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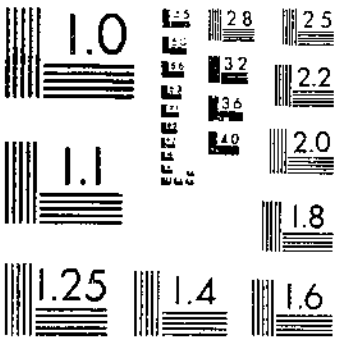
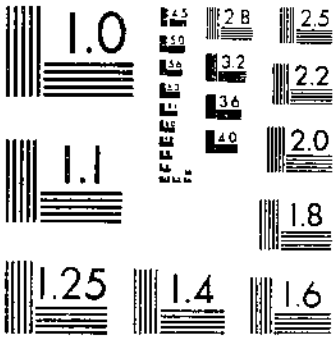


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A



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UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

TIMBER GROWING AND LOGGING PRACTICE IN THE SOUTHERN APPALACHIAN REGION

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Introduction by R. Y. STUART, *Forester, Forest Service*

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INTRODUCTION

Forestry in the United States is no longer merely a theory or a subject for discussion; it has got down to concrete things in the woods. 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. 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 experiences 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 Appalachian 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 Appalachian region. As time goes on, research and practical experience will add greatly to the success and certainty of the practice in our woods, just as, through experience and study, American agriculture has steadily become more highly developed and manufacturing processes have been perfected. But enough is now known about growing timber in the Appalachian region to go right ahead. Believing that the forest-land owners of this region are ready to engage in timber growing, the Forest Service has endeavored to place before them in concise terms the best suggestions and guides which its 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 unproductive. 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 Appalachian region 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.

The second group of measures, proposed as a system of management to produce full timber crops, 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. This is true particularly of forest regions like the southern Appalachians, which include a great variety of local situations, both in types of forest growth and in economic circumstances. 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 always 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.

As a broad conclusion, the Forest Service has tremendous faith in the commercial promise of timber growing to American 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 many points in the eastern United States show plainly enough 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 United 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 Forest Service earnestly asks the forest-land owners of the Appalachian region 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 TIMBER-SUPPLY PROBLEM IN THE SOUTHERN APPALACHIANS

The southern Appalachian region (fig. 1) consists of two long and rugged mountain systems surrounded and penetrated by well-populated plateaus and valleys. The western system of mountains comprises the Alleghenies and the Cumberlands; the eastern—or the southern Appalachians proper—takes in the Blue Ridge and Smoky Ranges and cross ranges. The mountains are mostly forest land (pls. 1 and 2) and are adapted by climate and soil for the

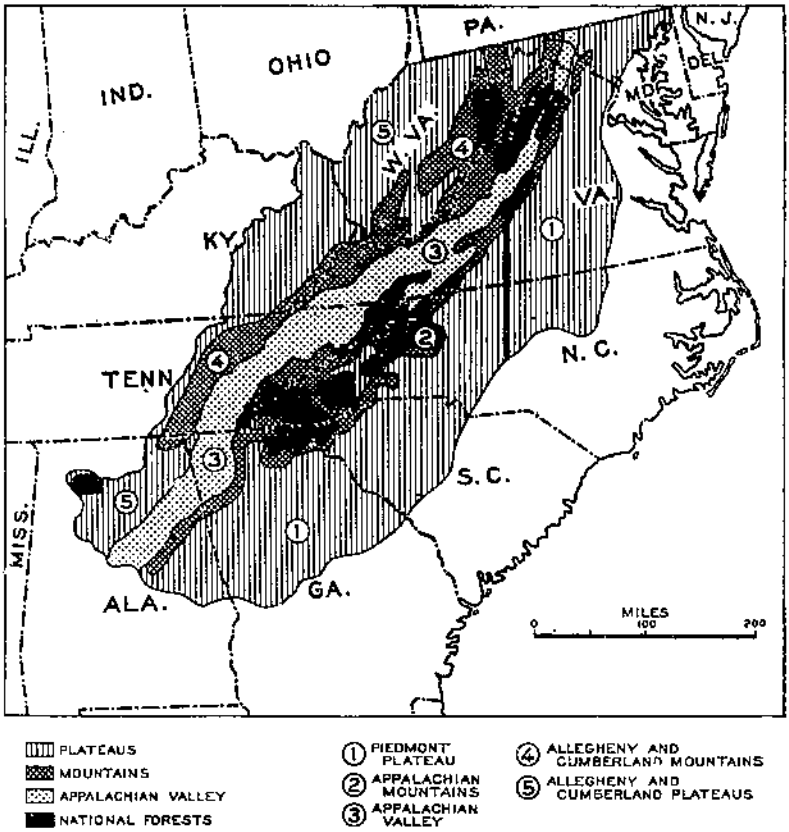


FIGURE 1.—Southern Appalachian region

growth of commercial forest products in variety unequaled outside of the Tropics. Heavy forests once covered these slopes, and these while they remained made the southern Appalachians a timber-producing center which grew in importance as industrial demands for wood products increased in the surrounding region. From the mountains there are many outlets by rail and motor road to near-by industrial centers in the great Appalachian Valley, which separates the two main ranges, and to those on the Allegheny, Cumberland, and piedmont plateaus, which skirt the mountains on the west, south, and east. Railroads lead in all directions through the region to

large markets and shipping points outside. The plateaus and valleys themselves are dotted with farm woods, isolated, or contiguous in strips or blocks, which are even more accessible to markets than the mountain timberlands.

After many years of logging the original timber supply of this region is nearing its end. Its replacement has been hindered by repeated cullings which removed most of the usable timber and left the poorest. Forest fires, insects, and the chestnut blight have also contributed to reducing the growth rate on otherwise productive forest soils. Thus, while there remain in the mountains a number of timber tracts large enough to supply double-band sawmills for one or two decades, as well as many smaller second-growth stands of much promise, the greater part of the forests have not only lost in actual value of standing timber but have suffered more or less severely in their capacity to produce valuable new growth. To maintain the large supplies of lumber and other forest products which have hitherto been available within the region for its industrial needs, the productive value of the timberlands must be preserved where it still exists and should be restored on the larger areas where it has been lost or reduced. The timber-supply problem of the southern Appalachian region is therefore mainly one of converting depleted and poorly growing forests into stands which will be both rapidly and continuously productive. It is the purpose of this bulletin to describe briefly the southern Appalachian forests, the demands upon them, the factors that affect their reproduction, growth, and value, and the kind of treatment which appears necessary to maintain the productivity of the forests, or, better, to insure perpetual timber yields of the largest amount and highest value that the soil will sustain.

DISTRIBUTION AND CONDITION OF TIMBERLAND

For the entire region the area of actual and potential timberland amounts to about 60,771,000 acres, or 59 per cent of the total land area. Of this, more than 21,000,000 acres are in the mountains, but nearly 40,000,000 acres are on the plateaus. Extensive timber tracts however, are found only in the mountains; on the plateaus the forest consists chiefly of farm woods of 50 acres or less. Farm woods also make up 30 per cent of the total forest area in the mountains, but here they are larger and generally adjoin one another and the more extensive timber tracts. Thus, the forests of the mountains and those of the plateaus and valleys differ both in continuity and size of separately owned tracts. Viewed as a source of perpetual supply, the farm woods present conditions quite different from those of the more concentrated timberlands in the mountains.

The eight national forests in the region on June 30, 1929, covered an aggregate area of 1,988,563 acres, or about 3 per cent of the total area of actual or potential forest. This area is being increased under the present Federal program for national forests in the southern Appalachians. National parks, for which land is now being purchased, are expected to cover 755,000 acres in North Carolina, Tennessee, and Virginia. According to recent statistics (*72*),[1] State

[1] Italic numbers in parentheses refer to Literature Cited, p. 89.

forests and parks occupy 15,393 acres in West Virginia, 3,835 acres in Maryland, 3,624 acres in Kentucky, 1,724 acres in North Carolina, and 588 acres in Virginia, or a total of 25,164 acres. Municipal and county forests and parks, largely for the protection of water supplies, aggregate 61,727 acres in North Carolina, Maryland, and Virginia. The total area now or soon to be under public administration as forests or park in the southern Appalachian States is therefore about 2,830,000 acres, or less than 5 per cent of the total forest area. Ninety-five per cent of the area suitable for timber growing in the southern Appalachian region is privately owned.

The area of timberland in public ownership is too small to make very much difference in the production of the region as a whole, no matter how well protected and managed the public forest may be. The forest problem is therefore chiefly one of privately owned tracts, large and small. In the mountains the large size of many of the holdings and the general continuity of forest land favor large-scale management. In the plateau and valley regions, accessibility and the chance of occupying labor during off periods offer different but equally advantageous possibilities for small-scale productive treatment. It is evident that if the southern Appalachian forests are to continue as a self-sustaining supply for the industrial and domestic needs of the region, this must be brought about through the intelligent practice of forestry, and that largely by the private owners.

In its present condition the forest varies from virgin timber stands to heavily cut-over land, from unburned to badly fire-damaged stands, and from freshly cut, newly reproducing areas to dense stands of second growth. Virgin stands remain in only a few places, mostly in the mountains. Their aggregate area has been roughly estimated at less than 300,000 acres in West Virginia, 220,000 acres in Virginia, and between 1,000,000 and 1,500,000 acres in the rest of the region. Even these estimates include a considerable area that has been lightly culled in the past. The remainder of the mountain timberland has been culled or cut over more or less heavily. The cuttings have generally been partial, removing the products that could be profitably taken at the time and thereby increasing the proportion of unmerchantable timber in the stand. Many tracts have been worked over repeatedly for different products at intervals of a few years. On the other hand, clear cutting was at one time extensively practiced in Maryland, Virginia, West Virginia, and a few places in the States farther south, to supply charcoal wood for the many iron furnaces that once were operated. On the lands thus cut over a dense, even-aged second growth has appeared, consisting principally of mixed hardwoods. Most of the second-growth stands that remain on the "coaled lands" are now from 30 to 80 or more years old.

The varying conditions that must be dealt with in bringing cut-over areas into continuous production will be discussed at a later point in the bulletin.

TIMBER GROWING FOR INDUSTRIAL NEEDS

As a source of supply for local industries and for shipment to outside markets the southern Appalachian forests have played an important part in the economic development of the region. The kinds

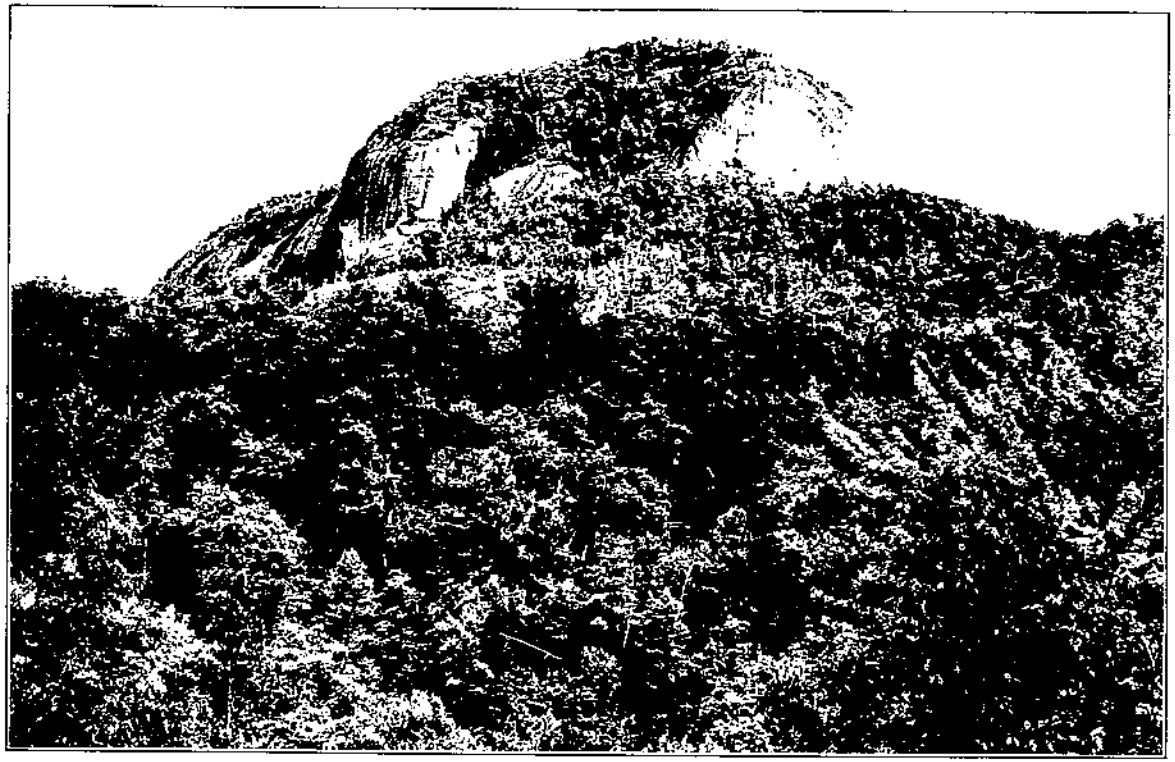
and quantities of materials removed and the methods employed explain in some measure the present condition of the forests.

DEVELOPMENT OF THE LUMBER INDUSTRY

Extensive lumbering began in the southern Appalachians later than in other eastern forest regions. It grew up in response to an increasing demand for the hardwood products which could be obtained in great variety and high quality in these virgin forests. In the early days cutting was confined to the forests immediately adjacent to the main rivers and their branches. When the development of the railroad systems through the territory made accessible the timberlands away from the rivers, and at the same time brought an active demand for crossties, timbers, and poles, logging gradually became important along the railroads. From that time on the timber industry in a new locality began with the building of logging railroads, or of wagon roads into the timber from a railroad shipping point. Band-saw mills cutting from 25,000 to over 100,000 board feet of lumber per day were erected within reach of bodies of timber large enough to sustain the mills through the period necessary to amortize the investment.

The kind and the quality of products that could be profitably exploited have undergone a marked change during this comparatively short period. Forty-five years ago only the walnut, cherry, and the finest of the yellow poplar, white pine, basswood, cucumber magnolia, and white oak were worth taking. Commonly only a light culling of the forest was made. Very few trees were logged that were under 30 inches on the stump, and no logs were taken at the mills that were less than 20 inches in diameter at the small end. Ten years later the usual cutting limit was 24 inches on the stump, and logs 18 inches in diameter could be handled in the mills; as a rule, only perfectly clear logs containing at least 350 board feet were accepted. By about 1900 the average cutting limit in the woods had dropped to 21 inches on the stump and the average small-end diameter of logs at the mill to 17 inches. By 1905, oak and chestnut trees 15 inches on the stump and poplar 14 inches or even less were being taken, and logs that contained 100 board feet were handled at the mills. Within the last few years, in seasons of active movement of lumber, trees 9 to 10 inches on the stump have been cut for lumber by large mills, while portable mills have cut to even smaller diameters, in spite of the fact that trees of such small diameters, as will be pointed out later, can rarely, if ever, be handled except at a loss—a fact frequently overlooked, especially by operators of small mills.

Meanwhile, markets have developed for species which had no value in the early days of logging. Black oak, scarlet oak, chestnut oak, and chestnut, which were passed by entirely in most of the first cuttings, are now logged extensively. Sugar maple has acquired value for flooring, while black gum, hemlock, birch, beech, and many other species that formerly were not considered, now have value enough to warrant cutting. At the same time, the grades of logs accepted by sawmills have dropped. About 35 or 40 years ago little was cut that would not saw out in lumber grading 50 per cent firsts and seconds. Probably 40 or 50 per cent of the rougher timber that



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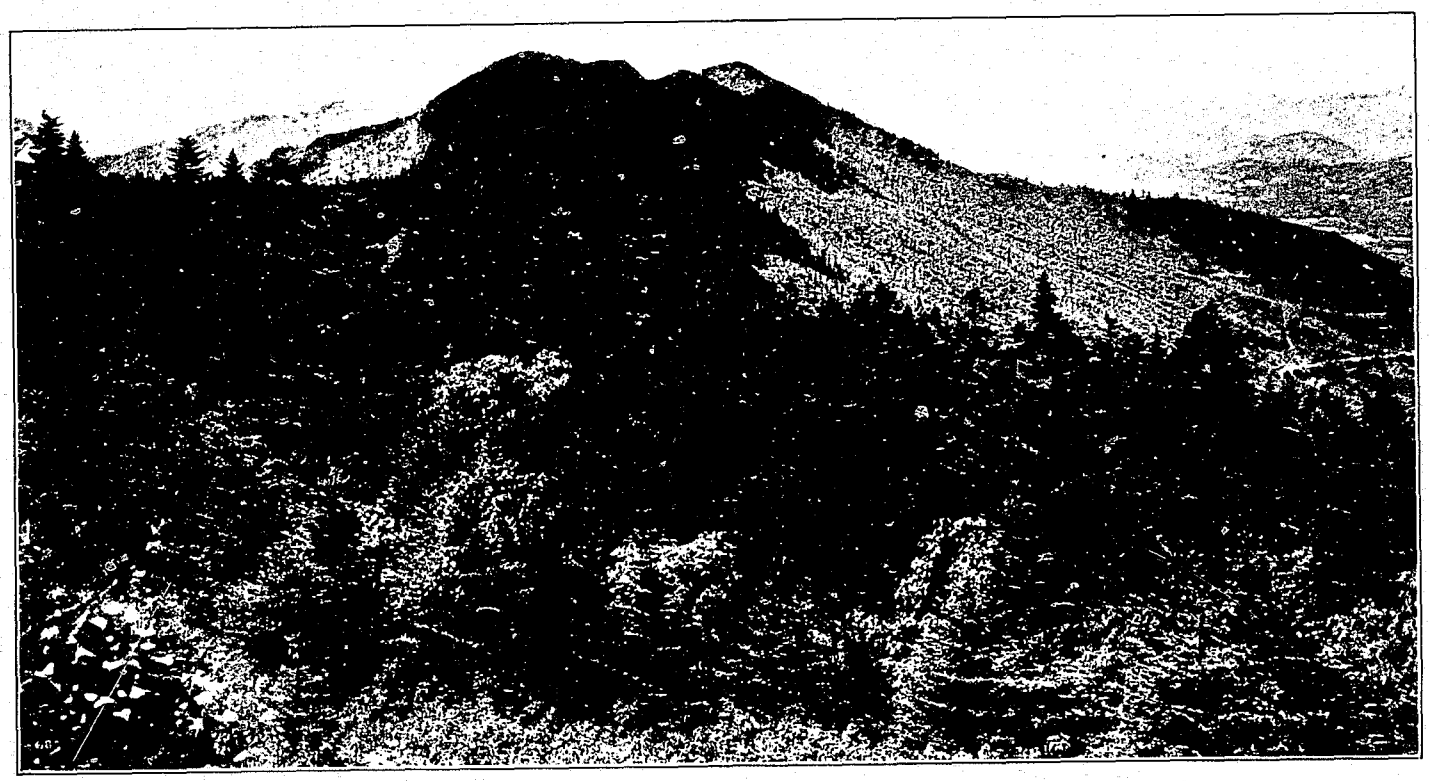
THE SOUTHERN APPALACHIAN HARDWOOD FOREST

This stand, near Lookingglass Rock in Pisgah National Forest, N. C., was culled in 1917 to diameters of 14 to 16 inches. By well-directed partial cuttings the yield of such stands can be perpetuated and their beauty preserved.



Asheville Photo Service O-689

A SPRUCE-FIR FOREST IN THE BLACK MOUNTAINS, N. C.

A narrow strip (mostly of fir) along the crest is all that remains of the forest that once covered the slopes. Most of the remaining stand is within the Mount Mitchell State Park and the Pisgah National Forest. The burned slopes have been planted with spruce and other conifers by the Federal and State forest services.

was waste in 1890 is now utilized, and the average grade of lumber has been lowered at least 30 or 40 per cent since then. In 1890, at Chattanooga, Tenn., poplar logs ran 60 to 70 per cent No. 1; 15 years later they ran about 15 per cent No. 1. The trend is toward the use of poorer species or poorer grades of the better species, for the purposes for which only high-grade materials were acceptable a few years ago.

The changes in market conditions resulted in constantly heavier cullings of the forest and less timber left standing. Until comparatively recent years, however, enough was left to justify the reworking of areas already cut over, especially as the demands for pulpwood and chestnut tanning-extract wood made possible the use of small sizes and previously worthless species. As a consequence a large part of the timberlands has been cut over again and again, sometimes six or eight times.

The increase in the variety of merchantable wood products led to more concentrated logging and to closer utilization at the manufacturing plants. For skidding and loading logs, steam apparatus partially replaced the horses, mules, and oxen once exclusively used for this work. Animals are still quite widely used, but on the few remaining large operations logging is now mainly by machine ground-skidding or overhead cable to a logging railroad. The use of animals is frequently combined with machine ground-skidding to increase range of operation. Some operators are employing gasoline tractors and trucks for hauling both logs and lumber. At the large mills, also, efficient utilization is being accomplished by means of gang saws, edgers, trimmers, and equipment for manufacturing otherwise waste material into lath, flooring, and other incidental products. There is a certain amount of trade in low-grade lumber and in trimmings and edgings that are shipped from the sawmills to furniture factories or plants equipped for the manufacture of a great variety of novelties, trimmings, moldings, etc., from small-dimension material. Some of the pulp mills and tanning-extract plants in the region have obtained a part of their supply from sawmills in the form of slabs and other waste material. The manufacture of veneer has established a demand for especially good logs, largely of yellow poplar.

A later chapter in logging history is concerned with the portable sawmill, which has become an important factor in the problem of continuous timber production. Large numbers of these mills with a daily capacity of 6,000 to 8,000 board feet have come into use, commonly in stands already culled or cut over, taking what remains merchantable of the saw log and tie timber left from previous operations. Much of the output is poorly manufactured and poorly graded and commands lower prices than would be obtainable under more efficient operation.

With no large investment ordinarily tied up in timber or timberland ownership, portable-mill operators, as a rule, have even less interest in the future of the lands cut over than do the large operators. In seasons of active demand set-ups are justified for tracts of 50,000 or 100,000 board feet, and the investment can be entirely liquidated in one or two months' operation. In periods of small demand, portable mills can shut down without difficulty. Consequently the number

of portable mills in operation fluctuates constantly and rapidly. The unregulated cutting now practiced by most portable mills is a threat to continuous timber production. The desirable trees are cut, the undesirable left standing, and a serious drain upon the growing stock is thus imposed which can not be so easily checked and corrected as on large operations. Employed with a view to the betterment of the stand, however, the portable mill can probably be more easily transformed into a constructive agent than can the large stationary mill with its heavy continuous demand for logs.

The lumber cut for the entire region was about at the maximum in 1909, when the output in hardwood lumber alone was about 4,000,000,000 board feet (*71*). As nearly as can be judged from available statistics (*72*), the present annual cut in the parts of the States included in the southern Appalachian region is approximately 2,250,000,000 board feet.

UTILIZATION OF SMALL TIMBER

Large quantities of wood in the form of railroad ties, pulpwood, tanning-extract wood and bark, mining timbers, cooperage stock, firewood, poles, posts, and many other products are cut annually in the region. Such exploitation may contribute either to the improvement or the deterioration of the forest. Most of these products are obtainable from trees of less than saw-log size. The removal of such trees when diseased, defective, poorly formed, or of inferior species, is usually beneficial, giving space for better growth in the remaining stand; but the heavy cutting for these purposes of young, thrifty timber during the period of its rapid growth into wood of high quality means a loss in future production. At the same time, the prospect of increasing need for small products by industrial plants in the region makes it necessary to provide for a continuous supply.

RAILROAD TIES

Annual replacements by the railroads entirely within the southern Appalachian region probably require more than 2,000,000 ties, or from 65,000,000 to 70,000,000 board feet of timber. The greater number of these are of oak, particularly the white oaks; but since the introduction of preservative treatment, ties of almost all species that reach tie size have been accepted at various points in the region.

To-day a large proportion of the ties are sawed, whereas 20 years ago the bulk of the ties were hewed (*74*). In hewing ties the cutter prefers straight-grained, clear trees 11 to 17 inches d. b. h.,[2] rarely as small as 9 inches. Such trees are commonly the ones that contain the greatest promise for lumber or veneer. As a rule tie hewers get only a single tie from each tie length cut out of trees less than 15 inches d. b. h., and the wood slabbed off is wasted. In the sawmill much of this material can be saved as clear side lumber or used for the manufacture of small-dimension products. Where sawed ties are as readily accepted as hewed ties and where logging is not difficult, sawing will almost invariably prove cheaper and more profitable than hewing. An exception is the small farm

[2] D. b. h.=diameter at breast height, or 4.5 feet from the ground.

woodland where tie cutting may often prove the most advantageous means of removing and utilizing a few trees from time to time for the improvement of the stand.

In the dense, even-aged second growth that has grown up on lands clear cut for charcoal, stands 50 or 60 years old will yield, on an average, 60 ties per acre.[3] The yield of the more open stands on ridge land may be 50 or even as low as 25 ties per acre at the same age, while in coves it may be 80 or more.

PULPWOOD

In 1929, 16 pulp mills were operating in the mountain and piedmont region, but since a number of these obtain part of their wood supplies from the coastal plain or other sources, the quantity supplied by the southern Appalachians is hard to estimate. The annual output of the mills that draw upon the mountain and plateau woodlands for much of their supply may be estimated as between 225,000 and 275,000 tons of pulp. Their annual wood consumption from mountain and plateau sources is probably from 400,000 to 500,000 cords

The pines and the softer hardwoods are the principal species used. Virginia and shortleaf pine are extensively manufactured into sulphate pulp for container board and kraft wrapping paper, while yellow poplar, basswood, black gum, red gum, maple, birch, and beech are pulped chiefly by the soda process for book paper. A very small quantity of spruce and hemlock is converted into pulp at a few ground-wood and sulphite mills, but the remaining stand of spruce available for pulp is too insignificant in amount, and the hemlock is generally too scattered to offer promise for any extended use of these species.

Within recent years the manufacture of container board out of spent chestnut chips from tanning-extract plants has made it possible to combine these two industries effectively at several places and to stimulate the salvage of chestnut that would otherwise be wasted. Extended to other fields, such combinations of wood-using industries could be made the means of obtaining closer utilization and of controlling the management of forest lands. One fact that has prevented the rapid development of soda-pulp operations in this region is that the hardwood species suitable for pulp are not closely concentrated but usually occur mixed with oaks and other hardwoods for which no commercially profitable pulping process has yet been discovered. A systematic form of utilization that will give value to all these species together, for pulpwood, lumber, and other forest products, offers a means by which the southern Appalachian forests may profitably be exploited and may be established on a basis of permanent timber production. Such joint operations must of course be conducted over an area sufficiently large so that the combination of industries can be supplied from the current timber growth, without necessitating clear cutting and thus depleting the reservoir of growing stock.

[3] From a study of the tie industry in the southern Appalachians made in 1904 by Raphael Zon.

On the national forests the hardwood species suitable for paper pulp—yellow poplar, basswood, chestnut, maple, birch, beech, buckeye, cucumber, cherry, and others—constitute about 29 per cent, and the suitable softwood species about 31 per cent, of the total stand.

