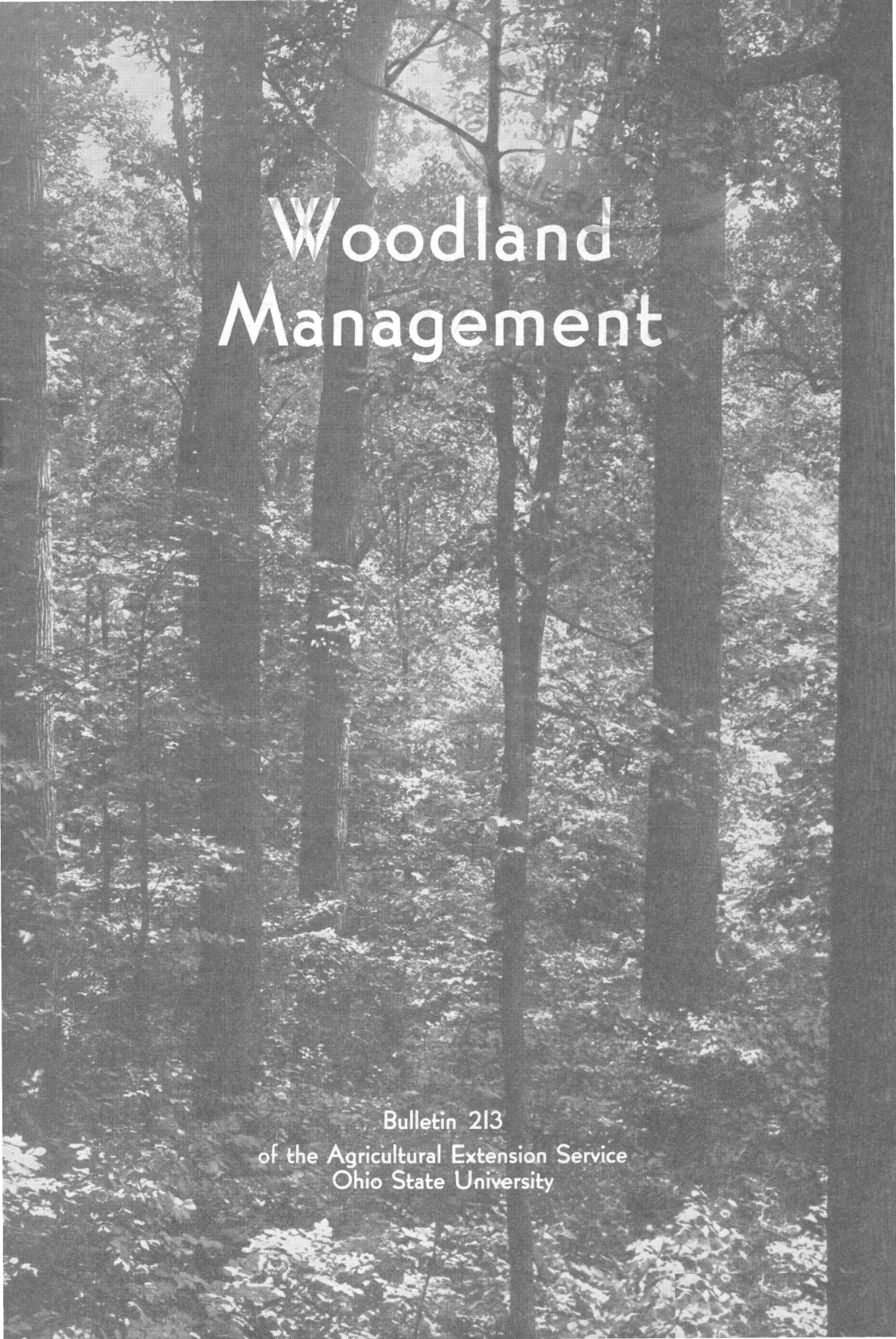

Woodland Management

Bulletin 213
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Contents

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The cover page shows a virgin yellow poplar forest on the Elizabeth Pixley farm near the Ohio River in Scioto County, Ohio. The picture was taken about 15 years ago, and at that time no trees had ever been cut in this solid stand of tulip or yellow poplar.

Woodland Management*

By

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Foreword

Most of the existing woods in the middle west are owned by farmers. Some owners derive good income from their woods; many do not.

County Land Use Planning Committees are recognizing that rather large areas of land, formerly under the plow, ought to be devoted to woods, and that the areas now in brush and poor timber ought to be so managed as to become productive woods.

Because the production of wood and wood products as a continuous crop offers excellent opportunities for returns to owners from those lands not suited for grain, hay, pasture, or row crops, this bulletin was written. Many owners have looked upon the woods as a mine of timber, to be cut and turned into pasture or field. They have burned the woods with the mistaken idea of improving the pasture, and have destroyed the young trees by grazing. The result is millions of loafing acres, poor woods, and poor pasture, the result of mismanagement.

Good land use demands that land produce what it ought to produce, and do so to the limit of its capacity. Woods, then, should produce good lumber, posts, and fuel, and should be kept producing them continuously for use on the farm and for sale. Such management is the *individual owner's* responsibility. Burning the woods reduces its capacity to produce; pasturing is the enemy of trees. Protection against fire and livestock — absolute protection — by the owner is the best insurance for a continuous flow of useful and profitable products from the woods.

Forestry is a part of farming; trees are crops, useful, profitable, beautiful. Woods furnish material, protect against drying winds, keep soil in place, aid in maintaining the flow of springs and streams, and provide cover and food for wildlife. They should be managed as a part of the successful farm enterprise. ◆

Acknowledgment

The Agricultural Extension Service of The Ohio State University is indebted to the following for their courtesy in supplying the photographs for the illustrations mentioned:

Forest Service of U. S. Dept. of Agriculture—Figures 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 14, and 15.
Soil Conservation Service of the U. S. Dept. of Agriculture—Figures 13 and 16.
Ohio Division of Forestry, Agricultural Experiment Station—Figures 9, 12, and 17.

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* This bulletin was prepared in collaboration with the representatives of the Central States Forest Experiment Station and Wayne National Forest of the Federal Forest Service, the State Coordinator of the Soil Conservation Service in Ohio and State Representative of the Bureau of Agricultural Economics in Ohio—all members of the U. S. Department of Agriculture—co-operating with the Agricultural Extension Service of the Ohio State University and the Ohio Division of Forestry, Ohio Agricultural Experiment Station.

It is intended primarily for the woodland owner on hill land south of the line of glaciation in Ohio, and elsewhere in the lower Ohio Valley, of the Central States Region.

General Characteristics of the Woods Crop

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Objectives in Management

When we speak of managing land we really mean that the operator is going to do things to the land that will make it more productive of goods and material. In this respect managing the woods is not different from managing any other farm crop. It responds to good treatment in the production of increased yields of better material. The objective in handling a woods is exactly the same as that in handling any other farm crop: the maximum yield of useful goods per acre. It really does not make any difference whether these goods are for use on the farm or for sale. In either case they represent income to the farmer, as they may replace products that would otherwise have to be bought from income or they may augment that income. The term "market" in this bulletin means both.

The quality of the wood produced must also be considered as a part of the yield, since the quality will determine usually the price received for it in the market. Sound, clear, straight-grained lumber properly manufactured commands higher prices in the market and is more useful than knotty, crooked stuff full of rot. Individual species also have an important role to play. Each has its peculiarities and its properties that fit it for particular uses. In this respect wood does not differ from other farm crops. Certain wheats are useful for certain purposes; some grasses and some legumes have special uses; no one would expect to satisfy a potato market with turnips.

Fitting the Crop to Suit the Ground

Like all crops, trees respond to soils and climates that suit them. A willow tree grows well on a soil near the river bank where an abundance of moisture is available. A shortleaf or pitch pine tree may grow and do rather well on a ridge where soil is thin and the water table very low. Although most trees may survive in almost any situation, if the objective is the production of useful material the species should be fitted to the particular location. It would not be profitable to attempt to grow white ash on a dry, hot, south slope, nor would red cedar grow particularly well by a river bank. Observation will reveal what trees will grow on various types of soil, slope, and water supply with which a farm is equipped.

Selecting the Crop to the Market

Use requirements and the market demands in the long run will determine what shall be grown and how it is to be prepared. In territories remote from large centers of lumber manufacture a local market for construction material may be rather good, and dictate the turning of a great deal of timber into that form. In most farming territories there is a good market for fence posts. This offers an excellent outlet for thinnings and material that may not be suitable for conversion into high-priced lumber products.

Fat hogs, finished and fine, top the market. Likewise, the market that is most critical of the quality of wood offered is also the market that will pay the best price. For example, white oak designed for bourbon barrels is required to be practically if not entirely free from all types of defects. Very high prices are paid for such material; at the present time 39-inch stave blanks sell in Missouri for $80.00 per thousand, or 8 cents apiece. Similarly, white oak suitable for veneer brings high prices in Ohio. On the other hand, some species used for rough crating or boxes may tolerate many knots and defects of various kinds in the wood; prices will be correspondingly low. It is also true that bulk utilization such as for cordwood or wood for hardwood distillation, or in some cases even pulpwood, pay less than markets that expend a great deal of money and labor in maintaining the product. The manufacture of dimension stock — that is, small pieces of wood sawed to size and machined to shape for subsequent assembly into manufactured products such as chairs, tables, beds, flooring, and the like, often give excellent returns.

In the long run the operator of a piece of woodland will find that he should try to get his tree crop fully stocked with those species (such as white oak, red oak, white ash, basswood, hickory, yellow poplar, black walnut, black cherry, and hard maple) that over a long period of time have been most in demand and have paid the best prices. It is true that markets come and go, and demand may vary from year to year. However, when dealing with a crop that requires many years to mature it is clear that there are opportunities for taking advantage of market situations as they arise because of the choice one has in time of cutting. The smart farmer knows the long-time trend of markets and plans his farming accordingly.

Taking Care of the Timber Crop

Trees may just grow, or be managed. A good farmer cultivates, weeds, and thins to improve his yields. Getting the timber crop in the best kind of shape to yield the best kind of material for high-grade markets cannot be done by merely allowing the trees to grow. There are certain operations that the manager must perform in order to get his stand of timber into the most productive condition. Just as with any crop that he grows in the fields, there will be many small and worthless trees growing in the woods that offer no possibility of return.

In a corn field they might be cockleburs, morning glories, ragweeds, and the like. In the woods blue beech, ironwood, thorn apple, and box elder have no possibility of a market and not much use. These should be removed and utilized for firewood or any other farm use for which they are adapted. Likewise, just as in row crops, stands of trees will often be found too thick or dense for good growth. In such cases good judgment would indicate the desirability of removal of a certain proportion of trees. The careful operator would choose those trees of best species and best form to leave for his permanent crop, and would remove other trees in order to give more room, more light, more water, and more space for his good trees to grow.

Getting Ready for the Next Crop

Just like other crops, trees respond to the treatment that they get in harvesting and in getting ready for the next crop.

For example, alfalfa that is overpastured or overcut will gradually deteriorate into a field that yields very little hay.

In harvesting tree crops the good manager will always have in mind the fact that he is coming back for the next crop, and the next. He will, therefore, cut those trees that he desires to cut in such a way as will minimize the injury to the younger trees and poles and saplings that remain. He will cut in such a way that he will not expose too much ground surface to the drying sun and hot winds of summer. Heavy cutting increases the danger of wind damage, and may be followed by heavy windthrow. He will time his cut in such a way as to benefit his remaining growing stock by the removal of the tree that he is harvesting. His objective will not be confined to obtaining material to sell, but he will always have in mind the principle that his cutting shall be designed to improve his growing stock, allowing young, thrifty trees to make better growth, and will look forward to a better harvest the next time.

Tree Crops Other Than Wood

In addition to returns from marketing and using wood products, the thrifty manager will always be alive to possibilities for marketing other products produced by trees.

In some parts of the middle west excellent annual returns are obtained from the operating of the "sugar bush." The work comes in late winter at a time when very little farm work can be done, and there is always a ready market and adequate price for the maple syrup and sugar.

Likewise, in some parts of the hardwood region excellent returns are obtained from the harvesting of walnuts, hickory nuts, and butternuts. From one county in Kentucky a few years ago over $100,000 worth of black walnuts and black walnut kernels were shipped. Many farm families earn considerable income in the winter evenings in preparing nut kernels for market. It is said that at no time has the market for black walnut kernels ever been completely satisfied. Hickory nuts also are in ready demand. Such crops as these can be harvested annually and the woods left in exactly the same productive condition as it was before the harvest was obtained.

How Trees Get Started

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Seed

Most farmers know all about how ordinary crops grow, produce seed, and what treatment the seed should have in order to insure good germination and growth for the ensuing crop. Trees go through exactly the same sort of processes.

Trees have many ways of producing seeds. Some grow inside of fleshy fruits: the persimmon, plum, apple, pawpaw; some have wings: the elms,

pines, maples and catalpas; some occur in cones: pines, hemlocks, spruces; and others have the form of nuts: walnuts, hickory nuts, basswood, butternuts; some produce male and female organs in the same flower: apples, black cherry, elms, basswood; some produce the male organs and female organs in separate flowers: walnuts, hickory nuts, maples; some have male and female trees: ashes, holly.

Good and Bad Seed Years.—Our pioneer fathers knew when good and bad seed years came for the oaks, hickories, walnuts, and beeches, because the hogs that ran in the woods depended upon the "mast" for sustenance. The things that go to make up a good or bad seed year vary according to the species of the tree.

