TIMBER GROWING AND LOGGING AND TURPENTINING PRACTICES IN THE SOUTHERN PINE REGION

MEASURES NECESSARY TO KEEP FOREST LAND PRODUCTIVE AND TO PRODUCE FULL TIMBER CROPS

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INTRODUCTION

Forestry in the United States is no longer merely a theory or a subject for discussion; it has gotten down to concrete things in the

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1 The bulk of the information presented in this bulletin was collected between 1921 and 1927 by the Southern Forest Experiment Station, New Orleans. The writer wishes to express his thanks to the station's entire staff, and particularly to E. L. Demmon and Lenthall Wyman for assistance in its collection and presentation. He is also deeply indebted for constructive criticism and suggestions to a number of southern lumbermen and foresters who examined the preliminary draft of this bulletin.

2 Since July 8, 1927, director of the Allegheny Experiment Station.
Nor is the growing of timber confined to public lands; it is slowly making headway on land in private ownership. It is becoming a form of land management, developed through practical measures for protecting forest growth from fire and other destructive agencies, for logging woodlands so as to carry over or reproduce a crop of timber, and for planting forest trees on cut-over areas. The value of timber, with other economic considerations, is causing landowners more and more widely to study the possibility of profitable reforestation. These developments have created a general demand for information on the timber-growing methods adapted to the various types of forest growth in the United States and what these methods will cost.

Timber culture, like the growing of farm crops, is necessarily governed in any country by the soil and climate, by the requirements of native forest trees, and by local economic circumstances. Lessons may be drawn from the experience of other countries, as the United States has drawn upon the forestry of Europe. But profitable methods of growing timber, particularly under the wide range of forest types and economic conditions in the United States, can be worked out only from our own experience and investigation, region by region. Owners of southern pine, for example, may well profit by the demonstrated value of a sustained yield of gum to the naval-stores industry of France. Whether the French methods of growing and chipping pine trees can be adapted to American conditions is doubtful, although investigations thus far show promise. Whatever is done in the way of working out or adapting methods to southern pine must take into consideration labor conditions in the South.

Hence, to meet the need for information on practical ways and means of growing timber profitably in the various parts of the United States, it is important that the results of our own experience and investigation to date be brought together and set forth in the clearest possible way. This the Forest Service has attempted to do in a series of publications dealing with 12 of the principal forest regions of the United States. The information presented has been gathered from many different sources, including the experience of landowners who have engaged in reforestation. An effort has been made to bring together the gist of what has thus far been learned about the growing of timber in the United States; and the results have been verified as far as possible by consultation with the forest industries, State foresters, and forest schools. This bulletin thus undertakes to set forth what are believed to be the soundest methods of reforestation as yet developed in our common experience and study in the southern pine region.

Necessarily, no finality is claimed for the measures proposed. Timber growing in every country has come about through a gradual evolution in industrial methods and the use of land. All too little is yet known of the best methods of growing timber in the southern pineries. As time goes on, research and practical experience will add greatly to the success and certainty of the practice in our woods, just as American agriculture has steadily become more highly developed or manufacturing processes have been perfected through experience and study. But we know enough now about growing
timber in the southern pines to go right ahead. Believing that the forest-land owners of this region are ready to engage in timber growing on a large scale, the Forest Service has endeavored to place before them in concise terms the best suggestions and guides which our experience to date affords.

In this bulletin the measures proposed have been arranged in two general groups. The first includes the first steps, or the least that must be done under the local physical conditions, to prevent timber-bearing land from becoming barren. These measures, in which the prevention of fire is of outstanding importance, represent broadly the lowest cost that must be incurred to keep forest lands reasonably productive. They have been worked out primarily from the standpoint of the landowner who may not be ready to engage in real timber culture but who wishes to prevent cut-over tracts unsuitable for any purpose except timber growing from becoming a liability on his hands. The Forest Service believes that these first steps, or minimum measures, should be speedily applied to all of the forest lands in the southern pine belt and that public policy should encourage their universal application in such ways as protection from fire and the adjustment of forest taxation to the business of timber growing.

Fires have been incredibly frequent and widespread in the southern pines. Over three-fourths of the forest acreage burned annually in the United States is in the pine belt of the South; and a concerted drive to control and eliminate the man-caused fire is the most urgent first step in forestry for this region. At the same time, extremely close cutting or turpentining has been an essential cause of the barrenness of probably ten million acres of southern pinelands, and still accounts largely for the addition of about one and one-third million acres a year to the idle land. Protection from fire and the leaving of seed trees go hand in hand as the minimum measures needed to replace the pine forests of the South.

The second group of proposed measures constitutes what may be called desirable forestry practice as far as our knowledge and experience to date enable us to determine it. These measures are designed to grow reasonably complete crops of the more valuable timber trees, making full use of the productive capacity of the land. Such recommendations are addressed primarily to the landowner who wishes to use his property up to its full earning power for timber culture. It is impossible to frame any general set of measures of this character that are adapted to the individual needs of particular holdings or industrial establishments. Hence, in presenting this group of suggested measures, the Forest Service has attempted only to outline the more general and fundamental things, with illustrative methods of forest practice. The details of intensive forestry, like the details of intensive agriculture or engineering, call for an expert survey to work out the plans and methods best adapted to a particular tract of land or a particular business. One of the most important features of planning for the management of a forest property or a supply of raw material for a forest industry is to devise not simply logging methods that will reproduce crops of timber, but a scheme of operation that will afford a continuous yield of the products desired. Thus only may sustained earnings be realized or a sustained supply of raw material made available.
It is not practicable to draw a hard and fast line between the first steps that will maintain some degree of productiveness on forest land and the more intensive measures that will bring the quantity and quality of wood produced up more nearly to an ideal management. The author has not attempted, therefore, to deal with the two general types of forest practice as separate and distinct, but has rather endeavored to present a common-sense and practical résumé of the various steps in timber growing in the form that will be most helpful to men to whom timber growing is a concrete business and logging problem. At the same time it is hoped that the bulletin will have value for the everyday reader who is interested in forestry as an important phase of land use in the United States and in the public policies designed to bring forestry about.

It is impossible for a publication necessarily dealing in broad terms with the conditions existing over a large region to attempt any brass-tack conclusions on the cost and returns of timber growing. The approximate cost of the measures advocated is indicated as far as practicable, with the extent to which they may be of benefit to logging operations, but with no attempt to segregate the items chargeable to harvesting one crop of timber from those which should be regarded as invested in a following crop. Conservative estimates of the future yields of timber that may be expected under the practices recommended are given where facts appear to warrant them; but no forecasts of the profits to be derived from commercial reforestation are attempted. The financial aspects of forestry can not be dealt with in general terms. Here again expert advice must deal with the land and business problems of the individual forest owner or manufacturer.

There are, for example, very wide variations in timber-growing capacity among the pine soils of the South. On sands underlain by permeable clay the growth may be three times as fast as on the deepest sands, such as parts of the Choctawhatchee National Forest; and these contrasts may occur within a distance of 25 miles. Timber growing may be so related to a going business or the protection of plant investments as to make its commercial returns substantially greater than in situations where these relations do not exist. All such factors point to the need for expert study of individual cases to determine satisfactorily the financial side of forestry.

As a broad conclusion, the Forest Service has tremendous faith in the commercial promise of timber growing to southern landowners. The law of supply and demand is working steadily to create timber values which will pay fair returns on forestry as a business. The economic history of other countries which have passed through a cycle of virgin-forest depletion similar to that which the United States is now traversing points to the same conclusion. The time is fast approaching when forestry, and forestry alone, will supply the enormous quantities of wood demanded by American markets. The fundamental laws of business tend in the nature of things to enable the markets for forest products to be supplied at a profit to the grower of timber. The returns already being obtained from this form of land employment at points in the South show that this relationship between the value of timber and the cost of producing it is already coming into being.
To the men who own forest-producing land in the Southern States or who are engaged in industries which require timber as raw material forestry now offers a commercial opportunity. Satisfactory returns from forestry can not be promised in sweeping terms any more than returns from the manufacture of lumber or paper. But the opportunity for a profitable employment of capital and business talent in the growing of timber merits the same consideration and the same expert guidance as industrial opportunities in the conversion of timber. This applies with special force to commercial institutions which have made large capital investments in manufacturing plants and distributing organizations, dependent for their maintenance upon a future supply of forest-grown material. It applies also to owners of land, in large tracts or farm woodlands, the earning capacity of which lies mainly in the growing of trees, and which, without tree growth, will become either a doubtful asset or an outright liability.

The industrial development of the South is rapid. It is bringing not only a larger home market for lumber but greater opportunities for the close utilization of timber and the profitable sale of small material for such products as pulp and paper. As a timber-growing region the South is favored by relatively cheap land, by cheap logging, and by her advantageous position in relation to the markets of the Northeastern and Central States and the agricultural Middle West. Her young pine timber grows rapidly. There are few regions where the returns in marketable forest products come earlier or in greater volume. The interest of the people of the South in forestry has increased tremendously in the last 10 years, and intelligent public support of industrial and farm forestry will be more and more evident.

The Forest Service earnestly asks the forest-land owners of the South to determine for themselves, with the same care with which they would approach any other business problem, whether timber growing does not offer a commercial opportunity which should be grasped. It commends this bulletin to them, not as a complete or authoritative scheme that can forthwith be followed with profit in their own woods, but as a starting point in utilizing the opportunities that forestry may offer.

R. Y. Stuart.

THE SOUTHERN PINE REGION AND FORESTS

The southern pine region, as defined in this bulletin (fig. 1), includes all forest lands in which pine is or was the chief species in the sandy coastal plain from Delaware and Maryland to Texas, on the bluffs and uplands on the east bank of the Mississippi River, and on the rocky hills of central Alabama, west-central Arkansas, and southeastern Oklahoma. Although by no means embracing the entire South, it will sometimes be referred to in this bulletin as "the South" for the sake of convenience. It is known as "the piney woods" to the great majority of those living within its borders. The piedmont plateau of Virginia, the Carolinas, and Georgia, of which the forests are also predominantly pine, is not treated in this publication of this series.
The importance of the southern pine region as a source of lumber may be judged from the fact that southern pine (all species combined) became the leading lumber-producing species in the United States late in the nineteenth century, and has remained so continuously ever since. During the 22 years from 1904 to 1925, 36 per cent of the Nation's lumber was cut from southern pine, chiefly in that portion of the South covered by this bulletin. In addition to lumber, southern pine has furnished vast quantities of crossties, piling, poles, posts, and minor forest products. In two species of southern pine, longleaf and slash, is found the world's chief source of naval stores. Also recent years have brought a great increase in the use of southern pines for wood pulp.

![Map of the southern pine region](image)

Figure 1.—The southern pine region as covered in this bulletin. Shortleaf and loblolly pines occur abundantly in the piedmont plateau also; and shortleaf pine in northern Arkansas, southeastern Missouri, and the lower portions of the Appalachian and Allegheny Mountains. No attempt has been made to indicate the numerous hardwood or cypress bottom lands included in the general region.

RANGE AND HABIT OF GROWTH OF THE SOUTHERN PINES AND PRESENT CONDITION OF CUT-OVER LANDS

The great bulk of the cut of southern pine comes from four species: Longleaf (Pinus palustris), shortleaf (P. echinata), loblolly (P. taeda), and slash (P. caribaea). The measures necessary, (1) to keep southern pinelands in productive condition, and (2) to utilize their full capacity to produce wood and naval stores under intensive management, are largely determined by the habits of growth of the pines themselves, the present condition of forest lands, and the manner in which timber is now being logged or turpentined. These
factors are briefly described for each species of pine separately, although two or more species may occur together or associate with hardwoods.

**LONGLEAF PINE**

Longleaf pine originally ranged from the extreme southeastern corner of Virginia southward to Florida and westward to Texas and was easily the most abundant pine of the coastal plain and other regions here considered. However, as a result of the cutting of the original forest and its replacement over large areas—particularly in North Carolina and Virginia—by other pines, the commercial range of longleaf has somewhat diminished. The tree still maintains a wide distribution in altitude, being found from the flatwoods of the coastal plain, sometimes only 10 or 15 feet above sea level, to the foothills of the Appalachian Mountains in northern Alabama.

Longleaf pine in both the virgin forest and second growth is characteristically a tree of pure stand—one in which 80 per cent or more of the trees are of a single species. Pure longleaf stands are, however, generally broken up along small drainage ways by narrow strips of hardwoods and other species of pine. On the border line between the coastal plain and the piedmont and Mississippi bluffs, longleaf is mixed with loblolly and shortleaf pine on the uplands; the same mixture is found at the northern limit of the longleaf range in Louisiana and Texas. On the flat, poorly drained lands along the coast, and particularly bordering ponds, longleaf mingles with loblolly and slash pines.

Longleaf pine produces abundant seed or mast only at rather long intervals. The virgin longleaf forest rarely bears a full crop of seed oftener than once in about seven years. Even on cut-over lands, where the scattered trees have the full light and abundant root space believed to favor seed production, seed is not borne in appreciable quantities oftener than every three or four years (24). It is this habit of infrequent seeding which places this species below all others of the region in satisfactory reproduction.

The seed itself is the largest borne by any of the southern pines, and is readily found and devoured by a wide variety of animals and birds. But its weight no doubt contributes to its marked ability to penetrate a mat of tangled grass and surface vegetation to the mineral soil necessary to successful germination. A satisfactory stand rarely fails of establishment merely because a proper seed bed was not exposed. In fact the burning occasionally advocated as necessary to clean the ground for the reception of longleaf pine seed may so expose the resulting seedlings to frost, direct-heat killing, and to drying out of the surface soil, as to defeat the very end sought; undoubtedly much depends on the weather following germination.

In competition with other species of pine and with hardwoods, longleaf seedlings are at a decided disadvantage, owing to their peculiar habit of very slow height growth during the first three to eight years, the length of this period depending on the quality of the site.

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3 Italic numbers in parentheses refer to Literature Cited, p. 113.
4 Site is the combination of soil and climate which determines the amount of wood which can be grown on forest land.
On the other hand, this growth of only a few inches in the first few years of its life gives the longleaf pine remarkable fire resistance. Over the greater part of the tree's range, germination takes place promptly after the seed reaches the ground in early winter. Up to the first autumn following germination the seedlings are, of course, readily killed by scorching. From this time until the seedlings are about 6 inches in height, their stems and buds are so completely protected by a heavy growth of needles, or "straw," that winter fires kill comparatively few of them. For two or three years after they first begin to make good height growth—a foot or more in a single season—the seedlings are again extremely sensitive to fire, and a considerable proportion of them are killed by fires. After this second period of sensitiveness, longleaf pine develops a heavy bark that enables it throughout the rest of its life to survive an extraordinary number of fires. Experiments have shown, however, that frequent fires result in a natural reduction in its rate of growth (20).

Hogs are locally a serious enemy of longleaf pine seedlings. It has been amply demonstrated by experiments that these animals, either of the razorback or more domesticated variety, can wipe out a stand of longleaf pine seedlings as much as 5 or 10 years old (20). They destroy the young seedlings by girdling them at and below the surface of the ground, at which point this pine has a heavy inner bark. They may cause serious damage to well-grown saplings by stripping the bark from the surface roots. No doubt hogs consume considerable quantities of longleaf pine seed also, particularly if other food is scarce in the late fall or winter.

Because of its slow early growth, longleaf pine is sometimes regarded as a less desirable species for timber growing than the other southern pines. This has persuaded some owners to plant other species on denuded longleaf land. On one forest property managed for sustained naval-stores production, hogs are allowed to range at will, with the object of eliminating longleaf in favor of the faster-growing slash pine. But it should be remembered (1) that longleaf is found naturally on the very poorest soils in the entire coastal plain, where growth of any species is certain to be slow; and (2) that particularly on such soils it is dangerous to upset natural conditions which are the result of centuries of adjustment of the forest to its environment. In other words, the planting of loblolly pine, for example, on dry longleaf pine land may be apparently successful for a number of years, yet in the long run prove disappointing, because of the inability of the substitute species to thrive under the rigors of drought. In mixed growth of slash and longleaf, the longleaf pine, while interfering very little with the faster-growing slash, may prove an invaluable insurance against the complete destruction of the stand in an accidental fire.

Longleaf is more susceptible to the brown-spot needle blight (Cryptosporium acicolum Thüm) than the other pines. Under some conditions this disease kills many seedlings less than a foot or two in height, and must stunt the growth of others.

The very heavy taproot of the longleaf pine enables even scattered trees, such as are left under forest management for seed production, to stand up under high winds. Only on soil types which have an impenetrable clay or hardpan within a foot or two of the surface, so
that the taproot can not develop, is longleaf thrown by any ordinary wind. The tropical cyclones which occasionally visit the piney woods, and which have cleared the way for the well-known stands of even-aged "harrican" (hurricane) timber, will of course uproot even longleaf. No tree, except perhaps cypress, is capable of withstanding the force of such winds. The relatively small trees characteristic of second growth suffer less than the mature veterans of the original forest, regardless of species (29).

Resistant to both fire and wind, longleaf pine has other virtues. At least in second growth, it has been found to withstand deeper chipping for naval stores than slash pine. Also longleaf continues to grow at a more uniform rate, both in height and diameter, than the other southern pines.

Although some extensive stands of splendid second-growth longleaf have succeeded the virgin timber, particularly in southern Georgia and Alabama and in northern Florida, a far greater proportion of longleaf pine land has been completely denuded—that is, stripped clear of seed-producing trees and repeatedly burned—than of loblolly, shortleaf, or slash pine land. Occasionally the seed trees have been destroyed by close cutting alone, as in the animal-logged area shown in Plate 2, A. More often, however, steam skidders combined with close cutting have been responsible for their destruction.

Good stands, frequently running from 10,000 to 15,000 board feet to the acre over large areas, have invited the use of the skidders, which, as ordinarily operated, break down or cripple many of the trees left standing by the fallers. Turpentining, followed by fires which kindle the old boxes or faces, has killed the virgin timber on thousands of acres. (Pl. 8, B.)

The absence of cultivated lands and of well-constructed roads, both of which in the shortleaf and loblolly pine belts act as fire breaks, has permitted the annual fires in longleaf forests to cover very large areas. The combined effect of close cutting, steam skidding, and burning is illustrated in Plate 2, B.

It is estimated that of approximately 42,100,000 acres of cut-over longleaf and slash pine land, 22,400,000 acres have not re-stocked, either because of fires, absence of seed trees, or both. The virgin stands remaining—about 8,600,000 acres—are being cut at the rate of 750,000 acres a year, of which about four-fifths is clear-cut. Cutting and destructive turpentining of second growth, or of remnants of the virgin timber left in early logging, cover approximately 1,200,000 acres a year, half of this area being denuded of seed-bearing trees. The trees remaining from earlier cuttings in virgin stands are often too scattered for profitable saw-timber operation, but are cut for poles, piling, and ties.

An example of practically complete denudation is a tract of longleaf pine land in southwest Louisiana cut over between 1914 and 1919. It originally bore a stand of about 15,000 board feet to the

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5 This and similar figures given later in the text are for the entire commercial range of the southern pines, including the piedmont plateau, in the following States: Virginia, the Carolinas, Georgia, Florida, Alabama, Mississippi, Louisiana, Texas, Oklahoma, and Arkansas. Separate information is not available for the area outside of the piedmont. That is, the region covered by this bulletin. It has also been necessary to include slash pine with longleaf pine, and loblolly with shortleaf. The figures are for January, 1926.
acre of prime timber. A tally was made in 1925 of the standing trees and seedlings on a strip 2 chains wide run at random for 4 miles through the tract. This showed, on each 5 acres, less than one living pine 4 inches d. b. h.⁶ or larger, and generally this occasional tree was so small or crippled as to be incapable of seed production. Longleaf seedlings, averaging only 28 to the acre, were almost wholly "advance growth," that is, they had been present under the virgin stand before it was cut.

SHORTLEAF PINE

Extensive pure forests of shortleaf pine are largely confined to the western portion of the southern pine region, chiefly southwestern Arkansas, northeastern Texas, and southeastern Oklahoma. Small stands, chiefly on old fields, containing 80 per cent or more of this pine occur at many points in the coastal plain outside of Florida, and are particularly abundant near the fall line (piedmont plateau boundary) in Virginia, the Carolinas, and Georgia, and in northern Mississippi. For the most part, however, shortleaf pine grows in mixtures with other tree species. With loblolly pine it occurs on innumerable old fields, and with upland hardwoods and loblolly on hundreds of thousands of acres of cut-over or culled land, from Virginia to Texas and Oklahoma.

Shortleaf pine probably bears seed as frequently and abundantly as any of the southern pines, and the small size of the seed enables it to be carried long distances by the wind, occasionally as far as an eighth to a quarter of a mile (22). It does not require mineral soil for germination, and on the exposed soil of old fields serious overcrowding often results from too abundant germination. However, a certain amount of crowding is necessary to the development of clean-boled trees, since shortleaf, no doubt owing to its ability to withstand shade, prunes itself in natural stands less rapidly than the other southern pines. A mixture of hardwoods in the stand is believed to encourage pruning.

Shortleaf seedlings have the advantage of sprouting vigorously if damaged by a light fire, provided they are not more than 10 or 12 years old at the time of the fire, and provided the fire did not occur during the vegetative season.

Pure stands of virgin shortleaf pine on the poorer sites are occasionally denuded by close cutting and repeated fires. (Pl. 2, C.) The area of nonrestocked shortleaf and loblolly (very largely shortleaf) land is approximately 6,250,000 acres, to which close cutting is adding about 160,000 acres yearly. But in general this pine, growing in lighter stands than longleaf and lending itself less well to the profitable use of steam skidders, suffers little denudation. The lighter stands are not the result of a lower growth rate but of the closer approach to an all-aged condition. In a stand where all ages of trees from seedlings to mature veterans are represented the volume of merchantable material present at any one time is very much less than in a stand where the trees are all of one age, and

⁶D. b. h. = diameter breast high. All the diameters given in this bulletin are diameters breast high, or at a point 4½ feet above the surface of the ground.
mature. Unless subsequent fires burn in the slash or tops, such an all-aged forest culled of its mature timber soon recovers and is ready for another cutting in 15 to 30 years. (Pl. 1, B.)

**LOBLOLLY PINE**

Pure forests of virgin loblolly pine were never common, and are now found only in southeastern Texas and southeastern Arkansas on flatlands just above the overflow level of the main streams. However, loblolly pines as individuals or in small groups grew naturally among the virgin hardwoods in a very wide variety of those bottom lands which are not subject to long overflow or backwater, and the tree has been very aggressive in extending its range into all lands adjacent. Because in the early days of the southern pine industry in the coastal plain it was the longleaf on the slopes and ridges that was cut and the loblolly in the draws and bottoms that was left standing, the latter had all the better of it in the subsequent reseeding of the cut-over land. Although fires were less destructive to the longleaf, the fondness of hogs for longleaf seed and roots threw the balance the opposite way. Pure stands of second-growth loblolly pine, both on old cuttings and on abandoned fields, are now scattered throughout the coastal plain north of central Florida, with the exception of the region of pure shortleaf pine earlier described.

The aggressiveness of this species is partly due to its abundant production of light, wind-borne seed and to its apparent ability to adjust its root habit to meet a wide variety of soil conditions. But it is chiefly due to its extremely rapid growth. In any even-aged mixture of pines or pines and hardwoods, loblolly almost always exceeds its associates both in height and diameter growth; but occasionally slash pine seems to do even better. Loblolly pine seedlings, although unable to sprout following a severe fire, early develop a very thick bark, and in the pole stage the tree is more resistant to fire than longleaf.

It is needless to say that loblolly pine land, unless ravaged by frequent fires, rarely remains denuded very long.

**SLASH PINE**

Extensive pure stands of virgin slash pine were rare except in the lower peninsula and Gulf coast of Florida. From South Carolina to eastern Louisiana individuals or small groups of slash pine, like loblolly, were present in the virgin forest along small streams and in swamps throughout the flatwoods of the coastal plain, and these have provided the seed for great acreages of beautiful second growth on adjacent cut-over longleaf land, and on occasional old fields. Abundant seed production, very vigorous early growth, and ability to adapt itself to a wide range of soils are characteristic of this species. It is, however, sensitive to fire for the first few years. With the spread of fire protection in the South slash pine will undoubtedly be greatly benefited in its competition with longleaf for the moist flatlands, and it shows some evidences of taking possession of the moderate slopes as well. It produces large quantities of naval stores, on the average more than longleaf, but is more sensitive to heavy chipping,
The wet areas in which slash pine commonly occurs do not burn often, but when dry enough to burn make a very hot fire, because of the abundant vegetation. Hence, slash pine land is not uncommonly denuded. Severe turpentining followed by windfall and fire is a source of widespread denudation of second-growth stands.

OTHER SOUTHERN PINES

Sand or scrub pine (*Pinus clausa*) is found chiefly in the hills of the peninsula of Florida, on sites where no other tree now appears able to establish and maintain itself, and in west Florida bordering salt water and the streams flowing directly into it. The tree grows very much faster than the longleaf pine, which is its most common associate in mixtures, and has some promise as a pulpwood and boxboard species. On the other hand it is limby, produces inferior lumber for general purposes, and is extremely sensitive to fire. Even-aged stands of well-grown sand pine are not uncommonly swept by crown fires, and would be completely wiped out were it not for the tree’s peculiar habit of opening its cones chiefly at high temperatures. That is, a stand of this species may have every tree destroyed by fire, but may arise from its own ashes as a result of the release of seed from cones remaining on the trees for years prior to the fire.

Black, pond, or pocoson pine (*Pinus rigida serotina*), which grows near the Atlantic and Gulf coasts, although inferior to loblolly pine, is sometimes mistaken for it. Like many another tree of poor form and quality of wood, it is a good deal better than nothing, and is decidedly worth producing on lands where no other species grows.

The spruce or cedar pine (*Pinus glabra*) borders many streams throughout the coastal plain from South Carolina to east Louisiana, and is in some respects the equal of loblolly pine, which it seems to resemble in habits.

None of these pines is of enough importance to warrant further discussion in this bulletin, and in fact very little is known about them.

ADVANTAGES OF THE SOUTH FOR TIMBER GROWING

The southern pine region as a whole has advantages for timber growing which are equaled by very few forest regions in the United States. These advantages are both natural and economic.

The southern pines as a group rank among the most rapidly growing tree species in the United States (17a). A fully stocked acre of second growth will produce 15 to 36 cords of rough (unpeeled) pulpwood at 20 years of age and 4 to 8 and 10 inches d. b. h., and 12,000 to 30,000 board feet (lumber tally) at 40 years and 7 to 12 and 16 inches d. b. h. These figures are for average land; the lower figures are for longleaf, the higher for loblolly. Such stands are growing at an average yearly rate (for the periods named) of 0.75 to 1.8 cords, or from 300 to 750 board feet to the acre.

The remarkably early age—25 to 30 years on average sites—at which loblolly, shortleaf, and slash pines begin to produce saw logs in commercial quantities may overcome a disadvantage under which most large manufacturers find themselves when considering the pos-
sibility of timber growing as a means of sustaining the cut of existing mills. This disadvantage is the comparatively short operating period left them before their virgin stumpage is exhausted. Where proper steps have been taken for the protection of the timber, second-growth saw logs will often have developed since early cutting, either on the operator's lands or on purchasable lands near by, and will keep his mills running after the virgin timber is gone. Longleaf pine, although somewhat slower than the other species to produce saw logs, on land of average quality reaches a size for profitable turpentining at 25 years.

The southern pines are not only remarkably quick growing, but are also of excellent form for high-grade utilization. Longleaf and slash, because of sparse branching, have relatively few knots, even in the upper portions of their stems, and all four species rapidly lose their lower limbs in dense second-growth stands. The long, clean boles, which are the striking characteristic of well-stocked southern pine stands, and which make possible the production of serviceable lumber from young trees, are well illustrated in Plate 1, A. The wood of the southern pines is adapted to a very large variety of purposes, which include construction timbers, dimension, interior finish, flooring, and special products. Longleaf and slash in particular are strong woods, and the heartwood of all species is durable. The lumber presents no serious problems in successful drying. Second growth in particular takes such preservatives as creosote very readily. It should, of course, be realized that young, quickly developed stands of second growth will not produce the same quality of lumber as the mature, slow-grown stands of virgin timber, and that open, wide-spaced stands will grow only very coarse lumber. The value of the pines for certain kinds of pulpwood is extremely high, because of the long fiber. No other American species have been successfully worked for naval stores on a commercial scale.

In ease of natural reproduction it would be hard to find species better adapted to timber growing than loblolly, shortleaf, and slash pines. Pine seed does not require a special soil for successful germination. It has been found to penetrate to mineral soil even through dense grass or underbrush, and to produce seedlings which are generally able to establish themselves. In spite of the variety and abundance of competing vegetation on southern pineland, the pines appear able, except perhaps under extreme conditions of poor soil and thorough establishment of brush, to grow up through the vegetation in numbers sufficient to make an excellent commercial stand.

Fires have been the greatest cause of failure of the southern pines to reproduce naturally throughout their range, and they are still a main obstacle to timber growing in the South. Yet in many respects the control of fire in this region is infinitely less of a problem than in other important forest regions. For example, it has been found that only a very minor proportion of these fires are set by lightning—the one agency beyond present human control. Man-made fires are preventable by man. Furthermore, the custom of burning the piney woods each year in order to freshen the pasturage is giving way before the southern stockman's growing realization that fires in the long run are as much of a hindrance to the stock industries as to the forest industries. Locality after locality in the
southern pine belt is demonstrating that once local people are convinced of the advantages to be derived from fire protection the prevention of fires is by no means impossible.

Like prevention, control of fire is on the whole easier in the South than in many forest regions. Although it is true that surface fires, if driven by high winds through dry grass or pine needles, are at times very difficult to stop, it is equally true that fire rarely mounts into the crowns of the trees. Fire fighting is vastly easier in the South than in forest regions where crown fires are the rule, or where fire may burn stubbornly for days in deep layers of decaying vegetable matter on the surface of the ground.

Finally, the damage done by fire to the average acre is less in the piney woods than in many parts of the United States. Of the millions of acres of pineland in the South which still burn over every year, only a portion—for the most part that bearing seedlings and saplings—suffers complete destruction of the timber crop. Half-grown stands are destroyed only occasionally, and mature stands rarely. Even under the best system of fire protection some land is bound to burn at times, but contrary to popular belief, it has been found that most fires are not appreciably hotter or more destructive on land long protected than on land frequently burned.

The southern pines have few serious enemies besides fire. Locally, grazing by sheep and goats may be destructive, but the number of sheep in the piney woods has steadily dwindled. More widespread, but by no means universal, is hog damage. Over perhaps a quarter of the longleaf belt hogs have played a part in keeping lands unproductive. Compulsory fencing, not only of hogs but of all classes of livestock, is gradually becoming the rule in the South. This will automatically eliminate grazing damage from areas definitely dedicated to timber growing and will perhaps go farther than any other one measure in overthrowing the practice of annual burning by stockmen.

No tree disease threatens to become a scourge in the southern pineries, although the needle blight kills some longleaf pine seedlings in their early stages. Among innumerable forest insects, a species of bark beetle occasionally becomes epidemic and kills considerable acreages of mature pine. The tropical hurricanes, which have wrought enormous local destruction to the virgin-pine forests of the South in times past, seem little likely to do comparable damage to the second-growth forests of the future.

The natural advantages of southern pinelands for timber growing are made doubly effective by their economic advantages.

Cheap land is still a characteristic of the southern piney woods. When timber was bought in the early nineties at $1.25 an acre the land was considered by the great majority of purchasers to have been thrown in; and even to-day the values attaching to bare land formerly in pine are very small. Large tracts of cut-over land, fairly well supplied with seed-bearing trees, may be bought for $2 to $10 an acre, and—what is of especial importance to those who would like to extend the life of their sawmills and other wood-using plants—land well stocked with young timber up to 10 or 15 years of age may be bought for $4 to $20 an acre. This is for the region as a whole; some at $10 is still available in every southern pine State.
stands, which within two or three decades will furnish saw logs, are being bought to-day in ever-increasing area by farsighted men interested in the perpetuation of going forest industries. Although the quality of the logs they will produce is generally below that obtained from virgin timber, now very hard to buy in large tracts, half-grown stands are often the better investment because of their cheapness and lower carrying charges.

As a result partly of the high value of their products and the proximity of the South to large and steady markets, the stumpage values of southern pines has risen in the last 25 years at a faster rate than have average softwood stumpage values for the United States as a whole. This is graphically shown in Figure 2, based on data compiled in the Forest Service by C. W. Boyce.

The flatness of the greater part of the coastal plain combines with the generally firm footing for logging animals to make this region

Figure 2.—The steady advance in stumpage value of southern pine. Longleaf pine includes slash also, and shortleaf includes loblolly. The South Atlantic States are Virginia, the Carolinas, Georgia, and Florida. The lower Mississippi States are Alabama, Mississippi, Louisiana, Texas, and Arkansas.
one of the cheapest in the United States for logging operations. Except in occasional extensive swamps, such as the Okefenokee in southern Georgia, where pine occurs in considerable quantities on islands, and in the Ouachita Mountains of Arkansas, removal of the timber presents very minor engineering problems. Timber of such size as to be difficult to handle, or country so rocky and elevated as to tax the ingenuity of logging engineers, is almost unknown in the South. Abundant resident labor, accustomed from boyhood to woods and sawmill work, is characteristic of the southern pineries.

The southern pineries are strategically located with respect to markets in the great industrial centers of the Northeastern and Central States and the agricultural Middle West. The center of this consuming territory is about 1,200 miles from southern Mississippi, which is now the chief manufacturer of lumber from virgin timber, but it is 2,750 miles from the west coast. The South itself is rapidly expanding its manufacturing industries and requiring increasing quantities of wood on its farms; it is thus already absorbing a remarkably high percentage of the output of its own forests. Although the total cut of southern pine was substantially less in 1922 than in 1925, the percentage consumed within the States south of Mason and Dixon's line (not including Missouri) increased from 42 to 51 in those three years.