TANNING-EXTRACT PRODUCTS

There are 40 to 50 tanning-extract concerns, tanneries, and large dealers in wood and bark in the southern Appalachian region. Formerly bark, mostly of chestnut, oak, and hemlock, was the only native forest product utilized by the tanneries, but with the introduction, 25 or 30 years ago, of chestnut wood as a source of tanning extract, this species increased rapidly in importance. To-day most of the extract plants depend upon chestnut for a large part of their supply. For several years, however, the market for tanning extract has been dull. Furthermore, the higher tannin content of other materials, chiefly quebracho, which can be imported relatively cheaply from foreign sources, has led to a partial displacement of native materials.

In order of quantities consumed, the greater part of the tanning-extract materials consists of chestnut wood, chestnut oak bark, and hemlock bark. A few plants use the bark of red, scarlet, and white oaks, spruce bark, sumac leaves, and chestnut oak wood. A few others make extract from the bark of black oak, but this product is a dyestuff rather than a tanning agent.

Chestnut-wood operations quite commonly follow logging for saw timber or for chestnut poles. These operations remove the chestnut trees that were too poor or small for logs, as well as portions of trees from which saw logs have been cut, including straight tops and branches to a diameter as small as 3 inches. Where chestnut forms a large proportion of the stand—as it very often does in the mountain hardwood forest—the result of this combined exploitation is to leave very little timber on the area. Were it not for the chestnut blight, which will be discussed at length on a later page, this reduction in growing stock would be regrettable. As it is, it becomes a means of salvaging material that would otherwise be wasted and of leaving the ground more free for the development of other species.

The bark is even more strictly a by-product of logging operations. Formerly timber was often cut for the bark alone, the stripped chestnut oak or hemlock trunks being left in the woods to rot. Very little waste of this kind is now noted. On the contrary, considerable bark is wasted on unpeeled logs sawed for lumber. This is ordinarily the case when trees are cut at other seasons than in the spring when bark can be easily peeled. Bark-peeling operations proceed either in the spring in advance of logging or after the unpeeled logs are delivered at the mill yard.

The combination of paper-board and wrapping-paper manufacture with extraction plants, as a means of more economical operation and better utilization, has already been mentioned.

MINE TIMBERS

According to statistics of the Bureau of the Census and the Forest Service (72), the mines of the southern Appalachian region

consumed in 1923 a total of 35,794,540 cubic feet of round timber and 81,870,000 board feet of sawed timber. About half of this was used in West Virginia.

Of the various timbers used by the mines the greatest demand upon the forest is for props and tram ties. Mine props vary in length from 3 to 12 feet and may be as small as 4 inches in diameter at the small end. Tram ties are 5 feet long and have a 4 or 5 inch face. These small sizes are obtainable from young second-growth timber. On some of the mining properties such stands are cut over as frequently as small quantities of this material can be obtained, thus greatly reducing the yield that would result from a few more years of growth. This overcutting at short intervals reduces the stand to a deteriorated sprout forest.

Mine timbers, like pulpwood and railroad ties, provide a means of utilizing the unmerchantable trees left in logging saw timber. At places in or near the coal-mining regions of West Virginia and eastern Kentucky many large trees, chiefly beech, were left on cutover areas, where they have become a serious detriment to the successful restocking of the forest. Where areas in this condition are sufficiently near coal mines their reworking for mine timbers will relieve the drain on other sources of supply and will at the same time improve the chances for desirable reproduction by the removal of the shade and root competition of the large trees. The growing condition of dense second-growth stands also can be improved by thinnings made to produce mine timbers.

COOPERAGE

Cooperage, particularly the manufacture of slack barrel staves and headings, is of some importance locally in the southern Appalachian region. In 1925 (*72*) about 275,230 slack barrel staves and 37,120 sets of headings were manufactured in the States wholly or partly included in the region. Forty per cent of the staves were made in Virginia.

Slack cooperage uses a considerable variety of woods in relatively small sizes for both staves and headings. Red gum is the most extensively used species for staves and pine for headings. Other species used for both purposes are elm, beech, maple, birch, cottonwood, ash, oak, and chestnut. This industry presents an opportunity for utilizing trees cut to improve the forest or to thin young or middle-aged stands.

Tight cooperage is made almost wholly from white oak, the only other species used to any extent being red oak. Since the nature of the product places high requirements upon the quality of the wood, the tight-cooperage industry competes with lumber production for the use of high-grade white oak and affords little opportunity for improved utilization.

FIREWOOD

Statistics on the use of wood for fuel gathered in 1908 (*47*) and in 1924 (*72*), indicate that the group of States which includes the southern Appalachian region consumes extremely large quantities of firewood, amounting in these two years, respectively, to 36 and 37

per cent of all the firewood consumed in the United States. Of this quantity, 50 per cent undoubtedly was taken from the region itself. According to these estimates, the output of firewood in the region decreased from about 15,380,000 cords in 1908 to 6,745,000 cords in 1924. It should be noted, however, that the 1908 estimate was for total consumption of fuel wood, whereas that for 1924, made in connection with the special United States census of agriculture (1925) was only for the quantity of fuel wood cut on farms. In 1908, 90 per cent of the consumption was on the farms and the remainder mostly in cities of less than 30,000 population.

Because of the greatly improved roads throughout the region, permitting delivery of coal by motor truck to many of the farms, it is likely that the consumption of wood for fuel has decreased somewhat since 1908. On the other hand, the same easier means of transportation has probably increased the use of wood in the cities. Firewood is likely to remain an important commodity in the Southern States, where furnace heating is much less common than in the North. The largest home use of farm woods is for firewood.

In the mountains considerable firewood is cut on the larger holdings of timberland. Many sales of firewood are made on the national forests. These are either improvement cuttings or thinnings, the former removing defective trees and waste material on cut-over areas, the latter taking a part of the trees from dense stands of second growth. Examples of stands thus thinned for firewood are to be found on the national forests, especially near towns and small cities. Some of the best are near Edinburg and Buena Vista, Va., on the Shenandoah and Natural Bridge National Forests.

OTHER PRODUCTS

In addition to saw logs, crossties, firewood, pulpwood, tanning-extract wood, cooperage stock, and mine timbers, which make up most of the wood volume taken annually from the southern Appalachian forests, are a number of other products of less importance Chestnut of suitable size and form is in demand for telegraph and telephone poles. The appearance of the chestnut blight stimulated active cutting for poles in many localities. Chestnut also furnishes a large number of fence posts and rails. The supply of these, as of the chestnut products previously discussed, may be expected practically to disappear within the next 10 or 15 years as a result of the blight.

Among the lesser products are dogwood and persimmon bolts for the manufacture of shuttles, spindles, and golf-club heads (*17*); hickory for golf club and other handles and for spokes; black locust for fence posts, insulator pins, and small poles (*18*); and a variety of small trees for novelties and rustic furniture. Some of these products are only locally important, while others provide a good market for material of proper kinds and dimensions over most of the region.

NEED FOR CONTINUOUS PRODUCTION

The figures for the annual output and consumption of forest products that have been quoted amount to a total of 6,000,000,000 board feet, as shown in Table 1. Since they are for different years and

were collected in different ways they afford only a very general approximation of the actual consumption of forest products in the region. The quantities shown are probably conservative, since it may be assumed that considerable material escaped the census takers and that the consumption as a whole has remained fairly constant within recent years. Table 1 does not give figures for the consumption of chestnut tanning-extract wood, since this, because of the chestnut blight, does not appear to be a replaceable resource. All of the other products can be placed upon a continuous basis of production; although, as will be shown later, only with greatest care can they be made perpetually available in the total amount shown.

TABLE 1.—*Estimated present annual production of lumber and other forest products in the southern Appalachian region (converted to board feet)*

Product	Quantity	Product	Quantity
	Board feet		*Board feet*
Lumber	2,225,000,000	Railroad ties	70,000,000
Fuel wood	3,250,000,000	Cooperage, poles, and other products	30,000,000
Pulpwood	225,000,000		
Mine timbering and ties	200,000,000	Total	6,000,000,000

To supply an annual demand for forest products approximating 6,000,000,000 board feet there are three classes of forest to be drawn on—virgin forest, cut-over forest, and second growth. The rapid rate at which the original virgin forest has been cut and the small area remaining clearly indicate that what is left will not last long. On the cut-over areas, as will be shown later, the present merchantable stand is altogether inadequate, even where sufficiently consolidated to justify logging. Future prospects for a continuous forest production adequate to meet regional requirements must rest, therefore, with the second growth.

A study of the yield capacity of well-stocked second growth, to be presented in Tables 8 and 9, makes it evident that the forests of the region will supply more than the estimated needs provided the destructive methods of utilization that are still widely practiced are supplanted by methods giving adequate protection and care to insure continuous timber production. According to Table 9, 310 board feet is the average annual growth per acre of 80-year-old, well-stocked second growth on Site II. Applying this yield to the 7,000,000 acres estimated as the total area of the more productive sites in the mountains gives a theoretically possible annual growth, without any treatment except protection from fire, of 2,170,000,000 board feet per year. Similarly, representing the annual growth on the drier sites by 90 board feet per acre—the average annual growth at 80 years shown for Site IV in the table—the yield of the 14,000,000 acres of drier site in the mountains would be 1,260,000,000 board feet per year. These figures are, of course, purely theoretical and are on a somewhat doubtful basis of area, since it is by no means certain that the sites for which the yields are selected truly represent the areas indicated. Furthermore, the forest under its present handicaps of fire damage, chestnut blight, insect damage, and unmerchantable large trees left standing after logging is totally incapable of supporting

this growth. But the estimates at least give some indication of the maximum possible production of the mountain timberlands if each acre were producing to capacity. For the whole mountain territory, excluding the spruce-fir forest as of relatively insignificant area, the annual output would be 3,430,000,000 board feet.

This leaves an annual deficit of about 2,600,000,000 board feet to be supplied by the forests of the plateaus and valleys, which aggregate about 40,000,000 acres. The annual growth necessary to make up this deficit would not have to be much more than 62 board feet per acre, which, as shown later in Table 9, could be supplied on average soils by raising stands to an age of only 40 years. Thus it is evident that the forest soils of the region are potentially capable of supplying all present needs, as far as quantity of product is concerned, with something to spare.

The actual present growth rate on southern Appalachian forest lands as a whole is obscured by lack of specific data, which could be obtained only by conducting a comprehensive survey. Examinations of many tracts scattered through the region indicate that a large part of such growth as is taking place is distributed among trees of little or no commercial promise. Such trees fall chiefly into the classes of large unmerchantable rejects from past logging, and smaller trees rendered defective by fire, decay, insects, or other causes. As will be seen in Table 6, the representative cut-over areas studied by the Appalachian Forest Experiment Station are only half stocked even with the unmerchantable trees figured in. Although many excellent small stands are scattered throughout the region, it is probably safe to say that the southern Appalachian timberlands as a whole are not making one-third of the growth which the soils are capable of maintaining. If this is the case, the present total annual growth for the whole region is far below that necessary to support the present annual consumption.

Part of this deficiency is doubtless temporary, for the rate of growth will increase as the reproduction on cut-over areas attains tree size. Such an increase, if it is to be of any value, is contingent upon protection from fire. Furthermore, it will not bring the growth rate up to the level of that in well-stocked second-growth stands so long as defective trees are allowed to monopolize a considerable share of the growing space.

The important facts relative to the future supply of forest products in the southern Appalachian region may be summarized as follows:

The yearly output of lumber and other forest products in the region approaches 6,000,000,000 board feet. Most of this supplies local industries and domestic needs; that which is exported brings wealth to the region. It comes partly from old-growth forest, virgin and culled, and partly from second growth that has reached commercial size. The utilization of mature old growth, if so cut as to ensure replacement with vigorous second growth, is logical and necessary. It results in substituting an active for a stagnant condition. If improperly taken, the result will inevitably be to perpetuate and extend the present growth deficit. This is true also of the second growth, and here there is the added possibility of waste of material in an active state of growth.

About 90 per cent of the mountain timberland is more or less depleted of merchantable timber. The natural replacement with thrifty second growth is handicapped by defective and unmerchantable trees left standing after logging. Forest fires, and to some extent insects, have killed or seriously damaged the smaller trees and reproduction over much of the area, converting seedling into sprout growth. Young stands on clear-cut or heavily cut-over areas grow much more rapidly than old-growth forest on corresponding sites. They produce yields comparable in amount to those of the virgin forest and in much shorter time. This growth can be increased in quality as well as quantity by the right kind of treatment. Protection from fire is the first essential.

Continuous timber production in the southern Appalachian region is principally a matter for private initiative, for over 90 per cent of the timberlands are privately owned.

TIMBER GROWING AND THE PROBLEM OF LAND USE

The timber-supply problem, as a matter of public importance chiefly in the hands of the private timberland owners, is one of getting an income from the land. Raising forest products may be a partial source of income on land held for other purposes as well, or it may be the only means of making the land pay. In either case the possibility of financial success should not be prejudiced by avoidable difficulties. One of these is the system of annual taxation of timber now in effect over most of region.

The annual tax on the value of standing timber may be partly responsible for indiscriminate and wasteful cutting in the past and may, if continued, affect unfavorably the holding of growing timber for future cutting. Under any circumstances the annual property tax on land and timber is not adapted to the development of forestry on cut-over lands, since during this period of development the returns will naturally be lower than when the forest is brought to a fully productive condition. A more appropriate system is greatly needed. The forest-tax situation, as part of the general rural-tax problem, will benefit from any measures taken to reduce excessive taxation of rural land and to insure a more equitable distribution of the cost of supporting schools and roads. Measures of various kinds have been proposed and to some extent put in effect for the purpose of relieving immature timber of the property-tax burden. At the present time the whole subject of taxation methods applicable to forest lands is under investigation by the forest taxation inquiry of the Forest Service, the purpose of which is to develop a satisfactory form of forest taxation.

Forest lands in the southern Appalachian region are customarily bought and sold at prices that have no definite relation to the income that might be obtained from them if they were to be systematically devoted to the raising of timber crops. The actual values of these lands must be fixed by the income to be derived from them under continuous forest production. Forest-land values will naturally be affected by the accessibility of the land and its quality as determined by the rate of growth and the value of the products it can supply. Thus there will be considerable difference between dry and moist

lands and between areas difficult and easy of access. Doubtless the true values based on continuous production will often be lower than the actual present prices at which the land has come to be valued as a result of recent transfers. For the better soils, however, the true value may sometimes be higher than the present sale price.

The uses of mountain forest lands for purposes other than timber production are few. Where they exist these uses often tie in very closely with commercial timber growing and in such combinations serve to increase the profits from the forest. For example, on coal or mineral lands held in fee, a well-managed forest is an almost indispensable asset for the duration of the operation; and after the mining operation has closed down the land can still be made to yield an income if the forest has been under management for sustained production. Another common reason for holding mountain lands is their value for recreation, hunting, and fishing. For these uses fire prevention is essential, as it is in the raising of timber. Timber growing can be conducted to great advantage as one source of revenue on lands held for recreational purposes.

Still another important use of mountain forests is for the protection of stream heads, and thus of commercial and city water supplies, electric-power reservoirs, and the navigability of streams. The influence of the forest in restraining flood waters and preventing erosion is vital to the welfare of the southern Appalachian region. It affects particularly the maintenance of reservoirs for town and city water supply and for power production. Power production has reached large proportions in the region. According to estimates made by the United States Geological Survey, the potential water power available 90 per cent of the time in the States wholly or partly included in the southern Appalachian region amounts to nearly 4,200,000 horsepower, or 11 per cent of the potential water power of the United States. The 401 power plants in the region, with a capacity of 100 horsepower or more, now develop a total of 2,924,237 horsepower. Most of this power is in streams that head in the southern Appalachian Mountains. Much of it is developed direct from the streams, without artificial storage in reservoirs. Power plants thus supplied must use fuel as a supplement to water power to a greater extent than if reserves of water were available during low-water periods in the streams. Unbroken forest on the watersheds will maintain a more regular and continuous stream flow than can be supplied by watersheds that have been heavily logged, cleared, or burned (*52*, *75*). Where reservoirs are employed their length of service depends upon the rate at which they become filled with silt. This in turn depends upon the rate of erosion above the reservoir. The best protection that the slopes could have against erosion is dense, unburned forest. (Fig. 2.)

The most severe erosion takes place when the mountain slopes are cleared and cultivated (*8*). Small farm patches on steep mountain sides are a common sight in many parts of the southern Appalachians. Plowing conceals the effect of wash from these cultivated slopes, but gullies quickly begin to form when such fields are abandoned. (Fig. 3.) The yearly wash of soil from an acre of land on the Yadkin River above Salisbury, N. C., has been computed (*1*) to average more than 850 pounds. Of this more than 125 pounds is organic matter,

F166333

FIGURE 2.—The beginning of erosion on skid trails, one year after horse logging in a spruce-fir forest

F12234

FIGURE 3.—The effect of surface run-off on a slope that was cleared, cultivated, and abandoned

the remainder being mineral soil. The organic matter is humus, chiefly from farming soils, and where this is the case it must be replaced if the soil is to be made productive.

In the hilly and rolling land below the mountains, erosion is especially conspicuous on abandoned farm lands. Ashe (*4*) points out that, although the proportion of cleared land on the watersheds is apparently not excessive, the condition and situation of much of it tend to jeopardize not only the value of the rivers, but the permanency of the soil as well. Unfavorable soil conditions have become far more general since 1880. The cultivation of extensive areas of hill country below the mountains, especially of the red clays in the extreme South, ceased between 1880 and 1900. The rural population moved to the factory towns; the negro labor immigrated to the cities. The surface of the farm land abandoned in this manner was quickly compacted and lost its porousness. Only a small portion of the heavy rains is absorbed by it, and much water that should be absorbed runs off, augmenting the floods. The springs formerly fed from the water stored in the soil have failed. The land itself has eroded in deep gullies.

Watershed protection is thus unquestionably an important object of timberland management in the mountain region, while in the plateau and valley regions the improvement and extension of farm woods to check erosion and conserve moisture are correspondingly urgent. In both situations, fire prevention, especially for the dry southerly exposures, is imperative. In well-stocked unburned stands on south slopes light cutting at rather long intervals can be safely practiced, but heavy cutting is almost certain to result in severe soil washing.

Thus forest protection and good management will benefit the region not only by providing permanent supplies of good timber but also by putting otherwise idle or half-productive land into active, remunerative use; by replacing a false with a true productive basis of land valuation; by maintaining permanent water resources and improvements for power development and city water supplies; by improving scenic values and recreational facilities for hunting, fishing, and camping, and thus tending to increase the attractiveness and popularity of the region to its own citizens as well as to tourists. The possibility of such public advantages to be gained through good forest management places forestry among the most important internal economic measures that present themselves to the people of a state or nation.

FACTORS THAT AFFECT CONTINUOUS TIMBER PRODUCTION

The measures used to obtain and secure continuous timber production will depend upon local conditions of timber and reproduction, conditions that for many reasons are extremely variable. The most important conditions to be considered are the species found in the stand (forest composition), the number of trees per acre (forest density), the present condition of the forest, the facility with which the various species reproduce themselves, and the growth rate of the various tree species. These conditions are in turn influenced by soil,

climate, direction of exposure, past logging, fire, insect depredations, and chestnut blight. Such influences affect the density, size, and promise of the young timber and reproduction. The conditions thus set up are so complex and variable that several different kinds of treatment may be required within a relatively small area.

COMPOSITION OF THE FOREST

About 140 species of trees are native to the Appalachian region. Of these about 60, listed in the Appendix (p. 87), are important commercially. All but 10 of the species are broad-leaved (hardwoods). The combinations in which these species are found (forest composition) are extremely varied, especially in the mountains. Many forest types are found (*56*), some clearly marked, others more complex and intergrading with each other. Although the best forest management will designate more than one kind of treatment within a single forest type, the types can be conveniently grouped for general description into four classes—moist slope and cove, dry slope and ridge, spruce, and plateau and valley forests. The first three make up the forests of the mountains.

MOUNTAIN FORESTS

MOIST SLOPE AND COVE FOREST

Cool, moist coves and shaded northerly slopes comprise probably a third of the mountain-forest area. This class of forest has three fairly well-marked divisions—cove, lower moist slope, and upper moist slope. The cove forest is found at altitudes of 2,000 to 4,000 feet in the southern mountains: lower in the north. It sometimes runs heavily to hemlock (pls. 3 and 4), sometimes to yellow poplar, but more commonly it is a varying mixture of many species, among which are white pine, basswood, black gum, black birch, cucumber magnolia, various hickories, walnut, red maple, buckeye, black locust, black cherry, sycamore, silverbell, sourwood, holly, and dogwood. This forest is now found mainly in the narrow coves and their adjacent lower slopes, the broader coves and valleys having long since been cleared for agriculture. Where found, it represents the best opportunity for profitable forest management in the mountains. These stands contain the largest number of valuable species, their rate of growth is most rapid, and they recover most readily from cutting and fire. The lower moist-slope forest occurs on northerly slopes at about the same altitudes as the cove forest. Chestnut and several species of oak and hickory form the bulk of the timber, but a number of the cove species are usually more or less abundant in mixture. The upper moist-slope forest, extending to altitudes of 5,000 feet or more in North Carolina, but lower in West Virginia, is a varying mixture of "northern hardwoods" (yellow birch, sugar maple, and beech), hemlock, buckeye, and several other species found also at lower elevations.

DRY SLOPE AND RIDGE FOREST

Dry slope and ridge forest (pl. 4, B) is found chiefly on southerly or westerly exposures extending up to the edges of the upper moist

slope and spruce forests, but often covers east slopes well around to the northeast. It is the most extensive of the three groups. A timberland inventory would probably place nearly two-thirds of the total forest area in this class. The forest is composed of the more drought-resistant species, largely chestnut oak, scarlet oak, white pine, pitch pine, and mountain pine, with black gum, red maple, hickories, dogwood, and sassafras in mixture. The dryness of these exposed sites favors fires, which here impoverish growth conditions more readily than in more moist situations. As a result the stands are very commonly scattered and defective, growth is slow, and reproduction is likely to be largely of inferior species. On large areas of young second growth the majority of the trees have become infected with heart rot through fire scars. Although such stands may seem to be growing thriftily, they actually represent an increasing liability and a difficult problem of forest management.

SPRUCE FOREST

The spruce forest is found at altitudes of over 4,500 feet in the mountains of North Carolina, Tennessee, and Virginia, and at altitudes of over 3,500 feet in West Virginia. Red spruce is the predominant species. In North Carolina and Tennessee the spruce is commonly mixed with southern balsam fir; at the highest altitudes the fir often predominates or occurs in pure stands. In West Virginia a common associate is hemlock. Hemlock and northern hardwoods, particularly yellow birch, mix freely with the spruce along the lower fringes of this forest throughout its occurrence in the region. There are typical examples of spruce forest at altitudes of 5,000 feet and over in the Black and Balsam Mountains of North Carolina and in the Smoky Mountains from Clingmans Dome northward along the border of Tennessee and North Carolina to Mount Guyot. (Fig. 4.) Smaller stands occur on a few isolated peaks in North Carolina, Tennessee, and the southern part of Virginia, east of the Appalachian Valley.

In West Virginia, spruce once covered considerable areas in the mountains, but all except a few scattered remnants of the original spruce forest have now been cut. Similarly in the Black and the Balsam Mountains, and in isolated areas, much of the spruce-fir type has been destroyed by logging, fire, and the southern pine beetle. The largest remaining body of original forest is probably one of about 45,000 acres in the Smoky Mountain National Park.

The spruce forest is unimportant as a source of forest products for the region as a whole, though it has considerable importance in particular localities. Its value as a protective cover for watersheds and as a scenic element increasing the attractiveness of the mountains for recreation are strong reasons for the preservation of this forest where it occurs and for its reestablishment on the areas from which it has disappeared.

PLATEAU AND VALLEY FORESTS

In composition the plateau (fig. 5) and valley forests are much like the dry-site and lower moist-site hardwoods of the mountains, but with a greater proportion of stands which run heavily to pine.

F166315

FIGURE 4.—A virgin spruce forest at high altitudes in the mountains. The trees in this dense forest vary greatly in size and age, making light partial cuttings desirable

A few of the common mountain trees—pitch pine, mountain pine, chestnut, basswood, buckeye, and some others—are uncommon or only locally important in the plateau forest, while several species that are important in much of the plateau and valley region—red gum, southern red oak, shortleaf pine, and Virginia pine—are rare or absent in the mountain forest.

Much of the same difference in composition exists between moist and dry sites as is found in the mountains. Protected ravines and northerly slopes have stands of cove hardwoods resembling those of the mountains, and yellow poplar grows well on the moist sites. Most of the watercourses are lined with river-edge hardwoods, chiefly river birch, sycamore, black willow, and red maple. Dry soils have stands prevailingly of oak, pine, or pine and oak mixed. The common oaks are southern red, scarlet, black, white, and post

F5296

FIGURE 5.—Plateau forest—a characteristic irregular, culled stand of oaks and shortleaf pine on a dry site

oaks, and they are usually mixed with hickories of several kinds and with other species, of which black gum is one of the commonest. Nearly pure stands of southern red oak are quite common in some parts of the region, and post oak sometimes predominates on poor soils.

Of the pines, shortleaf is the species most generally distributed, but Virginia pine ordinarily supplants it in northeastern Virginia and Maryland and occurs in places throughout the piedmont, commonly in pure stands. Along the eastern and southern borders of the piedmont and in the southern part of the Appalachian Valley, old-field loblolly pine is quite abundant on fresh to moist soils. Longleaf pine intrudes into the piedmont at places in the southern portion, but no longer in important stands. Pure stands of red cedar are frequent, particularly in the southern part of the Appalachian Valley.

F193263

SHADE MUST BE TEMPERED TO HARDWOOD REPRODUCTION

Virgin hemlock and hardwood cove forests cast heavy shade that must be greatly reduced if good hardwood reproduction is to be obtained. In this case, also, the shade is reinforced by an undergrowth of rhododendron and other shrubby species.

F11912 F27330A

TWO MOUNTAIN FOREST TYPES IN THE SOUTHERN APPALACHIANS

A, Culled hemlock and hardwood cove forest; B, dry slope and ridge hardwoods.

While the typical farm woods of the plateaus are small holdings, usually in strips back from the roads, and surrounded by cultivated fields, meadows, roads, or brush land, those of the foothills and the many parallel ridges in the Appalachian Valley are generally contiguous in larger bodies on the steeper and less fertile soils. On the lower interior plateaus of the mountains, in the southern part of the region, these woodlands reach altitudes of about 2,500 feet, and merge with the mountain forests.

The plateau and valley woodlands have been more altered by settlement than the mountain forests. Many of them are dense stands of second growth that have come in on abandoned fields. Pine now occurs almost entirely in second-growth stands, pure or mixed with hardwoods. On moist sites, promising second-growth stands of yellow poplar and other valuable hardwoods are numerous. The remaining old-growth stands have generally been culled of their best species.

RELATIVE VALUE OF THE SPECIES

One fact that has been repeatedly demonstrated in the logging history of the southern Appalachians is that the commercial values of the different tree species are not stable. New developments are continually arising to bring little-used species into economic importance. The species that can be logged profitably have constantly grown in number until now there are few of the different southern Appalachian trees that are not of some commercial promise. Since this extension of utilization is likely to go on indefinitely, the basis for selecting the species to be encouraged for future production should be not so much the present demand as the fundamental qualities of growth rate, mature size, form, soundness, vigor, and the technical adaptability of the wood. The last-named quality affords a basis for judging what the prospective commercial demand may be. Trees having wood qualities adaptable to more than one type of use are the most likely to maintain a stable value.