Spreading of Seeds.—Birds and rodents have a great deal to do with the spreading of the larger-seeded species. Squirrels often bury quantities of

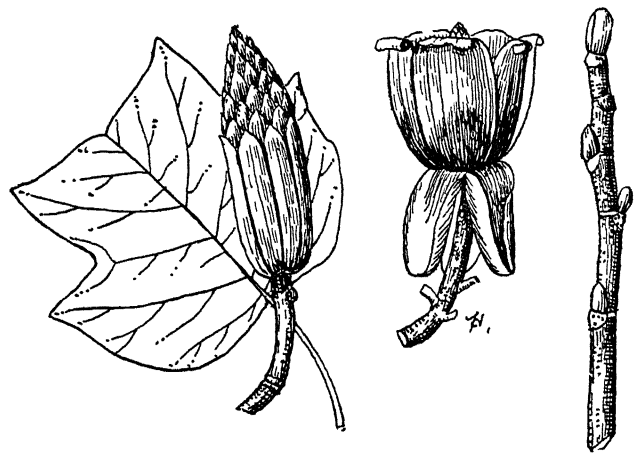

Fig. 1. Yellow Poplar. Leaf, seed cone, flower and twig.

acorns and nuts in various places, and they may later germinate. Some light-seeded species — maples, elms, ash, yellow poplar, sycamore, cottonwood — are equipped with wings which catch the wind and spread them far beyond the limits that the heavier-seeded species can cover (Fig. 1). Nature has all sorts of mechanisms through which seeds are spread. However, just spreading them is not enough. They must have proper conditions for germination and only a very, very small percentage of the seed that is borne ever develops into seedlings.

Germination

Just as with any other seed that goes into the ground, tree seeds are pretty delicate in their requirements for germination. Most of them — for example, pine, elm, ash, yellow poplar, and birch, do much better if they lie next to the mineral soil and are covered up a little. Many seeds do not

germinate unless they go through a very cold winter, for example, thornapples, dogwood, and some pines. Seeds from oaks, walnuts, hickories, basswood, pines, beech, maples, and black cherry are food for rodents or birds. Many of these seeds are carried away and dropped a considerable distance from the parent tree, thus spreading the species. Some of the small, harder-shelled species, if passed through the digestive tracts of birds or animals, are in better condition for germination than before they were eaten. Thus, the fruits of honey locust and osage-orange are eaten by cows; red cedar, hackberry, and black cherry are eaten by birds and the germinating quality of the seeds is improved.

There are no general rules covering the germination of tree seeds. Each species has its own definite requirements that must be met before the seed will germinate and become established. A proper supply of moisture is essential to good germination.

Influence of Surroundings on the Seedlings

After seeds have once germinated they are influenced by all the variations in conditions around them. Some species, such as cottonwood, willow, ash, white elm, sycamore, and hemlock, require moist sites; other species such as black walnut, southern yellow pines, and black locust, require full light and warm temperatures; still others, as the shortleaf and pitch pines, and chestnut oak, do well in dry situations. Species characteristic of moist, shady sites and moderate temperatures are beech, sugar maple, dogwood, and hemlock. All sorts of combinations of these factors are found as requirements.

Only a small proportion of the seedlings that germinate and get above the ground continue to grow. If a woods needs restocking, that is, if there are too few trees standing on the ground, it may pay the good manager to take certain steps to insure the development of seedlings in these locations. This may involve, for example, getting into the woods and tearing up the ground with a harrow in order to give seedlings a better chance.

It may often happen that seedlings that have germinated and are apparently growing are in heavy competition with other types of vegetation. Many weeds and bushes grow in a woods. They require light; they require moisture and fertility. In the heavy competition of nature only those plants that are best fitted to compete will survive. Seedlings that come through and finally outgrow the competing vegetation are usually in pretty good condition to go ahead and make trees.

Sprouting

Most hardwoods reproduce not only from seed but also from sprouts (Fig. 2). Examples are all species of oak and black locust. The stumps of young trees sprout much more vigorously than those of medium-aged trees; and stumps of many species when old do not sprout at all. These sprouts may come from the stumps or from the roots. Most of them of any value come from the stumps. Black locust is an exception.

Sprouts of most value come from low down on the stump or near the ground. The reason for this is that the stump itself may be and probably will be infected with decay. The heartwood of those sprouts growing from the top of the stump may become infected by the decay organisms. In the long run, therefore, they probably will be found developing into defective trees. In addition, sprouts from the top of stumps are weakly attached and easily broken over.

Planting

Why? A stand of trees may be so far degraded, so thin, or so barren of growing stock that it will be necessary to interplant with young trees in order to get a productive stand on the way without waiting for the production of seed and the growing of seedlings in the natural manner. Again the operator may plan to return a bare, cleared area or one lacking seed trees of desirable species to growing a crop of wood. Whether this should be done or not will usually be a matter for individual judgment.

What? The question then arises: What species should be planted? That will depend entirely upon the situation. Where the site is dry, open, and subjected to the direct influence of the sun and wind, it is not likely that the farmer can advantageously plant hardwoods. He may have to plant some of the evergreens in order to get anything to grow. On thin-soiled limestone or glady land, red cedar may come in naturally, provided seed trees are available in the vicinity. However, the objective in most

Fig. 2. Sprout clumps of yellow poplar from stumps of young vigorous trees. It is good business to select the best and straightest one to save and cut out the others. Ordinarily this ought to be done when the trees are small and of whip size.

cases in such regions should probably be the eventual return of the land to hardwood.

When pines are planted on sandy and shale soils, or on severely eroded soils, the ground is prepared by the deposit of litter for the natural coming in of hardwood seedlings later. The purpose will have been accomplished of having something growing on the land, improving the site, and making it ready for a better crop later on.

In other cases the situation may be such that the farmer can plant hardwood species directly. The edge of a moist, fertile terrace subject to gullying may be an excellent site for a crop of black locust for posts. The moist, fertile base of a sheltered slope may be available for planting some black walnuts. An odd corner of a fertile bottom land subject to overflow will produce a good crop of hardy catalpa posts and poles at an early age. A moist, north-facing, cleared ravine or cove which is washing may provide an excellent site to plant yellow poplar in whose shade hard maple will seed and thrive from a few seed trees to windward. A poorly drained patch bearing heavy, glacial soil may make an excellent spot to plant white ash and red and white elm.

Open patches resulting from former heavy grazing may be planted after breaking up the sod. The operator will aim to restock the type of woods now there. For example, it is folly to plant holes in a oak-hickory woods with the kinds of trees which go to make up a beech-maple or a bottom land type. In each of these cases the farmer will wish to choose his species according to the kind of soil and moisture conditions and amount of open spaces that he has to plant. A good chat with the Extension Forester or the County Agent ought to give him the information he requires as to what he ought to plant.

When? Like any other operation, planting must be done when conditions are right. In general, in the middle west, spring planting is most satisfactory. Depending on whether the season is early or late, ordinarily trees should be planted between February 25 and April 15, just as early as the frost is out of the ground. Planting should be done when trees are dormant.

How? Techniques of planting are well developed and knowledge concerning them can always be obtained from the Extension Forester's, State Forester's, or the County Agent's office. It is not enough just to go out and stick trees in the ground. They have to be planted properly or they will not grow and develop as they should. Care in planting always pays big dividends. The only trees planted that are worth anything are those that survive and grow (Fig. 3).

There are several general rules which the farmer will find are necessary to make a successful tree planting. These are as follows:

1. *Heel in the trees* in a dug trench in the shade, and cover the roots with moist dirt, when they are held a day or more before planting. Open the bundles and loosen trees before heeling in to prevent heating and get dirt around the roots.

The Essential Steps in Planting Forest Trees

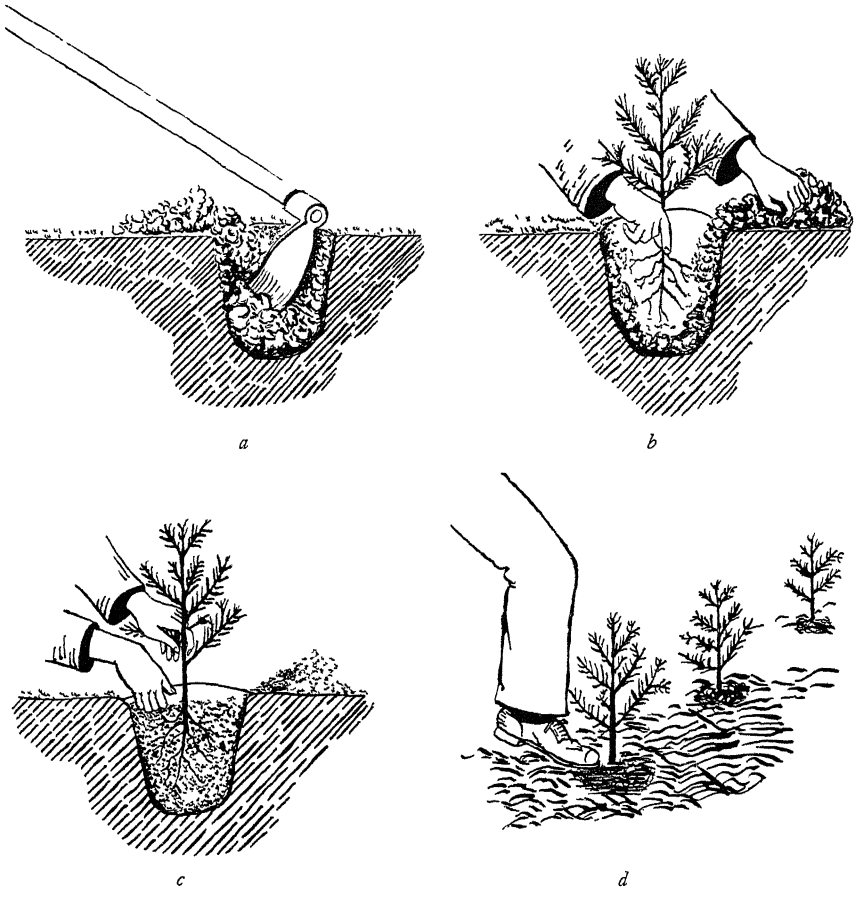

Fig. 3. (a) Dig hole big enough for roots to hang straight down without curling. (b) Hold root collar at ground level, partly fill hole and pack dirt. (c) Fill hole by stages, packing dirt firmly. (d) Firm the soil with foot, scrape loose soil and litter over the surface.

2. *Never let the roots be exposed* and *dried* by sun or wind. There may be exceptions, but hunting for them will cost you dearly. Carry trees in a wet bucket or pail, covered with wet burlap, when planting them.

3. *Scalp* a *spot* at least 12 inches square where each tree is to stand to free it of grass or weed competition.

4. *Dig* the *hole* for each tree *deep enough* so that the roots will hang down vertically. Whether a spade or grub hoe is used does not matter, but the roots *must not* be curled or wadded into a ball. Forest trees deserve as good a start as do apple trees or tomato plants.

5. *Take care* that the *root collar* (or place where the top joins the root) *is at* the *ground level,* or just barely lower to allow for settling of the dirt.

6. *Pack moist top soil* tightly about the roots, in stages, beginning at the bottom. Avoid dry leaves and grass or air pockets next to roots.

7. *Firm* the *soil around* the planted *tree with* the *feet.* You should not be able to pull up the tree except with considerable effort.

8. *Turn over* and replace any sod or litter to provide a mulch.

How Trees Grow

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Physiology of Growth

Trees grow just like any other plant. They obtain carbon dioxide from the air, water through their roots, and by the influence of light shining on their leaves manufacture sugar from which is made all of the various tissues that go to make up the tree. The roots also take up with the soil moisture mineral material in small quantity. The usual mineral requirements for tree growth are far less than those of ordinary farm crops. All of the work of building food materials and preparing them for transport is done in the leaves.

Importance of Water

A good supply of water is of enormous importance to a tree. Not only is about half of the tree made up of water, but it acts in the capacity of a transporting agent for all of the various materials that must be moved around through the tree. Water is taken up through the roots and most of it is evaporated through the leaves.