Public interest in timber growing in the South, as evidenced by the establishment of State forestry departments, has awakened to an amazing degree. A forester was employed yearlong by Maryland as early as 1906 and by North Carolina in 1909. Virginia and Texas began active forestry work in 1915 and Louisiana in 1917. Since 1924, Alabama, Oklahoma, Georgia, Mississippi, Florida, South Carolina, and Delaware have undertaken the work. Only one State in the South remains without a forestry department. A substantial sentiment in favor of timber growing in this State, however, is evident in the employment of an extension specialist in forestry. The counties in several States have contributed funds. Powerful aid has been lent through cooperative expenditures of the Federal Government, and the example set on the national forests. Table 1 shows the degree to which the Southern States have individually taken the public action which must largely precede or at least accompany private action in timber growing.

<table>
<thead>
<tr>
<th>Table 1.—Annual appropriations for forestry departments by the Southern States for 1928</th>
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<tbody>
<tr>
<td><strong>State</strong></td>
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<tr>
<td>Delaware</td>
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<tr>
<td>Maryland</td>
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<td>Virginia</td>
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<td>North Carolina</td>
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<tr>
<td>South Carolina</td>
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<tr>
<td>Georgia</td>
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</tbody>
</table>

1 Because of variations in methods of appropriation and in fiscal years as between the States the figures given are not in all instances precisely comparable.
A 48-year-old Lobolly Pine Stand on a Good Site

The trees are from 10 to 20 inches in diameter at breastheight (4½ feet above ground), and about 100 feet tall. The man in the middle distance gives comparative size. Note the long clear length characteristic of the southern pines. Georgia.

Shortleaf Pine Kept Productive by Selective Logging

Contrast the 300 board feet to the acre developing yearly in this Texas forest with the very poor prospect for a timber crop from the land shown in Plate 2, C. For details see page 11.
Close cutting and fires have converted one of the finest virgin longleaf pine tracts in Louisiana (A) into a waste on which there is no hope here of natural reforestation and have rendered equally valuable land in Mississippi (B) a drug on the market. No one will purchase such areas when millions of acres of similar land, studded with seed-bearing trees and needing only fire protection to make them productive, are for sale at the same price. Similarly, on shortleaf land in Oklahoma (C), close cutting and fires have left the land leafy but unproductive. Of 68 shortleaf pines above 9 inches in diameter originally standing to the acre here, an average of only 1.3 ragged individuals were left in logging. The few pine seedlings that start on such areas must struggle against worthless hardwoods.
Taxes, which in some instances have undoubtedly borne heavily upon the owners of southern forest lands, are not generally so high as is popularly believed. Louisiana and Alabama have adopted a policy of deferring taxes on forests until the trees are grown.

**MEASURES NECESSARY TO KEEP FOREST LANDS PRODUCTIVE**

In spite of its great natural and economic advantages as a timber-growing region, the South in 1926 (the last year for which detailed figures are available) could boast of only a very small percentage of its 100,000,000 acres of cut-over pineland as fully productive of a new crop of trees. The condition of this vast area was estimated to be as follows:

<table>
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<tr>
<th>Description</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denuded, without young growth or seed trees</td>
<td>10,000,000</td>
</tr>
<tr>
<td>Not restocked, but having enough seed trees to restock under fire protection</td>
<td>18,650,000</td>
</tr>
<tr>
<td>Fully or partially restocked to saplings and cordwood</td>
<td>35,500,000</td>
</tr>
<tr>
<td>Fully or partially restocked to saw timber</td>
<td>36,750,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100,900,000</td>
</tr>
</tbody>
</table>

Fire protection will permit the restocking, in time, of the second class of land, but no amount of protection can bring about any change in the 10,000,000 acres in the first classification. Less than 1 per cent of the last two classes may be considered fully stocked.

Roughly 14,000,000 acres of virgin pineland remained in the South in 1926. Nearly 5,000,000 acres of virgin, culled, or second-growth pine stands are each year logged or destructively turpentine. On about 1,330,000 of these acres all seed trees are destroyed. Few acres indeed are left in a condition to restock fully.

Agriculture and other uses for pineland cut over or wrecked by turpentine do not begin to take the place of timber growing. Therefore all but an insignificant part of this land is likely to lie practically idle unless put to work again producing wood. The problem of unproductive or only partially productive forest land is not solving itself. Idle land is a liability to its owner and a drag on the prosperity of the community. How to keep forest lands productive is of deep concern to thousands of southern pine-land owners. It is of vital interest to scores of piney woods communities which depend for their prosperity and often their very existence on the continued operation of a sawmill, turpentine still, or some other forest industry.

Fire protection must precede and accompany all other measures to restore lands to productivity or keep them productive. Close cutting and heavy turpentineing, stripping the land of all trees big enough to bear seed, are a second cause of barren land. The reservation of seed trees on all areas not already well stocked with young growth is necessary to keep the land productive. Finally, in some localities, grazing by hogs, and less often by sheep and goats, so seriously interferes with young pines that some degree of protection

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1 "Denuded" and "not restocked" together comprise the area elsewhere referred to as "nonrestocked."
against it is essential. These three measures—protection against fire, reservation of seed trees, and (locally) protection against livestock—will keep the great bulk of southern pinelands from becoming a liability to owner and community alike. Only the 10,000,000 acres stripped of seed trees will remain barren indefinitely unless planted or otherwise artificially reforested.

FIRE PROTECTION

In the South, as in every other forested region of the world, control of fire is absolutely essential to the successful growing of timber crops. Fires are the overwhelmingly important cause of the complete idleness of 18,650,000 acres of southern pineland, and of the partial idleness of at least 70,000,000 acres more.

NECESSITY FOR FIRE PROTECTION

FIRES IN VIRGIN TIMBER

Except for an occasional tract where hurricanes, very severe insect attack, or an unusually destructive summer fire wiped out the old forest and made way for a new crop of trees all of one age, it is altogether probable that the virgin forests of southern pine were many-aged. That is, on any acre, or certainly on any 10 acres, pines were of all ages, and therefore of all sizes from seedlings to mature trees. The space occupied by the roots, and overshadowed by the crown, of a single mature tree was on its death filled by a large number of seedlings. As these seedlings developed into saplings, and the saplings into mature trees, competition for light and moisture constantly reduced their numbers. Hence it is believed that throughout the original pine forests of the South there was typically a greater number of trees in any given diameter class than in the next larger class.

This typical distribution of trees according to diameter class in two large tracts is shown graphically in Figure 3, A and B. Tract A contained over 100,000 acres, of which a 1,745-acre sample is represented in the diagram (26); tract B contained 15,000 acres, of which a 757-acre sample is shown (8). From a little over 1 tree to the acre in the 15 to 20 inch classes, the number of trees in a diameter class in tract A rose steadily to 14 in the 2-inch class. In tract B the rise from 1 in the 22-inch class to 7 in the 2-inch class was somewhat less regular. The general upward trend in number of trees from the large diameters to the small is nevertheless plainly evident in both tracts.

Fires in the original pine forests were apparently very largely confined to those set by lightning. Many trees were struck, then as now, but most of the resultant fires were extinguished by the heavy rains which normally accompany lightning in the South. Fires were perhaps occasionally set by the Indians for special purposes, such as fostering a new growth of grass and thereby attracting game to restricted areas where it might be more readily shot. If so, in the Indians’ sparing use of fire probably originated a restricted burning by the white owner of livestock, which later grew into uncontrolled and wholesale use of fire in the piney woods. From the evidence at hand, it is impossible to believe that the pine forest could have re-
Figure 3.—Fire leaves its mark on the virgin forest. Normally, as in tracts A and B, there are more small trees than large, but in tracts C, D, and E there are fewer trees of the smallest sizes than of the sizes just above them. More frequent fires account for the difference.
newed itself year after year during the centuries-long occupancy of it by the Indians, had the red man practiced burning as regularly as his successor. Most virgin forests of the twentieth century, until very recently swept with ever-increasing frequency by the white man's fires, are no longer all-aged, but are fast becoming old-aged. Proof of this may be found in Figure 3, C, D, and E, and in Figure 4.

For many years the rocky Ouachita Mountains of central Arkansas have been burned nearly as regularly as the longleaf pine lands of the coastal plain. Figure 3, C represents the stand on about 115,000 acres in the Ouachita National Forest. Although there are some irregularities, no doubt due to the methods used in tallying trees on the 5 per cent cruise, it is evident that the number of trees to the diameter class increases from the 32-inch to the 10-inch class, and then drops off markedly. Fire is responsible for this progressive decrease in the number of trees below 10 inches; no other known agency over a long period of time destroys the younger trees in such great numbers. Should these tracts continue to burn as regularly as they have in the past it is plain that the number of trees would constantly decrease, because there would not be a succession of small trees to replace the veterans that are bound to die. Fire would slowly but surely wipe out the forest. Fire protection as now established on the national forests will halt this process.

The remaining diagrams in Figure 3 represent tracts of loblolly pine in bottom-land mixture with both other pines and hardwoods. The Alabama sample consists of 226 acres out of about 3,000; the Arkansas sample is nearly three times as large. Both tracts show abnormally few trees smaller than 3 inches in diameter, but these are in markedly better condition than the shortleaf pine of the Ouachita Mountains. This accords with the generally observed fact that loblolly bottom lands (commonly called "hammocks") are less often burned than the uplands.

It is in the longleaf pine belt that repeated fires have most seriously threatened to destroy the original pine forests of the South. Four localities, in five States, are represented by the samples graphically shown in Figure 4. The samples vary in size from 124 to 2,651 acres, and the tracts sampled are about 20 times as large. On every tract there is a diameter below which the number of trees per inch-class drops off, instead of increasing as it normally should. This diameter in A and B is 4 inches or less, but in C and D it is as high as 14 inches. Without enough young trees coming constantly along to replace the mature trees that die, such forests are on the highroad to final extinction.

As a further illustration of the extent to which damage from fire (on longleaf land probably from hogs also) has kept down the productivity of virgin or lightly culled land, two brief studies made by the Southern Forest Experiment Station may be cited. More than 2 miles of strip survey were run through typical pure stands of virgin shortleaf pine in west-central Arkansas. At the end of each

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*This is not intended in any sense as a criticism of the fire-protective organization of the States named. Most of the tracts were examined years before those organizations began to function, and all were examined before their efforts could have given young growth a chance to develop.*
Figure 4.—The fiery path of destruction. Generations of the white man's fires have prevented young trees from developing to take the place of the old in virgin longleaf forests. Another century or two of repeated burning would wipe out the forest altogether.
chain the investigators carefully estimated, for the square tenth-acre which they had just run, the percentage of the area which was growing trees at full capacity. Full capacity was not judged in terms of mature or merchantable trees only; as long as the ground was covered by pines of any size in sufficient numbers to develop into a satisfactory stand the unit was considered to be growing to capacity. Occasional small patches of land in the immediate vicinity, obviously growing all the trees which they were capable of supporting, were the standard for judgment.

The entire area was thus found to be growing trees at only 53 per cent of its capacity; more than a fourth of the tenth acres were growing 30 per cent of their capacity or less, and less than a fifth 80 per cent or more. A smaller area of longleaf pine land in southern Alabama was similarly examined. The tract had been cut over to a 16-inch stump limit about 22 years before. The average unit was found to be working to only 30 per cent of its capacity, and only a sixth of the units at half capacity or better. On both these areas abundance of seed had obviously been produced for years; unmistakable evidence of many fires was the key to the half utilization or less of these forest lands by the timber crop now on them. There is no reason to believe them exceptional.

Fires in virgin timber destroy not only the young growth on which depends the normal renewal of the forest, but also the mature trees. Many veterans that would otherwise have remained sound for years are eaten into by repeated fires (pl. 4, A) and, weakened by rotting fungi and boring insects, to which they are thus exposed, drop out of the stand during heavy winds. In a typical virgin longleaf pine stand in central Louisiana (16) the loss in burned-down trees over a period of three years amounted to 3.5 per cent of the volume of the stand. A study by the Southern Forest Experiment Station (15) of typical virgin pine stands in Texas, Louisiana, Arkansas, and Mississippi showed that among 10-inch trees 12 per cent of all shortleaf and 20 per cent of all longleaf trees were visibly fire-scarred, and that these percentages steadily increased with the size of the trees to more than 50 per cent of those 35 inches in diameter. A greater frequency of fires in longleaf stands accounts for the greater damage to this relatively thick-barked species.

The butt logs of fire-scarred trees are reduced in total scale and in value of the merchantable material remaining in them. The value of the lumber obtained from 218 fire-scarred shortleaf pine logs in Arkansas was compared with the value of lumber from 218 sound logs, and found to be $10.20 less per thousand feet, gross log scale.9

FIRES IN LOGGING SLASH

Cutting of either virgin or second-growth timber leaves the land in the most hazardous possible condition except that produced by a hurricane or blow down. The density of slash or tops left on the ground following logging of course varies greatly with the number of trees cut and the closeness of utilization. It is safe to say, how-

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ever, that up to 40 per cent of the ground may be covered by slash on clear-cut areas of saw timber in good stand, about 25 per cent representing a common condition. A fire burning in pine tops within two years of logging will ordinarily wipe out near-by advance reproduction and may destroy grown trees as well.

An excellent second-growth stand of mixed shortleaf and loblolly pines and hardwoods in northern Louisiana was cut in July to a stump limit of about 12 inches. A September fire in the slash killed all standing trees below 4 inches d. b. h., and those 4 to 14 inches in the following percentages: Loblolly, 87; shortleaf, 69; and hardwoods, 67. (Pl. 3, A.) Another early fall fire in slash from a heavy virgin stand of the same species in central Louisiana caused losses in the remaining stand in somewhat different proportions, namely: 50 per cent of the shortleaf, 25 per cent of the loblolly, and 31 per cent of the hardwoods.

Within from six months to two years after logging the needles have dropped from the pine tops and the hazard is somewhat reduced, but the tops continue to be a fire menace until the smaller branches down to an inch or more in diameter have rotted and the larger branches are lying close to the ground. Longleaf pine slash will add materially to the ordinary hazard for five to eight years following logging of virgin timber, and the slash of the other pines for three to five years. (Pl. 4, B.) The tops of second-growth trees have little heartwood, and their slash, though temporarily very dangerous, rots within two or three years. Since about 1,350,000 acres of virgin pine are annually cut over in the South, and 3,600,000 acres of second growth, it is probable that between 14,000,000 and 17,000,000 acres of pineland would at any one time be in a condition of special fire hazard if the slash on all areas were left to rot.

Fires in Cut-over Land

The 18,650,000 acres of cut-over southern pineland which has already been referred to as possibly productive but at present completely idle is believed to have enough seed trees to insure a satisfactory stand of seedlings if fires are kept out; but under present conditions this vast acreage does not bear even the beginnings of a crop of pine.

The same abundant rainfall and long growing season which enable the southern pines to produce wood at an astonishing rate foster a luxuriant growth of grass, herbs, and sometimes brush on cut-over land. When this vegetation is frosted, or when it becomes dry through prolonged drought, it makes a fire hot enough to destroy not only newly fallen pine seed, but pine seedlings and saplings of considerable size. Portions of every tract of course escape burning, even in a fire which appears to make a clean sweep, and this may allow the establishment in spots of a fair stand of longleaf seedlings under practically yearly burning; escape of longleaf land from burning during the year following a good mast may permit excellent restocking to take place. But anything approaching annual fires in shortleaf, loblolly, or slash pine cut-over land will kill a great majority of all seedlings before they have reached 5 years of age.

The effect of fire on longleaf pine seedlings in cut-over lands over a period of years has been studied by the Southern Forest
Experiment Station at several points. Among them is a tract at McNeill, Miss., where E. W. Hadley found that 56 per cent of the seedlings survived after two years in a grazed pasture annually burned, as contrasted with 75 per cent in a similar unburned pasture. The first fire occurred when the seedlings were but 2 or 3 months old and the second about a year later. Since in an adjacent area which had not been grazed the fire loss amounted to 82 per cent, the 56 per cent survival in spite of burning may be laid to chance reduction, by grazing, of the fuel about some of the seedlings. The experimental tract is representative of a large acreage of longleaf lands cut over early in this century. About one-tenth of the pine area is occupied by seed trees left in the original cutting, about one-fourth by a fair growth of longleaf seedlings, and the balance is open land.

At Urania, La., longleaf seedlings on a small plot free of all older growth were first subjected to fire when about 14 months old. None were killed by this or four successive winter fires, and the loss in a second series of five fires was no greater than that from natural causes, including disease, in an adjacent unburned plot. But at the end of the 10 years of repeated burning the leading seedlings on the burned plot were only about one-third as tall as those on the unburned, and their measurable volume of wood one-thirtieth as great (20). The tenacity with which these longleaf pine saplings clung to life under the abuse of repeated fires is illustrated in Plate 4, C.

It should be clearly understood that very much greater losses will result from fires running in cut-over longleaf lands during the season of active plant growth. For example, a summer fire which swept a tract at Urania, La., very similar to that just described, killed 87 per cent of the longleaf seedlings 0.5 to 4 feet high, and 38 per cent of those 4 to 15 feet high. Those below 0.5 foot largely survived, as is commonly the case. The heavy damage was due in part to the fact that this fire was burning over land kept "rough" for nine years. But a winter fire in a similar rough at Urania killed only 51 and 10 per cent, respectively, of the seedlings 0.5 to 4 feet tall, and 4 to 15 feet tall.

The effect of repeated fires in cut-over shortleaf pine land is illustrated by a tract in Oklahoma. The tally of a typical acre a year after the last fire showed that there were present among a very large number of hardwood sprouts, 790 sprouts of shortleaf, on an average about a foot and a half tall, and no seedlings whatever. Pines more than 4 feet tall and up to 6 inches in diameter at breast height were totally lacking. Evidently fires had been killing back the shortleaf seedlings as fast as they appeared on the area, and at the same time greatly encouraging the multiplication of the hardwood sprouts. Were fires henceforth kept out of this land the shortleaf, which greatly outnumbered and completely dominated the hardwoods in the original stand, would have to contend with about three times their number of hardwood sprouts. On another tract in the same locality the fires were for some reason—possibly the presence in

10 "Rough" is a word used universally in the far South to mean "unburned." The same word as a noun indicates an unburned area.
The Destructiveness of Fire in Logging Slash

Trees as large as 14 inches in diameter were killed when a September fire swept this Louisiana stand six weeks after logging. Only 28 loblolly and shortleaf pines, out of 141 trees left standing to the acre, survived.

Young Slash Pine Stripped of Its Foliage by Fire

The needles that would ordinarily have remained green on the tree for their second season are nearly all on the ground. The tree's ability to manufacture food for growth is thereby reduced, Mississippi.
Fire protection would have been cheaper here. Stumpage enough to pay for a year’s protection of 100 acres is about to rot, or be burnt up in succeeding fires. This is a part of the longleaf stand represented by Figure 4, D; B, still a menace after four years, this shortleaf top in an Oklahoma cutting would add to the heat of a new fire. Note also that there are no pine seedlings in it, although just beyond the man they number over 9,000 to the acre. Needless to say, there have been no fires since logging. C, survivors of 10 fires. These longleaf saplings have survived 10 winter fires experimentally set to test their resistance, but the measurable volume of wood produced is less than one-thirtieth of the wood grown in an adjacent unburned stand of the same age. Urania (La.) branch, Southern Forest Experiment Station.
This second-growth loblolly pine in Louisiana appeared sound enough, although scorched by a recent fire. But the bark of the tree shown in (A) was dead over an old fire scar and was readily knocked off. An ax was used to chop back the callus of the tree shown in (A) and (B) revealing the full extent of the original wound.
A. Why burning of turpentine orchards is not always effective. A month after this orchard burned, enough straw, killed by fire, had fallen around the raked face to offset the raking. Note the excellent installation of cup and apron; B, the toil of heavy chipping and subsequent fires.

At least 28 per cent of the turpentine trees in this abandoned Florida orchard have died or been broken off by the wind. Table 8 gives the details.
Healed faces on (A) a longleaf pine and (B) a slash pine. Fire has been kept out of these abandoned orchards in Georgia and Florida for at least 15 to 25 years.
A, An unjustifiable sacrifice. As a protection against accidental fires at a dangerous season this entire turpentine orchard was burnt on a calm winter day. Yet the number of faces thus protected was only 12 to the average acre, and on some acres dropped to 2. After 100 years of burning this culled land in west Florida is rapidly approaching a desert. No type of land is more in need of fire protection than such deep sands; B, no green tree has ever been cut here. This virgin stand of longleaf pine in Florida has been destroyed by turpentineing and fires alone.
places of unconsumed slash—more spotted, but usually severe enough where they did burn to kill the shortleaf outright. Here about 200 pines per acre between 1 foot in height and 6 inches in diameter had survived—a mere remnant of a full stand.

Loblolly pine, because it lacks the shortleaf's ability to sprout, is more often wiped out by fires when in the seedling and small-sapling stage. Slash pine, on the other hand, is somewhat more resistant than shortleaf, but cut-over land can reproduce to none of these species unless fires are kept out.

What has been said in the foregoing paragraphs about fire in cut-over lands of course applies also to old fields just reseeding to pine.

Fires in Second-Growth Stands

The vigorous trees more than 5 feet in height in sapling longleaf stands, and more than 10 feet high in such stands of the other chief pines, are not generally killed by occasional winter fires. This is because their bark near the ground has become a quarter to half an inch thick and because only the surface layer of fallen pine straw, or leaf litter, is usually consumed by such a fire. The lower layer is damp and remains unburned. Nevertheless, such stands if burned at all frequently are certainly retarded in their growth (14). Their foliage is killed (pl. 3, B), and the valuable mulch of fallen pine straw is on the average much shallower than on unburned land. "Cat faces," or wounds on trees at the base, which are common on large trees in the virgin forest, are less frequent in second-growth stands. Nevertheless cat-facing does occur in second-growth stands, although there may be no outward sign of the injury for years after the fire. The seriousness of such wounds is illustrated in Plate 5.

A fire is sometimes hot enough to run through the crowns of young pine in dense stands, and is then very destructive. Also, fire during the spring or summer always damages and in extreme instances may even totally destroy stands of well-grown southern pine of any species. The effect of such fires is variable, because conditions are never quite the same. There is evidence that the season of burning and general weather conditions have much more to do with the severity of damage than has the density of inflammable material on the ground. Several years' accumulation of litter—pine straw, hardwood leaves, dead grass, fallen bark and branches, and similar material—beneath a heavy stand of timber, may add to the severity of a fire. This, however, does not justify the practice sometimes advocated of removing this accumulation by periodic burning, for this accumulation does not normally exceed about 4 inches, even in stands which have been kept rough for years; after about the third or fourth season rot and oxidation of the litter keep pace with its accumulation. Very rarely does the litter beneath a southern pine forest reach a depth of 6 to 8 inches. Moreover, the entire layer of inflammable material dries out completely only during a prolonged drought, and if the surface layer alone burns the fire is not very hot. The point to be emphasized is that whether the woods are rough or otherwise, a fire during the growing season is likely to cause serious loss even in saw-timber stands.
Fire in a turpentine wood will often result in very heavy loss. As long as the trees are being worked it is the practice every winter to rake away the accumulated pine straw, chips, spilled gum, etc., from the base of the chipped trees, and to burn the orchard on a damp, calm day. Although this reduces the amount of flammable material to some extent, and keeps any later fires away from the faces in most instances, it by no means makes the orchard fireproof. Raking and burning are often done before the straw has ceased its normal late-winter fall, and the burning itself will sometimes cause a subsequent fall (pl. 6, A) that very promptly restores the risk of fire in large measure. As the season progresses, chips, spilled gum, and fallen scrape constantly add to the fuel at the base of the trees. When, therefore, a fire gets started during a mid-season drought it is readily carried across the raked ground to the resin-covered face. The average loss in labor, gum, and equipment (both cup and gutter are generally warped or otherwise injured beyond further use) is about 15 cents to the face, and from 5 to 20 per cent of the faces must be abandoned, at least for the season, entailing a further heavy loss. Many other faces dry out somewhat and fall off in yield. Furthermore every burned face that contributes to a dip lowers the grade of rosin obtained.

The greatest damage to the tree itself occurs, however, after work has been abandoned and the unraked face is exposed to fires. The pitchy surface kindles readily, and in a very few years the tree is either killed outright as it stands or is so weakened by rot or a very destructive boring insect as to blow down. The damage, of course, varies from tract to tract, and depends on the number of fires since the operation was concluded. On two typical areas in south Georgia and north Florida 15 to 33 per cent of all chipped trees were found to have died. (Pl. 6, B.) These percentages are undoubtedly conservative, since down trees soon rot or disappear in successive fires, and can not be counted. How many of the trees would have died as a result of the chipping alone it is impossible to tell, but it is significant that in two of the very rare instances where fire was excluded from an orchard for some years before chipping, as well as for the 12 to 16 years since chipping, healing of the faces has progressed rapidly (pl. 7), and only an occasional down tree is to be found.

A Standard of Fire Control

From the preceding pages it should be clear that although the degree of damage from fire suffered by pine stands of various species and ages and under various conditions may vary from complete destruction to mere stunting of growth, injury is never absent, and that in the face of repeated fires the forest can not renew itself. If southern pinelands are to be kept even reasonably productive they must be protected against fire during critical seasons and also during critical periods of several years in the development of the forest.

Any extensive tract of forest land in the South will always include some land that would suffer severely if burned, and this is true even
of many tracts as small as a farm woodland. But it will be practically impossible to give such land the protection it requires if neighboring areas less in need of protection are allowed to burn. Fires starting in mature timber sooner or later will endanger seedlings and saplings; or the smoke of burning turpentine woods will put fire lookouts out of commission or make effective patrol impossible in adjacent young growth. In other words, thorough-going protection is necessary for all classes of land. This does not mean, of course, that special protection should not be given certain classes that are susceptible to very severe damage; quite the contrary. If southern pineland in general is to be kept productive, it is believed that the proportion burned over yearly must be reduced to 3 per cent. If this is done, then by special protective measures it should be possible to keep the average loss to 1 per cent in turpentine woods, slash-covered areas, and young growth generally.

It is impossible to offer rigid proof that these or any other percentages are a necessary standard to set. It can only be said that they have been generally accepted as fair by the men in charge of forest-fire protection in the several Southern States, and that they are far below the standards commonly accepted in other forest regions. In judging them it is worth noting that during 1927, according to figures compiled by E. L. Demmon from State foresters' and other reports, exactly 3 per cent of the 51,591,000 acres then under organized protection in 11 States was burned over. These figures include some land outside the southern pine belt. Owing no doubt in part to varying degrees of protection given these lands, the percentage burned over covered a range of 0.3 to 10, but 7 of the 11 States had kept the losses in their protected areas to 3 per cent or less.

If the average area burned over yearly is as high as 3 per cent, in bad years this percentage is likely to be doubled, trebled, or quadrupled. Moreover, even though the average for an entire tract is kept as low as 3 per cent, some of the land is certain to burn very much oftener than once in 33 years. For example, if fire is successfully kept out of all stands of young trees, say, for the first 10 to 15 years following cutting of the old stand and the establishment of a new growth, the remaining stands, including perhaps two-thirds of the area, may suffer a loss of 4.5 per cent yearly without the average for the entire tract exceeding 3 per cent.

In order to keep the average yearly loss in southern pinelands generally to the figure given, it will probably be necessary to establish what is known as "1-hour control." This standard is, of course, generalized; since fire ordinarily spreads more rapidly in longleaf land than in shortleaf, fires should be reached more promptly in the former. Also in turpentine woods, on areas covered by slash or tops, and on areas of young growth below the age of fair resistance to winter fires, it will be necessary to better this whenever possible, and to take additional measures to reduce the hazard or facilitate fire fighting.

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11 By 1-hour control is meant the organization of fire-protective systems in such a manner that a fire will ordinarily be reached within one hour after it starts by a force of men adequate to control it.
Forest-fire protection of private lands in other parts of the United States has always been most effective when handled through a combination of public and private effort. There is no reason why the southern pine region should prove an exception.

Since the protection against fire of any areas in the coastal plain of the South is a development of recent years, and since up to this time funds for thorough-going protection have not been available in more than a few localities in the piney woods, no final specifications can be drawn for a fire-protective system capable of reaching the standards set up. Inasmuch as local circumstances always require the modification of a generalized system in any forest region, all the more promising known alternatives in the way of fire organization are mentioned below. Again, although for the sake of clarity the obligations of the public and the part necessarily played by the private individual are listed under separate heads, no hard and fast rule can be drawn as between public and private endeavor.

The Public’s Obligations

Every southern State that expects its citizens to keep their timberlands productive should (1) furnish at least a skeleton system of state-wide fire protection; (2) should educate the public in the seriousness of the fire problem and the need for care with fire in the woods; (3) should enact laws penalizing unlawful use of fire and provide for their efficient administration; and (4) should eliminate special fire hazards.

State Fire Organization

Experience has shown that at the head of any State fire-protective organization there should be a State forester or a State firewarden experienced in organizing and directing the work of others, trained in appraising the physical resources and risks represented by various classes of timber and types of forest, capable of educating the public, and unhampered by political pressure or other considerations outside of the necessities of his job.

The first step in localizing the fire-protective system of the State will ordinarily be the assignment of a division forester or division firewarden, employed yearlong, to each unit of about 2,000,000 acres of forest land. These men should take a leading part in the work of public education and should direct and coordinate the work of the rangers, lookouts, firewardens, and patrolmen, who are specifically engaged in the vital business of detecting and suppressing fires. Since the territory covered by each will comprise from four to a dozen counties, these men must possess most and preferably all of the qualifications of the State firewarden himself.

The second step in localizing the State system is the separation of each division (2,000,000 acres) into about 10 ranger districts, each in charge of a ranger employed by the month during and a

The duties and period of employment of these officers should not be confused with those of a ranger on a national forest. No exact parallel in terminology is possible as between a State fire protective organization, such as here described, and the administrative organization of the national forests.
little before the fire season, or from six to eight months, depending on weather conditions. The qualifications of these men include intimate knowledge of the country in which they are employed, and of its inhabitants, combined with acknowledged leadership or at least full respect in these communities. Their work consists in planning and administering, under the general direction of the division foresters, the local system of fire detection and suppression. They should take charge of fire fighting on serious fires and assist, chiefly by personal contact, in educating the public.

The local system of fire protection will ordinarily include lookouts in towers or on hilltops, to detect promptly every fire occurring in the surrounding territory, and resident firewardens, to whom the lookouts report by telephone all fires as soon as seen, and on whom rests the burden of actual fire fighting. The employment of "smoke chasers," or one or more extra men constantly at the fire towers and available to go at once to a fire as soon as it is seen, sometimes has advantages. An alternative to the tower method of detection is a system of intensive patrol, under which the same man is responsible both for the discovery and the fighting of fires within a small territory.

The location and manning of lookouts, the hiring of smoke chasers, the selection of both resident wardens and patrolmen at the most advantageous points, and the location of telephone routes are the chief business of the rangers in advance of the actual fire season. Once fires have become frequent, they will have their hands full keeping the whole organization working as a unit, and taking charge of emergency situations. During lulls in the season, and as far as possible at all times, the rangers should take advantage of their constant travel throughout the territory to preach the doctrine of fire protection, to keep close watch on those suspected of setting fires, to enlist the active help of those favoring protection and, in general, to bring the fire organization into direct contact with the local population. As the work becomes more highly organized it may be desirable to have located at each ranger's headquarters a central dispatcher, who, whenever a lookout reports a fire, dispatches to it the resident warden or other person most available for fighting the flames. Such a central dispatcher can thus relieve the ranger of much routine work and leave him more free to meet emergencies.

Fire towers and lookouts should not be considered as anything more than a means of detection. That is, the towermen should not be expected to leave their towers and go several miles to a fire, since in their absence far more serious fires may go unreported. Fire towers are of very small value unless connected by telephone with the men whose main job it is to suppress fires after they have started. One hundred and twenty-five thousand acres may be observed from a tower of average range (about 8 miles) in the comparatively flat coastal plain. Towers closer than 16 miles apart, so that the same fire may be picked up by two of them and hence readily located on a map, are of course an advantage. The lookouts should be on duty during all periods of real fire danger, or five to seven months in most years. A longer period of service, coupled with the employment of smoke chasers, may prove an economy if local wardens are paid for more than their actual services on the fire line;
that is, at the beginning or end of a fire season, when fires are comparatively few, a lookout and one or two smoke chasers may cost less than several local wardens. Since fires are often easier to see at night than by day, a night lookout is sometimes worth his cost.

The responsibility of the State may under unusual conditions end with the ranger force, or with the lookouts. Where holdings of a private landowner are large and compact the State can perhaps turn over to him the erection of fire towers, and the employment and direction of a local protective force. But if ownership of land is divided, or if the holdings of the large owner do not lie in a compact body, the State should carry on this work at the landowner's expense. Because the financial obligation for local effort is squarely on the individual benefited, further discussion of the local protective work is deferred to the section entitled "The Landowner's Part."

Education of the Public

A very large proportion—probably 95 per cent or more—of the fires occurring in the southern pine region are man-caused. The custom of burning the piney woods has already been described as of very long standing, and fires have gradually become so familiar to the average southern citizen as to be regarded as almost inevitable. A carefully planned and patiently executed campaign of education in behalf of fire control must therefore precede and accompany any effort at actual fire fighting. Just so long as the public believes that fires in the woods and cut-over lands are beneficial, or that they do no harm, every effort to control fires will prove unavailing or hopelessly expensive. Just so long as the public feels no need for care with its matches, smokers' materials, camp fires, burning of brush and trash, and other sources of fire in the woods, the most elaborate system of fire protection will be only moderately successful. The prevention of fires by persuading people not to start them is a foremost and never-completed task for every member of a forest fire protective organization.

Under the general direction of the State forester or firewarden it is the job of the State to educate its citizen in the facts of fire damage and the necessity of fire protection. The more formal methods of education are best handled by the yearlong employees, who should obtain systematic publicity for timber growing and fire protection by furnishing items and longer articles for the daily and weekly press, by preparing special circulars and bulletins, making public addresses, supplying moving pictures, erecting exhibits at schools and fairs, and by employing every other medium known to modern advertising and public education. Such education must cover not only the forest communities, but also, in this day of automobile travel and the increasing enjoyment of outdoor recreation, the cities as well. The less formal but often equally effective method of educating people by personal conversation should be used in season and out of season by the entire protective force.

