UNITED STATES DEPARTMENT OF AGRICULTURE

Agriculture Handbook No. 13

September 1950

FORESTRY HANDBOOK

for the Upper Mississippi Region

(Fifth Edition)

SOIL CONSERVATION SERVICE
Upper Mississippi Region
Regional Headquarters, Milwaukee, Wis.

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.
Price 45 cents

PREFACE TO THE FIFTH EDITION

Keeping pace with advances in knowledge means continual changes and revisions of texts. This Fifth Edition is an attempt to keep farm-forestry facts current and up-to-date.

But only a few of the facts have been changed and others added. The purpose of this handbook is the same as it was for previous editions: To supply in a single volume information necessary for the application of forestry principles to land use planning on farms and to aid in the development and application of complete farm conservation plans based on land capabilities.

The handbook is a compilation of the results of State and Federal research and of the observations of Soil Conservation Service technicians as applied to farm-forestry problems in the soil conservation districts of Soil Conservation Service's Region 3, the Upper Mississippi Region.

The material was not written for foresters, farmers, or the general public. It is designed for use of soil conservationists who assist farmers in more than 500 soil conservation districts in Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin. In a sense it is a first-aid text. By prescribing some of the simple treatments, we hope soil conservationists can be helpful to owners of sick land in need of planting, and of sick woodland in need of protection and management.

To take credit for any but a small part of the text would be gross plagiarism. The forestry division has acted simply as an editor and compiler and has freely used the writings of numerous authors. Many of their publications are listed as references and are worthy of study when more detailed information is desired.

Stanley S. Locke
Regional Forester
Upper Mississippi Region
Soil Conservation Service

Milwaukee, Wis.
August 1950

CONTENTS

GPO—O—SCS 217

TREES AND TREE GROWTH

LIST OF TREES

Except for a simple key to the pines it is not within the scope of this handbook to include a tree identification guide. The books listed on page 4 are readily available to all farm planners. These publications are valuable aids in learning to know the native and some exotic species that grow or have been extensively introduced in any locality.

The trees used in planting or commonly found in the farm woods of the Upper Mississippi Valley are listed:

Common name	*Botanical name*	*Other common names in local use*
HARDWOODS		
Box elder	*Acer negundo*	
Silver maple	*Acer saccharinum*	Soft maple
Red maple	*Acer rubrum*	Soft maple
Sugar maple	*Acer saccharum*	Hard maple, Rock maple
Yellow birch	(N) *Betula lutea*	
River birch	*Betula nigra*	
Paper birch	*Betula papyrifera*	White birch
Mockernut hickory	(S) *Carya alba*	
Bitternut hickory	*Carya cordiformis*	Pignut
Shagbark hickory	*Carya ovata*	Shellbark hickory
Chestnut	*Castanea dentata*	
Hardy catalpa	(S) *Catalpa speciosa*	Catalpa
Hackberry	*Celtis occidentalis*	Sugarberry
Dogwood	*Cornus florida*	Flowering dogwood
Persimmon	*Diospyros virginiana*	
Beech	*Fagus grandifolia*	
White ash	*Fraxinus americana*	
Green ash	*Fraxinus pennsylvanica lanceolata*	
Honey Locust	*Gleditsia triacanthos*	
Butternut	*Juglans ceneria*	White walnut
Black walnut	*Juglans nigra*	
Red gum	(S) *Liquidambar styraciflua*	Sweetgum
Yellow poplar	(S) *Liriodendron tulipifera*	Tulip poplar, whitewood, poplar
White mulberry	(E) *Morus alba*	Russian mulberry
Red mulberry	*Morus rubra*	Mulberry
Sour gum	*Nyssa sylvatica*	Tupelo, pepperidge, black gum
Sycamore	*Platanus occidentalis*	Buttonwood, buttonball, plane
Balm of Gilend	*Populus balsamifera*	
Cottonwood	*Populus deltoides virg.*	Poplar
Largetooth aspen	*Populus grandidentata*	Popple, poplar, aspen
Aspen	(N) *Populus tremuloides*	Popple, poplar
Black cherry	*Prunus serotina*	
Black locust	*Robinia pseudoacacia*	
White oak	*Quercus alba*	
Red oak	*Quercus borealis maxima*	
Jack oak	(N) *Quercus ellipsoidalis*	Pin or Hills oak
Shingle oak	(S) *Quercus imbricaria*	Laurel oak
Bur oak	*Quercus macrocarpa*	Mossycap oak
Blackjack oak	(S) *Quercus marilandica*	Jack oak
Chestnut oak	(S) *Quercus montana*	Rock oak
Chinquapin oak	*Quercus muehlenbergil*	
Pin oak	(S) *Quercus palustris*	Water oak

Common name	Botanical name	Other common names in local use
Post oak	(S) *Quercus stellata*	
Black oak	*Quercus velutina*	Yellow oak
Black willow	*Salix nigra*	
Sassafras	*Sassafras variifolium*	
Basswood	*Tilia glabra*	Linden, linn
Osage orange	(S) *Toxylon pomiferum*	Hedge, bois d'Arc
Red elm	*Ulmus fulva*	Slippery elm
American elm	*Ulmus americana*	White elm, soft elm, water elm
Rock elm	(N) *Ulmus racemosa*	Cork elm
CONIFERS:		
Balsam fir	(N) *Abies balsamea*	Fir, balsam
Norway spruce	(E) *Picea excelsa*	
White spruce	(N) *Picea canadensis or glauca*	Variety: Black Hills spruce
Black spruce	*Picea mariana*	
Jack pine	(N) *Pinus banksiana*	
Shortleaf pine	(S) *Pinus echinata*	Southern or yellow pine
Austrian pine	(E) *Pinus nigra*	Black pine
Ponderosa pine	(E) *Pinus ponderosa*	Western yellow pine
Red pine	(N) *Pinus resinosa*	Norway pine
Pitch pine	(S) *Pinus rigida*	
Northern white pine	(N) *Pinus strobus*	White or soft pine
Scotch pine	(E) *Pinus sylvestris*	
Loblolly pine (E)	(S) *Pinus taeda*	Old field or southern pine
Virginia pine	(S) *Pinus virginiana*	Jersey or scrub pine
Douglas fir	(E) *Pseudotsuga taxifolia*	Fir
Eastern red cedar	*Juniperus virginiana*	Juniper, red cedar, cedar
Tamarack	(N) *Larix laricina*	Larch
Northern white cedar	(N) *Thuja occidentalis*	Arbor vitae, white cedar, cedar
Hemlock	*Tsuga canadensis*	

