 | 371 | 2,597 | 2.69 | .95 | 1.15 | .71 | 1.50 | 1.54 | 1.17 | .92 | 3.04 | 3.25 | 31.11 | 14.17 | 40.66 | 21.54 |
| 26 | 3 | 400 | 1,200 | 2.65 | .94 | 1.13 | .70 | 1.52 | 1.56 | 1.15 | .90 | 3.02 | 3.23 | 31.11 | 14.17 | 40.58 | 21.50 |
| 27 | 1 | 432 | 432 | 2.59 | .92 | 1.12 | .69 | 1.53 | 1.57 | 1.15 | .89 | 2.99 | 3.20 | 31.11 | 14.17 | 40.49 | 21.44 |
| 28 | 2 | 467 | 934 | 2.53 | .89 | 1.11 | .69 | 1.54 | 1.58 | 1.15 | .88 | 2.96 | 3.17 | 31.11 | 14.17 | 40.40 | 21.38 |
| 29 | 4 | 503 | 2,012 | 2.47 | .87 | 1.10 | .68 | 1.54 | 1.58 | 1.15 | .88 | 2.93 | 3.14 | 31.11 | 14.17 | 40.30 | 21.32 |
| 30 | 2 | 540 | 1,080 | 2.41 | .85 | 1.09 | .68 | 1.55 | 1.59 | 1.15 | .87 | 2.92 | 3.12 | 31.11 | 14.17 | 40.23 | 21.28 |
| Total or weighted average | | | 48,361 | 2.75 | .97 | 1.22 | .75 | 1.45 | 1.48 | 1.31 | 1.08 | 3.26 | 3.49 | 31.11 | 14.17 | 41.09 | 21.94 |
| Total or weighted average, all trees | | | 49,032 | 2.75 | .97 | 1.22 | .75 | 1.46 | 1.49 | 1.32 | 1.09 | 3.28 | 3.51 | 31.11 | 14.17 | 41.13 | 21.98 |

pines, and then very slowly to 30-inch pines. The total cost of production, excluding stumpage for the average pine cut, represented by the 17-inch trees, is $23.48 per M feet.

For hardwood the same trend will be noted. The cost average of all hardwood cut, represented by the 20-inch trees, is $21.75.

## How Tree Size Affects Grade and Value of Lumber Produced

### GRADE OF LUMBER PRODUCED BY TREE SIZE

So much has been said and written to support the common and erroneous belief that second-growth timber can produce only small, rough logs of very low quality, it may be surprising to many to learn that under proper management the contrary is true. Management of second-growth shortleaf and loblolly pines in which the financially mature timber is selectively cut and only those smaller trees are taken that form the inferior and low-quality portion of the stand yields a relatively high percent of clear lumber even in the first cut. Under such management, reserving a substantial representation of larger trees at each cut, the owner will undoubtedly obtain from later cuts progressively more high-grade logs and lumber.

Table 35 and figure 12 give the percent of total volume of B and

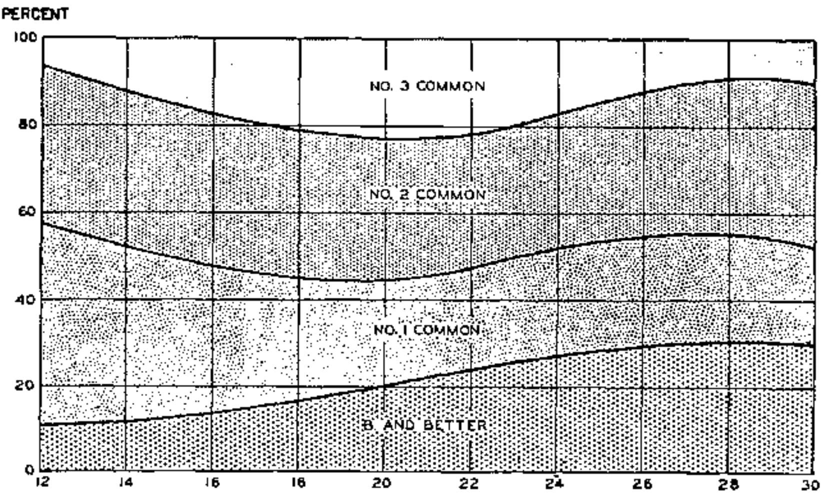


FIGURE 12.—Grades of green lumber produced from shortleaf and loblolly pine trees of various sizes. (Basis, tally of rough green No. 3 Common and Better lumber from all pine trees cut in study.)

Better and Nos. 1, 2, and 3 Common lumber produced on the green chain from the pine trees cut in the present study; some timbers also were cut and are included in No. 1 Common. In the present study, B and Better and No. 1 Common made up 47 percent of the total volume; No. 2, 34 percent; and No. 3, 19 percent. Such yields may be surprising but they are not unusual in selectively cut stands.

The grades of lumber produced from the hardwoods cut at the same time as the pines are given in table 36. A glance at this table will show that the amount of the higher grades produced from these trees was very small. It is apparent, therefore, that unless the price for bridge plank, ties, and sound wormy lumber equals logging and milling costs plus a reasonable amount for stumpage, it will not be profitable to cut these woods-run upland hardwoods into sawlogs. Generally it would be advisable to cut them into chemical wood or ties in the woods.

TABLE 35.—*Distribution of lumber*[1] *produced from pines of various sizes by tree diameter and lumber grade*

| Diameter breast high (inches) | B and Better | No. 1 Common[2] | No. 2 Common | No. 3 Common | Basis, trees | Basis, volume |
|---|---|---|---|---|---|---|
| | *Percent* | *Percent* | *Percent* | *Percent* | *Number* | *Board feet* |
| 12 | 11 | 46 | 37 | 6 | 1 | 33 |
| 13 | 11 | 44 | 30 | 9 | 12 | 1,229 |
| 14 | 12 | 40 | 36 | 12 | 37 | 5,157 |
| 15 | 13 | 37 | 35 | 15 | 30 | 5,448 |
| 16 | 14 | 34 | 35 | 17 | 43 | 8,037 |
| 17 | 15 | 31 | 35 | 19 | 63 | 15,955 |
| 18 | 16 | 29 | 34 | 21 | 69 | 20,771 |
| 19 | 18 | 26 | 34 | 22 | 67 | 23,139 |
| 20 | 20 | 24 | 33 | 23 | 42 | 14,943 |
| 21 | 22 | 23 | 32 | 23 | 27 | 12,940 |
| 22 | 24 | 23 | 31 | 22 | 15 | 7,537 |
| 23 | 26 | 24 | 30 | 20 | 9 | 5,733 |
| 24 | 27 | 24 | 31 | 18 | 13 | 8,774 |
| 25 | 28 | 25 | 32 | 15 | 10 | 7,447 |
| 26 | 29 | 25 | 33 | 13 | 5 | 4,134 |
| 27 | 29 | 25 | 35 | 11 | 3 | 2,573 |
| 28 | 30 | 24 | 37 | 9 | 4 | 3,941 |
| 29 | 30 | 23 | 38 | 9 | | |
| 30 | 30 | 22 | 38 | 10 | 5 | 2,627 |
| Total or average | 20 | 27 | 34 | 19 | 455 | 150,418 |

[1] Green-chain tally, in percent of total volume in each diameter class.
[2] Includes some timbers.

Most of this hardwood is post oak of a uniformly poor quality because of shake, rot, grubs, and mineral stain. A few high-grade post oak logs, however, can be produced in natural second-growth shortleaf-loblolly pine-hardwood stands. Most of the red oak and

TABLE 36.—*Distribution of lumber*[1] *produced from hardwoods of various sizes by tree diameter and lumber grade*

| Diameter breast high (inches) | 4/4 FAS | 4/4 No. 1 Common | 4/4 No. 2 Common | 4/4 No. 3 Common 3B | 4/4 sound wormy | Decking | Bridge plank, ties | Basis, trees | Basis, volume |
|---|---|---|---|---|---|---|---|---|---|
| | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Number* | *Board feet* |
| 12 | 1.5 | 11.5 | 11.3 | 10.6 | 9.9 | 1.0 | 54.2 | 1 | 76 |
| 13 | 1.5 | 12.0 | 11.7 | 10.0 | 10.9 | 1.0 | 52.9 | | |
| 14 | 1.5 | 12.5 | 12.1 | 9.6 | 11.7 | 1.0 | 51.6 | 5 | 595 |
| 15 | 1.5 | 13.0 | 12.5 | 9.3 | 12.4 | 1.0 | 50.3 | 13 | 1,833 |
| 16 | 1.5 | 13.5 | 12.7 | 9.1 | 13.0 | 1.0 | 49.2 | 15 | 2,430 |
| 17 | 1.5 | 14.0 | 12.8 | 9.0 | 13.7 | 1.0 | 48.0 | 26 | 4,784 |
| 18 | 1.5 | 14.5 | 13.0 | 8.8 | 14.2 | 1.0 | 47.0 | 25 | 5,125 |
| 19 | 1.5 | 15.0 | 13.2 | 8.6 | 14.7 | 1.0 | 46.0 | 10 | 4,313 |
| 20 | 1.5 | 15.5 | 13.2 | 8.6 | 15.2 | 1.0 | 45.0 | 31 | 7,781 |
| 21 | 1.5 | 15.8 | 13.4 | 8.6 | 15.7 | 1.0 | 44.0 | 12 | 3,276 |
| 22 | 1.5 | 16.0 | 13.5 | 8.7 | 16.2 | 1.0 | 43.1 | 18 | 5,310 |
| 23 | 1.5 | 16.0 | 13.6 | 8.9 | 16.8 | 1.0 | 42.2 | 10 | 3,190 |
| 24 | 1.5 | 16.0 | 13.5 | 9.0 | 17.4 | 1.0 | 41.6 | 6 | 2,084 |
| 25 | 1.5 | 16.0 | 13.4 | 9.1 | 17.8 | 1.0 | 41.2 | 7 | 2,597 |
| 26 | 1.5 | 16.0 | 13.0 | 9.5 | 18.0 | 1.0 | 41.0 | 3 | 1,200 |
| 27 | 1.5 | 16.0 | 12.5 | 10.0 | 17.9 | 1.0 | 41.1 | 1 | 432 |
| 28 | 1.5 | 16.0 | 11.9 | 10.7 | 17.7 | 1.0 | 41.2 | 2 | 934 |
| 29 | 1.5 | 16.0 | 10.9 | 11.5 | 17.1 | 1.0 | 42.0 | 4 | 2,012 |
| 30 | 1.5 | 16.0 | 9.8 | 12.3 | 16.7 | 1.0 | 42.7 | 2 | 1,080 |
| Total or average | 1.5 | 15.2 | 12.9 | 9.1 | 15.4 | 1.0 | 44.9 | 200 | 49,032 |

[1] Green-chain tally, in percent of total volume in each diameter class.

forked-leaf white oak found in these stands is of high quality. It is difficult to determine which trees will prove to be profitable sawmill trees, until they are felled and the logs can be graded.

### VALUE OF FINISHED LUMBER BY TREE SIZE

The values per tree of finished lumber produced in the study from pines and hardwoods of various sizes, given in table 37, were computed for pine and hardwood separately as follows:

1. The green-chain tally by grade for each log was multiplied by the values given in appendix table 72 for pine and in table 23 for hardwood, to obtain the total value of the finished lumber for each log.
2. The logs making up each tree were grouped together and the total value of finished lumber for each tree determined.
3. Average values for trees of each size were computed, these averages were curved, and values for each size class were read from the curve.

TABLE 37.—*Value of finished lumber*[1] *produced from pines and hardwoods of various sizes*

| Diameter breast high (inches) | Value of pine— | | Value of hardwood— | | Diameter breast high (inches) | Value of pine— | | Value of hardwood— | |
|---|---|---|---|---|---|---|---|---|---|
| | Per tree | Per M board feet | Per tree | Per M board feet | | Per tree | Per M board feet | Per tree | Per M board feet |
| 12 | $2.42 | $31.43 | $1.90 | $26.18 | 22 | $17.69 | $33.19 | $8.40 | $28.47 |
| 13 | 3.06 | 30.91 | 2.50 | 26.43 | 23 | 20.17 | 33.73 | 9.10 | 28.53 |
| 14 | 3.80 | 30.63 | 3.18 | 26.72 | 24 | 22.85 | 34.36 | 9.80 | 28.49 |
| 15 | 4.90 | 30.43 | 3.80 | 26.95 | 25 | 25.50 | 34.74 | 10.52 | 28.36 |
| 16 | 6.10 | 30.35 | 4.41 | 27.22 | 26 | 28.24 | 35.08 | 11.25 | 28.12 |
| 17 | 7.54 | 30.40 | 5.05 | 27.45 | 27 | 31.04 | 35.39 | 12.00 | 27.78 |
| 18 | 9.19 | 30.84 | 5.70 | 27.80 | 28 | 33.91 | 35.73 | 12.74 | 27.28 |
| 19 | 11.00 | 31.26 | 6.37 | 28.06 | 29 | 36.88 | 36.12 | 13.52 | 26.88 |
| 20 | 13.07 | 31.88 | 7.06 | 28.13 | 30 | 30.88 | 36.49 | 14.29 | 26.46 |
| 21 | 15.32 | 32.60 | 7.72 | 28.28 | | | | | |

[1] Green-chain tally.

The values of finished lumber obtainable from 1 M feet of green lumber after drying, dressing, and remanufacture are also given in table 37. Figure 11 shows in a diagram a comparison of values of finished lumber and costs of logging and milling for pines and hardwoods of various sizes. The lowest values for pines are in the 15-, 16-, and 17-inch diameters, probably because only defective, limby, or otherwise poor-quality trees of these sizes were cut. From a low of $30.35 per M feet for 16-inch pines the values increase consistently to $36.49 for 30-inch trees. Hardwood values increase consistently from $26.18 for 12-inch trees to $28.53 for 23-inch trees, thereafter decreasing to $26.46 for 30-inch trees. Table 37 and figure 11 show the small pine trees to have a relatively high value per M feet, doubtless because they were badly suppressed trees with clear long boles and very poor crowns. Such trees are usually quite old and yield good-quality lumber, but are poor risks for future growth. The fact that both pines and hardwoods gain in quality as well as in volume as they grow in size and pass into higher diameter classes is of much significance in forest management. Hardwoods, however, may finally reach a size and age at which they become defective and of less value per M feet than smaller sound trees.

## How Tree Size Affects Realization Value

Of most importance to forest owners are realization values, or the margin available for stumpage, profit, and uninsured risks. The figures for 1940 for pine and hardwood trees of different sizes cut in the study are given in table 38.

TABLE 38.—*Realization values*[1] *per M board feet lumber tally*[2] *for pines and hardwoods of various sizes*

| Diameter breast high (inches) | Pine | | | Hardwood | | |
|---|---|---|---|---|---|---|
| | Lumber sales value | Cost of logging and milling | Realization value | Lumber sales value | Cost of logging and milling | Realization value |
| 12 | $31.43 | $29.92 | $1.51 | $26.18 | $27.79 | −$1.61 |
| 13 | 30.91 | 28.21 | 2.70 | 26.43 | 25.59 | .84 |
| 14 | 30.63 | 26.65 | 3.98 | 26.72 | 24.31 | 2.41 |
| 15 | 30.43 | 25.32 | 5.11 | 26.95 | 23.45 | 3.50 |
| 16 | 30.35 | 24.30 | 6.05 | 27.22 | 22.89 | 4.33 |
| 17 | 30.40 | 23.48 | 6.92 | 27.45 | 22.44 | 5.01 |
| 18 | 30.84 | 22.91 | 7.93 | 27.80 | 22.19 | 5.61 |
| 19 | 31.25 | 22.49 | 8.76 | 28.06 | 21.98 | 6.08 |
| 20 | 31.88 | 22.18 | 9.70 | 28.13 | 21.77 | 6.36 |
| 21 | 32.60 | 21.98 | 10.62 | 28.28 | 21.69 | 6.59 |
| 22 | 33.19 | 21.83 | 11.36 | 28.47 | 21.66 | 6.81 |
| 23 | 33.73 | 21.77 | 11.96 | 28.53 | 21.60 | 6.93 |
| 24 | 34.36 | 21.69 | 12.67 | 28.49 | 21.59 | 6.90 |
| 25 | 34.74 | 21.64 | 13.10 | 28.36 | 21.54 | 6.82 |
| 26 | 35.08 | 21.58 | 13.50 | 28.12 | 21.50 | 6.62 |
| 27 | 35.39 | 21.55 | 13.84 | 27.78 | 21.44 | 6.34 |
| 28 | 35.73 | 21.51 | 14.22 | 27.28 | 21.38 | 5.90 |
| 29 | 36.12 | 21.49 | 14.63 | 26.88 | 21.32 | 5.56 |
| 30 | 36.49 | 21.51 | 14.98 | 26.46 | 21.28 | 5.18 |

[1] Realization values include stumpage, profit, and uninsured risks.
[2] Green-chain tally.

### PINE REALIZATION VALUE

Table 38 shows clearly that smaller trees utilized for logs were cut at a narrow profit margin for pine and a loss for hardwood. It is later shown that, by diverting low-grade logs to pulpwood or other use, trees as small as 12 inches can be utilized with a narrow margin of net return. Fluctuations in lumber values, however, make it desirable to avoid operating risks by cutting mostly in the larger diameter classes.

As has been pointed out previously, in view of the fact that lumber values and costs vary widely from year to year for a single mill and among different plants in the same year, no one should assume that the results obtained in this study can be applied directly to his conditions; rather he should substitute current values and known costs and calculate reliable realization values which can be applied directly.

Although the realization values obtained in this study are reasonably satisfactory, selective logging can be made still more profitable if better management is practiced. In the recent past it has been the common practice for most lumber companies in this region to cut into a log any section of a tree that was 12 feet long, or longer, and approximately 10 inches in diameter at the small end, little or no attention being paid to the smoothness or roughness of the logs or the amount of cull or sweep they contained. Despite the certainty that many logs would prove unprofitable, this practice was followed in this study, in order to determine which trees and which logs are profitable and which are unprofitable. From analysis of costs by logs it is apparent that (1) a good profit is made on most butt logs; (2) the cost of production about equals the sales value of the lumber for many of the second logs; and (3) the cost of production on many of the top logs is greater than the value of the lumber produced. In some cases the loss on the top log is sufficient to offset any profit on the other logs in the tree and actually results in a net loss for the tree as a whole. On the other hand, if the unprofitable logs are excluded these same trees below 14 inches in diameter will show a stumpage value above all costs.

It is definitely the intention in sound plans of selective cutting to send only those parts of the trees to the sawmill that can be profitably utilized. To make a small profit of $1 to $2 per M feet by including only profitable logs from these trees is much better than to sustain a loss of from $1 to $4 per M feet as a result of sending all logs to the sawmill.

Although 30-inch trees show a net realization value of $14.98 per M board feet as compared with $9.70 for 20-inch trees, it is not always desirable or possible to produce only very large trees. Most shortleaf and loblolly pine trees will not grow to 30 inches in size even though left for 300 years. Many of them are mature at 20 to 24 inches in diameter. Furthermore, most of the timber in the shortleaf-loblolly pine type is second growth of relatively small diameter and it would be economically impossible to shut down the mills for 20 or more years while waiting for these trees to grow into the larger diameter classes. It is much better to continue present operations by realizing as much as possible from the smaller sizes, but at the same time to improve and build up stands so that eventually they contain a fair proportion of these large and high-value trees. Furthermore, it may be possible, during the time required to grow one 30-inch tree, to grow several 18- or 20-inch trees on the same area. The point to be stressed is that, in selective cutting, attention must be paid to individual trees and even to individual logs.

### HARDWOOD REALIZATION VALUE

Logging and milling hardwood trees of relatively small size is also shown in table 38 to be definitely unprofitable for a large band mill such as that at Crossett. The cost of producing lumber from the 12-inch trees removed in the selective cutting is greater than the value of the lumber produced from these trees. Twenty-inch trees, which are about the average for all hardwoods cut, have a realization value of $6.36 per M feet, and 23-inch trees with a value of $6.93 represent peak return. Realization values for the stand can be considerably increased if the small and costly trees and top logs are not included.

The reasons for the failure to make at least logging and milling cost on the small hardwoods are quite similar to the reasons for the net loss on the smaller pine trees, namely: (1) Certain logs and some whole trees are of such low grade that they are really not sawlog material; (2) only the poorer trees below 17 inches in size have been removed in the selective cutting; (3) a large proportion of the hardwood trees in these stands are post oaks which are almost uniformly of low quality regardless of size. With this class of material, good profits can be made only if there is a very favorable market for car stock, bridge plank, and ties.

As already stated, the net loss on some trees and the low net return on others are not due to the selective type of cutting. Losses on such trees will occur regardless of the type of sawlog cutting. Under clear cutting, removal of more of the higher-quality small trees might change the average for certain diameter classes from a minus to a plus value; but this would only mask the very unprofitable nature of much of the other material as saw timber.

Again it should be mentioned that, if a timberland owner is interested in the business of growing timber as a crop, provision should be made for utilizing as firewood, acid wood, ties, or any one of a dozen other products that will yield a small profit, those trees that are unprofitable sawlog material.

An insufficient number of red and white oak trees was cut to justify a separate determination of total logging and milling costs and of the sales value of the lumber produced from them. From a limited analysis of the data available, however, it is apparent that most logs from second-growth trees of these two species yield lumber of a much higher average grade than that from post oak logs. Because of this fact and because the growth rate of these two species is nearly as good as that of shortleaf and loblolly pine and much greater than that of post oak, all immature and high-grade trees of these two species should be reserved for additional growth. This practice was followed in the experimental operation.

## Utilization of Tops from Sawlog Trees and Improvement Cuttings from Residual Stands

All persons familiar with timber know that if only the valuable saw-timber trees are cut, there will be at each return cut an accumulation of low-grade trees occupying ground that should be available to valuable trees. Also if tops from saw-timber trees are not utilized, fuel for forest fires will accumulate, making fire fighting more difficult. Finally, it is obvious that any net earnings from utilizing tops and thinnings will help swell the net proceeds from the forest property as a whole.

For these reasons two studies were made of cordwood utilization of two products salable on the area—pulpwood and distillation wood. At the time of the studies, only pines were salable for pulpwood. On some areas hardwoods also are used for pulpwood and probably will be in greater demand in the future. The area of the studies is one of the few in the United States where distillation wood, for which only the dense hardwoods are suitable, is utilized.

Immediately after sawlog cutting on each of the test blocks, a marking crew covered the area and marked for cutting into pulpwood all defective, injured, badly suppressed, and low-quality pine trees. Saw crews then began cutting these trees into pulpwood, at the same time with the tops left from the sawlog cutting. As soon as any considerable quantity of pulpwood had been cut it was hauled by truck to the nearest railroad, loaded on cars, and shipped to a pulp mill. Following the pulpwood cutting, the process was repeated for cutting of distillation wood from hardwood tops and poor-quality hardwoods removed in improvement cuttings.

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In order to determine the profitableness or unprofitableness of cutting tops as well as standing trees, a stop-watch time study was made of each portion of the pulpwood operation on about half of the total study area and of the distillation-wood operation on 28 acres of typical pine hardwood. Two men with the necessary equipment obtained records of diameter breast high and tree number for whole trees cut and sawlog tree number for tops cut into pulpwood and distillation wood; felling time for standing trees; limbing time per tree or top; bucking time for each stick; diameter inside bark for each stick; splitting time for each stick; delay time; and number of units of wood cut per block. In addition to these data, records were kept on the cost of labor, oil, wedges, saw filing, etc.

Two men usually composed a crew in cutting pulpwood and distillation wood, and, since they worked the same hours and used exactly the same equipment as did the crew felling and bucking sawlogs, the same crew rate of $0.706 per hour and man-hour rate of $0.353 (table 3) was paid.

## VOLUME, VALUE, AND COST OF PULPWOOD PRODUCED FROM TOPS OF SAWLOG TREES

Table 39, recording the average volume per top in cubic feet, and the production time, cost, and the gross and net value per cord and per 100 cubic feet of pulpwood produced from tops of 398 sawlog trees of various sizes, shows that tops from sawlog trees 20–22 inches

TABLE 39.—*Man-hour requirement, cost of production, and gross and net value per cord and per 100 cubic feet of pulpwood produced from tops of saw-timber pine trees of various sizes*

| Diameter breast high (inches) | Volume per top[2] | Per standard cord[1] | | | | Per 100 cubic feet[2] | | | | Basis, tops used[6] | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Time | Cost[3] | Value | | Time | Cost[3] | Value | | | |
| | | | | Gross[4] | Net[5] | | | Gross[4] | Net[5] | | |
| | *Cubic feet* | *Man-hours* | *Dollars* | *Dollars* | *Dollars* | *Man-hours* | *Dollars* | *Dollars* | *Dollars* | *Number* | *Percent* |
| 10 | 4.8 | 3.112 | 1.10 | 2.15 | 1.05 | 3.705 | 1.31 | 2.56 | 1.25 | | 96.1 |
| 11 | 5.7 | 3.131 | 1.11 | 2.15 | 1.04 | 3.727 | 1.32 | 2.56 | 1.24 | 1 | 94.1 |
| 12 | 6.7 | 3.150 | 1.11 | 2.15 | 1.04 | 3.750 | 1.32 | 2.56 | 1.24 | | 91.8 |
| 13 | 7.6 | 3.169 | 1.12 | 2.15 | 1.03 | 3.773 | 1.33 | 2.56 | 1.23 | 11 | 89.5 |
| 14 | 8.5 | 3.225 | 1.14 | 2.15 | 1.01 | 3.839 | 1.36 | 2.56 | 1.20 | 37 | 87.0 |
| 15 | 9.4 | 3.301 | 1.17 | 2.15 | .98 | 3.930 | 1.39 | 2.56 | 1.17 | 30 | 84.7 |
| 16 | 10.1 | 3.433 | 1.21 | 2.15 | .94 | 4.087 | 1.44 | 2.56 | 1.12 | 50 | 82.2 |
| 17 | 10.8 | 3.602 | 1.27 | 2.15 | .88 | 4.288 | 1.51 | 2.56 | 1.05 | 59 | 79.7 |
| 18 | 11.3 | 3.810 | 1.34 | 2.15 | .81 | 4.536 | 1.60 | 2.56 | .96 | 61 | 77.0 |
| 19 | 11.6 | 4.055 | 1.43 | 2.15 | .72 | 4.827 | 1.70 | 2.56 | .86 | 92 | 74.3 |
| 20 | 11.9 | 4.319 | 1.52 | 2.15 | .63 | 5.142 | 1.82 | 2.56 | .74 | 38 | 71.6 |
| 21 | 12.0 | 4.640 | 1.64 | 2.15 | .51 | 5.524 | 1.95 | 2.56 | .61 | 16 | 68.2 |
| 22 | 11.9 | 5.017 | 1.77 | 2.15 | .38 | 5.973 | 2.11 | 2.56 | .45 | 11 | 64.8 |
| 23 | 11.6 | 5.451 | 1.92 | 2.15 | .23 | 6.489 | 2.29 | 2.56 | .27 | 5 | 60.8 |
| 24 | 11.2 | 5.911 | 2.10 | 2.15 | .05 | 7.073 | 2.50 | 2.56 | .06 | 4 | 56.3 |
| 25 | 10.7 | 6.487 | 2.29 | 2.15 | −.14 | 7.723 | 2.73 | 2.56 | −.17 | 5 | 52.0 |
| 26 | 10.6 | 7.073 | 2.50 | 2.15 | −.35 | 8.420 | 2.97 | 2.56 | −.41 | 1 | 47.3 |
| 27 | 9.2 | 7.695 | 2.72 | 2.15 | −.57 | 9.161 | 3.23 | 2.56 | −.67 | 1 | 42.5 |
| 28 | 8.3 | 8.374 | 2.96 | 2.15 | −.81 | 9.969 | 3.52 | 2.56 | −.96 | 4 | 37.5 |
| 29 | 7.3 | 9.128 | 3.22 | 2.15 | −1.07 | 10.867 | 3.84 | 2.56 | −1.28 | | 32.5 |
| 30 | 6.2 | 9.958 | 3.52 | 2.15 | −1.37 | 11.855 | 4.18 | 2.56 | −1.62 | 2 | 27.0 |

[1] Standard cord=4 feet × 4 feet × 8 feet.
[2] Solid wood inside bark.
[3] Rate per man-hour=$0.353.
[4] Based on $2.15 per standard cord (84 cubic feet of solid wood inside bark) or $2.56 per 100 cubic feet of unstacked pulpwood in the woods.
[5] Margin between gross value and production cost. Includes stumpage, profit, and uninsured risks.
[6] Only 398 of a total of 535 tops could be utilized for pulpwood—large limbs on the remaining 137 tops making limbing and splitting impracticable. Percents are figured on total number of tops used for pulpwood, curved.


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FIGURE 13.—Top from a 3-log 20-inch pine tree (*A*) before and (*B*) after cutting of 16 sticks of pulpwood, scaling ¼ cord. Pulpwood can usually be cut at a profit from the tops of all trees 24 inches d. b. h. and smaller, and such utilization substantially reduces fire hazard.

in diameter yielded the greatest average volume of pulpwood per top or about 12 cubic feet; and that pulpwood from tops of all trees not more than 24 inches d. b. h. had a net value (fig. 13). The volume produced from tops of trees above this diameter decreased with increase in tree size, not because the tops of the larger trees did not contain more volume, but rather because the thickness of the limbs often made it very difficult, if not impossible, to split some cuts into pieces of the required size. In fact, out of a total of 535 tops on the pulpwood study area, it was feasible to cut pulpwood from only 398, or 74 percent. The percent of tops utilized in each diameter class, as given in table 39, would, of course, vary with operations, depending upon the size and nature of the timber cut.