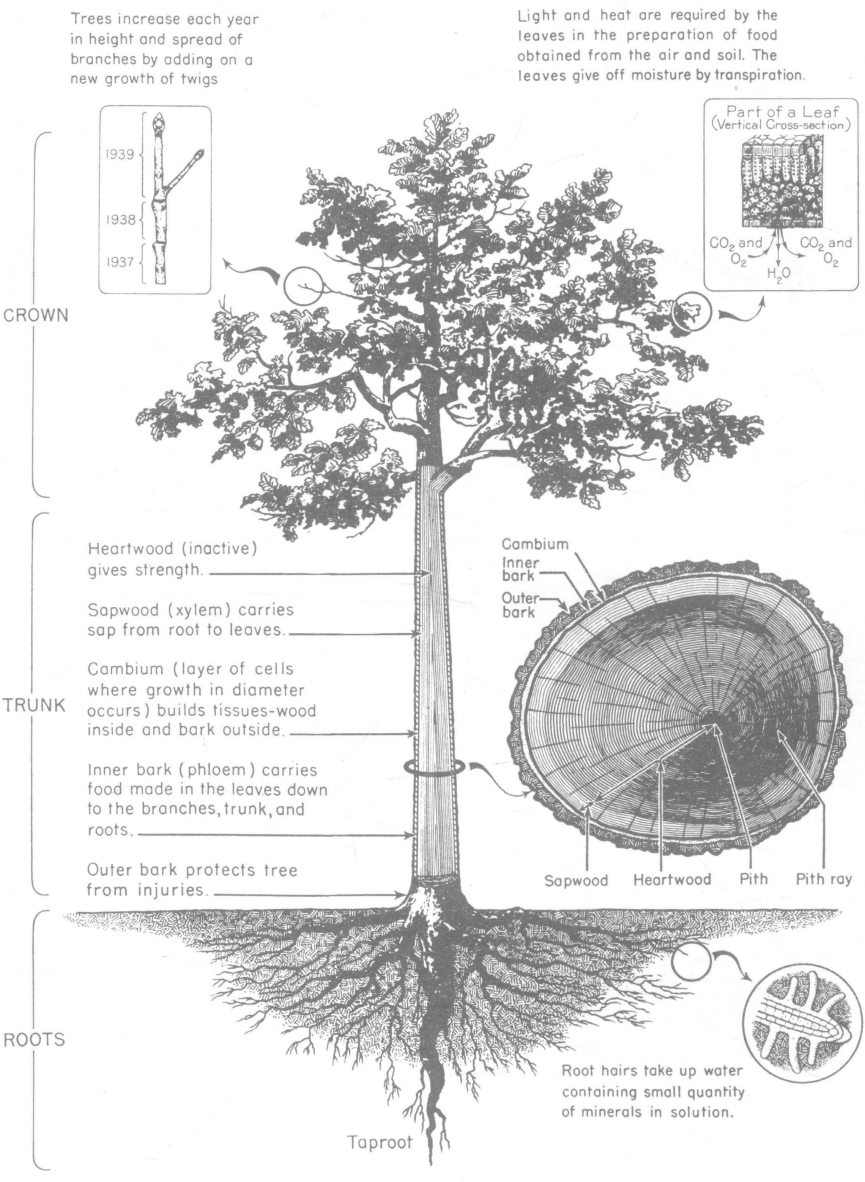
The amount of water that can be taken from the ground and evaporated through the leaves in the run of a day by a big hardwood tree is something really enormous. A heavy stand of beech about 55 years old has been calculated to use about 8 acre-inches of water during the growing season. Pine uses only about a fourth as much and so does well in dry situations.

However, roots of trees go far into the ground as a rule and cover a great deal of territory. When the water supply runs low, the leaves wilt, and sometimes when the supply is actually exhausted the tops die. A dead top never recovers.

Structure of the Trunk

The trunk of a tree actually grows on the outside. That is, the growing tissue is a little layer only about one cell thick just underneath the bark (Fig. 4). This is called the cambium layer. This single layer of cells is subdividing. Those new cells on the outside go to form the live part of the bark; those on the inside go to form new wood. As the bark grows toward the outside, the old, weathered outside bark often scales off. Not so with the wood. Every new layer of wood that is put on is on the outside of the preceding layer. We can tell the age of a tree, therefore, by taking a cross section at the base or near the stump and counting the rings of wood that have been laid on. Usually, each ring corresponds to a year of age.

HOW A TREE GROWS



The buds, root tips, and cambium layer are the growing parts. The tree takes in oxygen over its entire surface through breathing pores on leaves, twigs, branches, trunk, and roots.

Fig. 4. A diagram which illustrates briefly the parts of a tree in their relation to air, soil, and moisture.

The whole trunk, therefore, is a sort of series of cones placed one over the other. There is a very small cone at the bottom on the inside of the stump. Placed over it are successive cones of wood corresponding to each successive year of growth. Growth in length occurs only at the tips of the trunk, limbs, and twigs. It is clear, then, that the wood, once laid on in a trunk, stays in exactly the same position in which it is originally deposited. That is, a knot once formed 4 feet from the ground will always be 4 feet from the ground.

The Circulation System

After the wood has been formed for a period, it slowly ceases to be part of the living portion of the tree. That is, it changes from living or "sap" wood into dead or "heart" wood. Sapwood may be very thin, containing only one or two annual rings, as in hardy catalpa and chestnut, or very thick, containing up to 100 rings, as in ponderosa pine in the west. As sapwood changes to heartwood, it usually takes on a darker color, it becomes somewhat denser, and it receives various gums, resins, and deposits which are responsible for it being more durable. Good examples are the heartwood of osage orange, black locust, red cedar, mulberry, black walnut, and white oak. The oldest or central rings change into heartwood first, followed by those next to it.

Water that is taken up from the roots goes up the tree mostly through the outside portion of the live sapwood. It goes all the way up to the leaves, where part of it is used to combine with the carbon dioxide taken from the air to make sugar and starch. This material is then dissolved in the sap of the tree. It finds another route through the live bark on the outside of the trunk back down to the actively growing tissues of the trunk and root. This, in general, describes the system by which materials are moved around through the tree.

Influence of Light

The actual formation of things necessary for the growth of a tree depends entirely upon the combination of water and carbon dioxide under the influence of light. This process takes place in the leaves. The number of leaves, therefore, and the amount of light that they get determine, to a large extent, the rate at which trees grow. Therefore, the size of the top of a tree is important. It must also have plenty of room in which to expand and have a good chance at the available sunlight. Trees vary a great deal in their requirements.

What Happens in Girdling

When a tree is girdled, a very interesting situation arises. What actually happens is the supply of water is cut off. There are several ways of doing this. Most men, when they girdle a tree, chop clear through the outer rings of sapwood which are most active in transporting water from the roots to

the crown. Also, they effectively remove all of the bark, so the return trip from the crown to the roots cannot be made. The roots then simply starve. The top also starves, because it can't get any water, and the tree dies.

The situation may arise that we want to girdle a tree in such a way that it will not sprout. It has been found that if the girdling does *not* go into the sapwood, but merely goes through the bark and the cambium layer, the roots will continue to send water to the top, but nothing can come from the top back down to the roots. If this is properly done the roots will become exhausted and will not have left enough food material with which to send out sprouts. The tree may be a little longer in dying than would have been the case if the girdling had been done clear through the outer rings of sapwood, but the process is more complete, because the roots can no longer send up sprouts.

Rate of Growth

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Soil, Slope, and Water

The quality of a site for trees[1] is dependent upon the fertility of the soil, the slope of the country, the direction of the slope, and the amount of water available for tree growth. The depth of soil, the kind of rock underlying the soil, the presence or absence of hardpan, the length of the growing season, and the average temperature all have something to do with the size of the tree that will be produced. The important thing is to remember that trees, like other crops, do best on good sites. Some people have the idea that a tree will grow anywhere and do well. On the contrary, trees are just like corn in that they do best on land that is best adapted to tree growth.

Improving Site Through Management

The important thing to remember about site is that it does not always have to be left as we find it. It can be improved by good management practices.

For example, although we cannot do anything about the basic material out of which the soil is made, we can certainly improve its texture through proper management of our woods. The soil in a virgin forest is far different from soil that has been subjected to cultivation or grazing for a long period of years. The soil in the virgin forest will be found loose, porous, and crumbly; while that in the old field may be so compact that little water can soak in. The amount of water that can enter the soil from the surface is an important element in our study of site. This will depend a great deal upon the looseness of the soil, the degree to which it has been packed, and its general physical condition. It is also dependent to a very large extent upon the material that lies on top of the soil.

[1] The term "site" is defined in terms of the height growth that certain species of trees will make in a certain number of years.

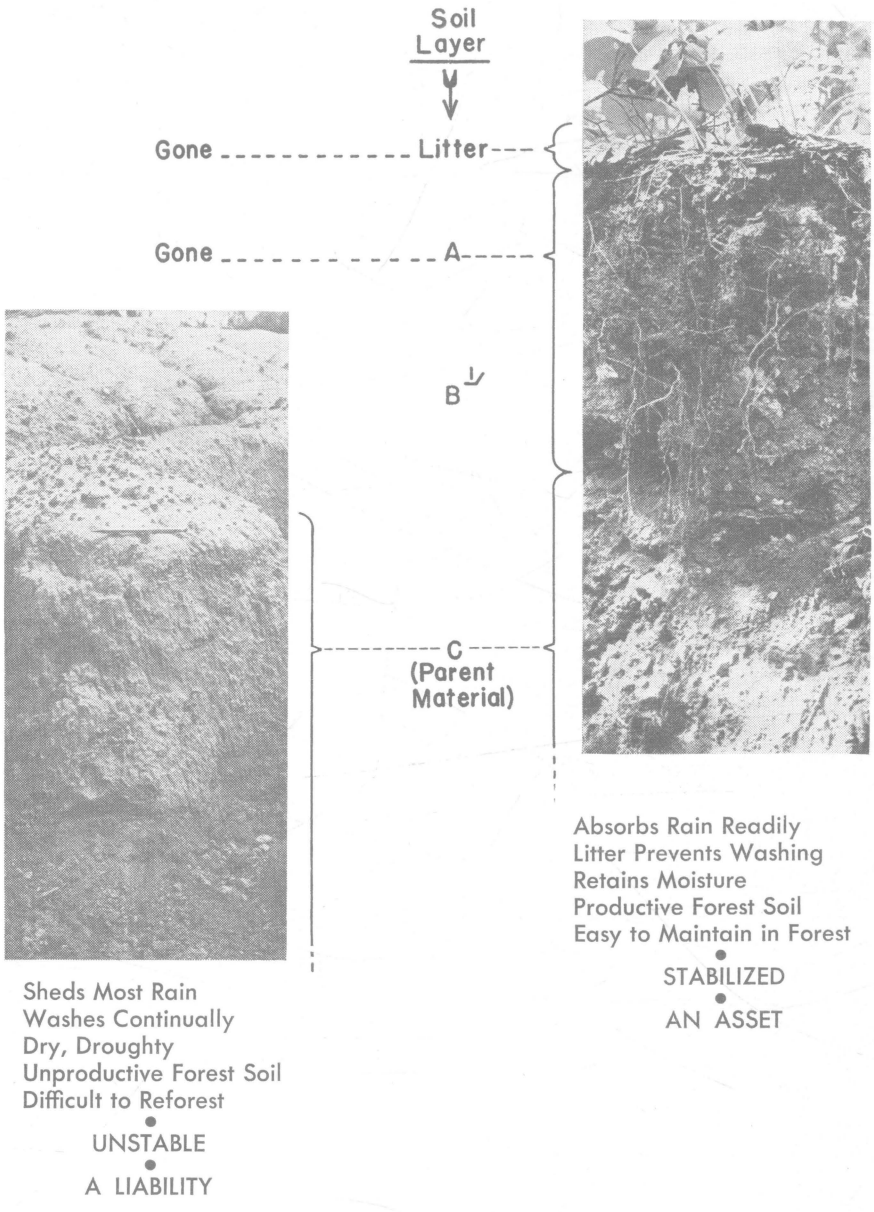

Fig. 5. A virgin normal forest soil contrasted to one deteriorated by clearing, cultivation, and erosion. A single fire does not greatly alter the soil; but repeated fires, by killing out the vegetative cover, initiate a series of events which eventually lead to the loss, through washing, of the fertile humus-bearing top soil.

[1] The B is very slight or absent in this particular soil.

A deep litter composed of dead and partially decayed leaves, twigs, and the like has an important effect on encouraging the entrance of rainfall into the soil. Water runs off a bare soil surface much more rapidly than from a soil surface covered with a good layer of litter. Because of this, springs and streams flow longer in well wooded country.

We know, also, that the amount of humus incorporated into a soil has a great deal to do with its capacity to take in water. Humus develops rapidly under a hardwood forest cover from decaying leaves and twigs. Exposure to too much sunlight and to heavy drying winds is destructive to humus. Fire is also destructive not only to the litter cover but to the organic matter that may have been incorporated in the soil through ages of forest growth.

Even an old field can be planted to trees and brought back into good condition. However, this will take a considerable number of years, because we shall have to keep out fire and livestock and accumulate all the fallen leaves possible which are needed in the development of litter and the incorporation of humus into the surface layers of the soil.

Fire and Pasturing

Fire has been referred to as an agent that degrades site. This is partly because of the destruction of litter and destruction of organic matter in the soil. The destruction of litter and organic matter reduces the capacity of the soil to take in water, and therefore reduces the amount of water available to the growing trees (Fig. 5).

Fig. 6. Litter destroyed and ground packed hard around trees' root systems. This makes a most unhealthy soil condition for the woods and so hardens the ground that it cannot absorb water and sheds rain like a tin roof. Notice, too, that there are no seedlings or pole-sized trees growing.

Pasturing also has a very definite effect on the quality of a site in that the continued trampling of stock packs the soil, making it less able to take in water (Fig. 6). In short, any operations that tend to decrease the capacity of the soil to take in water or to decrease its fertility are going to affect the production of timber adversely.

Height Growth

Height growth is important, because we want the greatest number of logs or the greatest number of feet of usable trunk in a tree that we can get. This will give the greatest possible volume of useful material that can be obtained in the growth of a single tree. Quality of the site, therefore, determines height growth and, in the same way, determines the amount of wood that can be obtained from a single tree or from a stand. Since there is plenty of room straight up to make growth, and the room horizontally is limited, our best opportunity to produce lots of material is in increased height growth.