Tree species can not be expected to develop their best qualities on soils unfavorable to them. Species adapted to moist soils will not compete successfully on dry sites with dry-site species, and it would be a mistake to favor yellow poplar, for example, except on a relatively moist soil. Better a vigorous stand of species now rated as less valuable than a poor, unthrifty growth of the best species. On good soils, however, it would be a mistake to permit the land to become stocked with species that will neither grow as rapidly nor yield as valuable products as the better of the moist-soil species.

The question of desirability for timber growing can not be answered by listing the species in any precise order of relative merit. Local circumstances will often affect the desirability of certain species. The general values of the species for forest management, however, are indicated in Table 2, in which the "desirable" and "less desirable" species are grouped by their suitability for moist or dry sites.

TABLE 2.—*Southern Appalachian trees classed as to desirability for timber production*

MOIST-SITE SPECIES

Desirable timber species [1]	Less desirable species	
	Timber species	Minor species [2]
Ash (sp.)	Beech	Birch, river.
Basswood (sp.)	Buckeye	Blue beech.
Birch, sweet	Butternut	Cherry, pin.
Birch, yellow	Chestnut [3]	Chinquapin.[3]
Cherry, black	Collectree	Crab apple.
Fir, southern balsam	Elm (sp.)	Dogwood.[3]
Gum, red	Gum, black [3]	Hawthorns.
Hemlock, eastern	Hemlock, Carolina [3]	Holly.
Hickory, mockernut	Hickory, bitternut	Hophornbeam.
Hickory, pignut [3]	Honeylocust	Magnolia, mountain.
Hickory, shagbark	Maple, red [3]	Magnolia, umbrella.
Locust, black [3]	Maple, silver	Maple, striped.
Magnolia, cucumber	Oak, pin	Mountain-ash.
Maple, sugar	Oak, shingle	Mulberry, red.
Oak, chinquapin	Oak, water	Persimmon.[3]
Oak, red	Sycamore	Redbud.
Oak, white		Rhododendron.
Pine, northern white [3]		Sassafras.[3]
Poplar, yellow		Serviceberry.[3]
Spruce, red		Silverbell.
Walnut, black		Sourwood.[3]
		Willow, black.

DRY-SITE SPECIES

Cedar, eastern red	Chestnut [3]	Chinquapin.[3]
Hickory, pignut [3]	Gum, black [3]	Dogwood.[3]
Locust, black [3]	Hemlock, Carolina [3]	Oak, blackjack.
Oak, black	Maple, red [3]	Persimmon.[3]
Oak, chestnut	Oak, post	Sassafras.[3]
Oak, southern red	Oak, scarlet	Serviceberry.[3]
Pine, pitch	Pine, mountain	Sourwood.[3]
Pine, shortleaf		
Pine, Virginia		
Pine, northern white [3]		

[1] Most of the species that are desirable on moist sites are less desirable where they occur on dry sites.
[2] Generally small trees.
[3] Species common on both moist and dry sites.

The grouping in Table 2, of course, implies consideration of quality and condition of the trees as well as of their location on soils suitable to them. For example, seamy old hickory is still a drug on the market, but second-growth hickory has great promise for a number of uses. Special adaptability to site may alter the ratings of desirability shown in the table. Thus river birch, sycamore, willow, and silver maple are the characteristic trees of the river-edge forest, where they may be among the most desirable of all species. Of the more abundant species there are only a few that because of slow growth, small size, or defect do not seem to have much commercial promise. Among these are sourwood, post oak, blackjack oak, and scarlet oak. Even these have certain values when large and sound enough, and should be classed only as relatively inferior to other species. Of the small trees, dogwood and persimmon have high value for small products (*17*), but since they grow slowly and generally attain only a small size a high rating can not be given them. The reproduction of the small species, particularly of dogwood and sourwood, is often a serious hindrance to the reproduction of more valuable species.

Of the larger timber trees, chestnut, the most abundant and generally useful species in the southern Appalachians, has been reduced within the last 20 years by the chestnut blight to a distinctly valueless species for timber production. In the reproduction on cut-over or burned areas its vigorous sprouting capacity interferes with the growth of other species without offering a justifiable hope that the chestnut will grow to merchantable size.

Of the moist-site species, yellow poplar (*8*) has the highest general rating of value, and its wood will probably always be in demand. Poplar saw-log trees have a high value, and those too small to yields logs, such as thinnings from too dense stands, can be used to advantage for paper pulp. On the moist soils to which it is adapted poplar is one of the most rapidly growing of the southern Appalachian trees. It is particularly free from any serious insect enemies and diseases. It reproduces poorly by sprout, but its seedling reproduction under proper conditions is excellent, as in Plate 5, B. The seed must not dry out and must come in contact with mineral soil; also the seedlings should have ample light from above.

Other valuable and relatively abundant species of the moist sites are northern white pine, red oak, and white oak. Northern white pine (*21*) is rather irregularly distributed, and there are considerable areas where it is rare or absent. It reproduces well, with frequent though not annual seed years, but the early growth of the seedlings is so slow that many are likely to be killed by the competition from any rank growth of hardwood sprouts and seedlings, shrubs, or herbs. Later growth is very rapid. Plantations of white pine on the Biltmore Estate, N. C. (*28*), show a more rapid growth than is indicated for the best quality of natural white pine stands in New England.

Northern white pine is not very fastidious and shows a capacity to succeed on some of the higher slopes which are not too dry or too exposed to winds. In the southern Appalachian region it has hitherto appeared relatively free from serious insect or fungous enemies, but elsewhere in its range a very serious disease, the white pine blister rust (*Cronartium ribicola*, Fischer), has done much damage, since 1900 or earlier, when it was imported from Europe on white pine seedlings (*57*). Fortunately wild currants and gooseberries, the alternate hosts of the disease, are generally rare at the altitudes at which northern white pine grows in the southern Appalachian region. Safety from the disease, however, is a very good reason for a strict quarantine on shipments of white pine planting stock from outside the region. Seedlings for planting in the southern Appalachians should be grown from seed within the region.

Red oak (*67*) occurs scatteringly through the upper coves of the lower moist-slope forest, and, in the form of short trees of fairly rapid growth, on some of the higher, relatively moist ridges. Like those of the other oaks, its acorns are subject to destruction by insects, rodents, and other animals, and require moist storage over winter and favorable soil conditions to insure germination in the spring. Seedling reproduction is likely to be scanty, but red oak sprouts well from small stumps.

White oak (*37*) reaches best development in the coves and on the lower moist slopes but is also found on the drier slopes and ridges.

It grows especially well in the coves of the Cumberland Plateau. However, as its growth, at best, is slow and its fall-germinating acorns are destroyed in large quantities by insects and rodents, its reproduction is not always to be depended upon.

Basswood (*12*, *64*) is a valuable species that is abundant in many places in the mountains. White ash (*59*, *60*, *69*), black cherry (*65*), black walnut (*7*, *11*, *13*, *41*, *70*), and cucumber magnolia are moist-site species of high commercial value, but they are not very abundant. These are among the best species to be encouraged on good soils. White ash is not so valuable as in the more northerly part of its range or in the Ohio Valley, but it reproduces by seed much more freely than basswood, walnut, and cucumber magnolia. Black cherry makes a rapid growth and is of value where it occurs in quantity.

Eastern hemlock (*22*) is the most shade-tolerant tree in the southern Appalachian forests. For its best development it requires a good moist soil and a cool, humid climate, like that of high altitudes in the mountains or of north-facing coves and slopes lower down. It appears to demand a certain amount of shade as a protection against the drying out of the soil and the loss of atmospheric moisture. The rate of growth is ordinarily slow, but young trees that get ample light grow rather rapidly, and shaded trees increase their growth rate considerably if the shade is lessened by the removal of adjacent trees. Eastern hemlock reproduction is not abundant in the southern Appalachians, probably because of ground fires and the consequent unfavorable conditions of the forest floor. Eastern hemlock lumber from this region is commonly regarded as inferior in quality to that from the North, but carefully graded lumber from especially good stands competes successfully with Pennsylvania (eastern) hemlock in Pennsylvania markets. Eastern hemlock is useful for wood pulp, and because of its ability to endure shade it is desirable as a mixture in the hardwood forest to increase the volume yield. Where small trees are found, or where good stands of advance growth exist, it is well to favor these.

Shagbark, mockernut, and pignut hickories (*9*, *46*, *68*) are species of great value in some parts of their ranges, as in the Ohio and Mississippi Valleys. In the southern Appalachians the hickories as a group have never been rated highly and are frequently ignored and left standing by the loggers. The old trees have as a rule grown slowly and produced wood inferior in quality to that of rapidly growing second growth. In moist situations the better hickories, particularly shagbark and mockernut, have potential value and can well be favored.

Black locust (*18*, *66*), like chestnut, is so little exacting in its site requirements that it is found nearly everywhere in the forest below the spruce. It is common on both moist and dry soils and is one of the most rapid growers up to small-pole size. It is likely to be abundant in young stands, especially those which have sprung up after fires, but is relatively short lived in the forest. It is commonly overtopped and killed out by other species when 10 or 12 inches in diameter. The locust borer (*Cyllene robiniae* Forst.) does considerable damage in places, but is not usually a serious enemy of locust in mixed stands. Black locust has a high value for posts and small

poles because of the durability of the wood in contact with soil. Consequently it is important as an intermediate yield in the treatment of young stands. Black locust can be very easily raised from the seed. It has been successfully planted to stop erosion.

The trees which are characteristic of dry sites occur there because they are able to withstand dry conditions rather than through lack of adaptation to better soils. They all occur here and there on the moist sites, where they grow more rapidly than on the dry sites and sometimes monopolize small areas. They are generally of less intrinsic worth, however, and are to be discouraged on the good growing soils.

Chestnut oak (*20*) is the most desirable of the dry-site oaks. It is useful for saw logs, railroad ties, and tanbark. It bears abundant annual crops of acorns, which germinate in the fall, and it reproduces well by sprout. Black oak also is a good timber tree on soils not too poor for the production of saw-log trees. Scarlet oak, though of fine form, is unusually subject to heart rot and in many localities becomes worthless by the time it has reached a diameter of 12 or 15 inches. (Pl. 5, A.)

The dry-slope pines in the mountains are usually pitch pine and mountain pine. Shortleaf pine (*2*) and Virginia pine (*58*) replace them on the plateaus and foothills. Shortleaf pine is by all odds the most important up to altitudes of about 2,500 feet. It produces excellent softwood lumber, grows rapidly as compared with most of the dry-site hardwood species, and reproduces freely, especially where fires have killed back hardwood growth. The seedlings of all the pines start slowly, require much light, and, with the exception of shortleaf pine, do not sprout when killed back to the ground. Pitch, mountain, and Virginia pine are species of promise for pulpwood. They are not of much present value for lumber, but in mixture with hardwoods on the ridges and dry slopes they often grow so well as to suggest the desirability of encouraging them in the prospect of increased future value. Unfortunately, shortleaf and, to a lesser extent, the other dry-site pines are subject to destruction by the southern pine beetle (*Dendroctonus frontalis* Zimm.) (*31, 51*), which appears to be particularly destructive in pure stands of pine.

Red maple, buckeye, and black gum, formerly almost entirely neglected in logging, have acquired a value for paper pulp where they are accessible to soda process mills. The maple and gum are common in the reproduction on dry as well as on moist cut-over lands.

Butternut, beech, and bitternut hickory have little present value in the southern Appalachian region. This is true also of sourwood, silverbell, sassafras, serviceberry, and the many species of hawthorn, chiefly because of their small size.

In the spruce forest the leading species are, of course, the native red spruce (*44*) and in the southern part of the region, southern balsam fir, the latter commonly increasing in abundance with increase in altitude. Commercially, the spruce is the better of the two. Its growth seems to be more rapid than that of the same species in New England. It yields excellent lumber and reaches large size; in the Smoky Mountains trees containing eight 16-foot logs, measured to a top diameter of 5.5 inches, are sometimes found. Spruce seeds heavily only at intervals of several years. Fir pro-

duces seed more frequently but not every year. Its growth is more rapid than that of spruce, but the tree does not reach so large a size. Fir is not so suitable for either lumber or pulp as is spruce, although its wood is used for both purposes.

THE YIELD OF THE FOREST

The differences in climate and soil which affect the composition of the forest also affect its density, growth rate, and yield. These differences are especially pronounced in the mountains where coves, ridges, and slopes of all degrees of steepness and exposure closely adjoin each other. Increases in the moisture of air and soil are ordinarily reflected by the presence of more rapidly growing tree species and larger numbers of trees of a given size per acre. The increase in the density of the stand tends toward the production of tall, straight, small-crowned stems, growing rapidly in height but slowly in diameter. (Pl. 4, A.) In the coves and on protected slopes the growth rate of the stand as a whole, owing largely to the greater height growth of the individual trees, is rapid as compared with that on the drier sites. Ridge tops with shallow, relatively dry soil will support only an open short-bodied stand of trees inclined to be crooked and defective. (Pl. 4, B.)

YIELD OF THE OLD-GROWTH FOREST

According to estimates and logging records, the original forest of the deep coves and shaded northerly slopes generally had a stand of from 15,000 to 50,000 board feet per acre, with an average of less than 25,000, taking into account all species and expressing the yield of tanning-extract wood and pulpwood in board feet. A 40-acre tract of cove hardwoods cut in 1912 near Lookingglass Rock in western North Carolina is said to have produced 40,000 board feet of yellow poplar per acre, with other species in addition. A yield of nearly 100,000 board feet per acre is attributed to a northern white pine stand cut years ago in Shady Valley, near the Virginia-Tennessee State line.

Outside of the coves the original stand was not so heavy. On fairly moist slopes it apparently ran from 7,000 to 15,000 board feet per acre, averaging about 9,000, while on the dry slopes the yield per acre was generally from 2,000 to 7,000 board feet, with an average of about 3,000. Authentic estimates of spruce in the Smoky Mountains give it an average yield of 18,000 board feet per acre, but many individual acres will run as high as 30,000 or 40,000 board feet.

Growth in the virgin forest is commonly slow, and if large areas are considered it is likely to be offset by decay. Most of the trees have practically ceased to grow in height and crown extension. The majority are mature and overmature, and such younger trees as have been able to fill openings where old trees have fallen are usually too much compressed by the crowns surrounding them to grow rapidly. Much of the growth that does take place is distributed uneconomically on poorly formed or defective trees. As compared with the active growth of young timber, the old-growth forest is in a nearly static condition.

YIELD OF REPEATEDLY CULLED FOREST

Over millions of acres in the southern Appalachians the forest has been repeatedly culled. A good idea of the resulting stand is afforded by Forest Service estimates for the eight national forests in the region, presented in Tables 3 and 4. The forests have a combined area of about 1,989,000 acres, which is a little more than 9 per cent of the entire wooded area in the mountains. They are distributed along the mountains from West Virginia to Alabama, so that the figures are fairly representative of the type of timberland mostly purchased for the national forests—cut-over land with a smaller stand of merchantable timber than is to be found on much of the other timberland in the region.

TABLE 3.—*Stand and distribution of saw-log timber in eight southern Appalachian national forests,*[1] *and percentage of species distribution by States*

Species	Stand	Distribution							
		West Virginia	Virginia	Tennessee	North Carolina	South Carolina	Georgia	Alabama	Total
Hardwoods:	*M bd. ft.*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Chestnut	288,821	7	15	9	26	----	16	----	13
Yellow poplar	270,633	4	7	17	10	15	9	14	12
Chestnut oak	246,847	24	23	7	10	5	9	4	11
White oak	179,539	13	8	4	6	6	13	21	8
Mixed oak [2]	168,926	4	8	4	9	9	14	6	7
Red oak	137,022	5	8	4	6	4	11	1	6
Hickory	57,167	----	3	1	4	2	3	6	3
Maple	22,838	11			3	----	----	----	1
Basswood	17,196	1			2	----	----	----	1
Yellow birch	11,277	2			2	----	----	----	
Beech	10,135	5			----	----	----	----	
Buckeye	7,822	----			----	----	----	----	
Cucumber	4,174	----	1	3	----	----	----	----	
Ash	3,092				----	----	----	----	2
Black locust	1,260	1			3	----	----	----	
Black cherry	1,066				----	----	----	----	
Black walnut	769				----	----	----	----	
Miscellaneous	122,249	3	4	10	3	----	2	3	5
Total	1,550,723	80	77	59	84	41	77	55	69
Softwoods:									
Yellow pine [3]	350,106	7	7	16	5	48	17	40	16
Hemlock [4]	250,546	7	8	20	9	4	3	5	11
Northern white pine	98,057	4	7	5	2	7	3	----	4
Spruce and fir	3,942	2	1	----	----	----	----	----	----
Total	702,735	20	23	41	16	59	23	45	31
All species	2,259,458	100	100	100	100	100	100	100	100

[1] Monongahela, Shenandoah, Natural Bridge, Unaka, Pisgah, Cherokee, Nantahala, and Alabama National Forests. Figures are based upon estimates of 1930. The total area of these national forests is 1,988,563 acres (June 30, 1929).
[2] Largely scarlet and black oaks.
[3] Shortleaf, Virginia, mountain, and pitch pines.
[4] 60 per cent of the total hemlock was reported from the Cherokee National Forest alone.

The total stand of saw timber reported on these eight national forests averages about 1,100 board feet per acre. The estimates for products other than saw logs are given in Table 4. These products (except tanbark) are the equivalent of 2,337,000,000 board feet. "Secondary" products thus amount to more than 50 per cent of the entire merchantable stand on the national forests. Much of the larger part is in mature and overmature timber and represents the salvage-

able material that should be cut for the best development of the second growth.

TABLE 4.—*Stand of products other than saw logs in eight southern Appalachian national forests, based upon estimates of 1930*

Form of product	Total stand	Form of product	Total stand
	Cords		*Pieces*
Extract wood	2,588,000	Railroad ties	3,293,000
Fuel wood	918,000	Posts	2,167,000
Pulpwood	493,000	Poles	168,000
Miscellaneous	24,000		*Cords*
Total cordwood products	4,023,000	Tanbark	613,000

While the yield on all cut-over land is generally small, the growth rate is much more rapid than in the virgin forest, owing to the rapid development of reproduction after heavy logging and to the increased growth of pole-sized trees left standing. The effect of repeated culling, however, has been to reduce the proportion of the best species and to diminish the seed supply upon which a natural seedling reproduction for the future stand is dependent. The abundance of the less valuable species is proportionately increased. (Pl. 8.) In order to determine the existing conditions of remaining trees and reproduction on the usual type of repeatedly cut-over, but not clear-cut, hardwood lands that have escaped recent fires, the Appalachian Forest Experiment Station has undertaken a survey of such areas by means of representative sample plots. The general method and some of the results have been discussed by Buell (*14*). The survey has thus far covered 14 cut-over areas in the mountains of Virginia, North Carolina, and Tennessee, and the results afford an idea of the character and promise of the present stand and reproduction. These results have been summarized in tabular form for five of the important hardwood forest types, the species being grouped as "desirable" and "less desirable," corresponding in general to the lists in Table 2. Table 5 shows the number of trees per acre 3.1 to 9 inches d. b. h. and those above 9 inches. The distinction between "good" and "poor" trees in this table is based upon straightness and soundness, although many of the trees tallied as "good" had small fire scars at their bases through which decay may perhaps have entered.

TABLE 5.—*Number of trees per acre in five important hardwood types on unburned cut-over lands in the southern Appalachians, classified according to size and quality of trees and desirability of species*

TREES 3.1–9 INCHES D. B. H.

Forest type	Desirable species		Less desirable species		Total	Basis [1]	
	Good trees	Poor trees	Good trees	Poor trees			
Dry slope and ridge:	*Number*	*Number*	*Number*	*Number*	*Number*	*Plots*	*Acres*
Black oak-scarlet oak type	20	7	30	20	77	12	5.5
Chestnut oak type	29	22	28	44	123	59	28.7
Moist slope and cove:							
Cove hardwood type	28	12	37	33	110	72	29.6
Northern hardwood type	10	11	16	23	60	12	4.9
Chestnut type	23	13	56	66	158	135	64.7

[1] The period since the last cutting varied from 2 to 19 years; 70 per cent of the area sampled had been cut over from 6 to 14 years.

F24167A F27929A

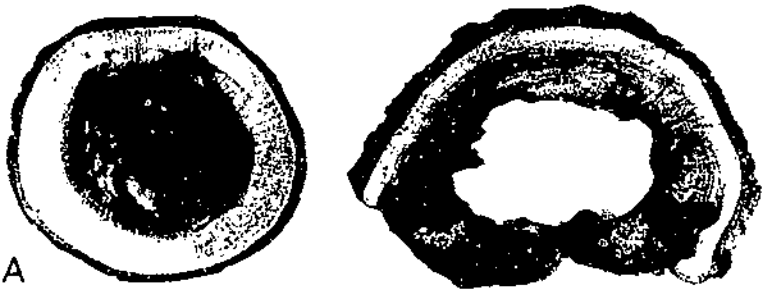
DENSE STANDS USUALLY FOLLOW TOTAL CLEARING

A, This second growth of dry-site hardwoods following clean cutting for charcoal wood is of scarlet and black oaks, 65 years old, about 60 feet tall, representing the growth on Site IV, as shown in Table X, Shenandoah National Forest, Va.; B, the dominant trees in this 67-year-old stand of second-growth yellow poplar on an old field averaged about 115 feet tall. It thus represents Site I as shown in Table X. The stand was cutled for saw logs in 1930, after the picture was taken. Pisgah National Forest, N. C.

F-9-13 F-17-35 F-15-A

VARIOUS EFFECTS OF FIRE

A, Sprout reproduction of hardwoods after fire in the dry slope and ridge forest of pine and hardwoods; B, fire-damaged young tree area containing hickory. Fire-scarred trees are subject to decay and should be cut or girdled to clear the ground for a better stand; C, a red oak tree broken down as a result of repeated fires and decay.



F-[illegible] F21-56

A, Cross sections of fire-damaged young oaks similar to those shown in Plate 6, B. The right-hand section represents a black oak severely burned 18 years ago and again 4 years ago. The white oak section [illegible] is from a 86-year old tree burned 37 years ago and again 21 years later. Both scars are completely healed over. Active decay is present in both sections; B and C, fire destroy the leaf litter in which they travel and which, were it allowed to decay, would contribute to the soil the organic matter that maintains its fertility, absorptiveness, and porosity. When the leaf mulch is destroyed by fire (C), mineral soil and tree roots are exposed.

F233629

STAND LEFT AFTER HEAVY SELECTIVE CUTTING

Defective trees and inferior species not cut for lumber or ties were girdled. Natural Bridge National Forest, Va.

TABLE 5.—*Number of trees per acre, etc.*—Continued

TREES OVER 9 INCHES D. B. H.

Forest type	Desirable species		Less desirable species		Total	Basis	
	Good trees	Poor trees	Good trees	Poor trees			
	Number	*Number*	*Number*	*Number*	*Number*	*Plots*	*Acres*
Dry slope and ridge:							
Black oak-scarlet oak type	16	2	20	5	43	12	5.5
Chestnut oak type	17	7	5	7	36	59	28.7
Moist slope and cove:							
Cove hardwood type	18	5	9	7	39	72	20.6
Northern hardwood type	17	5	4	9	35	12	4.9
Chestnut type	10	4	12	8	34	135	64.7

These figures, obtained on what are believed to be typical cut-over areas, strengthen the impression given by Table 3 that the cut-over forests of the southern Appalachians are generally understocked. For the five forest types represented in Table 5 the volume of wood in all the trees above 3 inches d. b. h. falls between 16 and 28 cords per acre, as shown in Table 6. In the black oak-scarlet oak type, with an average of 9.7 inches d. b. h., the 120 trees per acre have a volume of 22 cords. With the same average diameter, a well-stocked even-aged second-growth stand on a comparable site would have double the number of trees and double the volume per acre.

TABLE 6.—*Estimated deficiency in stocking of stands on unburned cut-over lands when compared with well-stocked second growth of corresponding site quality and similar average diameter breast high*[1] *by forest types*

Forest type	Average cut-over stand 3 inches and over, diameter breast high			Well-stocked second growth			Estimated deficiency in volume of average cut-over stands	
	Trees per acre	Average diameter breast high	Volume per acre	Trees per acre	Average diameter breast high	Volume per acre		
	Number	*Inches*	*Cords*	*Number*	*Inches*	*Cords*	*Cords*	*Per cent*
Dry slope and ridge:								
Black oak-scarlet oak type	120	9.7	22	241	9.7	44	22	50
Chestnut oak type	159	7.6	16	326	7.4	31	15	48
Moist slope and cove:								
Cove hardwood type	149	9.2	26	318	8.8	53	27	51
Northern hardwood type	95	11.2	28	285	10.0	67	39	58
Chestnut type	192	8.0	24	352	7.8	41	17	41

[1] The figures for well-stocked second growth are interpolated from the yield tables from which Table 8 was prepared. Site IV values were used for the dry slope and ridge forest, Site II for cove hardwoods and northern hardwoods, and Site III for the chestnut type. The interpolation resulted in generally lower average breast-high diameters for the well-stocked stands than are shown for the cut-over stands. The volume deficiencies of the cut-over stands are therefore conservative except perhaps for the black oak-scarlet oak type.

In all five examples the indicated deficiency in wood volume ranges from 41 to 58 per cent. Since the 290 sample plots upon which Tables 5 and 6 are based were widely distributed through the mountain region they probably represent fairly well the prevailing condi-

tions on cut-over areas. The wood volume alone, however, does not tell the whole story, for a part of it is made up of defective trees and of trees of the less desirable species. The proportion of straight, sound trees of desirable species in the stand is shown in Table 7.

TABLE 7.—*Proportion of good trees (i. e., straight, sound trees) of desirable species in typical unburned cut-over stands, by forest type*

Forest type	Trees 3.1–9 inches diameter breast high		Trees 9.1+ inches diameter breast high		All good trees	
	Number	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
Dry slope and ridge:						
Black oak-scarlet oak type	20	26	16	37	36	30
Chestnut oak type	29	24	17	47	46	29
Moist slope and cove:						
Cove hardwood type	28	25	18	46	46	31
Northern hardwood type	10	17	17	49	27	28
Chestnut type	23	15	10	29	33	17

The evidence of overcutting brought out in Table 6 is emphasized throughout Table 7, for in not one of the forest types represented are as many as one-half of the trees straight and sound and of desirable species. Among the small trees the inferiority is the more pronounced. Three-quarters or more of the trees in this size class are of the less desirable species or defective; and these stands, not having been burned severely or recently, are presumably in better condition than the large areas of cut-over forest that have been fire-swept. The indications are therefore strong that the greater part of the southern Appalachian hardwood forest is far below its potential productive capacity.

The effect of repeated culling of the southern Appalachian forests at short intervals may be summarized as follows:

The best species were logged earliest and most persistently; this reduced their seed supply and decreased their abundance in the reproduction as compared with poorer species. Valuable species, particularly yellow poplar, have been cut heavily to very small sizes for pulpwood and other small products. This has reduced the quality of the second growth by increasing the proportion of the poorer species. The effect of cutting always the best species, large and small, is that of a constant attrition, perhaps not marked at any one time, but cumulative and tending toward the elimination not only of the trees themselves but also of all means for their natural reproduction in future stands.

Moreover, not only the best species but the best trees of all merchantable species have been cut, increasing the proportion of the poorest. Defective trees left standing in the southern Appalachian forest occupy thousands of acres in the aggregate and interfere with the continuity and success of second growth.

