Department of Agriculture and Immigration of Virginia

GEO. W. KOINER, Commissioner

In co-operation with the Forest Service United States Department of Agriculture

HENRY S. GRAVES, Forester

SHORTLEAF PINE IN VIRGINIA

The Increase in its Yield by Thinning

By W. W. ASHE

Forest Examiner, Forest Service

RICHMOND:
DAVIS BOTTOM, SUPERINTENDENT PUBLIC PRINTING
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PLATE I.

Crowded small pole stand of shortleaf pine about 30 years old in need of thinning. The trees are slender and clean stemmed, but irregular in size. A large number of the smaller trees should be removed.

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Shortleaf Pine in Virginia

The study upon which this report is based was undertaken by the Forest Service in co-operation with the State of Virginia, the work being done under the direction of the officer in charge of State Co-operation in the Forest Service. By the terms of the co-operative agreement, the State is authorized to publish the findings of the investigation.

PURPOSES AND RESULTS.

At the request of Hon. C. A. Swanson, Governor of Virginia, the Forest Service, United States Department of Agriculture, in the autumn of 1909, made an examination of the second-growth shortleaf pine in old fields in the middle portion of Virginia. The cost of this work was borne jointly by the State of Virginia and the Forest Service.

The examination included a detailed investigation of stands of pine in old fields in Mecklenburg, Lunenburg, Brunswick, and Hanover counties, which was supplemented by a general examination of the stands in other counties in the middle part of the State. Its scope was:

(1) To ascertain the condition of the old-field stands and the value of their timber for lumber uses;

(2) To determine the effect of lumbering on the future yields of the stands and to ascertain whether conservative methods of cutting could be employed profitably;

(3) To determine the yield of stands of different ages;

(4) To recommend methods of thinning and cutting to accelerate growth;

(5) To devise methods of protection for young growth.

The conclusions reached as a result of the investigation can be summarized as follows:

Shortleaf pine is the most important tree in twenty south-central counties, but the yield from the pine lands is low because there is neither protection nor a definite system of cutting. The yield can be greatly increased and the quality of timber improved by a regular system of management.

(1) Better protection against fires and insects is required in most stands. Young stands, especially while in process of stocking,

suffer most from fires. Older stands are most endangered by insects. Protection against fire may be secured by means of fire lanes, posted warnings, restriction of night hunting, and patrol during dry seasons when neighboring lands are afire. The danger of loss from insects may be reduced by making frequent thinnings and by removing or by cutting infested trees.

(2) The average stand of pine is far too thinly stocked. This is due to insufficient natural seeding and to the thinning of young stands by fire and of older stands by insects. The yield of such thinly-stocked stands is considerably less, and the grade and value of the timber is lower, than from thickly stocked stands.

(3) Crowded areas occur in nearly all stands, and some stands are crowded throughout. Such crowded plots can be greatly improved by thinnings. The effect of thinnings is to accelerate growth, hasten maturity, and produce a superior quality of timber. The beneficial results of thinnings decrease with the age of the stand, but stands as old as forty-five years respond to them well.

(4) Where natural seeding has not formed dense stands within ten years, the stocking can be completed by the planting of seed; and, where natural seeding does not take place, whole areas may be seeded. Stands restocked in these ways can be expected to yield fully as well as the best natural stands and to return a fair rate of interest on their cost.

If management is applied, that is, if young stands are protected, full stocking secured, and the stands subsequently thinned, the yield of saw timber from a 40-year-old stand can be more than doubled and its value greatly increased. Shortleaf pine is already one of the chief sources of building material on the farms. Furthermore, the farms have more timber than is required for their own support, so that as the general demand for coarse lumber increases and its price rises, shortleaf pine in farm woodlots can be made an important source of commercial timber and a means of permanent income.

DISTRIBUTION AND IMPORTANCE

Second-growth or old-field shortleaf pine is the most important tree of middle Virginia and the Piedmont, south of the Rappahannock, in which region it probably occupies more than one-half of the total forest area and more than three-fourths of the farm forest area. It forms the dominant growth on more than 3,000,000 acres, on which it occurs either in pure stands or, more commonly,

with a slight mixture of other pines and of seedling and sprout hardwoods. It meets with least competition and forms the purest second-growth stands in the tier of southern counties west of Lunenburg county. It is not common north of the Rappahannock river, and is infrequent on the Blue Ridge mountains and in the Great Valley, while in Tidewater Virginia it grows only on the best drained clay soils, and in these sections, on account of the competition of other species, its second growth seldom occurs in pure stands.

Names and Distinguishing Characteristics

Shortleaf pine is also and more generally known as rosemary pine, spruce pine, and yellow pine. The original growth is frequently distinguished from the second growth in old fields under the names of forest or woods pine.

This tree is not to be confused with scrub or jack pine, which is also called spruce pine. Scrub pine is a smaller and inferior tree with a limby stem and smooth, scaly bark. It is largely replacing shortleaf pine in old fields in the northern portion of the State and in the upper edge of the Piedmont in and near the mountains, and is occasionally found mixed with shortleaf pine southeastward as far as Brunswick county. Nor is it to be confused with loblolly pine, which is known in extreme southern Virginia as shortleaf pine and, where it occurs near the coast, as longleaf, swamp, foxtail, or slash pine. Loblolly pine is the common pine on sandy soils in Tidewater Virginia, but it extends westward in association with shortleaf pine to Brunswick, Chesterfield and Louisa counties. The northern pitch, bull, or black pine of the mountains, which is yet another tree, seldom forms second growth in old fields.

The cone and leaf differences of these trees will be a further help in separating them:

Shortleaf pine has cones (burrs) seldom more than 1 1-2 inches long, and slender, straight needles, two or three together, twice as long as the cones.

Scrub pine has cones of about the same length as those of shortleaf pine (1 1-2 inches) but they are relatively broader. The needles are stout and twisted, with never more than two together, and are about the same length as the cones. Frequently the cones of scrub pine and shortleaf pine remain on the trees for many years after opening.

Loblolly pine has large cones, from 3 to 4 inches long. Its needles are borne in threes and are about twice as long as the cones. The cones of this species usually fall during the second summer, but sometimes they persist for several years.

Uses of Wood

The timber of second-growth shortleaf pine is largely sapwood. The formation of heartwood does not begin until the trees are about twenty-five years old. For many years thereafter the heartwood is limited to a small core, and more than two-thirds of the volume of trees fifty years old is still sapwood. The most important uses for the wood of the shortleaf pine are for building lumber, fuel, slack cooperage, box lumber, headings, and crates. The wood contains too much resin to be a desirable material for paper pulp stock without special treatment, although it is used to some extent for this purpose. On account of its softness it is not suited for railroad ties if the traffic is heavy, and, when used for this purpose should be made more durable by preservative treatment.

The large proportion of sapwood in the second-growth timber renders it undesirable for shingles, for which the durable heartwood of the old growth was extensively employed; and unfits it for other uses requiring exposure to the weather, unless it is thoroughly kiln-dried and painted. Logs more than fourteen inches in diameter from trees with clear boles yield lumber suitable for ceiling styles and panels of doors, sashes, window frames, interior woodwork, and also for flooring if rift sawed. Timber suitable for such uses must come not only from comparatively large trees, but from trees which early cleaned their stems and formed wood in the lower two-thirds of the trunk free of knots. That part of the tree which can be converted into lumber of this kind should command, on the basis of $25 for the finished lumber, a stumpage price of not less than $10 a thousand board feet.

Unless the price of cordwood stumpage is proportionately much higher than that of saw timber stumpage, the greatest profit from a crowded stand will be secured by reserving the larger trees for saw timber, and in the meantime thinning or culling the smallest trees for cordwood, stave stock, box boards, bolts, and similar purposes, for which small material is suited. If only selected trees are retained for saw timber they should be allowed to attain a large size in order to produce timber of high quality.

PLATE II.

A dense sapling stand of shortleaf pine 15 to 18 years old, but too small to be profitably thinned. While the clean condition of the floor is good, fire could do great damage in such a stand.

CONDITION AND COMPOSITION OF OLD-FIELD STANDS

As early as 1735 it had become a fixed part of the farming system of middle Virginia to clear new ground each year and to abandon to fallow a parcel of the oldest and most worn farming land. The land thus turned out was rapidly colonized with pines through seed blown by the wind from old trees nearby. When these pines had become large enough and the humus had been restored to the soil through them, the land was usually cleared again. Such a system of rotation of timber and cultivated crops was possible only in a region where land was abundant and cheap. It was due in part to the lack of local markets, which made it necessary to export a large portion of the crops and therefore to produce them as cheaply as possible, regardless of the effect upon the soil; and in part to the fact that these soils were not natural grazing lands, and the depleted humus could be renewed naturally and cheaply by the replacement of the native pines. Some of the existing groves of old-field pine thus originated before the Revolutionary War. Most of them, however, are younger, having originated during and just after the Civil War or in the subsequent periods of agricultural depression about 1880 and 1892. These stands are consequently of all ages; from the youngest, just in process of stocking land which has been turned out during the past decade, to those more than 100 years old. Stands between fifteen and forty-five years old are, however, the most numerous.

Such old-field stands were thus established naturally, and no efforts were made by the owners to increase their density when they were too open or to protect them, while young, from fire. They have seldom been thinned judiciously for improvement. As a result, they vary widely in density. Small tracts are usually well-stocked, since, if seed-bearing trees were nearby while stocking was taking place, seeds were in a few years scattered uniformly over the entire tract and such small tracts were often protected from fire by fences, or by adjacent cultivated fields. The trees in such well-stocked stands are slender and clean-bodied, with small crowns. The average tract, however, is poorly stocked. The trees are isolated, individually, or in irregular groups, and consequently short-bodied, knotty, and coarse-grained. This open condition of many of the stands is due to the fact that seed trees were too few or too distant while the stocking was in progress, or to the fact that the fields became grassy and the seedlings were killed by

fires that burned the grass. Scattered advance growth frequently has borne seed and so stocked the gaps. Such stands are irregular in age and size.