The value of the pulpwood after felling and bucking, but without stacking or penning, was $2.42 per unit of 144 cubic feet (4 feet by 4 feet 6 inches by 8 feet) in the woods, or $3.85 delivered f. o. b. the railroad 5 miles away. This is equivalent to $2.15 per standard cord (84 cubic feet of solid wood, inside bark), or $2.56 per 100 cubic feet, for pulpwood in the woods. The cost of production (table 39) increases rapidly, from $1.10 per cord for 10-inch trees to $3.52 per cord for 30-inch trees. By subtracting the production cost from the gross value of the wood, the net value for stumpage, profit, and interest is obtained.

Figure 14, which gives a graphic view of production costs and gross values, shows that pulpwood from tops of all trees 24 inches and smaller in diameter had a positive net value per cord. Although trees 20 to 22 inches in diameter yielded the greatest average amount of wood per top, the greatest net profit per cord, or per 100 cubic feet, accrued from tops of trees from 10 to 16 inches d. b. h. The net value per cord of pulpwood produced from tops of 21-inch trees was $0.51, whereas for 12-inch trees it was $1.04. This is because of the relatively large amount of limbing and splitting time required when producing pulpwood from tops of large-sized trees.

It should be remembered that the figures given here are based on averages, and some tops of trees over 24 inches d. b. h. will prove profitable, just as some under this size will prove unprofitable. Use of good judgment is therefore as necessary in selecting the tops to cut as in selecting the logs to send to the sawmill.

For the studies as a whole, the average tree cut into sawlogs was about 17 inches d. b. h. and the cost of producing pulpwood from tops of 17-inch trees averaged $1.27 per cord; the value of the wood was $2.15 and the difference, or $0.88, was the amount left for stumpage, profit, and uninsured risks. Thus, where the value of the pulpwood in the woods is at least $1.50 per cord and the costs are not more than those given in table 39, the cutting of tops into pulpwood will be a profitable financial proposition, in addition to substantially reducing a very real fire hazard. In working out the financial possibilities of cutting pulpwood from his own land, each forest owner must apply local values and costs of production. If costs of production are not available, the figures in table 39 can be used as a rough basis. These costs, based on a $0.30 per hour wage, should be adjusted for other wages.

## PERCENT OF TOTAL VOLUME USED FOR PULPWOOD AND FOR SAWLOGS

Table 40 shows, for all 535 pine trees of various sizes cut on the pulpwood-production study area, the volumes and percent of total

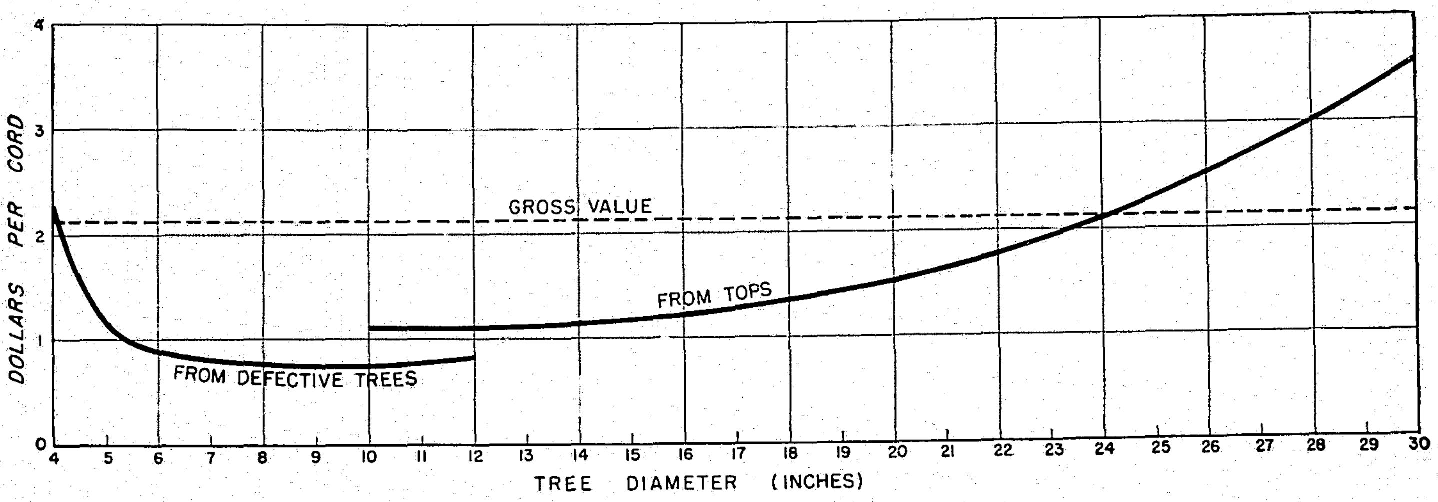


FIGURE 14.—Cost of producing pulpwood and value of product.

volumes utilized for pulpwood and left in tops unmerchantable because of limbs, crook, rot, and other defects. The volumes utilized for sawlogs were also computed for the 535 trees, but since these volumes by tree size were practically the same as volumes for similar tree sizes for the 1,207 trees cut on all test blocks, the latter figures were used, in order that sawlog volumes of pines of various sizes might be identical in all tables of this report. Of the total cubic-foot volume of these trees, 81 percent was cut into sawlogs, 13 percent into pulpwood, and 6 percent was unmerchantable. It must be remembered that the percent of total volume cut into pulpwood is low because of the 137 trees whose tops were rejected as too rough for profitable operation. It was found, both when cutting tops for pulpwood and when cutting sawlogs and pulpwood, that the amount and percent of the total volume unmerchantable for any product increases with increase in diameter of the tree. For trees 10 to 16 inches in diameter the percent unmerchantable is 3.0 to 3.9, whereas for trees 25 to 30 inches d. b. h. it is 9.2 to 10.4. Likewise the diameter of the top of the utilized portion of the tree and the length of the unused top increase with increase in diameter breast high.

## VOLUME, VALUE, AND COST OF PULPWOOD PRODUCED FROM INJURED, DEFECTIVE, AND LOW-QUALITY TREES

The volume produced, time required, cost of production, and gross and net values of improvement cutting per tree, per standard cord, and per 100 cubic feet for pine trees of various sizes were computed from field records of operations in removing injured, defective, and low-quality trees. Table 41 gives these data on a tree basis and table 42 on a cord and 100-cubic-foot basis.

TABLE 40.—*Volume and percent of total stem volume of pines cut into sawlogs and pulpwood and included in unmerchantable tops*

| Diameter breast high (inches) | Stem volume [1] cut into sawlogs | | Stem volume [1] cut into pulpwood | | Stem volume left in unmerchantable tops [2] | | Basis, trees [3] | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Sawlog volume | Other volumes |
| | *Cubic feet* | *Percent* | *Cubic feet* | *Percent* | *Cubic feet* | *Percent* | *Number* | *Number* |
| 10 | 10.0 | 64.9 | 4.8 | 31.2 | 0.6 | 3.9 | 2 | |
| 11 | 13.0 | 67.0 | 5.7 | 29.4 | .7 | 3.6 | 4 | 1 |
| 12 | 16.2 | 68.9 | 6.5 | 27.7 | .8 | 3.4 | 16 | 1 |
| 13 | 20.1 | 71.3 | 7.2 | 25.5 | .9 | 3.2 | 63 | 12 |
| 14 | 24.1 | 73.5 | 7.7 | 23.5 | 1.0 | 3.0 | 150 | 40 |
| 15 | 29.3 | 75.7 | 8.1 | 20.9 | 1.3 | 3.4 | 162 | 34 |
| 16 | 34.9 | 77.5 | 8.4 | 18.7 | 1.7 | 3.8 | 160 | 66 |
| 17 | 41.0 | 79.0 | 8.6 | 16.0 | 2.3 | 4.4 | 160 | 74 |
| 18 | 47.7 | 79.9 | 8.8 | 14.7 | 3.2 | 5.4 | 166 | 79 |
| 19 | 55.1 | 80.9 | 8.8 | 12.9 | 4.2 | 6.2 | 120 | 79 |
| 20 | 62.7 | 81.6 | 8.8 | 11.5 | 5.3 | 6.9 | 73 | 50 |
| 21 | 70.8 | 82.4 | 8.6 | 10.0 | 6.5 | 7.6 | 46 | 29 |
| 22 | 79.3 | 83.3 | 8.1 | 8.5 | 7.8 | 8.2 | 24 | 18 |
| 23 | 88.1 | 84.3 | 7.4 | 7.1 | 9.0 | 8.6 | 13 | 11 |
| 24 | 97.0 | 85.5 | 6.4 | 5.6 | 10.1 | 8.9 | 14 | 14 |
| 25 | 105.9 | 86.5 | 5.3 | 4.3 | 11.3 | 9.2 | 9 | 9 |
| 26 | 114.9 | 87.3 | 4.0 | 3.0 | 12.8 | 9.7 | 7 | 6 |
| 27 | 124.0 | 88.2 | 2.5 | 1.8 | 14.0 | 10.0 | 3 | 3 |
| 28 | 133.0 | 89.2 | .9 | .6 | 15.2 | 10.2 | 6 | 6 |
| 29 | 142.0 | 89.6 | | | 16.4 | 10.4 | | |
| 30 | 151.0 | 89.6 | | | 17.6 | 10.4 | 3 | 3 |

[1] Solid wood inside bark.
[2] Solid wood inside bark to a 4-inch d. i. b. top, assuming uniform taper between utilized top and tip of tree.
[3] 1,207 trees for sawlog volume; 535 trees for other volumes.

TABLE 41.—*Average volume, production time and cost, and gross and net value per tree of pulpwood produced from defective, injured, and low-quality pine trees of various sizes*

| Diameter breast high (inches) | Merchantable volume [1] | Time | Cost [2] | Value | | Basis, trees |
|---|---|---|---|---|---|---|
| | | | | Gross [3] | Net [4] | |
| | *Cubic feet* | *Man-minutes* | *Dollars* | *Dollars* | *Dollars* | *Number* |
| 4 | 0.60 | 2.83 | 0.017 | 0.015 | −0.002 | 4 |
| 5 | 1.99 | 4.57 | .027 | .051 | .024 | 32 |
| 6 | 3.68 | 6.71 | .040 | .094 | .054 | 39 |
| 7 | 5.70 | 9.39 | .055 | .146 | .091 | 58 |
| 8 | 8.16 | 12.89 | .076 | .209 | .133 | 40 |
| 9 | 11.20 | 17.31 | .102 | .287 | .185 | 24 |
| 10 | 14.95 | 23.15 | .137 | .383 | .246 | 23 |
| 11 | 19.45 | 30.80 | .182 | .498 | .316 | 13 |
| 12 | 24.42 | 40.64 | .240 | .625 | .385 | 4 |

[1] Solid wood inside bark.
[2] Rate per man-minute=$0.0059.
[3] Based on $2.15 per standard cord (84 cubic feet of solid wood) or $0.0256 per cubic foot.
[4] Margin between gross value and production cost. Includes stumpage, profit, and uninsured risks.

TABLE 42.—*Average cut per acre, production time and cost, and gross and net value, per cord and per 100 cubic feet of pulpwood produced from defective, injured, and low-quality pine trees of various sizes.*

| Diameter breast high (inches) | Trees cut per acre | Merchantable volume per tree [1] | Per standard cord | | | | Per 100 cubic feet | | | | Basis, trees |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Time | Cost [2] | Value | | Time | Cost [2] | Value | | |
| | | | | | Gross [3] | Net [4] | | | Gross [3] | Net [4] | |
| | *Number* | *Cubic feet* | *Man-hours* | *Dollars* | *Dollars* | *Dollars* | *Man-hours* | *Dollars* | *Dollars* | *Dollars* | *Number* |
| 4 | 0.05 | 0.60 | 6.604 | 2.33 | 2.15 | −0.18 | 7.862 | 2.78 | 2.56 | −0.22 | 4 |
| 5 | .43 | 1.99 | 3.215 | 1.13 | 2.15 | 1.02 | 3.827 | 1.35 | 2.56 | 1.21 | 32 |
| 6 | .53 | 3.68 | 2.553 | .90 | 2.15 | 1.25 | 3.039 | 1.07 | 2.56 | 1.49 | 30 |
| 7 | .78 | 5.70 | 2.306 | .81 | 2.15 | 1.34 | 2.745 | .97 | 2.56 | 1.59 | 58 |
| 8 | .54 | 8.16 | 2.211 | .78 | 2.15 | 1.37 | 2.632 | .93 | 2.56 | 1.63 | 40 |
| 9 | .32 | 11.20 | 2.164 | .76 | 2.15 | 1.39 | 2.576 | .91 | 2.56 | 1.65 | 24 |
| 10 | .31 | 14.95 | 2.168 | .77 | 2.15 | 1.38 | 2.581 | .91 | 2.56 | 1.65 | 23 |
| 11 | .18 | 19.45 | 2.217 | .78 | 2.15 | 1.37 | 2.639 | .93 | 2.56 | 1.63 | 13 |
| 12 | .05 | 24.42 | 2.330 | .82 | 2.15 | 1.33 | 2.774 | .98 | 2.56 | 1.58 | 4 |

[1] Solid wood inside bark.
[2] Rate per man-hour=$0.353.
[3] Based on $2.15 per standard cord (84 cubic feet of solid wood) or $2.56 per 100 cubic feet in the woods.
[4] Margin between gross value and production cost. Includes stumpage, profit, and uninsured risks.

With a value in the woods of $2.15 per cord after felling, bucking, and splitting, and before stacking or penning, there was a margin for stumpage, profit, and uninsured risks for all sizes from 5 inches d. b. h. up to and including 12 inches. A comparison of costs and values per cord is afforded also in figure 14. The minimum production cost of $0.76 per cord and the maximum net value of $1.39 both applied to 9-inch trees. The high cost of $2.33 and low net value of —$0.18 for 4-inch trees are the result of the labor involved in handling the many small sticks making up a cord. The slightly greater costs for 12-inch trees than for 9-inch trees were due to greater limbing requirements and difficulty in handling large, heavy pieces. Besides the trees included in table 42, a few 13- and 14-inch trees were cut into pulpwood. While an adequate sample was not obtained for these sizes, indications are that costs increased rapidly, owing chiefly to time consumed in splitting and limbing. The general practice was to leave round pieces 12 inches in diameter and smaller, but to split larger pieces. Most trees above 12 inches, however, contain a log with a greater net value than can be obtained from pulpwood.

As might be expected, the cost per cord of producing pulpwood from whole trees removed in improvement cuttings was less than that of producing pulpwood from tops of saw-timber trees, principally because of lower limbing and splitting costs. The felling cost charged to pulpwood cut from whole trees was only a small percent of the total cost of production.

## VOLUME OF PULPWOOD PRODUCED PER M BOARD FEET OR 100 CUBIC FEET OF LOGS

In preparing estimates of the possible yield of pulpwood from tops and injured trees for a given logging operation, it is often desirable

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FIGURE 15.—Pulpwood stored beside unloading spur, awaiting delivery to barker.

to know the approximate number of cords that can be cut per M board feet or 100 cubic feet of logs. Accordingly, conversion factors were derived from the data collected on the 76.07 cords cut on the area devoted to the pulpwood utilization study, as follows:

| | *Cord of pulpwood per M board feet or 100 cubic feet of logs* |
|---|---|
| Doyle-Scribner rule (154,060 board feet of logs) | 0.49 |
| Scribner rule (181,388 board feet) | .42 |
| International rule (197,822 board feet) | .38 |
| Cubic-foot rule (29,040 cubic feet) | .26 |

Although these yield factors may be applied directly only under similar log and pulpwood utilization practices, they will serve as rough approximations of probable yields for reasonably well-stocked second-growth stands of loblolly and shortleaf pine. Of the total volume of pulpwood produced about 68 percent came from defective whole trees, cut to improve the composition of the stand, and 32 percent from tops of saw-timber trees. The type of pulpwood produced is shown in figure 15.

### VOLUME, VALUE, AND COST OF DISTILLATION WOOD PRODUCED FROM TOPS OF SAWLOG TREES

The average volume per top in cubic feet, the production time and cost, and the gross and net value per cord and per 100 cubic feet of distillation wood produced from tops of sawlog trees of various sizes, are given in table 43. This table shows the volume of distillation wood per top as increasing only slightly from 14-inch trees up to 25-inch trees. As was true for pine, the larger tops actually contained a much greater volume of wood, but production was unprofitable for large portions of these tops because of excessive costs of removing large limbs and then splitting the knotty tops. Out of a total of 182 tops from hardwood trees utilized for sawlogs only 64, or 35 percent, were utilized for distillation wood; the others were considered too limby for profitable operation.

The time required per cord to produce distillation wood from tops increased from 4.681 man-hours for 14-inch trees up to 5.931 man-hours for 20-inch trees and then decreased to 5.497 man-hours for 25-inch trees. The gradual increase in time per cord is due probably to increasing size of limbs, making limbing and splitting more time-consuming. The decrease in time per cord for trees larger than the 20-inch size is due probably to the crews' rejecting more of the very limby tops, and possibly also to utilization of some of the larger straight limbs which required less labor than the very limby top stem. A few tops were taken from larger trees, up to 30 inches in diameter, but these were insufficient to affect the averages, because of the great irregularities in time required and volumes obtained.

TABLE 43.—*Average volume per top, production time and cost, and gross and net value, per standard cord and per 100 cubic feet, of distillation wood produced from tops of hardwoods of various sizes*

| Diameter breast high (inches) | Volume per top [1] | Per standard cord [2] | | | | Per 100 cubic feet [1] | | | | Basis, tops used [6] | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Time | Cost [3] | Value | | Time | Cost [3] | Value | | | |
| | | | | Gross [4] | Net [5] | | | Gross [4] | Net [5] | | |
| | *Cubic feet* | *Man-hours* | *Dollars* | *Dollars* | *Dollars* | *Man-hours* | *Dollars* | *Dollars* | *Dollars* | *Number* | *Percent* |
| 14 | 12.4 | 4.681 | 1.65 | 2.24 | 0.59 | 6.300 | 2.22 | 3.01 | 0.79 | 2 | 66.7 |
| 15 | 12.4 | 5.040 | 1.78 | 2.24 | .46 | 6.783 | 2.39 | 3.01 | .62 | 5 | 41.7 |
| 16 | 12.4 | 5.362 | 1.89 | 2.24 | .35 | 7.217 | 2.55 | 3.01 | .46 | 6 | 42.9 |
| 17 | 12.5 | 5.597 | 1.98 | 2.24 | .26 | 7.533 | 2.66 | 3.01 | .35 | 10 | 37.0 |
| 18 | 12.6 | 5.771 | 2.04 | 2.24 | .20 | 7.767 | 2.74 | 3.01 | .27 | 5 | 20.0 |
| 19 | 12.7 | 5.882 | 2.08 | 2.24 | .16 | 7.917 | 2.79 | 3.01 | .22 | 6 | 30.0 |
| 20 | 12.8 | 5.931 | 2.09 | 2.24 | .15 | 7.983 | 2.82 | 3.01 | .19 | 14 | 48.3 |
| 21 | 13.0 | 5.877 | 2.07 | 2.24 | .17 | 7.910 | 2.79 | 3.01 | .22 | 4 | 28.6 |
| 22 | 13.2 | 5.788 | 2.04 | 2.24 | .20 | 7.790 | 2.75 | 3.01 | .26 | 6 | 33.3 |
| 23 | 13.4 | 5.702 | 2.01 | 2.24 | .23 | 7.674 | 2.71 | 3.01 | .30 | 2 | 25.0 |
| 24 | 13.7 | 5.577 | 1.97 | 2.24 | .27 | 7.506 | 2.65 | 3.01 | .36 | 3 | 50.0 |
| 25 | 13.9 | 5.497 | 1.94 | 2.24 | .30 | 7.398 | 2.61 | 3.01 | .40 | 1 | 16.7 |

[1] Solid wood inside bark.
[2] Standard cord=4 feet x 4 feet x 8 feet.
[3] Rate per man-hour=$0.353.
[4] Based on $2.24 per standard cord (74.3 cubic feet of solid wood inside bark) or $3.01 per 100 cubic feet of unstacked distillation wood in the woods.
[5] Margin between gross value and production cost. Includes stumpage, profit, and uninsured risks.
[6] Only 64 of a total of 182 tops could be utilized for distillation wood, large limbs on the remaining 118 making limbing and splitting impracticable. Percents indicate proportion of total in each diameter class that was used.

The value of the distillation wood split from tops, but not stacked or penned, was $2.42 per unit of 138.6 cubic feet (8 feet long, 4 feet high, but with sticks 4 feet 4 inches long) in the woods, or $3.85 delivered at the plant, 6 miles away. This is equivalent to $2.24 per standard cord (74.3 cubic feet of solid wood, inside bark, making up the average cord), or $3.01 per 100 cubic feet, for distillation wood in the woods. The cost of production per cord increased from $1.65 for 14-inch trees to $2.09 for 20-inch trees and then decreased to $1.94 for 25-inch trees. The margin (representing stumpage, profit, and uninsured risks) left after subtracting these costs from the gross value of $2.24 per cord decreased from $0.59 for 14-inch trees to $0.15 for 20-inch trees, and then increased to $0.30 for 25-inch trees. The most important fact brought out in table 43 is that distillation wood was cut at a profit from tops of trees of all sizes. The results indicate that more tops in the smallest and largest sizes might have been utilized profitably and that some tops in the 18- to 22-inch classes should have been rejected. The margin in all classes is small, however, and the importance of selecting only these tops and portions of tops that can be utilized without excessive limbing and splitting should be emphasized.

## VOLUME, VALUE, AND COST OF DISTILLATION WOOD PRODUCED FROM INJURED, DEFECTIVE, AND LOW-QUALITY TREES

The volumes, time required, cost of production, and gross and net values per tree, per standard cord, and per 100 cubic feet for hardwoods of various sizes were computed from the field records of improvement cuttings, which removed injured, defective, and low-quality trees. Table 44 gives these data on a tree basis and table 45 on a cord and 100-cubic-foot basis.

TABLE 44.—*Average volume, production time and cost, and gross and net value, per tree, of distillation wood, produced from defective, injured, and low-quality hardwoods of various sizes*

| Diameter breast high (inches) | Merchantable volume [1] | Time | Cost [2] | Value | | Basis, trees [5] |
|---|---|---|---|---|---|---|
| | | | | Gross [3] | Net [4] | |
| | *Cubic feet* | *Man-minutes* | *Dollars* | *Dollars* | *Dollars* | *Number* |
| 4 | 1.0 | 12.00 | 0.071 | 0.030 | −0.041 | 11 |
| 5 | 1.8 | 14.60 | .086 | .054 | −.032 | 19 |
| 6 | 3.1 | 18.60 | .110 | .093 | −.017 | 17 |
| 7 | 4.7 | 23.60 | .139 | .141 | .002 | 12 |
| 8 | 6.4 | 29.00 | .171 | .193 | .022 | 15 |
| 9 | 8.6 | 36.00 | .212 | .259 | .047 | 11 |
| 10 | 10.8 | 44.40 | .262 | .325 | .063 | 7 |
| 11 | 13.6 | 54.60 | .322 | .409 | .087 | 10 |
| 12 | 16.8 | 66.40 | .392 | .506 | .114 | 10 |
| 13 | 20.2 | 79.60 | .470 | .608 | .138 | 20 |
| 14 | 23.9 | 94.00 | .555 | .719 | .164 | 13 |
| 15 | 28.0 | 110.00 | .649 | .843 | .194 | 17 |
| 16 | 32.2 | 127.40 | .752 | .969 | .217 | 4 |
| 17 | 36.6 | 145.80 | .860 | 1.102 | .242 | 6 |
| 18 | 41.2 | 164.60 | .971 | 1.240 | .269 | 1 |
| 19 | 46.0 | 184.60 | 1.089 | 1.385 | .296 | 4 |
| 20 | 51.0 | 206.00 | 1.215 | 1.535 | .320 | 3 |
| 21 | 56.2 | 227.60 | 1.343 | 1.692 | .349 | ---------- |
| 22 | 61.4 | 249.20 | 1.470 | 1.848 | .378 | 1 |
| 23 | 66.9 | 272.00 | 1.605 | 2.014 | .409 | ---------- |
| 24 | 72.5 | 295.80 | 1.745 | 2.182 | .437 | 2 |

[1] Solid wood inside bark.
[2] Rate per man-minute=$0.0059.
[3] Based on $2.24 per standard cord (74.3 cubic feet of solid wood inside bark) or $0.0301 per cubic foot.
[4] Margin between gross value and production cost. Includes stumpage, profit, and uninsured risks.
[5] 192 trees in all.

TABLE 45.—*Average cut per acre, production time and cost, and gross and net value, per cord and per 100 cubic feet, of distillation wood produced from defective, injured, and low-quality hardwoods of various sizes*

| Diameter breast high (inches) | Trees cut per acre [1] | Merchantable volume per tree [2] | Per standard cord | | | | Per 100 cubic feet | | | | Basis, trees [1] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Time | Cost [3] | Value | | Time | Cost [3] | Value | | |
| | | | | | Gross [4] | Net [5] | | | Gross [4] | Net [5] | |
| | *Number* | *Cubic feet* | *Man-hours* | *Dollars* | *Dollars* | *Dollars* | *Man-hours* | *Dollars* | *Dollars* | *Dollars* | *Number* |
| 4 | 0.30 | 1.0 | 14.860 | 5.25 | 2.24 | —3.01 | 20.000 | 7.06 | 3.01 | —4.05 | 11 |
| 5 | .68 | 1.8 | 10.044 | 3.55 | 2.24 | —1.31 | 13.518 | 4.77 | 3.01 | —1.76 | 19 |
| 6 | .61 | 3.1 | 7.430 | 2.62 | 2.24 | —.38 | 10.000 | 3.53 | 3.01 | —.52 | 17 |
| 7 | .43 | 4.7 | 6.218 | 2.19 | 2.24 | .05 | 8.369 | 2.95 | 3.01 | .06 | 12 |
| 8 | .54 | 6.4 | 5.611 | 1.98 | 2.24 | .26 | 7.552 | 2.67 | 3.01 | .34 | 15 |
| 9 | .39 | 8.6 | 5.184 | 1.83 | 2.24 | .41 | 6.977 | 2.46 | 3.01 | .55 | 11 |
| 10 | .25 | 10.8 | 5.091 | 1.80 | 2.24 | .44 | 6.852 | 2.42 | 3.01 | .59 | 7 |
| 11 | .68 | 13.6 | 4.971 | 1.75 | 2.24 | .49 | 6.691 | 2.36 | 3.01 | .65 | 19 |
| 12 | .36 | 16.8 | 4.894 | 1.73 | 2.24 | .51 | 6.587 | 2.33 | 3.01 | .68 | 10 |
| 13 | .71 | 20.2 | 4.880 | 1.72 | 2.24 | .52 | 6.568 | 2.32 | 3.01 | .69 | 20 |
| 14 | .46 | 23.9 | 4.870 | 1.72 | 2.24 | .52 | 6.555 | 2.31 | 3.01 | .70 | 13 |
| 15 | .61 | 28.0 | 4.865 | 1.72 | 2.24 | .52 | 6.548 | 3.31 | 3.01 | .70 | 17 |
| 16 | .14 | 32.2 | 4.899 | 1.73 | 2.24 | .51 | 6.594 | 2.33 | 3.01 | .68 | 4 |
| 17 | .21 | 36.6 | 4.933 | 1.74 | 2.24 | .50 | 6.639 | 2.34 | 3.01 | .67 | 6 |
| 18 | .03 | 41.2 | 4.948 | 1.75 | 2.24 | .49 | 6.659 | 2.35 | 3.01 | .66 | 1 |
| 19 | .14 | 46.0 | 4.969 | 1.75 | 2.24 | .40 | 6.688 | 2.36 | 3.01 | .65 | 4 |
| 20 | .11 | 51.0 | 5.002 | 1.77 | 2.24 | .47 | 6.732 | 2.38 | 3.01 | .63 | 3 |
| 21 | ------ | 56.2 | 5.015 | 1.77 | 2.24 | .47 | 6.750 | 2.38 | 3.01 | .63 | ------ |
| 22 | .03 | 61.4 | 5.026 | 1.77 | 2.24 | .47 | 6.764 | 2.39 | 3.01 | .62 | 1 |
| 23 | ------ | 66.9 | 5.035 | 1.78 | 2.24 | .46 | 6.776 | 2.39 | 3.01 | .62 | ------ |
| 24 | .07 | 72.5 | 5.052 | 1.78 | 2.24 | .46 | 6.800 | 2.40 | 3.01 | .61 | 2 |

[1] Trees cut per acre totaled 6.84; basis was 192 trees in all.
[2] Solid wood inside bark.
[3] Rate per man-hour = $0.353.
[4] Based on $2.24 per standard cord (74.3 cubic feet of solid wood inside bark) or $3.01 per 100 cubic feet.
[5] Margin between gross value and production cost. Includes stumpage, profit, and uninsured risks.

Table 45 shows that distillation wood, with a value in the woods of $2.24 per cord, had a negative value for stumpage, profit, and uninsured risks, after costs of production from 4-, 5-, and 6-inch hardwoods were deducted. A positive value per cord was obtained for all larger trees, increasing from $0.05 for 7-inch trees up to $0.52 for 13-, 14-, and 15-inch trees and then decreasing to $0.46 for 24-inch trees, which were the largest cut on the area. The reason back of the heavy costs for the smallest trees is the excessive time required to fell and limb the trees in proportion to the volume of wood obtained.