A third effect, which will be developed later, is the increase in the proportion of sprouts to seedlings, leading to deterioration of the stand.

In these effects are reflected the enforced economies and lack of incentive to better forest management that have characterized logging methods in this region in the past. Heavy competition resulted in

overproduction, low prices, and narrow profit margins. Under this pressure investments in timber and timberlands were depreciated for the period of operation, and no additional investment to maintain the lands in a productive condition was provided. What the forest might have been without this pressure will be discussed later.

YIELD OF SECOND GROWTH

The reproduction on heavily cut-over or clear-cut areas springs up into dense stands of second growth, broken only to the extent that large rejected trees of the old forest have been left standing. Stands that have followed total clearing are remarkably dense and uniform. (Pl. 5.) Where they have escaped fire damage such stands equal or excel in yields of lumber and other forest products the mature and overmature timber of the virgin forest. The quality of the lumber is not so high, since the individual trees are smaller; but the trees are young, thrifty, and small crowned, and there are more of them to the acre.

These well-stocked, even-aged stands afford the best index to the growth capacity of the southern Appalachian forest soils. Such stands have covered large areas (especially in the piedmont and foothill region of Virginia, eastern West Virginia, and Maryland) that were cut clean for charcoal wood during the era of the blast furnaces. They have come in throughout the region in smaller patches, particularly following heavy logging or fires that killed back the old stands completely or on land cleared for agriculture and later abandoned.

In order to determine the rate of growth and the yield of these well-stocked young stands of mixed hardwoods, 370 sample plots were measured [4] on many different qualities of site and in stands of different ages. The wood volumes in cords and board feet were graphically averaged and classified according to site, quality, and age. They are shown in Table 8. Of the five site classes shown, Sites I and II correspond to the moist-slope and cove forest, Sites IV and V to the dry-slope and ridge forest, and Site III to the poorer moist-slope or better dry-soil forest that constitutes the larger part of the mountain and plateau timberlands. The height of the taller (dominant) trees, shown in the third column, was used in connection with the age of the stand to determine the quality of the site, which is best expressed by height growth. The table also shows the average number of trees per acre, average diameter, and basal area [5] per acre for the trees down to and including the 6-inch and 10-inch diameter classes.

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[4] Most of these were measured in Maryland and Virginia by the U. S. Forest Service and the State forester of Maryland. Enough were measured later in the southern mountains to prove the general applicability of the yield tables when applied in accordance with the height of the dominant trees and the age of the stand.

[5] The basal area of a tree is its cross-section area at breast height, expressed in square feet. The total basal area per acre is a convenient measure for judging the density of stocking. It is computed from the tally of breast-high diameters.

TABLE 8.—*Average yields of well-stocked second-growth hardwood stands, on all sites*[1]

Site	Age	Height of average dominant trees	Yield per acre		Trees per acre		Average diameter breast high		Basal area per acre	
			6 inches and over d. b. h.	10 inches and over d. b. h.	6 inches and over d. b. h.	10 inches and over d. b. h.	6 inches and over	10 inches and over	6 inches and over d. b. h.	10 inches and over d. b. h.
	Years	*Feet*	*Cords*[2]	*Bd. ft.*[3]	*Number*	*Number*	*Inches*	*Inches*	*Sq. ft.*	*Sq. ft.*
Site I (best cove soils)	30	80	48	5,200	267	69	9.5	10.9	131	45
	40	93	64	14,300	240	142	10.9	12.0	156	112
	50	102	74	21,800	208	140	12.3	13.2	171	134
	60	110	82	27,300	175	136	13.6	14.2	177	149
	70	117	88	32,700	160	131	14.8	15.0	191	160
	80	122	93	37,600	148	126	15.6	15.7	197	170
Site II (moist slopes and coves)	30	67	32	1,400	255	52	8.4	10.6	99	18
	40	78	47	6,500	252	97	9.5	11.5	125	70
	50	86	57	12,200	226	119	10.7	12.3	140	98
	60	93	63	17,100	201	127	11.7	13.1	151	118
	70	99	69	21,300	182	130	12.7	13.7	160	133
	80	103	74	24,800	169	130	13.4	14.2	166	144
Site III (soils of intermediate quality)	30	54	21	400	235	13	7.4	10.4	70	8
	40	63	32	2,500	258	47	8.2	11.0	96	31
	50	70	40	5,700	248	90	9.1	11.5	112	65
	60	76	46	9,100	229	109	9.9	12.0	123	86
	70	81	51	12,300	212	121	10.7	12.5	132	103
	80	85	56	14,900	198	128	11.3	12.9	138	116
Site IV (better dry slopes and ridges)	30	40	8	.....	126	.....	6.5	.....	29	.....
	40	48	17	200	228	5	7.0	10.3	62	3
	50	54	24	900	253	22	7.7	10.9	81	14
	60	59	30	2,700	259	54	8.2	11.2	90	37
	70	63	34	5,100	251	89	8.8	11.6	107	65
	80	66	38	7,200	238	111	9.3	11.8	113	84
Site V (poorer dry slopes and ridges)	30	28	1	.....	41	.....	6.0	.....	8	.....
	40	33	6	.....	140	.....	6.2	.....	29	.....
	50	38	12	.....	233	.....	6.5	.....	53	.....
	60	42	16	50	284	1	6.8	10.2	71	1
	70	45	20	700	297	32	7.2	10.5	84	20
	80	47	23	1,700	288	61	7.6	10.7	92	38

[1] From tables prepared by W. D. Sterrett and the author from records of more than 350 stands of even-aged mixed hardwoods measured by W. W. Ashe, of the Forest Service, F. W. Besley, State forester of Maryland, and others. All timber scaled as sound and straight. The cord volumes were converted from cubic feet by means of a factor of 90 cubic feet of solid wood per cord of 128 stacked cubic feet

[2] One hundred and twenty-eight cubic feet as stacked.

[3] Scribner Decimal C.

The average yield of 80-year-old second-growth hardwoods indicated in Table 8 amounts to over 37,000 board feet per acre on the best sites (Site I) and to nearly 15,000 board feet on average land (Site III). In the poorest situations (Site V) it falls as low as 1,700 board feet per acre. Under treatment to be discussed later, the quality as well as the quantity of the yield can be increased in second-growth stands, and if allowed to reach the age of the virgin timber there is no reason why equally valuable lumber can not be raised, and in larger quantities.

The table also brings out strikingly the relation of height growth to site quality, which has been previously referred to, and the part played by the height of the timber in determining its yield. The great difference in growth capacity between the good and poor sites which is shown in Table 8 is still further brought out in Table 9. This table, compiled from Table 8, shows the average yearly growth per acre in cords and board feet.

TABLE 9.—*Average annual growth per acre of well-stocked second-growth hardwoods, in cords and board feet. (Computed from Table 8)*

IN CORDS, TREES 5+INCHES D. B. H.

Age (years)	Site I	Site II	Site III	Site IV	Site V
30	[1] 1.60	1.07	0.70	0.27	0.03
40	1.60	[1] 1.18	.80	.42	.15
50	1.48	1.14	[1] .80	.48	.24
60	1.37	1.05	.77	[1] .50	.27
70	1.26	.99	.73	.49	.29
80	1.16	.92	.70	.48	[1] .29

IN BOARD FEET, TREES 10+INCHES D. B. H.

30	173	47	13	-------	-------
40	358	162	62	5	-------
50	426	244	114	18	-------
60	455	285	152	45	1
70	467	304	176	73	10
80	[1] 470	310	183	90	21

[1] Figures indicate peak of annual growth.

The figures in Table 9, marking the approximate ages at which the average annual growth is greatest, indicate that for trees 10 inches and over in diameter the growth in board feet reaches its culmination at 80 years for Site I. For other sites the growth reaches its maximum at ages not shown in the table—90 years for Site II, 100 years for Sites III and IV, and more than 100 years for Site V.

The vigor and freedom from decay of second-growth stands is contingent upon freedom from fire. A severe fire will not only set back the growth rate but, as will be shown later, will also kill small trees and open wounds in larger trees through which decay often becomes implanted. The damage is, of course, increased by each successive fire that burns in the woods.

FOREST-FIRE DAMAGE

Each year during the period 1923–1927 forest fires burned an area averaging 639,334 acres, or 2.7 per cent of the 23,468,000 acres of timberland under cooperative protection in the mountain and plateau regions of four southern Appalachian States.[6] The average number of fires each year was 2,322. Without doubt fires are more numerous and extensive in the unprotected areas for which statistics are less satisfactory. For the entire region the area burned annually during the 5-year period was probably in the neighborhood of 3 per cent.

The large areas thus damaged make fires by far the most destructive of all influences in the southern Appalachian forests. On reproducing areas the proportion of hardwood sprouts is increased (pl. 6, A) and the composition may be radically changed. In young stands more small trees than large ones are killed or injured. Fire therefore affects the future of the forest much more than it does its present condition. Stands are destructively thinned, leaving the land occupied by the older, often overmature, trees and by young trees crippled by wounds and subsequent decay. The treatment of young

[6] Virginia, North Carolina, West Virginia, and Tennessee. Comparable statistics for those portions of the other States which lie within the territory covered by this report were not available for the 5-year period considered.

second-growth stands in which many of the trees have been injured is one of the most difficult problems of the region.

Forest fires in the southern Appalachians are usually surface fires that burn in the leaf litter. Their destructiveness is increased by accumulations of logging slash, especially of hemlock, pine, or spruce, and by the dry, fire-killed material, including standing dead timber, left after earlier fires. The occasional crown fires which kill entire hardwood forests to the ground occur during very dry seasons. Such fires burned at several places in the mountains during the exceptionally dry summer of 1925 and late spring of 1926. In May, 1926, a fire of this character in Burke, Avery, and Caldwell Counties, N. C., burned over an area of more than 6,000 acres, killing the forest and strewing the ground with fuel enough for another killing fire, should one be allowed to escape within the next 15 or 20 years. Such fires are, however, relatively infrequent and may actually do less damage in the hardwood forests than the ordinary fire which kills the smaller trees and damages many saplings and small poles.

Since the chief means of spread of the ordinary fire is the layer of fallen leaves on the ground beneath the trees, surface fires are most common in the fall after the leaf crop is partially down and in the spring when the winter rains have ceased and before the vegetation is far enough advanced to keep the forest floor from drying out. They are unusual in the active growing season and during the winter, occurring only in dry periods or when a great quantity of débris on the forest floor forms an unusual fire risk. For the southern part of the Appalachian region the active spring fire season begins about the middle of March and ends about the middle of May. The fall season lasts usually about eight weeks, from the middle of October. In the northern part of the region the fall fire season begins and ends earlier, and the spring season is shorter.

Fires are more often fatal to small than to large timber, but generally the greatest damage to the stand is found among the trees that are wounded but not killed. (Pl. 6, B.) Surface fires hot enough to kill all the small seedlings and sprouts will injure many of the smaller trees and even large thick-barked trees that have leaves or branches lodged against them.[7] Trees injured at the base usually do not die but continue to grow and occupy space. Many of them become infected, through the fire scars, with wood-rotting fungi. (Pl. 7, A.) The decay may sometimes be arrested, but it may also spread in the wood of the trunk, greatly reducing the quantity and value of the final product. Most of the decay found in hardwood stands throughout the Appalachian region is due to successive fires. (Pl. 6, C.) The trees thus crippled continue to spread their crowns and thus prevent the successful development of reproduction.

In addition to the killing and wounding of trees, fires cause a heavy loss in soil fertility by destroying the leaf litter. The annual deposit of leaf litter in a well-stocked hardwood forest (pl. 7, B) is

[7] A mathematical relation can be found between the size of the trees and the degree of kill or damage effected by a fire of given intensity in the hardwood forests. Tabulated records obtained by E. F. McCarthy, of the Appalachian Forest Experiment Station, on 311 acres distributed uniformly over 2,820 acres of burned forest in various parts of the Appalachian Mountain region show that any fire severe enough to kill 50 per cent of the 3-inch trees (regardless of species) will kill practically all the 1-inch trees, about 73 per cent of the 2-inch, 34 per cent of the 4-inch, 22 per cent of the 5-inch, 15 per cent of the 6-inch, 11 per cent of the 7-inch, 9 per cent of the 8-inch, and proportionately less of all the larger trees down to about 1 per cent of the 17-inch class.

in the neighborhood of 2 tons per acre (*32*). From the best data available it is estimated that this quantity of hardwood litter contains 25 to 35 pounds of nitrogen, 12 to 15 pounds of phosphoric acid, and 5 to 7 pounds of potash. Under normal forest conditions these nutritive elements will be slowly released through decomposition of the litter. When the litter is burned its mineral content is left behind as an ash which is quickly dissipated by leeching and washing. A new accumulation of leaf litter must be built up before the nutritive process of decay can again be effective. On south slopes, particularly, the accumulation of litter on a burned surface is a slow process. In the meantime the soil becomes compacted and washes. (Pl. 7, C.) The combined effect is to reduce its growth capacity. A marked change in growth conditions can often be noticed, as when a poor, slow-growing young stand develops, after fire, among better trees of a previous generation.

As a rule there is a loss of a long period of years before the soil, on exposed situations, can be restored to full growth capacity, and an even longer period before the damaged trees can be replaced by thrifty ones. A dry-site forest may thus be so badly deteriorated as to be a continuing liability to the owner.

Defoliation is a common type of injury by fire to young stands of second-growth pine. An example of such injury is furnished by the records of a permanent sample plot established by the Appalachian Forest Experiment Station in its experimental forest at Bent Creek, near Asheville, N. C. (*16*). This plot of a quarter acre was established in April, 1925, immediately after a severe fire. The stand on the quarter acre contained 514 shortleaf pines about 25 years old. At the end of the third year 133 of the 514 trees were dead, mostly from defoliation. This number represents 18 per cent of the cubic volume of the stand. Of all the trees that were totally defoliated, 43 per cent had died. Of 34 trees partially defoliated, 26 had lost from 61 to 80 per cent of their leaves, 7 from 41 to 60 per cent, and only 1 as little as 40 per cent.

As a result of the defoliation, the growth of the stand was materially retarded. Measurements of more than 20 per cent of the larger trees showed that the basal area of the stand increased about 12 per cent in the three years preceding the fire but only a little over 3 per cent in the three years following it. During these three years 12 of the larger trees formed no annual growth rings at all, 10 formed only 1 ring, and 9 only 2 rings.

Fires are the greatest hindrance to timber production in the southern Appalachians. First importance should be given to their prevention. Cut-over areas must be kept free from fire or they can not be expected to recover even a fair degree of productiveness. The destruction caused by fires extends beyond timber production and affects every other important use of the forest. Spring fires destroy the nests and eggs of birds and the young of game animals, while the water-storage value of forest soils, which is essential to the long life of reservoirs, is reduced by fires at any season. Furthermore, each fire leaves an accumulation of dead wood which increases the severity of any subsequent fire occurring before this dead wood decays. The practical elimination of fires would be by far the greatest step forward in the reconstruction of the southern Appalachian forests.

ESTABLISHMENT AND EARLY DEVELOPMENT OF STANDS

ON UNBURNED CUT-OVER LANDS

Abundant reproduction of seedlings and sprouts usually springs up on cut-over lands within a few years after a moderate or heavy logging. (Pl. 9.) Not only do most of the species reproduce well, but ordinarily the new growth contains seedlings which were present before the logging. Such advance reproduction shoots up rapidly when released by the cutting of the larger trees, and also produces sprouts if killed back by fire. Plentiful reproduction of desirable species is always present in the hardwood forest if a suitable number of seed-bearing trees of desirable kinds are left standing. Where such seed trees are deficient, some of the less desirable species are so prolific and of such rapid growth as to predominate in the stand, unless they are weeded out sufficiently to give the desirable species an opportunity to become established.

Next to fire, the greatest impediment to the establishment of reproduction is the presence of large and small trees left standing after logging. Their adverse effect upon the reproduction will increase as their crowns spread out. Where they consist of vigorous young trees of good species, they are, of course, usually to be preferred to the reproduction, but crooked or unsound trees are detrimental, and their removal will clear the way for a much better future stand.

The proportions of shaded and unshaded reproduction on representative cut-over areas are shown in Table 10. Only the larger reproduction, 0.5 to 3 inches d.b.h., is included. The smaller reproduction is of less promise on areas that have been cut over as long as those illustrated, since much of it will be shaded out by the larger seedlings and sprouts, as well as by the trees.

Table 10 illustrates the density of the natural reproduction that ordinarily springs up after cutting; in most cases planting would be both unnecessary and unpractical because of the intense competition for light and growing space that planted seedlings would have to meet. In the natural reproduction itself, more than half of the seedlings and sprouts are shaded by trees, shrubs, or larger reproduction and will probably never reach merchantable size.

TABLE 10.—*Shaded and unshaded reproduction*[1] *in cut-over but unburned hardwood forest*[2]

Forest type	Not shaded, per acre			Shaded, per acre		
	Desirable species	Less desirable species	All species	Desirable species	Less desirable species	All species
	Number	*Number*	*Number*	*Number*	*Number*	*Number*
Dry slope and ridge:						
Black oak-scarlet oak type	94	258	352	191	634	825
Chestnut oak type	135	312	447	121	399	520
Moist slope and cove:						
Cove hardwood type	103	191	294	115	261	376
Northern hardwood type	171	84	255	138	168	306
Chestnut type	114	350	464	155	803	958

[1] Includes only the larger seedlings and sprouts, from 0.5 to 3 inches d. b. h.
[2] Prepared from the records of the sample plots used for Tables 5 and 7. The numbers and areas of the plots measured in each forest type and the period since the last cutting are as shown in Table 5.

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MIXED HARDWOOD REPRODUCTION WITH SECOND-GROWTH WHITE PINE IN BACKGROUND

A light thinning among the hardwoods is needed to release desirable species from competition with those less desirable.

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DENSE UNDERGROWTH IS AN EFFECTUAL BARRIER TO DESIRABLE REPRODUCTION

A, White pine and yellow poplar reproduction under a heavy cover, mostly of dogwood sprouts; B, dense undergrowth of rhododendron in an overcut hardwood forest.

In the spruce forest a considerable difference is to be noted in the conditions that affect reproduction. Seed years of spruce are infrequent, and fir does not bear heavy crops annually. After heavy cutting, even without subsequent fire, the seedlings are likely to be killed by the drying out of exposed duff, moss, or litter on which they start, by frost heaving, or by suppression under the shade of weeds, shrubs, and hardwood sprouts and seedlings.

AFTER FIRES ON CUT-OVER LANDS

Fires lower the value of the future stand by increasing the proportion of the poorer species and of sprouts. Although reproduction after fire may be heavy, its quality and promise are likely to be lower than on unburned areas. Exceptions to this may occur when severe fires, happening at times when desirable species have produced good seed crops, may greatly assist in establishing these species by clearing the ground of competing vegetation. Thus good stands of pine or yellow poplar of seedling origin are sometimes found on areas that have been severely burned. After such reproduction has become established, fires are disastrous.

The usual effect of fire, however, is illustrated for the hardwood forest in Table 11, which shows the amount and kind of reproduction the first season after a fall fire on dry and moist sites.

TABLE 11.—*Tree reproduction less than 0.6 inch d. b. h. in the first season following a severe fire in dry-site and moist-site forests* [1]

Species	Reproduction per acre in dry-slope and ridge forest			Reproduction per acre in moist-slope and cove forest		
	Seedlings	Sprouts and sprout clumps	Total	Seedlings	Sprouts and sprout clumps	Total
Desirable:	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Yellow poplar		6	6	530	17	547
Chestnut oak	1	243	244		513	513
Red and white oaks					152	152
Birch [2]				8	8	16
Black locust	8	144	152		353	353
Yellow pines [3]	932		932	84		84
Total	941	393	1,334	622	1,043	1,665
Less desirable:						
Chestnut	1	498	499	8	749	757
Scarlet oak	1	251	252		126	126
Hickory		36	36		93	93
Red maple	1	235	236	329	657	986
Black gum		359	359		67	67
Sassafras		710	710	59	649	708
Sourwood		126	126		311	311
Dogwood		28	28		59	59
Total	3	2,252	2,255	396	2,711	3,107
Grand total	944	[4] 2,645	3,589	1,018	[4] 3,754	4,772

[1] Rock Creek, Unaka National Forest, Tenn. Burned in October, 1921. Examined in July, 1922.

[2] Mostly yellow birch, some sweet birch.

[3] Pitch, mountain, and shortleaf pines. In the dry-slope and ridge forest there were 41 single sprouts and 72 sprout clumps of pine per acre. These are not shown in the table as they are without any probable significance in the reproduction.

[4] On the dry site, single sprouts comprised 27 per cent and sprout clumps (tallied as units) 73 per cent of the sprout reproduction. On the moist site, these proportions were 41 and 59 per cent, respectively.

Single sprouts and sprout clumps on the burn cited in Table 11 make up 74 per cent of the reproduction on the dry site and 79 per cent on the moist site, and these proportions would have been much greater if all the sprouts in the clumps had been counted. Furthermore, the less desirable species have produced two or three times as many sprouts on the moist site as the more desirable. The sprouts alone are more than ample to restock the area, and because of the early growth impulse of sprouts the survival of the seedlings is endangered. This is especially true with the seedlings of the yellow pines, whose early growth is very slow. The more rapid-growing species, such as yellow poplar, will usually find space for growth in chance openings among the sprouts. A rapid decrease in the number of living trees per acre is to be expected as the stand grows. Table 8 shows, for example, that 40-year-old stands of well-stocked second growth on the better dry slopes and ridges will contain about 228 trees per acre that are 6 inches d. b. h. and over, or less than 6.5 per cent of the initial stand of sprouts and seedlings shown for this site in Table 11. The corresponding percentage for the moist slope and cove site is less than 5.5 per cent.

The effect of fire upon reproduction in the spruce forest of North Carolina is illustrated in Table 12 and Figure 6. The uncut spruce forest is nearly fireproof because of the heavy shade and consequent dampness of the forest floor. When cut over, however, the fire risk is very great, and a large part of the area formerly covered by this forest now has only scattered trees of spruce and fir. The table illustrates the negligible proportion of spruce, fir, and hemlock reproduction and the preponderance of yellow birch and of worthless small trees and shrubs that are characteristic of severe burns in the spruce forest.

TABLE 12.—*Reproduction per acre, less than 1 inch d. b. h., on burned and unburned cut-over areas in the spruce forest, by species*

Species	On unburned area [1]	On burned area [2]
Red spruce	88	10
Southern balsam fir	555	7
Hemlock	27	1
Yellow birch	715	4,197
Small tree species and tall shrubs	[3] 5,418	[4] 23,789
Total	6,803	28,010

[1] Cut in 1918–19, examined in 1922 (0.9 acre), Hornbuckle Creek, Jackson County, N. C. The original stand contained 76 spruce and fir and 3 yellow birch trees, per acre, over 12 inches in diameter breast high; of these, all the spruce and fir were cut. Present stand contains 458 spruce and fir, and 4 yellow birch trees per acre between 1 and 12 inches in diameter.

[2] Cut in 1917, burned in 1918 (fall), examined in 1922 (3 acres), West Fork, Pigeon River, Haywood County, N. C. The original stand contained 93 spruce and fir and 4 yellow birch trees, per acre, over 12 inches in diameter breast high; of these, all the spruce and fir and all but 1 of the yellow birch trees were removed. Present stand contains 2 fir trees and 2 yellow birch trees per acre between 1 and 12 inches in diameter.

[3] Rhododendron, 12 per cent; pin cherry, 69 per cent.

[4] Rhododendron, 10 per cent; pin cherry, 75 per cent.

In the spruce forest the characteristic cover after fire is of raspberry, blackberry, and other bushes, into which advances later a practically worthless stand of pin cherry, or of yellow birch seedlings for whose rapid growth or symmetrical development soil and exposure

are often unfavorable. Often burned-over areas are seized by rhododendron or laurel, producing the so-called "ivy slicks." The only way to restock spruce burns with spruce, fir, or other suitable softwoods is by planting, which should be done immediately after the burning, so as to avoid as far as possible the losses from competition with the shrubby vegetation which will quickly appear.

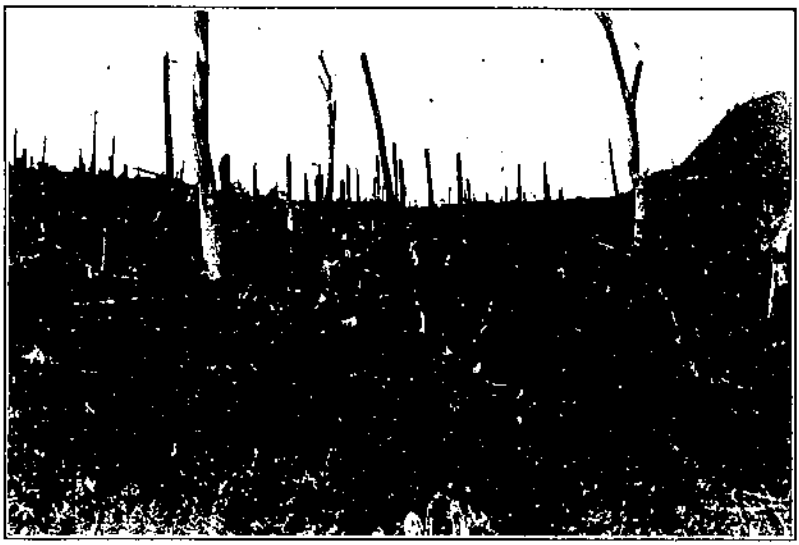

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FIGURE 6. The cut-over and burned spruce forest as it appears a few years after the burn—no sign of spruce or fir reproduction and no seed trees left to supply it. (Mount Mitchell, N. C.)

SEEDLING AND SPROUT REPRODUCTION

The reproduction on cut-over hardwood lands in the southern Appalachian region is generally a mixture of seedlings and sprouts. Under suitable conditions most of the hardwoods reproduce well in both ways. The conifers—pines, spruce, fir, hemlock, and red cedar—reproduce only by seed.[8] The different tree species in the forest have distinct individual characteristics of seed production and germination, capacity to produce successful sprouts, and early growth rate of seedlings and sprouts, and a knowledge of these characteristics can be utilized in logging to control the composition and value of the future stand.

As a rule, seedlings make better trees than sprouts. Sprouts at first grow more rapidly than seedlings, since they can draw on the root systems of the parent trees. They may outgrow seedlings for a few years or for several decades, but except in the case of chestnut and perhaps basswood they do not long maintain their superior growth and do not reach the large sizes attained by trees that have grown direct from the seed. Seedling trees also are likely to be healthier than sprouts, which frequently become infected with diseases present in the stumps or roots from which they have sprung.

[8] Shortleaf pine, as has already been noted, reproduces also by sprout, but not well enough to make this means practical under ordinary conditions.

Sprout growth exhibits a vigor in inverse ratio to the size of the stump from which the sprout originates. Seedling sprouts (single sprouts from small stumps of an inch or less in diameter) are practically as good as seedlings, over which they have the advantage of the early growth impulse. As a rule, sprouts from trees large enough to be cut for saw logs are weak and temporary. Of all the southern Appalachian species, basswood and chestnut are the only ones that commonly produce large timber from sprouts grown from the stumps of trees of saw-log size. Chestnut, or course, is out of consideration because of the blight, and basswood is not very abundant. Among the oaks, chestnut oak is the most prolific and persistent sprouter. The sprouting capacity of most species diminishes with successive cuttings.