Many of the older stands have been irregularly and often heavily cut for poles, cordwood, and even sawlogs. Most stands of sapling or larger size are too open for the best growth of the trees and for the highest financial returns.

The proportion of shortleaf pine in the old-field stands varies. North of the Rappahannock river the proportion of scrub pine mixed with the shortleaf increases, until in Fairfax county and the lower end of Prince William county it largely replaces shortleaf pine. It is also largely mixed with shortleaf pine in stands near the mountains. In the shortleaf pine stands in the eastern ends of Hanover, Chesterfield and Brunswick counties, there is a large proportion of loblolly pine, which entirely supplants the shortleaf farther eastward. South and southwest of Hanover county the only pine in the field stands is the shortleaf, but species other than pine form part of the mixture in a varying proportion, though they seldom make up more than ten per cent. in stands younger than thirty-five years old. In young stands these associated species vary with the kinds of seed-trees nearby. On lower slopes they are usually maple, poplar, sweet gum, and the oaks; on hilltops they are red cedar, oaks, hickory, black gum, persimmon, cherry, thorn, sassafras, and dogwood.

Permanency of Old-Field Pine Stands

As the field pine stands become older, especially after they have passed the thirty-fifth year, their crown cover tends to thin, and this favors the growth of the oaks and hickories, which come in from seed dropped by squirrels, crows, jays, etc., and are better able to grow beneath the cover than are young pines. Even after the pine in the stand begins to seed the proportion of these broadleaf species continues to increase, since the young pines can come in only when an extensive opening is made by the death of a large pine. There is thus a tendency toward a gradual re-establishment of the original forest type which prevailed before the land was cleared, namely, a mixture of oak, hickory, black gum, and pine, with pine forming a small proportion on the best soil and a large proportion—frequently more than half the number of trees—on the poor, dry or sandy soils. The pure pine stands are, therefore, a temporary type, which in time will be replaced by the permanent mixed-growth type.

It is not an invariable rule that "hardwoods follow pine" after cutting or that "pine follows hardwoods" after cutting or clearing. But pure pine usually forms the second growth if there is no shade or cover, as in old fields or on hardwood land which has been cut clear in late summer or early autumn, when the sprouting power of the hardwoods is low. If seed-bearing trees are near, such open land, whether in field or forest, is captured in a few years by pine, by means of its abundant, light seeds which are widely scattered by the wind. The heavy seeds of oak, hickory and black gum, which are carried largely by birds and squirrels, are disseminated too slowly and irregularly to enable such species to compete successfully with pine in stocking nearby open lands. Under these conditions, pine usually follows oak.

On the other hand, pine is unable to establish itself beneath dense shade, whether of pine or of hardwoods. For this reason young pine growth is seldom found under the trees except in older open pine stands. The seeds of hardwoods, however, are dropped from year to year in such stands and germinate; and the seedlings, through their persistency and ability to endure shade, will survive in shade in which a young pine can not live, although their growth in this case is extremely slow. When the large pines are cut, these stunted hardwoods, responding to improved conditions of light and root space, grow rapidly and if they are numerous they form the larger part of the growth which follows the pine.

In those portions of the State in which it occurs, scrub pine affects the permanence of the shortleaf pine stand on medium soils even more than do the hardwoods. Scrub pine seeds prolifically, when much younger and smaller than shortleaf pine, and the seedlings are tolerant of far more shade than those of the shortleaf. For these reasons, it not only excludes the shortleaf from old fields which are in process of stocking, but it successfully competes with the young hardwoods in occupying openings in stands of shortleaf pine in which the cover is too heavy for shortleaf seedlings to exist, and thus in part succeeds the shortleaf in shortleaf stands.

By reason of this aggressiveness, scrub pine is so completely replacing shortleaf pine over large areas in the northeastern part of the State and near the Blue Ridge that the economic range of shortleaf pine is being restricted.

MANAGEMENT

Forest management as applied to old-field stands may be summarized as the use of any methods of restocking, cutting, or thinning which will reduce the cost of growing timber or add to the value of the timber grown.

Natural stands are usually either understocked, at least in certain phases or during certain periods of growth, or else overcrowded.

The maximum growth is obtained by maintaining such a number of trees to the acre as will utilize the full capacity of the soil and at the same time secure the best development of the individual trees. Understocked stands do not use the full capacity of the soil and must be filled out to the required density by planting in the thin places. In crowded stands, on the other hand, the individual trees are retarded; they must be thinned in order to make them grow at their best rate. These requirements of the stand are discussed in connection with the subjects of thinnings and planting.

Another phase of management is cutting at the period of maturity as determined by either maximum yield or value. The rate of growth or accretion of a stand is not the same at all ages. The yearly growth rapidly increases from nearly nothing to a maximum, then slowly declines. When the rate of annual growth begins to decline, a loss in yield is entailed if cutting is deferred. The time at which the maximum of the average annual yield is obtained varies with the size of the timber which is desired; it would not be the same for lumber, which requires large timber, as for cordwood, for which small timber can be used. But while it is desirable to obtain the maximum annual yield from a stand, the cost of production is a factor which cannot be neglected.

The cost of production embraces the interest on the investment, the taxes, superintendence, protection, and the making of improvement cuttings and thinnings. As far as the needs of owners and the market conditions allow, a stand should be cut at financial maturity, that is, when it yields the best returns on the investment. These phases of management are considered in connection with yields of stands at different ages, and with the cost of growing timber. One of the most important considerations in management is the method employed for obtaining a prompt renewal of the stand in order to prevent the loss of interest on the investment by the idleness of the land.

Protection of stands from fire, from insects, and from fungus diseases is necessary to insure fully stocked stands and sound timber.

The figures relating to the growth and yield of shortleaf pine are based on stands which are growing on soil formerly covered with forests of shortleaf pine mixed with white oak, southern red oak (*Quercus digitata*), black oak, and white hickory. The rate of growth on such sites is regarded as the average or usual rate. Where the pine now grows on soils which were formerly covered with forests of shortleaf pine mixed with post oak, with black-jack oak, or with Spanish oak (*Quercus coccinea*), or with a large proportion of these oaks together with other oaks, the rate of growth and the yield of the stands will be considerably lower than that given.

Fully Stocked and Crowded Stands

A stand is fully stocked when it contains all the well-grown, vigorous trees which the soil can support. This number decreases with the age of the stand and the consequent increase in the size of the trees. In a natural twenty-year-old stand of shortleaf pine the number to the acre should exceed 1,500; at forty years it has decreased to about 750; at sixty years it has fallen to less than 450. This reduction of the number of trees in a stand progresses naturally. As the trees become older and larger, their crowns spread and their roots extend in search of food and moisture. Competition for light, food and moisture ensues, and this in turn results in the dying of the smaller and weaker trees, which are overtopped and crowded out by the more vigorous ones.

A fully-stocked stand, in which natural thinning is taking place rapidly, is *crowded* (plates I, II and IV). At any age the fact that a stand is crowded is indicated by a close crown cover and the presence of many dead trees and slender live trees with narrow crowns. In a young stand of this character less than thirty-five years old the crowding is so great that the crown of each tree almost touches the crowns of its neighbors and direct sunlight hardly reaches the soil. The shade is sufficient to prevent the start of young trees and most shrubs beneath the pines and the carpet of pine needles is so thick as to exclude grass, while small dead trees are numerous. In stands more than thirty-five or forty years old there is a wider distance between adjacent crowns, due to the rapid dying of the larger of the slender narrow-crowned trees. This opening of the stand admits more sunlight, and young oaks, hick-

ories, and other trees, as well as many shrubs, begin to grow beneath the pines. Dead trees and live trees with narrow crowns are not so numerous as in younger stands. The mat of pine needles is thinner in the older stands and grass is able to spring up.

A fully-stocked young stand of shortleaf pine has, therefore, a dense crown cover. In both young and old stands, if they are fully stocked, there are slender trees with narrow, spry crowns and dead trees which have been crowded out, though the latter are more abundant in the young stands. Whether a stand is crowded and in need of thinning may be determined by the greater or less abundance of crowded and dead trees, considered in connection with the age of the stand and the normal density of the crown canopy at a given age.

Understocked Stands

The average stand of shortleaf pine in middle and Piedmont Virginia, however, instead of being too densely stocked, is too thinly stocked. When the crowns do not interfere, or are round-topped with practically horizontal lower branches, the stand is too open for best growth.

Young and even middle-aged stands are frequently open, but their wide-spreading crowns eventually close and form a dense crown cover like that of a fully-stocked stand. But in this case dead trees and slender overtopped trees are absent; the crowns of the trees are too round and wide-spreading; the stems are too short and limby; and the number of trees to the acre is much less than in fully-stocked stands of the same height. (Table 9). Understocked stands of this kind do not require thinning. Moderately understocked young stands usually become crowded early enough to reduce some of the evils of understocking, but the stems of the trees are never so tall and free from limbs and knots as those which develop when there is crowding all through the life of the stand and their total yield is usually less than that of a fully-stocked stand. (Plate III). Young understocked stands should be filled out by planting.

In nearly every stand, however, there will be found at least groups of trees which will be benefited by thinning. The presence in the stand of numerous small dead trees and slender trees with spiry crowns is a clear indication that thinning is needed.

THINNINGS

The objects of thinnings are, first, to accelerate the growth and shorten the time necessary to bring the stand to maturity, and, second, by removing defective trees to produce a mature stand formed of perfect specimens and so increase the yield of lumber. The elimination of the weaker specimens by natural process takes place too slowly for the best development, because the growth of the trees which are ultimately to survive is retarded by the prolongation of the struggle for light and food. Yet limited crowding is necessary at certain periods to force height growth and to develop long, straight stems, reasonably free from limbs. Moreover, the number of trees to the acre largely determines the volume of the yield and has an important bearing on the value of the trees. Usually the crowded stands produce the greatest volume of wood at all ages; but when the size or diameter of the individual trees is of primary importance, as in the production of saw logs, less crowding is desirable. By means of judicious periodic thinnings, it is possible both to favor competition and to relieve overcrowding and in this way greatly to accelerate the growth of the remaining trees. Such thinnings reduce the number of trees, but they produce equally tall trees of much larger diameter, with straight, clean stems and but little taper. It is commonly held that if the larger trees are removed as they come to merchantable size the smaller trees will make accelerated growth. This is unquestionably true of many species and it is true also of shortleaf pine under thirty years old, but in pure old stands of shortleaf pine in Virginia the crowded and suppressed trees recuperate so slowly that it is not profitable to thin the stands in this way after they have passed the age of thirty-five years.