## VOLUME OF DISTILLATION WOOD PRODUCED PER M BOARD FEET OR 100 CUBIC FEET OF LOGS

On the area devoted to the distillation wood utilization study the total volumes of sawlogs and total volumes of distillation wood produced were measured. The following tabulation gives these volumes and also the amount of distillation wood per unit of logs, on the basis of the 48.61 cords produced:

| | *Cords of distillation wood per M board feet or 100 cubic feet of logs* |
|---|---|
| Doyle-Scribner rule (38,986 board feet of logs) | 1.25 |
| Scribner rule (47,672 board feet) | 1.02 |
| International rule (51,914 board feet) | .94 |
| Cubic-foot rule (77.27 cubic feet) | .63 |

Of the total volume of distillation wood produced about 78 percent came from defective whole trees, cut to improve the composition of the stand, and 22 percent from tops of saw-timber trees.

# IV. APPLICATION OF RESULTS OF CUTTING STUDIES TO FOREST MANAGEMENT

Previous sections of this report have discussed basic factors of sustained-yield management and experimental findings as to the applicability of light cutting practice in the southern pine-hardwood type. They have also discussed findings as to the relation of tree size to (1) the utilizable yield of pines and hardwoods in cubic feet and in board feet by three different log rules, (2) the ratio of lumber yield to log scale, (3) logging and milling costs, (4) sale values of lumber, and (5) net realization values of lumber. It is believed that each of the studies reported upon is directly significant in its bearing on the technics of logging time and cost studies and in its general bearing on industrial engineering in the field of forest products. One important objective of these studies was attained through the development of a dependable balanced system of logging and initial transportation to railroad or mill that is adapted to light harvesting cuts of timber. These experimental results all contribute toward a system of selective timber management for sustained yield.

The economic aspects of forest management involve unique relations between invested capital, current income, and future income. These unique relations are due to the factor of growth, which insures that, barring adverse activities of man, such as setting out fires and cutting destructively, the base investment capital in forest growing stock will be yielding, year in and year out, through depression and prosperity, at a substantial compound-interest rate. Closely related to this highly significant fact is the fact that in selectively managed forests, where growth is continuously concentrated on trees of merchantable size (that is, for shortleaf and loblolly pine, trees 6 inches or more in diameter), 80 to 90 percent of the investment is in such trees. Within the limits imposed by the time required to log, manufacture, and sell a given quantity of timber, usually the forest owner can choose between converting any part of the growing timber into immediate income and holding it for increase in value. While the properly administered forest property is a "long-term" investment, like other forest properties it is readily convertible into liquid form—in contrast, for example, with a railroad property. This ready convertibility has permitted many fine forest properties to be destroyed because of lack of thrift or foresight on the part of the owners. The following section deals with the questions how to determine financial maturity of individual trees and when to cut, so far as the data collected in these studies are applicable to this purpose.

## Selection and Removal of Financially Mature Trees, and Other Cultural Cutting

Correct selection of individual trees for cutting on each compartment is of primary importance both from the standpoint of immediate returns and from the standpoint of future yields and returns. In general, the objective is to improve the quality of the growing stock, the species composition, and the spacing of the trees as much as possible and as quickly as possible in order to grow a greater volume of high-quality material. Ordinarily, any cutting operation must be profitable, and trees that will not at least pay their way should not be selected for cutting unless there is a distinct and desirable cultural gain in the stand left for future cutting that justifies small immediate reduction of profit.

Financial maturity of a forest tree may be defined as the stage beyond which the tree will no longer make a profitable increase in value. Trees that should be removed because of financial maturity are of two classes: (1) Valuable individuals that have gone through their period of most rapid increase in volume and gain in quality and have reached the point beyond which annual increases in value do not constitute a satisfactory return on the base investment, and (2) other salable trees that show no promise of increase in value or show little promise in comparison with competing trees.

### THE LESS VALUABLE TREES

In order to clear the way for the more intricate financial problems of dealing with class 1 trees, the problem of class 2 trees will be discussed first. Class 2 trees are often subject to removal in thinnings or improvement cuttings, which, under selective management, are commonly concurrent with harvest cuttings of the larger timber.

Second-growth shortleaf-loblolly pine-hardwood stands commonly contain many trees of low quality. Some of these are limby "wolf" trees, containing not more than one present or potential sawlog each; others are crooked or defective; and still others are of unmerchantable species (figs. 16 and 17). A special need is to remove diseased and insect-infested trees. It is no less necessary to foster permanent investment values by removing these trees as soon as possible after the areas are put under management than to manufacture only profitable material in the mills. In many shortleaf-loblolly pine-hardwood stands low-grade hardwoods occupy from one-third to two-thirds of the effective growing space and seriously interfere with the growth of the pine and better-quality hardwood trees. Until they are replaced by more valuable trees it is practically impossible to develop well-stocked stands, that is, stands containing 8,000 to 12,000 board feet of profitable timber to the acre, which can be expected to lay on a usable annual growth of 300 or more board feet to the acre. In stands in which no utilization cutting will be done until 4 or 5 years after organized management is undertaken, improvement cutting should be done as soon as possible.

Previous sections of this report have shown that the pine removed in improvement operations can profitably be cut into pulpwood, for which there is a market throughout much of the southern pine-hardwood region. Low-quality hardwood trees can profitably be cut in many cases into chemical wood, pulpwood, ties, fence posts, and firewood, and in some cases, by use of small portable sawmills, into lumber.

The existing second-growth shortleaf-loblolly pine-hardwood stands characteristically contain few large trees of high quality but have a near-normal number of small trees. The latter often occur in overdense groups, and there is usually a problem of thinning and release cutting on portions of each acre even though other portions may be bare of trees. In thinning, the best trees with spacing that favors rapid growth are reserved as crop trees (fig 18). Generally an experienced technician can readily recognize the poorer trees and the spots that are too dense. There is opportunity, however, for exercise of the highest skill in selecting trees for cutting. As shown in Part III, the returns from cutting any individual tree of small size are low. There is, therefore, no great financial urge for cutting such trees unless no higher-value trees are available or the small trees are

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FIGURE 16.—*A*, Leaning tree with fire scar. *B*, Tree with redheart. It is no less important to increase investment values in the timber stand by removing low-quality trees than to use only logs of superior quality in the mill. Here, and in figure 17, are examples of trees to be taken in improvement cuttings, which should be one of the first operations under organized forest management.

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FIGURE 17.—Extremely limby tree. Rough dominant trees of this character should be removed before large knots make them useless for lumber or pulpwood.


FIGURE 18.—Even-aged stand thinned when about 35 years old. Trees in this stand will grow at differential rates. With cuts every 6 to 10 years, final removals will not take place before new tree groups provide part of the cut.

needed in a pulp mill or other dependent manufacturing plant. Commonly, decision on when to cut should be oriented toward the welfare of the remaining individual trees and of the stand or forest property as a whole.

Owing to lack of experience with selective cutting in the United States, often too many of the inferior trees are removed. Trees that may be functioning to prevent limbiness of better trees, to protect the soil, etc., should be reserved. In most stands of saplings or small-pole timber, density must be maintained to promote natural pruning of the crop trees.

It is frequently a sound rule to confine improvement cutting to trees that will pay costs or more. Where a stand has been opened by roads or otherwise to utilize the more valuable timber, costs charged to improvement cutting need not include any part of the development costs and may even omit other indirect costs. There are now large areas where much can be gained through improvement operations with little or no risk of financial loss. On some other areas, labor and other costs may be so high that the value of cordwood and other cheap forest products would be less than the costs of extraction. In such cases the forest manager should weigh all factors involved before cutting the low-value trees. He should take into account the advantages to future productivity and the timber requirements of any dependent industry. Other cuttings that involve financial loss include not only removal of unmerchantable elements of the stand but also release of seedlings and saplings that have been bent down by limbs from felled trees. Often there will be justification for making cuttings at some financial loss, especially if concurrent operations in saw timber on the same property are very profitable.

Where stands can be improved only at some net cost, the best method of financing is to set up a budget item for each fiscal year or shorter accounting period. This cultural budget item should take its place along with similar cost items for forest administration, taxes, fire protection, etc. It appears reasonable to provide sufficient funds in the cultural budget item at least to experiment with this type of cutting; where funds permit, operators may go further. Over a period of years, correct management of timberland already owned is almost invariably a less expensive way for an owner to increase his total annual production of timber than purchase of additional timberland.

Generally, release work can be done most effectively after cyclic utilization cuttings, when it is easier to judge what trees need further release and whether the released trees will remain undisturbed for at least a cutting cycle (fig. 19).

In most cases there will be a few medium-sized or large trees to the acre that cannot be cut profitably into any product and that would better be killed by girdling. Such trees may occupy, on the average, 0.01 acre each, and the cost of girdling will average less than $0.02 per tree. A total cost of $2 per acre of ground released is certainly not prohibitive and is very much less than is usually paid for good forest land.

Pruning, another class of forest work properly chargeable to the cultural budget, will usually influence financial maturity by changing the time or form of future utilization. For example, the pole and

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FIGURE 19.—Test block B, 4 years after selective cutting. For thrifty development of the reproduction, it will be necessary to reduce the overstory when the next cyclic cut is made.

piling industry prefers, for creosoting, trunks in which the knots are covered with clear, sound wood. Pruning 10 years or more in advance of cutting might qualify many trees for poles and piling that would otherwise be suitable only for pulpwood. A more common method of pruning is to start with trees under 3 inches in diameter and prune as many as 200 crop trees per acre by successive stages, at intervals of several years. Pruning may take the lower part of the live crown at several stages; it should not take, altogether, more than the lower third of the crown. Pruning is generally carried to a point on each tree above what is expected to be the first utilized trunk section—for example, a 16-foot butt log, a 22-foot telephone pole, or a 30-foot pile. Later thinnings or improvement cuttings favor the pruned crop trees. Like release cuttings, pruning should generally be undertaken only on an experimental basis at first.

Few workmen have been trained for these cultural operations. An operator who provides an experimental budget for such work should place a competent technician in charge, with instructions to train a crew of intelligent workmen. Youths entering employment for the first time are an important source of labor. Work can proceed efficiently only so fast as efficient labor becomes available.

It should be realized that with prices of timber lower than in Europe and labor costs generally far higher, many desirable forest practices common in Europe cannot be undertaken here. There is ample warrant for cutting to improve forest stands insofar as the value of the product equals or exceeds the cost, and for beginning, at least experimentally, some other cutting practices such as those just mentioned. The purpose is to restore to forest production spots of soil that are now occupied by worthless vegetation, thus transforming an unproductive item of investment to a productive one and laying the foundation for future increases in income. In the meantime, gradual removal of inferior components of stands may be the basis of substantial earnings from dependent industries.

### THE MORE VALUABLE TREES

In seeking to increase the growing stock of desirable species and individual trees, and to bring about a distribution of size classes that will maximize earnings of the forest property, it is necessary to meet the space and other cultural requirements of each crop tree, to watch it from the time it becomes a recruit in the small-timber class until its period of rapid growth and earnings is past, and to utilize it promptly at financial maturity. Cutting of healthy and vigorous trees should be so timed as to avoid any needless sacrifice of high-yielding investment value by premature conversion to current income or any sacrifice of earnings by deferring cutting too long. Such timing requires close financial calculations.

Up to the present, few all-aged second-growth pine-hardwood stands have been under selective management for periods long enough to permit accurate determination of the diameter growth of individual trees in stands so managed. Several of the stands studied, however, are comparable in age and density to managed stands. On the basis of growth information obtained through detailed studies of these stands given in column 4 of table 46, it is possible to predict the results from good management of the present understocked second-growth stands.[5]

For an operating company the difference between the sale value of lumber and the cost of logging and milling is the realization value, and the realization value of timber cut for other products, such as pulpwood, is determined similarly. These values, and the net increase in realization value per annum, are given in table 46 for pine trees of various sizes. For trees up to 11 inches d. b. h. the calculation of earnings is based on pulpwood utilization only, and for trees over 14 inches it is based on sawlog utilization only.

TABLE 46.—*Utilized volume per tree, rate of diameter growth, and increase in value per tree for pines in managed stands* [1]

| Diameter class (inches) | Utilized volume per tree [2] | | Diameter growth per 10 years | Time required for 1 inch diameter growth | Volume growth per tree per year [3] | | Realization value [4]: Pulpwood, per tree | Realization value [4]: Lumber, Per tree | Realization value [4]: Lumber, Per M board feet | Net increase in realization value per tree: Per 1-inch increase in diameter | | Net increase in realization value per tree: Per year | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
| | *Cu. ft.* | *Bd. ft.* | *In.* | *Yr.* | *Cu. ft.* | *Bd. ft.* | *Dol.* | *Dol.* | *Dol.* | *Dol.* | *Pct.* | *Dol.* | *Pct.* |
| 4 | 0.6 | | 1.7 | 5.9 | | | −0.002 | | | | | | |
| 5 | 2.0 | | 1.7 | 5.9 | 0.24 | | .024 | | | 0.026 | | 0.004 | |
| 6 | 3.7 | | 1.7 | 5.9 | .29 | | .054 | | | .030 | 125.0 | .005 | 21.2 |
| 7 | 5.7 | | 1.8 | 5.6 | .36 | | .091 | | | .037 | 68.5 | .007 | 12.2 |
| 8 | 8.2 | | 1.8 | 5.6 | .45 | | .133 | | | .042 | 46.2 | .008 | 8.3 |
| 9 | 11.2 | | 1.8 | 5.6 | .54 | | .185 | | | .052 | 39.1 | .009 | 7.0 |
| 10 | 14.8 | | 1.9 | 5.3 | .68 | | .246 | | | .061 | 32.9 | .012 | 6.2 |
| 11 | 18.7 | | 2.0 | 5.0 | .78 | | .316 | | | .070 | 28.4 | .014 | 5.7 |
| 12 | 22.7 | 77 | 2.2 | 4.5 | .80 | | .385 | 0.116 | 1.51 | .069 | 21.8 | .015 | 4.8 |
| 13 | 27.3 | 99 | 2.5 | 4.0 | 1.15 | 5.5 | .464 | .267 | 2.70 | .079 | 20.5 | .020 | 5.1 |
| 14 | 31.8 | 127 | 2.8 | 3.6 | 1.25 | 7.8 | .541 | .505 | 3.98 | .077 | 16.6 | .021 | 4.6 |
| 15 | 37.4 | 161 | 3.0 | 3.3 | 1.70 | 10.3 | | .822 | 5.11 | .281 | 51.0 | .085 | 15.7 |
| 16 | 43.3 | 201 | 3.2 | 3.1 | 1.90 | 12.9 | | 1.216 | 6.05 | .394 | 47.9 | .127 | 15.4 |
| 17 | 49.6 | 248 | 3.3 | 3.0 | 2.10 | 15.7 | | 1.716 | 6.92 | .500 | 41.1 | .167 | 13.7 |
| 18 | 56.5 | 298 | 3.4 | 2.9 | 2.39 | 17.2 | | 2.363 | 7.93 | .647 | 37.7 | .223 | 13.0 |
| 19 | 63.9 | 352 | 3.4 | 2.9 | 2.55 | 18.6 | | 3.083 | 8.76 | .720 | 30.5 | .248 | 10.5 |
| 20 | 71.5 | 410 | 3.4 | 2.9 | 2.62 | 20.0 | | 3.997 | 9.70 | .894 | 29.0 | .308 | 10.0 |
| 21 | 79.4 | 470 | 3.2 | 3.1 | 2.55 | 19.3 | | 4.991 | 10.62 | 1.014 | 25.5 | .327 | 8.2 |
| 22 | 87.4 | 533 | 2.9 | 3.4 | 2.35 | 18.5 | | 6.056 | 11.36 | 1.065 | 21.3 | .313 | 6.3 |
| 23 | 95.5 | 598 | 2.6 | 3.8 | 2.13 | 17.1 | | 7.152 | 11.96 | 1.096 | 18.1 | .288 | 4.8 |
| 24 | 103.4 | 665 | 2.3 | 4.3 | 1.84 | 15.6 | | 8.426 | 12.67 | 1.274 | 17.8 | .296 | 4.1 |
| 25 | 111.2 | 734 | 2.0 | 5.0 | 1.56 | 13.8 | | 9.615 | 13.10 | 1.189 | 14.1 | .238 | 2.8 |
| 26 | 118.9 | 805 | 1.8 | 5.6 | 1.38 | 12.7 | | 10.867 | 13.50 | 1.252 | 13.0 | .224 | 2.3 |
| 27 | 126.5 | 877 | 1.6 | 6.2 | 1.23 | 11.6 | | 12.137 | 13.84 | 1.270 | 11.7 | .205 | 1.9 |
| 28 | 133.9 | 949 | 1.4 | 7.1 | 1.04 | 10.1 | | 13.495 | 14.22 | 1.358 | 11.2 | .191 | 1.6 |
| 29 | 142.0 | 1,021 | 1.2 | 8.3 | .98 | 8.7 | | 14.937 | 14.03 | 1.442 | 10.7 | .174 | 1.3 |
| 30 | 151.0 | 1,093 | 1.0 | 10.0 | .90 | 7.2 | | 16.373 | 14.98 | 1.436 | 9.6 | .144 | 1.0 |

[1] Values predicted on basis of 1936 data for stands comparable *in age and density to stands selectively* managed since 1925.

[2] Volumes for diameters 4 to 9 inches from table 12, rounded to nearest 0.1 foot. Volumes for diameters 10 inches and up, *including sawlogs and pulpwood from tops*, from table 40. Board-foot volumes are green-chain tally.

[3] Calculated for each growth period (years required to grow 1 inch *in diameter) at end of period.*

[4] Pulpwood sales value minus cutting and hauling costs or lumber sales value minus logging and milling costs. Stumpage value would in each case be 50 to 60 percent of realization value.

[5] Results obtained in tests initiated in 1937 on the Crossett Experimental Forest to test cutting cycles of different lengths indicate that under the favorable conditions of southeastern *Arkansas annual growth rates of second-growth* shortleaf-loblolly pine-hardwood stands, which before the stands were placed under selective management averaged about 6 percent of the saw-timber volume, now average about 7.9 percent and can be stabilized at about 8 percent. (It *should be remembered that the* additional increment is being laid on by trees that are of better average quality than the trees present before management was undertaken.) As stands approach volumes of 8,000 to 12,000 feet b. m. per acre, the percentage rate is expected to become a little *less—but the yield* per acre will without doubt increase.

Saw-timber utilization through a large mill may start with 12-inch trees at an average value of 12 cents per tree, as compared with a pulpwood utilization value of 38.5 cents. Trees 14 inches and larger in diameter yield higher returns as sawlogs than as pulpwood. Annual increase in saw-timber value exceeds 15 percent for the 14- to 16-inch stage of diameter increase, and does not fall below 8.2 percent until after the 20- to 21-inch stage. Thus the highest percentage rates of investment return occur mostly within the growth stage represented by trees having diameters of 13 to 20.9 inches, and the greatest opportunity for building forest-investment earnings lies in this group. Any trees that are of good quality and vigor, if well spaced, should be held in the stand through this period of rapid value increase.

Table 46 warrants careful study. It shows that in the section and in the ways studied pine trees from 5 to 12.9 inches d. b. h. (the small-timber or pole group) have small net values for immediate utilization. A slight decline in market value of pulpwood or logs or a slight rise in costs might wipe out these small profit margins, and cutting operations based exclusively on such trees may be financially precarious. It is obvious, however, that unless a forest contains at all times ample numbers of these trees capable of developing into high-value trees, its future investment value will be circumscribed. The trees may be distributed either singly or in groups. Every subdivision of the forest property should have ample numbers of promising trees in this size class.

Of equal significance with value by diameter class is the annual rate percent of earnings (table 46, col. 14) from increase in realization value of individual trees. This starts on the smallest trees of the small-timber group at a high rate, based on pulpwood utilization. The high rate is not very significant because of the extremely low investment values to which it applies. For trees from 9 to 12 inches in diameter the rate, still based on pulpwood, is only moderate. Owing to the small financial values dealt with, timber marking and cutting problems for this group are related chiefly to removing inferior and other surplus trees. The poorer trees usually are readily identifiable, but considerable skill in selecting trees for cutting is required if the residual stand is to be properly stocked and spaced.

As the financial success of management is very closely connected with the handling of trees 13 to 20.9 inches d. b. h. (the medium-sized timber), the best available technical skill should be applied here. Every tree should have very close scrutiny in the marking for each cyclic cut. It should be remembered that a large proportion of the trees entering this size group will be cut before they grow into the large-timber group. "Passage" through this group usually takes 25 to 30 years. Thus most trees will be considered three to six times to determine whether to cut or leave. Each time, judgment should be based on size, quality, vigor, and space requirements.

The larger trees in this size group are much more valuable and are earning less by growth (table 46). If they are competing for space with smaller trees or show any sign of insect attack or disease, they should generally be cut. Only those of exceptional quality and vigor need be held in preference to smaller trees. Those of high quality well separated from others should be held if the cutting quota for the tract can be attained without them.

Pine trees of good quality in this size group are distinguished by 30 to 50 feet of straight, cylindrical trunk, free from protruding knots or other blemishes; by a live crown extending through 30 to 60 percent of tree height and made up of numerous moderate-sized branches rather than a few large branches; and, of course, by freedom from other visible defects or evidence of disease. To be classified as "best," trees should have grown uniformly not over 3.5 inches each 10 years—a point that can be judged with fair success from trunk and crown characteristics.

Vigor is indicated by a healthy crown extending through not less than 30 percent of tree height and including an ample quantity of needles of good length for the species, by firm bark, free from evidence of fungus attack, and by absence of large decayed knots or other lesions. Close observation and experience are needed to develop judgment of these characteristics.

Judgment of quality and vigor often involves choice between extremely vigorous but rough and large-branched dominant trees and smoother, more evenly grown codominant and intermediate trees. Rough dominants, if kept, will soon develop many large branches. They should, therefore, be among the first sawlog trees cut. This provides for an earlier yield of sawlogs from the young-tree groups than would otherwise be obtained. Logs from rough dominants cut at this size will saw into No. 2 Common lumber, rather than into lower grades as they would later. A variable proportion of the dominant trees will be suitable in quality to be kept for future cutting, but most of the larger trees of fine quality will develop from trees of the codominant and intermediate crown classes. When a stand has been brought under good management, it is poor business, as well as poor forestry, to cut relatively small high-quality trees that are increasing in volume at the rate of 8 or more percent per year or 30 percent or more in value for each inch increase in diameter, or large trees that are wind firm, healthy, of good quality, and growing at least 2 inches in diameter every 10 years.

Spacing in existing stands is extremely irregular. In each cutting cycle, tree selection should be directed toward better distribution of the stand. Experience and good judgment must be the chief reliance in attaining good spacing, but these should be checked by careful investigation of diameter growth rate related to crown size and stand density.

A rule of thumb for spacing crop trees in dense groups is to remove enough of the lower quality trees so that the spacing between the crowns of any two crop trees is equivalent to one-half of the sum of their respective crown widths. Other rules (*6*) have been devised that fix space between trees at some multiple of the tree diameters. Such rules may offer some guidance to the novice learning to mark timber for cutting, but should not be applied indiscriminately. For instance, it may be satisfactory for a group of as many as 8 or 10 trees to stand much closer to each other than any such rule would justify, if there are no other trees within 40 to 50 feet. In the understocked stands now to be dealt with the problem is to obtain the necessary volume at each cyclic cut without unduly reducing stand density. Few groups are overdense. For the time being, size, quality, and vigor are more important factors than spacing

In trees 21 inches d. b. h. and larger (the large-timber group), value per tree continues to increase but rate of earnings percent falls off. Generally a large percentage of the trees that pass 21 inches should be removed in the next regular cutting. Problems of relative size, quality, and spacing have largely been solved before any trees reach this size. Vigor adequate for further sustained rapid growth is the main reason for deferring cutting. Trees of exceptional vigor and quality may occasionally be held until they are as large as 30 inches. In some localities quality products, such as veneer logs, from trees of that size bring prices high enough to maintain increases in realization values and warrant postponing the cut.

The decline in rate percent of increase in tree value would occur later if forest owners received full intrinsic value for the best logs from trees of the best species. The fine-veneer industry produces hundreds, or even thousands, of dollars in value from a thousand board feet of logs. There is good reason to believe that in the future production of large trees will be even more profitable.

The innumerable decisions that have to be made on when to cut individual trees call for the highest technical skill and experience, if they are to contribute not only toward realizing satisfactory current income from the forest but also toward adjusting the growing stock so that it will yield greater returns in the future. The latter objective is the heart of the problem of building up investment values in southern forests.

The best selective management practice for stands in good condition for such management, one used commonly in several European countries and increasingly in the United States, follows this routine: (1) Among all the divisions of the forest that are in need of cutting, as many are chosen as the plan of management prescribes should be included in each annual cutting operation or as will yield the annual cut prescribed by the plan. (2) The saw timber or other high-quality timber that is financially mature or urgently needed is marked by a technician. (3) The marked trees are removed. (4) The technician resurveys the stand and marks salable trees of poor quality that should be removed. (5) These poor-quality trees are cut and worked up together with usable wood in tops of saw-timber trees, generally for some type of cordwood. (6) Having been adjusted in density and in character and prepared for fire protection, the stand is left undisturbed for 3 to 12 years to lay on growth and increase in value. The rapidity with which increase in value occurs depends on the skill used in carrying out the above-mentioned measures. Each following year other divisions of the forest are cut over in the same manner until the cutting cycle is completed and another cut is in order on the divisions cut over first.

### GOOD MARKING AND UTILIZATION PRACTICES

Owing to the wide variation in markets for forest products and in character of second-growth stands within the region, it is difficult to define the types of trees that should be removed and their priority of cutting further than has already been done. In the areas being logged, cutting should extend currently through all merchantable diameter classes and remove the following classes of trees:

1. Badly suppressed trees that are certain to die naturally before the next cut.
2. Trees that show unmistakable evidence of infection with redheart or other wood-destroying fungi, or bark-beetle infestation.

3. Leaning trees, and trees with fire scars or other injuries sufficiently severe to make them susceptible to wind damage.

4. Crooked trees that would never develop into high-quality saw timber. Small crooked trees that will yield pulpwood or chemical wood may be left for further growth if they do not interfere seriously with the growth of more valuable trees.

5. Extremely limby trees that would never produce lumber of an average quality better than grade No. 2C, and that would become less valuable for pulpwood or cordwood as the limbs grew larger.

6. Limby trees that would never produce even one No. 2 sawlog, if they are interfering with the growth of more valuable trees.

7. Trees of inferior species that have a very limited market as saw timber.

8. Mature and overmature trees that have passed the stage of optimum development and are now deteriorating.

9. Poorly formed and unthrifty trees that are crowding the better trees in overstocked stands.

In addition to trees of the above-mentioned classes, a sufficient volume of the larger good-quality trees should be removed to make up the total allowable cut. Thus, if the allowable cut amounts to 2,500 board feet per acre and the low-quality trees selected for cutting will yield only 500 board feet of profitable sawlog material, 2,000 board feet of the larger good-quality timber should be cut.

Large openings are not generally necessary in order to get reproduction on average sites. On the Crossett Experimental Forest abundant regeneration has occurred in openings even as small as those left by the removal of single, large, mature trees. Therefore, removal of groups of trees is not advantageous unless each of the trees making up the group is mature, defective, infested with insects, or for some other reason unsuitable for further growth. On poorer and drier sites large openings may be required. (It is recognized, however, that tree quality may in the future be improved by growing in groups, preferably of mixed pine and hardwoods, because this favors early shading off of side branches.)

Marking practice may vary from time to time with market conditions. When prices are high it may be desirable to cut a larger proportion of low-value trees because such trees will then yield an operating profit. At or near the low point of the business cycle, only the better trees may yield any net returns. By taking these facts into consideration progress can be made in stabilizing income from forest properties.

In order to make money in a sawmill the timber manager should give first attention to the woods. If woods and mill practice are properly correlated and only profitable logs are sent to the sawmill, in any mill that is even reasonably efficient good returns can be obtained from sawing second-growth shortleaf and loblolly pine and hardwood logs. On the other hand, if a large portion of the material that is cut into sawlogs is unprofitable, a sawmill will produce low returns regardless of how efficient it is. Even if a lumber company utilizes completely every tree felled, still its utilization practice will be poor if unprofitable logs are cut to any considerable extent.

Large expenditures to improve mill machinery and keep it in first-class condition, or to provide first-class supervision of mill operation, are worth while only if close supervision is exercised in the woods operations of cutting and utilization. It is very important, therefore, that a forester or some other person who understands log grades, mill-scale studies, and logging-cost studies be placed in charge of woods utilization for each individual mill. Such a manager should determine first the logging and milling cost by log sizes and the lumber-sale value of logs of various sizes and grades, and thus determine which trees and logs are profitable and which are unprofitable for the mill under any given set of market prices for lumber. Then he should supervise the cutting, strictly enforcing rules that prohibit the cutting of unprofitable trees and logs.

The present study indicates that for mills of the type studied, and with 1940 costs and prices, no tree should be marked for cutting into sawlogs unless it contains at least one grade No. 2 log 10 inches or larger in diameter inside bark at top; also, that no grade No. 2 log less than 10 inches or grade No. 3 log less than 14 inches in diameter should be cut from any tree even though the tree is on the ground and other logs have already been cut from it. Other limitations on cutting are revealed by tables 41 and 42. Material in trees or tops of trees that is unprofitable for sawlogs should either be cut into pulpwood, or some other product from which a profit can be made, or else be left in the woods.

These limits of utilization are based on uniform recovery of costs throughout the utilization field. It may justifiably be ruled that the more profitable tree and log classes, that is, the medium and large timber, should bear all of certain charges, such as road costs, and that subsidiary utilization need bear only direct costs. This may indicate utilization of some logs that cannot bear full costs. Throughout the greater part of the South values have now reached such levels that it is possible to assume uniform distribution of all costs and then consider relative values of trees and logs for different products. Where there is sufficient timber it is possible to select high types of logs for sawmill utilization and devote lower grades to other purposes.