(E) Not native to region
(S) Grows only in southern part of region
(N) Grows only in northern part of region

IDENTIFICATION OF PINES

Pines are the most widely planted genera in the Lake and North Central States, and some species have been introduced in localities where they do not occur naturally. Because the State tree-identification books cover only the native trees, the identification of species of introduced pines frequently is difficult. The following key will be helpful in distinguishing the pines which are or have been more or less commonly used in forest planting in the Upper Mississippi Region.

First count the number of individual needles in each cluster; then note arrangement and other needle characteristics. Examine the characteristics of the small branches and buds; if possible, find some cones from older trees.

A. Needles always 5 to cluster .... WHITE

AA. Needles always 3 to cluster

B. Cones 2 to 3 times as long as wide, with stout prickles; needles 6 to 9 inches long, at acute angle with branch.. LOBLOLLY

BB. Cones less than twice as long as wide, with slender prickles; needles 3 to 5 inches long, standing at nearly right angles to the branch.......................... PITCH

AAA. Needles both 2 and 3 to cluster, i.e., 2 and 3 needle clusters on same tree

B. Needles stout and coarse; branches stout, becoming gray-black at end of 2 or 3 years; cones borne near ends of branches; only one whorl of branches develops each year; buds resinous .... WESTERN YELLOW (Ponderosa)

BB. Needles slender and flexible; young branches pale green or violet, becoming red-brown tinged with purple; cones not borne at ends but near middle of branches; more than one whorl of branches per year; buds not or only slightly resinous .... SHORTLEAF

AAAA. Needles always 2 to cluster

B. Needles 3 to 7 inches long

C. Bark on 2-year-old branches divided into sharply defined scales, each peeling off as a whole; young branches not glaucous*

D. Needles quite stiff; young branches gray-black; cones break off completely at falling; cross section through needles shows, with hand lens, resin ducts midway between margin and center of leaf tissue .... AUSTRIAN

*Gloucous--covered with bluish-white or gray bloom.

AAAA. Needles always 2 to cluster (continued)

DD. Needles flexible; young branches reddish-brown; cones leave a few basal scales on stem after falling; cross section through leaf shows resin ducts near margin of leaf tissue .... RED or NORWAY

CC. Bark on 2 to 4-year branches not divided into sharply defined scales, peeling off rather irregularly; young branches glaucous*

D. Central trunk commonly forks into two or more stems .... JAPANESE RED

BB. Needles 3/4 to 3 inches long

C. Cones symmetrical, not incurved

D. Only one whorl of branchlets develops each year; cones borne on ends of branches; cone scales without sharp prickles. Bark on old branches orange-red brown; needles blue-green .... SCOTCH

DD. More than one whorl of branches develop each year; cones borne in middle of branches; cone scales with sharp prickles; branchlets greenish tinged with purple, becoming light gray-brown; branchlets glaucous*; gray-green needles .... VIRGINIA

CC. Cones unsymmetrical, incurved toward branch

D. Cone scales without sharp prickles; branchlets not glaucous*, slender, tough and flexible, pale yellow-green; needles yellow-green; more than one whorl of branches develop each year .... JACK

*Glaucous--covered with bluish-white or gray bloom.

REFERENCES

Trees, USDA Yearbook of Agriculture 1949, pages 763-798.

Manual of Trees of North America, Sargent. Houghton-Mifflin.

Manual of Cultivated Trees and Shrubs, Rehder. Macmillan.

Trees and Tree Planting Together With a Descriptive Catalog of Common Forest Trees of Minnesota and the Lake States, Anderson. Webb Publishing Co.

Trees of Minnesota, Minnesota Department of Conservation.

Forest Trees of Missouri, Missouri Conservation Commission Conservation Bulletin 7.

The Distribution of Important Forest Trees of the United States, USDA Miscellaneous Publication 287.

Native Woody Plants of the United States, Their Erosion-Control and Wildlife Values, USDA Miscellaneous Publication 303.

Forest Trees of Illinois, Illinois Department of Conservation.

Iowa Trees in Winter, Iowa State Extension Circular 246.

Evergreens, Michigan State College Extension Bulletin 178.

Michigan Trees, Otis, University of Michigan.

Ohio Trees, Ohio State University Agricultural Extension Bulletin 185.

Fifty Common Trees of Indiana, Shaw and VanCamp, Indiana Department of Conservation and Purdue University.

Forest Trees of Wisconsin, Wisconsin Conservation Department Publication 507.

HOW TREES GROW

The interrelation of all parts of a tree and the functions of its various parts can be seen in the diagram. The three principal parts of a tree are the crown, consisting of the leaves and branches, the trunk or stem, and the roots. In its entirety the crown or top of the tree may be thought of as a manufacturing plant. Carbon dioxide is taken from the air. Water is absorbed from the soil by the roots and transported up through the trunk to the leaves. In the presence of chlorophyl (the green substance in leaves), and with the energy supplied by the sun, carbon dioxide and water are combined into a series of organic compounds. Simplified, the chemical reaction is approximately:

$$6\ CO_2 + 6\ H_2O = C_6H_{12}O_6 + 12\ O$$

Sugar (glucose), the principal product, eventually is transformed into cellulose and lignin which form the woody tissues of the tree. Oxygen is the by-product.