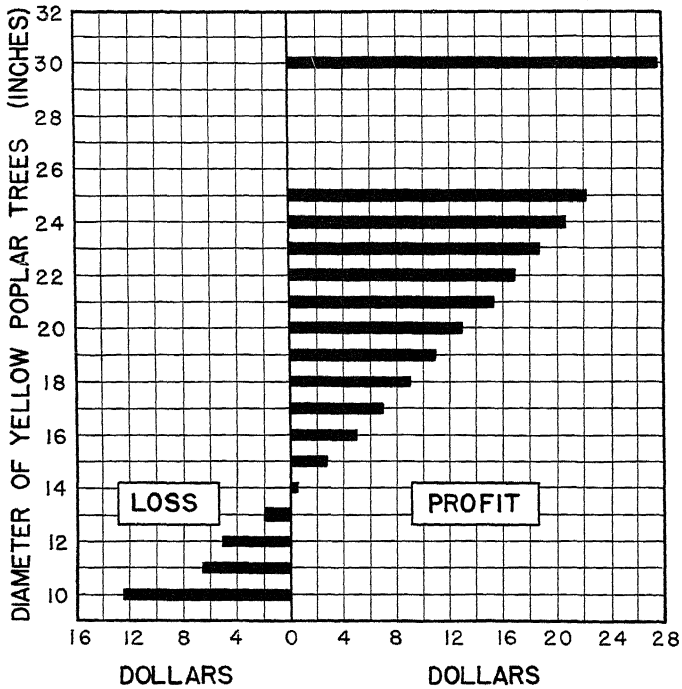

Fig. 7. Example of profit or loss per 1000 board feet of lumber, including stumpage, for yellow poplar trees in relation to tree size in 1926. (Ashe, W. W., 1926—Relation of size of trees to stumpage values and profits with special reference to hardwoods.) Paper presented to Appal. Logging Cong., Cincin., O.

Every effort should be made, therefore, to manage the woods so as to improve the quality of the site from year to year. This simply means protection from fire and grazing, protection against too much opening up to sun and wind, the propagation of species mixed in the stand that are known site improvers. These are such species as sugar maple, basswood, black locust, yellow poplar, oaks, elms, and ash.

Diameter Growth — Good Lumber in Big Trees

As stated previously, trees lay on their wood on the outside. Also, the best lumber is lumber that is freest from knots. Tall trees, grown under

good forest conditions, usually shed their limbs at a comparatively young age and the trunk continues to grow. It follows that the clear lumber will be laid on to the greatest extent on the outside of fairly large trunks. It thus becomes evident why it is not profitable to cut and market small trees just as soon as they have a little market value. It is just about that time that they are beginning to lay on good wood. There is also the added advantage of being able to cut wide boards from large trees, and these often command a premium in the market (Fig. 7).

Probably we cannot afford these days to grow trees to the enormous sizes that were found in the virgin forests that once covered the most of the central states. However, we can afford, if we manage our woods properly and have a good distribution of ages from comparatively old trees to very young trees, to grow trees of fairly good size that will yield good quantities of high quality lumber.

Where Are the Knots?

In almost any hardwood tree most of the knots will be found in the middle of the large logs and in the top logs. This is the result of the fact stated under "Diameter Growth," that the trees usually tend to shed their lower limbs as they increase in height and as the top spreads out. This is simply because there is no longer any light available for the leaves that are borne on the lower limbs, and they therefore die, dry up, and are shed. Sometimes in more intensive forest management it becomes a good idea to go through and remove the young limbs that would otherwise produce knots. This will be treated a little later.

Maturity of the Tree

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Physiological Maturity

When we speak of a "mature" tree we may be talking about two entirely different things. There is such a thing as "physiological maturity." By this is simply meant that the tree is as tall as it will ever be. At the same time it is putting only a very, very thin layer of wood around its trunk each year. The tree is just about taking in and manufacturing enough material to keep itself alive. The usual situation in such a tree is that its top will not be particularly thrifty looking; it may have a number of dead limbs around the top, and it gives a general appearance of being in its old age and decline.

This tree ought to be harvested.

Financial Maturity

Another kind of maturity is sometimes called "financial maturity." By this is meant that the tree has reached a state of slowed-up growth. It is no longer laying on wood fast enough to pay to keep it on the stump.

A tree may have reached financial maturity without really being worth anything. That is to say, its situation may be such in the stand that it cannot grow, it may be hollow, it may be full of rot, it may be crooked. At

any rate the term "financial maturity" simply means that the tree has ceased to be a prospect for any further gain, and it should be cut.

One quick and easy way to find out how fast a tree is growing is to cut a small vertical notch with an axe, not over an inch deep. Inspection of the small block which the axe broke out will show whether the last few rings are wide, medium, or narrow. Eight or less rings to the inch is rapid growth; fifteen or more is rather slow and unsatisfactory, but old trees putting on ten to twelve rings to the inch are producing wood of excellent quality. If the tree is growing slowly, then one must calculate or judge whether or not the amount of wood being put on is worth while, and on that basis determine whether or not the tree ought to be cut.

Good Growers and Poor Ones

In any field crop or row crop there are plants that grow faster than the others. In the forest this is also true, and from a given bunch of seedlings or sprouts there are usually some that grow faster and taller and in the long run have their heads above those of the surrounding trees. These are called "dominants." There are trees of the same or different species perhaps a little behind these more advanced individuals. These are called "codominants."

There are other trees that lose out completely in the race for light and water. They become poor, thin-crowned, scrawny-looking trees that are not doing much in the way of growing. These are called "suppressed" or "overtopped." They are comparable to the runts in a litter of pigs.

The actual mechanism by which these various rates of growth arise is simply one of competition for light and water and the ability of some individuals to outstrip others in the race. The suppressed trees do not usually make much growth as long as the dominants and codominants are around. The dominants and codominants mature and can be taken out of the stand.

Some kinds of trees, for example pine, hemlock, white oak, black oak, hard maple, beech, basswood, and elm, which have been overtopped and later released, may recover and begin to put on a remarkable rate of growth. They may have sufficient light and water, then, to develop a good crown and begin to put on both height and diameter growth, if not already too old and decrepit.

Other species, like black walnut, ash, and black cherry, once suppressed, show little ability to recover when given a chance. Good judgment again is about the only criterion by which management can determine what trees to cut. The dominant may be young and thrifty and growing. In which case, it should remain in the stand, if it be of good species, because it is making money. The same thing might be true of the codominant. The situation might arise where the dominant or the codominant might be defective, while there were sound, small, suppressed trees around. In this case, because of the low potential value of the larger trees, perhaps they should be removed so that the sound suppressed trees might have an opportunity to grow and put on good material that really would have a market.

The All-Aged Forest

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The Canopy

The most stable hardwood forest is one which can reproduce in its own shade. Forests of beech and maple and of elm-ash-maple are of this type. They provide the best growing condition for the continuous production of useful wood and normally will have all ages of trees in them, from the mature tree that is ready for cutting down to the small seedling that is just getting started.

Since the limiting factor in the growth of individual trees usually is light, and the leaves are the all-important things in using this light, the forest that is really doing the best it can will have a complete canopy of leaves shading the ground. That is, there will be very little light reaching the ground through the shade maintained by the trees. At the same time there may be very many layers of leaves, from the tops of the tallest trees down to the small seedlings that are just getting started on the ground. There will be old trees, thrifty mature young trees, good sound poles that have nearly made their maximum height growth, saplings that are still reaching up to the top, and so on down to the youngest specimens (Fig. 8).

Farmers who maintain productive woods never cut an area clean. Sudden exposure to full sun and drying winds will kill seedlings of many

Fig. 8. An all-aged oak-hickory woods. It contains large, medium, and small-sized trees of different kinds and ages. The owner protects it from fire and fences out all livestock. This woods is in good condition to keep on growing and producing wood crops.

shade-loving and desirable species. The trees that sprout most vigorously will take over the stand. The next crop, therefore, will consist largely of species that could endure dry conditions while young or those of sprout origin. A repetition of clear cutting converts the stand still further toward a forest of trees that does not include moisture-loving and non-sprouting species. It is by this means, combined with fire and pasturing, that much of the middle west has actually been "dried out" since the original settlement. In general, present woods contain more oaks and hickories and fewer beech, maple and ash.

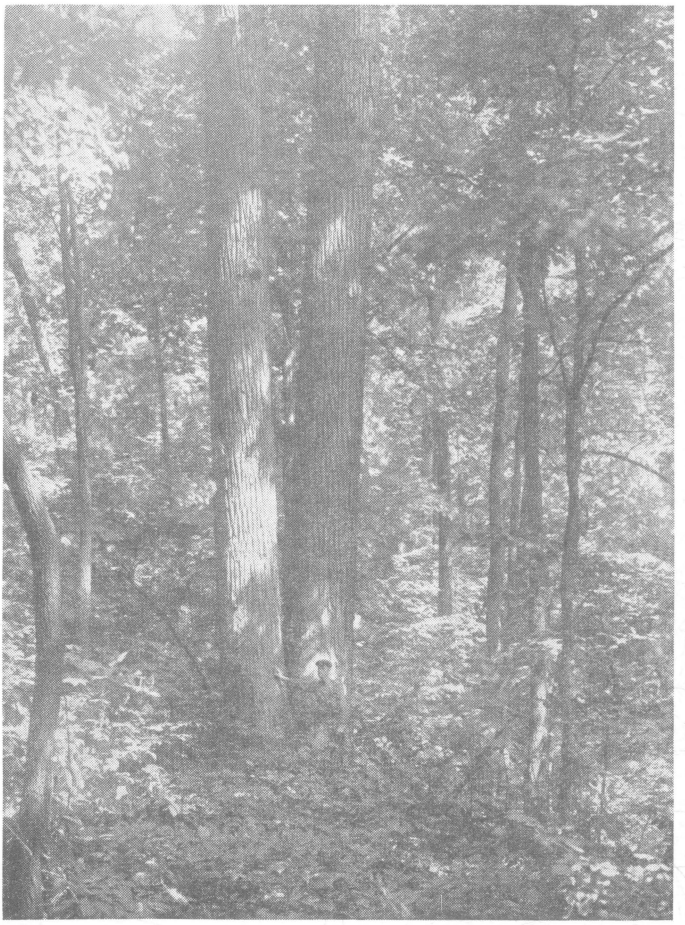

Fig. 9. Two excellent specimens of original growth yellow poplar in Ohio. The clean straight trunks bear witness to a dense woods and good soil. Straight logs command good prices.

Time and good management will restore the original good site.

A hardwood forest site, well mulched and moist, must never be opened to the full blast of summer sun and wind.

The Forest-grown Tree

The typical forest-grown tree is a tall, clean-boled affair with very few or no limbs for quite a distance up toward the top (Fig. 9). This is because there has been limited light in the heavy, dense hardwood forest, the lack of which has caused the shedding of the lower limbs at the tree grew. The good forest-grown tree will have a straight bole and the top will be far up above a long, smooth trunk. The top will usually shape itself so as to utilize most efficiently the light that is available.

The Open-grown Tree

In contrast to the forest-grown tree, the usual hardwood grown in the open is a very limby tree with a wide crown and a rather rapid rate of growth.

Such trees cannot produce good lumber because the trunk is liable to be full of knots, cross-grained, and crooked-grained. The clear length, that is, the trunk that is free from knots, is usually short and may not warrant harvesting and manufacture. The true forest-grown tree of the characteristics described above produces long trunks with a great deal of clear lumber.

Wolf Trees

There is another kind of growth that sometimes occurs even in the dense forest; some trees simply have so much growth capacity that they reach out and take in all of the territory around them. They are usually trees of comparatively short lengths of clear trunk, but with enormous tops and large spreading limbs reaching out over a lot of ground and overtopping all surrounding trees. They use up a large amount of space, take a lot of light that could be used by better quality trees, and take all the water from a large area without producing anything in the way of merchantable material. Such trees are called "wolf trees," and usually should be removed from the stand (Fig. 10).

The Even-Aged Forest

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How Such a Forest Starts

We have been talking about all-aged woods, or woods in which there are trees all the way from the veteran to the seedling. There are other kinds of woods — the even-aged. In nature, such stands are found only as the result of events like killing fires or heavy windstorms that have destroyed the larger, overtopping trees and permitted young ones to get started all at the same time. In some localities where stands have been clear cut for various purposes, such as the production of charcoal, sprout stands follow. Or, where worn-out old fields lie to windward of seed-bearing trees and are allowed to seed and to grow up, even-aged forests have resulted. Naturally, most plantings are classified as even-aged forests.

In the natural course of events, an even-aged forest will eventually be transferred into an all-aged forest because, as is the case among all living things, some individuals will live longer than others; and as the weaker ones pass out of the stand, younger, shade-enduring trees will replace them. The process of transformation from an even-aged woods to an all-aged is a very slow one.

Cutting for Conversion to All-aged Forests

If we are called upon to deal with an even-aged forest in management, the objective should usually be to cut and work in such a way as to convert it to an all-aged stand. This can be done, but it will take a good many years at the best. The processes are fairly simple, but they must be applied carefully and gradually during thinning or logging operations.