Every tree selected for cutting should be marked. Marking should be done by experienced men trained for the task, who will select the areas to be cut over on the basis of their relative needs for cutting. Because the great variety of conditions found in irregular second-growth stands of loblolly and shortleaf pine and hardwoods makes it hard to prescribe adequate marking rules, much reliance must be placed on the seasoned judgment of the men in the marking crew. These men must be able to distinguish the trees that should be reserved for future growth from those that should be cut. Poor marking is reflected in subsequent returns and cannot be remedied for many years.

It is commonly inadvisable to use a marking ax, as insect or fungus attacks may be induced. Paint applied with a brush is customarily used. Where large volumes of timber are to be marked, a paint gun of proper design speeds the work.

## Characteristics of a Silviculturally and Financially Productive Stand

Desirable physical and financial characteristics of a second-growth short leaf-loblolly pine-hardwood stand will be indicated by making a comparison between test block E, which is representative of many understocked forests of this type, and a well-stocked area (fig. 20 and table 47).

The stand on the well-stocked area (which is not the so-called normal stand) represents the average of the best 10 percent of the present all-aged stands on the Crossett Experimental Forest. It

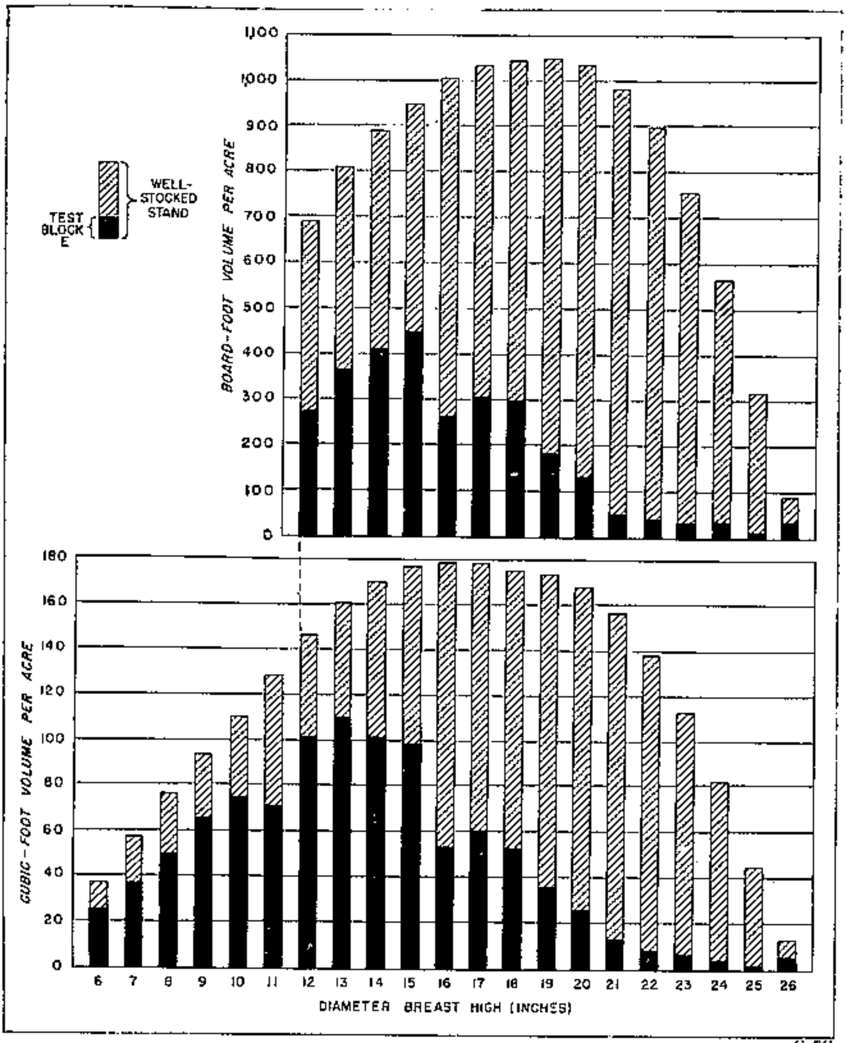


FIGURE 20.—Stand structure diagrams for test block E and a well-stocked area.

contains approximately 101 trees 6 inches d. b. h. and larger per acre, so distributed that most of the larger trees have sufficient room to develop large crowns and to produce annually a maximum volume of high-quality material. Its boardfoot volume has been estimated on the basis of a detailed cruise in which only merchantable logs were tallied. Assuming good markets for the common grades of lumber, this stand contains 12,112 board feet (International ¼-inch rule) of usable timber per acre in trees 12 inches and larger in diameter. Under market conditions that might be regarded as a general average, probably 10,500 feet per acre could profitably be logged and milled by a large sawmill (fig. 21). The volume in 6-inch and larger trees amounts to 2,570 cubic feet, of which 2,068 feet is in 12-inch and larger trees. (These statements refer to conditions at the end of the cutting cycle, before the cyclic cut is taken.) The timber stand on block E does not appear to be seriously understocked as regards total number of trees per acre. Like most other present-day second-growth stands, however, it is noticeably understocked with trees of the larger diameter classes (appendix table 79). This typical stand has approximately 58 percent as many trees over 5 inches in diameter as the well-stocked stand, but has only 23 percent as much merchantable volume.

TABLE 47.—*Cumulative table of stand and total and saw-timber volumes per acre of test block E and of a well-stocked forest area*

| Minimum diameter breast high (inches) | Trees | | Total volume | | Saw-timber volume (International ¼-inch rule) | |
|---|---|---|---|---|---|---|
| | Test block E | Well-stocked area | Test block E | Well-stocked area | Test block E | Well-stocked area |
| | *Number* | *Number* | *Cubic feet* | *Cubic feet* | *Board feet* | *Board feet* |
| 26 | 0.1 | 0.1 | 4 | 12 | 30 | 87 |
| 25 | .1 | .5 | 5 | 56 | 35 | 401 |
| 24 | .2 | 1.3 | 9 | 130 | 60 | 966 |
| 23 | .3 | 2.5 | 14 | 253 | 89 | 1,723 |
| 22 | .4 | 4.1 | 22 | 391 | 124 | 2,621 |
| 21 | .6 | 6.1 | 32 | 547 | 170 | 3,605 |
| 20 | 1.1 | 8.5 | 56 | 714 | 302 | 4,639 |
| 19 | 1.8 | 11.3 | 100 | 888 | 484 | 5,689 |
| 18 | 3.0 | 14.5 | 148 | 1,062 | 782 | 6,729 |
| 17 | 4.4 | 18.2 | 208 | 1,240 | 1,089 | 7,765 |
| 16 | 5.9 | 22.4 | 265 | 1,417 | 1,350 | 8,760 |
| 15 | 8.7 | 27.1 | 363 | 1,593 | 1,708 | 9,718 |
| 14 | 12.4 | 32.4 | 463 | 1,763 | 2,210 | 10,608 |
| 13 | 16.4 | 38.3 | 573 | 1,923 | 2,573 | 11,416 |
| 12 | 21.1 | 44.8 | 672 | 2,068 | 2,844 | 12,112 |
| 11 | 25.2 | 51.9 | 743 | 2,196 | | |
| 10 | 30.7 | 59.7 | 818 | 2,306 | | |
| 9 | 36.0 | 68.4 | 882 | 2,399 | | |
| 8 | 43.4 | 78.2 | 931 | 2,476 | | |
| 7 | 50.6 | 89.2 | 968 | 2,533 | | |
| 6 | 58.4 | 101.2 | 993 | 2,570 | | |

The condition of the stand on the well-stocked area is one that can easily be brought about by proper management of existing stands. It takes only 15 to 30 years to transform a stand with a surplus of small timber into one with a good proportion of large timber, if cuttings are properly distributed. Incidentally, the average grade of the logs in the unmanaged stand can be greatly improved through proper management practices already discussed.

Table 48, based on the example illustrated in figure 10 and on other examples cited, indicates closely how investment values would be distributed on the average fully utilized acre of forest within the shortleaf-loblolly pine-hardwood zone. The estimates on which this table is based are not, of course, precise, and maximum stumpage values for immediate cutting vary among different localities. On the whole, however, the estimates are believed to represent a very close approximation of the maximum productivity, investment values, and returns attainable by reasonably good forest practices. From the

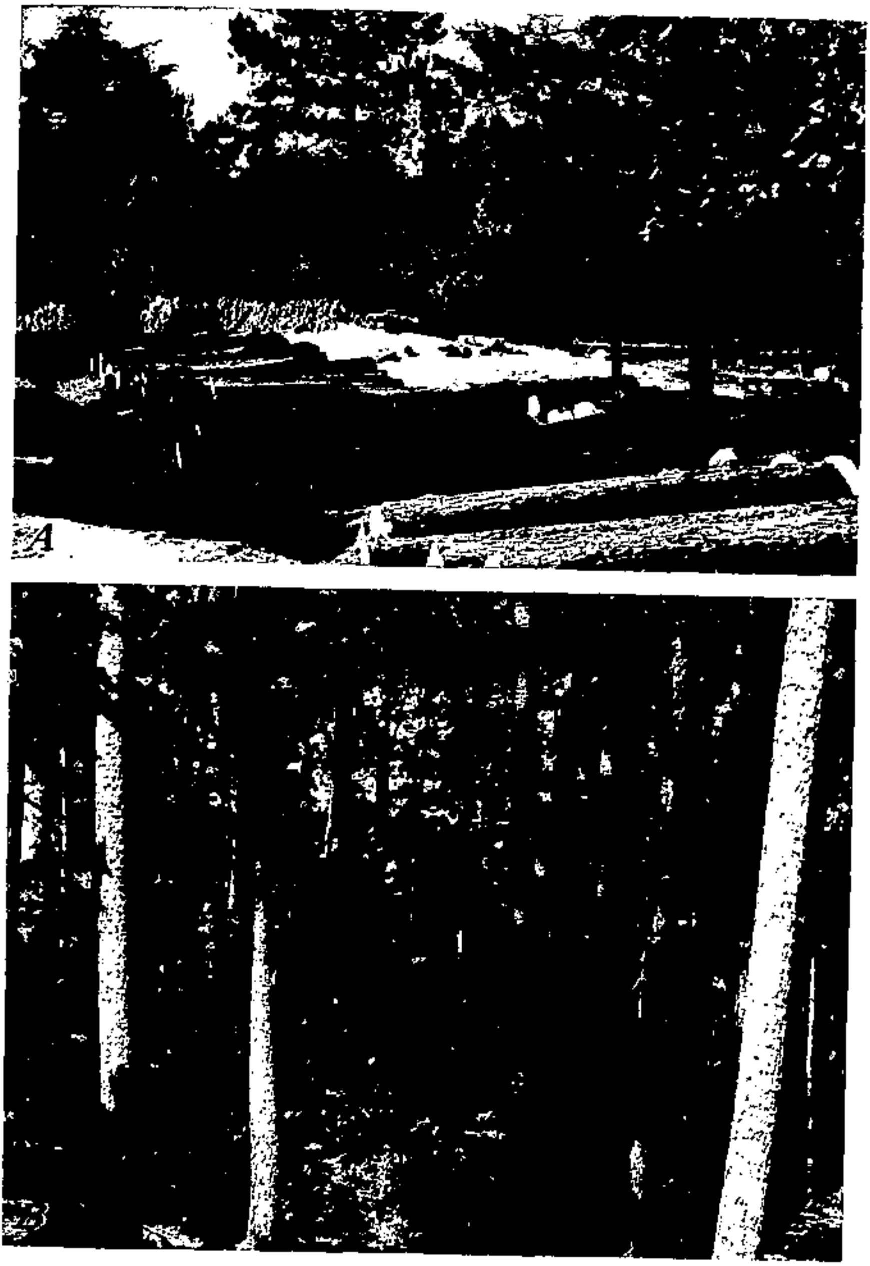

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FIGURE 21.—*A*, This bank of logs, pulpwood, and hardwood distillation wood represents the annual growth on 40 acres of well-stocked shortleaf-loblolly pine-hardwood land. *B*, This is the stand from which the material shown in *A* was taken as the fourth annual cutting of 1 year's growth.

gross investment returns shown in table 48, 1 to 2 percent must be taken to cover administrative costs (including fire protection, etc.) and taxes. Under the present conditions of understocking these costs seldom exceed 40 cents an acre annually.

TABLE 48.—*Desirable distribution of investment value on average fully stocked acre, before and after periodic cut on 5-year cycle*

| Forest investment item [1] | Uncut stand | | | | | Timber cut | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Merchantable trees | Volume | | Investment or utilization value | | Trees | Volume | | Value |
| | | | | Per unit | Per acre | | | | |
| | *Number* | *M ft. b. m.* | *Cords* | *Dollars* | *Dollars* | *Number* | *M ft. b. m.* | *Cords* | *Dollars* |
| Soil | | | | | 2.50 | | | | |
| Improvements | | | | | 1.00 | | | | |
| Seedlings and saplings | | | | | 2.50 | | | | |
| Small timber | 80 | | 8 | 1.00 | 8.00 | 20 | | 2 | 2.00 |
| Medium timber | 35 | 7 | | 8.00 | 56.00 | 8 | 1.6 | | 12.80 |
| Large timber | 10 | 5 | | 10.00 | 50.00 | 3 | 1.5 | | 15.00 |
| Total | 125 | 12 | 8 | 19.00 | 120.00 | 31 | 3.1 | 2 | 29.80 |

Residual stand

| Forest investment item [1] | Volume | | Investment value | Annual volume increment [2] | | | Annual value increment [2] | Potential gross annual earnings [3] |
|---|---|---|---|---|---|---|---|---|
| | *M ft. b. m.* | *Cords* | *Dollars* | *Percent* | *Feet b. m.* | *Cords* | *Percent* | *Dollars* |
| Soil | | | 2.50 | | | | 0 | 0 |
| Improvements | | | 1.00 | | | | 0 | 0 |
| Seedlings and saplings | | | 2.50 | | | | 0 | 0 |
| Small timber | | 6 | 6.00 | 6 | | 0.36 | 8 | 0.48 |
| Medium timber | 5.4 | | 43.20 | 8 | 432 | | 10 | 4.32 |
| Large timber | 3.5 | | 35.00 | 3 | 105 | | 3.5 | 1.22 |
| Total | 8.9 | 6 | 90.20 | 17 | 537 | .36 | 21.5 | [4] 6.02 |

[1] Within each 5 years the small-timber class should provide (in addition to trees cut) 10 to 15 recruits to the medium-timber class and receive at least an equal number of recruits, and the medium-timber class should provide (in addition to trees cut) about 3 to 5 recruits to the large-timber class.
[2] Simple interest rate.
[3] Realizable at next periodic cut, after 5 years.
[4] Equals 6.7 percent on residual investment including soil.

It appears that the average investment per acre in a fully stocked forest may eventually increase to about $100, which would earn a net of about 5 percent annually. On this basis, at present the investment opportunities in the average southern forest are utilized only to the extent of 25 to 30 percent.

Table 48 shows the expected periodic cut if the stand is managed on a 5-year cutting cycle. Cutting at this rate would utilize approximately the entire growth and therefore yield approximately the entire accrued money value. Owing to the size of the timber included in each periodic cut, costs of logging, rail transportation, and milling would be at their lowest level (as shown by ample data in this report), and realization value at a high level.

Under good management, cutting of merchantable saw timber in a quantity closely approximating the volume of medium and large timber in the residual stand after the periodic cut assumed to be made in 1942 would occur in the next three 5-year cutting cycles, as shown in table 49. After the 1957 cut a stand capable of yielding 8,900 board feet of logs and 6 cords of pulpwood would be left. In table 49 these future values are discounted to 1942.

TABLE 49.—*Approximate value, current and discounted to 1942, of three cuts, on a 5-year cycle, in residual stand represented in table 48, and of stand left by the third of these cuts*

| Item | Volume | | Current value | Value discounted to 1942 at given rate of compound interest | | | |
|---|---|---|---|---|---|---|---|
| | | | | 3 percent | 5 percent | 8 percent | 10 percent |
| | *M ft. b. m.* | *Cords* | *Dollars* | *Dollars* | *Dollars* | *Dollars* | *Dollars* |
| 1947 cut | 3.1 | 2 | 26.80 | 25.68 | 23.35 | 20.26 | 18.49 |
| 1952 cut | 3.1 | 2 | 26.80 | 22.17 | 18.29 | 13.80 | 11.49 |
| 1957: | | | | | | | |
| Cut | 3.1 | 2 | 26.80 | 19.13 | 14.33 | 9.39 | 7.13 |
| Residual stand | 8.0 | 6 | 90.20 | 57.90 | 43.38 | 28.43 | 21.59 |
| All 3 cuts | 9.3 | 6 | 80.40 | 66.98 | 55.97 | 43.47 | 37.11 |
| Cuts plus 1957 residual stand | 18.2 | 12 | | 124.88 | 99.35 | 71.90 | 58.70 |

Values presented in table 49 illustrate how prospective incomes of different dates may be consolidated at a given time by discounting at rates commensurate with apparent risks. During the transition from destructive liquidation to conservative investment practices, it is to be expected that the discount rate may be as high as 10 percent. However, in European countries with stable government well-managed sustained-yield forest properties have invariably been valued so highly that interest earnings were at a low rate on the capitalized value. Additional experience in sustained-yield management of forest properties in this country must be acquired before complete harmony can be established between valuations of timber for immediate cutting and valuations for holding as growing stock. Careful selection of timber to be included in each cyclic cut should gradually produce reserve stands in which most trees have greater value for further growth than for immediate cutting.

Indiscriminate clear cutting, which the authors believe is injurious in old growth because it disturbs the continuity of production, constitutes a more extreme waste in young stands. It has been shown under the discussion of financial maturity that vigorous pine trees 12 to 20 inches in diameter will make high earnings if they are simply left to grow. (This is true to a lesser degree of hardwood trees of that size.) The investment values of such timber often are capable of earning 10 percent or more annually. In stripping such timber from millions of acres each year, timber owners are sacrificing the stands at the time when they are about to make their most rapid growth and produce vast quantities of wood. Stripping of the stand usually causes loss of 10 to 30 years of the productiveness of the cut-over area.

Owing to the smaller tree sizes usable for pulpwood, stands can be stripped much closer in pulpwood than in lumbering operations. Where this short-sighted policy is followed for long over a large area the lumber industry must disappear, leaving to the pulpwood industry all the forest-production costs of fire protection, taxes, and administration.

Pulpwood produced under these conditions will inevitably be much more expensive than if forest management were such as to utilize the forest's capacity for producing higher-value materials. Careful studies, herein reported, have shown that pulpwood and other cordwood can be produced economically from tops of saw-timber trees and in improvement cuttings and thinnings. Conversely, the studies have shown that high-quality pine or hardwood sawlogs cannot be produced economically or to the full capacity of the forest without frequent removal of inferior trees and surplus small trees from which sawlogs cannot be obtained. The same is true in greater degree of cordwood industries that use hardwoods. From 40 to 50 percent of the total wood grown under careful management will be unsuitable in size and quality for high-grade sawlogs, and should be put to other uses.

It should be clear from the foregoing that the best management of a forest calls for integrated utilization of the timber. It is impossible to grow wood of strictly uniform sizes and quality, but disposing of surplus small trees at the proper time can greatly increase the rate of growth and the proportion of high-quality material. Wherever selective management is carefully practiced constant efforts are made to increase the percentage of large timber, and as a result higher-quality wood is produced.

## Determination and Periodic Check of Allowable Annual Cut

### CALCULATING THE CUT FOR THE PROPERTY AS A WHOLE

Although light selective cuts at frequent intervals may maintain certain yields on definite areas, it is necessary to know as early as possible the approximate volume of timber that can be cut annually from the entire property without depleting the growing stock. In the early years of organized management, determination of the volume of allowance annual cut must be based on a preliminary estimate or inventory of the total merchantable growing stock and a predicted growth in merchantable volume. Detailed surveys for obtaining these data are costly and wholly out of place, since yields of second-growth shortleaf and loblolly pine forests can be changed so rapidly through good or bad practices. For this reason, it is better, at the beginning, to be satisfied with reasonable approximations of volume of growing stock and rate of growth and to concentrate expenditures on management practices that will build up production.

If forest owners do not have information from recent timber cruises, the cheapest and best method of obtaining a reasonably accurate estimate of merchantable volume and growth rate is by a line-plot survey conducted by a competent technician. Such a survey will vary in intensity depending upon the size of the property and uniformity of the stands; usually less than 5 percent, and on large properties a much smaller percentage of the total area need be included in the sample plots. Based on the volumes of stands and rate of growth obtained on these sample areas, the total volume of the merchantable growing stock and annual increment for the property as a whole are determined. Methods of forecasting growth described by Wahlenberg in Department of Agriculture Technical Bulletin 796 (7) are recommended as effective. Theoretically, the maximum allowable cut for any period for a managed forest is the total estimated growth of merchantable size classes for a like period—actually the necessity of building up the less than fully stocked stands usually encountered limits the allowable to a volume somewhat less than the maximum cut indicated.

### SELECTING AREAS TO BE CUT

After the total allowable cut has been approximated for the property as a whole, the next step is to decide upon the location and order of the cutting operations. In determining the order of cutting, the need of the various compartments for cutting should be carefully considered, but in the final analysis the decision as to time and place will be affected by the requirements of good logging practices in order to reduce costs to the minimum. The cutting plan should not be rigidly binding, since changes in market conditions may necessitate changes in the volume of future annual cuts and also in the kinds of materials to be cut. During the first cutting cycle, it is, therefore, advisable to designate the areas for cutting only 1 or 2 years in advance rather than for 5 or 10 years. Normally, in large properties, it is best to fix the allowable annual cut for each block once every 5 or 10 years leaving freedom of action in the location of the cut to take care of cultural needs and other local conditions.

The cut during the early years of management should include (within economic limits) any compartments in which trees have been severely damaged by dangerous insect infestations, by recent forest fires, or by windstorms. It should also include within limits of the allowable cut those compartments most heavily stocked with financially mature or overmature timber as well as those younger stands seriously in need of improvement cuttings or thinnings because of overcrowding or other conditions unfavorable to growth and future yields of high-quality material. Intensive and costly surveys are not necessary in order to locate those compartments in need of immediate cutting, but a certain familiarity with stand conditions in the property must be maintained.

### CALCULATING THE ALLOWABLE ANNUAL CUT FOR COMPARTMENTS

Periodic cutting, such as is recommended in this publication, will not lead to better-stocked stands and increased and more valuable yields unless cutting of the growing stock is regulated on each compartment as well as on the forest property as a whole. A timberland owner entering upon conservative management is immediately confronted with the problem of determining for each compartment selected for cutting during a particular year, the cut of sawlogs, pulpwood, and other products that should be made. The total volume cut from all the compartments during the year should be in reasonable agreement with the total allowable annual cut for the whole property. For each compartment the cut should at least be equalled by growth on the reserve stands during the ensuing cutting cycle. In order to reserve as much high-quality growing stock as possible, light cuts are essential. With light cuts, larger areas must be logged in order to obtain the fixed volume required by the mill. Consequently, the whole property will be cut over within a relatively short period and successive cuts on each compartment will follow each other at intervals of 3 to 12 years. The short cycles should prove to be profitable, because a much better realization of the values of the growing stock will be obtained than with long cycles. Periods of fast growth immediately after cutting are less likely to be followed by periods of slow growth as the stands close in. Distribution of the trees is also under much better control than it would be if cutting were done at 15- or 20-year intervals.

Determination of allowable cut depends upon several factors of which the most important are growth rate expected and present volume of stand. Volume growth is usually estimated for a 3- to 12-year period. If the expected volume growth is computed in terms of a compound-interest rate, the percentage of the forest growing stock that theoretically can be added by growth in a given cutting cycle can be computed from the following formula, (7), in which p is compound interest growth percent and n the number of years in the cutting cycle:

$$\text{Allowable cut} = 100 - \frac{100}{(1.0\,p)^n}.$$

If a cut is to be made immediately, obviously only the volume of trees to be left should be used in calculating growth on the reserve stand.

Table 50 shows, for various compound-interest growth rates and various cutting cycles, the percentage of the volume that can be removed in any cut with the expectation that it will be restored before the next subsequent cut. It should be understood that such values as these are only approximate, owing to the fact that the growth rate may increase or, if the cutting cycle is long, decrease because of gradual closing in of the stand. In any case, until a stand has been under management long enough for the volume and the growth rate at the time of each cutting to become constant it will be necessary to use approximations and to depend to a considerable degree on judgment.

TABLE 50.—*Volume of cut,*[1] *in percent of forest growing stock, theoretically restorable at a given annual rate of growth within a given cutting cycle*

| Cutting cycle (years) | Ratio of restorable cut to volume of growing stock before cutting if maintainable compound-interest rate of growth percentage of residual stand is— | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* |
| 1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 7 | 8 | 9 | 10 | 11 |
| 2 | 2 | 4 | 6 | 8 | 9 | 11 | 13 | 14 | 16 | 17 | 19 | 20 |
| 3 | 3 | 6 | 9 | 11 | 14 | 16 | 18 | 21 | 23 | 25 | 27 | 29 |
| 4 | 4 | 8 | 11 | 15 | 18 | 21 | 24 | 27 | 29 | 32 | 34 | 36 |
| 5 | 5 | 9 | 14 | 18 | 22 | 25 | 29 | 32 | 35 | 38 | 41 | 43 |
| 6 | 6 | 11 | 16 | 21 | 25 | 30 | 33 | 37 | 40 | 44 | 47 | 49 |
| 7 | 7 | 13 | 19 | 24 | 29 | 34 | 38 | 42 | 45 | 49 | 52 | 55 |
| 8 | 8 | 15 | 21 | 27 | 32 | 37 | 42 | 46 | 50 | 53 | 57 | 60 |
| 9 | 9 | 16 | 23 | 30 | 36 | 41 | 46 | 50 | 54 | 58 | 61 | 64 |
| 10 | 10 | 18 | 26 | 32 | 39 | 44 | 49 | 54 | 58 | 61 | 65 | 68 |
| 11 | 10 | 20 | 28 | 35 | 42 | 47 | 52 | 57 | 61 | 65 | 68 | 71 |
| 12 | 11 | 21 | 30 | 38 | 44 | 50 | 56 | 60 | 64 | 68 | 71 | 74 |
| 13 | 12 | 23 | 32 | 40 | 47 | 53 | 58 | 63 | 67 | 71 | 74 | 77 |
| 14 | 13 | 24 | 34 | 42 | 49 | 56 | 61 | 66 | 70 | 74 | 77 | 80 |
| 15 | 14 | 26 | 36 | 44 | 52 | 58 | 64 | 68 | 73 | 76 | 79 | 82 |
| 16 | 15 | 27 | 38 | 47 | 54 | 61 | 66 | 71 | 75 | 78 | 81 | 84 |
| 17 | 16 | 29 | 40 | 49 | 56 | 63 | 68 | 73 | 77 | 80 | 83 | 85 |
| 18 | 16 | 30 | 41 | 51 | 58 | 65 | 70 | 75 | 79 | 82 | 85 | 87 |
| 19 | 17 | 31 | 43 | 53 | 60 | 67 | 72 | 77 | 81 | 84 | 86 | 88 |
| 20 | 18 | 33 | 45 | 54 | 62 | 69 | 74 | 79 | 82 | 85 | 88 | 90 |
| 25 | 22 | 39 | 52 | 62 | 70 | 77 | 82 | 85 | 88 | 91 | 93 | 94 |

[1] Allowable cut $= 100 - \frac{100}{(1.0\,p)^n}$.

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FINANCIAL ASPECTS OF SELECTIVE CUTTING IN THE MANAGEMENT OF SECOND-GROWTH
REYNOLDS, R.R.; BOND, W.E.; KIRKLAND, B.P. 2 OF 2

The figures given in table 50 represent maxima. If the total allowable volume indicated in this table is cut from each acre during each cutting cycle, there is little possibility of increasing the amount of the growing stock, although through selection the quality and distribution of the stock may be improved. Since one of the chief objectives of management, usually, is to increase the volume of the growing stock, the percentage of volume to be removed should be graduated according to the volume of growing stock present, from the maximum (given in table 50) for well-stocked stands down to perhaps half as much for poorly stocked stands.

The percentages of the growing stock to be removed in 5- and 10-year cutting cycles from stands of various volumes, calculated for a 6-percent compound-interest growth rate, which is typical for large areas of shortleaf-loblolly pine-hardwood forest, are given in table 51.

TABLE 51.—*Suggested proportion of volume of saw-timber growing stock*[1] *to be cut, in each cycle, from stands that are growing at the rate of 6 percent compound interest each year*

| Present growing stock per acre (board feet) | Volume of growing stock[1] to cut, by cutting cycle | | | | Present growing stock per acre (board feet) | Volume of growing stock[1] to cut, by cutting cycle | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 5 years | | 10 years | | | 5 years | | 10 years | |
| | *Percent* | *Bd. ft.* | *Percent* | *Bd. ft.* | | *Percent* | *Bd. ft.* | *Percent* | *Bd. ft.* |
| 10,000 | 25 | 2,500 | 44 | 4,400 | 5,000 | 16 | 800 | 30 | 1,500 |
| 9,000 | 23 | 2,070 | 41 | 3,690 | 4,000 | 15 | 600 | 27 | 1,080 |
| 8,000 | 21 | 1,680 | 38 | 3,040 | 3,000 | 14 | 420 | 25 | 750 |
| 7,000 | 19 | 1,330 | 35 | 2,450 | 2,000 | 13 | 260 | 22 | 440 |
| 6,000 | 17 | 1,020 | 33 | 1,980 | | | | | |

[1] Volume by International ¼-inch rule, in merchantable logs, of trees 10 inches or more d. b. h.