Water that is absorbed by the roots also contains minute quantities of minerals. The mineral requirements for tree growth, however, are much less than for most farm crops and their presence does not materially affect the essential chemical process of producing cellulose. This does not overlook the proteins, which are synthesized in plants only with the help of some 10 or more essential mineral elements. Soils may be, and commonly are, deficient in some of these elements in terms of protein for animal-food production. Most soils are not deficient in the usual elements required for wood production.

An understanding of how plant food is manufactured has two very important applications: Of the elements necessary to make cellulose, water is most likely to be limited; carbon dioxide, the minor mineral chemical elements, and sunlight generally are present in sufficient quantities. There are many environmental factors that affect the availability of water and therefore influence the supply of food needed for tree growth: Droughts, dry soils, soils so impervious the roots cannot get sufficient moisture, and mechanical injuries to the roots all limit the water supply.

The amount of leaf surface where the food is manufactured is the second important measure of tree growth. The crown, considered in terms of area of green leaves, is one of the best indications of tree vigor. A small, crowded, thin crown, or one that is partially dead indicates a defective or inefficient manufacturing plant. Full-crowned trees with no dead branches are producing the maximum amount of food because the plant is operating to capacity.

Trees grow in height and diameter. Height growth and the elongation of the individual branches results from cell division taking place at the extreme tip of each twig. Because there is no change in the cells once formed, it is clear that wood stays in the position in which it was originally deposited. A branch 10 feet from the ground today, therefore, always will be 10 feet from the ground.

The trunk and tree branches enlarge at the point where bark meets the wood. The growing tissue, called the cambium, is the minute layer of cells lying just underneath the bark. The cells of the cambium layer divide both inwardly and outwardly; those on the inside produce wood (the xylem), and the outside cells form the bark (the phloem). The old bark cells eventually scale off as they are pushed toward the outside of the tree by the new cells, but the inside cells stay in place and each year a new layer of wood is laid over the layer formed the previous year.

Site

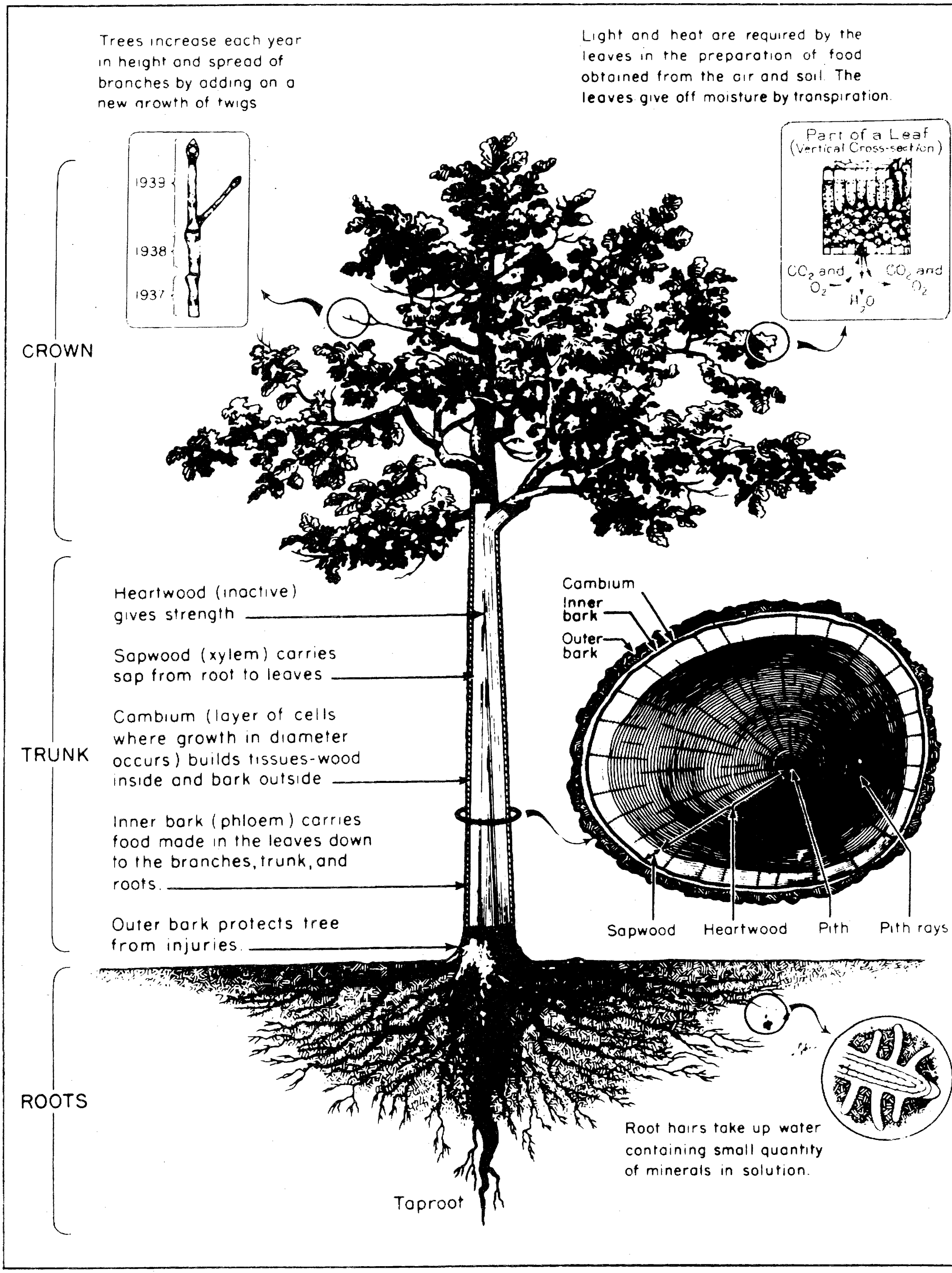
As used in forestry, the term "site" is a generic one and includes all the factors influencing the growth of trees in any given location. Soil is only one of these and often is of less importance than are others such as direction of slope (aspect), exposure, and climatic and biotic factors.