It is peculiarly the task of the State to carry on the educational campaign against fires, because no one landowner can have much success in keeping fire out of his property if surrounding owners are indifferent to or actively opposed to fire control.
The work of fire protection must of course have ample warrant in law at every stage. Most southern States to-day have a fairly comprehensive forest-fire code. In the South, for the present at least, it is probably necessary to concede the right of the individual owner to set fire to his own land if he chooses. In towns and cities this is denied him, on account of the impossibility of confining fire effectively to a single building in a crowded community, and in many States a permit to burn brush on one's own land is now required. The forest-fire law should at least place definite penalties on one who sets fire to his own land without exercising every precaution to confine it there, and of course more severe penalties on those who set fire to the property of another. Civil damages should be made collectible in both cases. The law should provide for the deputizing of the State's authority under certain definite conditions, this authority to include the right to arrest violaters of the law, and to call upon able-bodied citizens for fire fighting within reasonable distances of their homes. Permits for building camp fires on another's land, where no prohibitory notices are posted by the owner, may reasonably be required by law under some circumstances.

As a practical matter no code of forest-fire laws should be enacted which public sentiment at the time will not make enforceable. Protective regulations so severe that it is not possible to enforce them under ordinary conditions are worse than no law at all.

Elimination of Special Hazards

The State may also be expected to eliminate special fire hazards, either by direct action of its own or by requirements placed on those responsible for them. For example, it should require all trunk-line railroads not using oil as a fuel in their locomotives to keep their rights of way in as nearly a fireproof condition as possible by annually burning, at a safe time, the inflammable vegetation along the track, or better by mowing it. The State should also either require such screens or other devices in the front ends of all locomotives, and on the ash pans, as will prevent so far as possible the flying of live sparks; or, during seasons when hazard is very high, it should require railroads to employ fire patrolmen to follow their trains over stretches of track where it is mechanically impossible not to throw live sparks. It should have the same authority to require patrol and the use of a somewhat different type of spark-arresting devices on logging railroads and operations. The State may to advantage have the authority to fireproof its highways; that is, to burn off the vegetation on each side of them to the full width of the right of way, and possibly, under definitely prescribed conditions, beyond it. However, among several objections to this sort of work may again be mentioned the fact that smoke from fires of any kind may interfere with both lookouts and patrol.

The Landowner's Part

The organization thus far discussed is largely a skeleton organization, built to carry out the vital program already described of preventing fires by public education, of providing means for detect-
ing fires, and in general of coordinating the efforts of many individuals into an effective whole. However, since no amount of legislation and education will altogether prevent accidental fires, and since there will always be some deliberate burning of the woods, a skeleton organization alone will not reduce annual losses to an average of 3 per cent or less. It must be supplemented by further manpower. The direct return to each forest-land owner from keeping his property productive makes it reasonable that he provide this supplemental protection himself, or bear its cost. The farmer with a small woodland adjacent to his home contributes his own labor and that of his family when fire breaks out in or near his forest. The logger or naval-stores operator who has men at work on his property may reasonably be expected to go much farther and to organize his crews for fire protection. This is especially so of the logger, because his own logging machinery is a frequent source of fire, and because he constantly creates an extra hazard with his slash. The nonresident owner of cut-over land may not be able to contribute either his own labor or that of employees to fire protection, but he should certainly bear the cost of labor furnished, organized, and directed by the State.

Except for the construction of fire lines, the work of the private landowner will be largely confined to the fire season. It should be clearly understood, however, that the fire season in the piney woods is not invariably the same from year to year, and that conditions ripe for burning may develop at practically any season. Although the so-called “normal” fire season extends through the fall and winter months, it has already been emphasized that the most destructive fires of all occur during droughts in the vegetative season. Any system of fire protection must therefore be flexible and meet the needs of each particular season, abnormal as well as normal.

**Protection of Farm Woodlands**

A small forest tract, separated from other woodland by plowed fields, and within sight of a farmhouse inhabited the year around, is safer from fire than the great bulk of the piney woods. A fire promptly detected and reached can often be handled by the farmer alone, and in any farming community volunteer help is generally at hand in emergencies. Additional protection against fires burning into the woodland from outside may wisely be given by plowing fire lines completely around the tract, or on the sides exposed to outside fires. The details of fire-line construction are given under the later heading of “Protection of turpentine woods.”

**Protection of Large Tracts**

**Local Organization**

On large tracts, if fire towers are used, 1-hour control can be furnished by one resident warden to about 25,000 acres, or if no fire towers are used, by one patrooman to about 10,000 acres. As earlier explained, the towerman is not expected to fight fire himself, but is connected by telephone with resident wardens, and may be assigned one or more smoke chasers. The wardens are generally resident farmers, who work about their farms except when needed for actual
fire fighting. If there are no towers, both detection and fire fighting
must be cared for by one individual, best designated as a patrolman,
who spends his time during really dangerous weather in driving or
riding about over his district. The "timber man" or "woods
rider," employed by every sizable lumbering or turpentining opera-
tion will serve more or less as a patrolman, but dependence should
rather be placed on some one whose sole job during the fire season
is fire protection. Both warden and patrolman should have an
automobile or horses available at all times, be well provided with
tools, and have telephone connection with three to five additional local
fire fighters.

Except for a small annual retainer, most wardens need be paid
only for days spent in fire fighting. If they can not be hired on
this basis, smoke chasers may be more economical. Perquisites in
the form of free installation and use of a telephone, and of course
payment for necessary travel and supplies while engaged in fire
fighting, will help to make the resident warden job attractive. The
patrolmen are similarly paid only for days actually spent on the
road, and for their transportation expenses, although it may be
necessary to guarantee the equivalent of a minimum number of days
pay during the season.

The organization of an auxiliary force of fire fighters in the
neighborhood is an extremely important part of good local fire
organization. In favorable weather one or two men can extinguish
a small fire, provided they are hard workers, are skilled in such work,
and are equipped with adequate tools and fire-fighting devices. A
competent resident warden or patrolman can be depended upon to
handle alone a good proportion of the fires which are reported to
him or which he himself discovers. But when the woods are more
than ordinarily dry, or when high winds blow, half a dozen men are
needed to extinguish all but the smallest fire. The resident warden
or patrolman should have an agreement, well in advance of any
actual emergency, with at least six neighbors to turn out at once on
his request for aid in fighting fires. For work within a fixed dis-

cance, say, 3 miles from their homes, these helpers may not expect
pay, because of common interest in a community affair; beyond
such a distance it is fair and desirable to pay them at current rates
for day labor. Careful selection of the men, and requirement of
faithful service while on the fire line, will generally prevent any
deliberate firing of the woods in order to create work in slack seasons.

In parts of the South, particularly the longleaf pine region, it
will be difficult to find enough qualified residents to serve even as
wardens or patrolmen, and almost impossible to organize locally any
supplementary force of fire fighters. Under such circumstances
landowners may find that it pays to locate wardens and patrolmen at
desirable points by furnishing them farm land and even some
improvements at a nominal rent. The problem of supplying extra
fire fighters may be solved by cutting down the size of the districts
covered by these men, which will not only reduce the arrival time on
fires and the consequent difficulties of 1-man control, but will also
allow several wardens to work together on a fire. Lumber com-
panies should plan to send to bad fires certain crews engaged regu-
larly on other work, such as section crews, knot gatherers, tie hackers, and the handy men inevitable to any large woods enterprise. Turpentine operators, or other employers of labor in forest communities, may be expected to do likewise. Provided the problem is attacked with determination, the local fire organization will not be found as difficult to set up as might be at first expected.

The organization and direction of the local forces for general fire-protective work is ordinarily the task of the State. If each individual landowner erects and mans his own fire towers, hires his own resident wardens, smoke chasers, or patrolmen, and fights his own fires, much lost motion is likely to result; again, a few owners may be left to bear a burden which should rest on all in proportion to the size of their holdings. A single property left unprotected in a community endangers all of the neighboring properties being protected, and the bungling or carelessness of a fire-fighting crew on one tract can set at naught the best efforts of a good crew on an adjacent tract. For this reason the location of fire towers and the selection and direction of local men should be in the hands of the State rangers, backed by the training and experience of the State and division firewardens. The State may then reasonably seek reimbursement from the landowners benefited.

It can not be overemphasized that methods of organization and the intensity of the protection given forest lands should be fitted to local conditions.

FIRE PREVENTION AND ORGANIZATION IN WOODS OPERATIONS

On current logging and turpentining operations, no one factor will contribute more to the success of fire-protective efforts than a whole-souled desire on the part of every employee, from the water boy up, to prevent fires. Until these men realize that their employers are in dead earnest about fire control and that their own present and future jobs depend in very large measure on success in this endeavor, no resolution of a board of directors or order from a general manager will accomplish much. Education of his entire organization in the necessity for preventing and controlling fires, and for setting their personal example in care with fire in the woods, is the landowner's first and most important job in fire protection. If the landowner does not log or turpentine his own woods it is none the less his gain to see that those who perform this work for him are as insistent on fire protection as he would be.

One of the chief causes of fire in logging operations is sparks from the stacks and ash pans of locomotives, steam skidders, and loaders. Since few logging railroads run exclusively through the logger's own lands, and all of these devices operate in land covered with slash or tops, where fires spread easily to adjoining lands, a definite obligation rests on the operators to prevent, as far as possible, firing of the woods. The use of oil as a fuel should be encouraged, since this reduces to negligible numbers the sparks escaping from stacks and ash pans. The next best protection against the escape of sparks from the stacks of locomotives is probably the use of some form of "cabbage-head" stack. This device consists usually of an inner cone fitted over the ordinary straight smokestack and surrounded
by an outer jacket, in which the sparks emerging from the stack and striking against the cone are whirled about and broken fine before emerging from the jacket. Provided such stacks are properly adjusted, they have been found by repeated experience to be entirely practical at medium or low locomotive speeds, even on very heavy grades; they are less adapted to running at high speed. Their use in good repair has been found to reduce fires from locomotive sparks to a very small percentage of those caused when reliance is placed wholly on screens in the front ends. Screening the front ends appears to be all that it is practicable to do with trunk-line locomotives. The manufacturers of skidders and loaders have developed spark-arresting devices which substantially reduce the number of fires from the use of such equipment, provided an honest effort is made to use them and to keep them in first-class shape.

Elimination of fires resulting from ash-pan sparks is very much simpler; any good mechanic can put an ash pan in such shape as to prevent the escape of sparks, without seriously interfering with necessary dumping. Dumping should always be done in safe places.

If for any reason cabbage-head stacks can not be used on dummy engines, a patrol following each log train will generally be found to be more economical and satisfactory than burning fire lines along the rights of way. In the South, the extensive use of trams permitted by the absence of hills makes the burning of fire lines a very expensive proposition. Moreover, no fire line can long be depended upon which runs through standing timber; the burning of the lines causes a heavy leaf fall from standing trees, which within a few weeks after the fire is sufficiently inflammable to catch from locomotive sparks.

Prevention alone is not enough. Loggers and naval-stores operators will wish to organize for actual fire fighting. A very important feature of fire-fighting organization in logging and turpentining operations, both large and small, is the designation of some one individual at each camp or still to be responsible for extinguishing fires. This should make it possible to get a crew of fire fighters to a blaze in turpentine orchards or logging slash within half the time allowance set for efficient control of fire in the piney woods generally. The camp fire boss should be skilled in organizing fire-fighting crews, and in addition should have full authority to call upon any of the logging or turpentining crews to fight fire. He should have appropriate legal authority from the State as well. He must have at his disposal all necessary fire-fighting tools, and ought further to organize his work by appointing at each skidder and loader, and on any other main division of the logging or turpentining job, some individual whose responsibility it is to begin fighting fire whenever necessary.

**PROTECTION OF TURPENTINE WOODS**

The present practice of raking around all chipped trees in turpentine woods, which is a valuable insurance against the heavy losses possible from accidental fires, may have to be continued for the present in most localities, even where preventive means are taken. But raking will be more effective under a system of fire protection than without it. Raking early in the winter, before the pine straw
ceases falling, is by no means always effective. If, however, a thoroughgoing system of fire protection permits delay until the end of January, raking will render a 2½-foot circle about the base of the trees reasonably clear of inflammable material until early summer, when the presence of green grass, weeds, and similar low vegetation will reduce the fire hazard considerably. A mid-season raking might sometimes be justified by prolonged dry weather which intensifies fire danger. On the other hand, success in fire protection may in time make raking unnecessary; in restricted localities it is in fact already dispensed with.

Burning of turpentine woods after raking, although a custom forced upon the industry in the past by universal carelessness with fire in the piney woods, and further justified by the difficulty of getting about brush-grown woods with dip buckets and scrape boxes, has no place on forest land which is to be kept productive. It has already been emphasized that virgin longleaf pine forests are very open. There is a striking lack of small trees and of young growth, chiefly because of the decades of annual fires. Burning the turpentine woods intensifies this condition. The average acre of virgin timber in the western part of the naval-stores territory has from 40 to 80 faces to the acre, and on the poorest acres the number drops far below this. Yet the entire acre, of which less than half may be utilized by the chipped trees, is under present conditions regularly burned over during the two or three years of turpentinining.

Forty faces to the acre, on land capable of supporting several times as many, is the common average for second-growth stands in south Georgia and north Florida, which to-day produce over half the Nation's naval stores. Since under conservative methods it will pay to work these second-growth stands probably 12 to 15 years, their annual burning condemns the unused space within them to idleness for a period amounting to half the time necessary to bring seedlings to chipping size, and a third or fourth the time needed to grow a crop of saw logs. In culled lands, where the number of faces to the acre may fall to as few as 10 or a dozen, a still higher proportion of the land is kept idle by the annual turpentine fires. An extreme case is illustrated in Plate 8, A.

The evil results of fire in turpentine woods are not confined to a sacrifice of the producing power of a large part of the land in open stands. They may extend to a serious crippling of the whole system of fire detection in the region. Smoke from an extensive burn will so fill adjacent land as to render fire towers useless, often for days afterwards, and greatly reduces the effectiveness of patrol. Furthermore, the use of fire in the woods under any conditions, however plausible, introduces an element of risk and uncertainty into fire protection that increases its difficulty enormously.

As a substitute for annual burning, but not at present for raking, a system of fire lines, or firebreaks, is recommended. Fire lines are intended to afford a place from which a crew may safely set back fires, when direct fire fighting is impossible because of high winds or dryness of the forest. The lines are not expected to stop a fire outright save in very calm weather or at night.

The most generally useful line consists of plowed furrows, or a line raked or hoed to mineral soil, about 6 feet wide. This is about
5 furrows if plowed with an ordinary turning plow, or 3 with a middle burster. It is particularly important that the lines shall not run close enough to standing trees to receive any large amount of leaf fall; they may usually be crooked to avoid the trees, but occasionally trees near the lines will have to be cut. The felling of all snags and dead trees 15 feet or more in height within 8 rods of the furrows will also be necessary, in order to prevent sparks from blowing across the fire lines.

An alternative type of fire line to that just described consists of a burned strip, 50 to 100 feet wide, between plowed lines one or two furrows wide. It is a question whether snags need be felled for 8 rods on each side of this line. If not, this type of line will be the cheaper, and has the further advantage of sufficient width to be able, if freshly burned, to stop a bad fire even in the absence of any fire fighters. But it is open to several objections. It keeps in permanent idleness a substantial area. Grass and brush grow up quickly on it, and may greatly lessen its usefulness. Burning the strip between the furrows is uncertain and expensive, because the weather is often unfavorable at the very time it is most necessary that the work be done. Finally, the burning may fill the country with smoke on days when everything depends on clear vision for the lookouts or patrolmen.

Turpentine woods should not be blocked out by fire lines into units of fixed size, but should be divided on the basis of number of faces. No rigid limit can be fixed on the number of faces included in a block; 1,000 faces, representing an investment in gum and equipment of $100 to $150, is probably a satisfactory standard toward which to aim. Although experience in fire-line construction in flat or rolling sandy land elsewhere in the United States points to the desirability of keeping to a rather mechanical system of square blocks, in parts of the southern pine belt it may be better to depart from it. Portions of the coastal plain are dotted with ponds and crossed by drainage ways which may be so wet most of the year as to prevent fire-line construction, but which during bad droughts may be so dry that fires cross them readily. In such territory fire lines must for the most part follow the low ridges rather than straight lines across country. The units inclosed are therefore irregular in shape and size.

That fire lines are a means of stopping fires which no amount of man power could handle has been demonstrated in the longleaf pine belt time and again. For example, several hundred acres of promising young slash pine plantations in southeast Louisiana were in the path of a fire one dry, windy night in January, 1927. Up to the time it reached the fire line surrounding the plantations the fire had burned about 200 acres of cut-over longleaf pine land in the short space of 20 or 30 minutes. Two crews of fire fighters had arrived just ahead of the fire and were prepared to attack it from the line when they found that the line alone would hold it without any manual labor whatever. This was a burned line 50 to 150 feet wide, between two single furrows. In March, 1928, because the fire-fighting crews had no time to back-fire from it, a similar line was jumped by a fire burning across hilly cut-over land, but the next line down the wind held. This fire was set by incendiaries after mid-
night of a parching day, and was driven by a terrific north wind. Crews reached the fire so rapidly as to catch the incendiaries red-handed, but would have been helpless to hold the fire without the aid of the fire lines. The owners of the land involved in these instances have built 475 miles of fire line through it, and spend $3,000 to $5,000 a year on this form of fire protection. In the State of Louisiana as a whole forest owners have built 2,000 miles of fire line, and a single landowner in southern Georgia, over 200 miles.

**PROTECTION FOR SLASH AREAS**

Special measures are necessary for the protection of land covered with slash or tops from recent logging. If the slash burns on such land, both young growth and seed trees are threatened with complete destruction.

A little experimental evidence, coupled with general observation, indicates as earlier stated, that the slash from virgin longleaf pine timber requires 5 to 8 years to rot enough so that it will not add appreciably to the heat of a fire. Tops of other species in the virgin stand, having less heartwood, take 3 to 5 years. Second growth of any species up to the age at which it is usually cut has almost no heart in the tops, and the slash rots in 2 or 3 years. Close utilization in the tops, which reduces the quantity of large-sized material left on the ground, greatly hastens the process of rotting and may shorten the danger periods in virgin timber by 1 to 3 years, and in second-growth slash by perhaps a year.

The first step in the protection of slash areas is to pull all tops and logging débris away from the base of the seed trees. This is a precaution against complete denudation of areas which may burn in spite of every effort to protect them. In virgin timber, where tops are heavy, this work will require the use of a horse or mule, but in second growth a good axman can readily cut up the average top and drag it away piecemeal by hand to the required distance of about 15 feet. A main trunk or large limb, unless containing enough heartwood to "lighter" (become pitchy) rather than rot, is not as dangerous as the inflammable smaller branches with their dead foliage, and need not be removed. Provided felling crews are properly impressed with the need of keeping tops away from seed trees in cutting the surrounding stand, and swampers and skidder crews use the same caution when getting out the logs, not much large material will require removal. In very heavy slash all that it may be practicable to do with an occasional top is to lop it, that is, limb it and leave the limbs as close to the ground as possible. Pulling or lopping should follow immediately after the logs have been skidded out.

Until the tops have rotted to a point where they do not constitute any large additional menace, effective fire fighting is very difficult in slash areas not broken up into small blocks by means of fire lines. Under favorable weather conditions it may be possible to fight a fire in green slash without the aid of lines. But a high wind or dry slash, or both, create so terrific a hazard that nothing short of back-firing from a prepared line will hold the flames.

The lines should be of the same types as those described for use in turpentine orchards. Any large tops should be pulled away to a
distance of 1 rod from the outer edge of the lines. The presence of slash between the furrows will make burning of wide lines hazardous and difficult, and may eliminate from consideration their use in slash areas. The desirable size of the blocks inclosed by fire lines in slash is a matter necessarily based on cost and risk. Square blocks of from 160 to 640 acres, depending on the heaviness of the cutting and the resultant percentage of the area covered by slash, may be surrounded by lines at what appears to be a reasonable cost per acre when spread over an entire property employed in timber growing.

PROTECTION OF YOUNG GROWTH

Fire lines in turpentine orchards are justified by the high cash values at stake, and in slash-covered areas by the grave difficulties involved in fire fighting without them. Their use in areas of young growth is justified on different grounds. (1) There is the absolute need to keep fire out of seedlings and saplings less than 7 or 8 years old. (2) Although the local organization above described should be able to hold to 3 per cent the area burned over in a community as a whole, it is quite possible for this entire loss to occur on the property of one or two landowners. The burning of, say, 20 or 25 per cent of a property consisting of young growth still subject to heavy damage may be a staggering blow to the value of the tract as a whole. For this reason every prudent owner who wishes to keep his land productive will certainly give it such additional protection as he can obtain at reasonable cost. Fire lines are much more the direct concern and responsibility of the individual landowner than is the manpower engaged in local protection.

The frequency of fire lines, which governs the size of the blocks inclosed by them, should be varied to suit the hazard. Where the forest is all-aged and the young growth subject to severe damage is scattered, breaking an entire property up into blocks of about 640 acres is believed to be justified. Blocks as small as 160 acres are warranted in unbroken areas of young growth. If this growth has followed immediately after logging the intensive protection prescribed for areas of slash will give the seedlings a few years' start. But in many instances the period of such protection will not have brought the seedlings to the 7 or 8 years of age necessary to give the more vigorous ones resistance against ordinary winter fires.

COSTS OF FIRE PROTECTION

THE STATE ORGANIZATION

Rather limited experience under southern conditions indicates that the State fire organization above described should cost about 1.3 cents an acre a year. This covers the erection and operation of lookouts, the salary and expenses of the ranger force, and a small sum for reduction of special hazards, in addition to the overhead expense of the State and division firewardens’ offices. It should be noted that under the Clarke-McNary law the Federal Government is authorized to contribute in cooperative funds to a State undertaking fire protection a sum not greater than that spent by the State itself in
this work from State and private funds. The appropriation available ($1,200,000 in 1928-29) for this purpose is not sufficient, however, to allow the Federal Government to match more than a few of the State appropriations dollar for dollar, the maximum contribution being a little over $64,000 a year. The sum apportioned in 1928-29 to the 12 southern States maintaining fire protective organizations was $320,000, or about two-thirds as much as the States' expenditures.

The Local Organization

For farm woodlands, generally small in extent, the local organization will cost practically nothing. The land will be subject to but slight risks, and the owner, residing on or near it, can keep it under his immediate supervision at all times. For larger properties the local system of fire protection, exclusive of the special measures necessary to protect turpentine orchards, slash areas, and young growth, is estimated to cost 0.85 cent an acre a year. Where for any reason patrol must be substituted for a system of towers and resident wardens, the cost to the landowners rises as high as 3.7 cents an acre. The cost of fire fighting, although apt to vary greatly, is included in all estimates at a figure, spread over the entire area protected, of 0.5 to 0.6 cent an acre.

It should be understood that local conditions will have a very large effect on the methods and resultant costs of fire protection. This is true of the physical conditions such as timber type, topography, and road system, and particularly of the condition of local sentiment toward fire protection. The figures given should therefore be considered simply as a general guide.

Special Protective Measures

To maintain production on pinelands where lumbering or turpentine is in progress, or on which there is logging slash or young growth still subject to killing by winter fires, requires expenditures over and above those for the State and local systems of fire protection. These expenditures cover pulling tops to a distance of 15 feet from seed trees on extensive current cuttings and breaking up turpentine orchards and areas of slash and young growth into small blocks by means of fire lines. Raking around the trees will still be necessary in most orchards, but as the cost of this is an accepted item in naval-stores accounting it is not included among the special items of expense. Again, since most progressive lumber companies are already accustomed to screen their ash pans, and to use spark arresters on logging locomotives, skidders, and loaders, simply as a protection to their trestles, logs, and equipment, the cost of this protection can hardly be charged to protection of their lands.

Pulling Tops

With no actual figures from jobs where the timber was cut as recommended later in this bulletin, but with some information from comparable jobs, it is estimated that 25 cents an acre is an average charge for pulling tops. It is improbable that every seed tree will
need to be freed of slash, even at the beginning, and it seems likely that as the woods crews become thoroughly educated to the idea, keeping slash away from seed trees will be held in mind with ever-increasing effect. The more open the timber, the smaller will be the cost of this work.

FIRE LINES

Since fire lines have only recently come into considerable use in the southern pine region, methods and costs of construction are alike variable. The degree of slope commonly encountered, and the frequency of small drainage ways, which if numerous seriously interfere with plowing in straight lines, are factors in costs. So are the density of brush, number and kind of stumps, and similar natural obstacles to plowing. Under some circumstances a stout mule or horse will accomplish more for the money than a tractor, but under average conditions in the coastal plain the tractor is believed to be more efficient. Much depends on the skill of the plowman or tractor driver, and since this work is unfamiliar to nearly all, first costs are apt to be high.

A 6-foot, solidly plowed line is estimated to cost under average conditions about $7 a mile for original construction, which includes location, cutting of brush, removal of down logs, and the plowing itself. It should be possible to renew the line annually for one-half to three-quarters of the original cost. Felling of all snags, or dead trees over 15 feet in height, to a distance of 8 rods on each side of a plowed line, will vary directly in cost with the average number present on an acre. A tally of such snags on several miles of strip survey through longleaf pine land in Mississippi gave an average of 1 to the acre in cut-over land and 1.7 in virgin timber, eliminating those less than 7 inches in diameter at breastheight. The longer the period since cutting, the fewer the snags in cut-over land. Assuming 1.5 snags to the acre, and that a 2-man crew is capable of cutting 40 a day, the cost of snag felling per mile of fire line becomes $7.20. Finally, if the line runs through slash all tops and other inflammable material must be removed from a rod-wide strip on each side of the plowed line. At an acre cost of 50 cents, or twice that of pulling tops from seed trees, the cost per mile of line is $2.

The cost of constructing a mile of new fire line of this type through slash is then:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plowing</td>
<td>$7.00</td>
</tr>
<tr>
<td>Felling snags</td>
<td>7.20</td>
</tr>
<tr>
<td>Pulling slash</td>
<td>2.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>16.20</strong></td>
</tr>
</tbody>
</table>

In figuring the cost of fire lines it should always be remembered that the larger the area broken up by such lines, the more nearly the mileage of lines per unit of area is cut in half. This is because all lines except those on the extreme outer boundaries of the tract do double duty by protecting the land on both sides of them. To illustrate, 2 mile-square blocks side by side require only 7 miles of line, instead of the 8 miles they would need if they did not have one side in common; if 4 adjoin, in a square, they need only 12 miles of line, instead of 16; and so on. The average number of miles of
line to the block is thus reduced from 4 to 3½ and to 3 in the examples given.

Renewal of this type of line will require only replowing, at from $3.50 to $5.25 a mile if done yearly.

Table 2 shows the cost of breaking slash-covered tracts of various sizes into 10, 40, 160, and 640 acre blocks by means of fire lines of the type above described.

**Table 2.** Cost, in cents per acre, of fire lines through logging slash, as affected by size of block and by total acreage protected

<table>
<thead>
<tr>
<th>Size of block within fire line</th>
<th>40-acre tract</th>
<th>160-acre tract</th>
<th>640-acre tract</th>
<th>2,040-acre tract</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acres</td>
<td>First cost</td>
<td>Yearly upkeep</td>
<td>First cost</td>
<td>Yearly upkeep</td>
</tr>
<tr>
<td>10 61</td>
<td>10</td>
<td>9.4</td>
<td>25</td>
<td>6.2</td>
</tr>
<tr>
<td>40 40</td>
<td>20</td>
<td>6.2</td>
<td>15</td>
<td>4.7</td>
</tr>
<tr>
<td>160 20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>640 10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Costs through cut-over land, not slash-covered, are about 12 per cent lower.
2 Yearly upkeep is assumed to be $5 a mile.

Wider fire lines, where practicable, consisting of a burned strip 50 to 100 feet wide between double furrows, will not differ greatly in cost from the narrow, solidly plowed lines, unless a road or some natural break may be used in place of the furrows on one side.

**Total Costs for Typical Properties**

The costs per acre of the State and local system of fire protection, which together amount to about 2.2 cents, and include 0.55 cent for fire fighting, are based on the total area of pineland in a community. The cost of special measures of protection should, however, be charged against the particular property benefited. Because turpentine orchards, slash areas, and areas of young growth may make up anywhere from 0 to 100 per cent of an individual’s or company’s holdings, the total cost of protection per acre may vary greatly from property to property. Under these circumstances a few illustrations drawn from conditions most likely to be encountered will be more useful than a generalized summary of costs.

A farm woodland of 40 acres is culled yearly for fuel wood and posts used on the farm, and at intervals of a few years for saw logs, piling, and other material for sale off the farm. Because no cuttings cover any considerable acreage and seed-bearing trees are plentiful on all sides of the areas cut, there is no need for pulling tops away from seed trees. For $16 in teams and labor a 6-foot plowed fire line can be constructed entirely around the tract; no cash outlay whatever is required of the average farm owner. This line may be replowed yearly for $5. In a community of isolated farm woodlands this yearly expenditure of 12.5 cents an acre should make unnecessary any further local system of protection, or even the fire towers of the State system. The State will, however, be justified in conducting its educational work in such a community, and in maintaining the ranger force, although assigning a larger territory
to each ranger than in communities of greater hazard. The cost of the State organization will then be about 0.75 cent an acre. If, however, the farm woodland is part of an extensive area of forest land, the local system of protection should certainly include fire towers, and in most instances resident wardens and smoke chasers or patrolmen as well. This adds an acre charge of 0.5 to 0.8 cent. The grand total is then, in round figures, 13 to 14 cents an acre, including the cost of fire fighting. This cost is high, but should give vastly better protection than that which is planned for most lands.

A small sawmill, cutting 7,500,000 feet of pine a year, logs about two sections of land in 12 months. After 10 years of operation, during which his cut-over land has been rendered largely unproductive by fires, the owner decides to keep productive the 20 sections he will log during the remaining 10 years of his operation, and to preserve from fire such young growth as has started on the area already cut over. The first year 1,280 acres are covered with fresh slash, which must be pulled away from the seed trees, and through which fire lines must be built to divide the area into 160-acre blocks. The 20 sections already cut over are broken by fire lines into 640-acre blocks but, since the slash has already decayed or burned, the cost per mile of fire line is $14.20 instead of $16.20. The second year all the old fire lines must be renewed, and new lines built through two sections of fresh slash; similarly for each successive year up to the ninth. In the ninth year the 20 sections already cut over when protection was started no longer require protection by fire lines, and neither do the two sections cut over the first year. This assumes that satisfactory reproduction was here established in the first year or two of protection, and is now fairly resistant to fire. In the tenth and final year of cutting there is no change in the total length of fire lines, old and new. (Table 3.)

<table>
<thead>
<tr>
<th>Year</th>
<th>Lump sum</th>
<th>Cost per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>815</td>
<td>3.2</td>
</tr>
<tr>
<td>Second</td>
<td>455</td>
<td>1.7</td>
</tr>
<tr>
<td>Third</td>
<td>615</td>
<td>2.4</td>
</tr>
<tr>
<td>Fourth</td>
<td>805</td>
<td>3.1</td>
</tr>
<tr>
<td>Fifth</td>
<td>995</td>
<td>3.9</td>
</tr>
<tr>
<td>Sixth</td>
<td>1,185</td>
<td>4.6</td>
</tr>
<tr>
<td>Seventh</td>
<td>1,375</td>
<td>5.4</td>
</tr>
<tr>
<td>Eighth</td>
<td>1,565</td>
<td>6.1</td>
</tr>
<tr>
<td>Ninth</td>
<td>460</td>
<td>1.8</td>
</tr>
<tr>
<td>Tenth</td>
<td>460</td>
<td>1.8</td>
</tr>
<tr>
<td>Average</td>
<td>870</td>
<td>3.4</td>
</tr>
</tbody>
</table>

Pulling tops away from the seed trees on fresh cuttings costs $320 a year additional, or 1.25 cents an acre spread over the property as a whole. Yearly protection costs for this property are then: State system, 1.33 cents per acre; local system, 0.85 cent; fire lines, 3.4 cents; slash disposal, 1.25 cents; total, 6.53 cents. Had protection been given to the entire property of 25,600 acres from the beginning of the operation, the yearly cost would have been about 5.25 cents an acre.

Five thousand acres of second-growth longleaf and slash pine supply gum for a 10-crop still, and produce saw logs, piling, and cross-
ties from the worked-out trees. The trees vary in age, and each year some reach profitable chipping size, while others which have been cupped and back-cupped are ready to cut. There are about 20 working or resting turpentine faces to the average acre, together with 4 or 5 decaying tops, and much young growth subject to fire damage. This results in a combination of hazards on every acre, and probably justifies breaking the entire acreage up into 40-acre blocks by means of fire lines. The first cost of such lines, if the property is in a compact body, is about $1,100, the yearly upkeep only $340. The corresponding per acre costs are 22 and 6.8 cents. But the small size of the blocks and the scattered cutting justify leaving the slash where it falls, thus eliminating the expense of pulling tops away from seed trees, and the presence of the turpentining and logging crews saves the cost of the local fire organizations (0.8 cent). After the 1.3 cents of the State system is added the total annual charge slightly exceeds 8 cents. When it is considered that at least this amount is now spent yearly in raking around the 20 cups on an acre, and that thoroughgoing fire protection should in time make raking unnecessary, the expense of fire-line construction appears amply justified.

A tract of 50,000 acres of cut-over land, previously fire-swept but bearing enough seed trees to reforest naturally if given fire protection, is broken up by fire lines into 640-acre blocks at a first cost of about $2,500, or 5 cents an acre. This assumes that no slash remains from logging, which slightly reduces the cost of fire-line construction. The yearly upkeep of the fire lines is $900, or 1.8 cents an acre. Added to the cost of the State and local protective organizations, this makes a total of about 4 cents an acre a year.