For stands containing 10,000 feet or more, log scale, of sawlog timber per acre in trees above 12 inches in diameter, it is suggested that the cut be so calculated as to be equaled by the increment that may be expected during the ensuing cutting cycle, so that at the end of the period the stand will again contain 10,000 feet, log scale. This cut would include about 25 percent of the volume of the medium and large timber on a 5-year cycle, or 44 percent on a 10-year cycle. About 2,500 feet, log scale, would be removed from the stand on a 5-year cycle. In stands containing only 2,000 feet, log scale, to the acre, the cut would be held to 22 percent of the volume or 440 feet log scale, on a 10-year cycle, and to 13 percent of the volume, or 260 feet, on a 5-year cycle. The differences between increment and cut, or 12 and 22 percent of the stand, respectively, would be added to the growing stock. Similarly, smaller proportions of the growth would be cut from poorly stocked than from well-stocked stands.

Anyone wishing to use these data should first determine the approximate growth rate on the property involved, and if the rate is something other than 6 percent should revise the tabulated figures accordingly. A difference in cutting cycle likewise necessitates adaptation. After the table is constructed, an experienced forester can easily train a marking crew to estimate ocularly with a reasonable degree of accuracy the volume of material on each acre and to give individual treatment for each condition found.

The periodic cut of sawlogs, cordwood, etc., from each compartment should be measured and recorded. In order to check whether the total volume of the periodic cut on a given compartment is restored by at least an equivalent volume of growth during the ensuing cutting cycle, inventories of the growing stock of small, medium, and large timber should be taken immediately after the present cut and just before the next selective cut at the end of the cutting cycle. The difference in volume of these two inventories is the net volume increment of the compartment during the cutting cycle. If the inventory recognizes log grades as well as volumes, the change in quality and value as well as in volume, can be checked. A study of mortality and other factors influenced by cutting should be included. This continuous inventory method checks also the success or failure of the marking procedure and is made with a view to perfecting cutting and management procedures so as to realize maximum productivity.

In checking the cut against the growth for the whole property, it is not necessary or desirable to make checks in every compartment, but rather to use sample compartments well distributed in the various forest conditions throughout the whole property. Thus, over a period of several cutting cycles, experience can be accumulated gradually and made to produce both increasing volume yields and increasing financial returns. The results during each cutting cycle should be recorded systematically in a manner to disclose trends in growth, volume, and condition of small, medium, and large-timber growing stock. A method of setting up adequate forest management records is discussed in Chapter VIII of Selective Timber Management in the Douglas-Fir Region by Kirkland and Brandstrom (*5*).

## MANAGEMENT COSTS AND RETURNS

Private forest management depends not only on regular yields of saw timber, pulpwood, and other forest products but also on a reasonable margin of return over costs. Gross and net returns per acre per annum from stands with various volumes per acre, scaling down from 10,000 feet, cut according to the methods suggested here are given in table 52. If the entire amount of current growth is cut from a stand containing 10,000 feet log scale of profitable sawlog material per acre and in addition profitable pulpwood or other material, the yield per acre every 5 years should be 2,500 to 3,000 feet of logs worth $25 to $30 (at a stumpage rate of $8 to $12 per M feet b. m., International ¼-inch rule) plus 2 standard cords of pulpwood worth $2. The total gross income per acre every 5 years should be $27 to $31, and the annual income $5 to $6. Instead of these rounded-off stumpage values table 52 shows realization values taken from the study data.

Table 52 shows that deficiencies in growing stock reduce net returns from management even more than they reduce production rates per acre. This is because most timber-growing costs are determined by acreage, regardless of rate of production.

The conclusions to be drawn from these figures are quite apparent. The timberland owner has a choice of three programs of action: (1) He can continue to cut all the growth from badly understocked stands and obtain returns approximately equivalent to the carrying charges; (2) he can continually cut out the high-quality trees, until he has only cull and weed trees that will produce little or no income; or (3) he can remove less than the total volume growth of high-quality material and continually cut out the low-quality trees, and thus in a relatively few years increase the returns per acre by several hundred percent.

TABLE 52.—*Periodic (5-year cycle) and annual yields and returns per acre from second-growth pine-hardwood stands of various volumes per acre*

| Stand[1] per acre (board feet) | Yield in 5 years | | Gross returns | | | | Operator's profit[4] and risk | | Timber growing costs[5] | Net annual returns[6] | Value of growth added annually to growing stock | Net annual returns plus value of growth added to growing stock |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Per 5 years | | | | | | | | | |
| | Saw-logs | Pulp-wood | Saw-logs[2] | Pulp-wood[3] | Total | Per year | Per 5 years | Per year | | | | |
| | *Bd. ft.* | *Cords* | *Dols.* | *Dols.* | *Dols.* | *Dols.* | *Dols.* | *Dols.* | *Dols.* | *Dols.* | *Dols.* | *Dols.* |
| 10,000 | 2,500 | 1.98 | 27.02 | 2.28 | 29.30 | 5.86 | 7.18 | 1.44 | 0.25 | 4.17 | | 4.17 |
| 9,000 | 2,070 | 1.64 | 22.38 | 1.89 | 24.27 | 4.85 | 5.94 | 1.19 | .25 | 3.41 | 0.43 | 3.84 |
| 8,000 | 1,680 | 1.33 | 18.16 | 1.53 | 19.69 | 3.94 | 4.82 | .96 | .25 | 2.73 | .76 | 3.49 |
| 7,000 | 1,330 | 1.05 | 14.38 | 1.21 | 15.59 | 3.12 | 3.82 | .76 | .25 | 2.11 | .99 | 3.10 |
| 6,000 | 1,020 | .81 | 11.03 | .93 | 11.96 | 2.39 | 2.92 | .58 | .25 | 1.56 | 1.13 | 2.69 |
| 5,000 | 800 | .63 | 8.65 | .72 | 9.37 | 1.87 | 2.29 | .46 | .25 | 1.16 | 1.07 | 2.23 |
| 4,000 | 600 | .48 | 6.49 | .55 | 7.04 | 1.41 | 1.72 | .34 | .25 | .82 | .94 | 1.76 |
| 3,000 | 420 | .33 | 4.54 | .38 | 4.92 | .98 | 1.21 | .24 | .25 | .49 | .78 | 1.27 |
| 2,000 | 260 | .21 | 2.81 | .24 | 3.05 | .61 | .75 | .15 | .25 | .21 | .57 | .78 |

[1] Volume in trees 10 inches or more d. b. h., by International ¼-inch rule.
[2] Realization value, $10.81 per M board foot.
[3] Realization value, $1.15 per cord.
[4] Calculated on the basis of $2.75 per M feet as profit and risk for logging and milling and $0.15 per cord as profit and risk for producing pulpwood in the woods, but not including hauling.
[5] Including taxes, fire protection, administration, and forestry charges, but not including interest.
[6] Including stumpage, interest, and uninsured risks.

With full stocking of 10,000 feet or more per acre and a gross return for stumpage, profit, and uninsured risks of $5.86 per acre, the gross return on 50,000 acres would be $293,000 per annum and the net $280,500. This statement is of interest only as showing what could be accomplished on a forest property of considerable size by systematically building up growing stock over a period of several years; properties in such excellent condition do not exist. A stocking of 4,000 feet per acre may be typical of the better grade of existing second-growth shortleaf-loblolly pine-hardwood properties. For an area so stocked (table 52) the gross annual return per acre is about $1.41, and the gross return per 50,000 acres is $70,500. Deducting costs of $12,500 (table 53) leaves a net return for that acreage of $58,000.

TABLE 53.—*Estimated timber growing costs for a 5-year cutting cycle*

| Cost item | Cost per acre for 1 year | Cost per acre for 5 years | Cost per 40 acres for 5 years | Cost per 50,000 acres for 1 year |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |
| Administration | $0.05 | $0.25 | $10.00 | $2,500.00 |
| Forest protection | .05 | .25 | 10.00 | 2,500.00 |
| Taxes | .15 | .75 | 30.00 | 7,500.00 |
| Total | .25 | 1.25 | 50.00 | 12,500.00 |

## CONCLUSION

Contrary to earlier expectations, the modern world depends more and more on the products of the forest. In the existing war emergency it has become necessary to substitute wood in numerous uses for which metal and other materials have long been preferred. Forest products, particularly those of high grade, are becoming scarce. There are sound reasons for believing that in some fields the use of wood is only in its infancy. In the South, wood as a raw material is of paramount value because of its availability throughout an extensive territory as a support to widely distributed industries. The great public need for continuing production creates an equally great demand for management of forest resources.

To increase outputs of factory products, new capital must generally be invested. To increase a forest area's output of timber, extensive new investment is usually unnecessary; on the contrary, under the methods described here the process is attended by continual realization of net income from the forest, through frequent, widely distributed cutting operations.

Natural second-growth shortleaf-loblolly pine-hardwood stands west of the Mississippi River are characteristically uneven-aged. The old-field stands, though even-aged, are heterogeneous as to diameter class. It has been shown that the small-timber class (trees 5 to 12.9 inches d. b. h.) is of low value for immediate utilization but increases rapidly in size and value; that the value of the medium-timber class (trees 13 to 20.9 inches d. b. h.) is moderate but increases rapidly; and that the value of large timber is high but increases slowly. A system of selective management under which the material cut consists mainly of trees that are financially mature promises returns that may be expected to increase over a period of years. In making plans for selective management of a forest property, therefore, the first problem is to determine whether the initial restriction of yield per acre that may result from limiting the cut to financially mature trees will unduly increase costs.

Results and conclusions from the studies are summarized as follows:

1. The existing second-growth shortleaf-loblolly pine-hardwood stands are generally understocked and contain many worthless and low-quality trees. An owner of such a stand must raise both the quality and the quantity of the growing stock before he can obtain significantly increased returns.

2. A system of improvement cutting and light utilization cutting on a short cycle is the best means of raising both the quality and the quantity of growing stock and at the same time obtaining income from the property. Light cuts also result in much less fire hazard than heavy cuts.

3. The cost per unit volume of felling and bucking sawlogs is approximately the same whether the cut per acre averages 500 board feet or 5,000 board feet.

4. If use is made of trucks with dual-wheel trailers, which in dry weather can be driven to any point in the woods, the skidding, loading, and truck-hauling costs per unit volume are very little greater for a per-acre cut of 500 board feet than for one of 5,000 board feet. Use of this equipment makes it possible to log any portion of a large timbered area immediately after timber is damaged by fire, lightning, insects, or wind.

5. Costs of logging and milling per unit volume (specific figures on which are given in Parts II and III and in certain appendix tables) decrease as tree size increases.

6. Of the lumber produced from the pine logs selectively cut on the study area 20 percent was graded B and Better, 27 percent No. 1 Common, 34 percent No. 2 Common, and 19 percent No. 3 Common. Because most of the lower-quality trees were removed in the first cut,

the lumber grades will undoubtedly improve with each succeeding cut. The mill or green-chain tally for pine logs cut on the study area overran the Doyle-Scribner rule by 15 percent, but underran the International ¼-inch rule, the Scribner rule, and the cubic-foot rule by 11, 3, and 49 percent, respectively.

7. Data on relative realization values of trees by 1-inch diameter class, from 5 inches up, show a rise of value with increase in tree size. Rates of annual earning based on sawlog utilization culminate at about 15 percent on trees passing from the 14- to the 16-inch size and decline with increase in size from that point on.

8. The stumpage-realization value (difference between sales value of lumber and costs of production, excluding stumpage, profit, and uninsured risks) was usually negative for trees under 13 inches and positive for larger trees. Owing to variation in tree quality the line between positive and negative values is not sharply defined. Logging operators should aim to avoid cutting many trees of doubtful value. The stumpage realization value for a pine tree 17 inches in diameter, which was about the average size of trees cut in the study, was about $7 per M feet in 1940.

9. The importance of log grading is brought out by the fact, for example, that stumpage-realization value per M feet lumber tally was $11.01 for 12-inch No. 1 pine logs, $6.84 for 12-inch No. 2 logs, and $0.00 for 12-inch No. 3 logs. Values for other log sizes were found to vary similarly.

10. Because of the present widespread market for pulpwood throughout the shortleaf-loblolly pine region, tree tops and also whole trees that are unprofitable for saw timber and not needed as growing stock should be cut into pulpwood, or other products. When pulpwood was cut from tops of saw-timber pine trees, net values of $1.05 per cord for 10-inch trees down to $0.05 for 24-inch trees, and negative values for larger trees, were realized. When pulpwood was taken from defective and low quality trees in improvement cuttings, the largest net income per cord was $1.39, realized from 9-inch pines. Even 5-inch pines showed a net value of $1.02 per cord. For the whole experimental operation, on the average about one-half cord per M feet (Doyle-Scribner rule) of sawlogs was taken from tops and in improvement cuttings.

11. Under application of the principles of forest management set forth in this report to stands of various densities, the following net annual incomes are predicted: With 10,000 feet (International ¼-inch rule) growing stock per acre and a cut equaling the full amount of growth, more than $5 per acre; with 6,000 feet per acre and a cut amounting to about three-fourths of the growth, about $1.50 per acre (plus an annual addition to stumpage value of growing stock averaging about $1 per acre); with 2,000 feet per acre and a cut amounting to half the growth, about $0.20 (plus an addition to stumpage value of growing stock averaging $0.60) per acre.

12. The information obtained in the present studies indicates that owners of badly understocked stands have the choice of (1) removing volume as fast as it is added by growth or faster or (2) cutting less than is added by growth and gradually building up the stands to a well-stocked and highly productive condition. Under the first procedure the returns from present understocked stands are low because of the cutting of too many small trees, and future returns from further-

depleted stands may be less, whereas under the second the net returns, including increment on the growing stock, may be gradually increased. Besides earning all taxes and administrative and other timber-growing and logging costs, stands with 2,000 feet or more of saw timber per acre may increase to 10,000 feet or more of saw timber per acre, after which they should return annually $5 or more per acre.

In general, the tested results of these studies show that the great areas of pine-hardwood forests in the region west of the Mississippi River present a vast opportunity for enterprising management. The steadily increasing demand for forest products justifies great activity in this field. Success in management requires not only production of an increasing flow of forest products year by year but also production during the next 20 to 30 years of at least enough additional wood growth to double the present volume of standing timber. Even this increase would leave the yields and financial returns of the southern forests below their maxima. Despite present demands on the forests for war materials and substitutes for other materials, cutting should be conducted in a manner that will leave to the post-war world improved forest stands rather than forest ruins.

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# APPENDIX

## Commercial Tree Species Present in Stands Studied

| *Botanical name* | *Common name* |
|---|---|
| Pines: | |
| *Pinus echinata* | Shortleaf pine. |
| *P. taeda* | Loblolly pine. |
| Hardwoods: | |
| *Acer rubrum* | Red maple. |
| *Fraxinus americana* | White ash. |
| *Carya* (syn. *Hicoria*) spp | Hickory. |
| *Liquidambar styraciflua* | Sweetgum. |
| *Nyssa sylvatica* | Blackgum. |
| *Quercus alba* | White oak. |
| *Q. nigra* | Water oak. |
| *Q. phellos* | Willow oak. |
| *Q. rubra* | Southern red oak. |
| *Q. stellata* | Post oak. |
| *Q. velutina* | Black oak. |
| *Ulmus americana* | American elm. |

## Supplementary Tables

TABLE 54.—*Man-minute requirement and cost*[1] *per log for logging pines, by log size*

| Diameter inside bark (inches) | Felling and bucking | | Skidding | | Loading on trucks | | Truck haul[2] | | Total | | Basis, logs |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Number* |
| 8 | 7.00 | 0.041 | 4.50 | 0.046 | 1.70 | 0.018 | 4.80 | 0.082 | 18.00 | 0.187 | ... |
| 9 | 8.00 | .047 | 4.50 | .046 | 1.70 | .018 | 5.24 | .090 | 19.44 | .201 | 11 |
| 10 | 9.00 | .053 | 4.50 | .046 | 1.70 | .018 | 5.80 | .099 | 21.00 | .216 | 41 |
| 11 | 10.20 | .060 | 4.50 | .046 | 1.80 | .019 | 6.40 | .109 | 22.90 | .234 | 79 |
| 12 | 11.20 | .066 | 4.50 | .046 | 1.80 | .019 | 7.07 | .121 | 24.57 | .252 | 127 |
| 13 | 12.40 | .073 | 4.50 | .046 | 1.90 | .020 | 7.83 | .134 | 26.63 | .273 | 125 |
| 14 | 13.40 | .079 | 4.50 | .046 | 1.90 | .020 | 8.71 | .149 | 28.51 | .294 | 144 |
| 15 | 14.40 | .085 | 4.60 | .046 | 2.00 | .021 | 9.75 | .167 | 30.65 | .319 | 122 |
| 16 | 15.60 | .092 | 4.60 | .047 | 2.10 | .022 | 10.95 | .187 | 33.25 | .348 | 102 |
| 17 | 16.80 | .099 | 4.80 | .049 | 2.20 | .023 | 12.23 | .209 | 36.03 | .380 | 50 |
| 18 | 18.20 | .107 | 5.00 | .052 | 2.30 | .024 | 13.27 | .227 | 38.77 | .410 | 46 |
| 19 | 19.80 | .117 | 5.30 | .055 | 2.50 | .026 | 14.07 | .241 | 41.67 | .439 | 28 |
| 20 | 21.40 | .126 | 5.70 | .059 | 2.60 | .027 | 14.71 | .252 | 44.41 | .464 | 24 |
| 21 | 23.20 | .137 | 6.30 | .065 | 2.80 | .029 | 15.27 | .261 | 47.57 | .492 | 12 |
| 22 | 25.40 | .150 | 7.10 | .073 | 3.10 | .032 | 15.67 | .268 | 51.27 | .523 | 10 |
| 23 | 27.60 | .163 | 8.00 | .082 | 3.30 | .034 | 15.91 | .272 | 54.81 | .551 | 3 |
| 24 | 29.80 | .176 | 9.00 | .093 | 3.60 | .037 | 16.07 | .275 | 58.47 | .581 | 1 |

[1] Man-minute rates: Felling and bucking, $0.0059; skidding and loading, $0.0103; truck haul, $0.0171.
[2] Distance, 4 miles.

TABLE 55.—*Man-hour requirement and cost [1] per M board feet for logging pines, by log size*

| Log size: Diameter [2] (inches) | Log size: Volume (board feet) | Felling and bucking: Man-hours | Felling and bucking: Dollars | Skidding: Man-hours | Skidding: Dollars | Loading on trucks: Man-hours | Loading on trucks: Dollars | Truck haul [3]: Man-hours | Truck haul [3]: Dollars | Total: Man-hours | Total: Dollars |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DOYLE-SCRIBNER RULE | | | | | | | | | | | |
| 8 | 15 | 7.778 | 2.75 | 5.000 | 3.08 | 1.889 | 1.17 | 5.333 | 5.48 | 20.000 | 12.48 |
| 9 | 20 | 6.667 | 2.35 | 3.750 | 2.31 | 1.417 | .88 | 4.367 | 4.49 | 16.201 | 10.03 |
| 10 | 27 | 5.556 | 1.96 | 2.778 | 1.71 | 1.049 | .65 | 3.580 | 3.68 | 12.963 | 8.00 |
| 11 | 36 | 4.722 | 1.67 | 2.083 | 1.28 | .833 | .51 | 2.963 | 3.05 | 10.601 | 6.51 |
| 12 | 49 | 3.810 | 1.35 | 1.531 | .94 | .612 | .38 | 2.405 | 2.47 | 8.358 | 5.14 |
| 13 | 64 | 3.229 | 1.14 | 1.172 | .72 | .495 | .30 | 2.039 | 2.10 | 6.935 | 4.26 |
| 14 | 83 | 2.691 | .95 | .904 | .56 | .382 | .23 | 1.749 | 1.80 | 5.726 | 3.54 |
| 15 | 103 | 2.330 | .82 | .728 | .45 | .324 | .20 | 1.578 | 1.62 | 4.960 | 3.09 |
| 16 | 126 | 2.063 | .73 | .608 | .37 | .278 | .17 | 1.448 | 1.49 | 4.397 | 2.76 |
| 17 | 149 | 1.879 | .66 | .537 | .33 | .246 | .15 | 1.368 | 1.41 | 4.030 | 2.55 |
| 18 | 175 | 1.733 | .61 | .476 | .29 | .219 | .14 | 1.264 | 1.30 | 3.692 | 2.34 |
| 19 | 201 | 1.642 | .58 | .439 | .27 | .207 | .13 | 1.167 | 1.20 | 3.455 | 2.18 |
| 20 | 229 | 1.558 | .55 | .415 | .25 | .189 | .12 | 1.071 | 1.10 | 3.233 | 2.02 |
| 21 | 258 | 1.499 | .53 | .407 | .25 | .181 | .11 | .986 | 1.02 | 3.073 | 1.91 |
| 22 | 289 | 1.465 | .52 | .409 | .25 | .179 | .11 | .904 | .93 | 2.957 | 1.81 |
| 23 | 320 | 1.438 | .51 | .417 | .26 | .172 | .10 | .829 | .85 | 2.856 | 1.72 |
| 24 | 340 | 1.423 | .50 | .430 | .26 | .172 | .11 | .767 | .79 | 2.792 | 1.66 |
| INTERNATIONAL ¼-INCH RULE | | | | | | | | | | | |
| 8 | 37 | 3.153 | 1.12 | 2.027 | 1.25 | 0.766 | 0.47 | 2.162 | 2.22 | 8.108 | 5.06 |
| 9 | 45 | 2.963 | 1.05 | 1.667 | 1.03 | .630 | .39 | 1.911 | 1.99 | 7.201 | 4.46 |
| 10 | 51 | 2.778 | .98 | 1.380 | .86 | .525 | .32 | 1.790 | 1.84 | 6.482 | 4.00 |
| 11 | 65 | 2.615 | .92 | 1.154 | .71 | .462 | .29 | 1.641 | 1.69 | 5.872 | 3.61 |
| 12 | 80 | 2.333 | .82 | .938 | .58 | .375 | .23 | 1.473 | 1.52 | 5.119 | 3.15 |
| 13 | 97 | 2.131 | .75 | .773 | .48 | .326 | .20 | 1.345 | 1.38 | 4.575 | 2.81 |
| 14 | 117 | 1.909 | .67 | .641 | .39 | .271 | .17 | 1.241 | 1.28 | 4.062 | 2.51 |
| 15 | 139 | 1.727 | .61 | .540 | .33 | .240 | .15 | 1.169 | 1.20 | 3.676 | 2.29 |
| 16 | 162 | 1.605 | .57 | .473 | .29 | .216 | .13 | 1.127 | 1.16 | 3.421 | 2.15 |
| 17 | 186 | 1.505 | .53 | .430 | .27 | .197 | .12 | 1.096 | 1.13 | 3.228 | 2.05 |
| 18 | 211 | 1.438 | .51 | .395 | .24 | .182 | .11 | 1.048 | 1.08 | 3.063 | 1.94 |
| 19 | 237 | 1.392 | .49 | .373 | .23 | .176 | .11 | .989 | 1.02 | 2.930 | 1.85 |
| 20 | 264 | 1.351 | .48 | .360 | .22 | .164 | .10 | .929 | .96 | 2.804 | 1.76 |
| 21 | 292 | 1.324 | .47 | .360 | .22 | .160 | .10 | .872 | .89 | 2.716 | 1.68 |
| 22 | 321 | 1.319 | .46 | .360 | .22 | .161 | .10 | .814 | .84 | 2.663 | 1.63 |
| 23 | 350 | 1.314 | .46 | .381 | .24 | .157 | .10 | .758 | .78 | 2.610 | 1.58 |
| 24 | 378 | 1.314 | .46 | .397 | .24 | .150 | .10 | .709 | .73 | 2.579 | 1.53 |
| SCRIBNER RULE | | | | | | | | | | | |
| 8 | 29 | 4.023 | 1.42 | 2.586 | 1.60 | 0.977 | 0.60 | 2.759 | 2.84 | 10.345 | 6.46 |
| 9 | 36 | 3.704 | 1.31 | 2.083 | 1.28 | .787 | .49 | 2.426 | 2.49 | 9.000 | 5.57 |
| 10 | 45 | 3.333 | 1.17 | 1.667 | 1.03 | .630 | .39 | 2.148 | 2.21 | 7.778 | 4.80 |
| 11 | 55 | 3.091 | 1.09 | 1.364 | .84 | .545 | .34 | 1.939 | 1.99 | 6.939 | 4.26 |
| 12 | 69 | 2.705 | .95 | 1.087 | .67 | .435 | .27 | 1.708 | 1.76 | 5.935 | 3.65 |
| 13 | 86 | 2.403 | .85 | .872 | .54 | .368 | .22 | 1.517 | 1.56 | 5.160 | 3.17 |
| 14 | 106 | 2.107 | .74 | .708 | .44 | .299 | .18 | 1.369 | 1.41 | 4.483 | 2.77 |
| 15 | 126 | 1.905 | .67 | .595 | .37 | .265 | .16 | 1.290 | 1.33 | 4.055 | 2.53 |
| 16 | 149 | 1.745 | .62 | .515 | .32 | .235 | .14 | 1.225 | 1.26 | 3.720 | 2.34 |
| 17 | 171 | 1.637 | .58 | .468 | .29 | .214 | .13 | 1.192 | 1.22 | 3.511 | 2.22 |
| 18 | 196 | 1.548 | .55 | .425 | .26 | .196 | .12 | 1.128 | 1.16 | 3.297 | 2.09 |
| 19 | 221 | 1.493 | .53 | .400 | .25 | .189 | .11 | 1.061 | 1.09 | 3.143 | 1.98 |
| 20 | 247 | 1.444 | .51 | .385 | .24 | .175 | .11 | .993 | 1.02 | 2.997 | 1.88 |
| 21 | 274 | 1.411 | .50 | .383 | .24 | .170 | .10 | .929 | .95 | 2.893 | 1.79 |
| 22 | 302 | 1.402 | .49 | .392 | .24 | .171 | .11 | .865 | .89 | 2.830 | 1.73 |
| 23 | 330 | 1.394 | .49 | .404 | .25 | .167 | .10 | .804 | .83 | 2.769 | 1.67 |
| 24 | 358 | 1.387 | .49 | .410 | .26 | .168 | .10 | .748 | .77 | 2.722 | 1.62 |

[1] Man-hour rates: Felling and bucking, $0.353; skidding and loading, $0.617; truck haul, $1.028.
[2] Inside bark.
[3] Distance, 4 miles.

TABLE 56.—*Man-hour requirement and cost*[1] *per 100 cubic feet for logging pines by log size*

| Log size | | Felling and bucking | | Skidding | | Loading on trucks | | Truck haul[3] | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter[2] (inches) | Volume (cubic feet) | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* |
| 8 | 6.1 | 1.913 | 0.67 | 1.230 | 0.76 | 0.464 | 0.29 | 1.311 | 1.35 | 4.918 | 3.07 |
| 9 | 7.1 | 1.878 | .66 | 1.056 | .65 | .399 | .25 | 1.230 | 1.27 | 4.563 | 2.83 |
| 10 | 8.3 | 1.807 | .64 | .904 | .56 | .341 | .21 | 1.165 | 1.19 | 4.217 | 2.60 |
| 11 | 9.8 | 1.735 | .61 | .765 | .47 | .306 | .19 | 1.088 | 1.12 | 3.894 | 2.39 |
| 12 | 11.8 | 1.582 | .56 | .636 | .39 | .254 | .15 | .999 | 1.03 | 3.471 | 2.13 |
| 13 | 14.2 | 1.455 | .51 | .528 | .33 | .223 | .14 | .919 | .94 | 3.125 | 1.92 |
| 14 | 16.9 | 1.321 | .47 | .444 | .27 | .187 | .12 | .859 | .88 | 2.811 | 1.74 |
| 15 | 19.6 | 1.224 | .43 | .383 | .24 | .170 | .10 | .829 | .85 | 2.606 | 1.62 |
| 16 | 22.6 | 1.160 | .41 | .339 | .21 | .155 | .09 | .808 | .83 | 2.462 | 1.54 |
| 17 | 25.7 | 1.089 | .38 | .311 | .19 | .143 | .09 | .793 | .82 | 2.336 | 1.48 |
| 18 | 29.2 | 1.039 | .37 | .285 | .17 | .131 | .08 | .757 | .78 | 2.212 | 1.40 |
| 19 | 32.7 | 1.009 | .35 | .270 | .17 | .127 | .08 | .717 | .74 | 2.123 | 1.34 |
| 20 | 36.3 | .983 | .35 | .262 | .16 | .119 | .07 | .675 | .70 | 2.039 | 1.28 |
| 21 | 40.1 | .964 | .34 | .262 | .16 | [illegible] | .07 | .635 | .66 | 1.977 | 1.23 |
| 22 | 43.8 | .967 | .34 | .270 | .17 | .118 | .07 | .596 | .61 | 1.951 | 1.19 |
| 23 | 47.3 | .973 | .34 | .282 | .18 | .116 | .07 | .561 | .58 | 1.932 | 1.17 |
| 24 | 50.6 | .982 | .35 | .296 | .18 | .119 | .07 | .529 | .55 | 1.926 | 1.15 |

[1] Man-hour rates: Felling and bucking, $0.353; skidding and loading, $0.617; truck haul, $1.028.
[2] Inside bark.
[3] Distance, 4 miles.