Site is most commonly measured by the height to which the dominant trees of a given species will grow in a specific number of years (generally 50). Thus a site index of "80" for red oak simply means that on a particular site dominant red oak trees will grow to a height of 80 feet in 50 years. Obviously this is a better site for red oak than one expressed as "60."

Table 1 will be helpful in determining the tree-producing capacity of any given site, particularly in appraising areas to be planted.

The site cannot be judged accurately on the basis of single factors. Even if soil, exposure, and drainage are "excellent," more than likely there would be heavy competition from brush and herbaceous plants which will require costly site preparation and cultivation if planting is to be successful. Also, a light sandy site might have all the other favorable characteristics but be so excessively drained (droughty) as to limit its usefulness for growing trees.

The hazardous secondary effects of attempting to grow trees on deficient sites must also be taken into account. Insects and disease usually are damaging in direct proportion to site quality (p. 29). Heavy competition of bluegrass and quackgrass is closely correlated with winter die-back of black locust in the northern



The parts of a tree and their functions.

TABLE 1. --*Site quality*

Site factors	Excellent	Good	Fair	Poor
Soil (A horizon) Depth disregarding B	12 inches	8 inches	4 inches	2 inches
Soil (B horizon) Structure when moist.	Loose or only slightly coherent.	Mellow and friable.	Moderately compact.	Very compact.
Structure when dry.	Mellow, crumbly, porous, gardenlike.	Friable not difficult to dig.	Bakes into refractory clods, cracks when dry.	Dense and structureless or breaks into hard sharp pyramidal lumps.
Plasticity	Not plastic when wet.	Slightly plastic.	Moderately plastic.	Very plastic.
Color of subsoil.	Reddish-brown.	Brown or yellow.	Yellow-gray; mottled.	Drab or blue.
Aspect (Rolling or steep)	North and northeast.	Northwest.	East, west, or southeast	Southwest or south.
Exposure (Degree of protection from drying wind and sun)	Cove, sheltered, steep topography.	Cove, open, moderate dissection.	Slopes, open.	Ridge or flat open terrain.
Drainage (Surface)	Terraces; rolling upland.	Level upland with subsurface drainage.	Moraines; loose sand; low areas.	Swamp with high water table, excessively or poorly drained upland.
Competition (Biotic)	No competition from plants or animals, insects or disease.	Competition limited to low, sparse annual plants; no animals, insects or disease.	Moderately heavy brush or weed competition.	Heavy brush and herbaceous competition; insects, animals, or diseases prevalent.

part of the region. (Deficient soil moisture causes the trees to become partially dormant in midsummer; a resumption of the active growth period following fall rains then exposes the new plant tissue to freezing before it has had time to harden off.) See also p. 39 for damage done by mice wintering in heavily sodded areas.

Although various species of trees have different soil requirements, it can be said that generally they are less demanding than are agricultural crops and hence will grow on soils of lower fertility. Summarizing the relatively small amount of research that has been done on soils in relation to tree growth, and after the first few years of establishment, several general facts are evident:

(1) Insofar as the mineral requirements for trees are concerned, available nitrogen, phosphorus, and potassium usually are not seriously deficient in forest soils. Calcareous soils (limestone particles present, reaction pH 7 or above) do not favor native pines in the Central States. They are suitable for red cedar. With some possible exceptions, most hardwoods seem to grow equally well on calcareous and noncalcareous soils. Limestone-derived soils (residual from limestone but may be acid in reaction) are suitable for hardwoods (or pines if the reaction is below pH 6.5). Ligon reports that black locust grows better on limestone-derived or calcareous soils than on acid shale soils.

(2) Available but not excessive soil moisture is an extremely important requisite for good tree growth. In soils subject to drought, such as sands, the percent of organic matter and the amount of silt and clay present are important because these two factors influence water-holding capacity.

(3) Certain physical properties of soils in general directly influence tree growth are total depth of the A and B horizons, plasticity and compactness of the B horizon, drainage, and aeration. A deep, friable, moist but well-drained soil is best suited for tree growth.

(4) Absence of the A horizon is not serious where there is a deep, friable, and moist soil

profile. If the subsoil is compact and tight, however, the amount and depth of topsoil assumes the same importance in tree growth as it does in other plants.

(5) From the above generalization, it is clear that fertility alone, as used in an agricultural sense, is not an accurate measure of soil quality desirable to produce good trees. For example, Auten has found that yellow poplar, a species commonly thought of as requiring "good" soil, made the best growth in localities where the general "fertility" level was low. The successful growth was due to the youthful character of the soil profiles, the deeply dissected terrain which resulted in good drainage, and the slopes which favored slow evaporation rates and low soil temperatures.

Tolerance

Tolerance may be considered as the ability of a tree to grow under shade and in competition with other trees. Because competition is always relative — what species is competing with what other species, and on what kind of a site — the assignment of any specific degree of tolerance to a single kind of tree can not be exact.