In their capacity to reproduce by seed the tree species differ quite widely. The good seed crops borne by many of them are a source of food to rodents, birds, and insects, and only a small part of the seed produced escapes destruction. A few—notably basswood, holly, hemlock, and cucumber magnolia—often fail to reproduce (for reasons not as yet well understood) even when the seed supply is plentiful. Of the oaks, white oak and red oak are frequently deficient in seedling reproduction, but chestnut oak is usually prolific. Yellow poplar, also, is an excellent reproducer under favorable conditions of soil and moisture. Among the best, however, are some of the least desirable species, and this fact emphasizes the advantage of leaving seed trees of the better species in order to maintain or improve the quality of the forest composition. For all species that do not sprout well, seed trees are the best guarantee of successful reproduction. For those that do produce vigorous sprouts, seed trees are desirable as a means of rejuvenating the stand with a more lasting form of growth.

The efficiency of seed trees is lowered by the losses to which seeds may be subject in the forest. Seed destruction by squirrels, chipmunks, mice, birds, and insects is particularly important for the heavy-seeded species. From counts of acorns made under the crowns of 37 seed-producing trees of chestnut, white, black, and red oaks, Korstian (*34*) found that of a crop averaging 3,500 acorns per tree, 98 per cent were destroyed by animals or insects, or failed to germinate for other reasons. There is evidence that the seed of other valuable species is subject to similar heavy losses.

Other losses result from forest-floor conditions unfavorable to the germination of seed or the establishment of seedlings. It was found by Korstian that acorns which germinate on excessively compact soil are unable to take root. Two hundred acorns each, of red, black, white, and chestnut oaks, were put on a bare soil surface and covered 2 inches deep with hardwood-leaf litter. The same number for each species were similarly placed but without litter cover. On the bare areas an entire failure of seedling establishment resulted, whereas on the soil protected by leaf litter the survival was from 64 to 93.5 per cent. Only when the acorns are buried in mineral soil by heavy rains does there appear to be much chance of seedling establishment without a cover of leaf litter.

Yellow poplar, on the other hand, requires a mineral soil for germination, though soil moisture is necessary. Hemlock, sugar maple,

beech, birch, spruce, and fir will germinate in decomposed organic material, extending their roots through it to the mineral soil. Organic material in the soil has a stimulating effect upon reproduction of trees of all kinds; the vigorous growth of young stands on newly cleared sites is due to the large amount of humus in the forest soil (*63*).

When seed production is heavy, even though losses are as great as those above noted, there may be some germination of seedlings of desirable kinds; but the reproduction that results is usually too scanty to be of much promise for the future stand. Losses are sure to occur after germination, owing to the severe competition to which the reproduction is subjected. The especially desirable kinds should therefore be amply represented, and this can best be insured by leaving a considerable number of well-chosen seed trees.

Sprout reproduction is especially characteristic of burned cut-over lands (pl. 6, A) as brought out in Table 11; but even on unburned areas sprouts often outnumber seedlings. This is shown in Table 13, based on the same representative areas that furnished the data for Tables 5, 7, and 10. Sprouts form 38 to 53 per cent of the total unshaded reproduction in the several types represented, and far outnumber the seedlings of the desirable species. If the reproduction should be killed back by fire the ensuing growth would consist very largely of sprouts, as in the cases already discussed.

TABLE 13.—*Comparison of sprouts and seedlings among unshaded reproduction in unburned cut-over hardwood forest* [1]

Forest type	Seedlings per acre		Sprouts per acre		Total reproduction per acre
	Desirable species	Less desirable species	Desirable species	Less desirable species	
	Number	*Number*	*Number*	*Number*	*Number*
Dry slope and ridge:					
Black oak-scarlet oak type	79	118	15	140	352
Chestnut oak type	101	140	34	172	447
Moist slope and cove:					
Cove hardwood type	85	96	18	95	294
Northern hardwood type	53	68	118	16	255
Chestnut type	89	180	25	161	404

[1] Prepared from the records of the sample plots used for Tables 5, 7, and 10. The numbers and areas of the plots measured in each forest type, and the period since the last cutting, are shown in Table 5. The figures are for reproduction from 0.5 to 3 inches d.b.h. Since single sprouts from very small stumps quickly assume the characteristics of seedlings, all such were tallied as seedlings.

EFFECT OF COMPETITION IN YOUNG STANDS

Sprouts and seedlings of the less desirable species are commonly a serious menace to the reproduction of better species. In the older cuttings dogwood, sourwood, and other inferior small trees are frequently found to have outgrown better species and to form the greater part of the crown cover. (Pl. 10, A.) The time to prevent this is while the reproduction is small enough to be easily cut or broken back and before there has been much loss among the desirable species. What may be accomplished is illustrated by a weeding experiment now being conducted by the Appalachian Forest Experiment Station near Lookingglass Rock, Pisgah National Forest, N. C. A heavy reproduction of yellow poplar that started

after a burn in May, 1916, soon became overgrown by a dense cover of sumac and sprouts of inferior trees. In 1924 this cover was 10 to 25 feet high, while the average height of the poplars was only 2 or 3 feet; they were weak and spindling, and evidently suffering badly from the dense shade and root competition of the overtopping chestnut, silverbell, sumac, and other inferior species. About two-thirds of the stand of inferior species was cut back in 1924 on a sample area of 1 acre. Four years later it was found that the number of yellow poplars over 0.5 inch d. b. h. had increased by nearly 500 per cent, while the increase in the number of inferior species was less than 30 per cent. The poplars had gained in vigor and, on an average, were 3.8 feet taller than those on an adjacent sample plot that had been left untreated for comparison. There is now little doubt that yellow poplar will predominate in the future stand on the weeded area. On the unweeded area practically all of the poplar will be killed out by the inferior species that monopolize the crown cover.

Rhododendron and laurel often cover the ground with a dense shade underneath the forest crown cover (pl. 10, B) or outside of the forest, the laurel commonly on high slopes and ridges. Outside of the forest, these "ivy slicks" appear to have fast hold of the ground, preventing the development of tree seedlings. Presumably they were present under the original forest, which gave way to them through inability to renew itself, for under tree shade laurel and rhododendron thickets will entirely prevent tree reproduction. Considerable areas of otherwise good forest soil support only scattered defective old-growth timber, left after logging, with practically no undergrowth except these tall, heavy-foliaged evergreen shrubs.

Rhododendron and laurel usually grow in clumps or sprouts that spread out widely from the center. When cut back, quite a number of years will elapse before the clumps again come together. This gives time for the establishment of tree seedlings between the clumps. Numerous observations indicate that seedlings of poplar and other hardwood species have little trouble in keeping ahead of laurel and rhododendron sprouts if given an equal chance.

A somewhat similar condition exists on dry, burned areas where various huckleberries and other shrubs form a dense ground cover 4 or 5 feet high under thin stands of scarlet oak, pines, and other dry-site species left after logging. The shade is not so dense, but with the dryness of the soil, which accentuates competition for moisture, a combination very unfavorable to tree reproduction is set up.

In thin-soiled spruce forest, heavy logging may cause the death of rhododendron through the drying out of the soil. This frees the soil of the dense cover but adds to the inflammable accumulation of slash and litter that makes cut-over spruce forest the most dangerous fire risk of all the southern Appalachian forests. The drying of the soil when the cover is removed may also inhibit spruce and fir reproduction, except in moist spots between the rocks.

A common cause of injury in young second-growth stands is the presence of vines, particularly grapevines. These smother the crowns and bend small trees over by their weight, often damaging or destroying the greater part of a sapling stand. The obvious remedy is to sever the vines, where the damage has not already gone too far for recovery.

FOREST-INSECT DAMAGE*

Damage by forest insects to standing timber and to forest products represents an appreciable annual drain upon the timber supply of the southern Appalachians. While it has not been possible to make sufficient studies to evaluate these losses accurately, enough information has been obtained to show that insects are an important factor, as well as fire and chestnut blight, in directly affecting the continuous timber production of the region.

The greater part of this damage is caused by bark beetles which destroy living trees and by boring insects which affect the quality of the wood of trees. Seeds and seedlings also sustain considerable losses. Additional injury results from defects in the felled product. This may vary from a slight degrade to a total loss of the material for the purpose for which it was intended. Damage to lumber and to seasoned finished products is high because of the money represented in materials and in the labor expended upon them.

INSECTS AFFECTING LIVING TREES

Some of the more important insects which affect living trees, either causing death or defects in the parts which furnish commercial products, are the southern pine beetle, *Dendroctonus frontalis* Zimm., which kills all species of pine within its range; the chestnut timber worm, *Melittomma sericeum* Harris, an insect which causes "shot wormhole" defects in almost every chestnut tree; the oak timber worm, *Eupsalis minuta* Drury, which is responsible for the same type of defect in oaks, particularly in northern red and chestnut oaks; the Columbian timber beetle, *Corthylus columbianus* Hopk., which makes defects known as spot wormholes in white and chestnut oaks; the locust borer, *Cyllene robiniae* Forst., which infests practically all young reproduction up to the time it has reached a diameter of 6 inches, unless protected by shade; and the hickory bark beetle, *Scolytus quadrispinosus* Say, which is attracted to hickory trees that have become weakened by such agencies as drought, fire, or lightning.

Southern pine beetle epidemics are the cause of serious periodic losses to pines in the southeastern section of the United States. It has been estimated that the value of timber killed by this beetle alone during the past 40 years, based on present stumpage values, would amount to-day to about $50,000,000. A considerable portion of the pine killed during this time has been in the southern Appalachian region, particularly in the States of West Virginia, Virginia, North Carolina, and Tennessee. Although shortleaf and pitch pines are probably most susceptible to attack, other species, including white pine, have been killed over large areas, especially in West Virginia.

Southern pine beetle outbreaks are correlated with marked deficiencies in rainfall. Since the year 1922 many such "killings" have been found within national forests and State parks in western North Carolina and eastern Tennessee. In the drought years 1922, 1925, 1927, and 1930 beetles were abundant in these areas. During the record-breaking drought of 1930 what is believed to be one of the

* Prepared by R. A. St. George, Associate Entomologist, Division of Forest Insects, Bureau of Entomology.

largest epidemics since 1911 was located in the Smoky Mountains in the vicinity of the proposed new park area. As a result of these group killings, this beetle has been responsible for the change from pure pine to mixed pine-hardwood stands.

This beetle has also been attracted to recently burned areas. This was true in the case of three spring fires which occurred in pine stands located on the land of, or adjacent to, the Pisgah National Forest.

It is quite well known that summer cutting of pine creates conditions attractive to this beetle. In the Pisgah Forest it was found that this beetle followed a logging operation over a period of four or five years, from one mill site to another, infesting trees in the vicinity of the cuttings and of the mill. In addition the cull logs left in the woods and large tops down to a diameter of 4 inches served as breeding places.

The chestnut timber worm, in addition to causing defects which result in a degrade in lumber, also weakens the tree sufficiently to enable other less aggressive wood borers, as well as fungi, to establish themselves successfully. During a recent study [10] of Appalachian hardwoods to obtain information on small sawmill operations, it was ascertained that 82 per cent of the primary and 11 per cent of the secondary defects (shot wormholes) in chestnut logs and lumber were caused by this insect. Results of entomological investigations, conducted in cooperation with the Forest Service in this study, indicated that 96.2 per cent of the sound wormy grade of lumber was affected by this beetle, which resulted in a 50.6 per cent loss for the grade. The work of this insect is largely confined to parts of the tree which have been injured or weakened in some way.

The oak timber worm often causes considerable damage to large, mature, or overmature white oak trees. These defects (shot wormholes) in wood put to special use, such as for cooperage purposes, are often so extensive that the wood is rendered useless. This is especially true of some of the white oak removed in West Virginia. The northern red and chestnut oaks in the Pisgah and Shenandoah National Forests also contained some of these defects.

The Columbian timber beetle not only causes damage by making pinhole defects (spot wormholes) in logs and lumber but also has a black stain associated with it which discolors the wood for 2 to 3 inches each side of the gallery in oak. In yellow poplar these streaks are sometimes 5 or 6 feet long, and then the wood is designated as "calico poplar." In the above-mentioned cooperative study by the Bureau of Entomology the work of this beetle was found in 20.5 per cent of the chestnut oak and in 3.7 per cent of the white oak logs.

The locust borer is an insect which presents difficulties to the production of good-quality black locust in the southern Appalachians. It attacks practically all saplings up to post size, when grown in the open without adequate protection of shade. In some plantations this injury is so extensive that it makes the production of this species on a commercial scale unpractical. In such cases the wormholes are so numerous from repeated attacks, year after year, that the weakened

[10] GARVER, R. D., and MILLER, R. SMALL SAWMILL UTILIZATION OF APPALACHIAN HARDWOODS. PART I. LUMBER . . . U. S. Dept. Agr., Forest Service . . . p. 81. December, 1929. [Mimeographed.]

stems readily blow over in a windstorm. While this condition has not been observed in this section, yet about the only trees free from injury are those that have come up in a thick stand or under cover of other species.

Hickory bark beetle outbreaks are not frequent. However, whenever trees are weakened by conditions of drought or fire, this beetle is often attracted and trees are killed (*50*). Hickory trees weakened by fire during the spring of 1927 in the Pisgah National Forest were attacked by this insect and died.

INSECTS AFFECTING FOREST PRODUCTS

Recent estimates by the Bureau of Entomology of insect damage (*72, p. 17*) to all classes of forest products, not including replacements, has placed this loss at $50,000,000 for the entire country. In an earlier part of this bulletin it was estimated that the southern Appalachians produced about 6,000,000,000 board feet of products annually. If the percentages of loss in each class of products, estimated for the country as a whole, were applied to this figure and evaluated accordingly, the annual loss to forest products for this region would amount to $670,750. These figures were based on a loss of 2 per cent each for lumber, fuel wood, and railroad ties, and 5 per cent each for pulpwood, mine timbers, and cooperage. It is realized that these figures are only roughly approximate, but they indicate that there is probably a greater annual loss to forest products than might be suspected.

Injury to forest products is caused by beetles and "grubs" of certain wood-boring insects which cause pinhole and wormhole ("grub hole") defects in logs and lumber. Seasoned lumber and finished wood products are also damaged and sometimes completely destroyed by other insects known as powder-post beetles, which are capable of reducing wood to a powdery mass. Construction timbers and other wood materials utilized in buildings, bridges, railroad operations, and mining and rustic work are often infested by beetles or grubs of other insects and by termites. Stored oak, chestnut, and hemlock bark used for tanning purposes is, under certain conditions, damaged by insects. These insects work in the inner bark, reducing it to a powdery mass.

THE CHESTNUT BLIGHT

The accompanying map (fig. 7), prepared by the Office of Forest Pathology, Bureau of Plant Industry, shows for 1930 the status of the chestnut blight, which has already spread throughout the range of chestnut in the southern Appalachian region. In all the chestnut-producing counties of Virginia 80 per cent or more of the chestnut trees are infected. Forty-five counties of West Virginia, 22 of North Carolina, 3 of South Carolina, 10 of Georgia, and 7 of Tennessee are in the same condition of infection. In all the remaining 87 counties with extensive chestnut growth in these States and in Kentucky, from 30 to 79 per cent of the chestnut trees are infected. Forest pathologists who have studied the spread of the blight since its discovery in New York City in 1904 believe that by

1935 nine-tenths of the counties in the southern Appalachian range of chestnut will be 80 to 100 per cent infected (*26*).

Investigations by the Office of Forest Pathology (*25*, *25a*) have shown that once the disease has established itself in a stand its progress is fairly well defined and the future degree of infection, mortality, and consequent deterioration can be estimated quite closely.

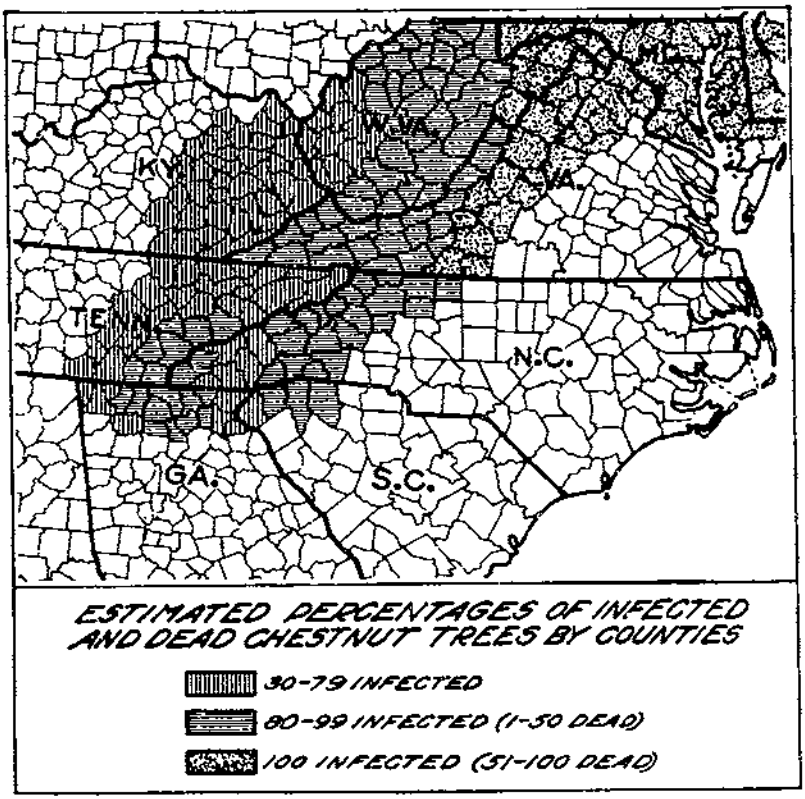

FIGURE 7.—Distribution of chestnut blight in the southern Appalachians

Table 14 presents the general trend of increase in the percentage of infected and dead trees as found on a number of areas in Virginia and Maryland.

TABLE 14.—*Progress of infection and mortality by chestnut blight following establishment of the disease, Virginia and Maryland, 1927* [1]

Period after infection of 1 per cent	Trees infected	Trees killed	Period after infection of 1 per cent	Trees infected	Trees killed	Period after infection of 1 per cent	Trees infected	Trees killed
Years	*Per cent*	*Per cent*	*Years*	*Per cent*	*Per cent*	*Years*	*Per cent*	*Per cent*
1	3		6	80	2	11	100	75
2	10		7	90	5	12	100	85
3	20		8	95	15	13	100	90
4	40		9	99	30	14	100	95
5	60		10	100	55			

[1] As presented in (*25*).

The increase in infection of about 10 per cent and in mortality up to 95 per cent appears to follow a definite order of progression. Thus the owner of chestnut timber who finds that 20 per cent of the trees are infected can be reasonably certain that after three years the trees will begin to die and that within seven years the stand will be completely infected and half the trees dead. With this knowledge the owners of considerable tracts of chestnut containing different degrees of infection can systematize the salvage operations. The owner of the 20 per cent infected stand can afford to wait three years without fear of serious loss, and to concentrate the salvage on the stands in which the disease has reached the most advanced stage. This delay may permit the owner of a recently infected stand to postpone or prolong the salvage so as to await a more favorable market.

Twenty-five years ago, before the significance of the blight then newly discovered in the North was realized, chestnut was just on the threshold of economic importance. After that it grew steadily in estimation and now combines more uses than any other tree in the southern Appalachian Mountains. It is one of the most widely distributed species, occurring not only in a distinct chestnut type, usually on north exposures, but also as an important component of the forest in coves and on lower slopes, dry slopes, and even ridges, up to an altitude of 5,000 feet. Since it is one of the most rapid-growing species and exceeds all others in its capacity to reproduce abundantly and well by sprouts, it apparently had the greatest promise for forest management.

In spite of the heavy loss through the blight, chestnut still is the most abundant timber tree in the southern Appalachian Mountains. According to Table 3 it comprises 13 per cent of the total stand of national-forest saw timber. Some of the individual national forests, however, report much larger percentages. According to the estimates for the Pisgah and Unaka National Forests, chestnut forms 27 per cent of the total saw-timber stand. Of the stand available for products other than saw timber, chestnut forms an even larger proportion. In the total cordwood stand reported by the national forests (Table 4) chestnut tanning-extract wood made up over 64 per cent; for the Nantahala and Natural Bridge Natural Forests the proportion was 97 per cent. Chestnut figured also in the estimates of fuel wood, railroad ties, and posts and formed practically the entire estimated number of poles. A rough estimate of chestnut extract wood made in 1925 placed the total stand in the southern Appalachian region at 33,700,000 cords, two-thirds of which was available to existing tanning-extract plants (*24*).

All research to find means for conquering the blight or arresting its spread has thus far proved fruitless. Although it is possible that in some way enough of the chestnut will be saved to permit its gradual return, the immediate concern of timberland owners is to salvage their present stands of chestnut in time to prevent total loss through death and decay. Unfortunately for the salvage of chestnut, the present demand for chestnut products is not nearly large enough to justify the hope that the bulk of the stand can be economically utilized. The disease is acting too rapidly and the distances from which much of the wood must be brought are too great for the operation to be profitable. Where chestnut will pay its way

out of the woods its early removal is distinctly desirable, both for the profit on the material that would otherwise be lost and to avoid delay in the regeneration of the forest.

For a year or possibly two after death a blight-killed chestnut tree will furnish just as good wood as any cut from a live tree. If the tree is left standing longer than two years the sapwood begins to decay, but the heartwood still remains sound and suitable for a great number of sawed products. In the next stage of deterioration the heartwood begins to dry out and consequently to check. Lastly, if within about six years the tree is not cut and taken from the woods the heartwood becomes infected with decay, which destroys its usefulness for practically all purposes except extract wood and fuel.

Table 15, prepared by the Forest Products Laboratory, lists the main uses for which blight-killed chestnut is suitable, according to the state of the wood when cut. Owners of chestnut timber would do well to consider possible markets in the order in which the products are grouped in the table. Manufacturers or users of these products should give chestnut all possible consideration, for their demands during the next 15 years will determine how much of this valuable wood can be saved from total loss.

TABLE 15.—*Utilization guide for blight-killed chestnut*

Period after death of tree	State of wood when cut	Best uses
Up to 2 years	Sapwood and heartwood sound	Poles and mine timbers. Highway and railway fence posts. Railroad ties. Boxes and crates. Core stock. Slack cooperage.
2 to 4 years	Sapwood decayed but heartwood sound and unchecked.	Yard lumber and planing-mill products. Millwork. Furniture and cabinet work. Coffins and caskets. Woodenware novelties. Rough construction.
4 to 6 years	Sapwood decayed; heartwood checked, but sound.	Farm fence posts. Tannin wood. Pulpwood.
6 years and after	Heartwood badly checked and infected with decay.	Fuel wood.

A large majority of commercial organizations prefer living chestnut to dead for their particular uses. For poles some companies accept only living trees, while others take dead chestnut as well. The larger purchasers will not accept chestnut poles showing blight cankers or decayed sapwood; other companies specify that the portions to go below ground shall be free from sapwood rot or cankers. For extract wood chestnut trees can be used for many years after they have been killed, although after about four years there is some loss in volume through the decay of sapwood. Studies by the Office of Forest Pathology, Bureau of Plant Industry, in cooperation with extract companies, indicate that the loss in tannin content is not excessive even in trees that have been dead 20 or 30 years (*45*).

The most profitable use for chestnut trees that meet size and form requirements is for poles. Trees between 10 and 17 inches d. b. h., capable of supplying poles 25 to 65 feet long, are usable if they comply with the specifications as to straightness, taper, and defects.

Only a small portion of the total stand, therefore, is usable for poles, but suitable trees are generally worth at least twice as much for poles as for saw logs (*48*). The stands that will produce the greatest percentage of poles are usually sprout stands that followed cuttings made 25 to 75 years ago. Blight-killed trees should be cut while green or as soon after death as possible in order to avoid loss in felling, since dead timber breaks more easily than green. As sound wood is required for poles the trees should not be left standing more than one or two years.

The loss of chestnut will greatly change the composition of the forest. A study of the character and effectiveness of natural replacement of blight-killed chestnut in the earlier-infected chestnut stands of the Northeast (*35*, *36*) indicates that the natural replacement of chestnut with desirable species is rapidly taking place. The new growth as it has appeared in the Northeast is largely red oak, white oak, chestnut oak, black oak, and scarlet oak, associated with hickory, white ash, sugar maple, and other valuable species. In addition to this, the species associated with the chestnut in the original stand gain greater growing space and a consequent stimulation in growth. The crowns of these trees are effectively closing the openings left by the death of the chestnut. The remaining stand has responded to the increased light and space with increased growth, ranging from 26 per cent in white oak to 63 per cent in red oak. Although this increased growth rate is smaller than was the growth rate of the chestnut, the stands, both young and old growth, are well on the way to recovery.

In the southern Appalachians much the same result can be expected. Of the many tree species with which chestnut associates on different sites, the majority are good reproducers, and a number are of rapid growth and considerable intrinsic value. Studies of chestnut replacement are now being conducted by the Appalachian Forest Experiment Station by means of permanent sample plots, and the indications are that the natural replacement of chestnut by other species in the South should be equal to that in the North, if not more effective (*33*). What these species will be, of course, depends upon the composition of the stands on the different sites and the aggressiveness of the different species in reproducing. A preliminary study made in 1920 by E. R. Hodson, of the Forest Service, resulted in the conclusion that there is in general sufficient advance growth of desirable species to restock the stands. On some unfavorable sites, however, the advance growth is inadequate, and where this condition is complicated by dense underbrush there is danger that the establishment of desirable species will be delayed for a long time.

The opinion has occasionally been expressed (*30*) that later generations of chestnut sprouts from the stumps of cut or killed trees are resisting the blight and may finally become immune or escape infection. If this should be the case, it is possible that here and there some of the chestnut may survive the disease so that the species will not be entirely exterminated.

A review of the chestnut-blight situation (*23*) suggests the following conclusions:

Satisfactory replacement with other species is generally to be expected.

Successive, short-lived generations of sprouts from blight-killed chestnut, with their tendency to spread out and monopolize growing space, endanger the development of other hardwood reproduction. This danger is augmented in mixed stands by the growth of shrubs and the shade from living trees. The tendency of the crowns of "hold overs" to expand and fill openings left by the death of the chestnut increases the shade still further. In the southern Appalachians the problem is rendered acute by the fact that some of the most desirable tree species are not able to endure prolonged shading.

Timber owners should take any profitable opportunity that arises to dispose of chestnut, preferably in advance of the blight.

ECONOMY IN RESERVING SMALL TREES FOR GROWTH

Lumbermen know in a general way that small logs and trees are more costly to cut and handle, and that they saw out a poorer quality of lumber than large ones, but the relative profit or loss involved in handling different sizes of trees is rarely given much consideration. Operations are constantly encountered in which trees too small to pay their way out of the woods are cut and manufactured into lumber. This constitutes both a direct financial loss to the operator and a reduction in the value of the stand for future cutting. As a factor in continuous timber production, young trees on the verge of commercial value are the very ones which it is most important to leave in the stand. To cut them at a loss is thus doubly uneconomic. Even when large enough to yield a slight immediate profit to the operator, their prospective value to the timberland owner will generally warrant leaving them for a future cut if they are straight and sound.