Classes of Trees

Before thinnings can be intelligently made, the classes of trees in a stand must be known and their relation to the growth of the stand understood. The live trees in a second-growth pine stand can be separated easily into three classes:

Dominant Trees.—These are the tallest and thriftiest specimens with the largest crowns. Their growth is rapid, both in height and in diameter.

Intermediate Trees.—These are the slender, clean-bodied trees, with narrow, compressed crowns which are nearly as tall as the

dominant trees. Their height growth is rapid, but, on account of their small crowns, their diameter growth is slow. Besides being unable to make good volume growth themselves, they retard the growth of the dominant trees.

Suppressed Trees.—These have fallen behind in height and are so much lower than the other trees that direct sunlight is largely excluded from them. They interfere very little with the growth of the larger trees.

When overshadowing and suppression pass a certain point the trees die. Three-fourths of the dead trees are in the suppressed class, but intermediate trees also die from overcrowding. Dead trees exert no influence upon the growth of the stand. When possible, however, they should be removed, since they contribute to the danger of disease, insects, and fire.

HOW HEAVILY TO THIN

Thinnings must be heavy enough to provide more light and crown space, and more root space and soil moisture for the trees that are left, yet they must never be heavy enough at one time to admit too much sunlight and cause the crowns to spread unduly, with a sacrifice in the rate of height growth. Too heavy a thinning results in temporary understocking and produces the opposite of the result desired.

To be most effective, thinnings should begin when a stand is twenty years old, and should be light and frequent. Early thinnings prevent the crowns from crowding before their symmetry is destroyed, and yet maintain sufficient crown rivalry to secure continuous height growth and promote the rapid shedding of the lower limbs. Before removing any tree, it is necessary to consider how its removal will affect the remaining trees, not only until the next thinning, but until the stand is mature and the trees are merchantable.

Thinnings should be made not less often than once every ten years. Even with ten-year intervals cuttings have to be too heavy for the best interest of the stand and excessive crowding takes place before a thinning is repeated. An interval of five years is recommended as the most desirable. This develops the full value of the stand, and also allows the cutting of enough cordwood from the thinnings to pay for the work. A careful observer will be able to lengthen the interval if the cost of thinnings requires it.

PLATE III.

Understocked large pole stand of shortleaf pine 80 years old. The trees are short-bodied and knotty and will yield only low grade lumber. The best that can be done with such a stand is to cut it, leaving slender, clean-bodied trees for seed trees.

WHAT TO REMOVE IN THINNING

Thinnings should remove such suppressed trees as are not necessary to complete the crown cover, since they have made their growth and exert little or no influence on the growth of the large trees. Species of lower value, like gums, post oak, maple, sassafras, and scrub pine, should also be cut, unless they are needed to keep the crown cover complete. Punky or diseased trees should be removed from stands of all ages. Short-bodied, crooked, knotty, forked, or otherwise defective pine trees should be cut from younger stands, but should be left in old stands when their removal would make openings which would not be filled by the spread of the surrounding crowns. Enough of the intermediate class should be removed to provide growing space for the trees that are left. The trees which are removed should be selected evenly through the stand. If several adjoining trees are removed, an opening is left which will be too long in closing. If trees are left in groups, excessive crowding in the interior of the groups will follow, and this will result in the loss by shading of the interior branches and unsymmetrical development of the trees. When there is a choice the trees which are left for permanent growth should have well-developed and symmetrical crowns.

ACCELERATION IN GROWTH FROM THINNING

Until they are thirty or even thirty-five years old, the intermediate as well as the dominant trees of shortleaf pine stands respond vigorously and rapidly to thinnings by accelerated growth. In older stands, the recuperative power of the intermediate trees declines and the recovery from the effects of overcrowding is slow. The recuperative power of the dominant class, however, is maintained until the trees are sixty years old, when the period of rapid height growth is well past and crown isolation has taken place. The ability of the intermediate trees in young stands to recover rapidly from the effects of close crowding, permits the cutting of the largest trees in such stands and the leaving of the slender, clear-stemmed intermediate trees to form the mature stand.

In Plate VI, fig. 1, which shows the cross section of a stem of shortleaf pine, is to be seen the results of accelerated and sustained growth which are due to repeated light thinnings. The crowded condition of the inner rings of growth show that the tree was a slender, intermediate tree before its crown was freed by the

original thinning, made, as shown by the number of wide rings, forty-seven years before the tree was cut. Several thinnings, made since the original thinning, have prevented any marked decline in the comparatively rapid rate of growth which took place after the crown of the tree was originally freed of overcrowding. The rate of growth is one inch of radius every eleven years, or about one inch in diameter every five years (the bark thickening as well as the wood),—an excellent average rate of growth to seek to maintain in the trees of a stand. It produces timber suitable for the highest classes of uses.

METHOD OF THINNING

The several thinnings are for the benefit of the final cutting and unless the thinnings are made at a profit, the yield of the final cutting must be far heavier as a result of the thinnings in order to make them worth while. In young stands then, it is possible to distribute a portion of the thinnings in the dominant class; in old stands, thinnings must be largely restricted to the suppressed and intermediate classes. Stands more than twenty years old, which have never been thinned, require heavier thinnings than stands of the same age which have been thinned previously.

Sapling Stands (*Younger than Tweny Years*).—Thinnings of sapling stands are seldom possible on account of the expense of making them and the small amount and poor character of the wood obtained. Under average conditions of growth, the wood which could be cut in a thinning in such a young stand would be from two to four inches in diameter and would make only a poor quality of fuel. Thinnings at this age are not recommended unless the wood can be used. (Plate II).

Small Pole Stands (*From Twenty to Thirty Years Old*).—A crowded stand twenty-five years old contains a number of large trees eight or nine inches in diameter breasthigh, and a few even ten inches; many of which are in the advance growth, two or more years older than the average age of the stand. Such trees are frequently bushy and very limby, with wide-spreading crowns. Usually all of the nine and ten-inch trees in such a stand and many of the eight-inch trees can be cut. These will furnish a small quantity of saw timber. In addition to the large trees, all of the trees below four inches, and usually about one-half of the five-inch trees can be removed. If no previous thinning has been made, about

200 trees five inches and larger could be cut to the acre. These should yield about ten cords of wood, of which the material above nine inches might be sawed into about 500 board feet of lumber. About 900 trees should be left to the acre. A thinning in a twenty-year-old stand should yield much less, and one in a stand more than twenty-five years old should yield more and leave fewer trees per acre. At these ages trees are making very rapid growth, and the branches of the crowns are sharply ascending, so that comparatively large openings are more quickly covered than in older stands. For this reason thinnings at this period present no serious difficulties, but it is desirable even in making a thinning at this age to have in view the trees which are to form the final stand and these should be the tree with very slender and clean stems, that will yield several logs, and from which lumber can be sawed free or nearly free from any except small knots. For the relative value of these trees compared with the larger dominant trees in a stand, see table 16. (Plate I).

Large Pole Stands (From Thirty to Forty Years Old).—All trees below six inches, most of the six-inch trees, and some of the seven and eight-inch trees, should be removed from a normal thirty-five-year-old stand. If no previous thinning has been made, not less than 200 trees could be cut, many of which would, however, be five inches or less in diameter. If a thinning has previously been made, there would be fewer trees to come out. A first thinning at this time should yield from fourteen to seventeen cords to the acre. Fewer trees are removed than in thinnings in younger stands, and greater judgment must be used in making selections. The method of cutting in strips can be economically used only by farmers who either do their own logging or who can personally superintend it. (Plate IV).

Mature Stands (From Forty to Fifty Years Old).—If a stand of this age has been previously thinned, about ninety trees to the acre would be available for removal, comprising a few six-inch trees which could not have been removed earlier without making undue openings in the crown cover, many seven-inch and eight-inch trees, and some nine-inch trees. If it were a crowded stand, not previously thinned, from 100 to 200 trees to the acre might be taken out, with a yield of not less than ten cords of wood per acre. However, unless the stumpage value of trees from fourteen to sixteen inches in diameter is greater than that of trees from twelve to fourteen inches, a size which the trees reach when about

forty-five years old, timber is produced at the lowest cost by cutting when the stand is about this age (see tables 12 and 17). Under ordinary conditions, the stand would be cut for lumber, and not thinned, at this period. (Plate V).

This method of thinning crowded stands is based on the *average crowded stand.*

Typical Stands.—Table I shows approximately the average number of trees of each diameter from four inches up, which were found in irregularly thinned stands growing under average conditions. This table is approximately correct for the average of a number of stands, but any individual stand at a given age will probably show considerable variation from it, both in the total number of trees per acre and in the number of trees in each class, since slight differences in the quality of the soil affect the number of trees to the acre at any age, and the degree of thinning influences both the number of trees and their size. It shows, however, the rapid elimination of the smaller trees, which are the ones which should be chiefly removed in the thinnings, and it will serve as a guide to indicate about the number of trees of each size which should be taken out at each thinning. The stands which have been grouped as thinned stands in some cases were undoubtedly naturally thinly stocked and their density has been further affected by artificial thinnings. For this reason the favorable conditions of these stands can not be entirely ascribed to thinnings.

TABLE 1.

Approximate number of trees four inches and over in diameter to the acre in unsystematically thinned stands of shortleaf pine (the twenty-year-old stand is unthinned).