Relative tolerance of species:

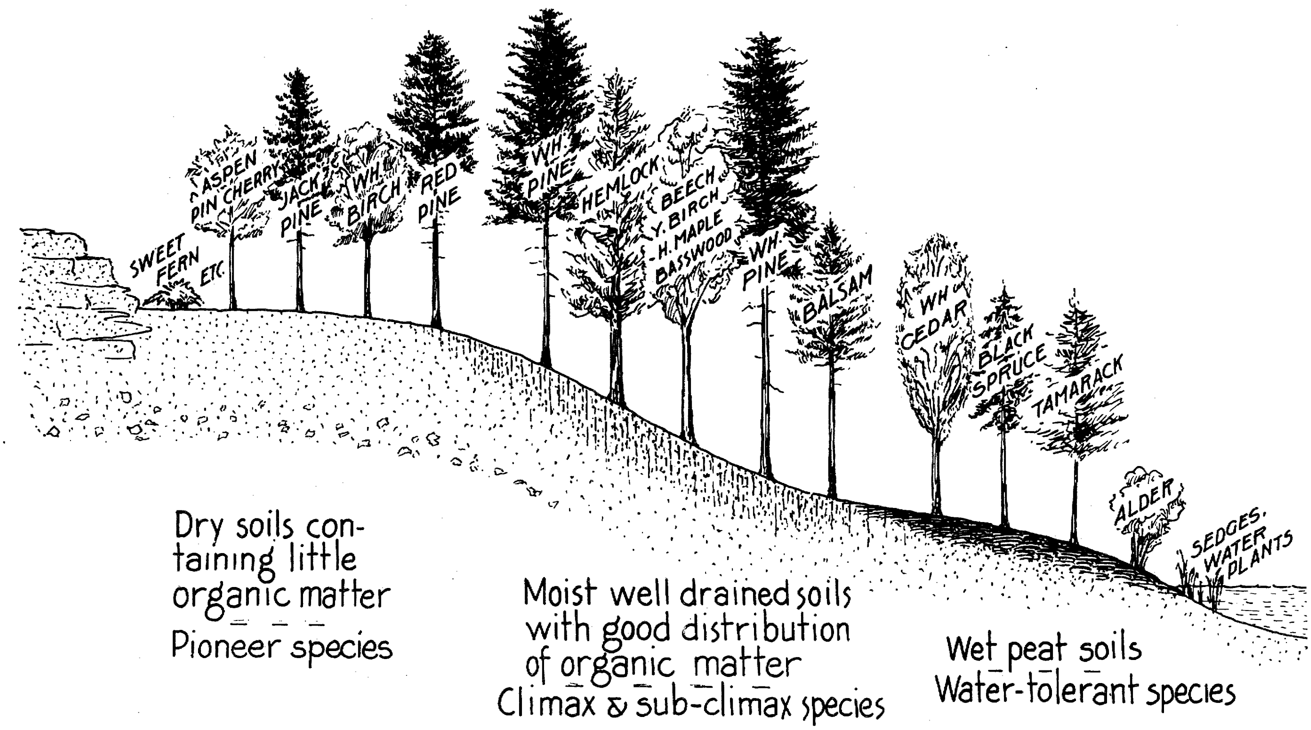
Tolerant	*Intermediate*	*Intolerant*
Balsam fir	Ash, white	Ash, green
Basswood	Birch, yellow	Aspen
Beech	Box elder	Birch, white
Cedar, white	Cedar, red	Butternut
Dogwood	Cherry, black	Catalpa
Elm, white	Elm, red	Cottonwood
Gum, black	Gum, red	Cypress
Hemlock	Hackberry	Locust, honey
Ironwood	Hickory	Locust, black
Maple, hard	Maple, soft	Oaks, red and black
Spruce	Oak, white	Osage orange
	Pine, white	Pine, 2- and 3-needled
		Sassafras
		Sycamore
		Tamarack
		Walnut, black
		Willow
		Yellow poplar

Nevertheless, the general concept of tolerance finds practical application when two or more species are planted in close association. If an attempt were made to plant a slow-growing intolerant like red oak close to more rapidly growing trees such as white or loblolly pine, probably the oak would fail to compete. On the other hand, spruce (a tolerant species) and white pine (which is quite tolerant when young) would survive in proximity to black locust and under most conditions would eventually overtop and eliminate the locust.

The degree of tolerance also is important in any woodland cutting or harvesting operations because the manner of cutting affects the kind of young trees that will reproduce naturally. A farmer who wanted natural reproduction of black walnut or yellow poplar, following cutting operations of mature trees, would be compelled to eliminate considerable competition before these two intolerants could develop and grow; it would be necessary to make large openings in the overstory of older trees. Contrarily, spruce, balsam, hard maple, or basswood reproduction could best be assured by the removal of a single large tree or two. These tolerant species then will reproduce to the exclusion of some of the less desirable and less tolerant species.

Varying degrees of tolerance in the same species have already been mentioned. Some of the more prominent regional variations should also be recognized. White ash, black cherry, and red cedar are considered relatively intolerant in the East, although in the western parts of their range they seem to withstand more competition. This is especially pronounced in red cedar. On the other hand, the red oaks appear to be intolerant in the Central States, but in the East can be classed as intermediate.

PLANT SUCCESSION



Typical succession of northern forest trees in relation to soil development and moisture

If undisturbed for sufficient time, land will develop a dominant type of vegetation through a series of successional steps. This vegetation is called the climax type. It is characterized by certain species of trees which are called climax species. (In arid or semiarid regions, the climax species may be grasses or shrubs.) Once established, no other species of plants can naturally invade and replace the climax, unless the type is subjected to some external form of destruction or unless there is a change in one or more site factors that brought the climax into existence.

All types of vegetation are subject to some external form of destruction. Logging, clearing land, and man-caused fires are forms of destruction. Excessive winds, damage by insects or disease, droughts, and fires caused by lightning are other forms of destruction to which forests have always been exposed and which temporarily may affect the climax type on a site. However, the same climax, i.e., the same combination of species, will eventually reappear unless a permanent change in the site has been brought about by the external force. For example, if land is drained there is a permanent reduction in the moisture available, and a more xerophytic climax results.

Despite the fact that something often happens which seems to upset the process known as plant succession, an understanding of ecological principles involved makes clear that succession is universal and continuous. After the cause of disturbance, either by nature or man, has been removed, development will proceed from the present stage to the climax very much as before.