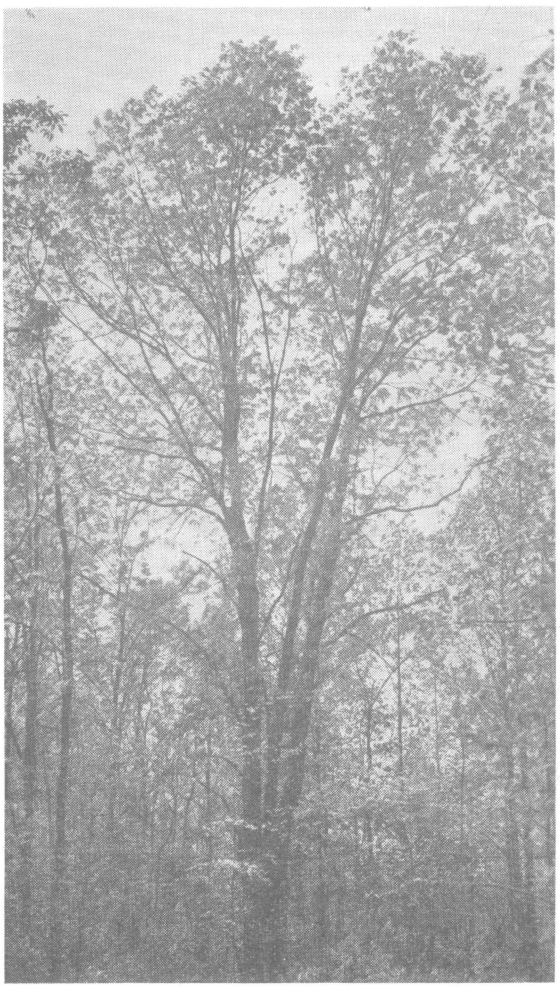

Fig. 10. A large wolf tree. Note how much room it takes, its many-branched top, limbs, and dominance over adjacent trees. It is good business to remove trees of this type at the first opportunity, and to use them for such logs, tie-cuts, and fuel as they contain, unless some special reason dictates that they be retained.

Selection for cutting should take in those specimens that ought to come out of the stand first. These are removed and then the openings seed from the trees remaining. New openings can be made subsequently as additional trees are cut.

This process will go on for a good many years, and eventually the forest will be made up of many ages of trees. The manager will have to strike a balance between immediate financial returns and the prospect of having a better forest.

Obviously, the principal reason for converting to an all-aged stand is in order to have a continuous return from the forest. If that is not the desire and the objective is merely to produce material, whenever that is ready for harvest, good returns can be made in handling woods as even-aged woods.

The Mixed Stand vs. Pure Stands

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A Mixed Stand Withstands Disease

The virgin forest of the middle west was usually a mixed stand of hardwoods. In some sections in the Ohio Valley and in the Ozarks, there were also considerable bodies of pine mixed in. As a matter of fact, from many points of view the maintenance of a forest as a mixed stand is quite advantageous. In the first place, diseases attack and sweep through stands of trees sometimes, subject to no control that man can devise. An example is the comparatively recent occurrence of the chestnut blight which has completely eliminated chestnut from our hardwood forests. Forests composed mostly of chestnut were left practically bare and with very little on the ground that could be marketed.

Pure stands fall victim to a disease and insects much more rapidly than mixed stands, composed of several species that are not susceptible to the same diseases. For that reason it is far preferable and safer to have a mixed woods rather than a pure one.

Markets and Uses

Eggs all in one basket are sometimes all broken at once. The uses and markets for wood are many and diverse. Good judgment dictates the growing of many kinds of wood so as to have ready species that may be required. The latitude in storage on the stump that is available makes it fairly certain that the owner will come out better that way than if he has specialized on one species.

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Defects and How They Arise

Some defects that are produced in growing timber are simply occurrences of nature about which we can do very little. For example the matter of cross grain sometimes is a defect that we believe to be hereditary; but we cannot do anything about it except to eliminate the tree from the stand and prevent its seeding in any new growing stock. The principal defects in hardwoods, however, occur as rot and knots.

Rots

Rots are of very many kinds and gain their access to the tree through breaks in the bark. They may be in the butts and produce the familiar hollow trees, or they may start at limb stubs and produce pockets of rot that may extend up or down the trunk. In either case, they produce areas within the sound wood that have to be cut out in manufacture. Since clear lumber is our desire, and clear lumber must be usually in boards of workable size, the presence of rot reduces the price to a great degree.

It is important to realize also that the more rot there is in a stand the more chances there are for rot to get started in sound trees. If a scar is

developed in a tree by any cause, obviously no decay can start there unless spores (the "seeds" of fungi and tree diseases) from some rot already in the vicinity are deposited and grow in the wound. It is for this reason that it is a good idea to remove defective and rotten trees from the stand as soon as possible. Eventually, one can work a stand into such a sanitary condition that even though wounds are made in the tree, there are small chances for infection.

Insects

Certain insects may also cause defect in trees. Some of them bore holes into the sapwood and many of them work in the dead heartwood. For example, there are the pinworms of white oak which effectively lower the grade of good white oak to the place where it cannot be used for high-priced bourbon cooperage. There are the familiar borers that penetrate the stems of living black locust trees. It is a fact that black locust growing at a rapid rate on a good site is not very susceptible to damage from the black locust borer. However, black locust growing slowly on a poor site is usually pretty well riddled by these insects. In general, thrifty trees on good sites are less susceptible to insect damage than trees growing at a slow rate on a poorly adapted site.

Burning and Pasturing

The great damaging effect of fire in hardwood stands is the causing of spots or patches of dead or burned bark around the base of the trees that

Fig. 11. Fire scars on bases of black and white oaks. Decay and insects have access to the trees' heartwood through these blemishes. Note that this damage has occurred on the basal and most valuable portion of the tree.

Fig. 12.—The contrast of a protected with a pastured woods. These woodlands were similar in 1932, with protection continuing in the woods on the left and heavy pasturing occurring on the right. The so-called "brush" on the left contains seedlings of sugar maple, yellow poplar and white ash. Before you have big trees you must have little ones! How would you establish the next crop of trees in the woods to the right of the fence, at a minimum cost?

subsequently develop excellent avenues for the entry of fungi, infection, decay, and insects (Fig. 11).

Most hardwood seedlings are very susceptible to injury from burning. Their bark is thin and the heat of the fire will kill the living tissues on the young tree. If the young seedling has made some growth and has reached the place where its top is above the reach of the fire, it will still be laid open to invasion by various kinds of rot, because lower parts of the trunk will be killed. Decay fungi of many kinds find their first access into the tree through the scar produced by burning. Once in, where conditions are favorable, they continue to grow. The big rotten spots and hollows of many old trees can be traced to infection of a young seedling or sapling as a result of burning.

The good manager will see to it that conditions in his woods are such as to encourage the growth and development of seedlings. Certainly, he will exclude livestock from the woods, because in some seasons of the year the young seedlings offer about the only feed that can be obtained in the woods. While the livestock will gain very little in nutrition from the consumption of the seedling, the next crop of trees will certainly suffer. The end product of pasturing the woods is a stand of old trees with nothing growing underneath (Fig. 12).

Pasturing does not go with a productive woods.

Wind and Ice

Wind often causes great damage in stands of timber by stripping off limbs and causing huge scars and gashes that may run far down a trunk. Such wounds offer excellent openings for the introduction of infection. The scars will lower the grade of a considerable amount of lumber.

The same thing is true of ice storms. The weight of ice which may collect on trees strips off limbs, causing scars in which rot starts easily.

There is also windthrow and blowdown during tornadoes. Protect against wind damage by maintaining a close stand of trees.

Improvement Practices

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Dead and Defective Trees

The main objective in considering practices that may be used to improve the quality and productivity of a stand of trees is to have all acres producing as much good material as possible. If trees that have no possibility of producing growth are occupying the ground, or if the growth that will be produced will not be in utilizable form, such trees ought to be removed so as to liberate space.

Dead trees are in a class by themselves. They occupy space and provide centers of infection for healthy stock. They ought to come out. All dead chestnut should be cut and used for logs, posts, etc. It will never be any better than it is now.

Then there are trees that, for certain very obvious reasons, cannot ever produce saleable logs. For example, they may be forked near the stump. The chances for such trees producing good logs are small, unless the forks are sound and straight and long. Probably they ought to be removed.

A large percentage of trees in our middle west woods have been fire scarred or damaged by poor cutting practices when they were young. Such trees are usually rotten at the stump and are often hollow. They may also have great pockets of rot scattered along in the trunk. Even though they may be thrifty and growing well, the rot will probably either keep up with or exceed the rate of laying on of good wood. The chances that they will produce good quality merchantable material are small, and, other things being equal, they should be removed. If the whole stand is fire-scarred, obviously the owner cannot remove it all at once. Judgment will have to be used. It may be that a defective tree occupies a spot of ground on which the owner may want to get a start of seedlings of a particular species represented by the defective tree. In such case, this tree would be kept in the stand until the establishment of seedlings in the surrounding territory was sure.

Trees may be deformed when young, or for other reasons may have pronounced crooks. Unless the trunk is sufficiently long to enable the cutting of straight logs above or below the crook, the chances of the production of good, straight-grained, clear lumber are very small. Judgment may dictate the removal of such trees.

Wolf Trees

Earlier there was a brief description of the wolf tree. The description may not be applicable to all types of trees that occupy ground at the expense of better trees for utilization. In general terms, a wolf tree will be of such a broad, spreading character, and have so many limbs growing close to the ground that the production of clear lumber is impossible. Some people feel that wolf trees represent inherited characteristics that make them undesirable for the production of seedlings. This may or may not be true.

No good farmer would try to breed a good dairy herd from scrub stock. Good judgment would indicate the desirability of removing trees of poor form and poor growth character from the stand, and depending only upon trees of good form and good growth character for reproduction.

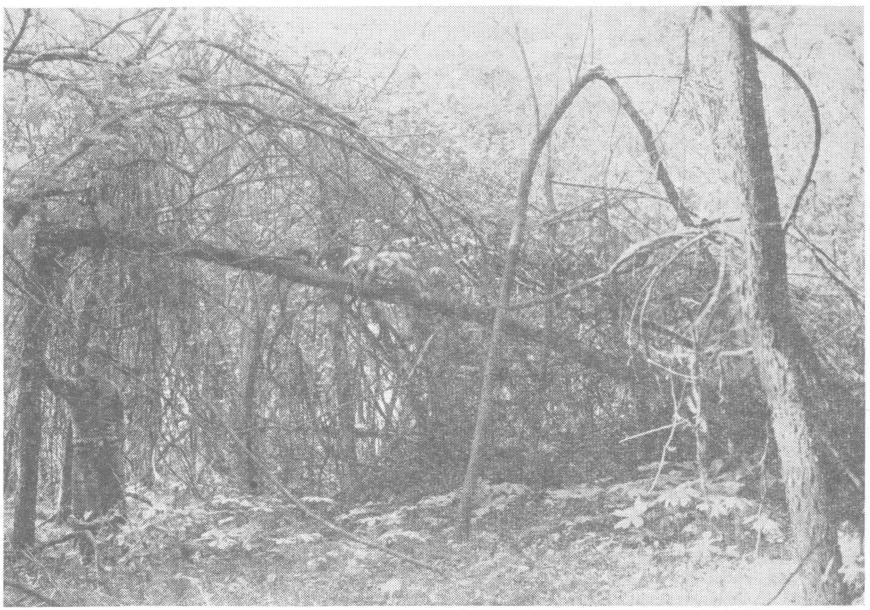

Fig. 13. Tall, lithe poles bent over, broken, and ruined by a burden of tangled vines which the owner failed to cut. Good management would salvage the cordwood, cut the vines and depend on sprouts from the young thrifty stumps cut low.

Vines

In most stands of hardwood, vines grow up the trees, twist themselves around limbs, spread over part or all of the trees' tops, and cause a great deal of damage. The vines not only require water and necessary minerals from the soil to keep them growing, but stifle the trees by spreading the vines' leafage on top of the trees.' They offer excellent lodging places for ice and snow that may cause considerable breakage during heavy winters (Fig. 13). There is no question that most vines ought to be removed from hardwood forests designed for the production of good merchantable timber.

They should be cut at the ground with an axe, or out in the open, pulled with a team, roots and all.

It is true, however, that a forest for maximum utilization and enjoyment on a farm must often produce other things than wood. The farmer may desire to have a good crop of wild grapes growing in the woods. He may have a market for the bright orange and red bittersweet capsules. If such vines are growing on trees that do not have any particular present or future merchantable value this set-up might be allowed to persist. Again, this is a matter for the farmer's individual judgment.

Weed Trees

Some species of trees that grow normally in hardwood stands have little or no utilization value. They are commonly called weed trees. It is difficult to lay down hard and fast rules in defining what is meant by weed trees. What may be a weed tree in one locality may have a fair utilization value in another. For example, in some localities dogwood is considered a weed tree. In other localities the beauty of dogwood in the spring is enough to cause farmers to wish to hold it in the stand. In still other localities comparatively small dogwood logs are used in the manufacture of shuttles used in the weaving industry. So, one may or may not call dogwood a weed tree. Redbud has perhaps no utilization value. Yet anyone familiar with the beauty of redbud in the spring would hesitate a long time before removing all redbud from a stand.

The situation might arise in which a woods rather well stocked with maple and ash would have a considerable number of beech trees existing in the stand. Where other species are not available, beech does make a usable grade of construction material and is even used for the manufacture of basket veneer where the market is available. Considerable quantities of beech are used in furniture at the present time. However, if in this particular case a conversion from beech to the more valuable maple or ash could be obtained by removal of the beech, certainly good judgment would indicate its removal.

Not so very many years ago elm was considered a true weed species. Yet, at the present time we find that elm is being rather widely used for the manufacture of slack cooperage, certain grades of cheap furniture, and many other uses. In fact, it has a rather good value. A thorough analysis of market should be made before elm is removed from the stand.