TABLE 57.—*Man-minute requirement and cost*[1] *per log for logging hardwoods, by log size*

| Diameter inside bark (inches) | Felling and bucking | | Skidding | | Loading on trucks | | Truck haul[2] | | Total | | Basis, logs |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Number* |
| 9 | 12.20 | 0.072 | 6.30 | 0.065 | 2.70 | 0.028 | 7.75 | 0.133 | 28.95 | 0.298 | 6 |
| 10 | 13.60 | .080 | 5.80 | .060 | 2.40 | .025 | 7.75 | .133 | 29.55 | .298 | 33 |
| 11 | 15.00 | .088 | 5.40 | .056 | 2.30 | .024 | 7.83 | .134 | 30.53 | .302 | 65 |
| 12 | 16.40 | .097 | 5.30 | .055 | 2.20 | .023 | 8.07 | .138 | 31.97 | .313 | 124 |
| 13 | 17.80 | .105 | 5.40 | .056 | 2.30 | .024 | 8.47 | .145 | 33.97 | .330 | 105 |
| 14 | 19.20 | .113 | 5.60 | .058 | 2.50 | .026 | 9.19 | .157 | 36.49 | .354 | 126 |
| 15 | 20.60 | .122 | 6.00 | .062 | 2.70 | .028 | 10.23 | .175 | 39.53 | .387 | 94 |
| 16 | 22.20 | .131 | 6.50 | .067 | 3.00 | .031 | 11.51 | .197 | 43.21 | .426 | 84 |
| 17 | 23.60 | .139 | 7.10 | .073 | 3.30 | .034 | 12.95 | .221 | 46.95 | .467 | 61 |
| 18 | 25.00 | .148 | 7.90 | .081 | 3.60 | .037 | 14.55 | .249 | 51.05 | .515 | 53 |
| 19 | 26.60 | .157 | 8.80 | .091 | 4.00 | .041 | 16.23 | .278 | 55.63 | .567 | 32 |
| 20 | 28.20 | .166 | 9.90 | .102 | 4.40 | .045 | 17.99 | .308 | 60.49 | .621 | 24 |
| 21 | 30.00 | .177 | 11.00 | .113 | 4.90 | .050 | 19.83 | .339 | 65.73 | .679 | 26 |
| 22 | 32.20 | .190 | 12.20 | .126 | 5.30 | .055 | 21.74 | .372 | 71.44 | .743 | 11 |
| 23 | 34.40 | .203 | 13.60 | .140 | 5.80 | .060 | 23.74 | .406 | 77.54 | .809 | 12 |
| 24 | 37.00 | .218 | 15.10 | .156 | 6.30 | .065 | 25.82 | .442 | 84.22 | .881 | 8 |
| 25 | 40.00 | .236 | 16.80 | .173 | 6.80 | .070 | 27.08 | .478 | 91.58 | .957 | 2 |
| 26 | 43.60 | .257 | 18.70 | .193 | 7.30 | .075 | 30.22 | .517 | 99.82 | 1.042 | 6 |
| 27 | 47.80 | .282 | 20.80 | .214 | 7.80 | .080 | 32.54 | .556 | 108.94 | 1.132 | 3 |

[1] Man-minute rates: Felling and bucking, $0.0059; skidding and loading, $0.0103; truck haul, $0.0171.
[2] Distnnce, 4 miles.

TABLE 58.—*Man-hour requirement and cost [1] per M board feet for logging hardwoods, by log size*

DOYLE-SCRIBNER RULE

| Log size | | Felling and bucking | | Skidding | | Loading on trucks | | Truck haul [3] | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter [2] (inches) | Volume (board feet) | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* |
| 9 | 29 | 7.014 | 2.48 | 3.621 | 2.23 | 1.552 | 0.96 | 4.454 | 4.58 | 16.638 | 10.25 |
| 10 | 37 | 6.126 | 2.16 | 2.613 | 1.61 | 1.081 | .67 | 3.491 | 3.59 | 13.311 | 8.03 |
| 11 | 47 | 5.319 | 1.88 | 1.915 | 1.18 | .816 | .50 | 2.777 | 2.86 | 10.827 | 6.42 |
| 12 | 59 | 4.633 | 1.64 | 1.497 | .92 | .621 | .38 | 2.280 | 2.35 | 9.031 | 5.29 |
| 13 | 74 | 4.009 | 1.42 | 1.216 | .75 | .518 | .32 | 1.908 | 1.96 | 7.651 | 4.45 |
| 14 | 92 | 3.478 | 1.23 | 1.014 | .63 | .453 | .28 | 1.665 | 1.71 | 6.610 | 3.85 |
| 15 | 112 | 3.065 | 1.08 | .893 | .55 | .402 | .25 | 1.522 | 1.57 | 5.882 | 3.45 |
| 16 | 134 | 2.761 | .98 | .808 | .50 | .373 | .23 | 1.432 | 1.47 | 5.374 | 3.18 |
| 17 | 158 | 2.489 | .88 | .749 | .46 | .348 | .22 | 1.366 | 1.40 | 4.952 | 2.96 |
| 18 | 183 | 2.277 | .80 | .719 | .45 | .328 | .20 | 1.325 | 1.36 | 4.649 | 2.81 |
| 19 | 209 | 2.121 | .75 | .702 | .43 | .319 | .20 | 1.294 | 1.33 | 4.436 | 2.71 |
| 20 | 236 | 1.992 | .70 | .699 | .43 | .311 | .20 | 1.270 | 1.30 | 4.272 | 2.63 |
| 21 | 264 | 1.894 | .67 | .694 | .43 | .309 | .19 | 1.252 | 1.29 | 4.149 | 2.58 |
| 22 | 294 | 1.825 | .64 | .692 | .43 | .300 | .18 | 1.232 | 1.27 | 4.049 | 2.52 |
| 23 | 325 | 1.764 | .62 | .697 | .43 | .297 | .19 | 1.217 | 1.25 | 3.975 | 2.49 |
| 24 | 357 | 1.727 | .61 | .705 | .44 | .294 | .18 | 1.205 | 1.24 | 3.931 | 2.47 |
| 25 | 390 | 1.700 | .60 | .718 | .44 | .291 | .18 | 1.196 | 1.23 | 3.914 | 2.45 |
| 26 | 424 | 1.714 | .61 | .735 | .45 | .287 | .18 | 1.188 | 1.22 | 3.924 | 2.46 |
| 27 | 459 | 1.736 | .61 | .755 | .47 | .283 | .18 | 1.182 | 1.21 | 3.956 | 2.47 |

INTERNATIONAL ¼-INCH RULE

| Diameter (inches) | Volume (board feet) | Felling and bucking: Man-hours | Felling and bucking: Dollars | Skidding: Man-hours | Skidding: Dollars | Loading: Man-hours | Loading: Dollars | Truck haul: Man-hours | Truck haul: Dollars | Total: Man-hours | Total: Dollars |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | 47 | 4.326 | 1.53 | 2.234 | 1.38 | 0.957 | 0.59 | 2.748 | 2.82 | 10.265 | 6.32 |
| 10 | 57 | 3.977 | 1.40 | 1.696 | 1.05 | .702 | .43 | 2.266 | 2.33 | 8.641 | 5.21 |
| 11 | 69 | 3.623 | 1.28 | 1.301 | .81 | .556 | .34 | 1.891 | 1.94 | 7.374 | 4.37 |
| 12 | 83 | 3.293 | 1.16 | 1.064 | .66 | .442 | .27 | 1.620 | 1.67 | 6.419 | 3.76 |
| 13 | 100 | 2.967 | 1.05 | .899 | .55 | .384 | .24 | 1.412 | 1.45 | 5.662 | 3.29 |
| 14 | 120 | 2.667 | .94 | .778 | .48 | .347 | .22 | 1.276 | 1.31 | 5.068 | 2.95 |
| 15 | 142 | 2.418 | .85 | .704 | .43 | .317 | .20 | 1.201 | 1.24 | 4.640 | 2.72 |
| 16 | 165 | 2.242 | .79 | .657 | .40 | .303 | .19 | 1.163 | 1.20 | 4.365 | 2.58 |
| 17 | 189 | 2.081 | .74 | .626 | .39 | .291 | .18 | 1.142 | 1.17 | 4.140 | 2.48 |
| 18 | 214 | 1.947 | .69 | .615 | .38 | .280 | .17 | 1.133 | 1.16 | 3.975 | 2.40 |
| 19 | 240 | 1.847 | .65 | .611 | .38 | .278 | .17 | 1.127 | 1.16 | 3.863 | 2.36 |
| 20 | 267 | 1.760 | .62 | .618 | .38 | .275 | .17 | 1.123 | 1.16 | 3.776 | 2.33 |
| 21 | 295 | 1.695 | .60 | .621 | .38 | .277 | .17 | 1.120 | 1.15 | 3.713 | 2.30 |
| 22 | 324 | 1.656 | .58 | .628 | .39 | .273 | .17 | 1.118 | 1.15 | 3.675 | 2.29 |
| 23 | 354 | 1.620 | .57 | .640 | .39 | .273 | .17 | 1.118 | 1.15 | 3.651 | 2.28 |
| 24 | 385 | 1.602 | .57 | .654 | .40 | .273 | .17 | 1.118 | 1.15 | 3.647 | 2.29 |
| 25 | 417 | 1.599 | .57 | .671 | .41 | .272 | .17 | 1.118 | 1.15 | 3.660 | 2.30 |
| 26 | 450 | 1.615 | .57 | .693 | .43 | .270 | .17 | 1.119 | 1.15 | 3.697 | 2.32 |
| 27 | 484 | 1.646 | .58 | .716 | .44 | .269 | .17 | 1.121 | 1.15 | 3.752 | 2.34 |

SCRIBNER RULE

| Diameter (inches) | Volume (board feet) | Felling and bucking: Man-hours | Felling and bucking: Dollars | Skidding: Man-hours | Skidding: Dollars | Loading: Man-hours | Loading: Dollars | Truck haul: Man-hours | Truck haul: Dollars | Total: Man-hours | Total: Dollars |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | 38 | 5.351 | 1.89 | 2.763 | 1.71 | 1.184 | 0.73 | 3.399 | 3.49 | 12.697 | 7.82 |
| 10 | 47 | 4.823 | 1.70 | 2.057 | 1.27 | .851 | .53 | 2.748 | 2.82 | 10.479 | 6.32 |
| 11 | 58 | 4.310 | 1.52 | 1.552 | .96 | .661 | .41 | 2.250 | 2.31 | 8.773 | 5.20 |
| 12 | 72 | 3.796 | 1.34 | 1.227 | .76 | .509 | .31 | 1.868 | 1.92 | 7.400 | 4.33 |
| 13 | 89 | 3.333 | 1.18 | 1.011 | .62 | .431 | .27 | 1.586 | 1.63 | 6.361 | 3.70 |
| 14 | 108 | 2.963 | 1.05 | .864 | .53 | .386 | .24 | 1.418 | 1.46 | 5.631 | 3.28 |
| 15 | 120 | 2.661 | .94 | .775 | .48 | .349 | .21 | 1.322 | 1.36 | 5.107 | 2.99 |
| 16 | 152 | 2.434 | .86 | .713 | .44 | .329 | .20 | 1.262 | 1.30 | 4.738 | 2.80 |
| 17 | 176 | 2.235 | .79 | .672 | .42 | .312 | .19 | 1.226 | 1.26 | 4.445 | 2.66 |
| 18 | 201 | 2.073 | .73 | .655 | .40 | .299 | .19 | 1.206 | 1.24 | 4.233 | 2.56 |
| 19 | 227 | 1.953 | .69 | .646 | .40 | .294 | .18 | 1.192 | 1.22 | 4.085 | 2.49 |
| 20 | 254 | 1.850 | .66 | .650 | .40 | .289 | .18 | 1.180 | 1.21 | 3.969 | 2.45 |
| 21 | 282 | 1.773 | .63 | .650 | .40 | .290 | .18 | 1.172 | 1.20 | 3.885 | 2.41 |
| 22 | 311 | 1.726 | .61 | .651 | .40 | .284 | .18 | 1.165 | 1.20 | 3.829 | 2.39 |
| 23 | 341 | 1.681 | .59 | .665 | .41 | .283 | .18 | 1.160 | 1.19 | 3.789 | 2.37 |
| 24 | 372 | 1.658 | .59 | .677 | .42 | .282 | .17 | 1.157 | 1.19 | 3.774 | 2.37 |
| 25 | 404 | 1.660 | .58 | .693 | .43 | .281 | .17 | 1.154 | 1.19 | 3.778 | 2.37 |
| 26 | 437 | 1.663 | .59 | .713 | .44 | .278 | .17 | 1.153 | 1.18 | 3.807 | 2.38 |
| 27 | 471 | 1.691 | .60 | .736 | .45 | .276 | .17 | 1.151 | 1.18 | 3.854 | 2.40 |

[1] Man-hour rates: Felling and bucking, $0.353; skidding and loading, $0.617; truck haul, $1.028.
[2] Inside bark.
[3] Distance, 4 miles.

TABLE 59.—*Man-hour requirement and cost* [1] *per 100 cubic feet for logging hardwoods, by log size*

| Log size: Diameter [2] (inches) | Log size: Volume (cubic feet) | Felling and bucking: Man-hours | Felling and bucking: Dollars | Skidding: Man-hours | Skidding: Dollars | Loading on trucks: Man-hours | Loading on trucks: Dollars | Truck haul [3]: Man-hours | Truck haul [3]: Dollars | Total: Man-hours | Total: Dollars |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | 10.4 | 1.955 | 0.69 | 1.010 | 0.62 | 0.433 | 0.27 | 1.242 | 1.28 | 4.640 | 2.86 |
| 10 | 10.8 | 2.099 | .74 | .895 | .55 | .370 | .23 | 1.196 | 1.23 | 4.560 | 2.75 |
| 11 | 11.9 | 2.101 | .74 | .756 | .47 | .322 | .20 | 1.097 | 1.13 | 4.276 | 2.54 |
| 12 | 13.6 | 2.010 | .71 | .650 | .40 | .270 | .17 | .989 | 1.02 | 3.919 | 2.30 |
| 13 | 15.8 | 1.878 | .66 | .570 | .35 | .243 | .15 | .893 | .92 | 3.584 | 2.08 |
| 14 | 18.6 | 1.720 | .61 | .502 | .31 | .224 | .14 | .823 | .84 | 3.269 | 1.90 |
| 15 | 21.7 | 1.582 | .56 | .461 | .28 | .207 | .13 | .786 | .81 | 3.036 | 1.78 |
| 16 | 25.0 | 1.480 | .52 | .433 | .27 | .200 | .12 | .767 | .79 | 2.880 | 1.70 |
| 17 | 28.7 | 1.370 | .48 | .412 | .25 | .192 | .12 | .752 | .77 | 2.726 | 1.63 |
| 18 | 32.6 | 1.278 | .45 | .404 | .25 | .184 | .11 | .744 | .77 | 2.610 | 1.58 |
| 19 | 36.6 | 1.211 | .43 | .401 | .25 | .182 | .11 | .739 | .76 | 2.533 | 1.55 |
| 20 | 40.7 | 1.155 | .41 | .405 | .25 | .180 | .11 | .737 | .76 | 2.477 | 1.53 |
| 21 | 45.0 | 1.111 | .39 | .407 | .25 | .181 | .11 | .734 | .76 | 2.433 | 1.51 |
| 22 | 49.5 | 1.084 | .38 | .411 | .26 | .178 | .11 | .732 | .75 | 2.405 | 1.50 |
| 23 | 53.9 | 1.064 | .38 | .421 | .26 | .179 | .11 | .734 | .75 | 2.398 | 1.50 |
| 24 | 58.3 | 1.058 | .37 | .432 | .27 | .180 | .11 | .738 | .76 | 2.408 | 1.51 |
| 25 | 62.8 | 1.062 | .38 | .446 | .27 | .180 | .11 | .743 | .76 | 2.431 | 1.52 |
| 26 | 67.4 | 1.078 | .38 | .462 | .29 | .181 | .11 | .747 | .77 | 2.468 | 1.55 |
| 27 | 72.1 | 1.105 | .39 | .481 | .30 | .180 | .11 | .752 | .77 | 2.518 | 1.57 |

[1] Man-hour rates: Felling and bucking, $0.353; skidding and loading, $0.617; truck haul, $1.028.
[2] Inside bark.
[3] Distance, 4 miles.

TABLE 60.—*Man-minute requirement per load and cost* [1] *per unit of volume for hauling* [2] *pines, by log size*

| Log size [3] (board feet) | Logs per load | Volume per load: Doyle-Scribner rule | Volume per load: International ¼-inch rule | Volume per load: Scribner rule | Volume per load: Cubic feet | Time per load: Locate set | Time per load: Load | Time per load: Bind | Time per load: Haul | Time per load: Total | Cost per M board feet: Doyle-Scribner rule | Cost per M board feet: International ¼-inch rule | Cost per M board feet: Scribner rule | Cost: Per 100 cubic feet | Basis, loads |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Bd. ft. | Bd. ft. | Bd. ft. | | Man-minutes | Man-minutes | Man-minutes | Man-minutes | Man-minutes | Dollars | Dollars | Dollars | Dollars | No. |
| 50 | 31.0 | 806 | 1,551 | 1,272 | 252 | 4.24 | 91.95 | 6.02 | 79.81 | 182.02 | 3.86 | 2.01 | 2.45 | 1.24 | 1 |
| 60 | 26.0 | 900 | 1,557 | 1,324 | 244 | 4.24 | 74.37 | 6.02 | 79.81 | 164.44 | 3.09 | 1.81 | 2.12 | 1.15 | 4 |
| 70 | 22.3 | 981 | 1,562 | 1,338 | 239 | 4.24 | 63.10 | 6.02 | 79.81 | 153.17 | 2.67 | 1.68 | 1.96 | 1.10 | 32 |
| 80 | 19.7 | 1,045 | 1,577 | 1,380 | 239 | 4.24 | 51.54 | 6.02 | 79.81 | 141.61 | 2.37 | 1.57 | 1.79 | 1.04 | 41 |
| 90 | 17.8 | 1,120 | 1,600 | 1,404 | 238 | 4.24 | 48.86 | 6.02 | 79.81 | 138.93 | 2.12 | 1.48 | 1.69 | 1.00 | 54 |
| 100 | 16.2 | 1,185 | 1,623 | 1,444 | 239 | 4.24 | 45.07 | 6.02 | 79.81 | 135.14 | 1.95 | 1.42 | 1.60 | .98 | 58 |
| 110 | 15.0 | 1,230 | 1,650 | 1,485 | 241 | 4.24 | 42.10 | 6.02 | 79.81 | 132.20 | 1.84 | 1.37 | 1.52 | .94 | 39 |
| 120 | 14.0 | 1,257 | 1,679 | 1,511 | 244 | 4.24 | 41.47 | 6.02 | 79.81 | 131.54 | 1.75 | 1.34 | 1.49 | .92 | 41 |
| 130 | 13.2 | 1,311 | 1,710 | 1,552 | 245 | 4.24 | 41.47 | 6.02 | 79.81 | 131.54 | 1.68 | 1.32 | 1.45 | .92 | 42 |
| 140 | 12.4 | 1,381 | 1,742 | 1,593 | 250 | 4.24 | 41.47 | 6.02 | 79.81 | 131.54 | 1.63 | 1.29 | 1.41 | .90 | 27 |
| 150 | 11.8 | 1,420 | 1,775 | 1,620 | 253 | 4.24 | 41.47 | 6.02 | 79.81 | 131.54 | 1.58 | 1.27 | 1.39 | .89 | 22 |
| 160 | 11.3 | 1,460 | 1,810 | 1,664 | 256 | 4.24 | 41.47 | 6.02 | 79.81 | 131.54 | 1.54 | 1.24 | 1.35 | .88 | 20 |
| 170 | 10.9 | 1,498 | 1,846 | 1,704 | 261 | 4.24 | 41.47 | 6.02 | 79.81 | 131.54 | 1.50 | 1.22 | 1.32 | .86 | 10 |
| 180 | 10.5 | 1,548 | 1,883 | 1,736 | 265 | 4.24 | 41.47 | 6.02 | 79.81 | 131.54 | 1.45 | 1.20 | 1.30 | .85 | 11 |
| 190 | 10.1 | 1,585 | 1,918 | 1,776 | 270 | 4.24 | 41.47 | 6.02 | 79.81 | 131.54 | 1.42 | 1.17 | 1.27 | .83 | 10 |
| 200 | 9.8 | 1,633 | 1,955 | 1,809 | 273 | 4.24 | 41.47 | 6.02 | 79.81 | 131.54 | 1.38 | 1.15 | 1.24 | .82 | 10 |
| 210 | 9.5 | 1,668 | 1,991 | 1,849 | 278 | 4.24 | 41.47 | 6.02 | 79.81 | 131.54 | 1.35 | 1.13 | 1.22 | .81 | 10 |
| 220 | 9.2 | 1,714 | 2,028 | 1,880 | 282 | 4.24 | 41.47 | 6.02 | 79.81 | 131.54 | 1.31 | 1.11 | 1.20 | .80 | 3 |
| 230 | 9.0 | 1,752 | 2,066 | 1,923 | 287 | 4.24 | 41.47 | 6.02 | 79.81 | 131.54 | 1.28 | 1.09 | 1.17 | .78 | 5 |
| 240 | 8.8 | 1,795 | 2,100 | 1,952 | 290 | 4.24 | 41.47 | 6.02 | 79.81 | 131.54 | 1.25 | 1.07 | 1.15 | .78 | 3 |
| 250 | 8.5 | 1,830 | 2,137 | 1,992 | 293 | 4.24 | 41.47 | 6.02 | 79.81 | 131.54 | 1.23 | 1.05 | 1.13 | .76 | 4 |
| 260 | 8.4 | 1,873 | 2,174 | 2,023 | 301 | 4.24 | 41.47 | 6.02 | 79.81 | 131.54 | 1.20 | 1.04 | 1.11 | .75 | 2 |
| 270 | 8.2 | 1,906 | 2,208 | 2,052 | 304 | 4.24 | 41.47 | 6.02 | 79.81 | 131.54 | 1.18 | 1.02 | 1.10 | .74 | 1 |

[1] Rate per man-minute, $0.0171.
[2] Distance, 4 miles.
[3] International ¼-inch rule.

TABLE 61.—*Cost of hauling pines per M board feet or 100 cubic feet for each half mile (beyond 4 miles), by log size*

| Log size[1] (board feet) | Doyle-Scribner rule | International ¼-inch rule | Scribner rule | 100 cubic feet | Log size[1] (board feet) | Doyle-Scribner rule | International ¼-inch | Scribner rule | 100 cubic feet |
|---|---|---|---|---|---|---|---|---|---|
| 50 | $0.14 | $0.07 | $0.09 | $0.04 | 170 | $0.07 | $0.06 | $0.06 | $0.04 |
| 60 | .12 | .07 | .08 | .05 | 180 | .07 | .06 | .06 | .04 |
| 70 | .11 | .07 | .08 | .05 | 190 | .07 | .06 | .06 | .04 |
| 80 | .11 | .07 | .08 | .05 | 200 | .07 | .06 | .06 | .04 |
| 90 | .10 | .07 | .08 | .05 | 210 | .07 | .06 | .06 | .04 |
| 100 | .09 | .07 | .08 | .05 | 220 | .06 | .05 | .06 | .04 |
| 110 | .09 | .07 | .07 | .05 | 230 | .06 | .05 | .06 | .04 |
| 120 | .09 | .07 | .07 | .04 | 240 | .06 | .05 | .06 | .04 |
| 130 | .08 | .06 | .07 | .04 | 250 | .06 | .05 | .06 | .04 |
| 140 | .08 | .06 | .07 | .04 | 260 | .06 | .05 | .05 | .04 |
| 150 | .08 | .06 | .07 | .04 | 270 | .06 | .05 | .05 | .04 |
| 160 | .08 | .06 | .07 | .04 | | | | | |

[1] International ¼-inch rule.

TABLE 62.—*Man-minute requirement and cost*[1] *per log for loading and hauling pines on railroads, by log size*

| Diameter inside bark (inches) | Loading on cars | | Train haul | | Track expense | | Total | | Basis, logs |
|---|---|---|---|---|---|---|---|---|---|
| | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Number* |
| 8 | 2.32 | 0.055 | 0.75 | 0.033 | 6.29 | 0.045 | 9.36 | 0.133 | |
| 9 | 2.27 | .054 | .77 | .034 | 6.45 | .046 | 9.49 | .134 | 11 |
| 10 | 2.21 | .053 | .80 | .035 | 6.77 | .048 | 9.78 | .136 | 41 |
| 11 | 2.15 | .051 | .82 | .036 | 6.94 | .049 | 9.91 | .136 | 79 |
| 12 | 2.15 | .051 | .85 | .037 | 7.10 | .050 | 10.10 | .138 | 127 |
| 13 | 2.15 | .051 | .87 | .038 | 7.42 | .053 | 10.44 | .142 | 125 |
| 14 | 2.15 | .051 | .90 | .039 | 7.58 | .054 | 10.63 | .144 | 144 |
| 15 | 2.21 | .053 | .95 | .042 | 7.90 | .056 | 11.06 | .151 | 122 |
| 16 | 2.21 | .053 | 1.00 | .044 | 8.39 | .060 | 11.60 | .157 | 102 |
| 17 | 2.27 | .054 | 1.07 | .047 | 9.03 | .064 | 12.37 | .165 | 50 |
| 18 | 2.32 | .055 | 1.17 | .051 | 9.84 | .070 | 13.33 | .176 | 46 |
| 19 | 2.38 | .057 | 1.29 | .056 | 10.97 | .078 | 14.64 | .191 | 28 |
| 20 | 2.44 | .058 | 1.42 | .062 | 11.94 | .085 | 15.80 | .205 | 24 |
| 21 | 2.55 | .061 | 1.57 | .069 | 13.23 | .094 | 17.35 | .224 | 12 |
| 22 | 2.72 | .065 | 1.77 | .077 | 14.84 | .105 | 19.33 | .247 | 10 |
| 23 | 2.95 | .070 | 1.99 | .087 | 16.77 | .119 | 21.71 | .276 | 3 |
| 24 | 3.23 | .077 | 2.21 | .098 | 18.87 | .134 | 24.31 | .309 | 1 |

[1] Man-minute rates: Loading on cars, $0.0238; train haul, $0.0437; track expense, $0.0071.

TABLE 63.—*Man-hour requirement and cost*[1] *per M board feet for loading and hauling pines on railroads by log size*

DOYLE-SCRIBNER RULE

| Log size: Diameter[2] (inches) | Log size: Volume (board feet) | Loading on cars: *Man-hours* | Loading on cars: *Dollars* | Train haul: *Man-hours* | Train haul: *Dollars* | Track expense: *Man-hours* | Track expense: *Dollars* | Total: *Man-hours* | Total: *Dollars* |
|---|---|---|---|---|---|---|---|---|---|
| 8 | 15 | 2.578 | 3.66 | 0.833 | 2.18 | 6.989 | 2.98 | 10.400 | 8.84 |
| 9 | 20 | 1.892 | 2.71 | .642 | 1.68 | 5.375 | 2.29 | 7.909 | 6.68 |
| 10 | 27 | 1.364 | 1.95 | .494 | 1.29 | 4.179 | 1.78 | 6.037 | 5.02 |
| 11 | 36 | .995 | 1.42 | .380 | 1.00 | 3.213 | 1.37 | 4.588 | 3.79 |
| 12 | 49 | .731 | 1.04 | .289 | .76 | 2.415 | 1.03 | 3.435 | 2.83 |
| 13 | 64 | .560 | .80 | .227 | .60 | 1.932 | .82 | 2.719 | 2.22 |
| 14 | 83 | .432 | .62 | .181 | .47 | 1.522 | .65 | 2.135 | 1.74 |
| 15 | 103 | .358 | .51 | .154 | .40 | 1.278 | .55 | 1.790 | 1.46 |
| 16 | 126 | .292 | .42 | .132 | .35 | 1.110 | .47 | 1.534 | 1.24 |
| 17 | 149 | .254 | .36 | .120 | .32 | 1.010 | .43 | 1.384 | 1.11 |
| 18 | 175 | .221 | .32 | .111 | .29 | .937 | .40 | 1.269 | 1.01 |
| 19 | 201 | .197 | .28 | .107 | .28 | .910 | .39 | 1.214 | .95 |
| 20 | 229 | .178 | .25 | .103 | .27 | .869 | .37 | 1.150 | .89 |
| 21 | 258 | .165 | .24 | .101 | .26 | .855 | .36 | 1.121 | .86 |
| 22 | 289 | .157 | .22 | .102 | .27 | .856 | .37 | 1.115 | .86 |
| 23 | 320 | .154 | .22 | .104 | .27 | .873 | .37 | 1.131 | .86 |
| 24 | 349 | .154 | .22 | .107 | .28 | .901 | .38 | 1.162 | .88 |
| **INTERNATIONAL ¼-INCH RULE** | | | | | | | | | |
| 8 | 37 | 1.045 | 1.49 | 0.338 | 0.89 | 2.833 | 1.21 | 4.216 | 3.59 |
| 9 | 45 | .841 | 1.20 | .285 | .75 | 2.389 | 1.02 | 3.515 | 2.97 |
| 10 | 54 | .682 | .97 | .247 | .65 | 2.089 | .89 | 3.018 | 2.51 |
| 11 | 65 | .551 | .78 | .210 | .55 | 1.780 | .76 | 2.541 | 2.10 |
| 12 | 80 | .448 | .64 | .177 | .46 | 1.479 | .63 | 2.104 | 1.73 |
| 13 | 97 | .369 | .53 | .149 | .39 | 1.275 | .54 | 1.793 | 1.46 |
| 14 | 117 | .306 | .44 | .128 | .33 | 1.080 | .46 | 1.514 | 1.23 |
| 15 | 139 | .265 | .38 | .114 | .30 | .947 | .40 | 1.326 | 1.08 |
| 16 | 162 | .227 | .32 | .103 | .27 | .863 | .37 | 1.193 | .96 |
| 17 | 186 | .203 | .29 | .096 | .25 | .809 | .35 | 1.108 | .89 |
| 18 | 211 | .183 | .26 | .092 | .24 | .777 | .33 | 1.052 | .83 |
| 19 | 237 | .167 | .24 | .091 | .24 | .771 | .33 | 1.029 | .81 |
| 20 | 264 | .154 | .22 | .090 | .24 | .754 | .32 | .998 | .78 |
| 21 | 292 | .146 | .21 | .090 | .24 | .755 | .32 | .991 | .77 |
| 22 | 321 | .141 | .20 | .092 | .24 | .770 | .33 | 1.003 | .77 |
| 23 | 350 | .140 | .20 | .095 | .25 | .799 | .34 | 1.034 | .79 |
| 24 | 378 | .142 | .20 | .099 | .26 | .832 | .36 | 1.073 | .82 |
| **SCRIBNER RULE** | | | | | | | | | |
| 8 | 29 | 1.333 | 1.90 | 0.431 | 1.13 | 3.615 | 1.54 | 5.379 | 4.57 |
| 9 | 36 | 1.051 | 1.50 | .356 | .94 | 2.986 | 1.27 | 4.393 | 3.71 |
| 10 | 45 | .818 | 1.17 | .296 | .77 | 2.507 | 1.07 | 3.621 | 3.01 |
| 11 | 55 | .651 | .93 | .249 | .65 | 2.103 | .90 | 3.003 | 2.48 |
| 12 | 69 | .519 | .74 | .205 | .54 | 1.715 | .73 | 2.439 | 2.01 |
| 13 | 86 | .417 | .60 | .169 | .44 | 1.438 | .61 | 2.024 | 1.65 |
| 14 | 106 | .338 | .48 | .142 | .37 | 1.192 | .51 | 1.672 | 1.36 |
| 15 | 126 | .292 | .42 | .126 | .33 | 1.045 | .44 | 1.463 | 1.19 |
| 16 | 149 | .247 | .35 | .112 | .30 | .938 | .40 | 1.297 | 1.05 |
| 17 | 171 | .221 | .32 | .104 | .27 | .880 | .37 | 1.205 | .96 |
| 18 | 196 | .197 | .28 | .099 | .26 | .837 | .36 | 1.133 | .90 |
| 19 | 221 | .180 | .26 | .097 | .25 | .827 | .35 | 1.104 | .86 |
| 20 | 247 | .165 | .24 | .096 | .25 | .806 | .34 | 1.067 | .83 |
| 21 | 274 | .155 | .22 | .096 | .25 | .805 | .35 | 1.056 | .82 |
| 22 | 302 | .150 | .21 | .098 | .26 | .819 | .35 | 1.067 | .82 |
| 23 | 330 | .149 | .21 | .101 | .27 | .847 | .36 | 1.097 | .84 |
| 24 | 358 | .150 | .21 | .104 | .27 | .878 | .38 | 1.132 | .86 |

[1] Man-hour rates: Loading on cars, $1.420; train haul, $2.620; track expense, $0.426.
[2] Inside bark.