Figure 5, furnished by courtesy of the Louisiana Department of Conservation, illustrates a portion of one of Louisiana's fire-protection areas. The entire forest area protected—165,217 acres—is equipped with 1 fire tower, 12 telephones, 72 miles of telephone line, and 260 miles of firebreaks. Protection is in charge of an assistant ranger, aided by a lookout man, 11 wardens, and 1 smoke chaser. Prior to the establishment of intensive protection not less than 85 per cent of the area burned over in the average year. This was reduced in 1926–27 to 12.3 per cent, in 1927–28 to 5.4 per cent, and in 1928–29 to 5.2 per cent, although during the three years the number of fires reported annually increased from 78 to 189. The average yearly cost of protection, exclusive of any expense of the State forester's office, was 4.71 cents an acre.

**DIVISION OF COST BETWEEN PUBLIC AND PRIVATE AGENCIES**

Emphasis has been laid on the fact that the protection of private lands against fire is a joint undertaking between public agencies and the landowner, and that, although under ordinary circumstances it is better that the State maintain the local fire protective organization, it may reasonably assess at least part of the cost against the properties protected. In its cooperative work with the States under the Clarke-McNary Act the Forest Service has proposed as an objective that the cost of adequate protection of forest lands be divided as follows: Federal Government, 25 per cent; State governments
and those of lesser political units, 25 per cent; private landowners, 50 per cent. Realizing the need for public leadership and encouragement in such matters, the Federal Government and the Southern

Figure 5.—Details of fire-fighting organization on a portion of one of Louisiana's protection areas

States have made a vigorous effort to fulfill their obligations. A skeleton protective organization along the lines previously described has been set up in all but one State, and in communities where the
landowners also have given their moral and financial support public effort has been greatly intensified. Table 4 shows that for the South as a whole public agencies are more than doing their part in forestfire protection.

**Table 4**—Southern forests areas needing fire protection and actually protected, with public and private expenditures, calendar year 1929

<table>
<thead>
<tr>
<th>State</th>
<th>Areas needing protection</th>
<th>Areas actually protected</th>
<th>Expenditures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Acres</td>
<td>Acres</td>
<td>Public</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(county, State, and Federal)</td>
</tr>
<tr>
<td>Delaware</td>
<td>380,000</td>
<td>380,000</td>
<td>2,005.72</td>
</tr>
<tr>
<td>Maryland</td>
<td>6,351,000</td>
<td>6,351,000</td>
<td>40,822.80</td>
</tr>
<tr>
<td>Virginia</td>
<td>17,327,000</td>
<td>10,755,000</td>
<td>65,922.99</td>
</tr>
<tr>
<td>North Carolina</td>
<td>21,335,000</td>
<td>9,721,000</td>
<td>94,491.76</td>
</tr>
<tr>
<td>South Carolina</td>
<td>12,379,000</td>
<td>946,000</td>
<td>20,394.96</td>
</tr>
<tr>
<td>Georgia</td>
<td>23,725,000</td>
<td>1,645,000</td>
<td>65,421.50</td>
</tr>
<tr>
<td>Florida</td>
<td>22,918,000</td>
<td>1,684,000</td>
<td>78,092.55</td>
</tr>
<tr>
<td>Alabama</td>
<td>30,259,000</td>
<td>17,242,000</td>
<td>66,313.03</td>
</tr>
<tr>
<td>Mississippi</td>
<td>19,500,000</td>
<td>560,000</td>
<td>76,369.77</td>
</tr>
<tr>
<td>Louisiana</td>
<td>17,900,000</td>
<td>4,352,000</td>
<td>89,363.72</td>
</tr>
<tr>
<td>Texas</td>
<td>23,332,000</td>
<td>8,010,000</td>
<td>69,745.41</td>
</tr>
<tr>
<td>Arkansas</td>
<td>22,757,000</td>
<td>4,257,000</td>
<td>27,461.25</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>12,949,000</td>
<td>1,374,000</td>
<td>24,970.70</td>
</tr>
</tbody>
</table>

1 Only about two-thirds pineland. Separate figures for pineland not available.
2 As reported by States in spring of 1930. There is a wide variation between States in the intensity of protection given areas reported as "protected."
3 The fact that State cooperation under section 2 of the Clarke-McNary Act is not yet in effect in Arkansas makes it impossible to give any figures showing cost of protection. Areas protected are mainly in the hands of some six or seven large companies whose per acre expenditures vary widely and are not readily ascertained or reducible to any common basis.

**LEAVING SEED TREES OR THEIR EQUIVALENT**

If all cutting and turpentining were to cease to-day, and fire protection of the degree just described were to be given henceforth to all southern pinelands, about 90 per cent of these lands would be, or would in time become, reasonably productive of forest crops. Only 10 per cent would require planting or other artificial reforestation. Cutting and turpentining, however, have not ceased in the South. As earlier stated, nearly 5,000,000 acres of pine stands are being cut or destroyed by turpentining each year. They include virgin timber, forest already culled, and second growth. The forest does not renew itself spontaneously, because these pines, unlike most hardwoods, do not sprout from the stump; neither is their seed stored up in the surface layers of the soil, ready to germinate when the cutting or death of the mature trees lets in enough sunlight to warm the ground.

If pineland is to be kept productive after cutting or turpentining one of three conditions must be fulfilled:

(1) Enough advance growth must be present when logging or turpentining is completed to form, at maturity, a stand of a commercial value at least equal to the cost of growing it.

13 Small shortleaf pines are an exception, but since the ability of shortleaf to sprout does not extend beyond the tenth or twelfth year of its life, at which time the trees are less than 4 inches in diameter at breastheight and are rarely cut for any purpose, the statement holds.
(2) Enough seed-bearing trees must survive logging or turpentining to produce such a stand within a reasonable time.

(3) Planting, or other artificial methods of reforestation, must be employed promptly.

Southern pineland bearing enough advance growth to produce a crop that will at least return the cost of growing it may be kept productive by fire protection alone. Some of the 5,000,000 acres, mostly of shortleaf and loblolly land, are in this condition. The longer the period that pineland has been protected against fire before the mature trees are cut or cupped to death, the more advance reproduction is present. Hence, within limits, fire protection will in time do away with the need for seed trees. Advance reproduction will follow fire protection most abundantly in virgin or culled stands, where the older trees are not close enough together to occupy all the growing space.

Information is altogether lacking as to the number of seedlings that should be present before logging or turpentining is begun in order to insure adequate stands at the completion of these operations. The fact that logging slash may occupy up to 40 per cent of the ground gives some indication of the inroads which felling alone is likely to make in advance reproduction. Removal of the cut material, especially with steam skidders, inevitably destroys young growth and at the very least results in its patchy distribution. The damage from turpentining should be much less, although some brushing out of underbrush and advance growth of pine is unavoidable.

No hard and fast rule can be given for the size of seedlings of advance growth and the number to the acre that will justify failure to leave seed trees. Longleaf pines less than 3 or 4 feet in height, and shortleaf, loblolly, and slash pine seedlings less than 6 to 10 feet, are subject to killing by so many agencies, including the occasional fire that must be counted upon even under an efficient system of fire protection, that as advance reproduction they should not be considered a safe risk on clear-cut or heavily turpentined areas. Such seedlings are 7 or 8 years old on average sites. If 600 to 700 longleaf pine seedlings to the acre, 700 to 900 loblolly or slash pine seedlings, or 1,000 to 1,200 shortleaf pine seedlings or sprouts, above these heights, remain after logging and turpentining are completed, it should be unnecessary to leave seed trees. But acres bearing any less advance growth should be left with seed trees, and under any circumstances the presence of seed trees is a valuable insurance against denudation should a severe fire wipe out the advance reproduction.

In view of the uncertainties which attend its preservation, dependence upon advance reproduction alone as a means of keeping forest land productive is rarely justified. Planting, or any other method of artificial reforestation, although proved successful under favorable conditions, is hardly more dependable. If a plantation is not rigidly protected, it may be wiped out by a single fire, and in the absence of seed trees the land then remains unproductive indefinitely. Moreover, planting and sowing require a cash outlay which is likely to appeal only to those whose aim is to obtain full timber crops from their forest land. For these reasons artificial forestation
is rarely to be considered a means for keeping land barely productive, but will be discussed later in the portion of this bulletin devoted to more intensive forestry measures.

The seed-tree method is by far the surest and most generally useful where intensive forestry is not possible. The problem of leaving enough seed trees on cut-over pineland resolves itself into two questions: What kind of a tree produces seed? How many must there be to supply enough seed for satisfactory natural reforestation? Plainly one question can not well be answered, at least in a practical way, without having the answer to the other in mind. It should also be said at the outset that present information does not allow of final answers to either question.

**WHAT IS A SEED TREE?**

The ideal seed tree is a healthy pine having a long, vigorous crown with abundant foliage. Its height is of no great importance, but few pines of any southern species, in virgin, culled, or second-growth stands, produce abundant seed until they are past 8 inches in diameter at breastheight, and the majority not until they are 10 or 12 inches.

Because of their full crowns, trees that have had ample growing space are to be preferred as seed trees to those which have been crowded or have grown in groups. Such trees are also better braced against windfall. Abundant foliage or straw is in itself a sign of vigor, but the best guaranty that a tree will continue vigorous is a pointed tip to its crown. (Pl. 9, A.) Such a tree is making steady growth in height, whereas a flat-crowned tree is not, and is probably on the decline in general health. Decay, as indicated generally by cat faces at the base of a tree, or rotten knots at various points, and more surely by “punks” on the trunk, makes wind breakage probable and so disqualifies the tree as a seed producer. For the same reason, no tree chipped for turpentine can be considered a satisfactory tree to leave for seed production.

Unless a tree is obviously weakened by old age or injury, the presence of abundant cones or burs either on the tree or on the ground under it is, of course, conclusive evidence that it will be a satisfactory seed tree. In critical situations, as on acres where no more than the lowest prescribed number of seed trees can be left, or where natural conditions are adverse to natural reproduction, nothing short of this evidence should be relied upon in selecting trees to leave for seed.

**LONGLEAF PINE SEED TREES**

The seed crop in an intermediate seed year is a safer index of what constitutes a good longleaf seed tree than one measured in a heavy seed year, such as occurs with longleaf every seventh year or so, for in a heavy seed year trees of all sizes bear an amazing number of cones.

Some light is thrown on the relation of diameter to seed production of longleaf pines by a classification of the trees on certain cut-over lands in southern Mississippi, made by the Southern Forest Experiment Station in 1925. The year 1924 had been a fair seed
year for longleaf pine in this section, in spite of droughts. The 1924 seed crop, as evidenced by cones on the ground or still on the trees in early February, 1925, was the basis for classifying the trees. The exact number of cones to each tree was not recorded, but the trees were tallied as having either a “scarce” or “abundant” supply of cones. The tally on 91 acres, in strips run at random across 6 miles of typical country, gave the results recorded in Table 5.

**Table 5.** Percentage of abundant seeders, by diameter classes, among 596 longleaf pines on cut-over land in southern Mississippi, 1924 seed crop

<table>
<thead>
<tr>
<th>Diameter class</th>
<th>All trees</th>
<th>Abundant seeders</th>
<th>Per cent</th>
<th>Diameter class</th>
<th>All trees</th>
<th>Abundant seeders</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inches</td>
<td>Number</td>
<td>Number</td>
<td>Per cent</td>
<td>Inches</td>
<td>Number</td>
<td>Number</td>
<td>Per cent</td>
</tr>
<tr>
<td>6</td>
<td>91</td>
<td>6</td>
<td>6</td>
<td>14</td>
<td>50</td>
<td>23</td>
<td>78</td>
</tr>
<tr>
<td>8</td>
<td>91</td>
<td>20</td>
<td>6</td>
<td>16</td>
<td>54</td>
<td>12</td>
<td>54</td>
</tr>
<tr>
<td>10</td>
<td>107</td>
<td>91</td>
<td>64</td>
<td>18</td>
<td>12</td>
<td>10</td>
<td>83</td>
</tr>
<tr>
<td>12</td>
<td>156</td>
<td>105</td>
<td>67</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The longleaf pines on 12 acres of less closely logged land in southern Alabama were classified as to 1924 cone production in a similar study by the station. Trees bearing less than 25 cones were considered poor seed producers; those bearing 25 to 100, medium; and those bearing more than 100, good. The tally and percentages of good and medium trees are given in Table 6.

**Table 6.** Percentage of good and medium seed producers, by diameter classes, among 297 longleaf pines on cut-over land in southern Alabama, 1924 seed crop

<table>
<thead>
<tr>
<th>Diameter class</th>
<th>All trees</th>
<th>Good producers</th>
<th>Medium producers</th>
<th>Total good and medium producers</th>
<th>Diameter class</th>
<th>All trees</th>
<th>Good producers</th>
<th>Medium producers</th>
<th>Total good and medium producers</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inches</td>
<td>Number</td>
<td>Number</td>
<td>Per cent</td>
<td>Inches</td>
<td>Number</td>
<td>Number</td>
<td>Per cent</td>
<td>Inches</td>
<td>Number</td>
<td>Number</td>
</tr>
<tr>
<td>6</td>
<td>24</td>
<td>2</td>
<td>17</td>
<td>14</td>
<td>57</td>
<td>23</td>
<td>79</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>53</td>
<td>2</td>
<td>17</td>
<td>16</td>
<td>48</td>
<td>31</td>
<td>94</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>52</td>
<td>5</td>
<td>26</td>
<td>18</td>
<td>17</td>
<td>11</td>
<td>88</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>46</td>
<td>22</td>
<td>78</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It is evident from Tables 5 and 6 that on the areas studied, which are believed to be representative of average soil and climatic conditions in the longleaf pine belt, only about 25 per cent of 8-inch trees on old cuttings can be counted upon to seed abundantly in intermediate seed years, and that not all 10-inch or even 12-inch trees are good seeders. Hence only selected trees, 10 inches or larger, can be counted upon as seed trees in virgin stands. It is of course true that the evidence cited above against small trees was collected in cut-over lands or in culled virgin stands, and that the average small longleaf pine in a virgin stand might do better if left as a seed tree. On the other hand, although many of the trees studied were originally the runts and culls of the virgin forest, yet during the 20 or more years since the forest was cut away around them they have grown under conditions favoring seed production.
The limited evidence available does not warrant regarding as good seed producers 10 and 12 inch longleaf pines in second-growth stands. On the other hand it shows no substantially greater ability for seed production among trees up to 16 inches d. b. h. Cone counts on upwards of 1,600 second-growth trees, 7 to 16 inches in diameter, have been made at the Starke (Fla.) branch of the Southern Forest Experiment Station in several years since 1923. Although widely spaced trees proved to be markedly better cone producers than those which were crowded, the largest average production for any diameter group—37 cones per tree for 20 open-grown trees averaging 12.5 inches, in the good seed year 1929—was not encouraging. Inasmuch as these pines were generally less than 40 years old, and observers of other species have set age limits, rather than size limits, for good seed production (4, 22), it is possible that these trees were too young. Whatever the explanation, it is evident that in second-growth longleaf stands seed trees must be selected with unusual care, and must be open-grown trees of somewhat larger size than in virgin or culled stands. Fortunately the greater number of trees to the acre in young stands generally affords a wider selection of trees than in virgin stands.

**Shortleaf Pine Seed Trees**

Shortleaf pine produces cones more often, more uniformly, and more abundantly than longleaf. It is well to remember, however, in judging the comparative production of the two species from a cone count, that the seeds in a shortleaf cone are fewer than in a longleaf cone, and that whereas the cones may remain on the branches of the shortleaf for years, they fall from the longleaf very promptly. A tally of the cone crop on a small area of pure longleaf pine and, partly virgin timber and partly cut over, in the foothills of the Ouachita Mountains of Arkansas is shown in Table 7. The cone crop of 1925 was a representative one in this region, but since it was impossible to count the new cones only, the total number of cones remaining on the tree was used as a basis for the tally. Trees bearing less than 100 cones were considered poor seed producers; those bearing 100 to 500, medium; and those bearing over 500, good.

**Table 7.—Percentage of good, and good and medium, seed producers, by diameter classes, among 871 shortleaf pines on virgin and cut-over land in west-central Arkansas**

<table>
<thead>
<tr>
<th>Diameter breast high</th>
<th>Good producers</th>
<th>Good and medium producers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Virgin timber</td>
<td>Cut-over land</td>
</tr>
<tr>
<td></td>
<td>Per cent</td>
<td>Per cent</td>
</tr>
<tr>
<td>Inches</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>12</td>
<td>10</td>
<td>71</td>
</tr>
</tbody>
</table>

|                   |                |                           |              |              | Per cent      | Per cent                 |
|                   |                |                           |              |              | Virgin timber | Cut-over land            |
|                   |                |                           |              |              | Virgin timber | Cut-over land            |
| Inches             | Per cent      | Per cent                 | Per cent     | Per cent     | Per cent      | Per cent                 |
|                   |                |                           |              |              | 14            | 33                       |
| 6                  |                |                           |              |              | 16            | 45                       |
| 8                  | 10             | 10                        | 10           | 5            | 18            | 50                       |
| 10                 | 10             | 71                        | 40           | 85           | 18            | 50                       |
| 12                 | 10             | 71                        | 40           | 85           | 18            | 50                       |

1 No data.
Table 7 in itself would indicate that shortleaf trees below 12 inches in diameter can not be counted upon to produce seed abundantly. However, it should be understood that the low rocky hills in which this study was made, although not representative of the poorest situations in which shortleaf occurs, are by no means as favorable to growth and reproduction of the pine as the sandy lands of the coastal plain. In the greater part of the cut-over territory covered by this discussion selected shortleaf trees from 10 inches d. b. h. up should produce satisfactory quantities of seed. Table 7 shows that in a virgin stand seed production is less than in cut-over land, and therefore larger trees should be left for seed wherever advance reproduction is not abundant in the virgin forest.

Provided trees with long and vigorous tops are selected, general observation indicates that shortleaf pines 10 inches in diameter should make good seed trees in second-growth stands. The average 10-inch tree in such stands, particularly on old fields, has been so crowded that it has a short and thin crown, and makes a poor tree for prompt seed production. The absence of advance reproduction makes it all the more necessary to leave trees already in bearing.

**LOBLOLLY AND SLASH PINE SEED TREES**

Wide observation, but little specific evidence, indicates that both loblolly and slash pines begin to bear good crops of seed when 10 to 12 inches in diameter at breastheight. A 10-inch limit may therefore be used with these species in both virgin and second growth; the seed trees must of course be selected specimens, and as old as possible. Some should be above the limit, as with longleaf and shortleaf.

**NUMBER AND DISTRIBUTION OF SEED TREES**

No inflexible rule can be drawn as to the number of seed trees per unit of area which must be left in order to obtain reasonably good restocking. Small cuttings—probably up to 5 acres—may be made without reserving seed trees, provided there are abundant seed trees on adjacent land. In farm woodlands where thorough fire protection may be counted upon, a few large bushy trees along fence rows or in neglected corners may effectively seed considerable openings. Again, a strip of land bordering a solid belt or large group of seed-bearing trees which are certain to remain uncut for several years will need no other source of seed. (Pl. 9, B.) This strip may be as much as 200 to 300 feet wide. The areas studied as a basis for this statement were in most instances to the south of the seed trees. However, there is reason to doubt whether good seeding would take place any further, even down the southwest wind that prevails throughout most of the year.

The number of seed trees needed on any particular tract will depend on many conditions, and of course, may vary within the tract. For example, on shortleaf lands, where advance reproduction is generally well developed and evenly distributed over the area, fewer seed trees will be necessary than in the average longleaf pine forest, where, as a result of years of burning, young trees are conspicuous by their absence. Again, one large tree, 16 to 18 inches in diameter at breastheight, will probably bear four times as much seed
as a tree of equal vigor but only 10 or 12 inches in diameter. If none of the smaller size are present on the acre, the single large tree may have to be left for seed instead. As between one large tree and several smaller ones, the choice will ordinarily be in favor of the small trees, partly because of the smaller value represented in them as a result of less volume and lower quality, and partly because various agencies, such as lightning, which rather frequently strikes isolated trees in logged-over land, are less likely to wipe out the seed supply on the acre concerned. Frequently two trees well located will throw seed more effectively over the surrounding area than four trees more or less grouped. On good sites, where the percentage of seedlings which normally survive the vicissitudes of youth is comparatively high, fewer seed trees are necessary than on a poor site.

In cut-over areas or abandoned turpentine orchards of more than 5 acres, 2 to 4 satisfactory seed trees to the acre appear necessary on shortleaf, loblolly, or slash pine land, and not less than 4 on longleaf land. No rigid proof can be submitted for this statement, however, for it is almost impossible to find in nature extensive areas of cut-over land which have these numbers, and only these numbers, of trees meeting the full requirements for seed trees, and in which fires or other destructive agencies have not been at work. Conditions must be created artificially to test the sufficiency or insufficiency of seed trees of a certain kind and in certain number before conclusive proofs can be offered. The Southern Forest Experiment Station has some such experiments under way, but not enough time has passed to permit of any final conclusions. In the meanwhile, fragmentary evidence and general observation must be relied upon.

The unit of reforestation need not always be as small as the acre, at least for shortleaf, loblolly, and slash pines. For such light-seeded and prolific species areas of 2 or 3 acres are sufficiently small. That is, 6 to 12 seed trees should reforest 3 acres, although on 1 of the 3 acres there may be none. In the majority of farm woodlands even these units may be disregarded.

Seed trees of the number and size believed necessary to reforest a tract of southern pine are not always present at the time of cutting, especially on culled or cut-over land from which poles, crossties, or products other than saw logs are to be taken. A poor selection of seed trees is also characteristic of virgin stands on very poor sites. An acre of virgin timber on an average or good site will rarely be without suitable trees, although occasionally trees of some size and commercial value will have to be reserved. How often this will occur may be judged by a comparison of the number of trees of seed-bearing size (9 to 12 inches d. b. h.) on the average acre in virgin tracts with the number on individual acres. Figures 3, 4, and 6 may be used for this comparison.

The dotted line in Figure 4, B, which represents the same tract of virgin longleaf pine in central Alabama as block A, Figure 6, shows that on the average acre the total number of trees 9 to 12 inches in diameter is about 6.5. Block A, however, shows that although 94.5 per cent of 160 individual acres for which data are available bore at least 1 tree within this range of size, only 81.5 per cent bore more than 3 trees; 67 per cent more than 5 trees; and less than 67 per cent
the average number, 6.5, or more. It is evident then, even conceding
that 9 inches is large enough for a seed tree, that every one of the 9
to 12 inch trees would have to meet the other requirements for a
seed tree and be reserved from cutting if as many as 81 acres out
of 100 were to be left in a condition to reproduce satisfactorily.
Either that, or trees over 12 inches must be reserved. If at least 6
trees within the diameter range of 9 to 12 inches must be present in
order to make possible the selection of 4 satisfactory seed trees, only
2 out of 3 acres could be left in shape to reproduce. In other words,
assuming that in an open forest such as this 4 out of 6 trees of these
diameters are real seed trees, it is safe to say that on about a third
of the acres trees 13 inches in diameter or larger must be left for
seed.

Block B, Figure 6, in a relatively small sample of virgin long-
leaf pine in southern Mississippi, in which the tally was by 2-acre
units, shows about the same percentage of units with six trees or more
as does the Alabama tract, but 10 per cent fewer units with four or
more.

Virgin stands of shortleaf pine on fair sites are far more apt
to present a good choice of two seed trees than most longleaf stands
of four. Diagram A (fig. 8) and block C (fig. 6) represent the
same virgin shortleaf stand in central Arkansas. The 125 acres,
representative of a much greater acreage, averaged about 9.5 trees
between 9 and 12 inches in diameter. Ninety-one per cent of the
individual acres bore at least two trees of these sizes, and about 77
per cent at least four. If two out of four trees will produce seed
satisfactorily, it should be necessary to go above the 12-inch diameter
for seed trees on perhaps only 1 acre out of 5. One good seed tree
of 14 to 16 inches to the acre is believed to be enough, unless the
site is very poor.
Block D (fig. 6) represents a large sample of virgin loblolly pine land in Texas, on which conditions are nearly as favorable for the selection of seed trees as they are on shortleaf areas. Although there is no specific information available on the condition of virgin slash pine stands, they are believed generally to occupy a position midway between longleaf and the other two species with respect to availability of seed trees.

Second-growth stands of any species of southern pine are rarely cut, even for pulpwood, before a considerable number of trees have reached 10 or 12 inches in diameter. In fully stocked, even-aged stands on average sites, at least two trees of 12 inches d. b. h. have developed by the time loblolly and slash pine stands reach 25 years, and at least three by the time longleaf and shortleaf stands reach 35 years of age. The vast majority of second-growth areas are not fully stocked, and are more or less open. Since the tendency of all open stands is to develop individual trees to any particular diameter at an earlier age than in crowded stands, and since the more open the stand the longer and more vigorous the top, the selection of seed trees of proper size and character ought rarely to be a problem in second growth not previously turpentined.

Turpentined stands, on the other hand, will often present a problem in the selection of seed trees. In current turpentining many trees as small as 6 inches are cupped, and a tract of second-growth slash or longleaf pine is rare in which cupping has not begun on all trees above 10 inches. All that can be done is to leave an extra large number of trees above 10 inches for seed, and to continue to rake about them yearly, on the chance that they will remain standing long enough to reforest the land. Trees are particularly subject to wind breakage which show on the surface of the old face or elsewhere the oval holes about the size of a lead pencil where boring insects have emerged.

HOW PRESENT LOGGING PRACTICE AFFECTS NATURAL REPRODUCTION

Cutting Limits

Even at the present time, when the markets for nearly all grades of southern pine lumber have improved to a point undreamed of 20 years ago, there is still a great diversity of cutting policies among large lumber manufacturers. Although the majority operating in virgin timber do not cut any trees which will not make a long log 8 inches in diameter at the small end, some cut to an 8-inch limit on the stump. In second growth the cut is in general to a much lower limit than in virgin timber, many mills in Virginia and North Carolina bringing in short logs as small as 5 or 6 inches at the upper end.

The majority of manufacturers cutting logs of the smaller sizes mentioned, particularly outside of Virginia and the Carolinas, admit freely that if there were nothing but small-log trees in a stand it would not pay to cut them. But they argue that they obtained these trees stumpage free, particularly if they have held the timber over any length of time, and that since every board foot cut from a given logging unit reduces by so much the cost per thousand feet of railroad construction and general overhead of the entire operation, they can afford to bring in otherwise unprofitable stuff. The fact that
companies with short lives ahead of their mills can not cut the smaller trees at all if they do not cut them now, has been used as an additional argument in favor of cutting them.

On the other hand, Ashe (5) has found from carefully conducted studies of good-sized operations in the Carolinas that the various steps in converting standing shortleaf pine trees into lumber cost from two to four times as much per thousand feet when the trees used are 8 inches in diameter as when they are 20 inches. Increased overhead he finds to be more than offset by higher prices received for the lumber when the smaller trees in a stand are not cut. Preliminary studies conducted in large virgin longleaf operations by the Louisiana Department of Conservation confirm Ashe's findings, as does Garver's and Miller's intensive research 14 among small mills in Arkansas. That higher limits of cutting than those commonly observed are economical, particularly for companies which intend to return over the same land in 15 or 20 years, has been demonstrated to their own satisfaction by at least half a dozen substantial manufacturers of virgin and second-growth pine in Arkansas, Louisiana, Mississippi, and Alabama. This unprofitableness in the cutting of small timber is discussed in more detail later, in connection with the measures necessary to produce full timber crops.

Small sawmill operators on the whole probably have fewer incentives to cut small trees than manufacturers with a heavy investment in railroads and overhead, and do not cut to as low diameter limits as many large millmen.

The limit set for saw-timber cutting, however, does not by any means determine the number of trees left standing at the close of felling operations. Many trees too small for saw timber are cut for other reasons, and under some circumstances a few uncut trees are broken and uprooted when their neighbors are felled. Tram operations require the cutting of a very large number of crossties and shim poles.15 On nearly every kind of logging job a considerable number of small, straight trees are cut for such miscellaneous purposes as corral or lot construction, skid poles, car stakes, and fuel. All trees are removed from strips 50 to 200 feet wide along spurs and main lines on tramroad operations, and from roads and loading grounds on wagon jobs.

The accidental loss of uncut trees when their neighbors are felled has been recorded in three brief studies, by the Southern Forest Experiment Station, of animal-logged areas in Texas, Louisiana, and Mississippi. The cuttings examined were all in virgin timber, that in Texas in shortleaf, the others in longleaf pine. Although in the three States 20, 30, and 36 per cent, respectively, of the trees left, including those as small as 4 inches in diameter, lost small limbs and bark when trees were felled against them, very few were broken or uprooted. The greatest damage was in longleaf stands in which the felled trees were above average size. On nearly 200 acres of virgin timber in Louisiana, cut for the experiment station and animal-logged, only one tree of the many reserved for seed was destroyed by the loggers; the tract included all types of forest from pure longleaf

15 Shim poles are round sticks, generally a little longer than ties, placed under the rails or ties in boggy places.
to mixtures of shortleaf and loblolly, and loblolly and hammock-land hardwoods. The cutting was given exceptionally close supervision, however.

Operations for smaller timber than saw logs often results in denudation. Upwards of 20,000,000 crossties of southern pine were cut in 1927. Many of these ties came from light stands operated solely for this product, the cutting being practically clear. On thousands of acres throughout the southern pine belt large quantities of poles and piling are cut every year from the scattered tall, slim pines left from earlier operations, thus robbing the land of its remaining source of seed. An increasing acreage of second-growth southern pine is cut to-day for pulpwood, and many of the pulpwood cuttings do not utilize merely a part of the stand, as in a thinning, but every tree above a diameter of 4 to 6 inches on the stump.

**SKIDDING AND HAULING**

The variation in methods of transporting logs from stump to track in tramroad operations, or from stump to mill, is as wide as the variation in cutting practice. Some tramroad operators use animals altogether, either on short ground hauls direct to the track or in the greater number of instances with high wheels, bummerars, or wagons. Others depend entirely upon steam-skidding devices. Frequently a combination will be employed, the equipment being fitted to the conditions encountered at any one point. Tractor logging is so uncommon in the southern pineries that its discussion here is unnecessary. Gasoline skidding, common in wet land in parts of the South, differs little from steam skidding, except that it does not require a tram or logging railroad, the logs being hauled on wagons from the skidder to the mill. High wheels and wagons are the common equipment for getting logs out of the woods on small sawmill operations and for moving poles, piling, ties, and cordwood.

The choice of steam or animals for moving logs to a tram is ordinarily based on essential differences in local conditions. Heavy stands of timber, such as virgin longleaf pine, which may run 10,000 to 15,000 feet to the acre over large areas, are logged with steam skidders at what is generally believed to be a saving over the cost of animal logging. The volume per acre below which it is no longer profitable to employ steam devices has never been accurately determined for southern conditions. The length of log usually cut has considerable influence on the choice of animals or steam, since it is difficult to handle long logs with animals, and there is a lowering of efficiency in skidding short logs by steam. Again, ground conditions are often a determining factor in the choice. In rough or rocky country the cost of building roads for vehicles is excessive, and, provided the stand is heavy enough, steam skidding may be an economy; also in swampy areas the footing is such during the greater part of the year as to make the use of animals for hauling or for returning tongs from steam skidders to the woods out of the question. Excessive brush may hamper animal logging.

Movement of forest products with animals does little damage to uncut trees except to bark a few along roads with the hubs of high wheels and wagons. The cutting of advance reproduction and un-
merchantable trees in connection with animal logging has already been described.

Under one method of steam skidding widely used in the South the logs are dragged in, fanwise, straight to the skidder from points up to about 700 feet away, and a horse or mule is employed to return the tongs to the woods. The destruction of advance reproduction and uncut trees which results from the convergence of the lines from every direction at the skidder is complete near the track, but farther back it seems possible to avoid such damage by choosing a route for the logs to be skidded which does not pass directly by or through the growth to be saved. By passing the cable around stumps and snags the incoming logs can sometimes be shunted past seed trees or reproduction.

Two examples of damage by ground-line skidders with horse or mule outhaul may be cited. On both these jobs a conscientious effort to avoid injuring standing trees was made by the woods crews. The first is in virgin longleaf timber in eastern Louisiana and southern Mississippi, where the trees removed were few in number but of large size, and where an average of 14 trees, 4 inches in diameter or larger, were uncut. A 26-acre sample was obtained in the course of a strip survey extending 1½ miles. Felling and skidding together destroyed outright 19 per cent of the uncut trees and bruised an additional 41 per cent. Only 40 per cent therefore remained uninjured, in contrast to the average of 67 per cent left uninjured on the two animal-logged areas, previously referred to, in the same locality. Since felling was done with equal care in all cases, this shows that at least 27 per cent of the uncut trees were damaged by the skidding alone. It should be particularly noted that much of the damage amounted to complete destruction.

The same type of skidder working in a heavy pole stand of longleaf pine in southern Alabama, from which nearly all the large trees had been culled in previous years, also left uninjured 40 per cent of the uncut trees, but destroyed 46 per cent. The fact that 50 pines per acre 4 inches in diameter and over were left uncut in this instance accounts for the heavy loss.

Under a second method of steam skidding commonly used in the South the tongs or chokers are returned to the woods by means of a light rehaul cable. The tail trees are generally placed about 80 to 100 feet apart, at distances of 500 to 900 feet from the railroad. A rehaul skidder moves up fairly frequently, so that the logs are removed from a piece of ground more nearly oblong than triangular. Hence the destruction of young growth and standing trees does not vary so much with distance from the skidder as in the first method. The tongs are carried back to the logs by hand from the skidder lane, and the logs are hauled obliquely into the lane, with consequent injury to everything in their path. Once in the lane, the logs, of course, come straight to the track.

Trees along the skidder lane are almost invariably so badly battered by the incoming logs as to die at once or at the best to live in a very weakened condition. Although the lines do not converge at the skidder, this destruction becomes more certain near the track because the trees there are exposed to injury by more logs than those farther back. From a few experimental records and in the opinions
of lumbermen themselves, it seems likely that destruction of uncut trees is as great with a rehaul skidder as with a ground-line (animal outhaul) skidder. Gasoline skidders can not differ materially in this respect from steam skidders.