The concept becomes more understandable if we view the species of trees which make up a climax type, as end products of a series of successional steps that began hundreds or even thousands of years ago, with solid rock, dry sand, or water. Certain plants which are called pioneer species became established in the crevices of the rocks or in water. They were adapted to that particular kind of site. As the soil on the barren sand or rock develops to a greater depth, as the organic matter increases, and as a foothold is built up by an accumulation of decayed plants, the pioneer species are gradually replaced by others. Finally the climax species are able to invade the site and gradually crowd out the other species. Hence, certain kinds of plants characteristically follow the various stages of soil development.

The approximate relative position of some of the common trees in the ecological succession is shown in the following list:

Conifers	*Hardwoods*	*Soil development*
	PIONEERS	
Red cedar		
Virginia pine	White or gray birch	Dry sands or shallow soils
Jack pine	Pin cherry	↓
Pitch pine	Aspen	↓
Shortleaf pine		↓
Loblolly pine	Bur oak	↓
	SUBCLIMAX	↓
Red pine		↓
White spruce	White oaks	↓
White pine	Red oaks	↓
	CLIMAX	Deep, well-developed soils with good drainage
Hemlock	Yellow birch	
	Beech	
	Hard maple	↑
	Basswood	↑
	SUBCLIMAX	↑
Balsam	Tulip poplar	↑
White cedar	Black walnut	↑
	White ash	↑
	Red gum	↑
Black spruce	American elm	↑
	Soft maple	↑
	Cotton wood	↑
	Black ash	↑
	PIONEERS	↑
		Swamp, wet bottom-land soils
Cypress	Willow	
Tamarack	Alder	

The practical application of plant succession is obvious. The climax species which demand the best soil development cannot be successfully grown on degraded sites. Conversely, pioneer species, if planted on good sites, will rather quickly give way to climax species. The principle is especially important in planting on farm land where so many prospective planting areas have been subject to destructive influences. The original cover has been stripped; the land has been plowed up and down the hill; the topsoil is gone. An attempt to reestablish climax species would be futile, even though the land at one time might have been covered with hard maple or basswood.

Another common application of this ecological principle occurs when the woodland owner attempts to maintain a pine forest instead of some of the less valuable hardwoods. In most regions, the hardwoods are the climax species and will succeed the pine. In the central hardwood region on good sites this is a desirable succession, because many of the native hardwoods are economically more valuable than pines. However, the pines and other subclimax species are the most desirable trees on poor, dry sites. Here, the problem is one of holding back the succession and checking the natural encroachment of the less valuable hardwoods. That is why controlled burning to discourage hardwoods is considered good forestry practice in the South.

Note that this list does not recognize any geographic range of the species. For that reason, one would not expect white pine, a northern tree, eventually to succeed shortleaf pine, a southern tree. That the principle of succession assumes a change in the soil should also be recognized. Thus, as long as poor drainage exists, water-tolerant species such as cypress or black spruce may persist indefinitely.

REFERENCES

Ready Reference to Conservation Farm Planning, U. S. Soil Conservation Service, Region 3, Milwaukee, Wis.

"Soil Characteristics, Topography and Lesser Vegetation in Relation to Site Quality of Second Growth Oak Stands in Connecticut," Herbert A. Lunt, Journal of Agricultural Research, September 1939.

"Prediction of Site Index for Yellow Poplar," John T. Auten, Journal of Forestry, September 1945.

"The Role of Soil Organic Matter in Reforestation," Wilde and Patzer, Journal of American Society of Agronomy, August 1940.

Forest Soils and Forest Growth, Wilde. Chronica Botanica Co.

"Some Soil Factors Associated with Site Quality for Planted Black Locust and Black Walnut," John T. Auten, Journal of Forestry, August 1945.

Science in Farming, USDA Yearbook of Agriculture 1943-47, pages 473-480.

Trees, USDA Yearbook of Agriculture 1949, pages 103, 114, 120.

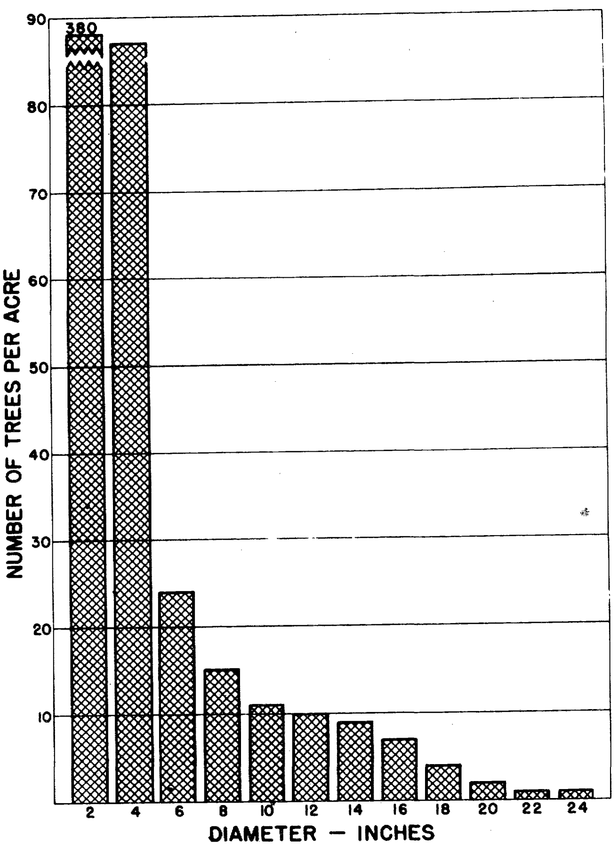
Soils of Wisconsin in Relation to Silviculture, Wisconsin Conservation Department Publication 525-49.