TABLE 64.—*Man-hour requirement and cost*[1] *per 100 cubic feet for loading and hauling pines on railroads, by log size*

| Log size: Diameter[2] (inches) | Log size: Volume (cubic feet) | Loading on cars | | Train haul | | Track expense | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| | | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* |
| 8 | 6.1 | 0.634 | 0.91 | 0.205 | 0.54 | 1.719 | 0.73 | 2.558 | 2.18 |
| 9 | 7.1 | .533 | .76 | .181 | .47 | 1.514 | .65 | 2.228 | 1.88 |
| 10 | 8.3 | .444 | .63 | .161 | .42 | 1.359 | .58 | 1.964 | 1.63 |
| 11 | 9.8 | .366 | .52 | .139 | .37 | 1.180 | .50 | 1.685 | 1.39 |
| 12 | 11.8 | .304 | .43 | .120 | .31 | 1.003 | .43 | 1.427 | 1.17 |
| 13 | 14.2 | .252 | .36 | .102 | .27 | .871 | .37 | 1.225 | 1.00 |
| 14 | 16.9 | .212 | .30 | .089 | .23 | .748 | .32 | 1.049 | .85 |
| 15 | 19.6 | .188 | .27 | .081 | .21 | .672 | .29 | .941 | .77 |
| 16 | 22.6 | .163 | .23 | .074 | .20 | .619 | .26 | .856 | .69 |
| 17 | 25.7 | .147 | .21 | .069 | .18 | .586 | .25 | .802 | .64 |
| 18 | 29.2 | .132 | .19 | .067 | .17 | .562 | .24 | .761 | .60 |
| 19 | 32.7 | .121 | .17 | .066 | .17 | .559 | .24 | .746 | .58 |
| 20 | 36.3 | .112 | .16 | .065 | .17 | .548 | .23 | .725 | .56 |
| 21 | 40.1 | .106 | .15 | .065 | .17 | .550 | .23 | .721 | .55 |
| 22 | 43.8 | .103 | .15 | .067 | .17 | .565 | .24 | .735 | .56 |
| 23 | 47.3 | .104 | .15 | .070 | .18 | .591 | .25 | .765 | .58 |
| 24 | 50.6 | .106 | .15 | .074 | .19 | .622 | .27 | .802 | .61 |

[1] Man-hour rates: Loading on cars, $1.429; train haul, $2.620; track expense, $0.426.
[2] Inside bark.

TABLE 65.—*Man-minute requirement and cost*[1] *per log for loading and hauling hardwoods on railroads, by log size*

| Diameter inside bark (inches) | Loading on cars | | Train haul | | Track expense | | Total | | Basis logs |
|---|---|---|---|---|---|---|---|---|---|
| | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Number* |
| 9 | 2.21 | 0.053 | 0.75 | 0.033 | 6.29 | 0.045 | 9.25 | 0.131 | 6 |
| 10 | 2.15 | .051 | .77 | .034 | 6.45 | .046 | 9.37 | .131 | 33 |
| 11 | 2.15 | .051 | .80 | .035 | 6.77 | .048 | 9.72 | .134 | 65 |
| 12 | 2.15 | .051 | .82 | .036 | 6.94 | .049 | 9.91 | .136 | 124 |
| 13 | 2.15 | .051 | .87 | .038 | 7.42 | .053 | 10.44 | .142 | 105 |
| 14 | 2.15 | .051 | .92 | .040 | 7.74 | .055 | 10.81 | .146 | 126 |
| 15 | 2.21 | .053 | .97 | .042 | 8.23 | .058 | 11.41 | .153 | 94 |
| 16 | 2.21 | .053 | 1.04 | .045 | 8.87 | .063 | 12.12 | .161 | 84 |
| 17 | 2.27 | .054 | 1.12 | .049 | 9.35 | .066 | 12.74 | .169 | 61 |
| 18 | 2.32 | .055 | 1.22 | .053 | 10.32 | .073 | 13.86 | .181 | 53 |
| 19 | 2.38 | .057 | 1.32 | .058 | 11.13 | .079 | 14.83 | .194 | 32 |
| 20 | 2.44 | .058 | 1.44 | .063 | 12.10 | .086 | 15.98 | .207 | 24 |
| 21 | 2.55 | .061 | 1.57 | .069 | 13.23 | .094 | 17.35 | .224 | 26 |
| 22 | 2.72 | .065 | 1.72 | .075 | 14.52 | .103 | 18.96 | .243 | 11 |
| 23 | 2.89 | .069 | 1.89 | .083 | 15.97 | .113 | 20.75 | .265 | 12 |
| 24 | 3.12 | .074 | 2.06 | .090 | 17.42 | .124 | 22.60 | .288 | 8 |
| 25 | 3.34 | .079 | 2.26 | .099 | 19.03 | .135 | 24.63 | .313 | 2 |
| 26 | 3.63 | .086 | 2.49 | .109 | 20.97 | .149 | 27.09 | .344 | 6 |
| 27 | 4.02 | .096 | 2.74 | .120 | 23.06 | .164 | 29.82 | .380 | 3 |

[1] Man-minute rates: Loading on cars, $0.0238; train haul, $0.0437; track expense, $0.0071.

TABLE 66.—*Man-hour requirement and cost*[1] *per M board feet for loading and hauling hardwoods on railroads, by log size*

DOYLE-SCRIBNER RULE

| Log size: Diameter[2] (inches) | Log size: Volume (board feet) | Loading on cars: *Man-hours* | Loading on cars: *Dollars* | Train haul: *Man-hours* | Train haul: *Dollars* | Track expense: *Man-hours* | Track expense: *Dollars* | Total: *Man-hours* | Total: *Dollars* |
|---|---|---|---|---|---|---|---|---|---|
| 9 | 29 | 1.270 | 1.81 | 0.431 | 1.13 | 3.615 | 1.54 | 5.316 | 4.48 |
| 10 | 37 | .968 | 1.38 | .347 | .91 | 2.905 | 1.24 | 4.220 | 3.53 |
| 11 | 47 | .702 | 1.00 | .284 | .75 | 2.401 | 1.02 | 3.447 | 2.86 |
| 12 | 59 | .607 | .87 | .232 | .61 | 1.961 | .83 | 2.800 | 2.31 |
| 13 | 74 | .484 | .69 | .196 | .52 | 1.671 | .71 | 2.351 | 1.92 |
| 14 | 92 | .389 | .55 | .167 | .44 | 1.402 | .60 | 1.958 | 1.59 |
| 15 | 112 | .329 | .47 | .144 | .38 | 1.225 | .52 | 1.698 | 1.37 |
| 16 | 134 | .275 | .39 | .129 | .34 | 1.103 | .47 | 1.507 | 1.20 |
| 17 | 158 | .239 | .34 | .118 | .31 | .986 | .42 | 1.343 | 1.07 |
| 18 | 183 | .211 | .30 | .111 | .29 | .940 | .40 | 1.262 | .99 |
| 19 | 209 | .190 | .27 | .105 | .28 | .888 | .38 | 1.183 | .93 |
| 20 | 236 | .172 | .25 | .102 | .27 | .855 | .36 | 1.129 | .88 |
| 21 | 264 | .161 | .23 | .099 | .26 | .835 | .36 | 1.095 | .85 |
| 22 | 294 | .154 | .22 | .098 | .26 | .823 | .35 | 1.075 | .83 |
| 23 | 325 | .148 | .21 | .097 | .25 | .819 | .35 | 1.064 | .81 |
| 24 | 357 | .146 | .21 | .096 | .25 | .813 | .35 | 1.055 | .81 |
| 25 | 390 | .143 | .20 | .097 | .25 | .813 | .35 | 1.053 | .80 |
| 26 | 424 | .143 | .20 | .098 | .26 | .824 | .35 | 1.065 | .81 |
| 27 | 459 | .146 | .21 | .099 | .26 | .837 | .36 | 1.082 | .83 |

INTERNATIONAL ¼-INCH RULE

| Log size: Diameter[2] (inches) | Log size: Volume (board feet) | Loading on cars: *Man-hours* | Loading on cars: *Dollars* | Train haul: *Man-hours* | Train haul: *Dollars* | Track expense: *Man-hours* | Track expense: *Dollars* | Total: *Man-hours* | Total: *Dollars* |
|---|---|---|---|---|---|---|---|---|---|
| 9 | 47 | 0.784 | 1.12 | 0.266 | 0.70 | 2.230 | 0.95 | 3.280 | 2.77 |
| 10 | 57 | .629 | .90 | .225 | .59 | 1.886 | .80 | 2.740 | 2.29 |
| 11 | 69 | .519 | .74 | .193 | .51 | 1.635 | .70 | 2.347 | 1.95 |
| 12 | 83 | .432 | .62 | .165 | .43 | 1.394 | .59 | 1.991 | 1.64 |
| 13 | 100 | .358 | .51 | .145 | .38 | 1.237 | .53 | 1.740 | 1.42 |
| 14 | 120 | .299 | .43 | .128 | .33 | 1.075 | .46 | 1.502 | 1.22 |
| 15 | 142 | .259 | .37 | .114 | .30 | .966 | .41 | 1.339 | 1.08 |
| 16 | 165 | .223 | .32 | .105 | .28 | .896 | .38 | 1.224 | .98 |
| 17 | 189 | .200 | .29 | .099 | .26 | .824 | .35 | 1.123 | .90 |
| 18 | 214 | .181 | .26 | .095 | .25 | .804 | .34 | 1.080 | .85 |
| 19 | 240 | .165 | .24 | .092 | .24 | .773 | .33 | 1.030 | .81 |
| 20 | 267 | .152 | .22 | .090 | .24 | .755 | .32 | .997 | .78 |
| 21 | 296 | .144 | .21 | .089 | .23 | .747 | .32 | .980 | .76 |
| 22 | 324 | .140 | .20 | .088 | .23 | .747 | .32 | .975 | .75 |
| 23 | 354 | .136 | .20 | .089 | .23 | .752 | .32 | .977 | .75 |
| 24 | 385 | .135 | .19 | .089 | .24 | .754 | .32 | .978 | .75 |
| 25 | 417 | .134 | .19 | .090 | .24 | .761 | .32 | .985 | .75 |
| 26 | 450 | .134 | .19 | .092 | .24 | .777 | .33 | 1.003 | .76 |
| 27 | 484 | .138 | .20 | .094 | .24 | .794 | .34 | 1.026 | .78 |

SCRIBNER RULE

| Log size: Diameter[2] (inches) | Log size: Volume (board feet) | Loading on cars: *Man-hours* | Loading on cars: *Dollars* | Train haul: *Man-hours* | Train haul: *Dollars* | Track expense: *Man-hours* | Track expense: *Dollars* | Total: *Man-hours* | Total: *Dollars* |
|---|---|---|---|---|---|---|---|---|---|
| 9 | 38 | 0.969 | 1.38 | 0.329 | 0.86 | 2.759 | 1.18 | 4.057 | 3.42 |
| 10 | 47 | .762 | 1.08 | .273 | .72 | 2.287 | .97 | 3.322 | 2.78 |
| 11 | 58 | .618 | .88 | .230 | .60 | 1.945 | .83 | 2.793 | 2.31 |
| 12 | 72 | .498 | .71 | .190 | .50 | 1.607 | .69 | 2.295 | 1.90 |
| 13 | 89 | .403 | .58 | .163 | .43 | 1.390 | .59 | 1.956 | 1.60 |
| 14 | 108 | .332 | .47 | .142 | .37 | 1.194 | .51 | 1.668 | 1.35 |
| 15 | 129 | .286 | .41 | .125 | .33 | 1.063 | .45 | 1.474 | 1.19 |
| 16 | 152 | .242 | .35 | .114 | .30 | .973 | .41 | 1.329 | 1.06 |
| 17 | 176 | .215 | .31 | .106 | .28 | .885 | .37 | 1.206 | .96 |
| 18 | 201 | .192 | .27 | .101 | .26 | .856 | .37 | 1.149 | .90 |
| 19 | 227 | .175 | .25 | .097 | .25 | .817 | .35 | 1.089 | .85 |
| 20 | 254 | .160 | .23 | .094 | .24 | .794 | .34 | 1.048 | .81 |
| 21 | 282 | .151 | .22 | .093 | .24 | .782 | .33 | 1.026 | .79 |
| 22 | 311 | .146 | .21 | .092 | .24 | .778 | .33 | 1.016 | .78 |
| 23 | 341 | .141 | .20 | .092 | .24 | .781 | .33 | 1.014 | .77 |
| 24 | 372 | .140 | .20 | .092 | .24 | .780 | .33 | 1.012 | .77 |
| 25 | 404 | .138 | .20 | .093 | .24 | .785 | .33 | 1.016 | .77 |
| 26 | 437 | .138 | .20 | .095 | .25 | .800 | .34 | 1.033 | .79 |
| 27 | 471 | .142 | .20 | .097 | .25 | .816 | .35 | 1.055 | .80 |

[1] Man-hour rates: Loading on cars, $1.420; train haul, $2.620; track expense, $0.426.
[2] Inside bark.

TABLE 67.—*Man-hour requirement and cost*[1] *per 100 cubic feet for loading and hauling hardwoods on railroads, by log size*

| Log size: Diameter[2] (inches) | Log size: Volume (cubic feet) | Loading on cars: Man-hours | Loading on cars: Dollars | Train haul: Man-hours | Train haul: Dollars | Track expense: Man-hours | Track expense: Dollars | Total: Man-hours | Total: Dollars |
|---|---|---|---|---|---|---|---|---|---|
| 9 | 10.4 | 0.354 | 0.51 | 0.120 | 0.31 | 1.008 | 0.43 | 1.452 | 1.25 |
| 10 | 10.8 | .332 | .48 | .119 | .31 | .995 | .42 | 1.446 | 1.21 |
| 11 | 11.9 | .301 | .43 | .112 | .29 | .948 | .41 | 1.361 | 1.13 |
| 12 | 13.6 | .263 | .38 | .101 | .26 | .851 | .36 | 1.215 | 1.06 |
| 13 | 15.8 | .227 | .33 | .092 | .24 | .783 | .33 | 1.102 | .90 |
| 14 | 18.6 | .193 | .28 | .082 | .21 | .694 | .30 | .969 | .79 |
| 15 | 21.7 | .170 | .24 | .075 | .20 | .632 | .27 | .877 | .71 |
| 16 | 25.0 | .147 | .21 | .069 | .18 | .591 | .25 | .807 | .64 |
| 17 | 28.7 | .132 | .19 | .065 | .17 | .543 | .23 | .740 | .59 |
| 18 | 32.6 | .119 | .17 | .062 | .16 | .528 | .23 | .709 | .56 |
| 19 | 36.6 | .108 | .15 | .060 | .16 | .507 | .22 | .675 | .53 |
| 20 | 40.7 | .100 | .14 | .059 | .16 | .496 | .21 | .655 | .51 |
| 21 | 45.0 | .094 | .13 | .058 | .15 | .490 | .21 | .642 | .49 |
| 22 | 49.5 | .092 | .13 | .058 | .15 | .489 | .21 | .639 | .49 |
| 23 | 53.0 | .089 | .13 | .058 | .15 | .494 | .21 | .641 | .49 |
| 24 | 58.3 | .089 | .13 | .059 | .15 | .498 | .21 | .646 | .49 |
| 25 | 62.8 | .089 | .13 | .060 | .16 | .505 | .21 | .654 | .50 |
| 26 | 67.4 | .090 | .13 | .062 | .16 | .519 | .22 | .671 | .51 |
| 27 | 72.1 | .093 | .13 | .063 | .16 | .533 | .23 | .689 | .52 |

[1] Man-hour rates: Loading on cars, $1.429; train haul, $2.620; track expense, $0.426.
[2] Inside bark.

TABLE 68.—*Total costs of logging, railroad transportation, and manufacture per log and per M board feet of lumber tally,*[1] *by log size*

PINE

| Diameter inside bark (inches) | Lumber tally per log | Cost per log: Logging | Cost per log: Railroad transportation | Cost per log: Manufacture | Cost per log: Total | Cost per M board feet: Logging | Cost per M board feet: Railroad transportation | Cost per M board feet: Manufacture | Cost per M board feet: Total | Basis, logs |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Board feet* | *Dollars* | *Dollars* | *Dollars* | *Dollars* | *Dollars* | *Dollars* | *Dollars* | *Dollars* | *Number* |
| 8 | 44 | 0.187 | 0.133 | 1.050 | 1.370 | 4.25 | 3.02 | 23.86 | 31.13 | ------ |
| 9 | 49 | .201 | .134 | 1.104 | 1.439 | 4.10 | 2.73 | 22.53 | 29.36 | 11 |
| 10 | 55 | .216 | .136 | 1.175 | 1.527 | 3.93 | 2.47 | 21.36 | 27.76 | 41 |
| 11 | 63 | .234 | .136 | 1.293 | 1.663 | 3.72 | 2.16 | 20.52 | 26.40 | 70 |
| 12 | 73 | .252 | .138 | 1.447 | 1.837 | 3.45 | 1.89 | 19.82 | 25.16 | 127 |
| 13 | 86 | .273 | .142 | 1.655 | 2.070 | 3.17 | 1.65 | 19.24 | 24.06 | 125 |
| 14 | 102 | .294 | .144 | 1.903 | 2.341 | 2.88 | 1.41 | 18.66 | 22.95 | 144 |
| 15 | 120 | .319 | .151 | 2.187 | 2.657 | 2.66 | 1.26 | 18.22 | 22.14 | 122 |
| 16 | 140 | .348 | .157 | 2.495 | 3.000 | 2.49 | 1.12 | 17.82 | 21.43 | 102 |
| 17 | 162 | .380 | .165 | 2.838 | 3.383 | 2.34 | 1.02 | 17.52 | 20.88 | 50 |
| 18 | 185 | .410 | .176 | 3.199 | 3.785 | 2.22 | .95 | 17.29 | 20.46 | 46 |
| 19 | 209 | .439 | .191 | 3.578 | 4.208 | 2.10 | .91 | 17.12 | 20.13 | 28 |
| 20 | 234 | .464 | .205 | 3.974 | 4.643 | 1.98 | .88 | 16.98 | 19.84 | 24 |
| 21 | 260 | .492 | .224 | 4.388 | 5.104 | 1.89 | .86 | 16.88 | 19.63 | 12 |
| 22 | 286 | .523 | .247 | 4.815 | 5.585 | 1.83 | .86 | 16.84 | 19.53 | 10 |
| 23 | 312 | .551 | .276 | 5.252 | 6.079 | 1.77 | .88 | 16.83 | 19.48 | 3 |
| 24 | 338 | .581 | .309 | 5.702 | 6.592 | 1.72 | .91 | 16.87 | 19.50 | 1 |

HARDWOOD

| Diameter inside bark (inches) | Lumber tally per log | Cost per log: Logging | Cost per log: Railroad transportation | Cost per log: Manufacture | Cost per log: Total | Cost per M board feet: Logging | Cost per M board feet: Railroad transportation | Cost per M board feet: Manufacture | Cost per M board feet: Total | Basis, logs |
|---|---|---|---|---|---|---|---|---|---|---|
| 9 | 66 | 0.298 | 0.131 | 1.897 | 2.326 | 4.52 | 1.98 | 28.74 | 35.24 | 5 |
| 10 | 72 | .298 | .131 | 1.933 | 2.362 | 4.14 | 1.82 | 26.85 | 32.81 | 21 |
| 11 | 81 | .302 | .134 | 1.998 | 2.434 | 3.73 | 1.65 | 24.67 | 30.05 | 38 |
| 12 | 93 | .313 | .136 | 2.105 | 2.554 | 3.37 | 1.46 | 22.63 | 27.46 | 58 |
| 13 | 107 | .330 | .142 | 2.268 | 2.740 | 3.08 | 1.33 | 21.20 | 25.61 | 47 |
| 14 | 123 | .354 | .146 | 2.489 | 2.989 | 2.88 | 1.19 | 20.24 | 24.31 | 62 |
| 15 | 141 | .387 | .153 | 2.768 | 3.308 | 2.74 | 1.09 | 19.63 | 23.46 | 34 |
| 16 | 160 | .426 | .161 | 3.086 | 3.673 | 2.66 | 1.01 | 19.29 | 22.96 | 32 |
| 17 | 180 | .467 | .169 | 3.434 | 4.070 | 2.59 | .94 | 19.08 | 22.61 | 19 |
| 18 | 201 | .515 | .181 | 3.809 | 4.505 | 2.56 | .90 | 18.96 | 22.42 | 18 |
| 19 | 223 | .567 | .194 | 4.227 | 4.988 | 2.54 | .87 | 18.96 | 22.37 | 9 |
| 20 | 246 | .621 | .207 | 4.367 | 5.195 | 2.52 | .84 | 18.85 | 22.21 | 6 |
| 21 | 269 | .679 | .224 | 5.060 | 5.963 | 2.52 | .83 | 18.81 | 22.16 | 6 |
| 22 | 292 | .743 | .243 | 5.482 | 6.468 | 2.55 | .83 | 18.77 | 22.15 | 3 |
| 23 | 315 | .809 | .265 | 5.916 | 6.990 | 2.57 | .84 | 18.78 | 22.10 | 3 |
| 24 | 338 | .881 | .288 | 6.349 | 7.518 | 2.61 | .85 | 18.78 | 22.24 | 2 |
| 25 | 361 | .957 | .313 | 6.794 | 8.064 | 2.65 | .87 | 18.82 | 22.34 | ------ |

[1] Green-chain tally.

TABLE 69.—*Relative production of lumber grades from pine logs of different sizes*

NO. 1 LOGS

| Diameter inside bark (inches) | Distribution of lumber by grade, in percent of log volume[1] | | | | | Diameter inside bark (inches) | Distribution of lumber by grade, in percent of log volume[1] | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | B and Better | No. 1 | No. 2 | No. 3 | Dimension and timbers | | B and Better | No. 1 | No. 2 | No. 3 | Dimension and timbers |
| 10 | 23 | 30 | 26 | 1 | 20 | 17 | 32 | 27 | 24 | 2 | 15 |
| 11 | 24 | 29 | 26 | 1 | 20 | 18 | 34 | 26 | 25 | 2 | 13 |
| 12 | 25 | 28 | 26 | 1 | 20 | 19 | 36 | 26 | 25 | 2 | 11 |
| 13 | 26 | 28 | 2 | 1 | 20 | 20 | 39 | 25 | 25 | 2 | 9 |
| 14 | 27 | 28 | 25 | 1 | 19 | 21 | 42 | 25 | 25 | 2 | 6 |
| 15 | 28 | 28 | 24 | 2 | 18 | 22 | 45 | 24 | 25 | 2 | 4 |
| 16 | 30 | 27 | 24 | 2 | 17 | 23 | 48 | 24 | 25 | 2 | 1 |

NO. 2 LOGS

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 14 | 67 | 19 | ----- | ----- | 16 | 15 | 20 | 39 | 7 | 19 |
| 9 | 14 | 58 | 28 | ----- | ----- | 17 | 16 | 18 | 43 | 7 | 16 |
| 10 | 14 | 49 | 31 | 5 | 1 | 18 | 17 | 16 | 48 | 9 | 10 |
| 11 | 14 | 41 | 32 | 6 | 7 | 19 | 18 | 14 | 53 | 11 | 4 |
| 12 | 15 | 34 | 33 | 6 | 12 | 20 | 19 | 13 | 58 | 10 | |
| 13 | 15 | 29 | 34 | 6 | 16 | 21 | 20 | 12 | 63 | 5 | ---- |
| 14 | 15 | 26 | 34 | 7 | 18 | 22 | 22 | 11 | 67 | | ---- |
| 15 | 15 | 23 | 36 | 7 | 19 | | | | | | |

NO. 3 LOGS

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 8 | 57 | 35 | | ----- | 15 | 4 | 15 | 58 | 16 | 7 |
| 9 | 7 | 49 | 42 | 2 | ----- | 16 | 4 | 11 | 62 | 17 | 6 |
| 10 | 6 | 41 | 46 | 6 | 1 | 17 | 4 | 9 | 65 | 17 | 5 |
| 11 | 6 | 33 | 48 | 8 | 5 | 18 | 4 | 8 | 69 | 17 | 2 |
| 12 | 5 | 27 | 51 | 10 | 7 | 19 | 5 | 6 | 74 | 15 | -- |
| 13 | 4 | 23 | 53 | 12 | 8 | 20 | 5 | 6 | 78 | 11 | -- |
| 14 | 4 | 18 | 56 | 14 | 8 | 21 | 6 | 5 | 83 | 6 | -- |

[1] Basis green-chain tally from 286 No. 1 logs, 364 No. 2 logs, and 352 No 3 logs.

TABLE 70.—*Relative production of lumber grades from hardwood logs of different grades*

| Log grade | Distribution of lumber by grade, in percent of log volume[1] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 4-4 FAS | 4-4 1 Com. 2 and 3A | 4-4 2 Com. | 4-4 3 and 3B | 4-4 Sound wormy | 8-4 FAS | 12-4 Decking | 8-4 Decking | Special items |
| No. 1 | 1.9 | 18.1 | 10.6 | 8.1 | 15.3 | 0.1 | 0.4 | | 45.5 |
| No. 2 | .9 | 14.9 | 12.1 | 9.6 | 16.1 | | .8 | 0.2 | 45.4 |
| No. 3 | .3 | 11.9 | 13.5 | 10.4 | 13.3 | ----- | 6.6 | .1 | 43.9 |
| No. 4 | | 12.0 | 10.7 | 14.3 | 17.8 | ----- | .5 | ... | 44.7 |

[1] Basis, green-chain tally from 335 logs.

TABLE 71.—*Loss in volume of green pine lumber due to drying, dressing, and remanufacture*

| Lumber grade and width (inches) | Volume lost[1] | Residual volume | Lumber grade and width (inches) | Volume lost[1] | Residual volume |
|---|---|---|---|---|---|
| | *Percent* | *Percent* | | *Percent* | *Percent* |
| B and Better grade: | | | No. 2: | | |
| 4 | 6.5 | 93.5 | 4 | 3.1 | 96.9 |
| 6 | 4.4 | 95.6 | 6 | 6.1 | 93.9 |
| 8 | 9.7 | 90.3 | 8 | 3.2 | 96.8 |
| 10 | 6.9 | 93.1 | 10 | 2.3 | 97.7 |
| 12 | 6.3 | 93.7 | 12 | 1.4 | 98.6 |
| No. 1: | | | No. 3: | | |
| 4 | 9.1 | 90.9 | 4 | 1.2 | 98.8 |
| 6 | 2.2 | 97.8 | 6 | 1.2 | 98.8 |
| 8 | 6.0 | 94.0 | 8 | 1.2 | 98.8 |
| 10 | 10.4 | 89.6 | 10 | 1.2 | 98.8 |
| 12 | 18.8 | 81.2 | 12 | 1.2 | 98.8 |

[1] Compiled from data of Garver and Miller (4).