A modification of the rehaul method is occasionally employed where it is the practice to cut short logs. It consists of placing the tail trees rather far apart and bunching the logs in the skidder runs with animals. The mechanical advantages of this method are the less frequent changes in the tail trees and moving up of the skidder, the greater opportunity for bringing in a number of small logs with the use of a choker, and a practical elimination of the delay in carrying the tongs back from the skidder runs to logs at some distance from it. The method has decided advantages from the timber-growing point of view, since only those trees are badly bruised by incoming logs which are located immediately along the skidder run. This method of steam skidding was used for a time by one of the earliest exponents of timber growing in the South, with a marked saving of young growth and standing trees.

Present Turpentine Practice and Seed Trees

In the western part of the southern pine belt the great bulk of longleaf and slash pine stands are in the hands of lumber companies which rarely permit their timber to be chipped for naval stores for more than two or three years before it is cut. A very high proportion is virgin timber. Since under the terms of his contract the turpentine operator in this region is generally required by the owner to pay for trees which die as a result of turpentineing, he exercises considerable care in chipping and other steps in the operation. Loss of timber is accordingly light, in spite of the fact that narrow-sap timber such as is represented by virgin stands is susceptible to injury in these processes. In Texas, Louisiana, Mississippi, and a part of Alabama turpentineing is entirely secondary to logging in the all-too-common reduction of pinelands to barrenness.

Conditions are very different in the eastern part of the southern pine belt, where the greater part of the turpentine woods is second growth. It is the common practice here to chip front faces for four years or more and then to back face the same trees for an equal period. Also, under the practice of yearly burning, the eastern orchards are scourged by fire for many years before abandonment, instead of only for two or three years, as in the western territory. Again, a much smaller percentage of the merchantable timber, particularly second growth, is held by lumber companies, and the cutting of saw logs, crossties, and other products is generally a process of salvage after turpentineing is completed.

Enormous loss of second-growth slash and longleaf pines in the eastern territory, particularly in Georgia and Florida, results from the destructive turpentineing methods commonly used. The destruction formerly wrought by the use of boxes is now equaled if not exceeded by that which follows abuse of the cup and gutter system.

16 The face or faces placed on a "round" tree, or one which has never before been turpentine, are called "front faces." Any faces later placed on the tree are called "back faces."
Gutters are driven unnecessarily deep into trees, chipping is often as deep as 1 or 1¼ inches, and faces are run together, eliminating the bark bars. These practices not only lower the vitality of every tree by greatly impeding the circulation of sap (not gum) within it, but also weaken the small trees mechanically. Lowered vitality results in "dry-facing," a condition which, together with excessive scraping of the longleaf faces at the end of the season, allows both boring insects and rot to enter the trees. These soon reduce the outwardly sound tree to a mere shell surrounding a core of worthless material. Raking ceases in abandoned orchards, and fires eat into the pitchy faces. Trees which do not burn down are snapped off in great numbers by high winds.

Table 8 illustrates the typical condition of second-growth stands, originally in splendid shape to continue growth, but wrecked by careless turpentining. The figures are a composite from three stands, boxed or cupped for an average of five years, and abandoned, on an average, one year.

Table 8.—Round, living turpentined, and dead turpentined trees, by species and diameter classes, in abandoned turpentine woods of even-aged second-growth southern pines

<table>
<thead>
<tr>
<th>D. b. h. (inches)</th>
<th>Slash pines per acre</th>
<th>Longleaf pines per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Turpentined</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alive</td>
<td>Dead</td>
</tr>
<tr>
<td>4</td>
<td>15.3</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>36.2</td>
<td>6.5</td>
</tr>
<tr>
<td>8</td>
<td>3.5</td>
<td>33.2</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>12</td>
<td>0</td>
<td>4.7</td>
</tr>
<tr>
<td>14</td>
<td>0</td>
<td>1.5</td>
</tr>
<tr>
<td>16</td>
<td>0</td>
<td>2.1</td>
</tr>
<tr>
<td>Total or average</td>
<td>55.0</td>
<td>97.1</td>
</tr>
</tbody>
</table>

1 Living trees only. A few round trees were dead from fire and natural causes.
2 Percentages figured from original tallies, not those per acre.

Table 8 shows clearly that whereas current turpentining practice is destructive of some trees as large as 14 inches in diameter, it is fatal particularly to 6 and 8 inch trees. The damage is caused by a combination of turpentining and fires subsequent to the abandonment of work. After raking ceases with the last chipping season, the vast majority of abandoned orchards suffer a yearly loss from fires in the old faces. The longer the period since abandonment, the heavier is this loss. But protected from fire or not, abandoned areas continue to suffer from the evil effects of previous dry facing—the steady ravages of boring insects, rot, and wind.

Severe damage from turpentining is by no means confined to second-growth stands. Table 9 and Plate 6, B, reflect conditions in a typical ragged, all-aged Florida stand in which boxing began in 1880 and which was subsequently culled for logs and cross ties and cupped for two additional periods of three years each. In this time as many as four faces were placed on the larger trees, often two and three at
once. The highest death rate occurred among the 12 to 16 inch trees, apparently because those smaller than this did not have as many faces, and those larger were better able to withstand the heavy working. The long period since the original work began also probably accounts for the heavier loss of longleaf pines than of slash. As shown in Table 7, and as borne out by common knowledge among naval stores operators, slash pine does not stand as severe working as longleaf, and it seems likely that many of the slash pines had succumbed and dropped out of the stand prior to the investigation.

<table>
<thead>
<tr>
<th>D. b. h. (inches)</th>
<th>Slash pines per acre</th>
<th>Longleaf pines per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Round 1 Turpentined</td>
<td>Round 1 Turpentined</td>
</tr>
<tr>
<td>Alive</td>
<td>Dead</td>
<td>Alive</td>
</tr>
<tr>
<td>-------</td>
<td>------</td>
<td>--------</td>
</tr>
<tr>
<td>4</td>
<td>11.0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>13.9</td>
<td>2.5</td>
</tr>
<tr>
<td>8</td>
<td>3.2</td>
<td>2.9</td>
</tr>
<tr>
<td>10</td>
<td>16.6</td>
<td>3.1</td>
</tr>
<tr>
<td>12</td>
<td>0</td>
<td>3.8</td>
</tr>
<tr>
<td>14</td>
<td>7.5</td>
<td>4.0</td>
</tr>
<tr>
<td>16</td>
<td>5.0</td>
<td>2.8</td>
</tr>
<tr>
<td>18</td>
<td>2.4</td>
<td>.3</td>
</tr>
<tr>
<td>20</td>
<td>0</td>
<td>.1</td>
</tr>
<tr>
<td>22</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>24</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total or average</td>
<td>28.1</td>
<td>49.3</td>
</tr>
</tbody>
</table>

1 Living trees only. A few round trees were dead from fire and natural causes.
2 Percentages figured from original tallies, not those per acre.

It is important to note from the combined tally of these two sample areas, taken at random in typical stands, that 19 per cent of all 6-inch trees in them were chipped, and that only two trees 10 inches in diameter or larger escaped turpentining.

Although small trees and second growth suffer more frequently in turpentining, and virgin timber is more generally turpentined with care, in some localities the large trees of virgin timber suffer heavy loss from ordinary commercial working for naval stores. For example, in the deep sands of western Florida, adjacent to the Choctawhatchee National Forest, there are entire sections of privately owned longleaf land where no green timber has ever been cut, yet which do not bear a living pine above sapling size. The original virgin stand of several thousand board feet to the acre has been wiped out by turpentining and subsequent fires. (Pl. 8, B.)

**NECESSARY MODIFICATIONS AND THEIR COST**

It should be evident from the foregoing paragraphs that the methods ordinarily used in logging and turpentining southern pine stands can not be counted upon to leave seed trees of the kind and number believed necessary to keep the land productive, or to preserve enough advance growth to form a commercial stand worth the expense of bringing it to maturity.
Just how effective in preserving advance growth any modification of current methods is likely to be can not be predicted. Evidence drawn from actual conditions is altogether lacking, and if available would carry little weight except for just those conditions. It is plain, however, that care in felling the mature stand so as to do the least possible harm to seedlings and saplings; animal logging as opposed to steam skidding; and keeping fire out of turpentine orchards, will give advance growth the best chance for survival. The cost under ordinary conditions would be practically nothing.

The chief, and except for organized fire protection the only, modification of logging and turpentining practices needed to keep most southern pinelands productive, is the reservation of seed trees. In virgin and second-growth stands seed trees must be especially selected in advance of both turpentining and logging. Upon one occasion only can any but picked trees be relied on as seed producers. In some uniform, thrifty stands of both virgin and second growth a saw-timber cutting to a rigid diameter of 12 to 14 inches would leave the land in good condition to reforest from the remaining trees. In such cuttings the direct outlay for selecting seed trees may be saved.

**MARKING SEED TREES**

The mechanics of designating or marking seed trees need not be gone into. Running parallel compass lines through the tract, and at regular intervals stopping to select the proper number of trees in a strip on each side, will probably be desirable, at least until the man in charge becomes expert in judging the number of trees per acre to be left. Since the whole future of the forest as a productive property depends in large degree on the intelligence and judgment of the man marking the seed trees, no other than the best-qualified man available should undertake the work.

The selection and marking of seed trees should not cost over 12 cents an acre in open virgin timber, on the basis of marking 65 acres a day, marked by a 2-man crew, consisting of a trained forester or other individual of equal competence to run the compass and select the trees and an assistant to do the actual marking. Marking may be done with paint, or, in cases where cutting will follow within a couple of months, with a blow from a flour sack containing slaked lime. In dense virgin timber the cost will be more, and in second growth may run as high as twice the figure given, or about 25 cents. Seed trees on 800 acres of second-growth loblolly pine were marked in Maryland at 27 cents an acre (\$2.70); brush was unusually dense, thus slowing the work.

**INVESTMENT IN SEED TREES**

In the light of facts already given it may well be doubted whether in virgin stands any actual stumpage investment is involved in 2 to 4 seed trees to the acre, 10 to 12 inches in diameter, and generally of inferior quality from a lumber standpoint. Even where the findings of Ashe, Garver, and Miller do not wholly apply, the stumpage value of such trees should certainly not be computed from the average rate in any locality; half that value would be a liberal allowance.
If virgin longleaf and slash pine stumpage is held at $10 a thousand board feet, the 150 board feet contained in 4 longleaf seed trees should then be valued at 75 cents, and the 75 feet in 2 slash seed trees at 38 cents. When in longleaf stands it is necessary to leave larger trees because those of a diameter of 10, 11, or 12 inches are not available; their volume may be as high as 250 board feet, which at the full stumpage rate increases the per acre investment to $2.50. The corresponding value for the smaller number of slash pines, which, diameter for diameter, do not have as great a volume as longleaf, is $1.

Virgin shortleaf and loblolly pine stumpage may be valued at $5 a thousand board feet, or $2.50 a thousand for seed trees. The 75 board feet contained in two seed trees of these species, 10 to 12 inches in diameter, then represents an investment of 19 cents. The 100 board feet represented by a single 14-inch tree at the full stumpage rate is valued at 50 cents.

Volumes in the 10, 11, and 12 inch classes are somewhat greater for second-growth seed trees than for virgin trees, because of greater average height, but in the larger classes are less because of greater taper. Since a considerable proportion of the volume of second-growth stands now being cut comes from trees of small diameter, the value of seed trees may fairly be appraised at the full rate for second growth. At $4.50 a thousand for all species, four small longleaf seed trees have a stumpage value of about 85 cents, and their equivalent in larger trees is the same or a little less. The two second-growth seed trees of the other species have a calculated value of 45 to 55 cents.

To the stumpage investment in longleaf and slash pine seed trees must be added turpentine values. Such values have changed from year to year very markedly, so that it is hard to arrive at average figures. In 1928 the price of a 4-year lease on average timber in Florida was $1,200 a crop. In 1926 the average for the entire South was probably nearly twice this. Using the 1928 figure and disregarding the fact that in parts of the South virgin trees are not worked for more than two or three years before they are cut, the three or four faces to the acre in virgin longleaf stands, and the two in slash stands, represent 36 to 48 cents and 24 cents, respectively.

Although the value of a 3-year lease is greater in virgin timber than in second growth, higher turpentine values must be assigned the latter because faces are usually worked much longer than four years. Seven to ten years is not uncommon in second growth. If $1,800 a crop is a fair average valuation to put on a long lease, the naval-stores values represented in seed trees are then 54 to 72 cents an acre for longleaf and 36 cents for slash.

Vigorous southern pines of the sizes most likely to be left for seed are growing rapidly in volume and the increase in quality of the wood produced makes their growth in value even more rapid. The investment in seed trees, if investment it is, is therefore usually not only recoverable in later years, but capable of yielding highly satisfactory interest. For example, longleaf pines, even the runts and

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\[1\] All tree volumes in the discussion of seed-tree stumpage values are by the Doyle rule. Although this rule grossly underestimates the volume of small trees, as has been repeatedly pointed out, it is still universally used in the South, and nearly all purchases and sales are made by it.
culls of the virgin stand such as were commonly left on cut-over lands in the early days of the southern pine industry, have been found (6, 9, and 1) to increase in diameter at a reasonable rate when freed from overtopping neighbors. Although height growth of such trees is generally negligible, recent studies of the Southern Forest Experiment Station have established the fact that rapid increase in diameter is not confined to breastheight, but extends all the way up the stem. Chapman (11) measured the growth of 400 longleaf pine trees in a tract of average quality, or a little better than average, in central Louisiana. About 11 trees to the acre had been left in a cutting in 1904. At that time they averaged 10 inches in diameter, and in 1924, 14 inches. In the interval stumpage values had increased from $2 a thousand feet to $10. An investment of $1 an acre in cut-over land in 1904, Chapman figured, had increased in 20 years to $20, exclusive of the values represented by the land itself and an abundant young growth.

A similar study by the experiment station of 318 longleaf pines on cut-over land of somewhat poorer quality in central Alabama showed nearly the same diameter increases, although the trees were not as invariably stimulated in their growth as on the better soil (17). Trees of the other species of pine, when released by cutting or by some accident of nature, are likewise able to take advantage of increased light and soil moisture and to grow at a very satisfactory rate (10, 22). This appears to hold for both virgin and second-growth trees.

The excellent growth made by trees left at random in old cuttings should be at least equaled by specially selected seed trees. Such trees, however, should be growing rapidly already and so will not increase greatly in growth rate after the cutting. Moreover, an occasional tree will be destroyed by lightning, insects, or other agency, and so be lost altogether. Although the stumpage left in seed trees from virgin timber now being cut will not increase in value in the next 20 years at the same rate as such stumpage has in the past, it is certainly true that with the virtual disappearance by 1950 of virgin southern pine in continuous stands, the wide boards of relatively fine-ringed wood generally contained in seed trees will command a premium.

Naval-stores values in seed trees are not so surely recoverable at a later date as stumpage values. This is because two to four faces to the acre can not be chipped at a profit, whereas even to-day as little as 1,000 board feet of lumber may be so cut from an acre, particularly when of good quality. However, some trees now unmerchantable for lumber may be present in the stand, and reach chipping size in 15 to 20 years. By that time the new crop of timber should have reached a size to warrant removal of the seed trees, and the presence of additional trees big enough to chip may make a naval-stores operation possible. The yields per face from trees 14 inches in diameter are 54 to 65 per cent greater than those from 10-inch trees (Table 18), and 14-inch trees will support two faces, at least for short periods of working.

Additional Seed Trees to Offset Logging Damage

On jobs where neither trams nor power skidding are employed, and where the timber fallers have been impressed with the need of preserving designated seed trees, the allowance for accidental loss
of seed trees need be nothing more than "playing safe" whenever there is doubt as to how many seed trees to leave. When shortleaf and loblolly stands are logged with trams, the location of spurs is generally known far enough in advance of marking to allow the marker to avoid designating trees on the rights of way. In stands of the turpentine-producing species, however, the seed trees have to be marked in advance of turpentining, or on most jobs two or more years before the final location of spurs. The likelihood that some of the trees will have to be cut from rights of way requires a slight increase in the number of trees marked—perhaps 10 per cent. Since the wood in broken or uprooted trees can be largely salvaged, the only loss in such trees is in naval stores values. The largest increase, however, must be made on steam-skidded or gasoline-skidded jobs. There it will be wise to increase the number of seed trees marked by 25 per cent in average timber, and by 50 per cent in unusually heavy timber.

**Summary of Costs**

The foregoing costs involved in leaving seed trees are summarized in Table 10. Estimated high and low costs are given, and in addition an attempt is made to arrive at a "most probable" total or a total which is believed to fit the average condition. Costs are calculated on the basis of an acre, not of a thousand feet cut.

<table>
<thead>
<tr>
<th>Item</th>
<th>Longleaf pine</th>
<th>Slash pine</th>
<th>Loblolly or shortleaf pine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Virgin timber</td>
<td>Second growth</td>
<td>Virgin timber</td>
</tr>
<tr>
<td>High costs:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stumpage 1</td>
<td>$2.50</td>
<td>$0.85</td>
<td>$1.00</td>
</tr>
<tr>
<td>Naval stores lease 1</td>
<td>.36</td>
<td>.72</td>
<td>.18</td>
</tr>
<tr>
<td>Marking</td>
<td>.15</td>
<td>.26</td>
<td>.15</td>
</tr>
<tr>
<td>Extra trees, power skidding 1</td>
<td>.18</td>
<td>.36</td>
<td>.09</td>
</tr>
<tr>
<td>Total</td>
<td>3.19</td>
<td>2.18</td>
<td>1.42</td>
</tr>
<tr>
<td>Probable costs:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stumpage 1</td>
<td>1.35</td>
<td>.84</td>
<td>.55</td>
</tr>
<tr>
<td>Naval stores lease 1</td>
<td>.36</td>
<td>.72</td>
<td>.18</td>
</tr>
<tr>
<td>Marking</td>
<td>.13</td>
<td>.16</td>
<td>.15</td>
</tr>
<tr>
<td>Extra trees, power skidding 1</td>
<td>.12</td>
<td>.05</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1.96</td>
<td>1.72</td>
<td>.93</td>
</tr>
<tr>
<td>Low costs:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marking</td>
<td>.12</td>
<td>.15</td>
<td>.12</td>
</tr>
</tbody>
</table>

As indicated in the text, these costs are generally recoverable, in whole or in part.

No allowance is made for increased logging costs, since it is the general opinion of southern pine lumbermen who have been consulted in the matter that, provided a skidder crew is really anxious to avoid the destruction of standing trees, it can be done in the greater number of instances at practically no extra cost. An exception is the statement of one experienced operator who put this cost as high as 33 cents a thousand, although he has never left any trees worth attempting to save.
GOOD AND POOR SEED TREES

At the left is a good longleaf seed tree with long crown and a pointed top denoting vigor. At the right is a flat-topped “red heart,” a type that almost always dies within two or three years after the surrounding trees are logged. Bogalusa (La.) branch, Southern Forest Experiment Station.

SECOND GROWTH CLEAR CUT FOR PULPWOOD

Everything down to 4 inches diameter breast-height was cut in this shortleaf stand, but the uncut portion on the left should insure natural reforestation of a considerable area. Note the straight clear stems—too good for pulpwood, when millions of cords of tops go annually to waste on sawmill operations. Louisiana.

A FIRE LINE IN LONGLEAF PINELAND

This 15-foot line was plowed by a team in four trips with a middle burster, at a cost of $4.35 a mile. (Photo by Louisiana Department of Conservation.)
A, Selective logging in a loblolly stand. This cutting to a diameter limit by a portable mill in North Carolina has left the land in splendid shape for another cut in 15 to 20 years. Real selection of the trees to be removed would have left it in even better shape; B, a thinning in slash pine. This 22-year-old stand in Georgia was thinned for future naval-stores operation to a spacing of about 12 feet each way, leaving 290 trees to the acre, 6 to 12 inches diameter breastheight. A cordwood or pulpwood market might have made this job pay for itself.
PROTECTION AGAINST GRAZING

Longleaf pine land in the immediate neighborhood of farms or communities where hogs are numerous, or adjacent to bottom lands where hogs are turned out to graze, can not reproduce to longleaf unless carefully fenced. Fortunately there are enough seed trees of other species, the seedlings of which the hogs rarely damage, to reforest some of these areas. In probably three-fourths of the longleaf pine belt fencing against hogs is unnecessary, but locally in the remaining one-fourth it must be done.

Sheep and goats will sometimes seriously injure any species of pine seedlings less than 3 or 4 feet in height, but only in rare instances will it be necessary to fence against them in order to keep land merely productive.

The grazing of cattle on pineland is more apt to be beneficial than harmful. It is, of course, impossible to raise pine of any species on lands heavily grazed, or in such forage types as carpet grass, where cropping and trampling both contribute to the death of the seedlings. Moderate grazing of a tract of longleaf pine land has, however, been shown experimentally (see p. 24) to involve no serious loss of seedlings on the area as a whole, and to cut down the losses from winter fires by more than half. These results were obtained on a cut-over area in south Mississippi, where the chief fuel is broom sedge and wire grass (Andropogon sp.). It is possible that the damage by-cattle to more slender-stemmed species of pine is greater, and the reduction of hazard in other forage types less. Nevertheless, grazing by cattle for as long a period as the forage persists is a valuable insurance against loss through accidental fires.

The cost per acre of fencing will, of course, vary greatly with the size of the tract enclosed, and its shape. The items of expense in erecting 24 miles of fence in south Mississippi in 1926, as furnished by the builder and reduced to the basis of a mile, are as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>32-inch woven wire</td>
<td>$105.60</td>
</tr>
<tr>
<td>2 barbed wires</td>
<td>$28.80</td>
</tr>
<tr>
<td>Staples</td>
<td>$2.50</td>
</tr>
<tr>
<td>Construction—contracted at 35 cents a rod to cut, haul, and set posts, and to stretch wire</td>
<td>$112.00</td>
</tr>
<tr>
<td>1 gate for every 3 miles</td>
<td>$3.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$251.90</strong></td>
</tr>
</tbody>
</table>

Posts were obtained within the tract itself, and were set a rod apart. The area inclosed was 14,000 acres, at a total expense of approximately $6,000. The first cost was thus 43 cents an acre. If the life of the fence is 10 years, and annual repairs amount to $10 a mile, the cost becomes about 6 cents an acre a year, and on a square tract would be less.

Forty miles of 4-strand barbed-wire fence, on posts 16 feet apart, was recently built in south Georgia for $131 a mile.

WILL IT PAY TO KEEP FOREST LANDS PRODUCTIVE?

STANDS OF SEEDLINGS TO BE EXPECTED ON AVERAGE LAND

Not all southern pineland may be kept productive by the simple measures just outlined. Such types of soil as "crawfish land," hard-
pans, and deep sands, the deep sands occupying the considerable area shown in Figure 1, are so unfavorable to the growth of the pines that only intensive methods could promise success. Whether such methods as are described in the latter part of this bulletin would prove practicable for such lands in private ownership is a question as yet unanswerable.

The stand of seedlings on southern pineland of average quality which has been kept productive by protection from fire and excessive grazing and by the preservation of two to four pine seed trees to the acre will vary considerably from tract to tract. Because no areas have been found which by chance have received exactly these benefits, and because no data from experimental areas are yet available, it is hard to present even average figures. However, some idea of the results to be obtained with longleaf pine by the measures named may be gained from Table 11, compiled by P. C. Wakeley from records of the Southern Forest Experiment Station.

Table 11 illustrates how slight an improvement in all of the conditions affecting natural reforestation will raise cut-over land from a hopelessly unproductive to a reasonably productive state. Land repeatedly burned and with less than two good seed trees per acre not

<table>
<thead>
<tr>
<th>Condition of seedling stand</th>
<th>Size of tract</th>
<th>Fire history</th>
<th>Longleaf pine seed trees</th>
<th>Longleaf pine seedlings per acre</th>
<th>Proportion of seedlings uniformly distributed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poorly stocked.</td>
<td>Acres 37</td>
<td>Only 35 per cent not burned within 1 year; 6 per cent not burned within 2 years.</td>
<td>4 inches d. b. h. or larger: Good seeders 1.8</td>
<td>10 inches d. b. h. or larger: Poor seeders 4.0</td>
<td>Proportion of scattered seed trees 2.9</td>
</tr>
<tr>
<td>Understocked.</td>
<td>35</td>
<td>79 per cent not burned within 1 year; 11 per cent not burned within 2 years.</td>
<td>Good seeders 3.6</td>
<td>Poor seeders 4.5</td>
<td>Established 43</td>
</tr>
<tr>
<td>Satisfactorily stocked.</td>
<td>20</td>
<td>40 per cent burned only twice in last 5 years.</td>
<td>Good seeders 6.1</td>
<td>Poor seeders 6.2</td>
<td>Others 80</td>
</tr>
</tbody>
</table>

This table summarizes actual conditions observed in the course of about 6 miles of surveys in typical south Mississippi lands cut over for about 20 years. For each unit of 1 to 2 acres contained in a strip on both sides of a compass line a separate tally was kept of the number of trees remaining from the virgin stands, and their condition as seed producers; and on a narrower strip, of the longleaf pine seedlings which presumably came from the seed of these trees. Notes were also made on the distribution of both seedlings and seed trees, and the fire history of each unit was reconstructed from the age of sprouts from fire-killed brush. The units were then grouped by total number of seedlings and the conditions for each group tabulated. Those units having less than 700 seedlings to the acre were considered poorly stocked, those having 700 to 1,600, understocked, and those having over 1,600 fully stocked.
well distributed over the area had, in the 20 years since cutting, produced only 233 established seedlings, or 360 in all. On ground not quite so often fire-swept in recent years, and with double the number of good seed trees somewhat better distributed—but still less than four good seed trees—530 seedlings were established, and 1,060 seedlings in all were present. Slightly over five good seed trees, well scattered, on land nearly half of which had not burned more than twice in five years and the rest not annually, produced 2,765 seedlings, of which 752 were established.

A lumber company operating in the level loblolly-shortleaf pine lands of southeastern Arkansas has since 1921 been cutting to a diameter limit now 15 inches on the stump, and has in addition usually left selected trees for seed. All of the seed trees were above the 10-inch limit set in this bulletin, and an occasional tree has exceeded 20 inches at breastheight. Late in 1927 the company’s forester tallied the young growth on 76 small plots well distributed through typical cuttings of four different years. The result is shown in Table 12.

Table 12.—Number of loblolly and shortleaf pine seedlings on seed-tree cuttings in southeastern Arkansas, 1927

<table>
<thead>
<tr>
<th>Year of cutting</th>
<th>All seedlings, per acre</th>
<th>1-year seedlings</th>
<th>2-year seedlings</th>
<th>Seedlings over 3 years old</th>
<th>Seed trees, per acre</th>
<th>Trees below cutting limit, per acre</th>
<th>Paris, plots</th>
</tr>
</thead>
<tbody>
<tr>
<td>1921†</td>
<td>1,958</td>
<td>2</td>
<td>9</td>
<td>20</td>
<td>(9)</td>
<td>2</td>
<td>28</td>
</tr>
<tr>
<td>1923</td>
<td>274</td>
<td>11</td>
<td>29</td>
<td>31</td>
<td>29</td>
<td>2</td>
<td>32</td>
</tr>
<tr>
<td>1924</td>
<td>30</td>
<td>1</td>
<td>24</td>
<td>44</td>
<td>31</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>1927</td>
<td>480</td>
<td>40</td>
<td>34</td>
<td>20</td>
<td>6</td>
<td>2</td>
<td>30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Per cent</th>
<th>Per cent</th>
<th>Per cent</th>
<th>Number</th>
<th>Number</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1921†</td>
<td>2</td>
<td>9</td>
<td>(9)</td>
<td>2</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>1923</td>
<td>11</td>
<td>29</td>
<td>31</td>
<td>29</td>
<td>2</td>
<td>32</td>
</tr>
<tr>
<td>1924</td>
<td>1</td>
<td>24</td>
<td>44</td>
<td>31</td>
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<td>4</td>
</tr>
<tr>
<td>1927</td>
<td>40</td>
<td>34</td>
<td>20</td>
<td>6</td>
<td>2</td>
<td>30</td>
</tr>
</tbody>
</table>

1 Within their own height of center of the plot
2 Year of good seed crop.
3 Cutting area burned in 1925.

In an earlier discussion of the advance growth which, surviving logging and turpentining, was necessary to justify leaving no seed trees in cuttings or turpentine orchards, 600 to 700 healthy longleaf seedlings to the acre, 7 or 8 years of age, was set as a fair standard. From 700 to 900 of such seedlings of loblolly or slash pine, and from 1,000 to 1,200 of shortleaf pine, were the requirements of productiveness for those species. Although in Table 11 the “satisfactorily stocked” land meets the longleaf requirement here established in spite of more frequent fires than are contemplated on productive land, it should be remembered that this stocking was accomplished only in the course of 20 years or more. Many of the seedlings are well past 5 years of age.

Two to four vigorous seed trees to the acre are believed to be capable of producing stands of pine seedlings such as these from one or two full seed crops. For loblolly, shortleaf, and slash pines this should take place within a period of five years after the completion of cutting or turpentining. Only one of the areas listed in Table 12 had been cut for so long a period, and this was more than reasonably well stocked. Longleaf pine, however, seeds heavily only
at about 7-year intervals, and it may happen that scarcely a longleaf seedling will start on freshly cut-over land for seven years, no matter how many seed trees are left. The average delay in starting the new crop will be three or four years, and if weather or other conditions should be unfavorable to the seedlings then started it will be 10 or 11 years before they are supplemented from another heavy seed fall. The great desirability of fostering advance reproduction by means of fire protection well in advance of cutting or turpentineing is thus very evident.

It is believed that seedlings of the prescribed numbers and age can not be counted upon to produce more than a third of a full crop of forest products, speaking in terms of value, not volume. Under favorable conditions they may produce as much as two-thirds of a crop. These estimates are based on a study of fully stocked stands, the results of which are presented later in this bulletin, and on a consideration of the effect of open spacing on the merchantability of the product. Open-grown trees produce knotty lumber and increase the cost of making pulpwood; on the other hand, they yield substantially more naval stores than do trees in dense stands. If uniform spacing could be counted upon, as in a plantation, the standard number, at least of shortleaf pines, would be unnecessarily high for the production of only a third of a crop. But even where the unit is as small as an acre, several hundred seedlings may be bunched in dense thickets, leaving much vacant or very poorly stocked land between. Production is thus greatly reduced.

THE TREND OF VALUES IN STUMPAGE AND TURPENTINE LEASES

The present-day value of forest lands kept productive of wood and naval stores of course depends on public faith in the future price of stumpage and turpentine leases. These prices are far more a matter for speculation than the rate of growth of the trees themselves. But it is plain from Figure 2 that the general trend of stumpage rates for southern pine has been upward, in common with that of all other species throughout the history of the lumber industry. That virgin longleaf pine stumpage has increased in value at a phenomenal rate is of less significance than that in the South Atlantic States, where the present timber is largely second growth, stumpage has steadily climbed at a faster rate than the average of all softwoods in the United States.

It is idle to speculate on the future of stumpage values. That such values can temporarily recede is shown by the curve in Figure 2 representing second-growth pine in the lower Mississippi region. Moreover, timber in small bodies, such as are becoming an increasingly important source of logs for southern pine mills, is generally for sale at a lower figure than the strongly held timber of large operators. On the other hand the national situation with respect to timber supplies favors the producer of southern pine.

The percentage of its own lumber which the South consumes has steadily gone up, and between 1922 and 1925 progressed from 42 per cent to 51 per cent (17a). This has been only in part due to the decrease in production as available stumpage has decreased. Whatever the cause, the gradual retirement of southern pine, for 30 years
the most abundant American wood, from the great competitive markets of the manufacturing East and the agricultural Middle West seems certain to raise lumber prices in these markets. An increasing proportion of their lumber must be transported from the west coast—a distance of 2,000 to 3,000 miles by rail, or 5,000 to 7,000 by water plus an inland rail haul. The average cost of these hauls is $5 to $10 above those from the southern pineries. The general rise of lumber prices in other sections of the country will in time be reflected in the local southern market. It seems possible that the grower of southern pine timber will in time realize advances on the value of his stumpage equal at least to the difference in cost of transporting lumber to middle-western and eastern markets from the South and from the west coast.

The information available on the price paid for turpentine leases in the past is very slight, but the same conditions which governed the rise in wood values on the stump in the South have operated to increase the cost of turpentinaing privileges. Twenty-five years ago operators commonly paid from $100 to $200 for a 3-year lease on a crop of 10,000 boxes. By 1925-26 these figures had increased tenfold; $2,000 had become quite common in Georgia (18). For exceptionally good timber $2,500 was occasionally paid. Back faces commanded about the same price as front faces, but high faces were, of course, valued at less than low. By 1928 prices had receded, and $1,200 for a 4-year lease was said to be a fair average in Florida (34).

The scantiness of the information on past values of naval-stores leases, as well as the recent serious inroads of substitutes for turpentine, make prediction of future values difficult. It does not seem unreasonable, however, to expect the present cost of leases for 3-year periods to extend in the future to additional periods made possible by conservative work, as later described.

THE TAX SITUATION

Much has been made of the burden of taxation on southern pine-land dedicated to timber growing. Yet it is significant that so far at least very little land has been surrendered to the States because of the owners' inability to meet taxes. The area of forest land allowed to lapse for taxes in the South has been incomparably less than in some other sections of the country. The reasons are many and diverse, but need not be gone into here.

Some typical instances of tax rates on cut-over lands in the pine region of the South may be mentioned. In southwestern Georgia such longleaf pine lands are assessed at $1 to $1.50 an acre, and the tax rate averages 20 mills on the dollar. The actual tax paid in this locality is therefore from 2 to 3 cents an acre a year. In southern Arkansas cut-over shortleaf and loblolly pine lands are assessed at $2.50 to $4 an acre. In 1928 the millage was generally 30 to 40, making the average tax about 10 cents an acre. In Louisiana east of the Mississippi River assessments run from $3 to $5 an acre on cut-over longleaf land, and a tax rate of about 30 mills makes annual taxes 9 to 15 cents an acre. In adjacent portions of Mississippi the tax rate, although very variable, is generally lower. It is significant that Louisiana, which taxes its cut-over lands as heavily as most
Southern States and much more heavily than some, has been a leader in the number of large companies adopting a timber-growing policy.