Age of stand	Diameter Breast High—Inches															
Years	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
20	600	400	300	50	10	. .	.	. .	. .	. .	. .	. .	. .	.	.	1,360
25	203	278	228	154	92	10	5	. .	. .	. .		. .	. .		.	970
30	70	170	176	136	106	69	25	10	1		. .	. .	. .	.	.	765
35	2	76	121	111	118	87	46	23	9	2	. .	. .	.	.	.	615
40		8	84	91	115	83	58	37	20	8	1	.	. .		.	505
45	. .		28	63	97	74	64	46	30	13	4	1	. .	.	.	420
50	. .	. .	6	34	70	63	63	50	37	21	9	2	. .		.	355
55	. .	. .	. .	12	34	48	53	52	41	26	15	7	1	.	.	289
60	. .			2	18	33	42	42	42	33	21	12	5	.	.	250
65	. .	. .	. .	. .	10	17	30	36	38	35	26	16	9	3	.	218
70	. .	. .	. .	. .	3	11	21	27	31	32	28	20	14	7	1	195

Table 2 shows for two stands about forty-five years old the effect of thinning in increased board yield and in the distribution of diameter classes. One is a crowded stand which has never been thinned; the other has been thinned for fifteen years in a desultory manner. Had the thinnings been systematically made, better results would have followed. The large number of trees between ten and fifteen inches in diameter in the thinned stand is noteworthy.

TABLE 2.

Effect of thinning on board-foot yield of shortleaf pine and the distribution of diameter classes (two stands about forty-five years old).

Diameter of Trees Breast High	Number of Trees of Each Diameter to the Acre	
	Unthinned stand	Thinned stand
4	16	8
5	52	10
6	168	32
7	124	38
8	112	32
9	84	74
10–12	56	132
13–15	8	18
Total live trees	620	344
Dead trees (all diameters)	176	16
Yield in board feet from trees 9 inches and over in diameter	12,740	18,770
Cords of stem wood with bark to the acre	61	50

Table 3 shows the average height of the trees in stands at different ages, and the average diameter of all trees in unthinned and irregularly thinned stands:

TABLE 3.

Average height and average diameter of all trees in fully-stocked stands of shortleaf pine.

Age of stand	Average Height of Merchantable stand	Average Diameter of all Trees	
		Unthinned crowded stands	Thinned stands
Years	Feet	Inches	Inches
20	32	4.0	4.0
25	37	4.8	5.3
30	42	5.5	6.4
35	47	6.2	7.3
40	51	6.7	8.2
45	55	7.3	8.9
50	58	7.7	9.6
55	61	8.1	10.1
60	63	8.5	10.7

Table 4 shows the number of trees nine inches and over in diameter breast high in unthinned and irregularly thinned stands, and the average diameter of such trees.

TABLE 4.

Average diameter and number of trees nine inches and over in fully-stocked thinned and unthinned stands of shortleaf pine of different ages.

Age of stand	Crowded Unthinned Stands		Thinned Stands	
	Number of Trees per Acre	Average Diameter of Trees	Number of Trees per Acre	Average Diameter of Trees
Years		Inches		Inches
20	. . . . .	. . . . .	. . . . .	. . . . .
25	1	9.1	15	9.3
30	7	9.3	105	9.6
35	47	9 5	167	10.0
40	88	9 6	207	10.4
45	125	9 8	232	10.8
50	156	9.9	245	11.1
55	182	10.1	243	11 4
60	200	10.3	230	11.7
65	213	10.5	208	12 0
70	210	10.7	192	12.8

PRODUCTION OF CORDWOOD FROM THINNED AND UNTHINNED STANDS

The yield of cordwood* is determined rather by the number of trees than by the size of the individual trees. The most crowded stands usually yield most heavily, and the yield appreciably declines as the stands become more open. This has a great influence upon the yield of old stands, since after the thirty-fifth year there is practically no increase in the yield in cords of unthinned stands, on account of the rapid dying of the smaller trees. For this reason, thinnings are not so profitable for the production of cordwood as for the production of saw timber; though the trees which would die are saved, and some additional growth is secured. If regular thinnings are made at intervals of five years, then at the age of forty-five years the increased yield, including the thinnings, is only thirty-three per cent., as against an eighty per cent.

TABLE 5.

Yield of thinned and unthinned stands in cords—Trees three inches and over in diameter.

	Unthinned Stands	Thinned Stands—Yield of Thinnings					
Age of stand	Volume at Different Ages	Volume of stand before each Thinning	Number of Trees which can be removed in each Thinning	Approximate average diameter of Trees removed	Volume of Trees removed in each Thinning	Total of all previous Thinnings at any Cutting period	Total of Thinnings and Stand*
Years (1)	Cords (2)	Cords (3)	(4)	Inches (5)	Cor (6)	Cords (7)	Cords (8)
20	47	47.0	930	3.3	6 1	. .	47.0
25	57	52.0	205	4.5	5.1	6.1	58.1
30	62	57 0	150	5.0	5.0	11.2	68.2
85	64	60.0	110	5.5	4 8	16 2	76.2
40	65	60.0	85	6.0	4.3	21 0	81.0
45	64	59.0	68	6.5	4 0	25.3	84.3
50	63	57 0	55	7.0	3 6	29.3	86 3
55	61	54.5	45	7.6	. .	32.9	87.4

*Column 8 is the sum of columns 3 and 7.

*Unless otherwise stated, all references to cords are to standard cords of 128 cubic feet, and the corded wood is measured with the bark on. Standard cords can be converted into long cords of 160 cubic feet by dividing by 1.25 or by multiplying by 4-5. Either standard or long cords with bark can be converted into cords without bark by multiplying by .77, if the wood comes from trees which average less than 7 inches in diameter, or multiplying by .82 if the trees average a larger diameter.

increase obtained at the same age by the thinning for lumber. Unless the value of cordwood increases with the diameter of the wood (as it should if the wood is used for heading or stave bolts) no added value per cord is secured by thinnings.

The yield in standard cords, stem wood with bark, of thinned and unthinned stands of shortleaf pine of different ages is shown in Table 5.

Table 6 shows the approximate number of trees to the acre in crowded stands of different ages, and in thinned stands. The difference between the number of trees in an unthinned stand and in the same stand five years after it has been thinned indicates approximately the number of trees which should be removed from the unthinned stand. In practice, it probably would be best to make two or more thinnings before reducing the number of trees in an old, crowded stand to the number in a normal, thinned stand.

TABLE 6.

Approximate number of trees of shortleaf pine to the acre in crowded and thinned stands.

Total Number of Trees per Acre			
Age of stand Years	Crowded Unthinned stand	Thinned stands	Number which can be removed from a previously Unthinned stand
20	1,950	1,250	980
25	1,440	970	675
30	1,235	765	620
35	1,030	615	525
40	860	505	440
45	710	420	355
50	535	355	. . . . .

Maximum Yield of Cordwood.—The maximum yield in cords is obtained earlier than the maximum yield in board feet. The best stands more than fifty years old give no heavier yield in cords than younger stands, because they have few trees to the acre, while neglected stands in which disintegregation is taking place show even a decline in the volume.

PLATE IV.

A crowded, large pole stand of shortleaf pine 40 years old, badly in need of thinning by removing the smaller pines and many of the hardwoods. Condition of larger trees, with long, smooth bodies, excellent.

TABLE 7.

Yearly increment of shortleaf pine in cords (stem-wood and bark) of all trees three inches and over in diameter, breasthigh.

	Unthinned Stands		Thinned Stands	
Age of stand	Average Annual Increment	Periodic Annual Increment for each 5-year Period	Average Annual Increment including Thinnings	Periodic Annual Increment for each 5-year Period
Years	Cords	Cords	Cords	Cords
20	2.3	. . . . .	2.3	. . . . .
25	2.2	2.	2.3	2.2
30	2.1	1.	2.3	2.0
35	1.9	.5	2.2	1.6
40	1.7	.4	2.	decrease
45	1.3	decrease	1.8	"
50	1.2	"	1.7	"
55	1.1	"	1.6	"
60	.8	"	. . . . .	"

In both thinned and unthinned stands on average sites the maximum yield in cords per acre is obtained by cutting between the ages of twenty and twenty-five years, at which time a yield of fifty-seven cords per acre can be secured, or an average of 2.2 cords an acre a year. The size of the wood which is obtained at that time is, however, much smaller than that from older stands, and this fact affects its value.

TABLE 8.

Cost per cord of growing shortleaf pine cordwood, stemwood with bark, in unthinned and thinned stands; including thinnings, land value $5.00 an acre, interest rate five per cent, and one per cent yearly in addition for taxes and protection.

Age of stand	Accumulated Cost of Land, at $5 per Acre, 5 per cent. interest, 1 per cent. added for taxes, less value of land*	Unthinned Stands		Thinned Stands					
				Thinnings			Net cost per Acre of producing Crop§	Final yield	Cost of growing per cord§
		Final yield	Cost of growing per cord†	Amount	Assumed value per cord	Accumulated value‡			
Years (1)	(2)	Cords (3)	(4)	Cords (5)		(7)	(8)	Cords (9)	(10)
20	$11.04	47	$ .23	6.1	$ .10	. .	$11.04	47	$ .23
25	16 46	57	.28	5.1	.15	$ .78	15 68	52	.30
30	23 72	62	.38	5.0	.20	1.97	21.75	57	.38
35	33.43	64	.52	4.8	.25	3.79	29.64	60	.49
40	46.43	65	.81	4.3	25	6.37	40.06	60	.66
45	63.82	64	.99	4.0	.25	9.50	54.33	59	.92
50	87.10	63	1.38	. . . .	. . . .	13.40	73.70	57	1.30

* Column 2 is obtained by calculating the interest at 5 per cent. plus 1 per cent. for taxes, making a total of 6 per cent., compounded annually on a land value of $5 per acre. Since the land will remain after the timber is sold, its value is not included in the cost of growing.

† Column 4 is obtained by dividing column 2 by column 3.

‡ Column 7 is the product of columns 5 and 6 compounded at 5 per cent every 5-year period. The value of wood removed in thinnings (column 6) is only nominal on account of its small size and the difficulty of making thinnings.

§ Column 8 is the remainder after deducting column 7 from column 2.