TABLE 72.—*Value per M board feet of green pine lumber* [1]

| Lumber grade and width (inches) | Value of 1-inch boards in lengths (feet) of— | | | | | | | Value of 2-inch boards in lengths (feet) of— | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 4 | 6 | 8 | 10 | 12 | 14 | 16 |
| B and Better grade: | | | | | | | | | | | | | | |
| 4 | $30.55 | $35.24 | $42.29 | $40.34 | $40.34 | $50.51 | $50.51 | $33.93 | $38.95 | $46.49 | $62.82 | $62.82 | $62.82 | $62.82 |
| 6 | 32.43 | 37.24 | 44.44 | 48.05 | 48.05 | 51.65 | 51.65 | 46.49 | 51.52 | 59.06 | 69.11 | 69.11 | 70.36 | 70.36 |
| 8 | 30.63 | 35.17 | 41.98 | 45.38 | 45.38 | 48.79 | 48.79 | 49.00 | 54.03 | 61.57 | 71.62 | 71.62 | 72.88 | 72.88 |
| 10 | 37.43 | 42.12 | 49.13 | 58.49 | 58.49 | 59.66 | 59.66 | 54.03 | 59.06 | 66.59 | 79.16 | 79.16 | 80.42 | 80.42 |
| 12 | 51.86 | 51.86 | 63.64 | 70.72 | 70.72 | 74.25 | 74.25 | 64.08 | 69.11 | 76.65 | 90.47 | 90.47 | 91.72 | 91.72 |
| No. 1: | | | | | | | | | | | | | | |
| 4 | 22.87 | 25.05 | 27.22 | 32.67 | 32.67 | 33.76 | 33.76 | 18.57 | 22.16 | 27.55 | 28.15 | 28.75 | 28.75 | 29.95 |
| 6 | 26.94 | 29.29 | 31.64 | 37.49 | 37.49 | 38.66 | 38.66 | 16.17 | 19.77 | 23.96 | 25.75 | 26.95 | 26.95 | 28.15 |
| 8 | 24.77 | 27.02 | 29.28 | 36.03 | 36.03 | 36.03 | 36.03 | 17.37 | 20.96 | 25.75 | 26.95 | 28.15 | 28.15 | 28.75 |
| 10 | 26.95 | 29.11 | 31.27 | 38.81 | 38.81 | 38.81 | 38.81 | 18.57 | 22.16 | 26.35 | 28.75 | 29.35 | 29.95 | 30.55 |
| 12 | 34.04 | 35.98 | 37.94 | 46.69 | 46.69 | 46.69 | 46.69 | 20.96 | 23.36 | 28.15 | 31.74 | 31.74 | 31.74 | 34.14 |
| No. 2: | | | | | | | | | | | | | | |
| 4 | 13.66 | 15.02 | 19.12 | 20.49 | 20.49 | 21.84 | 21.84 | 16.91 | 20.43 | 27.48 | 27.48 | 27.48 | 27.48 | 28.89 |
| 6 | 14.56 | 17.21 | 21.17 | 22.49 | 22.49 | 23.82 | 23.82 | 11.27 | 14.80 | 20.43 | 23.25 | 23.25 | 23.25 | 23.96 |
| 8 | 16.36 | 19.10 | 21.83 | 25.92 | 25.92 | 25.92 | 25.92 | 14.09 | 19.03 | 23.25 | 24.66 | 24.66 | 24.66 | 26.07 |
| 10 | 17.21 | 19.97 | 22.72 | 26.85 | 26.85 | 26.85 | 26.85 | 14.09 | 19.03 | 23.25 | 24.66 | 24.66 | 24.66 | 26.78 |
| 12 | 22.24 | 25.02 | 27.79 | 34.74 | 34.74 | 33.34 | 33.34 | 15.50 | 20.43 | 23.96 | 26.78 | 25.37 | 25.37 | 26.78 |
| No. 3: | | | | | | | | | | | | | | |
| 4 | 9.70 | 10.38 | 12.46 | 13.16 | 14.53 | 14.53 | 14.53 | 12.61 | 15.41 | 18.21 | 18.21 | 18.21 | 18.21 | 19.62 |
| 6 | 11.77 | 13.16 | 14.53 | 15.92 | 17.30 | 17.30 | 17.30 | 9.11 | 11.91 | 17.51 | 17.51 | 17.51 | 17.51 | 18.91 |
| 8 | 13.84 | 13.62 | 16.62 | 19.38 | 19.38 | 19.38 | 19.38 | 11.91 | 15.41 | 18.21 | 18.21 | 18.21 | 18.21 | 19.62 |
| 10 | 15.23 | 13.62 | 17.99 | 20.08 | 20.08 | 20.08 | 20.08 | 11.91 | 15.41 | 18.21 | 18.21 | 18.21 | 18.21 | 19.62 |
| 12 | 15.23 | 13.62 | 17.99 | 20.08 | 20.08 | 20.08 | 20.08 | 14.01 | 15.41 | 18.21 | 18.21 | 18.21 | 18.21 | 19.62 |
| Special items: | | | | | | | | | | | | | | |
| 4 x 4 | | | | 30.40 | 30.40 | 30.40 | 30.40 | | | | | | | |
| 4 x 8 | | | | 30.40 | 30.40 | 30.40 | 30.40 | | | | | | | |

[1] The values tabulated were obtained by reducing those of finished pine lumber (based on data for the first 8 months of 1940, given in table 22) in accordance with the volume losses caused by drying, dressing, and remanufacture.

TABLE 73.—*Man-minute requirement and cost* [1] *per tree for logging pines of various sizes*

| Diameter inside bark (inches) | Felling and bucking | | Skidding and loading | | Truck haul [2] | | Total | | Basis, trees |
|---|---|---|---|---|---|---|---|---|---|
| | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Number* |
| 12 | 19.98 | 0.118 | 11.42 | 0.118 | 10.15 | 0.174 | 41.55 | 0.410 | 16 |
| 13 | 23.00 | .136 | 12.49 | .129 | 11.98 | .205 | 47.47 | .470 | 63 |
| 14 | 26.13 | .154 | 13.62 | .140 | 13.92 | .238 | 53.67 | .532 | 156 |
| 15 | 29.37 | .173 | 14.81 | .153 | 15.99 | .273 | 60.17 | .599 | 162 |
| 16 | 32.84 | .194 | 16.02 | .165 | 18.37 | .314 | 67.23 | .673 | 160 |
| 17 | 36.56 | .216 | 17.24 | .178 | 20.93 | .358 | 74.73 | .752 | 160 |
| 18 | 40.40 | .238 | 18.48 | .190 | 23.65 | .404 | 82.53 | .832 | 166 |
| 19 | 44.57 | .263 | 19.71 | .203 | 26.52 | .453 | 90.80 | .919 | 120 |
| 20 | 49.15 | .290 | 20.93 | .216 | 29.58 | .506 | 99.66 | 1.012 | 73 |
| 21 | 54.00 | .319 | 22.20 | .229 | 32.79 | .561 | 108.99 | 1.109 | 40 |
| 22 | 59.21 | .349 | 23.47 | .242 | 36.12 | .618 | 118.80 | 1.209 | 24 |
| 23 | 64.78 | .382 | 24.70 | .254 | 39.54 | .676 | 129.02 | 1.312 | 13 |
| 24 | 71.00 | .419 | 25.96 | .267 | 43.06 | .736 | 140.02 | 1.422 | 14 |
| 25 | 77.75 | .459 | 27.19 | .280 | 46.64 | .798 | 151.58 | 1.537 | 9 |
| 26 | 85.00 | .502 | 28.38 | .292 | 50.42 | .862 | 163.80 | 1.656 | 7 |
| 27 | 92.38 | .545 | 29.50 | .304 | 54.38 | .930 | 176.26 | 1.779 | 3 |
| 28 | 100.78 | .595 | 30.58 | .315 | 58.45 | 1.000 | 189.81 | 1.910 | 6 |
| 29 | 109.85 | .648 | 31.60 | .325 | 62.79 | 1.074 | 204.24 | 2.047 | |
| 30 | 120.00 | .708 | 32.50 | .335 | 67.29 | 1.151 | 219.79 | 2.194 | 3 |
| | | | | | | | | | 1,201 |

[1] Man-minute rates: Felling and bucking, $0.0059; skidding and loading, $0.0103; truck haul, $0.0171.
[2] Distance, 4 miles.

TABLE 74.—*Man-hour requirement and cost*[1] *per M board feet (Scribner rule) for logging pines of various sizes*

| Diameter inside bark (inches) | Volume per tree | Felling and bucking | | Skidding and loading | | Truck haul[2] | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| | *Board feet* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* |
| 12 | 82 | 4.061 | 1.44 | 2.321 | 1.43 | 2.063 | 2.12 | 8.445 | 4.99 |
| 13 | 113 | 3.392 | 1.20 | 1.842 | 1.14 | 1.767 | 1.81 | 7.001 | 4.15 |
| 14 | 146 | 2.983 | 1.05 | 1.555 | .96 | 1.589 | 1.63 | 6.127 | 3.64 |
| 15 | 182 | 2.690 | .95 | 1.356 | .84 | 1.464 | 1.50 | 5.510 | 3.29 |
| 16 | 219 | 2.499 | .88 | 1.219 | .75 | 1.398 | 1.44 | 5.116 | 3.07 |
| 17 | 257 | 2.371 | .84 | 1.118 | .69 | 1.357 | 1.39 | 4.846 | 2.92 |
| 18 | 298 | 2.259 | .80 | 1.034 | .64 | 1.323 | 1.36 | 4.616 | 2.80 |
| 19 | 342 | 2.172 | .77 | .951 | .59 | 1.202 | 1.33 | 4.425 | 2.69 |
| 20 | 392 | 2.090 | .74 | .890 | .55 | 1.258 | 1.29 | 4.238 | 2.58 |
| 21 | 449 | 2.004 | .71 | .824 | .51 | 1.217 | 1.25 | 4.045 | 2.47 |
| 22 | 513 | 1.924 | .68 | .763 | .47 | 1.173 | 1.21 | 3.860 | 2.36 |
| 23 | 585 | 1.846 | .65 | .704 | .43 | 1.126 | 1.16 | 3.676 | 2.24 |
| 24 | 662 | 1.787 | .63 | .654 | .40 | 1.084 | 1.12 | 3.525 | 2.15 |
| 25 | 743 | 1.744 | .62 | .610 | .38 | 1.046 | 1.07 | 3.400 | 2.07 |
| 26 | 827 | 1.713 | .61 | .572 | .35 | 1.016 | 1.04 | 3.301 | 2.00 |
| 27 | 913 | 1.686 | .60 | .539 | .33 | .993 | 1.02 | 3.218 | 1.95 |
| 28 | 1,000 | 1.680 | .59 | .510 | .32 | .975 | 1.00 | 3.165 | 1.91 |
| 29 | 1,090 | 1.680 | .59 | .483 | .30 | .960 | .99 | 3.123 | 1.88 |
| 30 | 1,182 | 1.692 | .60 | .458 | .28 | .949 | .98 | 3.099 | 1.86 |

[1] Man-hour rates: Felling and bucking, $0.353; skidding and loading, $0.617; truck haul, $1.028.
[2] Distance, 4 miles.

TABLE 75.—*Man-hour requirement and cost*[1] *per 100 cubic feet for logging pines of various sizes*

| Diameter inside bark (inches) | Volume per tree | Felling and bucking | | Skidding and loading | | Truck haul[2] | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| | *Board feet* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* |
| 12 | 16.2 | 2.056 | 0.73 | 1.175 | 0.72 | 1.044 | 1.07 | 4.275 | 2.52 |
| 13 | 20.1 | 1.907 | .67 | 1.036 | .64 | .993 | 1.02 | 3.936 | 2.33 |
| 14 | 24.1 | 1.807 | .64 | .942 | .58 | .963 | .99 | 3.712 | 2.21 |
| 15 | 29.3 | 1.671 | .59 | .842 | .52 | .910 | .93 | 3.423 | 2.04 |
| 16 | 34.9 | 1.568 | .56 | .765 | .47 | .877 | .90 | 3.210 | 1.93 |
| 17 | 41.0 | 1.486 | .52 | .701 | .43 | .851 | .88 | 3.038 | 1.83 |
| 18 | 47.7 | 1.412 | .50 | .646 | .40 | .826 | .85 | 2.884 | 1.75 |
| 19 | 55.1 | 1.348 | .48 | .596 | .37 | .802 | .82 | 2.746 | 1.67 |
| 20 | 62.7 | 1.307 | .46 | .556 | .34 | .786 | .81 | 2.649 | 1.61 |
| 21 | 70.8 | 1.271 | .45 | .523 | .32 | .772 | .80 | 2.566 | 1.57 |
| 22 | 79.3 | 1.244 | .44 | .493 | .30 | .759 | .78 | 2.496 | 1.52 |
| 23 | 88.1 | 1.226 | .43 | .467 | .29 | .748 | .77 | 2.441 | 1.49 |
| 24 | 97.0 | 1.220 | .43 | .446 | .28 | .740 | .76 | 2.406 | 1.47 |
| 25 | 105.9 | 1.224 | .43 | .428 | .26 | .734 | .76 | 2.386 | 1.45 |
| 26 | 114.9 | 1.233 | .44 | .412 | .25 | .731 | .75 | 2.376 | 1.44 |
| 27 | 124.0 | 1.242 | .44 | .397 | .24 | .731 | .75 | 2.370 | 1.43 |
| 28 | 133.0 | 1.263 | .45 | .383 | .24 | .733 | .75 | 2.379 | 1.44 |
| 29 | 142.0 | 1.289 | .45 | .371 | .23 | .737 | .76 | 2.397 | 1.44 |
| 30 | 151.0 | 1.325 | .47 | .359 | .22 | .743 | .76 | 2.427 | 1.45 |

[1] Man-hour rates: Felling and bucking, $0.353; skidding and loading, $0.617; truck haul, $1.028.
[2] Distance, 4 miles.

TABLE 76.—*Man-minute requirement and cost*[1] *per tree for logging hardwoods of various sizes*

| Diameter inside bark (inches) | Felling and bucking | | Skidding and loading | | Truck haul[2] | | Total | | Basis trees[3] |
|---|---|---|---|---|---|---|---|---|---|
| | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Man-minutes* | *Dollars* | *Number* |
| 12 | 12.80 | 0.076 | 7.12 | 0.073 | 11.99 | 0.205 | 31.91 | 0.354 | 1 |
| 13 | 16.36 | .097 | 8.58 | .088 | 12.31 | .211 | 37.25 | .396 | ---- |
| 14 | 20.00 | .118 | 9.08 | .103 | 12.85 | .220 | 42.83 | .441 | 5 |
| 15 | 23.82 | .141 | 11.40 | .117 | 13.67 | .234 | 48.89 | .492 | 13 |
| 16 | 27.58 | .163 | 12.80 | .132 | 14.65 | .251 | 55.03 | .546 | 17 |
| 17 | 31.15 | .184 | 14.20 | .146 | 15.84 | .271 | 61.19 | .601 | 26 |
| 18 | 34.63 | .204 | 15.58 | .160 | 17.20 | .294 | 67.41 | .658 | 25 |
| 19 | 38.22 | .225 | 16.98 | .175 | 18.79 | .321 | 73.99 | .721 | 19 |
| 20 | 41.80 | .247 | 18.38 | .189 | 20.60 | .352 | 80.78 | .788 | 31 |
| 21 | 45.38 | .268 | 19.82 | .204 | 22.70 | .388 | 87.90 | .860 | 12 |
| 22 | 49.03 | .289 | 21.20 | .218 | 25.04 | .428 | 95.27 | .935 | 18 |
| 23 | 52.60 | .310 | 22.58 | .233 | 27.56 | .471 | 102.74 | 1.014 | 10 |
| 24 | 56.28 | .332 | 24.04 | .248 | 30.38 | .519 | 110.70 | 1.099 | 6 |
| 25 | 59.98 | .354 | 25.60 | .264 | 33.33 | .570 | 118.91 | 1.188 | 7 |
| 26 | 63.62 | .375 | 27.27 | .281 | 36.41 | .623 | 127.30 | 1.279 | 3 |
| 27 | 67.20 | .396 | 29.10 | .300 | 39.73 | .679 | 136.03 | 1.375 | 1 |
| 28 | 70.80 | .418 | 31.09 | .320 | 43.10 | .737 | 144.99 | 1.475 | 2 |
| 29 | 74.41 | .439 | 33.17 | .342 | 46.61 | .797 | 154.19 | 1.578 | 4 |
| 30 | 77.99 | .460 | 35.40 | .365 | 50.20 | .858 | 163.59 | 1.683 | 2 |

[1] Man-minute rates: Felling and bucking, $0.0059; skidding and loading, $0.0103; truck haul $0.0171
[2] Distance, 4 miles.
[3] Total, 200 trees.

**TABLE 77.**—*Man-hour requirement and cost*[1] *per M board feet for logging hardwoods of various sizes*

| Diameter inside bark (inches) | Volume per tree | Felling and bucking | | Skidding and loading | | Truck haul[2] | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| | *Board feet* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* |
| DOYLE-SCRIBNER RULE | | | | | | | | | |
| 12 | 31 | 6.881 | 2.43 | 3.829 | 2.36 | 6.446 | 6.63 | 17.156 | 11.42 |
| 13 | 43 | 6.342 | 2.24 | 3.326 | 2.05 | 4.771 | 4.91 | 14.439 | 9.20 |
| 14 | 57 | 5.847 | 2.07 | 2.918 | 1.80 | 3.757 | 3.86 | 12.522 | 7.73 |
| 15 | 73 | 5.438 | 1.92 | 2.603 | 1.60 | 3.121 | 3.21 | 11.162 | 6.73 |
| 16 | 92 | 4.997 | 1.76 | 2.318 | 1.43 | 2.654 | 2.73 | 9.969 | 5.92 |
| 17 | 113 | 4.595 | 1.62 | 2.095 | 1.30 | 2.330 | 2.40 | 9.020 | 5.32 |
| 18 | 136 | 4.244 | 1.50 | 1.910 | 1.18 | 2.108 | 2.16 | 8.262 | 4.84 |
| 19 | 160 | 3.981 | 1.41 | 1.769 | 1.09 | 1.957 | 2.01 | 7.707 | 4.51 |
| 20 | 185 | 3.766 | 1.33 | 1.650 | 1.02 | 1.856 | 1.91 | 7.278 | 4.26 |
| 21 | 211 | 3.584 | 1.26 | 1.565 | .97 | 1.793 | 1.84 | 6.942 | 4.07 |
| 22 | 239 | 3.419 | 1.21 | 1.478 | .91 | 1.746 | 1.79 | 6.643 | 3.91 |
| 23 | 270 | 3.247 | 1.15 | 1.394 | .86 | 1.701 | 1.75 | 6.342 | 3.76 |
| 24 | 303 | 3.096 | 1.09 | 1.322 | .82 | 1.671 | 1.72 | 6.089 | 3.63 |
| 25 | 338 | 2.958 | 1.04 | 1.262 | .78 | 1.643 | 1.69 | 5.863 | 3.51 |
| 26 | 374 | 2.835 | 1.00 | 1.215 | .75 | 1.623 | 1.67 | 5.673 | 3.42 |
| 27 | 411 | 2.725 | .96 | 1.180 | .73 | 1.611 | 1.66 | 5.516 | 3.35 |
| 28 | 450 | 2.622 | .93 | 1.152 | .71 | 1.596 | 1.64 | 5.370 | 3.28 |
| 29 | 491 | 2.526 | .89 | 1.126 | .69 | 1.582 | 1.63 | 5.234 | 3.21 |
| 30 | 534 | 2.434 | .86 | 1.105 | .68 | 1.567 | 1.61 | 5.106 | 3.15 |
| INTERNATIONAL ¼-INCH RULE | | | | | | | | | |
| 12 | 68 | 3.137 | 1.11 | 1.746 | 1.08 | 2.939 | 3.02 | 7.822 | 5.21 |
| 13 | 80 | 3.409 | 1.20 | 1.788 | 1.10 | 2.565 | 2.64 | 7.702 | 4.94 |
| 14 | 94 | 3.546 | 1.25 | 1.769 | 1.09 | 2.278 | 2.34 | 7.593 | 4.68 |
| 15 | 112 | 3.545 | 1.25 | 1.696 | 1.05 | 2.034 | 2.09 | 7.275 | 4.30 |
| 16 | 134 | 3.431 | 1.21 | 1.592 | .98 | 1.822 | 1.88 | 6.845 | 4.07 |
| 17 | 158 | 3.286 | 1.16 | 1.498 | .92 | 1.671 | 1.72 | 6.455 | 3.80 |
| 18 | 184 | 3.137 | 1.11 | 1.411 | .87 | 1.558 | 1.60 | 6.106 | 3.58 |
| 19 | 212 | 3.005 | 1.06 | 1.335 | .82 | 1.477 | 1.52 | 5.817 | 3.40 |
| 20 | 242 | 2.879 | 1.02 | 1.266 | .78 | 1.419 | 1.46 | 5.564 | 3.26 |
| 21 | 274 | 2.769 | .98 | 1.205 | .74 | 1.381 | 1.42 | 5.346 | 3.14 |
| 22 | 307 | 2.662 | .94 | 1.151 | .71 | 1.359 | 1.40 | 5.172 | 3.05 |
| 23 | 342 | 2.563 | .90 | 1.100 | .68 | 1.343 | 1.38 | 5.006 | 2.96 |
| 24 | 379 | 2.475 | .88 | 1.057 | .65 | 1.336 | 1.37 | 4.868 | 2.90 |
| 25 | 417 | 2.397 | .85 | 1.023 | .63 | 1.332 | 1.37 | 4.752 | 2.85 |
| 26 | 457 | 2.320 | .82 | .995 | .61 | 1.328 | 1.37 | 4.643 | 2.80 |
| 27 | 499 | 2.244 | .79 | .972 | .60 | 1.327 | 1.37 | 4.543 | 2.76 |
| 28 | 543 | 2.173 | .77 | .954 | .59 | 1.323 | 1.36 | 4.450 | 2.72 |
| 29 | 590 | 2.102 | .74 | .937 | .58 | 1.317 | 1.35 | 4.356 | 2.67 |
| 30 | 639 | 2.034 | .72 | .923 | .57 | 1.309 | 1.34 | 4.266 | 2.63 |
| SCRIBNER RULE | | | | | | | | | |
| 12 | 62 | 3.440 | 1.22 | 1.915 | 1.18 | 3.223 | 3.31 | 8.578 | 5.71 |
| 13 | 75 | 3.636 | 1.28 | 1.907 | 1.18 | 2.730 | 2.81 | 8.270 | 5.27 |
| 14 | 90 | 3.703 | 1.30 | 1.848 | 1.14 | 2.380 | 2.45 | 7.931 | 4.89 |
| 15 | 107 | 3.710 | 1.31 | 1.776 | 1.10 | 2.129 | 2.19 | 7.615 | 4.60 |
| 16 | 126 | 3.648 | 1.29 | 1.693 | 1.04 | 1.938 | 1.99 | 7.279 | 4.32 |
| 17 | 147 | 3.532 | 1.25 | 1.610 | .99 | 1.796 | 1.85 | 6.938 | 4.09 |
| 18 | 169 | 3.415 | 1.21 | 1.537 | .95 | 1.696 | 1.74 | 6.648 | 3.90 |
| 19 | 192 | 3.318 | 1.17 | 1.474 | .91 | 1.631 | 1.68 | 6.423 | 3.76 |
| 20 | 217 | 3.211 | 1.13 | 1.412 | .87 | 1.582 | 1.63 | 6.205 | 3.63 |
| 21 | 245 | 3.087 | 1.09 | 1.348 | .83 | 1.544 | 1.59 | 5.979 | 3.51 |
| 22 | 275 | 2.972 | 1.05 | 1.285 | .79 | 1.518 | 1.56 | 5.775 | 3.40 |
| 23 | 308 | 2.846 | 1.01 | 1.222 | .75 | 1.491 | 1.53 | 5.559 | 3.29 |
| 24 | 343 | 2.735 | .96 | 1.168 | .72 | 1.476 | 1.52 | 5.379 | 3.20 |
| 25 | 380 | 2.631 | .93 | 1.123 | .69 | 1.462 | 1.50 | 5.216 | 3.12 |
| 26 | 419 | 2.531 | .89 | 1.085 | .67 | 1.448 | 1.49 | 5.064 | 3.05 |
| 27 | 460 | 2.435 | .86 | 1.054 | .65 | 1.439 | 1.48 | 4.928 | 2.99 |
| 28 | 503 | 2.340 | .83 | 1.030 | .63 | 1.428 | 1.47 | 4.804 | 2.93 |
| 29 | 548 | 2.263 | .80 | 1.009 | .62 | 1.418 | 1.46 | 4.690 | 2.88 |
| 30 | 595 | 2.185 | .77 | .992 | .61 | 1.406 | 1.45 | 4.583 | 2.83 |

[1] Man-hour rates: Felling and bucking, $0.353; skidding and loading, $0.617; truck haul, $1.028.
[2] Distance, 4 miles.

TABLE 78.—*Man-hour requirement and cost [1] per 100 cubic feet for logging hardwoods of various sizes*

| Diameter inside bark (inches) | Volume per tree | Felling and bucking | | Skidding and loading | | Truck haul [2] | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| | *Cubic feet* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* | *Man-hours* | *Dollars* |
| 12 | 10.4 | 2.051 | 0.72 | 1.141 | 0.70 | 1.921 | 1.98 | 5.113 | 3.40 |
| 13 | 13.1 | 2.082 | .74 | 1.092 | .67 | 1.566 | 1.61 | 4.740 | 3.02 |
| 14 | 16.0 | 2.083 | .73 | 1.039 | .64 | 1.339 | 1.38 | 4.461 | 2.75 |
| 15 | 19.1 | 2.079 | .73 | .995 | .61 | 1.193 | 1.23 | 4.267 | 2.57 |
| 16 | 22.4 | 2.052 | .72 | .952 | .59 | 1.090 | 1.12 | 4.094 | 2.43 |
| 17 | 25.0 | 2.005 | .71 | .914 | .56 | 1.019 | 1.05 | 3.938 | 2.32 |
| 18 | 29.6 | 1.950 | .69 | .877 | .54 | .968 | .99 | 3.795 | 2.22 |
| 19 | 33.5 | 1.901 | .67 | .845 | .52 | .935 | .96 | 3.681 | 2.15 |
| 20 | 37.7 | 1.848 | .65 | .812 | .50 | .911 | .94 | 3.571 | 2.09 |
| 21 | 42.1 | 1.796 | .64 | .785 | .48 | .899 | .92 | 3.480 | 2.04 |
| 22 | 46.8 | 1.746 | .62 | .755 | .46 | .892 | .92 | 3.393 | 2.00 |
| 23 | 51.8 | 1.692 | .60 | .726 | .45 | .887 | .91 | 3.305 | 1.96 |
| 24 | 57.0 | 1.646 | .58 | .703 | .44 | .888 | .91 | 3.237 | 1.93 |
| 25 | 62.5 | 1.600 | .57 | .683 | .42 | .889 | .91 | 3.172 | 1.90 |
| 26 | 68.2 | 1.555 | .55 | .666 | .41 | .890 | .92 | 3.111 | 1.88 |
| 27 | 74.4 | 1.505 | .53 | .652 | .40 | .890 | .92 | 3.047 | 1.85 |
| 28 | 80.0 | 1.459 | .51 | .641 | .40 | .888 | .91 | 2.988 | 1.82 |
| 29 | 87.8 | 1.413 | .50 | .630 | .39 | .885 | .91 | 2.928 | 1.80 |
| 30 | 95.1 | 1.367 | .48 | .620 | .38 | .880 | .91 | 2.867 | 1.77 |

[1] Man-hour rates: Felling and bucking $0.353; skidding and loading, $0.617; truck haul, $1.028.
[2] Distance, 4 miles.

TABLE 79.—*Stand and stock table per acre of test block E compared with a well-stocked area*

| Diameter inside bark (inches) | Number of trees | | Volume of saw timber [1] | | Total volume [2] | |
|---|---|---|---|---|---|---|
| | Test block E | Well-stocked area | Test block E | Well-stocked area | Test block E | Well-stocked area |
| | *Number* | *Number* | *Board feet* | *Board feet* | *Cubic feet* | *Cubic feet* |
| 6 | 7.8 | 12.0 | | | 24.3 | 37.2 |
| 7 | 7.2 | 11.0 | | | 37.0 | 57.2 |
| 8 | 6.5 | 9.8 | | | 49.6 | 76.4 |
| 9 | 6.2 | 8.7 | | | 64.1 | 93.1 |
| 10 | 5.5 | 7.8 | | | 74.5 | 110.0 |
| 11 | 4.1 | 7.1 | | | 70.7 | 127.8 |
| 12 | 4.7 | 6.5 | 271 | 696 | 99.4 | 145.6 |
| 13 | 4.3 | 5.9 | 303 | 808 | 109.8 | 159.9 |
| 14 | 3.4 | 5.3 | 412 | 890 | 100.1 | 170.1 |
| 15 | 2.8 | 4.7 | 448 | 949 | 97.9 | 175.8 |
| 16 | 1.5 | 4.2 | 261 | 1,004 | 57.2 | 176.4 |
| 17 | 1.4 | 3.7 | 307 | 1,036 | 60.2 | 176.0 |
| 18 | 1.2 | 3.2 | 208 | 1,040 | 55.9 | 175.0 |
| 19 | .7 | 2.8 | 182 | 1,050 | 35.4 | 173.3 |
| 20 | .5 | 2.4 | 132 | 1,034 | 25.0 | 167.3 |
| 21 | .2 | 2.0 | 46 | 984 | 9.7 | 155.8 |
| 22 | .1 | 1.6 | 35 | 898 | 7.6 | 138.2 |
| 23 | .1 | 1.2 | 29 | 757 | 5.4 | 113.9 |
| 24 | .1 | .8 | 25 | 565 | 3.7 | 82.6 |
| 25 | | .4 | 5 | 314 | .7 | 44.5 |
| 26 | .1 | .1 | 30 | 87 | 4.4 | 11.9 |
| Total | 58.4 | 101.2 | 2,844 | 12,112 | 992.6 | 2,570.0 |
| 12 plus | 21.1 | 44.8 | 2,844 | 12,112 | 672.4 | 2,068.3 |

[1] International (¼-inch) log scale.
[2] Merchantable (inside bark).

END