Possibly the chief cause for forest-land owners' anxiety over the tax situation is not the present level of taxes, but the fear lest taxes be unwarrantably increased in the future, particularly on land which begins to show the promise of second growth. There can be no doubt that tax rates have on the whole steadily advanced in the past, and that some large land-owning companies, which are also proprietors of sawmills subject to advances in assessment, have occasionally paid taxes on their cut-over land in excess of any actual value.

However, a recent decision by the Louisiana Supreme Court is worth noting in this connection. A lumber company with large cut-over land holdings in a parish where 70 per cent of the land was owned by nonresidents was assessed at an average rate of $9.51 an acre by the local and State authorities. It took the matter into the courts. There it contended that only 30 to 40 per cent of its holdings were tillable land, and that not more than 12.5 per cent of the resident-owned land in the parish was in actual cultivation. The company pointed out that $50 an acre was needed to clear such lands for cultivation, and established the fact that it had widely advertised these lands locally and in the South and Middle West at $3.50 to $4 an acre for two years, without securing a purchaser. The supreme court set aside the $9.51 valuation as "clearly speculative" and the assessment is now at $3.50. There was some young growth of timber present, and the land was later bought for its future forest value.

It seems probable from this instance that the courts on a reasonable showing will refuse to permit increases in assessments not based on cash values.

There is a most encouraging tendency on the part of the southern public to recognize the injustice of imposing high annual taxes on properties which at present in the majority of cases yield only periodic revenue. The State of Louisiana offers contracts of reforestation, running for as long a period as 40 years, to those who undertake to reforest their cut-over lands. There is now 300,000 acres of forest land, in tracts varying from 40 acres to a little over 50,000 acres, under such contracts of reforestation. Assessments of land under contract are confined to the value of the bare land at the time the contract was entered, and when the timber is cut a yield tax is charged. Alabama has a similar law, under which 50,000 acres have been dedicated to timber growing as "auxiliary State forests," assessed at the value of the bare land. Mississippi has recently passed a law exempting from taxation for a period of 10 years the timber values on land devoted to timber growing. Legislation of this character is being agitated throughout the South.

A further fact should be kept in mind in estimating the trend of future taxes. The more universally timber growing is practiced as a result of the simple measures above outlined, and others more intensive, the greater will be the area of young timber growth over which to spread the taxes necessary to the support of any community. A very slight additional tax on each acre of an entire

19 Lyon Lumber Co. v. Louisiana Tax Commission et al., 158 La. 990, 105 So. 39.
county may yield sums which if levied from occasional owners of growing timber will rest upon them as a heavy burden. Here, as in many other respects, forestry is its own remedy for many of the troubles which assail those who practice it.

**COMPARATIVE SALABILITY OF BARREN AND PRODUCTIVE LAND**

The owners of southern pineland may be divided into two broad classes: (1) Those who look forward to continued ownership and use of the land after the present crop of wood or naval stores is removed, and (2) those who have no further interest in the land than to sell it at the highest price obtainable. Owners of the first class, if they intend to maintain the land in forest at all, will not be interested in measures which assure only a third of a crop on it. They will wish to go much further, and employ measures designed to produce full forest crops. The latter part of this bulletin is devoted to their problems.

Owners of the second class are mostly, although not altogether, lumbermen who years ago began their business in the South by acquiring title to timbered land. This was the customary and simplest way of obtaining the timber, and in fact the only way under the public land laws. The majority, after years of sawmilling, now find themselves involuntary owners of land whose disposition is a very difficult problem. Each year their saws add to the size and difficulty of their problem. Such landowners are now anxiously examining various uses for the thousands of acres which have been left on their hands as a by-product of their industry. Their plight is discussed at some length in another publication (17a), and need be only briefly summarized here.

Ten to 15 years ago a great effort was made in the South to develop cut-over pinelands and abandoned turpentine orchards for farming. Lumber company after lumber company sank large sums in demonstration farms and colonization schemes, which in most cases were failures. The failure was frequently not due to the fact that the land was too poor to produce crops. It is of course true that large areas of former pinelands of the South are not fit for farming under any condition, and that additional areas may be profitably farmed only when markets for farm products are good, or when the land is handled with more than ordinary skill. But the census of 1920 showed that there has been an actual shrinkage of land in farms in all but four Southern States since 1910, and in those it is extremely doubtful if more than a small percentage of the increase came from the clearing of pinelands. In Virginia and North Carolina the area of improved land in farms also shrank in the decade from 1910 to 1920. The attempt to develop cut-over pinelands for farming came at the very time when the whole tendency of American agriculture was to use less land, and use it more intensively.

Locally, remarkable success has been attained in the production of special crops on ordinary "piney woods" land. But the area now unimproved in the pine region of the South is too vast, and represents too large a percentage of the total area, to be greatly reduced by extension of trucking, strawberry growing, and similar intensive uses.
The use of cut-over pinelands for intensive grazing appears on the surface to be very promising, owing to the favorable weather conditions in the South. It is impossible, however, to escape drawing conclusions from a comparison of the number of livestock in the South now and a few years ago. The shrinkage has been striking. The causes are numerous, and need not be discussed here. It is enough to point out that the real development of southern pine cut-over lands for grazing will require substantial investments in fencing, tick eradication, fire protection, stock improvement, and other intensive measures. These investments most temporary owners hesitate to make, particularly at a time when the livestock business of other sections is on none too profitable a basis.

The least expensive and most hopeful use of abandoned turpentine orchards and cut-over southern pinelands generally is at present the growing of a new crop of timber, perhaps combined with a certain amount of cattle grazing. Timber is a crop to which the land is unquestionably suited. It is a crop which may be produced in moderate quantities without cultivation, hand planting, or fertilizer. In the South it grows with amazing rapidity and, as stumpage, has a more stable value than perhaps any other crop. Southern farmers are acquainted with the last-mentioned fact, for in periods of depression they have often turned to their woodlands for the cash which they could not obtain from cotton or livestock. In such periods of depression stumpage and turpentine values, of course, recede slightly, but their recession has so far been less than that of other crop values.

The South as a whole is gradually awakening to these facts concerning cut-over pineland. Within 15 years public sentiment toward timber growing has changed from a state of indifference often bordering on actual hostility to one of friendly interest and support. State after State has established a forestry department and gone to work to curb forest fires and otherwise improve conditions for timber growing. Encouraged by this public action, an increasing number of individuals and corporations are buying forest lands for the definite purpose of growing trees on them. They are not buying barren land, but land already productive. To those whose ownership in southern pineland is involuntary and frankly temporary, and who have the choice of wrecking their remaining timber by close cutting and destructive turpentining or of operating it so that the land remains in a productive condition, this situation offers an opportunity. Already in parts of the southern pine belt cut-over land having an abundance of young growth not yet merchantable commands a premium. Whether this premium will compensate any particular landowner for whatever expense is involved in leaving his property in a productive condition is a question for him to answer. In answering it he should keep in mind that barren land is a certain liability to its owner, and a staggering burden to the community at large.

RÉSUMÉ OF THE NECESSARY MEASURES

The measures necessary to keep all but the poorest of southern pineland productive after cutting or turpentining are few: Fire protection, seed trees or their equivalent, and some local protection against grazing.
Fire protection of private lands should be so organized through a combination of public and private effort that "1-hour control" is provided for pinelands generally. This should make it possible to keep the acreage burned over yearly to an average of 3 per cent of the total forest area. More intensive protection, obtained sometimes through greater man power, but more often through slash disposal and the use of fire lines, should be given turpentine orchards, slash-covered areas, and areas of young growth, with the object of reducing to 1 per cent the proportion burned. The cost of fire protection (including fire fighting), spread over an entire property, will vary considerably. The common range on large properties will be from 4 to 8 cents an acre, depending on the forest type and the presence of special hazards. In farm woodlands it may vary from practically nothing to 14 cents an acre, the latter sum, however, providing a very high standard of protection.

Unless an abundant advance growth of seedlings is already present on land to be logged or turpentined, seed trees must be left to insure a new crop. These should be carefully selected among vigorous, long-crowned trees not less than 10 to 12 inches d. b. h.; they should not be scarred or turpentined. Two to 4 to the acre are necessary for loblolly, shortleaf, and slash pines, and not less than 4 for longleaf. The investment in such trees, where chargeable at all in view of the fact that in most cases they can be logged and manufactured only at a loss, is normally from $0.50 to $2 an acre; the only actual outlay is the cost of selecting the trees, or 13 to 24 cents an acre. The investment is generally recovered, with interest in the form of growth, when the trees are later cut.

Fencing of longleaf pine seedlings and saplings against hogs, and young growth of all species against sheep and goats, is locally necessary where the stock are numerous or may at times concentrate on small areas.

The above measures are expected to result in the following stands of pine seedlings at 7 or 8 years of age: Longleaf, 600 to 700 per acre; loblolly or slash, 700 to 900; shortleaf, 1,000 to 1,200. These numbers of seedlings may be counted upon to produce one-third or more of a full crop of timber at maturity, and should be sufficient to give the land upon which they grow a recognized value above that of barren or denuded land.

MEASURES NECESSARY TO PRODUCE FULL TIMBER CROPS

The measures outlined in the preceding pages are not expected to do more under average conditions than keep southern pinelands reasonably productive. They may result in as little as a third of a possible forest crop; that is, in stands having no more than one-third the merchantable wood, or one-third the yield of naval stores, which may be produced under good natural conditions.

Few permanent owners of forest land are likely to remain content with a third of a crop, or even with two-thirds. The farmer, for example, who depends upon his own woodland for the fence posts, fuel, and building material needed on the place and who finds in crossties, piling, and saw logs a cash crop worthy of a place in diver-
sified farming, will in most instances be willing to make the very little additional effort to grow a full crop, especially since it involves no cash outlay. Fire protection is extremely simple and effective in most farm woodlands, and availability of labor and teams favors intensive handling of the forest.

Because the investment in their plants is very heavy, most if not all southern manufacturers of pulp and paper will be interested in timber growing as a means of perpetuating a going business. They will hardly be satisfied to keep their lands barely productive, but will wish to grow full timber crops.

There is a strong tendency in the naval-stores industry to get away from the old leasing system, with its many uncertainties and the cutthroat competition for timber that often encourages the working of small stuff, and to substitute ownership of the land by the operator. The relatively small acreage needed to supply gum continuously to a still of profitable size should make timber growing particularly attractive to the naval-stores operator, and timber so grown is not likely to be only a partial crop.

Again, not a few operators of both large and small southern pine mills still have enough standing timber ahead to interest them in prolonging, and in some instances perpetuating, the life of their sawmills. Every year added to the life of a sawmill reduces the sum which must be charged against depreciation of the plant and the logging equipment. As an alternative to continuing operation of the present mill at full capacity for 5 or 10 years more, then reinvesting in virgin timber in the West, and having to build up a new "good will" in a market perhaps strange to them, many such operators will prefer to curtail their output somewhat and, by making their present stumpage last until new supplies mature, operate indefinitely in southern pine. A few may even be able to purchase enough additional stumpage to maintain their present output while new timber, raised under a system of partial cutting, is maturing. In either case it will certainly be the aim of such lumbermen to grow full crops.

Finally, some owners of southern pineland may have no very definite plans for supplying a wood-using industry or a turpentine still with raw material from their properties, but will nevertheless regard productive forest lands as a permanent investment. Although no forest land in the South has been long enough under intensive management (the very details of which are still in doubt) to show what it can do, enough is already known about the growth of the southern pines in full stands to justify such an attitude.

**DESIRABILITY OF FULLY STOCKED STANDS**

Table 13 shows the yields to be expected from even-aged stands of second-growth southern pine which have been fully stocked from the beginning. These yields are on an acre basis, and for an average site for each species. This average is not necessarily the average for the entire range of the species concerned. It represents the site most commonly encountered by the field crews engaged in the region-wide study of rate of growth of the southern pines, from which the figures are taken. On the poorest sites encountered the
board-foot yields fell to zero at the lesser ages, and both board-foot and cord yields were at least 50 per cent below at the greater ages. Similarly, on the best sites yields at the earlier ages were several hundred per cent above the average, and at the later ages were 25 to 100 per cent above. Variations in board-foot values by the Doyle rule were even greater. Detailed figures of growth on all sites are contained in other publications (17a, 30).

### Table 13.—Yields per acre of fully stocked, even-aged stands of second-growth southern pines, at various ages on average site for each species

<table>
<thead>
<tr>
<th>Age</th>
<th>Lobolly pine</th>
<th>Longleaf pine</th>
<th>Shortleaf pine</th>
<th>Slash pine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Saw timber</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Doyle rule 2</td>
<td>International rule 2</td>
<td>Doyle rule</td>
<td>International rule 2</td>
</tr>
<tr>
<td>15</td>
<td>19</td>
<td>0</td>
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<td>7</td>
</tr>
<tr>
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<td>28</td>
<td>0</td>
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<td>27,500</td>
<td>49,000</td>
<td>64</td>
</tr>
<tr>
<td>75</td>
<td>87</td>
<td>29,000</td>
<td>50,500</td>
<td>67</td>
</tr>
<tr>
<td>80</td>
<td>88</td>
<td>30,000</td>
<td>52,000</td>
<td>69</td>
</tr>
<tr>
<td>85</td>
<td>90</td>
<td>32,000</td>
<td>56,000</td>
<td>72</td>
</tr>
<tr>
<td>90</td>
<td>92</td>
<td>33,500</td>
<td>58,500</td>
<td>74</td>
</tr>
<tr>
<td>95</td>
<td>95</td>
<td>35,000</td>
<td>60,500</td>
<td>76</td>
</tr>
<tr>
<td>100</td>
<td>97</td>
<td>36,500</td>
<td>62,500</td>
<td>78</td>
</tr>
</tbody>
</table>

1 All trees 3.6 inches d. b. h. and up, to a top diameter inside the bark of 3 inches.
2 All trees 8.6 inches d. b. h. and up, to a top diameter inside the bark of 7 inches; one-fourth inch saw kerf.
3 All trees 6.6 inches d. b. h. and up, to a top diameter inside the bark of 5 inches; one-eighth inch saw kerf.

It should be understood that the board-foot yields in Table 13 are based on the utilization of smaller trees (7 inches d. b. h. for the International rule, 9 inches for the Doyle) than are commonly cut for saw logs to-day in the greater part of the South. In fact it has already been pointed out that trees as small as are cut on many commercial operations do not pay expenses. But as time passes utilization will become closer, approaching the standards already reached in New England and other parts of the country, where large timber has practically disappeared. Yields in board feet by the International rule are given as representing just about lumber tally, without any overrun.

The Southern Forest Experiment Station has published (33) preliminary tables showing the yield of naval stores from individual slash and longleaf pines of various diameters, but has not attempted to put this information on an acre basis. However, timber growers and landowners are chiefly interested in the number of cups which may be hung on an acre of second-growth timber at various ages.
Without making any allowance for two faces on the larger trees, Table 14 shows how many trees of various diameters large enough to turpentine are found in fully stocked, even-aged stands on average sites. On poor sites, the trees are more numerous, but of smaller size; on good sites the trees are fewer but larger. Provided they are conservatively worked, 9 or 10 inch trees are regarded as large enough for turpentining.

Table 14.—Number of trees per acre of various diameters 8 inches and up, in fully stocked even-aged stands of second-growth longleaf and slash pines, at various ages, average site

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Number of longleaf pine trees, by diameter classes</th>
<th>Number of slash pine trees, by diameter classes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8 in.</td>
<td>10 in.</td>
</tr>
<tr>
<td>15</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td>25</td>
<td>24</td>
<td>27</td>
</tr>
<tr>
<td>30</td>
<td>37</td>
<td>40</td>
</tr>
<tr>
<td>35</td>
<td>41</td>
<td>44</td>
</tr>
<tr>
<td>40</td>
<td>46</td>
<td>49</td>
</tr>
<tr>
<td>45</td>
<td>51</td>
<td>54</td>
</tr>
<tr>
<td>50</td>
<td>56</td>
<td>59</td>
</tr>
<tr>
<td>55</td>
<td>61</td>
<td>64</td>
</tr>
<tr>
<td>60</td>
<td>66</td>
<td>69</td>
</tr>
<tr>
<td>65</td>
<td>71</td>
<td>74</td>
</tr>
<tr>
<td>70</td>
<td>76</td>
<td>79</td>
</tr>
<tr>
<td>75</td>
<td>81</td>
<td>84</td>
</tr>
<tr>
<td>80</td>
<td>86</td>
<td>89</td>
</tr>
<tr>
<td>85</td>
<td>91</td>
<td>94</td>
</tr>
<tr>
<td>90</td>
<td>96</td>
<td>99</td>
</tr>
<tr>
<td>95</td>
<td>101</td>
<td>104</td>
</tr>
<tr>
<td>100</td>
<td>106</td>
<td>109</td>
</tr>
</tbody>
</table>

The figures given in Tables 13 and 14 are for even-aged stands. Such stands while young have no merchantable volume of wood and do not yield enough gum to pay for the chipping. As time passes, a few of the largest trees reach a size to yield salable wood or naval stores in paying quantities, but generally it is only when the majority of the trees have reached such a size that it pays to cut or cup them. The stands, if fully stocked, then yield the volumes of wood or contain the number of trees shown in the tables. The average yearly growth in wood over the period required to mature an even-aged stand, or over what is known as the “rotation,” is found by dividing the volume present at the end of the rotation (Table 13) by the number of years in it. Table 15 gives these figures. Similarly, Table 14 is the basis for Table 16, which shows the average yearly increase in number of trees 8 inches or more in diameter, and 10 inches or more, for stands of the turpentine species at various ages.
TIMBER GROWING AND TURPENTINING PRACTICES

Table 15.—Average yearly growth per acre of fully stocked, even-aged stands of second-growth southern pines, at various ages on average site for each species

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Longleaf pine</th>
<th>Shortleaf pine</th>
<th>Slash pine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Saw timber</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(with bark)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Doyle rule</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>International</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>1.3</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>20</td>
<td>1.4</td>
<td>0.5</td>
<td>0.9</td>
</tr>
<tr>
<td>25</td>
<td>1.5</td>
<td>1.0</td>
<td>1.2</td>
</tr>
<tr>
<td>30</td>
<td>1.6</td>
<td>1.5</td>
<td>1.7</td>
</tr>
<tr>
<td>35</td>
<td>1.7</td>
<td>2.0</td>
<td>2.2</td>
</tr>
<tr>
<td>40</td>
<td>1.8</td>
<td>2.5</td>
<td>2.7</td>
</tr>
<tr>
<td>45</td>
<td>1.9</td>
<td>3.0</td>
<td>3.1</td>
</tr>
<tr>
<td>50</td>
<td>2.0</td>
<td>3.5</td>
<td>3.6</td>
</tr>
<tr>
<td>55</td>
<td>2.1</td>
<td>4.0</td>
<td>4.2</td>
</tr>
</tbody>
</table>

Table 16.—Average number of trees per acre which reach the 8-inch and 10-inch diameter classes each year in fully stocked, even-aged stands of second-growth longleaf and slash pines, at various ages, on average site for each species

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Longleaf pine</th>
<th>Slash pine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Number</td>
</tr>
<tr>
<td></td>
<td>Trees reaching 8 inches d. b. h.</td>
<td>10 inches d. b. h.</td>
</tr>
<tr>
<td>15</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td>0.5</td>
<td>1.0</td>
</tr>
<tr>
<td>25</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>30</td>
<td>1.5</td>
<td>2.0</td>
</tr>
<tr>
<td>35</td>
<td>2.0</td>
<td>2.5</td>
</tr>
<tr>
<td>40</td>
<td>2.5</td>
<td>3.0</td>
</tr>
<tr>
<td>45</td>
<td>3.0</td>
<td>3.5</td>
</tr>
<tr>
<td>50</td>
<td>3.5</td>
<td>4.0</td>
</tr>
<tr>
<td>55</td>
<td>4.0</td>
<td>4.5</td>
</tr>
</tbody>
</table>

No studies have been made of the rate of growth of the southern pines in uneven-aged or selection stands. These differ from even-aged stands in that they always contain some, but often only a few trees big enough to cut or turpentine. The rest are of all sizes from seedlings up to those just below maturity. The growth in merchantable material on a unit area is represented by a few trees which reach maturity on it each year. It is probable that growth is about the same as in an even-aged stand. At least until more information is obtained from systematic study, the figures in Tables 15 and 16 may be taken to represent the average yearly growth of both even-aged and selection stands.
To date no studies have been made of the yields of mixed stands of pines or of pines and hardwoods. It is probable that these yields would not vary greatly from those of pure pine stands, at least in cordwood volume.

The figures on the rate of growth of the southern pines were obtained in carefully selected portions of stands which had without exception volunteered, or grown up without human aid. Very few had received more than chance protection against fire or other enemies, and the great majority had been burned at least every 5 or 10 years since they became resistant to light fires. Seed for their establishment had been abundant, and in some instances overabundant; but in every case it had been so scattered on the area as to produce crowding in some places, and relatively open spacing in others.

Such stands represent an average of the best that the southern pines have produced under natural conditions—that is, when not hopelessly interfered with by man’s fires. The region-wide study of growth previously referred to showed that because of lack of seed, the scourge of fire, and lesser causes, probably less than 1 per cent of the piney woods is producing as full a timber crop as these stands are. In figuring the full productive capacity of a specific property it would therefore be conservative to discount the yields by 10 or 15 per cent, in spite of the fact that the measures for intensive forest management about to be described should create conditions fully as favorable on the average as those under which the volunteer stands arose. On the other hand, it should be possible in time to better these yields—at least on limited areas and under conditions favorable to the sale of small material.

What constitutes a full forest crop when trees yield both naval stores and wood is not easy to say, since in some respects the two uses are antagonistic. That is, turpentining a fast-growing tree for several years lowers the grade of finishing lumber obtainable from the butt log although not affecting the strength of the wood; again, an open-grown, limby tree yields abundant gum but poor wood for most purposes. At present rates for stumpage and turpentine leases small trees are more valuable for their gum than for their wood, and large trees are worth more as lumber, piling, or poles than as gum producers. How these relationships will be affected by future stumpage prices and leasing costs it is quite impossible to say. The problem is further complicated by probable lowering in the rate of wood production when a tree is worked for turpentine under American methods.

At present the bulk of American naval stores is produced from trees which the owners regard as chiefly valuable for these products; the second growth of longleaf and slash pines in Georgia and northern Florida is being turpentined with little regard for the effect on the wood in them. In the western part of the pine belt, however, where the naval-stores production is almost all from virgin timber, owners will not permit work likely to result in degrade of the lumber. All things considered, measures designed to grow full forest crops of longleaf and slash pines should produce substantial quantities of both gum and wood.

The measures necessary to produce full crops of the southern pines, as judged both by quantity and quality, are just beginning
to be studied. Although helpful conclusions will from time to time be drawn from the investigations now under way by the Forest Service and other agencies, complete evidence for or against some measures can not be reached for many years. Some of the suggestions offered in the following pages necessarily represent little more than the best judgment of those who are growing and studying the southern pines.

INTENSIVE FIRE PROTECTION

In spite of the rapid strides which have been made in forest-fire protection in the South during the past few years, the limit of fruitful effort has been reached on very few, if any, forest properties. The standard for fire protection set up to keep lands only reasonably productive would confine the average yearly loss in a community to 3 per cent of the pine area. Theoretically, this means that fire would run over the ground only once in 33 years, a period which will allow the southern pines to reach ample size to resist any except summer fires. Practically, however, the more exposed land may suffer two or three fires in a generation, and the less exposed may scarcely ever burn. One fire, occurring in a tract of young reproduction that was delayed in establishment by lack of seed and had not yet reached the fire-resistant stage, might wipe out the results of 10 or 12 years’ effort in timber growing. Recurring at intervals of 10 to 15 years, fire might keep this tract barren indefinitely. The high yield of forest products obtainable from full crops of the southern pines, and the early age at which they mature, justify more intensive efforts in fire protection than those prescribed for merely keeping land productive.

The State system may be strengthened by adding to the immediate staff of the State firewarden two or more inspectors for each 10,000,000 acres of land under intensive protection. An organization of the size needed for such a territory will not run itself, but requires constant and thoroughgoing supervision. Because the local rangers and wardens are sometimes handicapped in catching incendiaries, who can easily watch their movements, special men attached to the State office are sometimes helpful in solving the problem of incendiariism. Towermen may effectively be employed nearly yearlong in longleaf pine territory. Under hazardous conditions in the longleaf pine belt a resident firewarden may profitably be assigned to each 10,000 acres, and he will sometimes need two or three special fire fighters to help him.

Fire lines may, of course, be used to break up forested areas into smaller blocks than those proposed hitherto, and the lines may be wider. Both smaller blocks and wider lines seem desirable in the longleaf pine region, where fire travels fast and roads and natural firebreaks, such as streams, are infrequent. The State of Louisiana, in its “protection areas,” is now constructing 15-foot plowed fire lines (pl. 9, C) through grassy longleaf land, and aims to leave no block larger than 640 acres within these lines. Later this will be reduced to 160 acres. On the other hand, it is not planning to con-

20 Much of the material contained in this and the succeeding paragraph was furnished to the writer by W. R. Hine while State forester of Louisiana.
struct any more lines in the shortleaf territory, but rather to open up old roads as firebreaks and as means of rapid travel to fires. The territory assigned to each resident warden is about 20,000 acres. Louisiana has had much difficulty in burning wide fire lines between furrows, and now prefers the narrower fully plowed lines. One large lumber company in eastern Louisiana has constructed many miles of 10-foot solidly plowed lines; at least in dry weather these serve as roads over which it operates a specially equipped fire truck.

SLASH DISPOSAL

Because a recently cut area filled with slash or tops is in the most dangerous possible condition, prompt reduction in the hazard is highly desirable. Moreover, the tops of some pine species, notably shortleaf, are large and bushy, and create a heavy mat of fallen pine straw which apparently prevents the roots of young seedlings from reaching the ground. (Pl. 4, B.)

On the Ouachita National Forest in Arkansas the method of disposing of shortleaf pine slash most generally employed is to pile it at some distance from seed trees in piles 6 to 8 feet across and 4 feet high, and to burn the piles when there is enough moisture to keep fires from spreading. Burning is not feasible where much advance reproduction is present, because more young trees are destroyed than are given room by the removal of the tops. The cost of piling and burning is 60 to 75 cents a thousand feet of timber cut. Another method of disposal now under trial on this forest, where only a part of the stand is cut at any time, is to lop the tops and scatter them so that they lie close to the ground and can not carry fire into the crowns of the remaining trees. Studies have shown (21) that close contact with the ground hastens the decay of slash (at least of shortleaf pine) very little in most situations, and not at all on such dry areas as steep hillsides facing the south and west. Decay has been found to be slower in piled shortleaf slash than in tops left as they lie after logging, which points to the desirability of always burning the piles.

A method of slash disposal developed by an Alabama company cutting longleaf pine to a diameter limit of about 18 inches has recently been under trial on longleaf land being reforested in Louisiana. It consists of dragging all large tops free of standing timber and promising young growth to a distance of 5 to 10 feet, and of burning the leaves and smaller branches as soon as they are dry enough to be fired with lightwood torches. This requires that burning continue throughout the year, and during dry summers is likely to result in injury to some standing trees, in spite of the effort to confine the work to damp days. Tops which can be dragged to greater distances from seed trees are not burned, but are lopped down and left to rot. A foreman, two axmen, and a teamster with two horses dispose of the tops in this way on a job cutting 150,000 board feet a day, at a cost of about 60 cents an acre. This method of brush disposal has its greatest usefulness in localities where general success has not yet been attained in fire protection, and where for several years seed trees and young growth are in considerable danger from slash fires.
In parts of the South a very large number of fires are set in the sincere belief that annual burning improves the forage for range livestock. In spite of the constant shrinkage in number of livestock grazing in the piney woods in recent years, there are still many hundreds of thousands of cattle, sheep, goats, and hogs running at large in unfenced areas. These animals are for the most part owned by farmers or residents in the region who have title to very little land themselves, but who make use of the forage on great areas owned by their neighbors. The tradition of grazing stock on the open range is very strong in many southern communities, having originated when the land was public domain and having been strengthened by generations of undisturbed use. The mere fact that title to both land and timber was long since legally acquired by lumber companies or others has not greatly altered the attitude of the stockmen toward their use of the range. They argue that if they withdraw their stock from the land, large quantities of forage will go unconsumed. This is unquestionably so, since in the great majority of cases the forest industries make no attempt whatever to utilize the forage resources of their properties. Only occasionally have they attempted, by fencing, to assert their right to the exclusive possession of the land.

Except in restricted areas, some utilization of the forage by cattle or horses would be no bar to timber growing. On the contrary, as already pointed out, grazing under some circumstances has proved of distinct value in cutting down the amount of inflammable material on cut-over longleaf pine land. But unfortunately the average southern stockman has come to believe that in order to make the most out of the piney woods range it is necessary to burn it over yearly, and has in consequence deliberately fired the unfenced land grazed by his stock. Hence, wherever in the South stockmen are an important source of fires, a judicious policy of fencing will be very effective in fire prevention. A substantial fence around a property advertises to the world that the owner places some value on it, and there is almost everywhere a surprisingly strong rural respect for a fence. It happens that in parts of the South fencing is also a great aid to the range, because confinement of stock to pastures increases the severity of grazing and trampling, and favors such excellent introduced forage plants as lespedeza and carpet grass; it is often the only effective method of controlling stock for eradication of ticks and other parasites; and it is the surest means of controlling breeding, and making effective the introduction of better sires.

A hasty or ill-considered policy of fencing, on the other hand, may be a grave mistake. That is, it will invite not only the setting of fires but also the destruction of the fence itself by lawless elements. There have been instances where erection of a fence has resulted in prompt cutting of the wire at every post. The policy to be followed will of course vary with the locality and with the kind of stock. Generally, however, the offer of continued free use of the fenced range as long as it remains unburned will generally fully meet the plea that reduction of the available range by fencing will starve animals long ranged in the locality and leave the forage resources
unutilized. Numerous hogs, of course, cannot be tolerated on long-leaf land, or sheep and goats in large numbers on pineland of any kind. The injustice of putting the burden of fencing upon the forest landowner is no greater than that placed on the owner of cultivated fields, who has to protect his crops by fencing. The final solution of the fencing problem will come only through the enactment of effective (which generally means state-wide) “no-fence” laws, requiring the owner of stock to restrain it under fence. Whenever and wherever the farmers and the timber growers can show that their interests are of more value to the community than the interests of the users of the open range, such laws will be passed.

Occasional forest-land owners have employed the expedient of buying out the stockmen who they have reason to believe are particularly active in burning the range. By themselves entering on a moderate scale into stock raising on their own properties, which they eventually fenced, still others have met the argument that the fencing of their land would result in much waste of forage. Any measures which tend to eliminate fires set because of grazing will go a very long way toward eliminating fires altogether.

RESULTS AND COSTS

At least 99 per cent of the pinelands of the South are today producing less than a full crop of wood and naval stores. Intensive fire protection alone would in time bring probably 90 per cent of the southern pinelands to a higher degree of productivity than they have known in the white man’s day. It would within a generation allow a highly satisfactory crop of young growth to spring up on all cut-over pinelands except the 10,000,000 acres estimated to be denuded of seed trees, and perhaps some very poor sites. By fostering at all times a new growth of pine or hardwoods in the innumerable openings of existing stands, it would make infinitely easier the task of obtaining a second, third, and many subsequent crops after those stands are cut. Coupled with the system of partial cutting soon to be described, it should eliminate on all but very poor sites the delays in natural reproduction which often result from depending simply on seed trees to start a new crop of timber.

Intensive fire protection by improving soil conditions will increase the rate of growth of trees and their ability to produce naval stores. Soil improvement will be brought about to some degree by the return of vegetable matter annually to the soil, but probably chiefly by the creation of proper physical conditions—that is, a loose instead of a compact structure. The moisture-holding capacity of soil beneath a mulch of pine leaves, or of dead grass and other vegetable matter in open land, is markedly better than that of soil constantly exposed to the beating of rain and the direct rays of the sun. Just how large an effect these improved soil conditions will have on the growth of pine and associated trees it is not yet possible to say; the process of improvement may be long continued.

The increase in cost of intensive fire protection over the protection prescribed as necessary to keep land from becoming barren should be much less than the resultant increase in productivity of the land. This does not mean that intensive fire protection alone
will bring southern pineland to full production, but simply that without such protection the land can not possibly produce a full crop. Methods will naturally be adapted to the conditions within the particular tract to be protected, and there will be considerable variation in costs, as shown below.

Protection of small, isolated tracts, such as most farm woodlands are, has been described (p. 32). A good fire line plowed entirely around the woodland will meet the very low risks involved in a property which is often within view of the farmer owner and which has little logging slash on it at any one time. Because the cost of the fire line is spread over a comparatively small area, and because, in the absence of forest land on the other side of the line, it is not shared by adjacent acreages, the cost is high.

A large tract—say, a township—of cut-over land on which the slash has rotted and second-growth pine is beginning to be established, either by natural means or by planting, is in a hazardous condition throughout. If there are seed trees on the tract the maximum effect of a single fire will be to wipe out the current seedlings, which will in time be replaced by others. Protection of such tracts by plowing fire lines around each 160 acres will generally be justified. In plantations it may pay to construct lines around each 40 acres. Should slash be present on any area, the smaller blocks would be desirable.

Eighteen to twenty thousand acres of shortleaf and loblolly pine is estimated to be enough under full production to supply perpetually a mill cutting 10,000,000 board feet a year. Intensive protection of such a property will vary with the kind of management. If it is handled on an even-aged basis it will be divided into a number of tracts corresponding to the number of years needed to mature a crop of timber, each tract being cut clear (save for seed trees) when it reaches maturity. Under intensive protection the slash areas and areas of young growth should be cut into 40-acre blocks by fire lines and the slash pulled away from the seed trees in all current cuttings. Such areas will constitute a fifth or sixth of the whole tract, and the remaining four-fifths or five-sixths will be adequately protected by the intensified State and local fire systems earlier described.