Scarlet oak is not considered a commercially desirable species. Yet, there are times when a stand may be composed so largely of scarlet oak that to remove all of it would open up the woods to such an extent that establishment of good species might be very difficult. Judgment would indicate a rather slow removal of the scarlet oak from the stand. In certain sections of the middle west blackjack oak is definitely a weed species because it exists to such an extent in the stand that there is no possible way of utilizing all of it. A weeding operation would dictate the removal of all possible blackjack oak from the stand. Yet, if this were done the stand would undoubtedly

be opened up to the place where resultant limby growth and drying out of the site would be obtained. Again, go slow.

In sections where there is no market for pulpwood obviously such things as aspen, certain poplars, willows, and cottonwoods might be considered as weed species. If, however, a good market for pulpwood is available, these species might command fairly good prices.

In short, there is no real definition of a weed tree that can be given unless all factors of stand conditions and market are taken into consideration. What is a weed species today may prove to be a valuable species 20 years from now, and, conversely, a valuable species today may not be nearly so valuable in the next generation. Therefore, the same factors of judgment and ability to analyze future trends hold good in handling woods as in the laying-out of other farm plans by any good farmer.

Thinning

Trees are just like any other crop. They can come in so thickly that they crowd themselves and none of them make good growth. The same thing must be done in handling stands of trees when this condition arises that is done in handling any row crop. Thin.

How much to thin and what to thin is always a matter for individual judgment on the part of the person managing the woods. The number of trees to be left per acre will depend upon the quality of the site. The best sites need the fewest trees and the poorest sites the most in order to get the most growth from the ground. There are all sorts of variations within these limits.

Also, thinning should be done as indicated before, in such a way as to maintain a fairly uniform growth rate. If an old, suppressed stand is too heavily thinned, it is entirely possible for trees to start growing so rapidly that the resultant lumber produced will not be of very good quality. This is especially true in stands of evergreens. The rule should be in all cases to try to maintain fairly uniform rate of growth.

Slash Disposal

The proper disposal of the slash that is left from weeding and thinning operations is always a matter that calls for some work and some thought. Aside from the ragged appearance of a forest in which tops have merely been allowed to lie, there is the attendant fire danger of such long-standing, dried-out piles of wood, and the further danger of insect and fungus invasions from such material (Fig. 14). Small saplings and seedlings, knocked down or bent over by tops and limbs, should be released from this weight. Generally, in hardwood forests, good practice seems to dictate the lopping of slash and scattering it over the ground. Within a comparatively few years it will have been all converted into litter and humus and will have added its part to the improvement of the site. If the owner chooses to pile and burn the brush, he should be very careful with fire, since it frequently breaks out of control even when conditions seem safe.

1. A rough branchy top, 3½ years after logging, which ought to be worked into firewood.

2. New leafy slash comprising a high fire hazard when dry.

3. The same area as in (2) with tops lopped ready for rain and snow to flatten them down.

Fig. 14. Need of slash disposal.

Pruning

The self-pruning process by which lower limbs are removed is rapid in the case of light-demanding species like yellow poplar, white ash, sycamore, cottonwood, black walnut, black cherry, and black locust. In other species, this process does not take place fast enough to prevent the formation of many knots in the interior portions of the trunk. It may sometimes pay the woodland manager to saw off small lower limbs.

In the case of hardwoods, pruning should remove only limbs under 2 inches in diameter. Pine limbs of larger size may be removed without infection because of the exuding of pitch, which forms a protective coat. The cutting should be made close to the trunk. Pruned limb scars heal over most rapidly on hardwoods if the limbs are removed in late March just as growth begins. Wood grows around a dead stub, resulting in a knot reaching from the origin of the original branch to the end of the stub.

In no case should young branches be removed if they have formed heartwood, because rot may enter through the scar.

Regulating Rate of Growth

Cutting should be so regulated as to maintain a steady, even growth of the trees that comprise the stand. That is to say, the density of the stand composed of small, medium, and large trees should be watched and managed so as to maintain an even rate of growth. In the all-aged stand, care should be exercised not to open up the stand too rapidly by cutting so as to liberate individual trees too much. If this is not watched, the released trees sometimes will lay on wood too rapidly and produce wood that is of distinctly low quality.

Even rate of growth produces even-textured wood that will lie straight and not warp or cup as badly as material that has grown at variable rates.

Low Stumps

In harvesting timber it generally pays to cut stumps as low as possible. This results in sound sprouts of better quality and leads to less labor in later improving the stand.

Suckering

Usually a stump will produce more sprouts than good management would allow to grow. When the sprouts have become well developed and have shown their true character, the good manager will remove those that do not appear thrifty or give indications of developing into good trees. Usually, those sprouts near the tops of stumps ought to be removed. Of those coming out around the root collar, select the best, thrifty, straight sprout that has its heads above the others and gives every indication of developing into a fine tree.

Protection from Livestock and Burning

It cannot be repeated too often that the best improvement practices in the hardwood region will be of no avail in producing a thrifty forest full of good sound growing stock, unless the stand is protected from fire and from the effect of livestock in pasturing. Regardless of the presence of public fire suppression systems, it is to the interest of each woods owner to be his own fire guard, and to be *personally responsible* for keeping fire out of his woods and to stop those which start accidentally.

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Utilization

Most hardwood forests in the middle west are in such a condition that great care will have to be taken in harvesting to see that the woods actually go uphill rather than downhill. Most of these woods are in a shape corresponding to a dairy herd managed by a man who was interested only in day-to-day returns, and had no regard for the building up of his permanent herd. He has continually bred from culls and sold his best stock. As a result he has nothing but a herd of culls and his herd is of very low productivity.

Most farmers have been selling the better material as fast as it came to the place where it would return a dollar. The result is that the woods are full of small defective material that has very low present utilization value. It will take years to bring many of these woods back into productive condition.

Harvesting to Improve the Woods

Harvest can be done in such a manner as actually to improve the woods. While immediate returns from such harvesting operations may be small, the added growth and added value to the woods will more than compensate in the long run for the temporary sacrifices made in immediate returns. *Sustained yield* means that a woods is to be managed in such a way that it will continuously return the amount of wood that the site is capable of producing. For example, if it is growing 300 board feet per acre per year, on the average, we can cut about that amount. If it produces only 100 board feet, we cut only that amount or *the growth*. If a man grows 20 hogs a year but sells 30, clearly he is selling off his breeders and soon will have none.

It is the same with the woods. Certainly very few woods in the middle west are now in the condition of producing to their full capacity continuously. The only way they can ever be brought into this condition is to forego part of the return by cutting very lightly (or none at all) for a considerable number of years, and thereby build up the volume of growing stock. By that is meant cutting annually less than the actual growth of the woods.

A woods might be full of old, rotten trees, but have a pretty fair stocking of saplings and thrifty poles. Good management would probably indicate a pretty heavy cutting to remove all of the old, defective material and get it out of the way of the young growing stock. But, for convenience, the average operator will probably extend this cutting over a number of

years. When all the old mature trees have been harvested nothing should then be cut for several years, or until some of the best poles have reached maturity. When that desirable situation arrives, then we begin to select individual poles from the standpoint of utilization — cutting always with the idea that what we cut will benefit the remaining stand. When the stand is actually growing the maximum amount of wood that it is capable of growing, then we can begin to harvest, annually, the average yearly growth. Then we have reached *sustained yield.*

It must be clear that this harvesting annually of the annual growth does not all have to take place in the same year. Sometimes, although rarely, a very advantageous market might dictate a little overcutting.

Market Mature Timber

In general, the objective of all harvesting operations should be to bring the stand to the place where the owner would have to market only mature timber, because mature timber brings the greatest return and has made use of the full capacity of the ground to produce wood.

Work Off the Worst Material

Another thing that should be kept in mind is always to work off the worst of the stand as soon as possible. As long as the remaining part of the stand is thrifty and growing well, cutting should be confined to the lower grade material. If it cannot be sold, most of it can undoubtedly be used on the farm. Some species that will have very poor market value may serve perfectly well for rough construction timber. The same thing will be true for trees of poor form and for poor grades of material that were available from trees that also produced some good material.

The Inventory

About the only process that is really available for estimating when sustained yield has been reached, or for determining just what the annual cut ought to be in order to stay on sustained yield, is the inventory.

This does not have to be a very complicated matter. In general, however, it would be an excellent idea for the woodland manager to keep a current inventory of his stock. This would not imply that he would have a record of every seedling and every sapling on the place. It would imply, however, that he would know what he had in the way of species and diameters and logs that could be put on the market at any time.

When he made a cut, his inventory could be adjusted for that cut. Also, before he made the cut it might be good business for him to revise his inventory and include the poles that had grown into tree size since the previous inventory. Then he would know what he had on the ground and what he could remove without disturbing his balance. A good way to go about taking inventory may be found in Farmers' Bulletin 1210, available for the asking from the County Agent.

Cutting for Existing Markets and Use

The inventory will be maintained and largely used to fit the harvest for existing markets and current use. This presupposes that the farmer is acquainted with the existing market, although it is perfectly well realized that in many cases this is not true. The average farmer managing a woodlot in the middle west knows very little about the market for the timber that he produces. The location of the individual tract of timber will be the determining factor. If near a large center of poulation with well established wood-using industries, undoubtedly a wide and varied market for most of the species produced will be available.

There is almost always a cross tie market near most tracts of timber in the middle west. Cordwood markets may or may not exist, depending upon the location of the tract of timber with respect to competing fuels and the centers of population capable of consuming cordwood. The fencepost market in the middle west is a very broad one, and is at the present time very largely supplied with material coming from the south. Unfortunately, it is also true that a very large part of the wood-using industries in the middle west now derive heavy percentages of their raw materials from the south. These markets exist close at hand for the midwestern farmer who wants to produce timber.

It is suggested that individual farmers who want to know where the markets are for the species and qualities they have on their land, or contemplate producing, should get in touch with their Extension Forester or County Agent.

Finding New Markets

Undoubtedly, existing markets could be widened to include a great deal of material that now has no market, if a proper organization could be put behind the effort. The individual farmer will have very little opportunity for developing new markets for his material. He will probably have to depend upon the present log market or the local mill for his outlet. However, organizations of farmers, cooperatives, and the like could extend their markets into fields now considered too remote for their individual efforts.

Options in Selection for Cutting

The good manager will know his market and know what is in good demand at good prices. That will largely dictate what he will harvest in any particular year. At the present time, for example, the market for black cherry is not particularly pressing. Yet in the past, black cherry has been in demand for the manufacture of fine furniture. Anybody knows that fashions in furniture go in cycles, and the chances are good that black cherry will return again as a fine furniture wood. Therefore, a man to be managing his stand properly, really ought to have black cherry growing in it somewhere.

There is the widest opportunity for the exercise of judgment in what kind of a mixture to maintain in the stand. Certainly, the farmer is going

to want to grow materials that will be useful on the farm. That means he will want some trees that are good for posts and firewood. He will want trees from which he can make good structural material to repair his own buildings. If he wants to sell in the market, then he will have to have trees of good quality and good species for which there is a market, but he will not have to depend upon a market as it occurs today. Timber can be held until the market is right.

Fortunately, the owner does not always have to cut a tree when it has reached maturity. As long as it is alive and thrifty it can stand on the stump without any particularly large cost. He can, therefore, wait until a good market has appeared before he cuts and sells. This is called *storage on the stump,* and in this respect the timber crop differs from most field crops which must be placed under cover. Storage on the stump can continue as long as the wood remains in good condition. When signs of disease and decay arrive it should be harvested.

Selling the Timber

Cutting Off an Area.—The average farmer in the middle west has for many years sold timber for a lump sum of cash. That is, the timber buyer has offered him a certain amount of money for the timber on a certain piece of land, and that has been the basis of sale. The cutting has been with no regard for continuous production of a timber crop from the land, and the result has been degradation of the forest. This is the easiest way to sell timber, and the least profitable. There are many other ways of selling timber.

Stumpage Sales.—Sometimes timber is sold for a stumpage price; that is to say, the owner sells timber for a certain price per thousand board feet on the stump. The owner reserves the right to mark trees that are to be cut, and the purchaser cuts according to rules laid down by the timber owner. If the timber owner is well acquainted with the market and knows how to scale trees on the stump, he may make a profitable sale. However, not very many farmers know these things. There is another factor to be considered in selling timber, and that is the possibility of selling labor.

Selling Labor.—When timber is sold on the stump, of course the purchaser does the felling, bucking, and hauling. Naturally, the farmer gets nothing except the stumpage value of his timber. There is no particular reason, since farmers are often partially unemployed during the winter months, why they should not market logs instead of trees. That is to say, the labor involved in felling the trees, bucking them, trimming them, loading them, and hauling them might just as well return to the individual farmer as to the timber purchaser. Where markets are available for logs, individual farmers may often find that a considerable amount of cash can be secured in this way in addition to the stumpage value of the timber. This does not detract from the necessity of selling according to an accurate scale, and according to a predetermined price per thousand board feet.

Deliver logs promptly after cutting them to avoid end-checking. Never leave merchantable logs lying around the woods for a considerable time,

because the sapwood may blue-stain and become worthless, or flat head or other borers may destroy the value of this part of the log.

Scaling

The owner who sells his timber on a basis of net scale of sound timber at an agreed price is wise. When the farmer insists that sale by scale is a part of the timber sale contract, he is well on the way toward realizing the value of his logs. Without this provision, the timber buyer's offer of $100, $200, $500, or $1,000 is an attractive bait to the owner; but he should be realistic enough to know that such an offer has every probability of being below the value. Instead of accepting, he should inquire from the Extension Forester or State Forester through his County Agent, or from reputable sawmill men, what is a fair current stumpage value for his kind, quantity, quality, and log grade of timber, and so fortify himself in his transaction with the timber buyer.