§ Column 10 is obtained from dividing column 8 by column 9.

Cost of Growing Cordwood.—Table 8 shows the cost of growing cordwood in both thinned and unthinned stands at a five per cent. interest rate.

PRODUCTION OF SAW TIMBER

Influence of Density of Stand Upon Yield of Saw Timber at Different Ages.

Maximum yield in lumber is obtained neither from stands which are continuously very crowded nor from understocked stands, but from stands which are periodically and lightly thinned after having been crowded.

The most marked effect of thinnings in crowded stands is in the amount and quality of the yield in board feet. The stands which were measured to determine the effects of thinnings had been thinned in no definite manner; in some cases only the smaller trees, in other cases also some of the larger ones, had been cut out,

as farm needs required. Some of these thinned stands were evidently somewhat understocked; some were still too crowded; and others, at the time the measurements were made, had not had time to respond fully to the thinnings. It is probable that by systematic thinnings of the kind recommended the yield shown in the tables could be further increased ten or even twenty per cent.

Table 9 shows the yield of stands which have different numbers of trees to the acre; in other words the yield is of understocked, thinned, and crowded stands. The yield is based on cutting to nine inches in diameter breasthigh, which is equivalent to about eleven inches on the stump. In the understocked stands the crown cover is practically as complete as in the thinned and crowded ones, but all the trees are low and short-bodied and few slender or dead trees are present. (Plate III).

TABLE 9.

Yield of stands of shortleaf pine having different numbers of trees per acre. (influence of density of stands upon yield of saw timber).

Average Understocked Stands			Fully Stocked Stands which have been Thinned		Crowded Stands, Unthinned	
Age Years	Number of Trees to the Acre	Yield in Board Feet	Number of Trees to the Acre	Yield in Board Feet	Number of Trees to the Acre	Yield in Board Feet
30	350	3,800	765	8,400	1,235	200
40	300	5,700	505	16,400	860	6,000
50	150	6,900	355	20,400	535	13,100
60	100	7,800	255	23,000	395	16,800

The yield of an understocked stand when more than thirty years old is only about one-half of that obtainable from a fully stocked stand of the same age, after thinning. Many of the trees in open, understocked stands attain a diameter of nine or more inches sooner than do trees in crowded stands, for in crowded stands the continued competition retards the diameter growth of the individual trees. This explains why crowded stands thirty years old are not producing merchantable timber.

In the average understocked stand the cost of growing the timber is far in excess of its present stumpage price. This is largely due to the small yield. If sold at $2 per thousand board feet, timber from understocked stands pays less than two per cent. on the assumed investment of $5 an acre.

Table 10 shows the influence of density upon the cost per 1,000 board feet of growing shortleaf pine stumpage in old-field stands, based on net returns at five per cent., taxes one per cent. in addition, land value $5 an acre.

TABLE 10.

Influence of number of trees, or of density of stand on cost of growing 1,000 board feet in old-field stands of shortleaf pine.

Age of stand	Accumulated Cost of the Investment per Acre less the Value of the Land	Average Under-Stocked Stands		Crowded, Unthinned Stands		Thinned Stands, Neglecting Value of Thinnings	
		Yield per Acre	Cost per M ft	Yield per Acre	Cost per M ft.	Yield per Acre	Cost per M ft.
Years		Bd. ft.		Bd. ft.		Bd ft.	
30	$ 23.72	3,800	$ 6.30	. . . . .		8,400	$ 2.82
40	46.43	5,700	8.10	6,000	$ 7,73	16,400	2.83
50	87.10	6,900	12 60	13,100	6.65	20,400	4.27
60	159.90	7,800	20.51	15,000	10.66	23 000	6.82

At every age if thinnings are made without loss, the cost of growing stumpage in fully stocked thinned stands is less than the cost of growing it either in crowded or understocked stands. If thinnings do not pay for themselves the cost is higher, and if they pay a profit, the cost is lower.

Age of Cutting for Maximum Yield.—The maximum annual yield in board feet from trees nine inches and over in diameter breasthigh is obtained from thinned stands when they are cut at forty-eight years of age. At that time in such a stand, the average annual yield per acre is about 410 board feet, and the diameter of the average-sized tree is about 9.5 inches breasthigh, or 11.5 inches on the stump.

For unthinned stands, the *maximum annual yield* is obtained by cutting when about fifty-seven years old. The average diameter of the trees in such a stand is about 8.2 inches at breast-height or 9.8 inches on the stump. Table 11 shows the yearly increment in board feet of trees nine inches and over in diameter breasthigh.

TABLE 11.

Annual increment per acre in board feet of trees of shortleaf pine nine inches and over in diameter breasthigh.

Age of stand	Thinned Stand (Thinnings Neglected)		Unthinned Stand	
	Average Annual Increment	Periodic Annual Increment for each Decade	Average Annual Increment	Periodic Annual Increment for each Decade
Years	Board feet	Board feet	Board feet	Board feet
30	280	. . . . .	. . . . .	. . . . .
40	410	800	150	. . . . .
50	408	400	262	710
60	383	260	250	190
70	357	200	238	170

Cost of Growing Saw Timber.—If only the maximum annual yield were to be considered in growing timber it would undoubtedly be advisable in all cases to hold timber until this could be secured. The cost of carrying the investment, however, is a factor which cannot be overlooked. The land has a sale value, and taxes are paid upon it yearly. In addition, the cost of protection, such as maintaining fences, extinguishing fires, etc., must often be borne.

In making a calculation of the cost of growing timber it is necessary to determine, from the time stocking took place to the time when the timber is cut, the accumulated taxes paid on the land and the interest compounded annually on the investment represented by the value of the land and the cost of stocking it. In making this calculation, both the actual and tax assessment value of the land has been assumed to be $5 an acre for the entire period of growth. The tax rate and other expenses are assumed to be one per cent. on this valuation. If the owner is content with a gross interest of six per cent. on his investment, then the net rate, after deducting taxes and other expenses, will be five per cent. a year.

In the old-field stands there is no cost of stocking to consider. The profits of thinnings are supposed to be the same as those given in column 7, Table 8, for cordwood.

In order to obtain a six per cent. investment which, after allowing one per cent. per annum for taxes and protection, will yield five per cent. net, the following yields and prices must be secured. The value of the land is placed at $5 an acre. If stump-

age is sold at less than the cost of growing 1,000 board feet, or if the stands cut less than the amounts given at the different ages, less than five per cent. net is obtained on the investment. If stumpage is sold at a higher price and the value of the land is not more than $5 an acre, then the investment will yield more than five per cent.

TABLE 12.

Cost of growing shortleaf pine saw-timber in unthinned and thinned stands, including thinnings. Land value $5 an acre; interest rate five per cent; one per cent in addition allowed for taxes.

Age of stand	Unthinned Stand			Thinned Stand		
Years	Accumulated Cost of Investment Land at $5 an acre, 5% interest, 1% added for taxes, less cost of land	Yield Bd. ft.	Cost of growing per M bd. ft.	Net Cost per acre of producing crop*	Final yield Bd. ft.	Cost of growing per M bd. ft.
20	$11.04	. . . .	. . . . .	$11.04	. .	. . . . .
25	16.46	. . . .	. . . . .	15.68	900	$17.00
30	23.72	200	. . . . .	21.75	8,400	2.59
35	33.43	1,400	$23.80	29.64	13.400	2.21
40	46.43	6 000	7.64	40.66	16,400	2.44
45	63.82	10,200	6.25	54.33	18,700	2.90
50	87.10	13,106	6.70	73.70	20,400	3.61

* After deducting value of thinnings as shown in Table 8.

The cheapest cost of production, with interest at five per cent. and taxes at one per cent., or six per cent. for both is $6.25 a thousand board feet from unthinned stands and $2.21 from thinned stands.

The period when the cost of growing the timber is the lowest is known as the *financial maturity*. If timber is held longer than the period of financial maturity, there must be a considerable advance in its value to cover the cost of carrying it, that is, the accumulated interest and taxes, and this is particularly true of old stands the volume of which is increasing very slowly or perhaps actually declining.

The owner of timberland is interested in knowing the rate of interest he may expect from his investment when the product sells at a give price. Tables 13 and 14 show the interest yielded by stands of old-field pine at different ages, with the land worth $5 an acre and with stumpage selling at $2 a thousand feet and cordwood at twenty-five cents a cord. In table 14

for cordwood from a thinned stand, it is assumed that thinnings produce the returns allowed in column 7, Table 8.

In the table for board feet from a thinned stand, thinnings are supposed to be made without either profit or loss. The interest yielded is gross, and includes taxes and the cost of protection—items which would usually amount to about one per cent. of the land value and would correspondingly reduce the returns.

TABLE 13.

SAW TIMBER STUMPAGE AT $2 A THOUSAND BOARD FEET.

*Gross rate per cent yielded by stands of old-field pine on a land value of $5 an acre.**

Age of stand	Thinned Stand			Unthinned Stand		
	Yield per Acre	Value of stand neglecting Thinnings	Gross rate per cent. Yielded on Land Value	Yield per Acre	Value of stand	Gross rate per cent. Yielded on Land Value
Years	Bd. ft.		Per cent.	Bd. ft.		Per cent.
30	8,400	$16.80	4.3	. . . .	. . . . .	. . . . .
35	13,400	26.80	5 0	. . . .	. . . .	. . . .
40	16,400	32.80	5 0	6,000	$12.00	2.5
45	18,700	37.40	4.5	10,200	20.40	3.2
50	20,400	40.80	4.0	13,100	26.20	3.3

TABLE 14.

CORDWOOD STUMPAGE OF FINAL YIELD AT 25 CENTS A CORD.