Tables 16 and 17 illustrate for two actual cases studied by the Forest Service the pronounced effect that a regard for the profit or loss involved in handling different sizes of trees may have upon the financial success of a lumber operation. In these studies, individual logs representing trees of different sizes were followed from the tree through the mill, and the total cost of logging and milling, including the overhead charges, was determined from these cost records. The value of each tree in terms of current lumber prices was similarly determined from records of the amount and grades of lumber sawn from its component logs. As brought out in these tables, the difference between the selling price of lumber and the total cost of manufacture must cover both the operator's margin, which he will need to ensure a profit on the operation and to provide against possible losses, and the stumpage value of the timber, or the amount he can afford to pay for it if the operation is to yield the desired profit margin. For illustration, a profit of 20 per cent on the total cost of operation has been arbitrarily used in the tables; any other desired percentage of profit may of course be substituted. The stumpage values shown (see last column of Tables 16 and 17) represent the amounts an operator could afford to pay for trees of corresponding sizes in order to clear a profit of 20 per cent on his investment. The stumpage value might be further subdivided to recognize a profit on the stumpage itself, which the owner might reasonably expect; but since this is rarely considered in stumpage transfers it has not been differentiated. The profit and stumpage per tree were derived from the figures per thousand board feet by means of volume tables showing the volume in lumber by the

Scribner Decimal C log rule, of trees of different diameters. For Table 16 the volume table used was for net volume, after deducting from the log volumes for defect, sweep, etc. For Table 17, a gross log scale volume table was used.

TABLE 16.—*Stumpage values of red oak trees of different sizes; derived from lumber value and total cost of production*[1] *and assuming an operator's margin of 20 per cent of production cost for profit and risk*

Diameter breast high (inches)	Cost of producing lumber[2] (per M ft. b. m.)	Selling price of lumber (per M ft. b. m.)	Available for stumpage value and operator's profit	20 per cent profit on cost of production	Available for stumpage after deducting 20 per cent profit	
					Per M board feet	Per tree
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
13	33.63	37.89	4.46	6.69	−2.23	−0.11
14	32.18	38.10	5.92	6.44	−.52	−.04
15	30.98	38.80	7.82	6.20	+1.62	+.15
16	29.84	39.16	9.32	5.97	3.35	.39
17	28.70	39.53	10.83	5.74	5.09	.71
18	27.79	40.04	12.25	5.56	6.69	1.14
19	26.75	40.24	13.49	5.35	8.14	1.63
20	25.98	40.64	14.66	5.20	9.46	2.18
22	24.36	41.03	16.67	4.87	11.80	3.54
24	23.15	41.71	18.56	4.63	13.93	5.20
26	22.24	42.32	20.08	4.45	15.63	7.35
28	21.49	43.06	21.57	4.30	17.27	9.84
30	20.96	44.15	23.19	4.19	19.00	13.20
32	20.62	45.25	24.63	4.12	20.51	17.33
34	20.31	46.26	25.95	4.06	21.89	22.33
36	20.16	47.36	27.20	4.03	23.17	28.04
38	20.06	48.50	28.44	4.01	24.43	34.45

[1] Compiled from the following: GARVER, R. D., and MILLER, R. SMALL SAWMILL UTILIZATION OF APPALACHIAN HARDWOODS. U. S. Dept. Agr., Forest Service, Forest Prod. Lab. 103 p. 1929. All values are computed for net log scale (gross log scale, Scribner Decimal C rule, minus allowance for defect).

[2] Includes cost of sawing, skidding, milling, supervision, maintenance, depreciation, insurance, taxes, hauling and piling lumber, inspection, selling, roads, and trails. It also includes an amount varying from $0.26 to $0.44 per tree for additional brush lopping done after the log cutting was completed.

TABLE 17.—*Stumpage values of yellow poplar trees of different sizes; derived from lumber value and total cost of production*[1] *and assuming an operator's margin of 20 per cent of production cost for profit and risk*

Diameter breast high (inches)	Cost of producing lumber[2] (per M ft. b. m.)	Selling price of lumber (per M ft. b. m.)	Available for stumpage value and operator's profit	20 per cent profit on cost of production	Available for stumpage after deducting 20 per cent profit	
					Per M board feet	Per tree
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
13	31.85	29.85	−2.00	6.37	−8.37	−0.95
14	30.45	30.90	+.45	6.09	−5.64	−.85
15	29.20	32.00	2.80	5.84	−3.04	−.56
16	28.20	33.20	5.00	5.64	−.64	−.14
17	27.50	34.50	7.00	5.50	+1.50	+.40
18	26.80	35.95	9.15	5.36	3.79	1.19
19	26.20	37.35	11.15	5.24	5.91	2.18
20	25.65	38.80	13.15	5.13	8.02	3.37
22	24.70	41.65	16.95	4.94	12.01	6.70
24	23.90	44.50	20.60	4.78	15.82	11.27
25	23.65	45.80	22.15	4.73	17.42	13.75
30	23.10	50.10	27.00	4.62	22.38	27.86

[1] Compiled from Ashe (*5, p. 31*).

[2] The average costs per thousand board feet of the variables were: Felling, $2; skidding, $6; loading and railroad haul, $2; milling, $3.75; total, $13.75. The costs that did not vary, or varied only slightly were: Railroad construction, $2; inspection and loading, $2; selling, $2; office, $3; depreciation, $2.50; total, $11.50. The average total cost for yellow poplar was $25.25 per 1,000 board feet; 7 logs per 1,000 board feet.

The figures for red oak, presented in Table 16, are based mostly upon a single small circular-saw operation in western North Carolina, with additional information from three other small mills. The average output of these mills was about 7,300 board feet a day. The timber in which they operated represented a fair average for the culled mountain forest of the region.

It is evident that when operating costs and lumber values are as shown in Table 16, the smallest red oak tree an operator can cut and still make 20 per cent profit on his investment will be 15 inches in diameter. For any tree smaller than this he will have to be satisfied with a smaller profit or an actual loss. On the other hand, the amount available for stumpage value at a constant profit margin increases steadily with the size of the tree. Thus under the conditions shown in Table 16 a 15-inch red oak is worth $0.15 as it stands, while one only 3 inches larger is worth $1.14, and a 20-inch tree $2.18. From this point on the value increases quite rapidly with the diameter. When individual trees are worth as little as a dollar, the owner should not permit them to be cut without taking into consideration the added value they would have if left to grow a few years.

Figures like those in Table 16 are of course directly applicable only to the specific operation in which they were obtained, but the same general relationship of size to feasibility of removal exists in all cases (*6*). In a similar study, made at a hardwood band mill in the mountains of North Carolina (*5*), production costs and graded lumber values of yellow poplar trees were found to be as shown in the first three columns of Table 17. The amounts shown in the table for stumpage of different-sized trees, if a profit margin of 20 per cent is desired, were derived from the difference between values and costs, as in Table 16.

In the case cited in Table 17 the lumber from 20-inch yellow poplar trees was worth $8.95 per thousand board feet more than that from 13-inch trees, and it cost $6.20 less to log and manufacture it. A balance of $13.15 per thousand was available for stumpage and profit in the case of the 20-inch trees, but for the 13-inch trees a deficit of $2 is indicated. Figuring the profit margin at 20 per cent of the cost of production, trees below 17 inches d. b. h. had no stumpage value in this particular operation, while 20-inch trees had a stumpage value of $3.37. The stumpage value rapidly increases with increase in diameter.

Since both logging and manufacturing costs and the price of lumber are variables, Tables 16 and 17 can serve merely as illustrations. There will always be a neutral size, however, at which, if a fixed margin of profit is figured, the stumpage value is zero. In the cases cited this is between 14 and 15 inches (Table 16) and between 16 and 17 inches (Table 17). For any designated margin of profit this neutral size varies not only in different operations but also in the different parts of the same operation. An increase in logging cost—as, for example, if skidding costs increase $2 per thousand board feet in order to reach less accessible timber—will automatically cause an increase in the neutral size. Furthermore, large mills with considerable fixed and relatively small operating costs can afford to log to somewhat smaller diameters than small mills in which the operating costs are large as compared with the fixed expenses. The neutral size

will also vary with the species, owing to differences in lumber prices and costs of logging. In general, however, it is clear that some trees large enough to make saw logs are too small to be handled for lumber except at a loss. It is manifestly to the interest of sawmill operators to determine the neutral size for the different species and for different localities in the operation.

MEASURES NECESSARY TO KEEP FOREST LANDS PRODUCTIVE

The measures for fire prevention and logging practice that are outlined in the following pages represent the minimum of protection and care needed to put timberlands into condition for continuous production. On areas that have been depleted by fire and unrestricted cutting these measures should, of course, result in an actual increase in yield of timber; but they are not adequate to obtain the largest and most valuable perpetual yields. Recommendations for further treatment to produce full timber crops are added under a later heading.

FIRE PREVENTION

Fire prevention is the first means to be employed in restoring growth capacity and improving the forest for continuous production. It has been shown that fires have in the past caused more injury to the forest than logging or any other influence. Decay introduced where fire has scarred the trees without killing them discounts the future value of otherwise rapid-growing trees. Destruction of leaf litter and humus, especially on the dry sites, has set back for years the date when mature timber crops might be expected. The value of future stands is further endangered by the preponderance of sprouts over seedlings on burned areas. In these ways repeated burnings have gradually worn down millions of acres of thrifty forest land to a point where possible timber production is far below that on acres adequately protected. Fire prevention is therefore the first step upon which all future development of the forest depends.

CAUSES OF FIRES

Of the average of 2,322 fires that burned each year from 1923 to 1927 in the protected counties of Virginia, North Carolina, West Virginia, and Tennessee, probably 99 per cent were man-caused. Lightning fires are very uncommon in the southern Appalachian region. The causes of these fires are shown in Table 18.

TABLE 18.—*Distribution by causes of fires in the mountain, plateau, and valley regions of four southern Appalachian States,*[1] *1923–1927*

Causes of fires	Fires per year		Causes of fires	Fires per year	
	Number	*Per cent*		*Number*	*Per cent*
Incendiary	453	19.5	Lightning	14	0.6
Hunters, campers, smokers	376	16.2	Miscellaneous and unknown	656	28.0
Brush burning	320	13.8			
Railroads	267	11.5	Total	2,322	100.0
Lumbering	242	10.4			

[1] Virginia, North Carolina, West Virginia, and Tennessee. Acknowledgment is made to the State foresters of these States for the data from which the table was compiled.

The largest number of fires of known cause were classified as incendiary. This, however, does not necessarily mean that they were set with malicious intent. It is the usual practice in the Southern States (*10*) to report all uncontrolled or wild fires as incendiary, if set on purpose, whether or not the element of malice is present. Thus, many fires are probably reported as incendiary that are set to kill snakes, to uncover chestnuts, or in an effort to improve the range for grazing. In many parts of the region the sentiment against burning is growing, and the number of incendiary fires, though still large, is probably much smaller than it was 10 years ago.

The growth in the number of tourists, campers, and hunters who visit the forest each year carries with it an increasing menace of fire. More than 16 per cent of the total number of fires during the 5-year period were caused by such persons. Some of these fires are likely to be set in out-of-the-way places so that their prevention and control are both important and difficult. This class of fires should be influential in setting the standards for the organization of patrol and fire-fighting forces.

Railroads and lumbering may be classed together as occupational causes of fire. Together they are responsible for more fires than any other class—about 22 per cent of the fires classified in Table 18. Both are controllable, by mechanical and other means, and involve risks that can be foreseen and prepared for more readily than those from the other causes.

Being man-caused, the majority of the southern Appalachian fires are avoidable, and the outlook for prevention is therefore more encouraging than, for example, in the Rocky Mountains, where 50 per cent of the fires in the decade 1916–1925 were caused by lightning. Another circumstance that bears upon the danger of fires starting, as well as upon the possibility of prompt and effective suppression, is the degree to which the forest lands are settled. While there are no completely satisfactory statistics from which this can be accurately determined, the 1920 census of rural population of individual States (which includes the inhabitants of cities of less than 2,500 population), compared with the forested area, furnishes at least an indication. According to these figures, Maryland, Virginia, West Virginia, North Carolina, Kentucky, and Tennessee have a forested area of only 7 acres for each rural inhabitant, while in six Western States—Washington, Oregon, California, Idaho, Montana, and Colorado—the area for each rural inhabitant is 33 acres. Since more people are living in or passing through the forest in the southern Appalachian region than in the Western States, the risks of man-caused fires are greater, but on the other hand control measures are more easily and quickly applicable.

NEED FOR COOPERATION

Since the loss from forest fires affects both the individual timberland owner and the public, protection from fire is logically a matter for public and private cooperation. The present accepted Federal and State policy contemplates a protective fund contributed half by timberland owners and half in equal shares by the Federal Government and the States (including the counties). This fund is

administered by the States. The fire-control forces that can be mustered under this fund, however, are generally too small to furnish the protection needed at all places in a territory as rugged as the mountainous parts of the southern Appalachian region. Thus, while the efficiency to be gained through the state-wide protective organizations makes it desirable that all timberland owners should contribute to it, the private owners should cooperate even further by reducing their own fire risks and hazards and providing for emergency suppression forces. The private protection of forests, in relation to that afforded by public agencies, is comparable to private protection of homes and factories in cities with efficient fire organizations.

By cooperating with one another and with State forces, owners of timberlands can obtain good protection at a relatively small cost, which can be considered as insurance upon the improvements, equipment, and other investments in growing timber. Protective organizations of timberland owners have functioned successfully in many parts of the United States. In West Virginia two have been in existence for a number of years; groups of landowners have been organized more recently in other States. The success of individual and of local organizations, however, will be increased in proportion to the progress of the public effort to prevent fires. This emphasizes the need of widespread cooperation.

Past experience has resulted in the development of efficient methods of fire protection. The needs of the future are, first, to supply the funds necessary to extend and intensify these methods and, second, to bring about a universal appreciation of the value of forests and of the many-sided loss from forest fires. Intensive campaigns of education among the users of the forest, and insistence upon the rigorous enforcement of laws aimed to prevent fires, are two ways in which timberland owners, by taking part in the general effort against fires, can help to safeguard their own properties. A third and, in the long run, the least expensive and most efficient method is the more and more intensive development of forest lands as actively producing resources. When this is accomplished fire prevention will become merely incidental to forest management, as it is in some of the European countries.

GENERAL MEASURES

The details of fire-control procedure will depend upon the kinds of risk and their relative importance, the kind, amount, and distribution of inflammable material, the number and reliability of the local inhabitants who can be called upon to detect and suppress fires, the age of the timber, the topography, and other considerations. There are certain general principles, however, that are applicable to all conditions.

ORGANIZATION

The outstanding requirement for successful protection is a responsible, effective, and easily working organization of funds and personnel, maintained by the State in cooperation with the counties, the Federal Government, and individual or organized timberland owners. The functions of the organization must be to prevent,

detect, and suppress fires, and since burning is largely due to general ignorance of the damage done by fires an important part of the work will be educational.

Educational activities are now recognized by all the States as of fundamental importance in the campaign against fires. Efforts are being made to reach all communities and all forest users, through the schools, churches, and such organizations as the Boy Scouts. Special lecturers are employed on this work in some States, and moving pictures and other means of arousing local interest in preventing fire are widely used. The added danger from fire represented in the increased use of the forest by fishermen, hunters, campers, and tourists calls for constant reiteration of the importance of preventing and extinguishing fires. The diffusion of information upon the damage from fire has thus become one of the essential duties of fire-protective organizations.

All the States included wholly or in part in the Appalachian region have organized fire-control for es. Because of inadequate financial support, however, these organizations have never been able to command the man power and equipment to render them fully effective. The limited funds available have been stretched out over large areas, providing in many cases only a skeleton system of fire protection and leaving many other areas without even the beginnings of an organization. Fire-prevention activities have been largely discretionary with the individual counties, the degree of activity in any county being determined not only by the adequacy of the State's resources but also by the willingness of the county to cooperate through voted funds. Two States, Virginia and West Virginia, have laws which provide that the counties shall pay fire-suppression costs. Many of the counties in the southern Appalachian States have elected to remain without protection. It is to the interest of timberland owners to see that protection is furnished and to amplify it by their own action to the extent necessary to safeguard their properties.

The central State organization has, or should have, a detailed plan of protection for the several counties. The average extent of woodland in a county is about 150,000 acres. A county of average size is as large an area as can usually be handled with any degree of effectiveness by a single head warden. The head warden should be employed during the fire season and should work under the direction of the central headquarters. The head warden's district should be subdivided into small areas, each in charge of a warden. While the size of these districts will depend upon local conditions—particularly the distribution of the woodlands, the seriousness and distribution of the risks, available means of transportation, and the readiness of the local residents to cooperate—they ought not to include more than 10,000 or 15,000 acres of woodland.

If a lookout system is provided, the number of wardens may be less than if the detection of fires is dependent wholly upon patrol. The lookout system, in which observers are stationed during the fire season at fire towers or other points of vantage, has proved very successful in most of the southern Appalachian States and elsewhere and is coming more and more into use. In clear weather lookouts

can see effectively to a distance of at least 10 or 15 miles, representing an area of 200,000 to more than 400,000 acres. Smoky or hazy weather, of course, greatly reduces the visibility. In general, the effectiveness of the lookout system depends upon the reliability, intelligence, and alertness of the men selected for this duty, and equally upon the reliability of the supporting system of telephone communication and the perfection of the fire-fighting organization ready to start for a fire at a moment's notice and remain with it until it is extinguished. It is essential that the local telephone lines within the area commanded from the observation point be so organized as to permit the lookout to notify all wardens immediately of the location of a fire and particularly those located nearest the fire. Fire towers are more necessary in flat or rolling country than in mountainous country where observers can be stationed on commanding mountain tops or ridge crests.

North Carolina plans a system of 40 lookout towers for about 4,200,000 acres of forest land in 25 mountain counties. This would give an average of about 100,000 acres for each tower, corresponding to a radius of a little over 7 miles. The system is somewhat more intensive than the general one above suggested, but will be more effective during periods of low visibility. Eight towers and two mountain tops were manned in the fall of 1927 in cooperation with counties and individuals and in the case of the stone tower on Mount Mitchell in cooperation with the Federal Government.

Local wardens are customarily paid for actual time spent in fire patrol, fire fighting, burning protection strips, posting warnings, and other prevention activities. Their duties include the establishment of patrol routes, the custody and effective distribution of fire-fighting tools, and the organizing of a reliable fire-reporting and fire-fighting system manned by local residents. Much depends upon the character and local reputation of the men appointed as wardens. The selection of men who can command the respect and ready cooperation of their neighbors will result in reducing the cost and increasing the effectiveness of the system.

Protection can not safely be limited to the most valuable, most promising, or best located stands; there is always a risk of fires spreading into them from less valuable lands adjoining. The preventive system should cover all forest lands, regardless of location or quality.

The cost of the system will vary according to the extent and severity of the risk, the cooperation of the local residents, roughness of the country, and the promptness with which a fire-fighting crew can be transported to the fire. In rough country and areas difficult of access ample roads and trails for reaching fires quickly must be developed and kept clear. Heavy accumulations of slash must be guarded with special care. Thus the cost of preventive measures may rise in extreme cases to as much as 10 cents per acre per year. In the southern Appalachian States, however, the present standard on protected areas is attained at costs ranging from less than 1 cent to a little more than 3 cents an acre a year. The amount set up by the cooperative agencies as the estimated need for average mountain timberland in the entire region is 3½ cents an acre a year.

FIRE-WEATHER WARNING SERVICE

Past studies indicate that the efficiency of the protective organization can be greatly increased through the agency of a fire-weather warning service. As the result of a study of storm movement and forest inflammability, McCarthy (*42*) showed that the danger of fire in the forest changes with weather conditions, which vary with the progress of storms across or near the Appalachian region. Since the storms travel generally from west to east, the time at which their rate of movement will bring them to the southern Appalachian region can be forecast. McCarthy concluded that conditions of wind, sunshine, and relative humidity favorable to forest fire are the regular aftermath of a storm, and can be forecast with more certainty than precipitation; and that unusual hazard is caused by continuation of high pressure (marked by shifting of the winds from the ocean and gulf to a continental source, bringing colder and drier air and fair weather) over or west of the Appalachian region, or by the passing of a storm without precipitation in the region. The advantage of a fire-weather warning service is that it would permit the shifting of the fire-fighting personnel and the concentration of the largest man power in preparation for times of special danger from fire. Such systems are now in effect in some other forest regions of the United States, but none has yet been put into operation for the southern Appalachian region.

REDUCTION OF RISKS

Since the leaf litter on the floor of the forest is the principal means by which fires spread in the southern Appalachian forests, the burning or scattering of brush left in logging is neither necessary nor effective except in limited areas of special risk. These measures are costly, and more can be gained at less expense by well-organized protective personnel. In specially hazardous places, however, as along railroad rights of way, the ground should be kept clear of inflammable material. Along railroads a strip at least 4 rods (66 feet) wide on each side of the track should be cleared of brush and leaves at least once a year, by burning. The responsibility for keeping the right of way cleared should fall to the railroads, but since the width of the right of way is ordinarily inadequate, the cooperation of the owner of adjoining land is necessary. In Virginia the railroads are permitted, with the consent of the owner, to burn waste and woodland in strips 50 feet wide adjacent to those burned on their own lands, and may be authorized to burn in spite of the owner's protest. The burning of strips of adequate width should be assured by proper legal measures, or the railroads should be required to furnish equivalent protection by speeder patrol after trains in addition to the burning of the right of way at points of hazard.

The use of spark arresters and the systematic inspection of these and of ash pans should be required. This should be in addition to, and not in lieu of, the controlled burning of the protective strips, since practical difficulties experienced in the control of protective devices on locomotives show that these are not entirely reliable. Railroad section men should be instructed to extinguish fires which originate on or near rights of way.

Operators of portable sawmills should be held responsible for damage from fires starting from their sawmills. In addition they should be compelled to screen their stacks and to organize their mill crews to extinguish fires which may start near the mills. Slash and inflammable débris should not be allowed to accumulate near a mill, and isolation strips at least 8 rods wide around the sawdust pile as well as around the sawmill should be cleared of débris by burning or other means when the mill is so located as to constitute a risk.

The burning of slash, brush, or grass, whether to eliminate risk or to clear lands for agriculture, is in itself a risky undertaking and a common cause of fire in the southern Appalachian States. The record of fires in Virginia and North Carolina during the three years from 1926 to 1928, inclusive, shows that brush burning caused 23 and 22 per cent, respectively, of the fires reported in these States. Such burning should be very carefully controlled. It should be done only by responsible persons and in cloudy or damp weather, free from wind. The several States have more or less satisfactory laws covering this subject, but few if any are wholly adequate. Persons who propose to burn brush should be expected to notify in advance the occupants of adjoining lands, as well as the local firewarden, but such notice should not excuse them from liability for damage should fires escape from their lands. Persons setting any such fires should be held responsible for extinguishing them.

In general it is important that responsibility for the escape of fires should be recognized. The enactment of laws recognizing the value of standing timber, including reproduction and young growth, and fixing the right to civil damage from burning, will do a great deal to check carelessness in allowing fires to spread. Effective means should be found to insure the clearing up of rights of way along much-used highways or adjacent to woodlands, and it should be a part of the duties of the protective organization to placard such roads and patrol the more hazardous places during the fire season. The menace from camp fires and hunters should be cared for by legislation, and the laws should be energetically enforced. As a means of protecting the forest against undue risk the governors of the States should have the power to close the hunting season during a very dry period, when a large number of hunters are a serious menace to the forest.

SPECIAL MEASURES

Fires in logging slash are hotter, more destructive, and more difficult to extinguish than the ordinary leaf-litter fires, and slash-covered areas therefore require special protection. In the moist slope and cove forest the slash as a rule decays to a not very inflammable condition in four or five years after logging, but on the drier slopes and ridges it may remain a serious menace for a year or two longer. The danger from slash on the ridges and slopes is greater also because the slash there dries out quickly and may become inflammable within a few hours after rain. Fires that start on dry slopes may gather enough headway to carry them over large areas of moist-site forest as well.

MOUNTAIN FORESTS

The extreme fire risk is that in the spruce forest after logging (fig. 8), where the slash is usually so heavy that no methed of disposal to reduce the fire hazard is practical. Although the natural spruce forest is damp enough to resist the encroachment of fire and to cause the decay of small litter to a practically safe condition in three to five years, when logging has opened up the stand the slash dries very rapidly and becomes extremely inflammable. This drying out of the slash also delays decay and extends the fire menace until the crowns of the second growth have established a shade. Where there is clear cutting, devastating fires can be prevented only by the most unremitting care. Under the system of partial cutting that will be discussed later, the risk from slash in the spruce forest will be greatly reduced. A large portion of the logged spruce land in the

FIGURE 8.—The slash after clear cutting in spruce forest remains for years an extreme fire menace. (Pigeon River watershed, Haywood County, N. C.)

Black and Balsam Mountains was burned as a result of logging operations. The discharge of sparks by locomotives pulling heavy loads on steep grades has been responsible for numerous fires. Even though fires are avoided at the time of logging, the inflammability continues and is increased by annual accumulations of dead grass, weeds, and leaves. After the logging is over, the danger of fire comes mainly from campers, hunters, and visitors to the mountains.

The special fire danger caused by logging in the mountain forests should be guarded against in the following ways:

All slash created in clearing for the railroad should be burned, together with all light slash on a protective strip along each side of the railroad. The width of the strip will depend upon the topography, the presence of water, and other physical features. In level country and on the low side of the track on slopes, 4 rods may be sufficiently wide for safety; but on grades where locomotives use

forced draft it may be necessary to widen the strips to as much as 6 rods. Around steam skidders or other stationary engines the ground should be cleared of inflammable material for a radius of at least 8 rods. Dry and windy days should not be selected for the burning. The first burning ought not to cost more than $10 an acre, or $80 a mile of strip 4 rods wide, even when the slash is fairly heavy, except perhaps in the spruce forest. It should be possible to keep these strips clear by later burnings at a cost of not more than $30 a mile.

All engines should be equipped with approved spark screens and other protective devices necessary to prevent the scattering of fire. Extreme care should be taken to keep the spark screens in good condition. They should be inspected frequently and the engineers held responsible for their condition. Similar responsibility should be imposed for the dumping of ashes in safe places, such as cuts.

Effective patrol should be maintained by the operator, with special patrol after all trains during danger periods. The patrolman should be furnished with the necessary fire-fighting tools, which he should keep at convenient points; and he should have such means of communication as might be required to make his work effective.

When a fire is discovered, the operator should at once send to the spot a crew of men large enough to control it.

In the spruce forest it is well to leave strips of green timber as fire barriers on both sides of logging railways and between different parts of the operation. These should be 50 or 75 feet wide, or as much as 100 feet on slopes above the track. They may include the timber available from one or more skidder sets so as to facilitate its removal at the end of the operation.

After the close of the logging operation and the removal of all steam equipment, the cut-over area should be under patrol during fire seasons for four or five years after cutting in the hardwood forest, and for 10 years after cutting in the spruce forest. In the hardwoods, the patrol may be at the rate of one man for a watershed of 5,000 or 10,000 acres containing slash. In the spruce the district patrolled by one man should not exceed 3,000 or 4,000 acres. The patrolman should have access by telephone to a lookout or the local headquarters of the fire organization of the region. The annual cost of such patrol will vary from about 7 cents an acre for the spruce to about 2 cents an acre for the hardwood cut-over areas. When the danger from slash has abated, general fire-preventive measures should be sufficient. Where partial cutting has been employed the intensity of the patrol can be lessened except at points of special danger, as along railroads.