Relation of Soil Characteristics to Site Index of Loblolly and Shortleaf Pines in the Lower Piedmont Region of North Carolina, Coile, Duke University School of Forestry Bulletin 13.

SILVICULTURE

GENERAL

Silviculture is the growing and reproducing of a community of forest trees on a permanent basis. Its application to farm woodlands is similar to the application of horticulture to an orchard. It aims to establish trees if they are not present, or, if they are present, to improve their quality and rate of growth and to insure their permanence.



Number of trees per acre of different diameters in a southern Michigan woodland. Good silviculture has been practiced here for a quarter of a century.

The ideal farm woods is a community of small, intermediate, and large-size trees--trees of all ages (see illustration above). The owner of such a woodland simply harvests the older trees annually or periodically and permits the younger age classes to occupy the ground where the large trees grew. He is maintaining his woods' capital; he is insuring a permanent operation; he is practicing silviculture. To obtain these objectives he should carefully consider each of the following questions when harvesting a tree:

Size. Is the tree to be cut the right size to be usable for the product needed? For example, small trees will not make sawlogs; it would be wasteful to cut large, choice trees for fuelwood.

Species. Is the tree the best species available for the intended use? Cottonwood is not good for fuel, but it is very acceptable as pulpwood. Also, if it is a desirable species, should it be left to furnish seed for new trees?

Maturity. Is the tree ripe? Does it show signs of deterioration from old age or from insects and disease? Dead tops, evidence of insect damage, or rot are signs indicating that the tree should be cut.

Growth. Is the tree growing fast? Does it have a full crown and comparatively smooth bark, which indicate thrift and vigor? If so, and if it has potential marketable value, it should be retained as a part of the growing stock -- the wood's capital capable of bearing a high rate of interest. See page 56 for more detailed discussion.

Reproduction. What kind of reproduction will result from the cut? Preventing the regeneration of brush and comparatively worthless species is one of the principal aims of silviculture. One of two methods of cutting, or modifications on a small scale, generally will assure reproduction of the more valuable trees which are present:

Selection. Only scattered mature trees are cut. No part of the ground larger than the crown of a single tree or two is exposed.

Group selection. A modification of the above: Several large, though not necessarily mature, trees are cut on one area. Obviously this results in larger openings than when a single tree is removed. The openings should not exceed half an acre, preferably a little wider than the height of the tallest trees.

Leaving a few scattered seed trees or clear-cutting all merchantable trees are two drastic modifications of group selection. Although recognized by foresters as applicable to some circumstances, neither practice is generally recommended for eastern farm woodland. Seed trees are always subject to wind damage, and site conditions frequently become unfavorable to seed germination following sudden exposure of the ground to sun and wind. Clear-cutting likewise results in site deterioration, and commonly only the undesirable species are left to reseed the area.

Hardwoods* have the capacity to regenerate from sprouts, but the resulting trees, known as coppice, do not as a rule develop so satisfactorily as those from seed. Sprouts, therefore, will start from the stumps of hardwood trees cut by any of the above methods, and in amounts proportionate to the degree of cutting, the age, and the kind of tree.

Young trees sprout with greater vigor than old ones, and some species exhibit greater capacity than others. Birch, hickory, and shortleaf pine are among the comparatively less prolific sprouters. Experiments indicate that trees cut in the fall, winter, or early spring sprout more vigorously than those cut in midsummer.

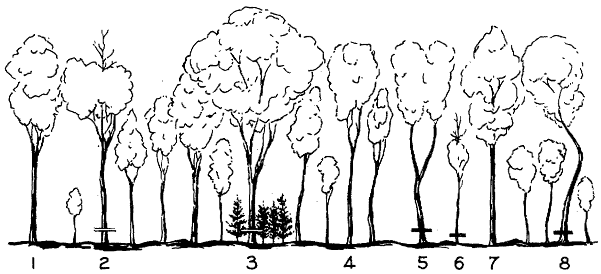
The amount and kind of trees and tree seed on the ground at the time of cutting, the seed crop on the trees that are left standing, competition from other woody and herbaceous plants, and the influence of site factors on soil moisture affect the kind of seedling reproduction obtained under any degree of cutting. Assuming favorable conditions for germinating seed, however, the various degrees of cutting will result in reproduction about in proportion to the tolerance of the species. The following list will be useful as a general guide as to the kind of trees most likely to reproduce from each of three methods of cutting:

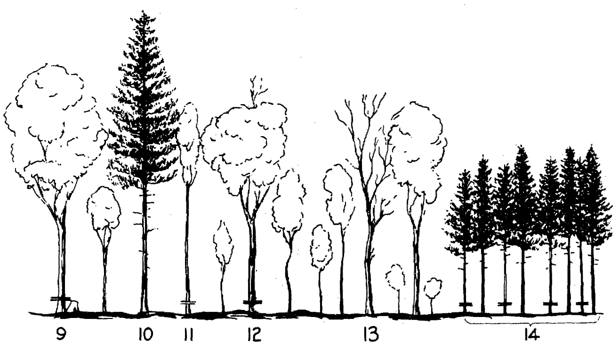
Method	*Probable resulting reproduction, assuming seed trees to be present*	*Remarks*
Selection	Hard maple, basswood, elm, black cherry, beech, hickory, white ash, hemlock, red and white cedar, spruce, tolerant shrubs.	Only method recommended on steep, southly facing slopes. Intolerant species ordinarily will not reproduce satisfactorily.
Group selection	All oaks, black walnut, yellow poplar, pines; in short, most all intermediate and intolerant species, in proportion to seed available at time of cutting.	Use on east, north, or west slopes, or flats, where desired reproduction is intolerant. Too large openings on dry sites will encourage site deterioration and only brush and weeds will come in.
Clear-cut	Sprouts of existing hardwoods; light-seeded trees such as aspen, cottonwood, elm, boxelder, birch; shrubs; briars; herbaceous plants.	Generally not recommended for farm woods. May be necessary on small areas in order to secure sprout reproduction where there is a heavy undergrowth of shrubs and undesirable species. Black locust, catalpa, Osage-orange, and jack pine may be reproduced by clear cutting. In addition to heavy cutting, the exposure of mineral soil and the lopping and scattering of the cone-bearing tops is necessary for the reproduction of jack pine.