*Gross rate per cent yielded by stands of shortleaf pine in old-field with a land value of $5 an acre.**

Age of stand	Thinned Stand			Unthinned Stand		
	Final yield	Total Value, per Acre, including Accumulated Value of Thinnings at 4% compound interest	Gross rate per cent. Yielded on Land Value	Yield per Acre	Value of stand	Gross rate per cent. Yielded on Land Value
Years	Cords		Per cent.	Cords		Per cent.
20	47	. . . . .	. . . .	49	$11.75	4 3
25	52	$13.74	4.0	57	14 25	4.2
30	57	16.08	4.0	62	15.50	3.8
35	60	18.44	3.8	64	16.00	3.5
40	60	19.65	3.6	65	16.25	3.0
45	59	23.94	3.5	64	16.00	2 8
50	57	26.43	3.2	63	15.75	2.5

* Gross rate per cent. includes taxes and cost of protection as well as the interest on the investment.

VALUE OF TREES AND STANDS

The lumber from second-growth stands of shortleaf pine, when sawed into boards one inch thick and graded according to the rules of the North Carolina Pine Association, sells for a higher price than if it is sold ungraded, or than if it is sold in the form of framing. The lumber which is sawed from young stands less than 35 years old is as a rule too narrow, and that from stands in which the trees have not been crowded, is too knotty to justify grading. The older the stand the more valuable becomes the lumber which can be cut from it not only on account of greater widths but also a larger proportion of the high grade. If the trees of different diameters in a crowded stand which is about 50 years old (the age of maturity) are carefully sawed into boards of even width and uniform thickness, they will yield approximately the amounts of the different grades of lumber which are given in Table 15. The figures in this table are based on actual measurements of grades which were made at a mill where trees of these sizes and age were being cut.

TABLE 15.

Total volumes in board feet, and the amount of the grades of lumber in trees of different diameters and heights in dense stands of short-leaf pine 45 to 60 years old.

Diameter breast-high Inches	Total height Feet	Number of 16 foot logs	Diameter inside bark at the top Inches	Amounts of the Different Grades Sawed From Trees					Total volume 1-4 inch saw kerf Bd. ft.
				No. 1.	No. 2. Board	No. 3. Board	Box or frm'g Fee	Other grades et	
7	48	1⅓	5.0			4	12	6	22
8	53	1¾	6.0		2	6	14	6	28
9	57	2	6.5		4	13	15	6	38
10	62	2¼	6.5	4	8	18	19	6	55
11	66	2½	6.5	8	12	25	28	6	79
12	70	3	7.0	18	23	27	35	6	109
13	75	3	7.0	26	33	37	40	6	142
14	78	3	7.5	32	38	48	56	7	181
15	80	3¼	7.5	47	40	63	67	9	226
16	80	3½	8.0	70	48	75	76	11	280
17	80	3¼	8.0	74	60	104	87	13	338
18	81	3¼	8.0	83	76	120	103	16	398
19	81	3¼	8.5	92	92	143	115	18	460
20	81	3½	9.0	105	115	167	122	18	527
21	81	3½	9.0	120	133	197	125	18	598
22	81	3½	9.0	136	163	230	129	20	678

The smaller trees in stands of this age are long-bodied and clear stemmed, have very little taper and thin bark, and, although

PLATE V.

Mature stand of shortleaf pine. Trees nearly uniform in size and ready to be cut for lumber. Groups of slender, windfirm trees can be left for seed trees.

the boards which can be sawed from such trees are narrow, they are comparatively free from knots and will justify grading if handled in connection with the wider boards from the larger trees. Trees of the same size in younger stands are more tapering and more knotty, and the lumber is of lower grade.

Air-dried lumber of the different grades, consisting of mixed width, but less than 12 inches wide, is quoted (November, 1912) at the following prices per 1,000 board feet, delivered at Norfolk, Richmond, Petersburg, Lynchburg, and Roanoke: No. 1, $26; No. 2, $24; No. 3, $20; Box, $18; Red heart and cull, $16; Bark strip, Nos. 1 & 2, $20; Bark strip, box $12. In Table 16 these values have been applied to the amount of different diameters delivered at Norfolk and the other points named above.

TABLE 16.

Value delivered at Norfolk, Richmond, Petersburg Roanoke, and Lynchburg, of the graded lumber cut from trees of different diameters and heights growing in crowded second-growth stands 45 to 60 years old and the value of single trees and their stumpage per 1,000 board feet under different costs of sawing and delivery at these points.*

Diameter breast-high	Value of lumber delivered at Norfolk, Richmond, etc.		Stumpage value per tree with expenses of sawing and delivery per 1,000 board ft. at		
	From each tree	Per 1,000 board ft.	$10	$12	$14
7	$ .35	$15 95	$ .13 †	$ .08	$ .40
8	.47	16.40	.18	.12	.06
9	.66	17.40	.28	.21	.13
10	1.01	18 35	.46	.35	.24
11	1 53	19.30	.74	.58	.42
12	2.16	19.80	1.06	.85	.63
13	2.86	20.15	1.44	1.16	.87
14	3.79	20.95	1.98	1.62	1.26
15	4.75	21.40	2.58	2.12	1.67
16	6.30	22.50	3.58	3.02	2.46
17	7.60	22.55	4.23	3.56	2.89
18	8.95	22 50	4 79	4.18	3.38
19	10.40	22.45	5.73	4.81	3,89
20	11.80	22.40	6.53	5 48	4.42
21	13.40	22.40	7.41	6.22	5.02
22	15.17	22.35	8.37	6.01	5.65

*Heights which are given in table 15.

†Obtained by deducting the cost of sawing and delivery per 1,000 board feet from the delivered value per 1,000 board feet, reducing the remainder to the value of one board foot and multiplying by the number of board feet per tree as shown in table 15; thus, $15.95 less $10.00 equal to $5.95—$5.95 divided by 1000 and multiplied by 22 is equal to $.13.

In table 15 the expenses of sawing and delivery, $10; $12; and $14 per 1,000 board feet are supposed to represent a low,

a medium, and a high cost of operation, and are made up of the cost of logging, felling, sawing, grading, interest on the investment and carrying charges, cost of selling, delivery at market and loading, drying, and profit of the operator. A profit of from $2 to $3 a thousand feet should be allowed in portable mill operations, the profit varying according to the size and length of the operation. It is noteworthy that while the value of the lumber per 1,000 board feet which is yielded by trees of different diameters increases rapidly up to 16 inches in diameter, there is a decline in the value per 1,000 feet of the lumber which is sawed from trees of diameter above 17 inches. This is due to the fact that the largest trees in these stands have larger and more numerous knots in their stems and yield a lower proportion of the high grades of lumber than do the slender, more clean stemmed, intermediate, and suppressed trees.

If the number of trees of each diameter per acre in a 45-year old stand (see Table 2) be multiplied by the value per tree of each respective diameter, the sum of these amounts will give the total value of the stand per acre, and from this the value per 1,000 feet of the stand. A similar set of values can be determined for trees in younger and older stands. These are given in Table 17.

TABLE 17.

Value per 1,000 board feet of the lumber which can be sawed from dense unthinned stands of short-leaf pine under different costs of manufacture and delivery.

Age of stand years	Value per 1,000 board feet under a cost of operation and delivery of		
	$10	$12	$14
30	$ 5.40	$ 3.40	$ 1 40
40	6.00	4.00	2.00
50	7.05	5.05	3.05
60	8.60	6.60	4.40
70	10.05	8 05	6.05

If the values in Table 17 are compared with the cost per 1,000 board feet of growing timber, shown in Table 10, it will be seen that the investment, if the stand is unthinned, does not yield five per cent. net, except under a logging cost of $10 and when the stand is cut at the age of 50 years.

In a regularly thinned stand from which the very knotty trees have been systematically removed when the stand was young,

leaving only the longest-bodied and clearest stemmed trees at each cutting and in which the trees have been forced to large diameters by isolation after the clear stem-length is 50 feet in length, it is believed that the stumpage value can be forced to a value of $8 a 1,000 feet under a logging cost of $12 when 50 years old. This would yield about $250 per acre.

WASTE IN CUTTING SMALL TREES

The following table shows the actual volume in board feet of trees of different diameters and heights when cut with a saw taking a kerf of one-fourth inch; the volume in board feet when scaled by Doyle-Scribner log rule; the volume of stem, wood only, in cubic feet; the number of board feet, Doyle-Scribner rule, per cubic foot of volume; and the percentage of waste.

TABLE 18..

Volume in board feet and in cubic feet and per cent of waste in sawing trees of shortleaf pine of different diameters.

Diameter Breast-high	Total Height	Actual Volume ¼ inch Saw Kerf	Volume as scaled by Doyles Scribner rule	Volume of Stem Wood only	Actual number of Board feet, per Cubic foot	Per cent. of waste in Stump, Tops, Slabs and Kerf
Inches	Feet	Board feet	Board feet	Cubic feet		
7	50	22	8	7	3.	75
8	55	28	16	10	3	75
9	60	38	25	13	3.	75
10	64	55	38	17	3.3	72
11	68	79	56	20	4.	66
12	72	109	80	24	4.5	62
13	76	142	111	29	4.9	59
14	79	181	134	36	5.	58
15	82	226	170	45	5.	58

The loss in scaling by Doyle-Scriber rule exceeds seventy-five per cent. of the total cubic volume of the stem until the tree reaches a diameter of thirteen inches, breasthigh. This large proportion of waste is an excellent reason for not cutting young stands for saw timber or for not cutting the small trees in old stands unless they are suppressed trees.

LUMBERING AND RESTOCKING

Simultaneously with lumbering comes the subject of securing a second stand of young pine to replace the one which is cut.

After ordinary culling, such as is practiced for farm use, or in clear-cutting stands of pine for lumber or for fuel, hardwoods generally form the main part of the young stand. The reasons for this are explained under the heading "Permanency of Old-Field Pine Stands." To obtain reproduction of pine, it is necessary: (1) To cut nearly clean, that there may be abundant light; (2) To leave seed-bearing pine trees scattered over the area or standing nearby; (3) To cut out the large trees of such hardwoods as dogwood, post oak, hickory, persimmon, etc., which have sprung up beneath the pines, and which would suppress many pine seedlings by their shade; (4) To bring as much of the mineral soil to the surface as possible. The hardwoods should be cut in September, when their sprouting capacity is lowest.