PLATEAU AND VALLEY FORESTS

Fires can be much more easily prevented in the isolated strips and blocks of farm woodland than in the large forest areas of the mountains. These woods are under more constant observation, communication is easier, and fire-fighting forces can be more quickly assembled and brought to the scene of the fire. There is little excuse for fire in farm woods. Nevertheless, considerable areas in the aggregate are burned over each year and great damage is done.

In the foothills of the mountains and on the long parallel ridges in the Appalachian Valley the plateau forest sometimes covers extensive areas and here the suggestions for fire prevention that were given for the mountain forest apply. Areas cut over less than five years should be protected with special care. Often the observer system may to advantage be substituted for actual patrol. Owners of farm woods and timber tracts on the plateaus should insist upon full cooperation of their counties in the State protective system. They should themselves use the utmost care to prevent the spread of fires set in lands adjacent to their woodlands and should observe constant vigilence each spring and fall to detect promptly any fire that may start near by.

LOGGING PRACTICE

IMPROVEMENT OF POOR STAND CONDITIONS

The additional treatment required to maintain forest production in some measure, once adequate fire protection is assured, is very simple. What form it is to take must be determined from the conditions now encountered on cut-over areas—conditions which in detail are variable in the extreme. However, the situation may be sufficiently well characterized by the following four general conditions that, according to the data already presented, are most widely prevalent:

(1) Deficiency of good trees and of desirable species like yellow poplar, red oak, and white pine, among both the large and the smaller size classes.

(2) Surplus, in both size classes, of defective trees and of less desirable species like sourwood, red maple, and black gum.

(3) Deficiency of tree reproduction of desirable kinds.

(4) In burned stands, a heavy preponderance of sprouts in the reproduction.

Whether or not these conditions can be corrected in the course of logging without extra expense depends entirely upon the density, quality, and accessibility of the stand. The treatment indicated in the majority of cases will be as follows:

Emphasis should be placed upon getting rid of as many defective trees as possible along with the more salable timber, so as to clear the way for the growth of reproduction.

Where promising small trees occur in groups it is usually desirable to leave them for continued growth.

Small isolated trees, on the other hand, are likely to develop limby trunks and spreading crowns, and may best be removed if practicable. The cleared spaces thus left between groups of maturing second growth will later be filled with tree reproduction.

Care should be observed in logging to prevent breakage of the trees to be left for growth. Broken trees should be removed.

To ensure the continuance of good species in the future stand the seed supply should be built up, where inadequate, by reserving a few well-distributed seed trees.

After logging, the stand should not be cut over again until it is in such condition that the second cutting will leave half or more of the area stocked with sound young trees. This new stand, reinforced by reproduction in the openings left by cutting the larger trees, will

comprise the growing stock for future cuttings under a plan of management such as will be discussed later. The time interval between the first and second cuttings should be determined by the size and condition of the stand left and the growth capacity of the site, and not entirely by commercial feasibility of operating. Only on the best sites with a fairly good young stand left after the first cutting should a second operation be considered in as short a time as 10 years. On dry sites, or when only a thin stand of young trees is left after the first cutting, a return cutting may not be advisable for 20 years or even longer.

These principles can be adapted to a wide range of forest conditions. They permit the removal of large sound timber along with defective trees, large and small, and their object is to provide space for the growth of promising young trees and the reproduction of desirable species. As compared with the old destructive methods of culling, some sacrifice may result where products from the inferior trees cut can not be sold to advantage. How far an operator will wish to proceed with this practice will depend upon what he desires to invest in measures that may not offer an immediate financial return. The line between constructive and destructive cutting is a critical one, and great care must be observed if the forest is not to be left in a poorer rather than a better condition. In particular, every effort should be used to free the ground of the shade and root competition of the defective and otherwise unpromising trees. The aim should be to open up the forest, leaving as much as possible of the promising stand in groups.

Where many of the trees are defective or unpromising so that only a scattered stand of small trees would be left under the selective treatment above outlined, the cutting should be as clean as possible except for a few trees of desirable species left for seed production. On areas that are not too inaccessible, markets can usually be found for railroad ties, mine timbers, cooperage stock, pulpwood, fuel wood, or other small products that will afford a means for disposing of trees unfit for saw logs. There are, of course, areas that can not be profitably logged at present under the suggested treatment. They include the heavily cut over (pl. 11, A) and severely burned land, as well as steep, rugged, or remote areas that are not well enough timbered to justify the relatively high cost of logging them. Unless an actual investment were to be made on such lands in anticipation of deferred returns, no productive treatment for them would be possible other than protection from fire for the period necessary to develop a paying stand.

Nearly every large tract of timberland contains more or less dry-ridge and upper-slope land where timber is short bodied and the yields are low. These lands have usually suffered severely from fire. They have been culled, largely for chestnut oak, and the proportion of less desirable species and of defective trees has thereby been increased. Also, they are the more difficult of access, so that light cuttings would be too expensive to be justified. The best treatment here is to log as heavily as practicable, removing especially the poorer species and defective trees, but to leave a few trees of good species to furnish seed. A period of several decades will intervene before any further cutting will be practicable or desirable.

The case is different on north-facing and east-facing slopes, on lower south and west slopes, and in coves and on flats where relatively moist conditions prevail. (Pl. 11, B.) Here growth is more rapid, there are more tree species, and a larger number of them are of special value. Cuttings can be made more frequently and for a greater variety of products than on the drier sites. An example of selective logging done cooperatively by the Appalachian Forest Experiment Station and Berea College, on the latter's forest tract at Berea, Ky., will serve to illustrate the values and costs of such logging in culled stands on good sites.

The selective logging at Berea was done in 1923. About 33 years earlier the stand had been culled of everything merchantable at that time, but many small trees and some large defective ones had been left standing. At the time of the selective cutting many of the smaller trees previously left had become merchantable. This later cutting took 420 trees from an area of 2.8 acres laid out by the experiment station as a sample plot. The volume removed amounted to 10,000 board feet. This was logged and sawed up at a total cost of $142.74 into lumber valued at $242.50. The combined stumpage value and profit, not counting wood cut for fuel for Berea College, therefore amounted to approximately $100, or $35.63 per acre. Only average cost figures were kept, so that it is impossible to determine the stumpage and profit for the different kinds and qualities of logs. The figures indicate, however, that the low grades of lumber produced were logged at a loss, while for the higher grades the stumpage and profit amounted to more than $25 per 1,000 board feet. The cutting removed the overmature and defective as well as some of the sound timber. It left the area of 2.8 acres with an open stand of only 173 trees, but these were of good species, sound, well-formed, and in fine condition for growth. In five years the average diameter of the trees left had increased 3 or 4 inches, and many smaller trees had grown up into the openings. The area could probably be cut over again with profit at the present time, but by postponing this second cut for a few years a much higher yield will result, and a better stand can be left for future growth.

On steep slopes some erosion may occur after a heavy opening up of the hardwood forest, but unless the area is repeatedly burned there is little danger that it will become serious. The network of roots will act as a preventive, and this will be quickly reinforced by the growth of tree reproduction and forest shrubs. The chief danger is in deeply worn skid roads, which are likely to become run-off channels. They should be filled at places with logging slash and stones.

In the spruce forest there now remain only a few small bodies of timber that are available for cutting. The general practice in the past has been clean-cutting for saw logs and pulpwood, resulting in heavy accumulations of slash and destructive fires. (Fig. 9.) A few examples of selective cutting in West Virginia indicate that this method can be used successfully. The danger of wind throw is serious if large trees are left exposed by the cutting; not so serious if large trees are removed. The removal of only the largest trees will reduce the density of slash and permit its early decay under the shade of the trees left. It will also favor the reproduction of spruce

and fir, which are much more likely to become established in the partially cut forest than in the dense hardwood reproduction that comes in on clean-cut areas.

SELECTION OF SEED TREES

The purpose in leaving seed trees is to provide a means for preserving desirable species in the future reproduction. The adverse effect of repeated cullings on the reproduction has already been noted. The continuation of this process would eventually deplete the forest of its best species, especially if the reproduction were destroyed by fire. Seed trees do not have to be particularly large trees, and if numerous trees are left for growth that are near the profitable size limit for lumber (as defined in a preceding section)

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FIGURE 9.—Steam logging in the spruce forest of the Black Mountains, N. C. All merchantable trees were cut, leaving a heavy inflammable slash. Fires in the slash later destroyed all the spruce and fir that remained after cutting, leaving the area as shown in Figure 6

no other provision for seeding need be made. Where stands are cut heavily, however, seed trees should be specially reserved.

The number and distribution of trees for adequate seeding will depend upon topography, weight of seed, and reproductive capacity of the species dealt with. Heavy seed, like that of oak, hickory, walnut, cucumber magnolia, and gum, falls close to the trees, and will roll, be washed, or be carried by animals for short distances only. Five or six well-distributed heavy-seeded trees to the acre will go a long way toward seeding in satisfactorily on flat lands, if the seed is not subject to especially heavy losses; on hilly land even fewer trees will serve. Light, winged seed, like that of yellow poplar, birch, ash, basswood, maple, and the conifers, is widely distributed by wind, and an area of 1 or 2 acres may be fairly well seeded in by a single well-located tree. A commanding position and favorable prevailing winds are influential in extending the scope of seed distribution.

Seed trees should of course be of seed-bearing age or size. This size or age varies with the species, the site, and the condition of the stand in which the trees have been growing. Seed trees should have full and healthy crowns and should have received full light from overhead and preferably some from the sides as well. They should not be smaller than 10 inches in diameter. Dominant trees of this size are usually already becoming good seed producers. Production increases as the tree grows, up to an advanced age, when the size and fertility of the seed yield diminish. Seed trees may be thrifty, dominant, well-crowned second-growth trees, capable of making growth on their own behalf as reserves for the next cutting; or they may be mature trees that are still active bearers. Small, thrifty, well-crowned trees are superior to large ones, since they possess low intrinsic and high potential value, are capable of making a good growth, and may be harvested as especially valuable timber trees at a later cutting.

The cost of seed trees amounts to the stumpage value, which is indicated for different sizes in Tables 16 and 17. In most cases leaving relatively small, sound trees will be an investment in growth as well as in seed production.

MANAGEMENT OF FORESTS TO PRODUCE FULL TIMBER CROPS

To get out of forest land the highest possible value in timber trees requires more intensive and detailed treatment than fire protection and the few simple cutting rules designed merely to restore or maintain a moderate production. A detailed program of cutting and thinning or weeding should be adopted, and for large tracts this program should be elaborated into a definite schedule of cuttings, or management plan, such as is fully discussed in the standard works on forest management and elsewhere (*19*, *29*). In such improvement cuttings, present income will as a rule be partly subordinated to the prospect of larger and continuous returns. In the following discussion of management of forests to produce full timber crops, farm woods, which present certain economic possibilities for management that set them apart from larger tracts, will be handled separately. In general, methods of treatment will be much the same as for individual stands of timber in the larger tracts.

Once the forest condition necessary to produce full timber crops is attained, it can be maintained indefinitely. This may be done by harvesting successive crops at yearly or other intervals, the size of the crop cut being held down to the amount of growth that the stand can make. This in turn is governed by the quality of the particular soils in which the stand grows. The advantage of thus limiting yield to growth, by what is termed sustained-yield management, is that such management substitutes a relatively large, fixed, and valuable yield for the smaller output that would be available sporadically if the timber was allowed to grow without systematic treatment. Sustained-yield management guarantees a steady supply of wood products conformable to the needs of local industries. In their present state, however, the southern Appalachian forests fall far short of the point of productiveness at which they will sustain a continuous yield of the products desired and must be built up to this point.

The essential feature that is now universally lacking is a reserve of healthy desirable timber with ages so balanced from seedling up to maturity as to sustain a continuous yield. Such a reserve of young trees is called an adequate or "normal" growing stock.

The best way to go about acquiring a normal growing stock is (1) to conserve promising immature trees and (2) to encourage a full reproduction of desirable species. A general idea of the conditions to be met and of the reproductive and other characteristics of the various species is given in the first part of this bulletin. These characteristics, particularly the soil and light requirements of the individual species, must be carefully regarded. Most of the desirable species, as well as many of the less desirable, require ample light for reproduction and growth. Yellow poplar, white ash, black cherry, and the pines are examples of desirable light-demanding species; hemlock, beech, and maple are more shade-enduring. Spruce and fir are desirable species that will reproduce and grow under moderate shade.

Stirring the litter on the forest floor so as to bring seeds in contact with mineral soil is important for yellow poplar and more or less advantageous for other species, although it is not necessary for spruce, fir, hemlock, birch, and a few others, which are able to reproduce satisfactorily on moist decomposed woods litter. For the species that require mineral soil, logging usually disturbs the litter sufficiently to accomplish the purpose.

The frequency with which a stand may be cut depends upon the quantity and size of the timber previously reserved and on its growth rate. When a good growing stock has been established, light cuttings may be repeated at intervals of 10 or 15 years. In the absence of a good growing stock time must be given to develop one, which may double the interval between cuts in any particular stand. The entire tract may, however, be divided into units for annual cutting in such a way that by the time the whole area is cut over the unit first operated will again be ready for cutting. In this way the tract will yield annually and continuously.

FULL-CROP MANAGEMENT FOR LARGE TIMBER TRACTS BELOW THE SPRUCE ZONE

METHODS OF CUTTING

The two general methods of cutting are clear cutting and partial or selective cutting. In clear cutting the entire stand is removed—small as well as large trees—except for such trees as may be left for seed. In selective cutting, trees that are large enough to yield a substantial profit are removed and the promising young trees are left for further growth, even though some of them may already contain merchantable material. The young trees selected to be left should have long, straight, sound boles and dense, fairly compact, and healthy crowns. Such small trees may represent 40 or 50 years of growth already attained, and may need only a relatively few years more to become large enough for some select use. The choice of treatment will depend to some extent upon whether or not all the trees present in a stand can be marketed profitably. For example, a pure stand of yellow poplar or of pine may be entirely merchant-

able, the larger trees for lumber and the smaller for pulpwood or some other product; while in a stand of mixed species and sizes, only a part of the trees may be large enough to justify cutting for any purpose. In a given forest tract clear cutting may be justified for some stands and partial cutting for others. The cutting method to be used should be decided upon in advance as a part of the general management plan for the tract and in accordance with the best prospective income and the reproductive and growth characteristics of the species present.

Examples of the utility of clear cutting are presented in the early charcoal operations mentioned at another place in this bulletin, resulting in fine stands of even-aged second-growth hardwoods. Here trees of all sizes and species could be used, although it is by no means certain that even then all were used with greatest profit. For the stands that have resulted, however, present standards of value rarely make clear cutting advisable. These stands should rather be considered in terms of the sizes at which each species can best be cut to command the highest price. Selective cutting is therefore recommended.

In mixed stands, selective cutting is thus a means of growing each species to its most profitable size. Since the species differ in growth rate this means assigning a different period of life, or "rotation period," to each species or to groups of species resembling each other in growth rate. For saw and veneer logs large trees with long, clear boles are necessary. As was indicated in Tables 16 and 17, value increases rapidly with size and 24-inch trees are considerably more valuable than 18-inch trees. The diameter selected as the minimum for cutting should be determined by balancing the greater value of large trees against the time required to reach large size, which will be longer for white oak than for poplar or basswood. On the other hand, some species, like black locust and scarlet oak, can not be grown practicably to large size; small-pole size is about the limit for the former, and tie size (14 or 15 inches d. b. h.) for the latter, because of the danger of loss from decay above these sizes. Dogwood reaches mature size at 8 to 12 inches d. b. h. (*17*).

Partial or selective cutting can be practiced by removing either single trees or small groups of trees. Group selective cutting recommends itself especially where clumps of good reproduction are already present on the ground, ready to spring up into the openings thus provided for them. The severity of the cut should depend upon the species, density, and commercial value of the stand. In stands of northern hardwoods (beech, birch, and maple) and hemlock, reproduction will take place after lighter cutting than is necessary for the moist slope and cove forest. Where the reproduction to be encouraged will be of yellow poplar, ash, basswood, red oak, white pine, or other valuable light-needing species, heavier cuttings are justified. In the dry-slope and ridge forest cuttings should be lighter and at longer intervals than in other forest types because of the slower growth and thinner stands.

Partial cutting is obviously best suited to logging by animals, rather than by machine. Skidding by overhead or ground cables would be ruinous to the trees left and to the advance reproduction.

The summaries of stand and reproduction presented in Tables 5 to 7 show that a start toward a growing stock of different-sized

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EXTREMES OF MANAGEMENT IN MOUNTAIN FOREST

A, A heavily cut-over south slope in southern Appalachian hardwoods. Some of the small trees are of promise but many are defective and should be removed to provide light and space for reproduction; B, a stand of mixed hardwoods in the lower moist-slope forest after a selective logging. The openings left by the logging, 12 years before the picture was taken, are rapidly being filled by young trees and by the spread of the larger tree crowns.

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REPRODUCTION OF SOUTHERN BALSAM FIR AND RED SPRUCE FILLING A SMALL OPENING IN THE SPRUCE FOREST ON MOUNT MITCHELL, N. C.

trees is already present on most of the cut-over areas. Some of the trees left as too small in past cuttings have since reached merchantable size and smaller trees are now filling the spaces between them. By a proper regulation of cuttings, marketable material can be removed at intervals, while the growing stock is being brought into order. Areas that have recently been heavily cut over or that have been severely burned can not, of course, be expected to yield a paying crop at an early date, but there are many tracts that are rapidly approaching a merchantable condition. The history of the past culling operations contains numerous instances of stands reworked four or five times at short intervals before being entirely exhausted. This is an indication of the possibilities in selective cutting. By allowing longer intervals between successive cuts and by reserving promising trees for later removal the owner may expect, instead of denudation, a perpetuated and steadily improved yield.

Excellent opportunities for forest management are afforded by well-stocked second-growth stands, the growth and yield of which were shown for different sites in Tables 8 and 9. If unburned, or at least not severely burned, such stands represent the best condition of growing stock for continuous treatment that the present southern Appalachian forest has to offer. As far as can now be foreseen, the ideal result of many years' management of a forest tract would be a series of such stands, graduated according to age, so that a continuous succession of cuttings would follow as the different stands matured.

It would not be necessary, however, to cut the stands clean. As previously shown, this would be suitable only when all or practically all the trees can be cut with profit. The young stands can be managed by thinnings (to be discussed later) and the older stands by partial cuttings in which select trees of fully merchantable size are removed, leaving the larger number of smaller trees to increase in volume and quality.

IMPROVEMENT CUTTING AND GIRDLING

The first steps in management for full-timber crops in the hardwood forest, with or without a mixture of pine and hemlock, will be generally the same as those previously recommended for keeping forest lands productive, but with some additional improvement measures. These additional measures, which represent an investment in the development of an adequate growing stock, include the removal of the large unmerchantable timber and the poor small trees to insure the best growth of the desirable young trees and reproduction. If the quantity of merchantable timber is not sufficient to justify immediate logging the stand may be left until a paying yield, made possible through the growth of smaller trees, can be obtained without overcutting. Trees on the border line of value for lumber (Tables 16 and 17) will soon reach profitable size.

Improvement cuttings of this nature can be made relatively cheaply. One that was made in 1929 on the Natural Bridge National Forest in Virginia [11] will serve to illustrate methods and costs. The stand was chiefly of oaks, chestnut, and white pine, with yellow

[11] The data given are from a report on the cutting by Forest Supervisor H. M. Sears.

poplar and hemlock in the coves, and with considerable hickory, black gum, red maple, and other species for which there was no sale value at the time. A heavy reproduction, chiefly of white pine and yellow poplar, had appeared, following the opening up of the stand by chestnut-pole cuttings in 1920–21 and 1924–25. In 1928 the saw timber on this area was selectively logged. No white pine, yellow poplar, white oak, or red oak trees were removed that were less than 16 inches d. b. h., but the other species were marked for cutting to smaller diameters. The saw timber removed in this cutting averaged about 5,000 board feet per acre.

At least 1,500 board feet per acre was left standing, contained in smaller trees from 12 to 18 inches d.b.h., largely white pines, poplars, and red oaks, but including also a great many small and a few large trees of less valuable kinds. This stand was still heavy enough to imperil the future growth of the excellent white pine and poplar reproduction, and an improvement cutting was accordingly made in which the less promising species were felled or girdled. As a rule, only the saplings 4 inches d.b.h. and less were actually cut, all trees larger than this being girdled. The average number per acre of trees cut or girdled was 293, and of these more than 90 per cent were in the 2 to 4 inch class. These small trees were mostly dogwood, sourwood, and red maple. Of the trees 9 inches and larger that were girdled, most were of red maple, black gum, and hickory, but there were only 10 such trees per average acre.

The expense of the actual felling and girdling was $1.35 per acre, under somewhat higher labor costs than would ordinarily be necessary. Also, because of the unusual reproduction to be released from shade, more work was done than would commonly be required. Ordinarily the better red maples, black gums, and hickories might have been saved to advantage for later demands. If this had been done, the cost would probably have been reduced to less than $1 an acre.

Girdling, of course, leaves the area in an unsightly condition for many years, and for this reason, where appearances are to be regarded, as along roads and trails, it may be preferable to fell the trees. Girdling, however, avoids the breakage of young trees and reproduction that would be almost inevitable if the trees were cut. Standing dead trees lose their branches and tops gradually through decay and when they fall they are not likely to cause much damage. They are not a very serious fire menace in this region.

WEEDING

On areas densely covered with rhododendrons, laurel, dogwood, sourwood, sassafras, and other shrubs or small trees, reproduction of desirable species has small chance of success. The cost of removing entirely a heavy cover of this kind would commonly be prohibitive, except by burning, which is dangerous. But a light partial cutting of the underbrush to release individual seedlings from shade can be made with relatively little expense. An example of such release cutting, to free good reproduction of yellow poplar, is given on pages 45 and 46. The cost of such operations will naturally vary with the quantity of reproduction that is to be released, the size and kind of brush, and other conditions. Working in fairly dense brush and confining his

efforts to the release of only a part of the best seedlings (say, 100 per acre), a good axman should be able to cover an acre a day. The freeing of some of the best reproduction from shade and competition is particularly important where good reproduction is scanty. Release cutting, however, is not universally necessary, and good reproduction may often be obtained without recourse to it.

THINNING

Wherever a market for small material can be found that will pay for the cost, dense young stands should be thinned at intervals to increase the quality and growth rate of the trees left. Thinnings should be directed toward favoring the growth of the most promising trees and best species. The smaller trees and particularly the defectives and the less desirable species should be removed. Thinnings are most effective if begun early in the life of the stand and repeated at 5 or 10 year intervals, or whenever the crowns of the trees left have closed up the openings made by the previous thinning. The thinning should leave the crown cover of the woods as evenly opened up as possible, with only such space around the crowns of the better trees as can be filled by their growth during the following 5 or 10 years. Larger openings can not, of course, be avoided where widespreading, defective trees are removed. Such openings will later be filled partly by the crowns of adjacent trees and partly by reproduction.

The kind and quantity of material to be removed in thinning depend on local differences in the composition, age, and density of the stands and hence are widely variable. Examples of one kind of thinning, which removed the smaller trees and left the larger ones standing, are described in a publication previously cited (*28*). Another type of thinning—one of three kinds applied experimentally by the Appalachian Forest Experiment Station in a dense 40-year-old stand of second-growth yellow poplar at Cranberry, N. C.—is illustrated in Figures 10 and 11. Here the larger trees were removed with the expectation that the thinning would increase the growth rate of the smaller trees left. Seventeen "long cords" (of 160 cubic feet) were removed per acre, and the stand after cutting contained 24 long cords per acre. The trees removed in thinning were sold as pulpwood.

Detailed discussions of the principles of thinning will be found in the standard textbooks on forestry.

SLASH DISPOSAL

The disposal of logging slash to favor reproduction or reduce fire hazard is not so much of a problem in the southern Appalachian region as it is in some other parts of the country. Where the accumulations are heavy, however, it is best to lop and scatter the branches that are 4 or 5 inches or more in diameter so that they will be close to the ground and decay rapidly. Care should be taken not to break or smother good reproduction under slash.

SPRUCE-FOREST MANAGEMENT FOR FULL CROPS

That partial cutting is practicable in the spruce forest and that it will be effective in perpetuating the stand is indicated by actual results from partial cuttings in West Virginia. Stands have been

culled or cut over twice for the larger trees, leaving an on-coming stand of small trees and reproduction. A study of the southern Appalachian spruce forest as affected by logging and fire, made by

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FIGURE 10.—A selection thinning in a 40-year-old stand of second-growth yellow poplar that came in after clean cutting for charcoal wood. Dominant trees 95 feet in height indicate Site I. Before thinning the stand contained 41 long cords (ca. 160 cubic feet) per acre. (Cranberry, N. C.)

C. F. Korstian, for the Appalachian Forest Experiment Station, yielded evidence that partial cutting, coupled with effective fire prevention, is much the best means of making the spruce forest continuously productive.

This conclusion is confirmed by observations of the capacity of spruce and fir to establish reproduction in open or lightly shaded spots in the forest (pl. 12), the scarcity of the seedlings on clean-cut areas, especially after fire, and the small chance they have of growing

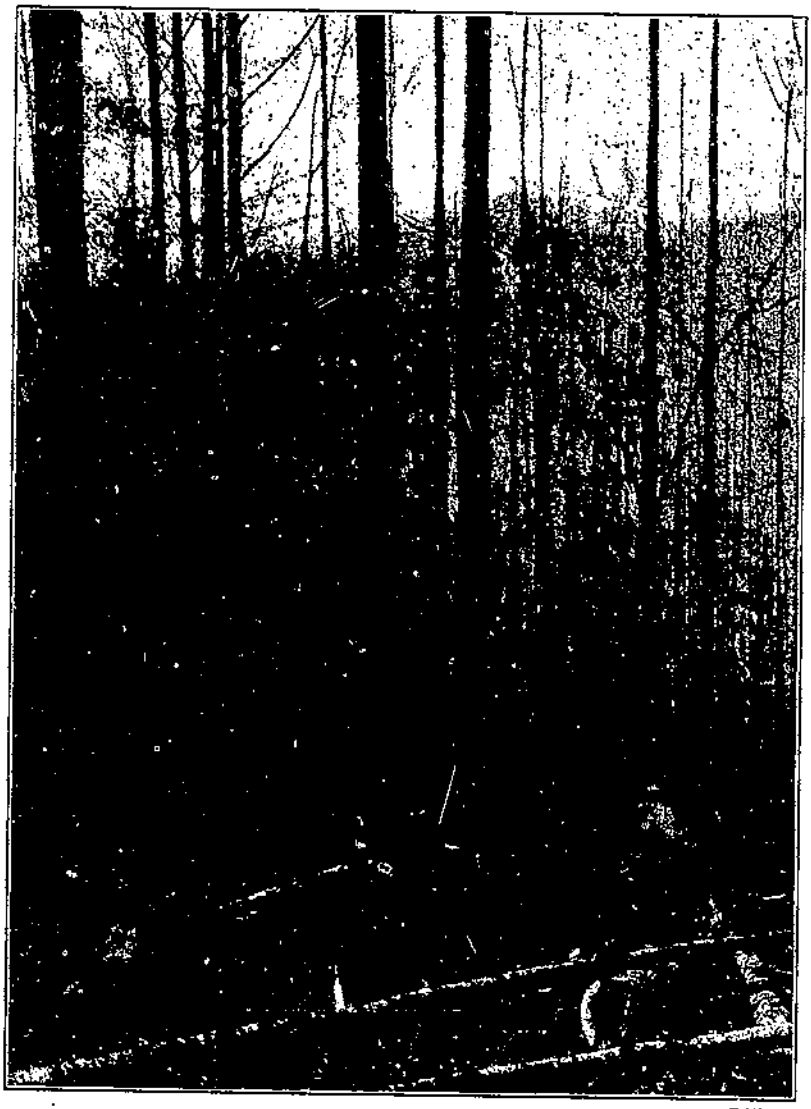

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FIGURE 11.—After thinning: The trees banded in Figure 10 have been released from competition; the stand still contains 24 long cords to the acre; in smaller trees, 17 cords having been removed and sold for pulpwood

up through the dense growth of hardwoods that customarily springs up on such areas. Partial cutting is further justified by the reduced fire menace when the forest floor is kept moist by partial shade and when the slash produced in logging is only from scattered trees

rather than from the whole stand. In the partial cutting the larger trees should be removed singly or in small groups, admitting some light through the crown cover but not opening the forest enough to cause windfall or the rapid invasion of hardwoods. Broken, diseased, insect-infested, and poorly formed trees should be removed. The time for a second cutting will depend upon the size and number of trees left in the stand and the rate at which the small openings in the crown cover close up. In most cases a return will be possible in 15 to 25 years. By such partial cuttings the stand will be kept in an active, producing condition.