If the same shortleaf or loblolly tract is handled on an all-aged basis, trees of all ages from seedlings to mature specimens are present on every acre, or every two or three acres, and cutting at intervals of 10 to 20 years removes the mature trees only. Here the lessened hazard in young growth subject to killing or severe injury on any particular acre warrants making the blocks within fire lines 160 acres; but the lines must be established and constantly maintained throughout the property. The small number of trees cut at any time eliminates continuous areas of slash, and no pulling of tops appears necessary. In portions of the shortleaf pine belt additional man power in the local protective organization may be more effective than increased use of fire lines and can be employed at some saving in total cost.

Where long-term turpentineing is practiced in second-growth longleaf or slash pine, a little over 10,000 fully productive acres, half longleaf and half slash, is necessary to supply a 20-crop still with
gum perpetually. If the forest is made up of even-aged stands intensive protection should break these into blocks as small as 15 acres, each supporting 1,000 faces on fully productive land. After turpentining is finished and the trees are cut, several blocks may be thrown together into units of about 60 acres. Tops should be pulled from seed trees, as in shortleaf and loblolly stands. Not far from half of the tract should at all times be protected by fire lines around large or small blocks. In an all-aged forest of turpentine species 25-acre blocks will contain 1,000 faces, either currently worked or resting, and should be surrounded permanently by fire lines.

The cost of intensively protecting the above-described properties is given in Table 17. These figures include 0.85 cent an acre for the cost of the local protective system, and 2 cents for the State system (50 per cent more than under ordinary protection). An allowance is made for fire fighting in all cases.

**Table 17.—Cost of intensive protection of wooded areas**

<table>
<thead>
<tr>
<th>Type and acreage of wooded areas</th>
<th>First year</th>
<th>Succeeding years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cents per acre</td>
<td>Cents per acre</td>
</tr>
<tr>
<td>Isolated farm woodlands:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 acres</td>
<td>40</td>
<td>13</td>
</tr>
<tr>
<td>160 acres</td>
<td>20</td>
<td>7</td>
</tr>
<tr>
<td>Cut-over land, no logging slash, 23,040 acres:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With seed trees</td>
<td>12.5</td>
<td>6</td>
</tr>
<tr>
<td>Planted</td>
<td>22</td>
<td>8.5</td>
</tr>
<tr>
<td>Shortleaf or loblolly pineland, current logging, 20,000 acres:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Even-aged management</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>All-aged management</td>
<td>14</td>
<td>6.5</td>
</tr>
<tr>
<td>Longleaf or slash pineland, current turpentining and logging, 10,000 acres:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Even-aged management</td>
<td>8.5</td>
<td>8.5</td>
</tr>
<tr>
<td>All-aged management</td>
<td>28</td>
<td>11</td>
</tr>
</tbody>
</table>

High hazards in longleaf and slash pine properties, arising out of turpentining, make intensive protection relatively costly. But it should be realized that such protection will—at least eventually—justify the turpentine operator in ceasing to rake around chipped trees. Since raking costs not less than 7 cents an acre in even-aged stands, and 14 cents an acre in all-aged, the intensive protection will almost pay for itself. Table 17 brings out the effect on protection costs of the size of the tract protected, and the comparatively heavy investment during the first year that will be required under certain conditions if an entire tract is placed under protection immediately. As a practical matter the first high cost may be spread over several years if the landowner is willing to take temporary risks with part of his property.

**IMPROVED CUTTING PRACTICE**

The chief difference between the measures necessary to keep forest land merely productive and those needed to work it to full capacity is in the manner of harvesting the timber crop. This is true both in turpentining and in logging, but it will be more convenient to discuss turpentining practice later under a separate heading.
CLEAR CUTTING WITH SEED TREES

It seems possible to produce full timber crops on much southern pineland by a more intensive application of the method used to keep the land merely productive; that is, cutting the existing stand clear and leaving seed trees. All old-field stands and most second-growth stands on cut-over land have originated on land cut clear or nearly so, the seed coming from adjacent timber or scattered trees spared by the logging. They are normally even-aged, and continued clear cutting perpetuates this condition.

Where long-continued crowding has reduced the crowns of pines in a dense, even-aged stand to very small proportions—to a length, say, of less than one-fourth the total height of the trees—comparatively few trees are likely to make satisfactory growth if reserved for future cuttings, and under such circumstances clear cutting seems desirable (4).

To make sure of ample seed in clear cuttings, more and particularly larger seed trees are needed than those described as necessary to keep land merely productive. Long-crowned, vigorous trees 14 inches in diameter at breastheight, or larger, are more certain to produce large quantities of seed than those 10 and 12 inches in diameter; and if three to six large trees to the acre are left, a full stand of young growth should be assured. However, present evidence on this point is by no means conclusive, and there is no assurance at all that a good seed crop will immediately follow cutting. This is a serious defect of any method of clear cutting.

Seed trees should never be depended upon to produce full forest crops on shallow soils where the trees are subject to uprooting by heavy winds (not hurricanes, which blow down mature trees on any type of soil). The presence of stiff clay or hardpan within a foot or two of the surface should be a warning against the seed-tree method.

The age at which even-aged stands are clear-cut is a matter of great importance, as will be seen from a study of Table 15. A long-leaf pine stand, for example, cut for cordwood at 30 years has made an average yearly growth twice as great as if cut at 15 years; if cut for lumber at 50 years, the yearly growth is over twice as great as if cut at 30 years. Slash pine, on the other hand, has already reached its best average yearly rate of cordwood production at 15 years. If the full growing capacity of the land is to be realized, stands should be cut only when they have reached their best yearly growth rate, so far as carrying charges and business requirements permit.

SELECTIVE LOGGING

Selective logging is believed to be a surer method of keeping land fully productive than any method of clear cutting. By selective logging, or cutting, is meant the removal from a stand of the large mature trees and defective smaller ones, and the reservation, for further growth and for seed production, of at least the soundest and most vigorous of the younger trees. (Pl. 10, A.) The better the site and the more even the distribution of the trees by size the more likely is this method to give good results. On very poor sites, in overmature virgin stands, and in very crowded second growth it is not recommended.
The proportion of the trees removed in selective logging may vary within wide limits. Since light cutting tends to be more expensive than heavy cutting, the practice must be governed by business considerations. A farmer may with profit cut a few of the largest trees from every acre of his woodland at intervals of five years or less. A lumberman logging with a tram, on the other hand, may not find it financially possible to remove any particular stand in more than two cuts. For him, selective logging may mean removal of the bulk of the volume now and in 15 to 25 years a return for the rest of the original stand.

Selective logging should always insure full stocking. No cutting should be so heavy as to fail to leave abundant trees of seed-producing size, capable of reseeding all openings left by the removal of mature trees. On medium or poor sites it is equally important that the cutting be not too light to permit seedlings to obtain a foothold and develop at a good rate. On good sites the southern pines (even longleaf to some extent) appear able to take advantage of small openings, although of course at a slower rate of growth than in large openings. On medium and poor sites, seedlings will not long survive in small openings owing to the shading and particularly the root competition of the surrounding trees. If it is the extreme competition of the larger trees that makes a system of partial cutting of doubtful value on very poor soils.

To increase the rate of growth of the forest is a third principle of selective logging. This may be done by cutting the slow-growing trees so that a new forest may take their place, and by leaving for future increase in volume trees that are already growing at a good rate. It is obviously a waste to fail to cut mature trees whose growth is very slow or is offset by decay. It is equally a waste to cut trees which are now barely merchantable and are still growing rapidly. Although it is possible in selecting trees for future growth to recognize a fast-growing tree by such outward characteristics as the luxuriance and healthy color of the foliage, or a rounded or pointed top (showing that height growth has not stopped), or grayness of the bark (that of an old tree is very yellow), a more reliable guide is an actual examination of the recent growth rings. A special instrument known as an increment borer, or hollow auger, is almost indispensable for this purpose.

Quality growth, however, should not be sacrificed to quantity growth. Too great a stimulation of growth rate is not desirable. Studies at the Forest Products Laboratory of the Forest Service indicate that southern pines growing at a medium rate usually produce wood which is heavier and correspondingly stronger than that of trees grown at the excessively slow rate characteristic of some virgin stands or the very rapid rate common in second-growth stands.

Partial cutting should, on the other hand, foster quality growth by removing trees of poor form and quality. Decaying, injured, or crooked trees may occupy practically the same space as those with a sound, straight trunk and long clear length. One tree of medium size and good form, capable of producing a pile, pole, or saw logs, may demand as much space as two or three stunted trees which will
not reach anything but cordwood size within the time required by the single tree to mature its very much more valuable product. The inferior trees should be cut; the better left for growth.

A final guiding principle in making selective cuttings is that each acre, or even part of an acre, should be considered as a unit in itself. Absolute flexibility is necessary in applying any method of partial cutting if the best possible growth is to be attained. Such factors as species and present condition of forest site must be kept in mind at all times. Cutting should always be adapted to the character of the stand actually present. Partial cutting of a very mature stand containing few small trees is a mistake. It would also be a mistake to attempt a selective cutting in very dense second growth where crowding over a long period has so reduced crown lengths that recovery after release from competition is certain to be slow. A thrifty stand of young trees which is already somewhat open, and in which heavy cutting would encourage limliness of the trees remaining, should be only lightly cut. The influence of site and species on cutting methods may be illustrated by areas where both shortleaf and loblolly occur in mixture, and where the site is better adapted to one species than to the other. For example, shortleaf and loblolly pines together very often seed worn-out fields. On the disturbed soil the loblolly will do well for a short period, but if fertility has been nearly exhausted, or if the land was relatively poor to begin with, it may not be able to maintain its growth as well as the shortleaf. In such instances the cutting should be heavier in the loblolly.

**Advantages**

Selective logging, in addition to insureing full stocking of subsequent stands and a high rate of growth in both quantity and quality of the present stand, has other advantages of equal importance.

Selective cutting shortens or totally eliminates the delay in establishing a new crop, which often results from clear cutting. Some seed is produced in the forest practically every year. For reasons by no means understood, a tree here and there in the stand will bear a few cones in a year when its companions produce practically none. It is obvious, therefore, that the lighter the cutting and the greater the number of trees left, the more constant the supply of seed. Again, cutting from a stand all but a few seed trees inevitably exposes the soil to the drying effect of both sun and wind. This not only reduces the survival of seedlings which germinate immediately after the cutting, if the weather is at all dry, but apparently is often a sufficient shock to the seed trees to delay by several years their production of a full crop of seed. In the meanwhile the site is sometimes taken possession of by underbrush, such as scrub oak, which, although rarely preventing reproduction and development of the young pines, certainly has the effect of delaying them.

A substantial obstacle to successful timber growing is still undoubtedly the fact that second-growth forests on the average produce lumber of much lower quality than the virgin forest. None contain trees as large as the veterans of the virgin forest. What is much more important, their trees do not often have the percentage of summer wood needed for strength, the wide heartwood needed
for durability, or the clear length and moderately fine grain needed for production of finish and better grades in general. This is largely due to the fact that the great bulk of second-growth southern pine is in the even-aged stands resulting from clear cuttings. As compared with the mature trees of the virgin forest, they are very young, and the individual trees in them have grown two or three times as fast as those in virgin stands. It is possible by repeated selective cuttings to convert the majority of even-aged stands to all-aged stands, and in them produce fully as high-quality lumber in the future as has grown in the past. Selective logging of virgin stands already in an all-aged condition will prevent the sacrifice in quality common in the production of even-aged stands.

Selective logging offers to some sawmills and other wood-using plants a means of bridging the gap between the exhaustion of their present stumpage and the maturing of new supplies on land now being cut. A going lumber company, for example, may have denuded its land in the past and have only enough virgin stumpage to maintain its present output for 15 years. It can, by establishing fire protection and leaving abundant seed trees, produce full crops of young growth on its lands even under a continued policy of clear cutting. But at the end of the 15 years it will have to shut down for lack of logs, since none will have matured on its cut-over lands in that period. Assume, however, that instead of clear cutting from now on, this company cuts selectively, with the object of returning over the same ground at 15-year to 25-year intervals, and if possible having a sufficient cut to log its mill continuously. Its present cut and its present stumpage may not permit this. But if it reduces its output by one-third, thus making its raw material last 22\(\frac{1}{2}\) years instead of 15, and purchases enough young second growth capable of yielding saw logs in 15 or 20 years to extend its life another 7\(\frac{1}{2}\) years, at the end of 30 years it may well be in shape to operate continuously. Everything, of course, depends on the growing capacity of the soil.

Little definite information may be given as to how fast trees left in selective cuttings will grow, because the only figures yet available are for comparatively few trees left by chance in past logging operations. Some 50 trees of the latter class were investigated by the experiment station (6) at Urania, La. Height growth since logging was negligible, but diameter growth showed a marked stimulation, both for trees completely released by cutting of the surrounding trees and those little released. Ring counts and measurements at breast-height showed a diameter growth, for groups averaging 8 to 12 inches d. b. h. at the time of release, of 4.8 to 5.8 inches during the 20 years after release, in contrast to a growth of only 0.7 to 1.4 inches during the 20 years before release. Comparable increases were found to have been made at higher points on the trunk. The fact that less growth after release was found among longleaf pines in central Alabama (17), and that complete release was needed to obtain any marked response, should be interpreted as a caution against expecting the Louisiana increases everywhere. On the other hand, careful selection of the trees to be left for additional growth will certainly tend to improve growth rates.
Some idea of the results possible from selective logging in shortleaf pine may be obtained from the history and present condition of a tract in Texas (pl. 1, B), now included in the Cherokee State Forest. This was cut over in 1912, to a diameter limit of about 14 inches on the stump, or 13 inches d. b. h. It is believed that with the exception of a few old red hearts, which have been left out of consideration on this account, all trees now 13 inches d. b. h. or larger have reached their present size since the cutting. A tally of 18 acres, made in 1925–26, showed an average of 7.8 of the 13-inch pines to the acre, 6.1 of the 14-inch, 4.5 of the 15-inch, and 3 of the 16-inch. The 21 trees contain about 4,200 board feet, mill tally. This is a yearly growth in these trees alone of 300 board feet for a 14-year period. In spite of frequent fires, there is also an excellent stand of trees 9 to 12 inches in diameter. From these an equal volume of saw logs should develop in another 14 years, if the stand is again cut to the same diameter limit. A cutting truly selective, rather than to a rigid limit, is to be preferred.

In small properties, such as farm woodlands, selective logging offers about the only solution of the problem of obtaining a yearly or at least periodic return. Most farmers will choose rather to use their surplus labor and teams at odd seasons every year in getting out the current products of their woodlands, than at long intervals to sell the stumpage for clear cutting by a sawmill operator or a contractor for ties or poles.

**Costs**

**For Fire Protection**

Since partial cutting spreads logging operations over a wider territory than clear cutting, the proportion of any selectively cut tract with slash on it and requiring intensive protection is larger than on a clear-cut tract. The extra cost of fire lines is somewhat offset by the greater availability of fire-fighting crews, which reduces transportation charges and the acreage burned over. (Table 17.)

**For Marking**

A diameter limit rigidly adhered to will not result in a successful selective cutting. If a tally is available of the trees of various diameters in a tract, a diameter limit is of course useful in calculating roughly how much wood will be removed in partial cuttings of varying severity (8, 26, 27, 29). But it is extremely important that the limit be disregarded when trees below it are inferior, and when trees above it must be left in order to insure a plentiful supply of seed. Marking the trees to be cut is therefore essential. It should be obvious that trees to be left in partial cuttings must be selected with great care and by trained and competent men. Selection well in advance of logging and marking with paint or some other semipermanent substance will cost probably twice as much as marking seed trees only. In partial cuttings it is apt to be simpler to mark

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21 Part of the data here presented was furnished through the courtesy of the State forester of Texas and his staff.
the trees intended for cutting rather than those to be left, and checks on the felling crews are surer. Costs should be from 25 to 50 cents an acre.

FOR LOGGING

No attempt is made here to discuss logging costs except as they are increased over ordinary costs by the removal of only a part of the stand.

The reduction of the volume per acre cut, and the need to preserve just as much as possible of the young growth, will almost automatically eliminate the use of the steam skidder. Opinions differ widely as to the relative cost of steam and animal logging under identical conditions. Steam skidders are much less commonly used in shortleaf than in longleaf pine stands, and it is the former which lend themselves most readily to partial cutting. Elimination of the skidder on jobs where conditions favor its use may cost from $0.50 to $2 a thousand feet cut, and occasionally more.

Increase in costs as a result of cutting only part of the merchantable stand at any one time will be considerable on tramroad operations. It is evident that if a mile of railroad spur is laid through four forties containing 1,500,000 board feet of lumber, and if the actual cut amounts to only 1,200,000 feet, the expense chargeable to railroad construction per thousand feet will be a fourth greater than if the stand were clear-cut. This increase may amount to 10 or 15 cents a thousand. On the other hand, old cuts and fills in the pine region last for a remarkably long time, and may be utilized after a lapse of 10 or 20 years with very little additional work. The reduction in cost of subsequent tramroad construction made possible by their presence is probably 50 per cent or more of the original cost on main lines, and 25 per cent on spurs, in the more rolling portions of the coastal plain.

Certain items of overhead expense are increased when the cut from a unit of timber land is lessened through partial cutting. These undeniable additions to overhead and the cost of logging are counterbalanced in whole or in part by reductions in other items of logging cost and by increases in the selling price per thousand feet as a result of betterment of the average grade. Ashe (5) thus sums up his findings in a shortleaf pine operation in the North Carolina pine territory:

In felling and bucking the man capacity is practically twice as much working up trees having a diameter of 20 inches as when working up trees which are 8 inches. If this work is done by day labor the cost is nearly twice as much; if done by contract or on a log basis the difference must still be paid for. In skidding it requires nearly three times as long to skid 1,000 feet b. m. of lumber in logs which are 8 inches in diameter as it does to skid the same amount in logs which are 20 inches in diameter. This same proportion holds practically irrespective of whether skidding is with cable or team.

The capacity of a loaded car practically determines the cost of hauling, for a car loaded with small logs weighs as much and costs as much to haul as a car loaded with large logs. A car loaded with logs 10 inches in diameter has a capacity of 1,150 board feet mill cut; one loaded with 20-inch logs carries 3,220 feet, or three times as much, and it requires 4 times as long to load 1,000 feet of the smaller timber as that quantity of the larger size.

In an average band mill it requires twice as long to saw one thousand board feet of lumber from logs which average eight inches in diameter as from logs
which are twenty inches in diameter. Consequently, the mill has only half the output if operating upon the smaller size as it would have if operating upon the larger size and the cost of sawing is more than twice as much. Certain types of mills have been constructed especially to handle small logs, but even in the most efficient mill of this type, as well as in gang sawmills, it still costs far more per thousand feet mill cut to operate small logs than those of larger size.

On this job at least, where the 8 to 12 inch trees made up about 15 per cent of all trees, and the average tree was close to 20 inches in diameter, the increase in average selling price was calculated to more than offset the increase in overhead per thousand feet resulting from failure to cut the small trees. On small sawmill jobs cutting shortleaf pine in Arkansas, Garver and Miller \(^22\) found that trees 10 inches d. b. h. and smaller were manufactured into lumber at an actual loss, and that it took at least a 14-inch tree to yield a reasonable return for profit and risk, with anything left over for stumpage.

Further light is thrown on this subject by a study, made in 1924 by the operator of a modern band mill, of the grade of lumber produced from nearly 1,900 shortleaf pine logs of different diameters. The logs were obtained from a clear cutting such as is shown in Plate 2, C. A tally was kept not only of the amount of lumber of various grades sawed from these logs, but of the percentage which went into 1 and 2 inch stock. The logs were so graded that it was possible to avoid lumping the output of small top logs from large trees with that of butt logs from small trees. “Clear” logs included small logs which were surface clear, and logs 16 inches and over in diameter with two or three knots. No. 1 logs were those containing numerous small knots that would make largely No. 1 lumber. The percentages of B and Better, No. 1, No. 2, and No. 3 lumber in these grades of logs, over a range of 7 to 18 inches in diameter, are shown in Figure 7; also the percentage of 1-inch lumber, in itself a good indicator of grade. The increase in proportion of high grades and of 1-inch lumber with increase in diameter is striking. Largely as a result of this study, the operator now cuts few trees less than 14 inches in diameter.

**CULTURAL OPERATIONS**

As timber becomes more valuable in the South, it may be well to heed the experience of other sections of the country, where timber growing has been longer practiced and where intensive care of the timber crop has been justified by earlier maturity or higher quality of the final product. There is no reason why such care should not pay. Intensive care includes such so-called cultural operations as cleanings, thinnings, and release cuttings.

**CLEANINGS**

Cleanings remove from a stand early in its life species of trees which are of little value and which interfere with the development and growth of the better species. Such cleanings may profitably be made in mixed stands of pine and hardwoods. Examples are

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to be found in brush woods, hammocks, and similar lands adjacent to small streams, in which loblolly pine sometimes has difficulty in establishing itself when repeated culling of the pine has reduced the seed supply and given the hardwoods the upper hand. Both short-

leaf and longleaf on poor sites are often badly handicapped by the competition of hardwoods.

No effort should be made to eliminate the hardwoods indiscriminately from these mixtures, since with fire protection it may be possible to mature some of the valuable species in practically the same length of time as pine. Again, it is entirely possible that the stiffer-limbed hardwoods in a mixture with pine hasten natural pruning of
the pine by mechanical action, and on that account are well worth retaining in small numbers. Red gum or sweetgum (*Liquidambar styraciflua*), yellow poplar (*Liriodendron tulipifera*), and the better species (those cut now when sound) of oak, ash, elm, and hickory, are probably as valuable as the pines in good soils. On poor soils and even rocky uplands, white oak (*Quercus alba*) and post oak (*Q. stellata*) are similarly worth preserving under fire protection. Elimination of the inferior species, however, such as maple, the scrubby oaks, and pignut hickories, is advisable, since even under favorable conditions they can not be expected to produce wood equal in value to that of the pines. In very young stands the systematic removal, with a light ax or machete, of hardwoods hampering pines, may well prove worth the cost. The work should be done while the hardwoods are still of such size that a single stroke will break or cut them down. No such work is known to have been done in the South, but somewhat similar work in New England stands of mixed hardwoods and white pine have cost from $2 to $4 an acre. Since the material so cut is rarely of any merchantable value, this is a direct outlay.

**THINNINGS**

Thinnings remove from young stands trees which are of desirable species but of inferior form or rate of growth, or which are crowding better trees. In dense, even-aged stands, or even-aged groups in selection stands, excessive crowding slows down the rate of growth to a point where none of the trees can develop satisfactorily, and it is this condition that is remedied by thinning. The objects of thinning—as of all cultural operations—are to improve the quality of the final product and to reduce the time required to grow it; also to salvage for man's use trees that are otherwise destined to die of crowding and be lost through rot. Reproduction is not expected as a result of thinning. It is for the benefit of the existing stand, not of a succeeding one.

Shortleaf appears more likely to benefit from thinning than the other chief species of southern pine. The average number of trees to the fully stocked acre is greater, and overstocking appears to be more common, particularly in old field stands. Care must be taken, however, that thinnings do not encourage limniness by giving short-leaf pines too much light among the lower branches. Longleaf pine has the virtue of bearing few branches and pruning its stem naturally if only slightly crowded, so that even wide-spaced stands produce clear lumber. This indicates the possibility of thinning longleaf heavily so as to encourage turpentine production without greatly lowering the quality of the wood production. The extraordinary early growth of slash and loblolly appears to result in rapid natural thinning, rendering artificial thinning of little value except in the salvage of the material in the weaker trees. However, thinning young slash pine stands to develop vigorous trees for turpentining may prove desirable.

**METHODS**

The two most common methods of thinning are known as thinning from below and thinning from above.
In thinning from below, the larger trees in each stand are freed from the rather feeble competition of the shorter and less vigorous trees, and are thus able to reach full maturity at the earliest possible date. The chief drawback in this method of thinning lies in the fact that all of the material removed is of small size and, unless local markets are particularly favorable, can not be sold even at the cost of cutting. The method known as thinning from above, although less practiced in North America than the one just described, seems to be well worth a trial in the South. Under this method the trees in a stand best suited to make up the final crop at maturity are singled out, and thinning is directed toward those larger neighbors which are chiefly interfering with their growth. The trees selected for leaving are not necessarily the largest trees, but those having a good clear length, coupled with vigor. Since some of the larger trees are taken out under this method, the smaller, overtopped ones are generally left to cast shade and prevent the soil from drying in the openings. The great advantage of the method is the fact that it yields material likely to have good sale value.

The common-sense method of thinning in southern pine stands is not to adhere too rigidly to either of these systems of thinning; thinning from below will often be out of the question as a financial proposition, and thinning from above may cause considerable breakage of the smaller trees. A modification has been suggested by Ashe (3), under which all large, limby trees are cut, as well as the smallest trees where merchantable; the medium-sized trees, with good but not excessive clear length, are left to put on a rapid growth of high-grade wood.

The age at which thinnings are begun and the interval between thinnings are generally arrived at by a compromise between what is desirable from the standpoint of most rapid growth of the trees (quality considered) and the cost of the work. A certain amount of crowding is of course necessary if the trees are to be pruned naturally of their lower limbs by shading, so that an open, understocked stand, if needing thinning at all, will not need it until later in life than a dense stand. Ideally, thinnings should be begun as soon as the dominant trees—those receiving on their crowns some side light as well as overhead light—fall off in diameter growth; or at least as soon as trees containing merchantable material start to drop out of the stand as a result of crowding. In any thinning, of whatever type, trees that seem likely to die before the next thinning are cut if usable, because otherwise they will be destroyed by rot. Practically, thinnings are not often recommended until the material removed will at least repay all costs of removal. From that time forward they are repeated if possible at intervals of 5 to 10 years, although these figures are not fixed. Thinnings should create no openings that are too large to be filled by the growing crowns of the remaining trees by the time of the proposed next thinning.

Costs

Although as a general rule thinnings are not recommended if they involve a cash outlay, that is if they do not yield material of enough value to pay for the cutting, under some circumstances it may pay to invest a small sum in them. Plate 10, B, shows a slash pine stand
thinned at a cost of about $1.50 an acre (including selection of the trees to be left), there being no market for small cordwood. The owners had in mind here improvement of spacing for naval-stores production. The Georgia forestry department has experimented with thinning slash pine stands as young as 5 to 8 years by selecting 100 of the most promising saplings on each acre and removing all their competitors within a distance of 5 feet. This has cost $1.75 to $2 an acre, and should leave the stand in excellent shape for early turpentining.

Crowded portions of young longleaf stands, in which the trees could be felled with one stroke of an ax, were thinned by a lumber company at an average cost of about 25 cents an acre for 1,200 acres of irregular growth in southern Alabama. The spacing aimed at in this thinning—8 to 10 feet each way—could have been increased to advantage, at perhaps twice the cost. The selection of the trees to be cut and the actual cutting in such young stands, where costs must be kept low because there are no returns, may be combined in the hands of intelligent day laborers if supervision is close. This is because the choice of trees to cut is based principally on size and a rather mechanical spacing. A crew of half a dozen laborers under a good foreman should be able to cover 30 to 40 acres a day in average slash or longleaf pine sapling stands. It will cost more to thin continuous areas of dense growth.

The later thinnings in southern pine stands may be expected to yield material which will not only return all labor costs involved but small stumpage values also. Thus Akerman (2) reports a margin of $5.47 an acre from a second thinning in a 32-year-old loblolly pine stand in Georgia which had been thinned 15 years before at a very small financial loss.

Returns

The return in final yields to be obtained from thinning the southern pines may not yet be confidently predicted, for few stands have been thinned and those relatively recently. Whether repeated thinnings, say, from the time fuel wood is obtainable up to first-class saw-log maturity, will result in a final stand greater in board-foot volume than would have developed had the stand been left unthinned, is doubtful. Unquestionably, however, the mature trees in a stand thinned even once or twice will yield higher grade lumber, because they are straight, clean-stemmed, and of comparatively large size; and any profit made on material taken out in the thinnings will be a clear gain. The thinned stand should also reach maturity a few years earlier than the natural stand. Even less is known about the value of thinnings in stands handled primarily for naval-stores production, but they are regarded hopefully by many well-informed men.

Release Cuttings

A release cutting is the cutting or killing of large trees of poor species or form which are interfering with young growth of good species. Although these large trees may occasionally be pines which are not needed for seed production, they are far more commonly unmerchantable hardwoods. A single tree will sometimes shade or rob of food the young growth on a quarter acre, and its removal even at a cash outlay may be justified. Certainly coarse-limbed or
defective hardwoods that can be converted into any material at all that will pay costs should be cut for the benefit of young growth of pine or hardwoods. If the trees contain no usable wood, girdling, or "frilling" accompanied by pouring coal oil or arsenical poisons into the wound, may be resorted to. Frilling consists in hacking through the bark with an ax all around the tree, without removing a chip. The most effective time to do the work appears to be late winter.

Destroying large trees to release young growth is expensive if the wood has no market value. A small amount of this work recently undertaken on the Ouachita National Forest in Arkansas, where the undesirable trees, chiefly oaks, were felled and the tops lopped and piled, indicates that it may cost as much as $2 an acre. Naturally the variation in size and number of trees destroyed makes a general figure of little value.

**IMPROVED TURPENTINING PRACTICE**

In all too many turpentine orchards a large number of trees "dry-face" before the end of the normal chipping period, and cease to yield any gum. Some die. Particularly in second-growth stands, a large proportion of the surviving trees are so riddled by borers and consumed by rot that they may not increase at all in usable volume, although remaining on the ground and by their competition for light and food preventing young growth from coming in. Many are in such a weakened condition that they are unable to produce seed for natural reproduction. Eventually most of these turpentined trees are broken by the wind before they are able to reach crosstie, saw-log, or pole size. In virgin stands not cut immediately after turpentining is finished, the faced trees encumber the ground for many years and, although not nearly so numerous as in second-growth stands, may often keep as large a proportion of the land idle. In both second-growth and virgin stands ordinary methods of naval-stores production are the primary cause of a serious lowering in the rate of forest production.

The most necessary modifications of turpentining practice are as follows:

- Putting one face only on trees not large enough for profitable cutting after turpentining is finished.
- Elimination of boxes.
- Avoidance of deep cuts in setting and particularly in raising tins. This may be accomplished by the use of 2-piece saw-tooth aprons, and by nailing gutters or aprons.
- Limiting width of faces to not over one-third the girth or circumference of the tree.
- Preservation of bark bars at least 4 inches in width between the faces.
- Restriction of depth of streak to at most 0.75 inch in longleaf, and 0.5 inch in slash.
- Care in scraping to avoid exposure of dry wood.

In the narrow-sapped timber of virgin stands the streak should not be deeper than 0.5 inch, even in longleaf pine. This is the practice on the Choctawhatchee National Forest. On that forest no cup may be hung on any tree below 10 inches d. b. h.; not more than one cup on trees below 16 inches; not more than two on trees below 24 inches; and not more than three on any tree, regardless of size.
These modifications of ordinary turpentining practice involve no costs that are not fully offset by increased yields either in the current or later working periods. By these means it should be possible nearly to eliminate dry facing and death of turpentined trees, except such as would die anyway of natural causes. Furthermore, the trees will continue to grow after chipping ceases, provided, of course, there are no fires in the abandoned orchard, and will be ready to work again after a rest. Some lowering in rate of growth is probably to be expected. Cary (7) found that ordinary commercial chipping reduced both diameter and height growth of chipped trees by about one-third. On the other hand, the very careful turpentining methods employed in France (25) are said to reduce the growth of maritime pine scarcely at all.

Theoretically it should be possible to chip trees for many years before they are to be cut. Practically it is unlikely that in future management of longleaf and slash pine lands for full production the quality of the wood grown on them can be dismissed from consideration. Under the best turpentining practice some rot and insect damage will occur if the trees are not cut for many years after their first cupping, and pitch soaking, blue staining, and similar defects will develop in the butt logs. It is therefore suggested that three 4-year periods of work, with a year of rest between, be the limit for turpentining vigorous trees and that not more than one face be worked at a time. The cupped trees would then be cut at the end of 14 years.

After the first 4-year working and 1-year rest the trees are to be back cupped for another four years, care being taken to place the back face as close to the front as is possible without running the risk of reducing the bark bar to less than a 4-inch width at any time. In the tenth year the third face will be placed between the other two, and worked the same number of years. Such a system of three 4-year periods of work can not be applied at all to trees as small as 8 or 9 inches without reducing the width of face to less than 6 inches, considering the requirements for bark bars. Even on 10 to 12 inch trees the faces can not be wider than 7 or 8 inches. Since 7-inch faces have of late years been hardly profitable to work, no trees below 10 inches should be worked under this plan.23

All streaks should be narrow, that is, the chipping should proceed slowly up the tree. Experiments show that on both virgin and second-growth timber faces raised more than 12 to 16 inches by 32 streaks yield no more gum over a 4-year period than low faces. The lower the face, the less wood is exposed to degrade as a result of chipping.

Except on very poor sites most 10-inch trees will in the 14 years of chipping reach merchantable size for ties, piles, poles, or saw logs. This should also be seed-producing size, and although seed production will probably be less than from round trees, it should be

23 For practical purposes a 7-inch face on a tree of any size may be taken to yield about the same as a 7-inch tree, other conditions of course being the same. The average yield of 7-inch slash and longleaf trees is seen from Table 18 to be less than 25 barrels of spirits, and 25-barrel timber on recent markets has not paid its way.

119604°—30—7
enough to maintain a stand fully stocked at all times. If it is
planned to cut the stand clear, the necessary seed trees must be left
unchipped.

SELECTIVE TURPENTINING

By selective turpentining is meant turpentining of only a part of
the trees in a stand rather than all trees of sufficient size to hold a
cup, and also suiting the style of chipping to the condition of the
tree. In underlying principles and advantages it is parallel to
selective cutting, already discussed, and the reader is therefore
referred to earlier pages.

Prominent among its advantages is the opportunity to avoid the
working of unprofitable faces. This avoidance resembles the re-
moval of slow-growing trees and the leaving of vigorous in selective
cutting. Even healthy faces may be relatively unprofitable if they
are on trees of too small a size or too slow a growth. The influence
of diameter of the tree on yield of naval stores may be seen from
Table 18. Because a great many factors influence the yield of
turpentined trees, such as soil, weather conditions, manner of chip-
ing, and year of working, the figures given have their greatest use
as a mean of comparing large and small trees (33). Since it costs
practically as much to work a 6-inch tree as a 14-inch tree, it is very
evident that there is an enormous variation in the profits to be ob-
tained from turpentining large and small trees. Selective turpentin-
ing will enable the operator to avoid working trees which are hope-
lessly low in yield.