Two methods of cutting are suggested. One method, leaving isolated seed trees, is for use where the entire stand must be cut at one time. The other, cutting in strips, or groups, can be applied when there is a steady market for saw logs, as when there is a nearby permanent sawmill, or logs can be shipped to such a mill, and when it is possible to make two or more cuttings, not less than five years apart, in a stand, always having in view, however, the development of the valuable long-bodied and clean-stemmed trees (table 16) which are to form the mature stand.

Isolated Seed Trees.—When the saw-timber must be removed at one cutting it is advisable to prepare for the final cutting at the time of the last thinning by developing seed trees. At forty-five years of age, the production of seed by shortleaf pine is still extremely light, particularly in dense stands. If there are no old forest pines which will serve for seed trees within 100 yards of the tract, one object of the last thinning should be to select and develop trees for seed trees.

Vigorous, large-crowned trees should be selected for this purpose. They should be not less than four to the acre, and should be evenly distributed or else located on the tops of hills or knolls. Their crowns should be entirely freed by heavy thinnings on all sides. This should lead to the production of a heavy crop of cones and fertile seed within five years. If the crowns again crowd before lumbering, they should again be freed by further thinning.

When lumbering takes place, all merchantable trees should be cut except these seed trees, which should be able to produce enough seed in a few years to restock the land. (Plate V). If the seed trees are windfirm they can go over until the next stand is cut;

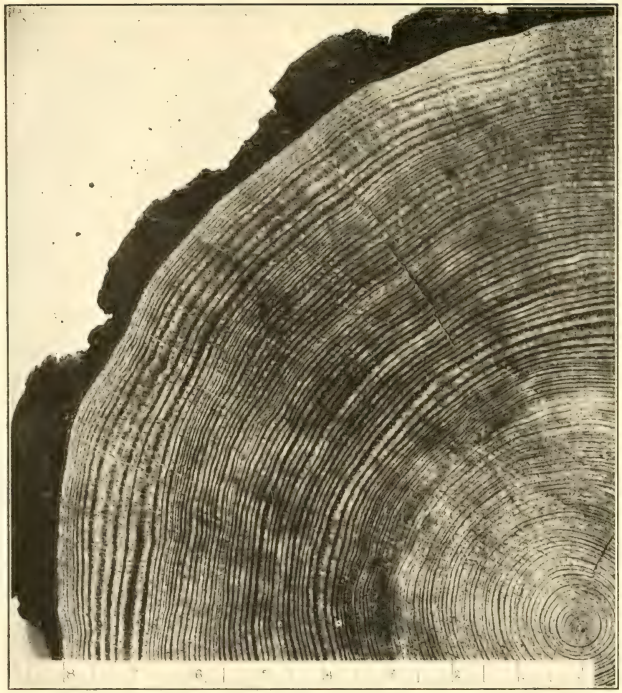

PLATE VI.

Fig. 1. A typical case of sustained rapid diameter growth, resulting from repeated thinnings, in a tree of shortleaf pine which was overcrowded for many years. Wood of such a tree is free from large knots, and its stumpage is worth $8 a 1,000 board feet under a cost of operating of $12.00.

Fig. 2. Stem of a small sprout sapling of shortleaf pine, crooked and scarred at the neck as a result of the original seedling having been killed to the ground by fire. Stump and root rots gain entrance through such scars.

if they fall, they can be used without breaking down too many of the small trees in the young stand. Since the period of restocking by this method would probably occupy from four to six years, the soil would not be fully used during this time.

Cutting in Strips.—Complete and rapid stocking is better assured by cutting in strips, but this method presupposes a continuous market for saw logs. The area should be clear-cut over strips not exceeding 200 feet in width, alternating with strips of equal width which are only culled of the smaller trees. On level ground these strips should be at right angles to the roads; on hilly land they should lie up and down the slopes. The wooded strips should be heavily thinned by the removal of all except the largest trees, which should not exceed twenty to the acre, and should be left well isolated. These trees will serve as seed trees, and on account of their large number they should seed the entire area heavily within five to ten years. As soon as a thorough restocking is assured they can be cut. Some of the young trees will be broken down, but the loss will not be serious. The diameter growth of the seed trees after the thinning will be large because of this isolation. Blanks ten or more feet square left after the seed trees are cut should be planted by seed spotting as described under the directions for planting. The two loggings will increase the danger from fire, requiring additional precautionary measures to be taken.

This method can be varied by leaving the seed trees in groups.

Cutting Unthinned Stands.—Both of the above methods presuppose that the stand which is being cut has been thinned, and consequently is formed entirely or largely of trees of merchantable size.

An understocked stand, similar to that shown in plate III, and in which the trees are largely of merchantable size, can be cut so as to secure a restocking, by leaving some of the more slender but well crowned trees for seed trees.

The problem of cutting a crowded stand to the best advantage and in a manner to secure a restocking is more difficult. The trees in such a stand have a much greater range of diameter than those in a thinned stand. There is a large number of small suppressed and intermediate trees which may be too small to be cut economically for saw timber (see "Waste in cutting small trees," page 35). In such a case it may be desirable to remove the stand in two or more cuttings, made at intervals of five or more years. At the first cutting only the largest trees should be cut, particularly

those which have short and knotty stems. Such as have very slender clean stems and good crowns should be left, but enough of the largest trees should be taken to open the crown cover one-third. Such a cutting might remove one-tenth of the total number of trees but more than one-half of the saw log volume of the stand. At the second cutting not only should most of the trees which have grown to merchantable size be removed, but also such of the smaller stunted trees as have shown no indication of thrift since the first cutting. The trees which are left should be choice clean-stemmed specimens with medium sized, but thrifty crowns. They can be left at the rate of ten to twenty to the acre. Such trees as have weak stems which would be likely to be bowed or broken by wind or sleet should not be left. Thickets of high shrubs and broadleaf trees should be cut. It is probable that by the time of the second cutting groups of young seedlings, about one foot in height, will have appeared beneath the openings made by the first cutting. Seed from the trees which are left after the second cutting will complete the restocking. Two courses can be followed in regard to the trees which are left after the second cutting. Either they can be removed after thorough seedling establishment is assured, or they can be held over and cut at some thinning period of the young stand. If trees with fifty feet of clear length and diameters of from ten to twelve inches are left after the second cutting and are held until they are twenty to twenty-four inches in diameter their stumpage value will increase from three to five times. This increase in value will be due entirely to the greater size of the logs, which will yield a high grade of lumber and can be sawn with small waste. (See Tables 16 and 18 and Plate II, Fig. 1).

No method of cutting a crowded unthinned stand, however, will give as great a yield in board feet per acre, or will produce logs of as high a grade, as can be obtained from a well-thinned stand.

PLANTING WASTE LAND

On many farms in middle Virginia there are tracts of gullied, or shallow soiled or rocky, or other poor or waste land which are either without a growth of pine or are stocking extremely slowly and irregularly. Shortleaf pine could be planted profitably on such tracts. The sound seed of this pine sprout so freely, and the growth of the young seedling is so rapid, that direct seeding can

be made in place of using young plants. Seed should be planted in spots six feet apart in well loosened soil and lightly covered, not deeper than one-half inch with earth. One of the two following methods can be used. If the tract can be plowed, shallow furrows can be laid off at intervals of six feet with a shovel plow or small turning plow, and the seed dropped at six-foot intervals in the furrows and lightly covered with a weeding hoe. If a plow cannot be used, the earth can be loosened with a light grub hoe over a spot six or eight inches square, and the seed planted and lightly covered in the middle of this spot. If the soil is either dry or light and sandy the planter should step on the spot after covering to bring the earth in close contact with the seed and insure germination. Set poles should be used to keep the rows straight.

The seed of shortleaf pine has a low germinating percentage, seldom more than forty-five per cent., and a number of seed, twelve or fifteen, should therefore be dropped in a hole. As many as can easily be held between the thumb, index finger and second finger will insure a stand. There are about 50,000 seed to a pound, so that a pound, if carefully handled, will plant an acre. The smallness of the seeds, however, makes them difficult to handle, and an inexperienced planter will usually drop more than are necessary for obtaining a stand. Planting should be done at any time between the middle of February and the first of April, whenever the soil is in suitable condition. Protection from fire and cattle is absolutely necessary until the trees are three or four inches in diameter and the bark thick enough to afford reasonable protection, which will require from ten to fifteen years.

Returns from Plantations.—If such plantations are carefully thinned their yield should greatly exceed that of natural stands.

The cost of planting an acre and of carrying the investment is calculated on the basis of a land value of $10 an acre, with five per cent. compound interest, which includes an allowance of one per cent. an acre a year for taxes and protection. This land value is low for soils which will produce good shortleaf pine. The prices at which stumpage must be sold to net four per cent. on the investment are shown in Table 19.

Cost of land	$10 00
Cost of seed one pound per acre	2 50
Cost of planting per acre	1 50
Total initial cost of investment	$14 00

TABLE 19.

Cost of producing shortleaf pine stumpage in plantations with five per cent gross interest on investment.

Age of stand years	Accumulated Cost of Investment, per Acre, Interest compounded at 5 per cent, less Initial Value of Land	Credit of Thinnings made in middle of Decade at 10 cents a Cord standing, with accumulated interest at 4 per cent, net*	Yield in Board feet of Trees 9″ and over in Diameter Breast high	Cost per 1,000 Board feet of growing Timber	Final Yield in Cords of Trees 5″ and over in Diameter Breast high	Cost per Cord of growing Cord wood
20	$ 27.10	. . . . .	. . . . .	. . .	21	$ 1.28
30	40.20	$ 7.00	5,800	$ 5 55	51	.65
40	78.56	20.80	14 800	3.83	60	.96
50	150.58	40 28	19,300	5.69	60	1 84

* On account of the small amount of the thinnings and the short periods during which the money from them would be invested, only 4 per cent. is allowed on them.

Thinnings made at middle of decades yield about eleven cords at twenty-five years, fifteen cords at thirty-five years, and ten cords at forty-five years per acre.