Examples of poor deals through selling timber for a lump sum, away below its actual value, are too numerous. Recently a buyer paid $5 for a yard tree of black walnut in southern Indiana. He is reported to have sold the butt log to a Louisville company cutting veneer for over $100 because it had a wavy, highly figured grain. This tree must have produced a log at least 16 inches in diameter to have rated as a veneer log. If it scaled 160 board feet, the value received by the owner was at the rate of $31 per thousand, only half or a third of the stumpage value.

As has been outlined in the preceding topics, calculate or find out how much timber you have to sell, be it one tree, a dozen, or 40 acres of them. Find out the stumpage value by log grade, diameter, and length. If the buyer wants it at that price, have the prices per thousand log scale and log grade stated in your agreement (see last page) together with the name of log scale to be used. Finally, scale the logs yourself; don't accept the buyer's scale without checking it. There should be a reasonably close agreement within 2 or 3 per cent.

Scaling on the Stump and on the Ground

It is possible to make a close estimate of volume in trees to be cut and sold while they are standing, or to scale each individual log as cut after the trees are felled. For standing trees, tables known as *volume tables* are available in some localities which show the volumes on the average of trees of different diameters at breast height (=4.5 feet above the ground and referred to as "d.b.h.") and either total or merchantable height. Very few of these tables that apply to trees in the central states region are available, however; they never have been made. For small inventories, they are not necessary.

Lacking tables, we can estimate the volumes of trees by estimating the log lengths and the diameters *inside* the bark at the top of each of these logs, and then adding them together. For example, take a white oak that is 28 inches at d.b.h. and about 60 feet high, with an estimated straight mer-

chantable length of 42 feet. (A peeled, white, 8-foot pole set up at the base of the tree will assist in getting the "feel" of estimating heights.) We know there will be about a 1-foot stump, leaving 41 feet for logs. The buyer says he wants to cut 10- and 12-foot logs. Therefore, you can scale four 10-foot logs (=40 feet) and adding 3 inches to each for trimming allowance will account for the 41 feet.

Now for the diameters: The tree is 28 inches d.b.h. and the top diameter where the trunk breaks into two limbs is about 13 inches *with* the bark, say 12 *inside* the bark. More of the taper is in the two bottom logs than in the top two. Say we estimate the inside diameters at 11 feet (1-foot stump + 10.3 foot log = 11.3 feet), at 21.5 feet, at 32.0 feet, and at 42.0 feet to be 24 inches, 18 inches, 15 inches, and 12 inches. We record them as follows:

Recording the Tree Cuttings

D.B.H. class (inches)	Species	Log Length (feet)	Diameters (inches)	Volume by International Rule—(board feet)
28	White oak	10′	24″, 18″, 15″, 12″	

or they can be separated out and listed as:

Butt 10′.....24″
2nd 10′.....18″
3rd 10′.....15″
4th 10′.....12″

The next step is to look up in a log rule table the volumes of logs of these diameters and length. Then add them together. Using the International log rule (¼-inch kerf) (a copy is shown on page 45) we get:

Gross Volume

Butt 10′ long, 24″ diameter, contains.....255 board feet
2nd 10′ long, 18″ diameter, contains.....140 board feet
3rd 10′ long, 15″ diameter, contains..... 95 board feet
4th 10′ long, 12″ diameter, contains..... 55 board feet

Total volume of tree = 545 board feet

Note that this is *gross* volume. Any reduction for rot and cull can be judged only through experience and watching logs opened at the mills. This procedure is repeated for each tree to be sold. Totals by species will give the number of logs, their diameters, and volumes by size classes, or all together.

Another log rule, the Doyle, is in common use in the central states region. Its values are much too low for small logs under 21 inches, and too high for logs 32 inches and more in diameter. The official rule used by the Federal Forest Service is the Scribner Decimal C. The International log rule is recommended because of its accuracy (Fig. 15).

After the trees are cut down and bucked into logs, "scaling" consists of (1) measuring the average diameters of each log at the small end, the length in feet (allowing not over a 3-inch excess for trimming allowance) and (2) determining the gross volume of a log of these dimensions by the

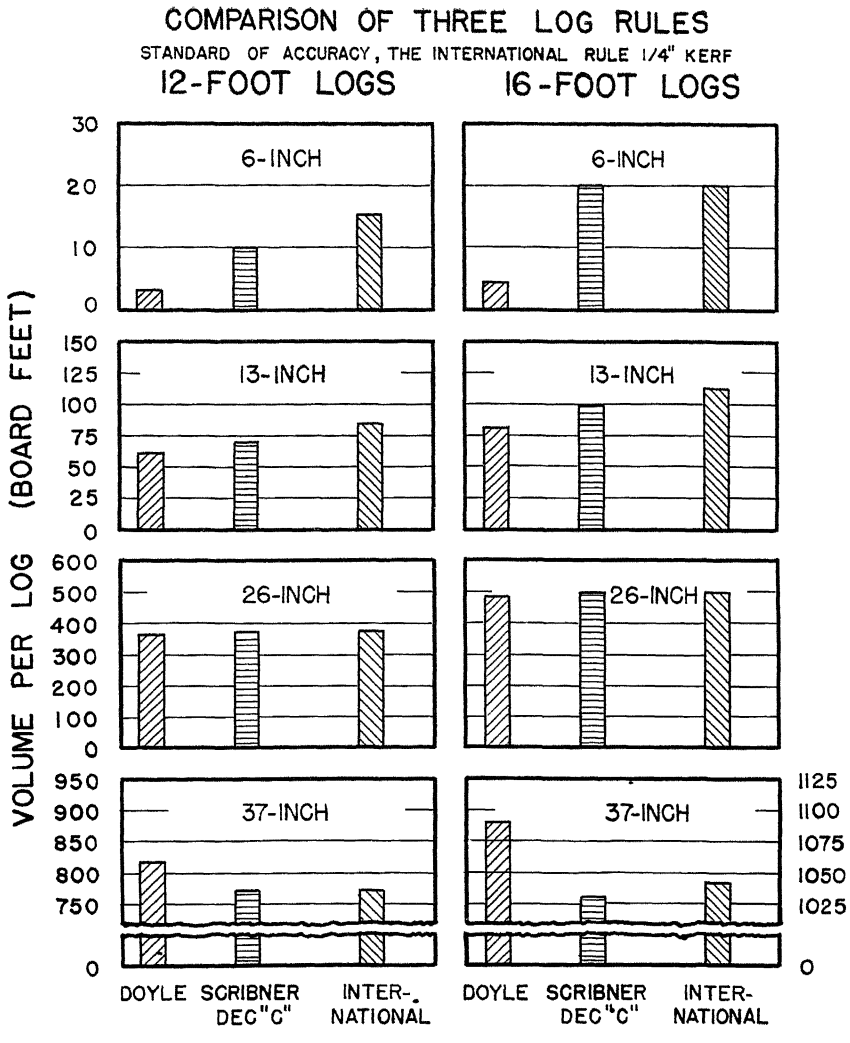

Fig 15 Comparison of the Scribner Decimal C Log Rule with the Doyle and with the scientific and accurate International Rule

log rule; deducting for cull, rot, shake,[1] catface,[2] sweep,[3] or other defect, and (3) recording the net merchantable volume of each log.

It is a good practice to *number* the log for any check-back. Measure the diameter in inches by taking the longest and the shortest and averaging them (Fig 16) If you don't have a scale stick, use a yard stick or carpenter's rule For example, a log measures 16 inches the long way and 14 inches the short,

[1] *Shake*—a separation along the grain usually between the rings of annual growth
[2] *Catface*—an old fire scar in the butt
[3] *Sweep*—usually a long, gentle curve in a trunk

so we call it a 15-inch log. Fractions of inches are rounded off to the nearest inch; a 10¼-inch log is a 10-inch, and a 10¾-inch log becomes an 11-inch log. When they hit on the half-inch (for example 10½ inches) we try to throw one down, the next up, etc.

In the notebook, tally the logs by number, species, diameter, length, gross, cull, and net scale. Thus:

Note Book Tally

Log No.	Species	Diameter inches	Length feet	Scale—International		
				Gross Bd. ft.	Cull Bd. ft.	Net Bd. ft.
1	White oak	20	12.3	210	50	160
2	White oak	16	12.1	130	—	130
3	White oak	15	10.4	95	10	85
4	Red oak	17	12.3	150	20	130
5	Shagbark hickory	12	14.3	85	30	55
	(and on through the list of logs sold)					
168				18,360	1,600	16,760

Fig. 16. Scaling an oak log on the log deck of a portable mill. Both the long and short diameters are read and averaged to get the log diameter. Note the center rot which must be scaled out.

Then the *net* total scale is 16,760 board feet; white oak, so much; red oak, so much; shagbark hickory, so much; etc. How to allow for cull can be learned only by experience, and by seeing logs sawed into lumber.

Home Uses

In recent years there has been an increasing tendency for farmers of the middle west to pay all their attention to the producing of field crops, and to buy in the market the materials that they need on the farm. This has been true of wood as well as fuel and food. The farmer with a woods should give a great deal of thought to the fact that his woods is capable of producing many things that he needs on the farm.

Fences and Posts.—The farm needs fences, and those fences need posts. Posts can be produced in the farm woods. Likewise, many fences can be constructed from materials produced in a local sawmill from logs that may not have a very high market value. Wooden fences used to be an accepted part of the farm plan. There is no reason why wooden fences cannot again be a useful part of the operation. Cheap and effective processes for preserving wood against decay are well known. Farmers can obtain information concerning them by writing to the Forest Products Laboratory, Madison, Wisconsin.

Fuel for Home Use.—The matter of the use of wood for fuel has been referred to numerous times. It is clear that a great deal of material now on the ground in midwestern farm woods will have to be disposed of in the form of fuel, simply because that is the only known way in which it can be used. Many farmers, however, continue to buy fuel and allow good wood and tops to go to waste in their woods. They should give thought to the desirability of saving cash and replacing purchased fuel by wood produced on their own land. There are now in existence improved stoves that are far more efficient in the consumption of wood than the old-fashioned stoves with which most of us are familiar. Likewise, central heating systems are being developed that are designed especially for the use of wood as fuel.

It might be pointed out also that during the winter months when opportunities for profitable employment on the farm are slack is a good time to get out into the woods and cut cordwood. The operation can almost always be so conducted as to return a double profit—the actual production of fuel for consumption on the farm, and the improvement of the stand of timber.

Fuel for Market.—In producing fuel for market, the farmer should always give full attention to the fact that the market is better for good, seasoned, well sorted material. Too often the farmer has cut trees that might well have been left to grow, sawed them up and hauled them off to market green. The result has been that in many localities wood as a fuel is not accepted. The proper procedure for the preparation of wood for the market is to cut it in the winter and allow it to season during the following summer. The period for marketing would then be the following fall, at which time the ricked wood would be well seasoned and ready for good use.

Proper attention should be paid to cutting wood to uniform length, and that length the one demanded by the local market. Likewise, sorting according to size and species will be found a useful means of promoting utilization.

Wood for Buildings and Repairs on Farm.—The average farm uses in the neighborhood of 2,000 board feet of lumber per year for various purposes around the place. There may be repairs to old buildings, or there may be new buildings to be constructed. Cash is usually required for the purchase of lumber for the carrying on of these operations, in spite of the fact that the farm with a good productive woodlot already has on the place the material in raw form for the execution of all types of construction required. All that is necessary is to take the logs to the local sawmill, get them sawed up into lumber according to order, haul the lumber back home, stack it, allow it to season, and then do the work.

Top logs, refused by the log buyer, can profitably be sawed at a local mill into boards or dimension, seasoned, and used on the farm. Many cases are known in the middle west where men have saved large sums of cash by having productive woods from which they could draw lumber when it

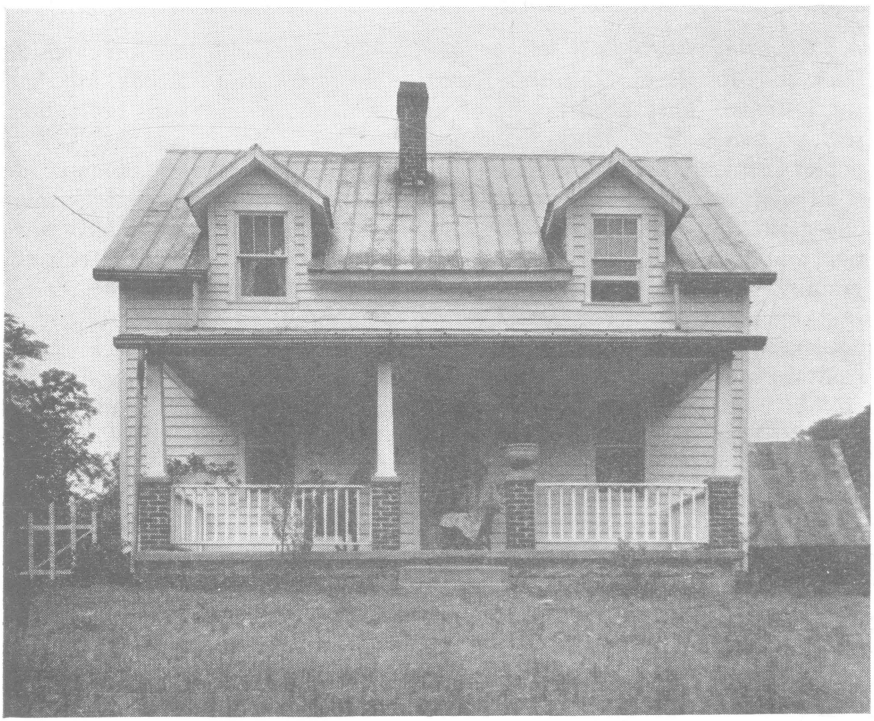

Fig 17. The new home of George A. Lockard in Huntington Township, Ross County, Ohio, built almost entirely from native yellow poplar and black cherry from his woods. This six-room house, worth $4300 to $4500 if bought, actually cost only $1103 for cement, brick, a carpenter and such supplies plus his labor, and logs from his own woods. The logs and lumber came, not from cherished old growth, but from a splendid woods which was a cornfield only 53 years ago, in 1887.

was needed. One case in point arose when the farmer lost his large dairy barn by fire. Fortunately, he had a good woodlot upon which he drew for the necessary logs, providing lumber for replacing this barn. After deducting all costs of the local mill, this man found that he had saved $1,200 from what would have been his lumber bill had he gone into the market and bought lumber for construction.