TABLE 18.—Calculated yield of turpentine, in barrels of spirits per crop, from
second-growth longleaf and slash pines of various diameters at Starkes, Fla.,
1925

<table>
<thead>
<tr>
<th>Diameter of tree at breast-height</th>
<th>Yield from longleaf pine</th>
<th>Yield from slash pine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inches</td>
<td>Barrels</td>
<td>Barrels</td>
</tr>
<tr>
<td>6</td>
<td>15.3</td>
<td>20.3</td>
</tr>
<tr>
<td>7</td>
<td>22.2</td>
<td>26.2</td>
</tr>
<tr>
<td>8</td>
<td>29.4</td>
<td>32.2</td>
</tr>
<tr>
<td>9</td>
<td>36.2</td>
<td>38.4</td>
</tr>
<tr>
<td>10</td>
<td>43.1</td>
<td>44.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Diameter of tree at breast-height</th>
<th>Yield from longleaf pine</th>
<th>Yield from slash pine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inches</td>
<td>Barrels</td>
<td>Barrels</td>
</tr>
<tr>
<td>11</td>
<td>50.0</td>
<td>50.4</td>
</tr>
<tr>
<td>12</td>
<td>56.9</td>
<td>56.2</td>
</tr>
<tr>
<td>13</td>
<td>64.1</td>
<td>62.2</td>
</tr>
<tr>
<td>14</td>
<td>70.9</td>
<td>68.4</td>
</tr>
</tbody>
</table>

1 Vigorous trees only. Second-year work, one face per tree (trees over 10½ inches cupped 15 years previ-
ously), chipped one-half by one-half inch, 33 streaks.
2 Vigorous trees only. First-year work, one face per tree, chipped one-half by one-half inch, 33 streaks.

Not only size, but the rate at which the tree has recently been
growing appears to have a very marked effect on gum yield. This
rate is best expressed in terms of the number of annual growth rings
in the last inch of growth measured from the bark toward the center
of the tree. Preliminary figures obtained by the Southern Forest
Experiment Station indicate that the yield of gum from slash pines

24 This is probably the influence of width of face, at least within the range of diameters
given in Table 18. Under ordinary practice, which was followed in the study whence the
table was derived, width of face is about one-third the circumference of the tree, regard-
less of the tree’s size. However, faces wider than 14 inches do not yield in proportion
to their width, low yield at the peak apparently offsetting the extra width.
having but three rings in the last one-half inch (that is, which in the last three years grew one-half an inch in radius, or an inch in diameter) was 60 per cent greater than the yield from a tree having 10 rings in the last one-half inch. These figures are for trees of about the same total diameter.

In selective turpentining, it should be possible to take advantage of this knowledge by suiting the style of chipping to the tree. At the same time that thrifty trees capable of yielding heavily during the 12-year period of chipping which has been recommended are thus carefully worked, slow-growing and failing individuals may be turpentined to death. That is, they may be worked with a wide face, or two faces on trees 8 inches and above, with the object of getting all the gum possible in three or four years and exhausting the trees in the process. Their death will favor the growth of the thrifty trees and give room for reproduction to start. To draw the line between thrifty and unthrifty trees will require a thorough knowledge of growth rates in the particular stand concerned.

Costs

To the operator who buys a lease at so much a thousand faces there is no increase in costs as a result of selective turpentining. That is, provided the number of faces per acre to be worked is not cut below 10 or 12, and provided his general expense and depreciation per crop are not raised by lessening the volume of gum coming currently to his still. Operators who have paid a lump sum for the turpentining privileges on a given tract for a short period will lose money whenever they fail to hang a cup on any tree capable of yielding a net profit.

Careful selection of the trees to be worked, some lightly for considerable periods, others very heavily for short periods, will involve a cash outlay for the landowner, whether he works his own timber or leases it. The cost should be about the same as for marking trees in selective cuttings—25 to 50 cents an acre. This expense will, however, make the marking unnecessary, since it is the chipped trees which are removed when cutting begins.

Thinining by Turpentining to Death

The same process described for working the poorer trees in mature stands under selective turpentining may be used to thin young stands of longleaf or slash pines in advance of turpentining the main crop of trees. Working the smaller trees to death by placing wide faces or two faces on them takes the place of cutting; chipping to death trees containing merchantable wood merely postpones cutting by two or three years.

The fact that yield of gum increases with increased width of growth rings will influence the spacing of the trees in thinning longleaf or slash pines. Trees given plenty of room will have few rings to the last inch of growth and will yield more naval stores than trees growing at the best rate for high-quality wood production. The early returns obtainable from gum appear to justify some sacrifice in quality of the wood. Thinnings will therefore be heavier
in stands to be turpentined than in those which are not. (Pl. 10, B.) With this exception the earlier discussion of thinning methods applies also to thinning by turpentining to death.

PLANTING

Planting or some other form of artificial reforestation is the only means left of restoring to productivity lands which have been so thoroughly stripped of seed trees as to be unable to reseed naturally. It is also useful in bringing partially stocked lands up to full production by filling small blanks or openings which might not restock naturally for some time. But as a substitute for natural regeneration on a large scale it has already been described as inadvisable. The fact that seeding or planting costs are a cash outlay and that a bad fire may make it necessary to repeat them in whole or in part should be carefully weighed before the land is stripped of the trees which would supply the seed for another stand of seedlings at no further cost.

If artificial methods of producing forest crops are ever justified as a substitute for natural methods it is on lands without advance reproduction, under the following conditions:

When it is doubtful whether any trees which might be left will bear an abundant seed crop within a reasonable time. This situation may arise with longleaf pine in particular.

When planting is plainly the cheaper method, even considering the cost of replanting if fire wipes out the plantations. For example, it may occasionally be found that the virgin longleaf forest over considerable acreages, such as a forty, contains only very large and overmature trees. To reserve even one or two large trees to the acre may cost more than planting, and lightning or the sudden change in conditions produced by cutting the surrounding stand is likely to prove fatal to the seed trees. Such stands of other species are rare, and fortunately longleaf plantations are less subject to serious fire damage than those of slash, shortleaf, or loblolly pine.

When all trees suitable for seed production have already been turpentined. This is an almost universal condition in the second-growth stands of the eastern naval stores territory, and the only alternative to seeding or planting is an increase in the number of trees left, and continued raking about them. A similar condition making seeding or planting necessary is the absence of trees of seed-bearing size from a stand which is to be cut clear, as for pulpwood. This, however, is not at all common.

In considering whether or not to plant, it is well to remember that artificial forestation with southern pines has not yet been thoroughly tested on adverse sites, such as deep sands or rocky lands, or in the face of abundant scrub oak, palmetto, and other growth that will crowd the planted pines. On the other hand, planting of sites adapted to it has one great advantage—proper spacing of the young trees. Natural seeding is prodigal and wasteful, and generally results in a stand so spaced that some of the saplings are overcrowded and unnecessarily weakened, while others have so much room as to grow up limby and coarse-grained. Planting trees at regular intervals may save the cost of an early thinning. Although no old plantations may be cited as evidence, it seems entirely possible that good spacing from the beginning will cut the time required to reach pulpwood maturity by 3 to 5 years, and saw-log maturity by 5 to 10 years.
Methods

Details of the methods used in artificial reforestation are described in earlier Government publications. Only an outline will be given here.

The gathering of seed and its direct sowing on the land to be reforested would appear to be the cheapest method. But experience both in the South and elsewhere in the United States has shown that planting is almost always cheaper in the long run. Broadcast seeding is particularly to be avoided, primarily because it sacrifices the advantage of good spacing.

The selection of the species of pine to plant on any site should be very largely governed by the character of the original growth. Although it is possible that the faster growing species, loblolly and slash pine, may grow to maturity if planted on dry and high land which in the virgin forest was covered by longleaf or shortleaf pine, their use is risky. Both loblolly and slash pine normally grow in the virgin forest on soils which are wet, or at least well supplied with moisture. It is possible that the slash pine, which seems to be a very aggressive species, has been confined to the wetter lands by the white man’s annual fires, and when fire protection is assured can be successfully grown in drier situations also. Again, loblolly pine has an extremely adaptable root system, and without any direct aid from man has already invaded thousands of acres in Virginia and the Carolinas which were originally the habitat of longleaf only. Nevertheless, the use of these species on hilly land or well-drained sands should be considered as an experiment. The only safe thing to do is to plant the original species, assuming that what has grown on a tract in the past can grow there again and is best adapted to that site.

For similar reasons the use of local seed as a source of planting stock is to be recommended. Seed collected in one portion of the wide range of such a species, for example, as shortleaf pine will produce seedlings adapted to the climatic and soil conditions there, but perhaps poorly adapted to the conditions in another portion. Seed collected locally from vigorous trees of good development should be used wherever possible.

Nursery-grown planting stock has been found to be very much superior to wild stock (seedlings dug up in the woods). It is enough to say of nursery practice that experience has demonstrated fairly well that the seed of all four of the chief species should be sown in the nursery in the early spring; that the seed should be covered either with a light layer of sterile sand or with burlap, the burlap to be removed as soon as germination is complete; that if the seedlings can be watered, shading is unnecessary; that the use of chemical weed preventives may materially reduce the cost of hand weeding without seriously injuring the seedlings; and that longleaf seedlings should be grown at the rate of 30 or 40 to the square foot of bed, and other species at the rate of 50 to 70 to the square foot. The burlap covering will usually give protection from seed-eating birds, and any serious attacks by mice can be broken up by use of poisoned grain.
More than one season's growth in the nursery will rarely be necessary for the southern pines. The seedlings may be lifted any time during the first winter following germination and planted directly on the land to be reforested. A very simple and easy way to prepare cut-over land for planting and keep the planting rows parallel is to plow furrows one way of the site. On hilly ground they should follow the contours, not cut across the hills and draws. Such furrows should be from 6 to 8 feet apart, the wider spacing appearing satisfactory for slash pine and certainly for longleaf. The seedlings are planted about the same distances apart in the rows. In planting the openings in natural stands to complete the stocking, regular spacing is more difficult to attain. A long-handled dibble, or instrument resembling a crowbar, is the most satisfactory tool for planting.

The foregoing measures have been found to be quite satisfactory on ordinary favorable sites. That is, survival at the end of the first season has been found to range between 75 and 95 per cent where the work was done with ordinary care.

COSTS

The cost of planting southern pine will vary somewhat with the species and the availability of seed. Shortleaf and loblolly pines bear appreciable quantities of seed nearly every year, and for these the cost of seed should be fairly uniform—from $1.50 to $3 a pound for loblolly, and from $2.50 to $5 for shortleaf pine. Small quantities, such as are ordinarily most convenient to obtain from nurserymen or seed dealers, will naturally cost considerably more. Longleaf pine, on the other hand, bears seed only at long intervals, and no satisfactory method has yet been found for storing it. The cost is therefore low in good seed years, sometimes as little as $1 a pound, but in poor years the seed may be almost unobtainable. The usual range is from $1.50 to $2.50.

Pine seedlings have been raised in large quantities at a cost of $1 to $4 a thousand satisfactory seedlings, including the cost of seed.

On cut-over land with little brush an experienced crew of one man and a boy, using a dibble in plowed furrows, should plant 1,500 to 1,800 seedlings, spaced 6 to 8 feet apart, in a day. The cost is therefore about $3 a thousand seedlings, or roughly speaking, $3 an acre. Replacements, should they be necessary, will cost probably two or three times as much per seedling and will hardly pay if survival is as high as 75 per cent and the fail places are evenly scattered.

The total cost of artificial reforestation will be from $4.50 to $6.50 an acre, including the cost of plowing the rows. A cash investment of any such amount is decidedly worth intensive fire protection, such as fire lines around every 40 acres. Well-spaced, vigorous trees should reach a size to resist fires somewhat earlier than crowded natural growth.

PROTECTION AGAINST INSECTS

Insects are sometimes extremely destructive in the southern pineries. For example, in 1925 over 500,000,000 board feet of merchantable pine timber in Texas and Louisiana died from insect attack, following a very severe drought.
For detailed information on southern forest insects, and directions for their control, various publications of the Bureau of Entomology of the United States Department of Agriculture, and of the State entomologists, should be consulted. Only a few facts about the most important insects will be given here.

Bark beetles (*Dendroctonus frontalis* Zimm.)—chubby black insects about a quarter of an inch long that in great numbers attack standing trees and kill them by girdling them under the bark—are occasionally very destructive in the shortleaf and loblolly pine forests of the coastal plain, although less common there than in the piedmont. These tiny insects are not ordinarily present in large numbers throughout the piney woods, but at times concentrate their attack on small areas, locally known as “worm deadenings,” where they kill every tree. Anything which weakens the trees, such as a severe fire or extended drought, renders the forest less able to withstand a bark beetle attack. The cutting of a few trees in a stand during the spring or summer appears to attract the insects to the neighborhood, and to encourage a concerted attack on living trees.

If during the summer months the foliage of any considerable number of pines in a small area is observed to be turning yellow, the trunks above the first log should be examined for what is known as pitch tubes. Pitch tubes are little accumulations of fresh pitch bled from the entrance holes of bark beetles. They appear as white spots dotted about over the bark of the tree. If these evidences of the presence of bark beetles are found, logging operations should be directed into the tract at once, and all of the trees which appear at all unhealthy should be cut. There is no known means of saving trees already attacked, but prompt cutting will salvage valuable material and tends to prevent the beetles from spreading. The cutting of trees whose foliage has turned completely brown is quite futile as a measure of control, since the beetles have long since left such trees.

The danger of bark-beetle attack may be somewhat reduced by confining logging operations to the winter months. This is of course possible only on small jobs such as those in farm woodlands.

The Nantucket tip moth larva, or worm (*Rhyacionia frustrana* Com.), whose adult closely resembles the ordinary house moth, has been found to kill the main shoot of young loblolly and shortleaf pines. It is more common in cut-over land than in the forest. Because a side branch very promptly takes the place of the lost leader, the moth ordinarily does nothing more than deform the young trees. But where the infestation is extremely heavy, it is estimated by entomologists that 5 to 10 years may be added to the period required to bring a stand to saw-log maturity. The moth rarely attacks slash pine, and does not bother longleaf at all. No effective control measures have yet been devised, but fortunately the trees are nearly immune from attack after reaching a height of 10 to 15 feet.

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25 Bark beetles should not be confused with the ordinary pine sawyer and flat-headed borers, which in the summer time get into logs or standing dead and dying pine trees. Such beetles never attack living trees, and therefore do not affect plans for keeping forest lands productive.
The turpentine borer (*Buprestis apricans* Hbst.) causes a great deal of destruction by boring into the dead sapwood and heartwood of green trees exposed to his attack by turpentining (19). A face which dries or from which the gum is removed by excessive scraping or the action of fire, checks readily, and allows the adult beetles to lay their eggs in the cracks of the face. The resultant grub or worm bores its way at random through the tree for probably two or three years. It plays a surprisingly large part in ruining the wood and finally weakening the tree to such a degree that it is broken by even ordinary winds. This damage to turpented trees can be avoided only by the use of conservative methods of turpentining, followed by fire protection as long as the tree stands.

**PROTECTION FROM DISEASE**

As in the preceding section, the purpose here is to give only a few of the more important facts upon which protection may be based. A needle blight (*Septoria acicola* (Thüm.) Saccardo), which in the course of a season may kill many of the needles of any species of pine, appears at present to be serious only on longleaf. In some locations and in some seasons longleaf seedlings die of the disease in great numbers, but as yet so little is understood about the process that no remedy or preventive can be suggested with confidence.

Two types of heart rot are concerned in the destruction of the wood of living trees of southern pine—red heart, due to the fungus *Trametes pini*, and butt rot, due mainly to *Polyporus schwinitzii*. The former starts from spores, microscopic bodies corresponding to seeds, which germinate on dead branches or branch stubs. Wood in the first stage of infection is known as "sound red heart" and admitted to the lowest grades of lumber. The butt rot, because it can not penetrate healthy bark or thoroughly resin-coated wood, is largely dependent on fire scars for entrance and to a great extent can be controlled by fire prevention. Wounds on either butts or roots made during logging may also admit butt rot. The longer a tree lives the more liable it is to infection by both of these types of heart rot. Hence one method of combating the rot fungi is to cut trees, and particularly wounded trees, before they reach an age when attack is almost certain. There is great need for information on method of infection, age at which heartwood develops, and age at which the rot commonly gains a foothold.

Chipping a tree for turpentine breaks the bark, and would expose the wood to the spores of rotting fungi if it were not for the heavy flow of resin which very promptly covers the wound. When a tree dry faces under too heavy chipping or as a result of fire or excessive scraping the pitchy face checks open and allows the spore to reach exposed wood. Decay of the interior of the tree is very rapid. As there is no known cure for the rot, once established, prevention is of the greatest importance. It consists in modification of ordinary turpentining methods and fire protection.

All available information on tree diseases of this region may be obtained from the Office of Forest Pathology, Bureau of Plant Industry, United States Department of Agriculture, and from the plant pathologists of the State agricultural experiment stations.
REFORESTATION OF POOR SITES

A small percentage of pine soils are of such poor quality for tree growth that neither clear cutting with the reservation of seed trees nor any system of selective cutting can be confidently expected to keep them productive. How to make them produce full forest crops is at present even more uncertain. Chief among them, at least in continuous extent, are the sand hills of the Carolinas and Georgia, and the deep sands, without a clay subsoil or "foundation," of western Florida and adjacent parts of Alabama. (Fig. 1.) On these sands longleaf pine is the overwhelmingly predominant species.

One obstacle to the natural reforestation of the sand hills by means of seed trees is the condition of these tracts (not cut-over land proper), as a result of years of abuse. Although rarely clear-cut in a single operation, most of them have been culled from time to time, until the present stand is only a remnant of the original forest. The trees left are generally flat-topped, overmature, and of low vigor, although of fair diameter. Even the largest produce seed sparingly in ordinary years. Studies of the 1924 cone crop on the Choctawhatchee National Forest showed that but 8 per cent of 10-inch trees bore 50 cones, which may perhaps be taken as the lowest number for an abundant seeder in a fair seed year. Only a third of the 17-inch trees did as well, and not over half in any diameter class. Large acreages of these lands are almost barren of any young pines. Constant fires and the gradual disappearance of the original forest of pine have favored the growth of various kinds of brush, chiefly scrub oaks and palmetto. This brush, and frequent long droughts, have made it difficult for the pine seedlings to survive, especially as their growth is at best slow. Hogs have further decimated their ranks.

Until investigations by the Forest Service are further advanced than at present only general suggestions may be offered for the management of the deep sands. It is certain that fire protection is necessary for as many years as possible in advance of cutting or turpentining. Because of the extreme openness of the stands, a large percentage of most tracts is not fully utilized by the roots of mature pines, and there is every reason why this ground should be given the opportunity to reproduce to pine if the competing brush and grass will permit. Fires every one or two years have in the past repeatedly destroyed countless slow-growing seedlings, and caused the hardwood brush to sucker freely from the roots. Although many seedlings would undoubtedly have been smothered by fallen oak leaves or starved out by all kinds of other vegetation, some would have survived to work their way up through the brush. Absence of fire allows the oaks to assume tree size, and in so doing they gradually thin out sufficiently to give the young pines beneath them a chance.

Every effort should be made through fire protection to get young growth started. In so poor a soil as these sands there is, however, a wide area around every mature tree where pine seedlings have great difficulty in surviving for any length of time, because all available soil moisture is taken up by the long-established roots of the larger tree. If the tree is cut, the area surrounding the stump often remains
bare because of lack of pine seed. In other cases, since seed trees of first quality are rarely present, many poor seed trees must be left, and these offer too much competition to permit seedlings to get started.

Under similar conditions in Europe (of course with other species) the practice is to put off cutting the stand until two or three years after a good seed year, and then to cut clear, depending on the survival of enough seedlings beneath the parent trees to reforest the openings. Although it will not often be possible to defer the logging of southern pine in this way, long-continued fire protection before logging should have somewhat the same effect. Because of the greater fire hazard in North America, it is probably not safe to remove all seed-bearing trees.

Planting or some other method of artificial reforestation after clear cutting is of course a possibility, but one which, to the extent of our present knowledge, offers but little encouragement on poor soils. Cutting the stand in strips not over 100 yards wide, leaving an uncut strip about a third or half as wide between, is another possibility on large operations where it is feasible to return some years later for the uncut trees.

MANAGEMENT OF FOREST LANDS FOR SUSTAINED YIELD

The measures here described, if employed with intelligence and a full knowledge of underlying principles, should in time render the great bulk of southern pinelands fully productive. Intensive fire protection will make possible an abundant reproduction of pine seedlings in advance of cutting or turpentining, and will preserve against destruction both this and later young growth; it will put an end to the fire scarring which has been a chief contributing cause of injury to living trees by insects and disease; and it will permit of soil conditions favorable to tree growth. Fencing will afford the protection against hogs, sheep, and goats which is sometimes necessary to young growth. Conservative methods of turpentining will prevent many of the present serious losses of gum and wood. Clear cutting, with reservation of abundant seed trees, will provide for the establishment of new forests in localities where advance growth is not sufficient for a full stand. Selective logging will not only keep a new generation of trees always coming on, but will improve the average rate of growth of the existing stand, both in quantity and quality.

Thinnings in young stands dedicated to forest production will at least raise the quality of the final crop and will shorten the period needed to mature it. Planting will improve the stocking of open stands, and on occasional areas will prevent delays unavoidable in natural reproduction. Protection, largely in the form of preventives against insect and fungous attacks, will avert loss of standing timber and losses in timber quality.

The effectiveness of these measures in bringing forest lands to full productivity will depend upon the skill with which they are applied. Just as in any other profession or business, men trained in the science and art of timber growing should, other qualifications being equal, surpass in management of timberland those who have had no training. Forest-land owners in the South interested
in managing their land for forest production will therefore do well to consult the forestry officials of their respective States, or other competent advisers.

A roster of these officials will be found on page 112, and a list of private or consulting foresters at work in the southern pine region may be obtained from the Forester, United States Forest Service, Washington, D. C. The extension foresters of the several States confine their work to farm woodlands, but the State foresters advise owners of large properties as well. In the nature of the case these public officials can rarely go farther than preliminary examinations and recommendations, leaving detailed and continuous advice to foresters employed directly although not necessarily exclusively by the property owner. Published results of investigations by the Southern Forest Experiment Station of the Federal Government may be obtained by addressing requests to its headquarters at New Orleans, La.

The forest-land owner who plans to make his property fully productive will not stop with a consideration of forest practices alone. He will wish to put his timber growing on a business basis. There are evident disadvantages in raising a crop which does not ripen each year, but only at comparatively long intervals. The long wait for the trees to mature is beyond any question the great obstacle to timber growing the world over, and even in regions of such rapid growth as the South it can be overcome only by careful planning and intelligent management. A plan of management whereby a fairly uniform quantity of forest products may be harvested yearly, or every few years, is essential to any productive forest property, regardless of size. Such a sustained yield can not be attained without a plan.

The preparation of a workable plan of management for a forest property requires a thorough inventory of the present forest; a careful study of the rate of growth of which the land is capable, and to which over a long period of years all cutting must be restricted; and the drafting of a cutting budget designed to fit the existing stand and the growth rate. Sound understanding of the technic of such work is fully as necessary here as in the actual woods practice.

A sustained yield of forest products is possible from either even-aged stands, such as result from clear cuttings, or all-aged stands, such as are fostered by any kind of selective cuttings. The smaller the property, however, the less practicable it is to attempt to obtain an annual yield from a succession of clear cuttings, and in fact to obtain annual yields at all. Thus in a 40-acre farm woodland in which saw logs mature in 40 years clear cutting of an acre each year is less likely to be employed than periodic selective cutting of the larger trees over a substantial part of the tract. In practice, it is not likely that the farmer would cut saw logs anywhere on the property oftener than about every five years, although he might continue to cut cordwood each year.

The advantages of obtaining a sustained annual yield from a forest property are many; some of them have been stated or implied earlier in this bulletin. Annual revenue solves the problem of forest taxation in nearly all communities where tax assessments and tax rates
are not in themselves excessive. Again, the item of depreciation—a very considerable one in many instances—is reduced, and the often substantial benefit of business good will continues to operate in favor of the "going concern," when a forest industry so orders its raw material as to be able to remain in business indefinitely.

Lastly, a sustained annual yield leads the way out of the compound-interest difficulty. The fact that trees, even the fast-growing southern pines, take years to mature into merchantable material, and that an investment in bare forest land can not be expected to yield its first return before 15 to 25 years, has led to a general acceptance of the idea that interest rates for forest investments must always be compounded. This may have deterred some southern forest-land owners from investing money in the protection of their properties and from taking the various other steps necessary to make the land productive. The argument is heard most frequently among lumbermen owning large properties. But it may well be questioned whether the owner whose land cost him nothing, because it was thrown in with the timber at a fixed price for the whole, is justified in charging either simple or compound interest for future use of the land for timber growing.

Most southern pine manufacturers are involuntary landowners, becoming possessed of their property as a by-product of their main business—the conversion of trees into lumber and other products. Even seed trees on these properties rarely represent a cash investment on which interest must be compounded, since in the original purchase nothing was paid for them. If it were possible to take these same tracts, convert them promptly into cash, and then reinvest the money in a business which over a long period of years could be expected to earn interest compounded, there would be better grounds for charging compound interest. As a matter of fact the acreages of cut-over southern pineland are too vast to-day to permit of the sale, except at low valuations, of land without a promising crop of young growth.

Only simple interest is chargeable against the investment in a going property, that is, a property producing an annual income. A storekeeper, for example, does not keep rent and taxes on his books and pyramid their value by compound interest year after year, but rather charges them off yearly from current sales. It seems unreasonable to require that forest properties invariably pay interest at a compound rate, and once a forest property is put on a going basis there is an annual return from which to meet the charges of simple interest.

**EXAMPLES OF PRODUCTIVE PROPERTIES**

A few examples, from public and private practice, are given here to show how the intensive measures just discussed, sometimes rather academically, are being applied to-day to specific forest properties. The Ouachita National Forest has already been referred to as lying in a region which in times past has suffered severely from fires. In spite of a very strong local sentiment in favor of burning the woods, in the past few years a determined campaign of education, an increasingly effective system of detecting and reporting fires, better roads, and vigorous organization for fire-fighting, have reduced the
percentage of the forest burned over to a yearly average of 1.4 per
cent. The average yearly cost from 1924 to 1928 was 62\% cents an
acre, including fire fighting. Under carefully prepared plans of
management, the timber is being sold to commercial operators and
by them cut on a selective basis to a flexible diameter limit of 14
inches, which in this region of relatively slow growth permits of a
return over the same area only once in 30 to 40 years. The cutting
of healthy trees is confined to those which have reached 120 to 140
years of age. On areas of more than 1 or 2 acres which do not have
any trees near the 14-inch limit (15-inch trees being the smallest cut),
larger trees, preferably 15 to 18 inches in diameter, are left for
seed.

In spite of an allowed cut often averaging as little as 2,000 board
feet to the acre over an entire watershed in a rocky and mountainous
locality, all stumpage offered in late years on this forest has been
sold under competitive bids at from $6 to $8.50 a thousand board
feet, Scribner rule. On some recent sales the purchaser has been
required in addition to deposit $1 a thousand for cultural opera-
tions, chiefly release-cuttings, carried out by the Forest Service
for the benefit of the young growth of shortleaf pine. These prices
are $2 to $3 above those paid for stumpage in the same locality
intended for clear cutting, and reflect the comparatively high quality
of the material removed.

In the same shortleaf pine region one of the largest private hold-
ings of forest land in the United States is being put under a definite
plan of forest management. An inventory of the existing stand,
and careful estimates of both present and possible growth, will be the
basis for planning future annual cuts, as on the national forest. The
same 14-inch flexible diameter limit is used, but because of better
growing conditions the pine is expected to mature at 75 to 100 years.
Under technical direction a vigorous effort is being made to im-
prove the condition of the forest by removing diseased pines, cutting
course hardwoods into ties, and thinning young pine stands, par-
ticularly in old fields. The fire protective system includes lookout
towers, 300 miles of specially constructed telephone lines, resident
wardens in districts of about a township in size, all under well-
planned and centralized supervision. Fire protection, including
fire-fighting, costs 3 to 4 cents a year, without any direct help from
public agencies. Purchase of interior holdings as offered, especially
land with young growth, is a part of the general plan of rounding
out the property into a unit for the perpetual operation of several
modern sawmills.

The South's growing pulp and paper industry is the basis for
several very large recent purchases of southern pineland cut over
several years ago, or being currently logged to an agreed limit. Ow-
ing to the heavy investment in plant, the purchasers are unhesitat-
ingly taking the steps necessary for good, if not full, forest produc-
tion on their lands. A north Louisiana company has erected three
steel fire-lookout towers, and contributes 2 cents an acre annually
to the State fire protective fund, for expenditure, with a like sum
contributed jointly by the State and Federal Governments, on or
near its property. It leaves three or four excellent shortleaf or
lobbly seed trees, 12 inches or more in diameter at breastheight,
to the acre. In common with every pulp company owning timber or operating in the South to-day, it plans at least to consolidate its holdings by further land purchases.

An east Louisiana sawmill and pulp company plans for perpetual operation of its pulp mill, and if possible its sawmill, from longleaf pine land kept fully productive. In a vigorous and well-organized campaign against fires it has constructed 480 miles of fire lines and 65 miles of telephone lines, and has fenced about 50,000 acres. In 1926-27 its fire losses in four tracts ranging from 28,000 to 250,000 acres varied from 0.9 to 7.2 per cent, with 5.5 per cent for the whole 400,000 acres of company and adjacent land protected. The cost of organized protection, including the expense of fire fighting, was about 3.5 cents an acre in 1926-27, and has since run as high as 4.2 cents. Some public contribution is included in these figures, but none of the company's overhead. The company neither cuts nor turpentine trees below 11 inches in diameter, and in addition leaves two good seed trees to the acre; if small trees are unavailable it does not hesitate to leave their equivalent in 14 to 18 inch trees. Of land that was denuded before any consideration was given to forestry, it has artificially planted between 16,000 and 17,000 acres to various pines. Two large recent purchases to consolidate its holdings totaled about 80,000 acres.

An Alabama company operating exclusively in longleaf pine has for years cut and turpentine to a diameter limit that is now about 18 inches and which reserves as much as 2,500 board feet to the acre in large areas. Steam skidders are not used. Slash is dragged free of standing timber and promising young growth to a distance of 5 to 10 feet, and the leaves and small branches are burned as soon as they can be fired with lightwood torches. If tops can be dragged to greater distances they are not burned, but are lopped down and left to rot. Fencing of 30,000 acres aids in fire protection.

An associated company operating in shortleaf and loblolly pine in northern Louisiana and southern Arkansas has made detailed studies of its timbered and cut-over lands, as a guide to land use and sound forestry policies. It cuts to a flexible limit of 14 inches in virgin timber, going above the limit where necessary to leave one or two first-class seed trees to the acre. In young, thrifty second growth on old fields and elsewhere it aims to thin the stand and return in 20 years for the reserved trees. It has not hesitated to spend 16 cents an acre in the selection and marking of seed trees, and about half as much for an inventory of its property.

As a final example of the many southern pine properties on which thousands of dollars of private capital are being spent annually in efforts of one kind or another to produce full forest crops, may be mentioned a very large tract in Georgia bought for naval-stores production. The first step has been a thorough stock taking, and the preparation by trained men of a plan of management under which production will be carefully balanced against growth. Under this plan all trees 10 inches and larger are being conservatively worked for turpentine for 10 years before being cut. Timber now round will be worked an additional five years. Fire protection has been vigorously organized, with special emphasis on fire lines, of which over
200 miles have been constructed. After three years of fire protection the property has reproduced to an excellent stand of slash pine seedlings throughout.

It is not the intention to imply that intensive timber growing—productive of every board foot of lumber, stick of pulpwood, or ounce of gum that the land is capable of growing—is being practiced on any of the large properties just described, or on others which might with equal reason be mentioned here. For one thing, few communities in the piney woods are yet free enough from fires to permit full forest production. Most farm woodlands are closer to freedom from fires than any of the tracts described. The fact to keep in mind, however, is that already in the South there are landowners who are firmly committed to the idea of forest production. They are committed to it because they have confidence in the final success of fire protection, and in the extraordinary power of southern pine-land to grow trees.
APPENDIX

FORESTRY OFFICIALS IN THE SOUTHERN PINE REGION

Director, Southern Forest Experiment Station, New Orleans, La.
State Forester, Commission of Forestry, Montgomery, Ala.
State Forester, Forest Conservation Commission, Dover, Del.
State Forester, Florida Board of Forestry, Tallahassee, Fla.
State Forester, State Board of Forestry, Atlanta, Ga.
Superintendent of Forestry, Department of Conservation, New Orleans, La.
State Forester, Department of Forestry, Baltimore, Md.
State Forester, State Forestry Commission, Jackson, Miss.
State Forester, Department of Conservation and Development, Raleigh, N. C.
State Forester, Oklahoma Forest Commission, Oklahoma City, Okla.
State Forester, State Forestry Commission, Columbia, S. C.
Director, Texas Forest Service, College Station, Tex.
State Forester, State Conservation and Development Commission, University, Va.
Extension Forester, Alabama Polytechnic Institute, Auburn, Ala.
Extension Forester, 310 Federal Bank and Trust Building, Little Rock, Ark.
Extension Forester, State College of Agriculture, Athens, Ga.
Extension Forester, Louisiana State University, Baton Rouge, La.
Extension Forester, University of Maryland, College Park, Md.
Extension Forester, 510 Millsaps Building, Jackson, Miss.
Extension Forester, State College Station, Raleigh, N. C.
Farm Forester, College of Agriculture, College Station, Tex.
Extension Forester, Virginia Polytechnic Institute, Blacksburg, Va.

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(27) REED, F. W.

(28) ST. GEORGE, R. A., and BEAL, J. A.

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