The minimum cost of producing lumber would be about $3.83 per 1,000 board feet, when a stand is about forty years old.

The minimum cost of producing cordwood would be about sixty-five cents a cord at an age of thirty years.

These figures, which are conservative, indicate that plantations can be expected to yield at least five per cent. gross or four per cent. net after allowing one per cent. or ten cents an acre a year, for taxes and protection. With regularly made and carefully executed thinnings, the yield would probably exceed that of the irregularly thinned stands on which the calculations are based and the cost of production would be lowered; in other words a higher interest rate would be obtained.

In order for a plantation to yield five per cent. net or six per cent. gross, allowing one per cent. an acre a year for taxes and fire protection, the following returns, which are fair and reasonable, must be obtained from stands of different ages.

TABLE 20.

Cost of producing shortleaf pine stumpage in plantations with six per cent gross interest on investment.

Age of stand Years	Accumulated Cost of Investment, per Acre, Interest compounded at 6 per cent., less Initial Value of Land	Credit of Thinnings made in middle of Decade at 50 cents a Cord, standing with accumulated interest at 4 per cent net*	Yield in Board feet of Trees 9″ and over in Diameter Breast high.	Cost per 1,000 feet of growing Timber	Final Yield in Cords of Trees 5″ and over in Diameter Breast high	Cost per Cord of growing Cord wood
20	$ 34.80	. . . . .	. . . . .		21	$ 1.66
30	70.36	$ 7.00	5,800	$ 10.91	51	1.23
40	134.06	20.10	14,800	7.70	60	1.88
50	247.88	40.28	19,300	10.77	60	3.30

*On account of the small amount of the thinnings and the short period during which the money from them would be invested only 4 per cent. net is allowed on them.

In neither of the foregoing calculations is any allowance made for superintendence, and possible losses from insects, sleet and snow breakage, and windstorm damage, but it must also be remembered that the constant increase in the price of timber is likewise neglected.

THE PROTECTION OF STANDS

The two important dangers to pine stands, fire and insects, are in a measure interrelated. Those trees which have been weakened or injured by fires invite insects, while stands which are littered by the wood which has died from insect depredations, and which have become grassy on account of openings made in the crown cover where trees have been killed by insects are particularly exposed to serious damage from fire. With both dangers, prevention is the most effective means of control.

Fires.—While the danger of fire is always present, it is far more serious in connection with young stands and particularly those in process of stocking, such as fields which have recently been turned out, or newly cut or lumbered land. Fires injure such young stands at any season of the year in which they may occur. Although many individuals of shortleaf pine between one and two feet high, when killed by an early spring fire, will sprout, the sprouting capacity is irregular and unreliable (Plate VI, fig. 2). Moreover, most of such sprouts die in a few years, while many of the survivors are forked. After the tenth year, the heavy shade of

crowded stands and the thickened bark greatly reduce the danger of fire, but even the heavy bark of old trees does not afford complete protection from hot spring fires when these are driven by a strong wind. Thickly stocked shortleaf pine stands do not, as a rule, become grassy or foul with shrubs and herbage, and consequently do not require periodic winter burning for the purpose of protection, such as may often be necessary for pole stands and mature stands of loblolly and longleaf pines. Although no visible damage may be done to older trees by such burnings, the rate of growth is reduced by the destruction of the pine straw and the humus, while even the slight scorching of trees may lead to the entrance of insects or fungi.

Young stands and areas which are in process of stocking are most effectively protected from fire by establishing and maintaining open fire lanes, free from straw and litter, completely around them or on the exposed sides. A shallow furrow can be plowed every year on both sides of the lanes, and the intervening strip can be raked clear, or it can be burned during damp, quiet weather. In older stands the straw and litter can be raked off the lanes each autumn and used for stable beddings. Well established lanes, if they are free from stumps and shrubs, may conveniently be raked with a side delivery rake. By locating lanes at intervals through a large tract, as well as around it, it is separated into blocks which are individually protected. Where possible, roads and paths should be used for lanes. Since there is great danger of a serious fire during and immediately after lumbering, extra protective precaution should be taken at that time. A fire that occurs at that time will frequently destroy the pine seedlings, but the replacement of the hardwoods and shrubs takes place at once by sprouting. Repeated fires eliminate the pines. When timber is sold or when logging is done by contract, an enforceable fire penalty clause should be inserted in the contract, in order to obtain the necessary protection.

The Federal Government under the terms of section 2 of the Weeks Law extends its co-operation to States in assisting them to protect the forested water-sheds of navigable streams from fire. In order to secure assistance of this kind a State must have provided by law for a system of forest fire protection and must have appropriated funds for the purpose. Scarcely a more important step could be taken by the State of Virginia towards the conservation of its forests than the establishment of a fire pro-

tective system. The readiness of the Federal Government to co-operate under the terms of this law as soon as the State itself makes a start is an incentive to immediate action. In the shortleaf pine area of Virginia the water-sheds of the Appomattox, James, Roanoke and Rapidan rivers could be protected by such co-operation.

Insects.—The danger of fire is greatest to seedling stands, but the possibility of insect damage, although it is always present, increases after the trees are twenty years old. One of the most pernicious insects is the pine bark beetle, *Dendroctonus frontalis, Zimm.* which devastated the coniferous forest of middle and western Virginia between 1888 and 1892. This species channels the inner bark in the middle part of the stem and eventually girdles the trees, thus killing them. Other beetles infest the wood of the living tree, and yet others attack only dead or dying trees. The fecundity of the pine bark beetle is so great that several large broods are produced in a single summer, and when conditions are favorable they propagate in enormous numbers and cause serious depredations. Pure stands in old fields invite destructive attacks, since in them the insects can readily spread from tree to tree.

The best way to hold this insect in check is to keep the trees in thrifty condition by preventing overcrowding, by removing wood which would serve as breeding places, and by cutting out infested trees. It is particularly desirable to make these protective cuttings before the spring and early summer broods of the insects come out and spread. Infested trees should be promptly removed as soon as noticed. The removal of weak trees in thinning eliminates them as sources of breeding, while cutting low stumps and close utilization, or the piling and burning of tops—operations which are sometimes advisable for other reasons—remove much other wood. The cutting of live trees should be limited as far as possible to the winter, but dead trees can be cut at any time. Special care should be used in summer cutting not to leave freshly-cut tops touching live trees, and to remove promptly trees that have been killed by lightning. When cordwood or logs which are spring or summer cut cannot be promptly removed, they should be peeled or racked in the sun, that they may dry. Detailed information in regard to protection against this beetle is contained in Farmers' Bulletin, No. 476.

Fungus Diseases.—The most important known fungus which attacks shortleaf pine is *Trametes pini*, the cause of redheart.

This is a dark brown snuff-colored "punk" which gains entrance into the heartwood of the upper part of the stem through knot holes, and into the lower part by wounds caused by falling trees, fire scars, (Plate VI, fig. 2), and insects. Trees which show the "punk" should be promptly cut.

Pine stands are also exposed to damage from windstorms, and from sleet and wet snow. The damage by wind cannot be prevented. Fortunately, shortleaf pine, when it grows on deep soils, is anchored by a long, strong taproot, and is very windfirm. On shallow soils, particularly a hard-pan near the surface which checks the descent of the taproot, it windfalls badly. Slender trees are occasionally bent or even broken by wind. Frequent light thinnings render the trees in such stands more windfirm.

Sleet and wet snow are dangers against which there is no adequate protection. The weight of sleet and wet snow frequently breaks the leaders, and in crowded stands may bend many stems beyond recovery, break them, or even uproot them. The only precautionary measure is to strengthen the resisting power of limbs and stems by thinning. Trees in young stands less than twenty years old are the most likely to be broken and bent, while trees in older stands, in which isolation is taking place, are the most apt to be overturned. Frequently, insect depredations follow this kind of damage.

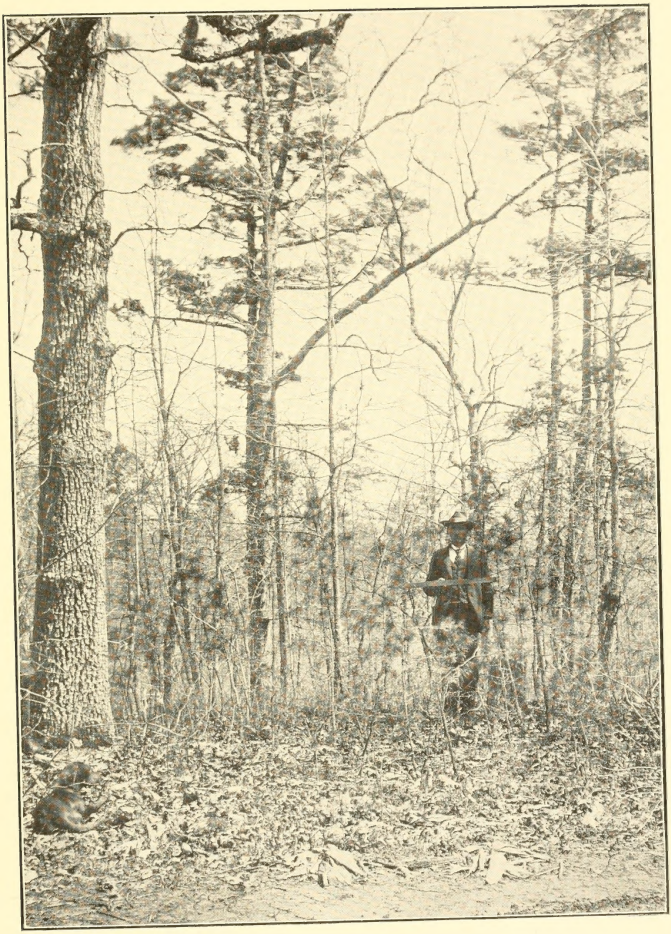

PLATE VI.

A culled stand of mixed pine and hardwoods. The defective oak in the left foreground is partially shading groups of thrifty pine seedlings and should be removed. The large pines in the background serve as seed trees. The seedlings are greatly exposed to fire.