Since the bulk of the wood volume of the stand may be contained in relatively few large trees, a cutting that removes only 20 per cent of the crown cover of the stand may take a much larger percentage of the total volume. Thus a paying yield may be obtained without greatly opening up the forest. Scattered merchantable hardwoods should be removed at the first cut, but where they are abundant so that their removal will seriously expose spruce and fir trees to wind throw, some should be left until a later cutting.

On cut-over and burned spruce land a satisfactory new stand of spruce, fir, or other softwoods can rarely be obtained except by planting. Planting should follow immediately after the burning to keep down the cost of the planting and to avoid the competition with raspberry, blackberry, and other bushy vegetation that will soon appear. Even when a burned area is planted promptly after fire, it will frequently be necessary later to cut back the natural reproduction of hardwoods, especially on the better soils.

Experiments to determine the species most suitable for planting on cut-over and burned spruce lands have been conducted since 1923 by the Appalachian Forest Experiment Station at high altitudes in the Black Mountains of North Carolina. In addition to the native red spruce and southern balsam fir, 15 introduced conifers were tested. The results for red spruce and southern balsam fir, as summarized from the spruce study above cited, are of interest. Southern balsam fir has given the best evidence of success, with a survival of from 82 to 85 per cent of the seedlings set out five years ago. The survivors averaged from 1.5 to 1.8 feet tall in 1929 and are growing vigorously. In three separate plantings of red spruce from 60 to 85 per cent survived and the trees averaged about the same height as the fir. The growth of spruce and fir during the first few years is always slow, and from now on a considerably more rapid height growth may be expected. Of the 15 introduced species, some have already failed and none has as yet demonstrated its superiority to the native spruce and fir for reforesting the devastated spruce lands. The best planting stock to use is evidently red spruce and southern balsam fir, preferably grown locally from locally collected seed. This stock should consist of thrifty transplants, grown two years in the seed bed and one or two years in transplant rows.

MANAGEMENT OF FARM WOODS

Farm woods are neglected opportunities on thousands of farms in the southern Appalachian region. Instead of being handled for a steady income, as they might easily be, a common practice has been to cull out the best material whenever it could be sold or used.

This has resulted in such poor stands that many owners have lost interest in their woods as a source of income. Lack of familiarity with markets and prices for wood products has placed farmers at a disadvantage, and much timber has been sacrificed for low-paying uses when some of it, at least, might far better have been left for growth to more valuable sizes. The aggregate loss through poor management of farm woods is serious to the region as a whole. The area of farm woods is so large (49 per cent of the total area of timberland) that if all were under good management for continuous production the united crop would go far toward meeting the wood requirements of the region.

Farm woods offer opportunities for treatment that are not possessed by the large tracts of timberland. They are in small units which can be easily managed in the course of other work on the farm. Labor and teams can be used in them during slack periods for other farm activities. There is no heavy investment in land, stumpage, and special equipment. Fuel and other wood products needed on the farm itself can be supplied from unmerchantable trees cut to benefit the stand. In the plateau and valley region the farm woods are usually accessible by good roads and by rail to sawmills, pulp and paper factories, and other establishments that require constant supplies of forest products. Such markets are an incentive for the management of farm woods to supply continuous yields of the most profitable materials. For these reasons it is relatively easy and practical for farmers to apply the intensive methods that lead to full timber crops.

The treatment that should be given farm woods to enable them to earn a steady income depends upon their condition, age, and composition. Conditions vary all the way from thin, overgrazed, or overburned stands in which the trees left are of no value except for fuel, to dense stands of thrifty timber. Some farm woods contain only mature trees; others are made up of young reproduction that came in when a previous stand was cut clean or a field was abandoned for cultivation. Many stands are of young second-growth pines or hardwoods, and some are of mixed ages, often with a young growth of hardwoods under an older stand of second-growth pine. Each stand, therefore, presents a problem that must be worked out independently, with a view to developing the most valuable and rapidly growing species and maintaining the largest and most profitable yield. Poor, thin stands can not be converted rapidly into good ones. The process is a slow one, and sometimes it is best to clear the ground and start a new stand by planting. Dense stands can, however, be improved by light partial cuttings in old growth or thinnings in second growth at intervals of 3 to 10 years.

The treatment of farm woods and the marketing of farm forest products are discussed in several Federal bulletins (*37*, *38*, *39*, *40*, *62*) and also in a number of State publications.

OLD-GROWTH STANDS

In most old-growth farm woods partial cuttings, as previously described, will be practical. The purpose of the first cuttings will be to get rid of the poorer trees. Trees with widespreading crowns should be removed, since they will otherwise retard the growth of

reproduction beneath them. Especially good trees of desirable species should be left for increased growth. A good procedure, after the preliminary improvement cutting, is to divide the farm woods into small blocks, to be cut over in successive years. In a 50-acre woods, if 5 acres are lightly cut over each year, 11 years will have gone by before the first block is revisited, and by that time another light cutting on the first block may have become desirable. Overcutting should not be permitted, and plenty of time should be allowed for each block to recover before any further cutting is done in it. The first cuttings should be in groups, so far as possible, and the reproduction which comes in on the small areas so cleared should be improved by weeding out the undesirable kinds. The subsequent cuttings may be aimed to increase the size of the openings and so of the reproducing areas. Thus eventually the woods will be restocked with young trees of different ages, and the process of cutting may be repeated indefinitely.

SECOND-GROWTH STANDS

In dense second-growth stands thinnings should be made, as previously described. The early thinnings, while giving the best trees space to grow rapidly, should not be heavy enough to permit the trees left to develop widespreading crowns. It is best to thin lightly and often. A good rule is to thin when possible so as to leave a space of not more than 3 to 5 feet between the crowns. A space of this size will probably be filled in as many years by the spread of the branches, and the thinning should then be repeated. The thinnings should be started as early as possible in the life of the stands. The trees removed, even when small, will often help to pay for the operation in the form of fuel, bean poles, grape stakes, etc. Early thinnings should, of course, remove inferior species and crooked or defective trees. As a result of a well-executed sequence of thinnings, the stand will ultimately contain only sound, straight trees of the best species, with long boles and compact crowns. Besides giving intermediate yields of small-sized material for use on the farm or for sale, consecutive thinnings, properly made, concentrate the growth of the area upon a relatively small number of trees which are thus brought to saw-log size more quickly than if nature were unaided.

SPECIES TO BE FAVORED

In partial cuttings and thinnings the species to be favored of those present in the stand can best be the species that are well adapted to the condition of the soil. A key to the relative desirability of species adapted to moist and to dry soils is given in Table 2. In the farm woods of the plateaus and of the great Appalachian Valley the dry-soil species that it will be well to favor, where they occur, are shortleaf pine and southern red, black, chestnut, and white oaks. In moister situations a great variety of species is to be found, the more desirable of which are shortleaf and white pines, black walnut, yellow poplar, white ash, black cherry, black locust, basswood, white oak, red oak, southern red oak, and mockernut and shagbark hickories. In still moister places, as along stream beds, red gum, yellow poplar, white ash, and several species of oak should

be favored. These species are mostly intolerant of shade, and their reproduction requires plenty of light.

Where shortleaf pine occurs it is one of the very best species to favor. Loblolly pine is even better, though its occurrence is limited in the region under discussion to the eastern and southern edges of the piedmont plateau and the southern part of the Tennessee Valley. These and Virginia pine (scrub pine) commonly grow in dense, even-aged old-field stands which are subject to management by thinnings and a final clear cutting when the trees reach large size, a few trees being left standing to seed up the cut-over area.

CONTROL OF GRAZING

Grazing rarely causes serious injury in the large unfenced timber tracts in the mountains, but in fenced farm woods it often results in complete destruction of the reproduction. What is not eaten is broken, stripped of bark, or bent over and trampled. The trampling compacts the soil, rendering it unreceptive to tree seedlings and unfavorable for good growth of larger trees. Many of the larger trees die in the tops as the result of trampling. Gradually the pastured farm woods become thin and unhealthy as the trees continue to die off. Hope of improvement is lacking so long as the cattle are allowed to remain.

Livestock should be excluded from farm woods that are in process of reproduction, at least until the new crop of seedlings or sprouts has grown beyond danger of injury. In thinly wooded tracts that have been heavily overgrazed this may mean a period of 15 or 20 years. Closing the woods to grazing involves little loss, since investigators have found that grass grown under tree shade is poorer in sugars and other carbohydrates, and therefore less nutritious, than if grown in the open (*73*). The density of grass produced in the woods is also much less than in the open. The tree shade desired for cattle should be provided by fencing off a small part of the woods expressly for that purpose.

COOPERATIVE MARKETING

Although in every other respect the individual owner of farm woods may successfully apply the principles of efficient forest management in the production of a continuous supply of high-grade forest products, he is likely to fall seriously short of reaping a just return when he attempts to market his products single handed. He sometimes has as many as three middlemen between himself and the manufacturer, each of whom will draw a profit. If the price offered by the manufacturer is $8 a cord f. o. b., the farmer may receive only $5 a cord for his cut products in the woods. Direct dealing with the manufacturer is obviously preferable, but since an individual farmer may have only a small amount of wood to dispose of this is not always possible. In any case, a still better arrangement will be for all or a number of farmers living near each other to combine to organize their sales on the basis of competitive bids and for quantity shipment.

Where a farmers' federation or similar organization already exists, it is a comparatively simple matter to include in its activities

the systematic marketing of farm-forest products. An illustration can be cited in the case of the Farmers' Federation of Western North Carolina, which in 1930 organized a bureau for the sale of material from the farm woods. The federation employs a woods agent, whose duty is to obtain favorable contract agreements with purchasers of a variety of woods products, which are assembled from numerous farms and shipped by the carload. Cash is paid for products presented at the federation's warehouses located at strategic points in the region served. Profits, above a small percentage for operating expenses, are shared. Although this marketing agency is very young, several markets hitherto unused by farmers have already been developed. Shipments have already been made of ornamental shrubbery, chemical distillation wood, black locust posts and insulation-pin stock, red oak ties for treatment, dogwood for shuttle blocks, and veneer logs of several species. The collection and shipping of these products is now proceeding regularly. In addition, several new uses for blight-killed chestnut are being worked out to supplement the present uses as poles and tanning-extract wood. The federation is going into the development of new markets intensively and is making every effort to bring the farm woods of the region to their rightful place as sources of revenue (*48*).

An objection sometimes made to cooperative marketing of farm-forest products is based upon the belief that such products can be produced on any one farm only at long intervals and in small quantities. This belief is justified for poor, pastured woods but not for woods in a good producing condition. Well-managed cooperative marketing and a well-managed wood lot will make it possible for a farmer to market wood products at frequent intervals, no matter how small the amount, and will assure the best prices. Best of all, it will organize the disposal of these materials on a permanent basis so that a farmer can look forward to a steady income from his woods and can plan well in advance a paying program of improvement.

SUMMARY OF RECOMMENDATIONS FOR HANDLING FOREST LANDS

TO KEEP FOREST LANDS PRODUCTIVE

FIRE PREVENTION

Cooperative fire protective forces, maintained by county, State, and Federal Governments, to be supplemented by timberland owners, individually or through associations.

Cooperative patrol and lookout systems to be maintained, with special vigilance during fire seasons; patrol to be concentrated upon areas of special hazard.

Local fire-fighting forces to be recruited and kept in readiness under appointed wardens.

Slash disposal only on protective strips adjacent to railroads, highways, sawmills, etc.

Protective equipment to be required on locomotives, sawmills, etc., in forested country.

Advance notification to occupants of adjoining lands and to local firewardens when fires are set to burn brush or for other purposes.

Responsibility for escape of fires to be ensured by legal measures.

All means to be used to inform and educate local residents, campers, tourists, and other users of the forest as to the risks and losses from fire.

INSECT CONTROL [12]

The adoption of measures for the prevention or control of forest insects as well as forest fires will aid further in putting timberlands into a condition for continuous timber production.

MEASURES AGAINST INSECTS IN LIVING TREES

Briefly, an important step in the protection of pine against attacks of the southern pine beetle consists in encouraging the development of mixed stands of pine and hardwoods. Such stands not only are less susceptible to further bark-beetle outbreaks but also will produce a better grade of softwood lumber. Summer cutting of pines should be avoided whenever possible. Fires in pine areas increase the danger from pine-beetle attack and also destroy the hardwoods within the area, thus tending to create pure pine stands, which are always subject to attack.

The prevention of injury by the chestnut timber worm, the oak timber worm, and the Columbian timber beetle is rather difficult. As they infest mature, overmature, or young trees, which have been injured mechanically by the breaking off of limbs or by such agencies as fire, lightning, or frost, which break or scar the bark, the only measure that can be adopted is to encourage the removal of heavily infested brood trees during cutting operations, when such a procedure is practical, since such trees serve as a source of infestation to the timber in the surrounding forest.

Locust-borer attack can be largely eliminated by silvicultural practices. Studies (*15*) made on the habits of this insect have shown that shade is an important factor in protecting young growth. Locusts that are protected by shade through close, mixed plantings until the trees have attained a diameter of about 6 inches are not subject to extensive injury by this insect. A thick growth of trees in nature appears to sustain very little injury. This also aids in producing straight, unbranched boles. If such protected stands are thinned too soon, insects are attracted and the trees injured. Very little injury will result from pruning and thinning after the bole of the tree has reached a diameter of 6 inches.

Injury caused by the hickory bark beetle to weakened trees can not be prevented except by adopting such practices of forest management as will keep the trees in a sound and vigorous condition.

MEASURES AGAINST INSECTS AFFECTING FOREST PRODUCTS

In general, pinhole and wormhole defects in green logs and lumber can be eliminated by handling the product so that it will be in a condition unfavorable for attack by insects. Often this can be ac-

[12] Prepared by R. A. St. George Associate Entomologist Division of Forest Insects, Bureau of Entomology. For further information the following should be consulted: (*15, 49, 51, 53, 54, 55*).

complished by adopting changed practices in forest management which differ only slightly from those in use in the regular operations. The following procedure is suggested to eliminate or minimize this injury:

Allow as little delay as possible between the felling of the tree and its manufacture into rough products, especially during the active season.

Round timber that must be left in the woods during the period of danger should be placed on skids or precautions taken otherwise to facilitate the rapid drying of the inner bark, or else the opposite extreme should be adopted and the logs completed immersed in water.

The removal of bark from all poles, posts, and other materials which will not be seriously damaged by checking, should be undertaken.

The bark should be removed from the edges of lumber, especially heavy dimension stock. Kiln-drying or end-racking of certain kinds of lumber will aid in preventing injury by most insects.

Damage by powder-post beetles to seasoned lumber and unfinished and manufactured wood products can be largely prevented by periodical inspection and proper classification, piling, and handling of stock.

Damage by insects to tanbark will be slight if the latter is utilized within two to three years after its removal from the tree.

LOGGING PRACTICE

HARDWOODS, HEMLOCK, AND PINE

Mature timber to be cut, using every means to market all defective and unpromising trees.

Promising small trees to be reserved in groups, what trees are large enough to be logged at a profit being determined before cutting.

Isolated trees and trees broken in logging to be cut to as small diameters as can be utilized, so as to leave open spaces for reproduction.

On areas of an acre or larger that would be cleared under above practice, good seed trees of desirable species to be left.

Subsequent logging to be postponed until stand is again in condition to support a paying operation and still leave a nucleus of young trees and reproduction for future cutting.

Cuttings to be lighter and less frequent on dry sites than on moist.

SPRUCE FOREST

If it is desired to perpetuate the softwood stand, a light to moderate selective logging is recommended, removing other species along with the larger spruce trees and leaving small spruce for later cuttings.

Cut-over spruce lands to be left under fire protection for growth of a new stand.

TO PRODUCE FULL TIMBER CROPS

LARGE TIMBER TRACTS

Thorough protection from fire, as outlined under measures to keep forest lands productive.

Systematic development of the tract by means of a definite schedule of cuttings so planned that a reserve of immature timber of different ages will be built up and maintained. These may be either clean cuttings, designed to develop the growing stock entirely from reproduction, or partial (selective) cuttings to permit immature trees as well as reproduction to form the basis of the new crop. The latter method is especially desirable in mixed forests in which different species become merchantable at different ages and sizes.

In stands managed by partial cuttings, trees to be removed singly, or in groups where clumps of good reproduction are already present.

Machine logging not to be used in partial cutting.

Unmerchantable large trees and unpromising small ones to be cut or girdled. The cost of this should ordinarily be less than $1 an acre.

Where desirable young growth is shaded or crowded by dense underbrush or less desirable tree species, some of the desirable saplings should be freed by light release cuttings. This should cost, on the average, about $2.50 an acre, but will rarely be necessary over an extended area.

Second-growth stands to be improved by thinning and weeding.

SPRUCE FOREST

Cutting to be generally by individual scattered trees or very small groups, comprising the removal of broken, diseased, insect-infested, and poorly formed trees.

On cut-over and burned spruce lands planting is usually the only way to insure a satisfactory new stand of softwoods; even if done promptly after the fire it will frequently be necessary to assist the planted seedlings by cutting back hardwoods that seed in.

FARM WOODS

Series of light partial cuttings at intervals are generally the best treatment for well-stocked old-growth woods, removing the poorer and widespreading trees in the first cuttings. Trees to be removed in small groups so far as possible, the size of the openings thus made to be gradually increased in later cuttings.

Dense second-growth stands to be thinned lightly at intervals, which may be as frequent as five years, depending upon rate at which the openings close up.

In thinnings and partial cuttings, the least valuable species to be removed, favoring those of value that seem best adapted to the soil conditions.

For thin, overgrazed woods, planting.

Livestock to be excluded from farm woods that are reproducing.

Systematic operation by dividing the woods into blocks to be cut over serially, even in small farm woods.

Cooperative marketing by farmers as a means for joint sale, to highest bidders, of small individual quantities of wood products.

PUBLIC ACTION NEEDED FOR BETTER DEVELOPMENT OF TIMBERLANDS

The strong interest of the public in good forest management carries an obligation for the enactment of public measures to protect and stimulate timber and game production. As previously shown, 95 per cent of the southern Appalachian forest and woodland is privately owned. To encourage the economic development of this land, public policies covering the major phases of forest protection, taxation, education, demonstration, and research should be made effective. All means should be taken to bring about the best use of the greatest possible area of timberland, and thus to increase its productivity as a source of supply for local needs as well as for export to other parts of the country. Programs to accomplish this should include the following important items:

Substantial increases in State and Federal funds for forest-fire prevention and suppression. This is the most necessary of all action to improve forests for continuous production. Special effort should be directed toward getting all counties to participate by voting cooperative funds. The resources of the State foresters for combating fires should be increased. Cooperative protective organizations of timberland owners should be encouraged.

A fire-weather warning service for the southern Appalachian region. Studies (*42*) indicate that such a service would be entirely feasible in this region, as it is proving in others. It would permit concentration of man power at times of special danger and thus work for economy and efficiency of the protective forces.

State or cooperative investigations of forest resources to determine (1) the location and extent of land particularly fitted for timber growing and (2) the quantity of merchantable timber and immature timber adapted to the different classes of industrial use. Provisions for Federal participation in such investigations are contained in the McSweeney-McNary Act.

Acquisition of well-located public forests. In order to insure good distribution of an adequate area of public forests, as well as to serve all public interests to best advantage, definite programs for forest-land acquisition should be conducted by both the State and the Federal Governments. The advantage, also, of county and town forests has been demonstrated abroad and even at some points in the United States. In the southern Appalachian region there are already nearly 62,000 acres of county or municipally owned forests and parks (*72*). Much of this is held for watershed protection. For the combined advantages of timber production, game protection, education, and recreation, cities can well afford to purchase and develop near-by tracts of woodland or of worn-out farm land suitable for planting.

Encouragement of investigations of the rate of growth of forests, their reproduction and management, and the improvement of protective measures.

Studies of the conditions that determine the influence of forests upon erosion and stream flow, with particular reference to the silting up of stream channels and reservoirs and the regularity of the flow.

Provision for research into better utilization of forest products, with a view to extending the markets for small trees and inferior

species and thus reducing materially the cost of cleanings, weeding, and thinning.

Investigations to determine the best methods of maintaining and protecting game in the forest, as a part of efficient forest management.

Educational programs to develop popular appreciation of the values of forests. Fire prevention should be emphasized as the basic requirement for forest production. Educational activities should be directed to all users of the forest through the press, schools, and other agencies.

Increased demonstrations of good forest practice in farm woodlands, through State forestry extension services. Actual examples of good forest management in each county will serve more than anything else to spread an understanding of its methods and advantages.

Encouragement of cooperative marketing by farmers as a means of developing sustained-yield management of farm woods.

Adoption of State laws providing forms of forest taxation that will protect growing timber from a burdensome application of the general property tax.

APPENDIX

SOURCES OF TECHNICAL ADVICE AND SERVICE FOR PRIVATE FOREST MANAGEMENT

The organization of forest lands for management, the preparation of plans, and the execution of these plans call for the special knowledge and experience possessed by technically trained foresters. There are numerous sources, in the southern Appalachian States, from which information and advice can be obtained. First among these are the State forestry offices at Baltimore, Md., Charlottesville, Va., Raleigh, N. C., Columbia, S. C., Charleston, W. Va., Frankfort, Ky., Nashville, Tenn., Atlanta, Ga., and Montgomery, Ala. The State foresters and their district foresters stationed at other towns and cities are prepared to give advice as to the best handling of forest tracts and to cooperate in their protection. In several of the States stock for forest planting is now being raised in State cooperative nurseries and can be obtained at cost by State residents upon application to the State forester.

Examinations of tracts for management, valuation of forest lands, and the preparation of plans for management can best be put in the hands of competent consulting foresters. Where permanent residence of a forester on the tract is not required—as it may not be during the preliminary period of management—consulting foresters may be engaged to supervise all management activities provided in the working plan.

For farm woods, a cooperative forestry extension service is maintained in most of the States, and advice on management and the marketing of forest products can readily be obtained. The farm extension forester is usually located at the State agricultural experiment station.

COMMON AND SCIENTIFIC NAMES OF TREES REFERRED TO IN TEXT

The following list includes the more common tree species of the region. Trees which commonly do not reach saw-log size are designated by an asterisk. The nomenclature is that used by Sudworth (*61*).

Common name	Scientific name
Ash	*Fraxinus* sp.
Basswood	*Tilia* sp.
Beech	*Fagus grandifolia*
*Beech, blue	*Carpinus caroliniana*
Birch, river	*Betula nigra*
Birch, sweet	*Betula lenta*

Common name	Scientific name
Birch, yellow	*Betula lutea*
Buckeye, Ohio	*Aesculus glabra*
Buckeye, yellow	*Aesculus octandra*
Butternut	*Juglans cinerea*
Cedar, eastern red	*Juniperus virginiana*
Cherry, black	*Prunus serotina*
*Cherry, pin	*Prunus pennsylvanica*
Chestnut	*Castanea dentata*
*Chinquapin	*Castanea pumila*
Coffeetree	*Gymnocladus dioicus*
*Crab apple	*Malus* sp.
*Dogwood	*Cornus florida*
Elm, American	*Ulmus americana*
Elm, slippery	*Ulmus fulva*
Elm, winged	*Ulmus alata*
Fir, southern balsam	*Abies fraseri*
Gum, black	*Nyssa sylvatica*
Gum, red	*Liquidambar styraciflua*
Hackberry	*Celtis occidentalis*
*Hawthorn	*Crataegus* sp.
Hemlock, Carolina	*Tsuga caroliniana*
Hemlock, eastern	*Tsuga canadensis*
Hickory	*Hicoria ovalis*
Hickory, bitternut	*Hicoria cordiformis*
Hickory, mockernut	*Hicoria alba*
Hickory, pignut	*Hicoria glabra*
*Hickory, pignut	*Hicoria pallida*
Hickory, shagbark	*Hicoria ovata*
Hickory, bigleaf shagbark	*Hicoria laciniosa*
Hickory, southern shagbark	*Hicoria carolinae-septentrionalis*
*Holly	*Ilex opaca*
*Hophornbeam	*Ostrya virginiana*
Locust, black	*Robinia pseudoacacia*
Locust, honey	*Gleditsia triacanthos*
Magnolia, cucumber	*Magnolia acuminata*
*Magnolia, mountain	*Magnolia fraseri*
*Magnolia, umbrella	*Magnolia tripetala*
Maple, black	*Acer nigrum*
Maple, red	*Acer rubrum*
Maple, silver	*Acer saccharinum*
Maple, sugar	*Acer saccharum*
*Mountain-ash	*Sorbus americana*
*Mulberry, red	*Morus rubra*
Oak, black	*Quercus velutina*
*Oak, blackjack	*Quercus marilandica*
Oak, chestnut	*Quercus montana*
Oak, chinquapin	*Quercus muehlenbergii*
Oak, pin	*Quercus palustris*
Oak, post	*Quercus stellata*
Oak, red	*Quercus borealis*
Oak, southern red	*Quercus rubra*
Oak, scarlet	*Quercus coccinea*
Oak, shingle	*Quercus imbricaria*
Oak, swamp white	*Quercus bicolor*
Oak, water	*Quercur nigra*
Oak, white	*Quercus alba*
Pine, mountain	*Pinus pungens*
Pine, northern white	*Pinus strobus*
Pine, pitch	*Pinus rigida*
Pine, shortleaf	*Pinus echinata*
Pine, Virginia	*Pinus virginiana*
Persimmon	*Diospyros virginiana*
Poplar, yellow	*Liriodendron tulipifera*
*Redbud	*Cercis canadensis*
*Rhododendron, great	*Rhododendron maximum*
*Sassafras	*Sassafras variifolium*

Common name	Scientific name
*Serviceberry	*Amelanchier canadensis*
*Silverbell	*Halesia carolina*
Silverbell, mountain	*Halesia monticola*
*Sourwood	*Oxydendrum arboreum*
Spruce, red	*Picea rubra*
Sycamore	*Platanus occidentalis*
Walnut, black	*Juglans nigra*
*Willow, black	*Salix nigra*

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