There is probably no better way of saving money against emergency in the way of reconstruction of a destroyed building or repairing a dilapidated old building than on the stump in the woodlot. It is an efficient form of insurance.

Excellent opportunities exist on almost every farm for the utilization of material produced on the farm for the modernizing of houses and revamping of interiors. Floors wear out or are dented and broken; interior trim becomes bruised and damaged; sometimes partitions are needed or removed; stairways may be moved or changed; an additional room may be needed; or the outside plumbing may be moved inside. All these changes require lumber, 2 by 4's, 2 by 6's, and other dimension which the farm woods can supply more economically than it can be purchased with cold cash. A little foresight, planning, and enterprise can save much of the cash outlay (Fig. 17).

Choosing the Right Wood for the Job.—Care should be used in choosing the woods for the several uses. Excellent floors are made of oak, ash, and sugar maple. They need not be of narrow strips; wide boards of random width (4 to 6 or 7 inches) have a charm that is very desirable. Yellow poplar is splendid for framing and siding; while the knotty common grade is all right for subflooring, it is too soft for most finishing, and lacks color and grain. For trim, white oak, cherry, walnut, and ash are both decorative, fine, and dignified. Red-hearted sycamore, quarter-sawed, carries a beautiful grain.

One thrifty farmer in Ross County, Ohio, built his house out of yellow poplar, sawed from his woods, and trimmed it inside with black cherry from the same source. Another farmer in Knox County, Ohio, reconditioned an old homestead, built originally about 1815. Sugar maple and beech provided the repairs in framing, yellow poplar the siding, and oak the flooring. A new stairway was made, wainscoted with black cherry worked into square panels. An unfinished attic was converted into an extra bedroom. A white pine, planted 50 years ago, was felled, sawed, and seasoned. The planed lumber provided beautiful knotty pine walls, so popular nowadays, for that bedroom beneath the eaves.

These cases (and many others) require planning, enterprise, and thrift, and they yield benefits and satisfaction at a very nominal cash outlay. The home woods can serve the farm *well* if the owner will only *protect* it, work *with* it, and *use* it conservatively.

Log Rules

◆

International Log Rule (¼″ Kerf)

Diameter of log (inches)	Volume of Log in Board Feet for Lengths									Diameter of log (inches)
	8 feet	9 feet	10 feet	11 feet	12 feet	13 feet	14 feet	15 feet	16 feet	
6	10	10	10	10	15	15	15	20	20	6
7	10	15	15	15	20	20	25	25	30	7
8	15	20	20	25	25	30	35	35	40	8
9	20	25	30	30	35	40	45	45	50	9
10	30	35	35	40	45	50	55	60	65	10
11	35	40	45	50	55	65	70	75	80	11
12	45	50	55	65	70	75	85	90	95	12
13	55	60	70	75	85	90	100	105	115	13
14	65	70	80	90	100	105	115	125	135	14
15	75	85	95	105	115	125	135	145	160	15
16	85	95	110	120	130	145	155	170	180	16
17	95	110	125	135	150	165	180	190	205	17
18	110	125	140	155	170	185	200	215	230	18
19	125	140	155	175	190	205	225	245	260	19
20	135	155	175	195	210	230	250	270	290	20
21	155	175	195	215	235	255	280	300	320	21
22	170	190	215	235	260	285	305	330	355	22
23	185	210	235	260	285	310	335	360	390	23
24	205	230	255	285	310	340	370	395	425	24
25	220	250	280	310	340	370	400	430	460	25
26	240	275	305	335	370	400	435	470	500	26
27	260	295	330	365	400	435	470	505	540	27
28	280	320	355	395	430	470	510	545	585	28
29	305	345	385	425	465	505	545	590	630	29
30	325	370	410	455	495	540	585	630	675	30
31	350	395	440	485	530	580	625	675	720	31
32	375	420	470	520	570	620	670	720	770	32
33	400	450	500	555	605	660	715	765	820	33
34	425	480	535	590	645	700	760	815	875	34
35	450	510	565	625	685	745	805	865	925	35
36	475	540	600	665	725	790	855	920	980	36
37	505	570	635	700	770	835	905	970	1040	37
38	535	605	670	740	810	885	955	1025	1095	38
39	565	635	710	785	855	930	1005	1080	1155	39
40	595	670	750	825	900	980	1060	1140	1220	40

From: Chapman, H. H.—"Forest Mensuration." J. Wiley & Sons, N. Y. 1924. Table LXXX, p. 494.

Doyle Log Rule

Diameter of log (inches)	Volume of Log in Board Feet for Lengths									Diameter of log (inches)
	8 feet	9 feet	10 feet	11 feet	12 feet	13 feet	14 feet	15 feet	16 feet	
6	2	2	2	3	3	3	3	4	4	6
7	4	5	5	6	7	7	8	8	9	7
8	8	9	10	11	12	13	14	15	16	8
9	12	14	16	17	19	20	22	23	25	9
10	18	20	22	25	27	29	31	34	36	10
11	24	28	31	34	37	40	43	46	49	11
12	32	36	40	44	48	52	56	60	64	12
13	40	46	51	56	61	66	71	76	81	13
14	50	56	62	69	75	81	87	94	100	14
15	60	68	76	83	91	98	106	113	121	15
16	72	81	90	99	108	117	126	135	144	16
17	84	95	106	116	127	137	148	158	169	17
18	98	110	122	135	147	159	171	184	196	18
19	112	127	141	155	169	183	197	211	225	19
20	128	144	160	176	192	208	224	240	256	20
21	144	163	181	199	217	235	253	271	289	21
22	162	182	202	223	243	263	283	304	324	22
23	180	203	226	248	271	293	316	338	361	23
24	200	225	250	275	300	325	350	375	400	24
25	220	248	276	303	331	358	386	413	441	25
26	242	272	302	333	363	393	423	454	484	26
27	264	298	331	364	397	430	463	496	529	27
28	288	324	360	396	432	468	504	540	576	28
29	312	352	391	430	469	508	547	586	625	29
30	338	380	422	465	507	549	591	634	676	30
31	364	410	456	501	547	592	638	683	729	31
32	392	441	490	539	588	636	686	735	784	32
33	420	473	526	578	631	683	736	788	841	33
34	450	506	562	619	675	731	787	844	900	34
35	480	541	601	661	721	781	841	901	961	35
36	512	576	640	704	768	832	896	960	1024	36
37	544	613	681	749	817	885	953	1021	1089	37
38	578	650	722	795	867	939	1011	1084	1156	38
39	612	689	766	842	919	995	1072	1148	1225	39
40	648	729	810	891	972	1053	1134	1215	1296	40

From: Mattoon, Wilbur R. and Barrows, William B.—"Measuring and Marketing Farm Timber." United States Department of Agriculture—Farmers' Bulletin 1210. (Revised April, 1930.) Table 8, pages 18-19.

Scribner Decimal C. Log Rule

Volumes rounded off; to use, add a cipher to each tabular value.

Diameter of log (inches)	Volume of Log in Board Feet for Lengths									Diameter of log (inches)
	8 feet	9 feet	10 feet	11 feet	12 feet	13 feet	14 feet	15 feet	16 feet	
6	0.5	0.5	1	1	1	1	1	1	2	6
7	1	1	1	2	2	2	2	2	3	7
8	1	1	2	2	2	2	2	2	3	8
9	2	2	3	3	3	3	3	3	4	9
10	3	3	3	3	3	4	4	5	6	10
11	3	3	4	4	4	5	5	6	7	11
12	4	4	5	5	6	6	7	7	8	12
13	5	5	6	7	7	8	8	9	10	13
14	6	6	7	8	9	9	10	11	11	14
15	7	8	9	10	11	12	12	13	14	15
16	8	9	10	11	12	13	14	15	16	16
17	9	10	12	13	14	15	16	17	18	17
18	11	12	13	15	16	17	19	20	21	18
19	12	13	15	16	18	19	21	22	24	19
20	14	16	17	19	21	23	24	26	28	20
21	15	17	19	21	23	25	27	28	30	21
22	17	19	21	23	25	27	29	31	33	22
23	19	21	23	26	28	31	33	35	38	23
24	21	23	25	28	30	33	35	38	40	24
25	23	26	29	31	34	37	40	43	46	25
26	25	28	31	34	37	41	44	47	50	26
27	27	31	34	38	41	44	48	51	55	27
28	29	33	36	40	44	47	51	54	58	28
29	31	35	38	42	46	49	53	57	61	29
30	33	37	41	45	49	53	57	62	66	30
31	36	40	44	49	53	58	62	67	71	31
32	37	41	46	51	55	60	64	69	74	32
33	39	44	49	54	59	64	69	73	78	33
34	40	45	50	55	60	65	70	75	80	34
35	44	49	55	60	66	71	77	82	88	35
36	46	52	58	63	69	75	81	86	92	36
37	51	58	64	71	77	84	90	96	103	37
38	54	60	67	73	80	87	93	100	107	38
39	56	63	70	77	84	91	98	105	112	39
40	60	68	75	83	90	98	105	113	120	40

From: Chapman, H. H.—"Forest Mensuration." J. Wiley & Sons, N. Y. 1924. Table LXXXVI, p. 506.

Sample Timber Sale Contract[1]

◆

Agreement entered into this 10th day of December, 1939, between John Doe, of Pickering, Ohio, hereinafter called the seller, and William Roe of Junction, Ohio, hereinafter called the purchaser.

Witnesseth:

ARTICLE I. The seller agrees to sell to the purchaser, upon the terms and conditions hereinafter stated, all the living timber marked or designated by the seller and all merchantable and dead timber, standing or down, estimated to be 35,000 board feet, more or less, on a certain tract of land situated in the township of Smith, County of Marshall, State of Ohio, and located on the farm belonging to the seller, and about one-half mile west of his farmhouse.

ARTICLE II. The purchaser agrees to pay the seller the sum of three hundred dollars ($300), more or less, as may be determined by the actual scale, at the rate of ....dollars ($....) per thousand board feet for white oak and hard maple, ...dollars ($....) for red oak, hickory, red maple, and beech, ...dollars ($....) for yellow poplar, and ..... dollars ($....) for black walnut, payable prior to the date of removal of material in installments of one hundred dollars ($100) each.

ARTICLE III. The purchaser further agrees to cut and remove said timber in strict accordance with the following conditions:

1. Unless extension of time is granted, all timber shall be cut, paid for, and removed on or before April 15, 194..
2. Saw timber shall be scaled by the ... . log, rule, and measured at the small end along the average diameter inside the bark to the nearest inch. The sapwood of black walnut shall not be scaled out as a defect.
3. The maximum scaling length of logs shall be 16 feet, greater lengths shall be scaled as two or more logs Upon all logs an additional length of 4 inches shall be allowed for trimming. Logs overrunning this allowance shall be scaled not to exceed the next foot in length.
4. No unmarked timber of any kind shall be cut All *marked* trees shall be cut by purchaser. No timber under 12 inches in diameter at breast height will be marked by the seller.
5. A log, 9 feet long or more to an 8-inch top (1 tie), and any other log which is 33 per cent or more sound will be considered merchantable.
6. Stumps shall be cut so as to cause the least possible waste, stumps of trees up to 16 inches in diameter not higher than 12 inches above the ground and those of trees above this size at a distance above the ground not greater than three-fourths of their diameter.
7. All trees shall be utilized in their tops to the lowest diameter for commercially salable material.
8. Young trees shall be protected against unnecessary injury; only dead trees and the less valuable kinds may be used for construction purposes in connection with lumbering.

ARTICLE IV. It is mutually understood and agreed by and between the parties hereto as follows:

1. All timber included in this agreement shall remain the property of the seller and shall not be removed until paid for in full
2. In case of dispute over the terms of this contract, final decision shall rest with a reputable person to be mutually agreed upon by the parties to this contract; and in case of further disagreement, with an arbitration board of three persons, one to be selected by each party to this contract and a third to be the State Forester or his chosen representative.

In witness whereof the parties hereto have hereunto set their hands and seals this . . . . day of ...., 193...

WITNESSES:

. ...

. ...

[1] Adapted from the one by Mattoon, Wilbur R and Barrows, William B , 1921—"Measuring and Marketing Farm Timber," U. S Dept of Agriculture, Farmers' Bulletin 1210, pp 50-51.