*Shortleaf and pitch pines are the only eastern conifers having sprouting ability.

IMPROVING THE WOODS

In some respects the farm woodland is like a garden -- a farmer cannot grow good vegetables unless he does some weeding and thinning. It is the same way in the woods. When a man is cutting timber, he should think of improving the quality and the conditions for growth of the trees that are left if he expects to get a good crop in the future. The following diagram and the explanation will illustrate usual situations.





Trees 1, 4, 7, and 10--Good, healthy trees, with full crowns, making rapid growth. Should not be cut. All future wood operations should favor them until they are big enough to be harvested as sawlogs or veneer logs.

Tree 2--Tree with dead top. Should be cut and utilized. This tree has no prospects of good growth; is subject to disease and insect damage, and probably will die in a few years. However, if the dead top is a result of mechanical injury, say from a sleet storm, and the tree is otherwise thrifty, it probably should be left to grow larger.

Tree 3 --A "wolf" tree. Should be taken out or girdled*. This tree is hindering or suppressing the growth of nearby trees as well as reproduction underneath. It is of little value itself.

Tree 5--Forked tree. Should be cut and utilized as soon as possible. Its poor form will never permit its use as high quality material, the older it gets the harder it will be to cut.

Tree 6--Suppressed tree. Even though of desirable species, this tree will never recover nor amount to anything. It should be cut and utilized for fuel or props.

Tree 8--Crooked and poorly formed tree. Same recommendation as for tree 5.

Tree 9--Tree from a stump sprout. Probably is rotten on the inside, or will be if it joins the old stump very high up. Should be cut and utilized.

Tree 11--A "whip." Too weak and narrow crowned to have promise as a crop tree. Should be cut and used before it dies, breaks off, or blows down.

Tree 12--Fire-scarred and decayed trunk. Cut and utilize.

Tree 13--Dead tree. This tree probably is not damaging the remaining stand. If it cannot be used there is no object in cutting it. If only a limited amount of material is needed, it is better to take trees like numbers 2, 3, 5, 8, and 9 than the dead ones. Consider also that a dead tree may be beneficial to wildlife.

Tree 14--Trees, 4 to 8 inches in diameter, growing too close. Should be thinned out. Leaving only the best formed and the most desirable ones, thus permitting their faster growth. The trees cut may be used for posts, pulp, or fuel. (See "Thinning".)

The above discussion is applicable only to woodland which has not been excessively grazed and which has a fairly dense stand of trees. In severely grazed woods having comparatively few old trees and a heavy sod or brush cover underneath, the best form of woodland improvement is complete protection. Little cutting of any kind should be done until an accumulation of leaf litter has restored something approaching natural forest soil conditions.

Thinning

Contrary to the commonly held viewpoint, trees do not grow taller as a result of close spacing; in fact, competition for water and sunlight may cause stagnated growth. Similarly the elimination of crowding, i. e., thinning, will not materially affect rate of height growth, except in tolerant species that have been suppressed to a point where they no longer occupy a dominant place in the stand.

In order that trees less than 10 inches in diameter will have sufficient growing space, the following guide will determine roughly the optimum spacing between trees: The average diameter of the trees plus 4 should equal the desired spacing in feet. Thus, trees averaging 7 inches in diameter should be about 11 feet apart; if closer, thinning is needed. For trees 10 inches or more in diameter measured at breast height, the diameter plus 6 will give better spacing.

*Hardwoods commonly develop basel sprouts even after girdling. Sprouting is discouraged by removing the bark only and not cutting into the sapwood.

Tree height also has been used as a guide to thinning, the rule being that for best growth the space between trees should have the following relation to height:

Tolerant trees - - - - -	1/6 of total height.
Intermediate trees - - -	1/5 of total height.
Intolerant trees- - - - -	1/4 of total height.

Applying this rule-of-thumb to a plantation of jack pine 40 feet in height would indicate a spacing of about 10 feet between trees.

Pruning

Pruning is another operation employed to increase the future value of standing trees. As used in forestry, pruning is not intended to accomplish the same objectives as in horticulture or landscape work where the purpose is to increase fruit production or remove unsightly limbs. In silvicultural practice the side branches of trees are cut off so that wood subsequently formed will be free of knots.

In the natural forest, most trees grow close enough to be self-pruning, and in naturally reproduced hardwoods or closely spaced conifers artificial pruning is infrequently practiced. In coniferous plantations, natural pruning is slow and with white pine particularly, the side branches persist many years.

If pruning is to fully accomplish the purpose intended and is to be economical, several important rules should be remembered:

(1) Confine pruning to the pines and possibly spruce which are being grown for the production of high-grade lumber. Pruning pines like jack, Scotch, pitch, or Virginia or species raised for pulpwood or railroad ties is a questionable venture. Neither is the pruning of hardwoods economical except for occasional select trees to improve form; such pruning because of the danger of heart rot may do more harm than good.

(2) Pruning should be accomplished in two operations, the first when the trees are not less than 3 and not more than 5 inches in diameter, at which time all the lower branches are cut off to a height of about 6 or 7 feet; the second several years later when the trees reach a diameter of 7 or 8 inches, at which time the remaining side branches up to a height of 15 to 17 feet should be removed. If the first pruning is delayed until the trees become too large, there will not be sufficient clear material laid on to pay for the increased labor of cutting the large branches.

(3) Pruning should be done with a saw, and the cut made as close as possible to the trunk. The use of axes or other tools which do not give a clean close cut should be avoided.

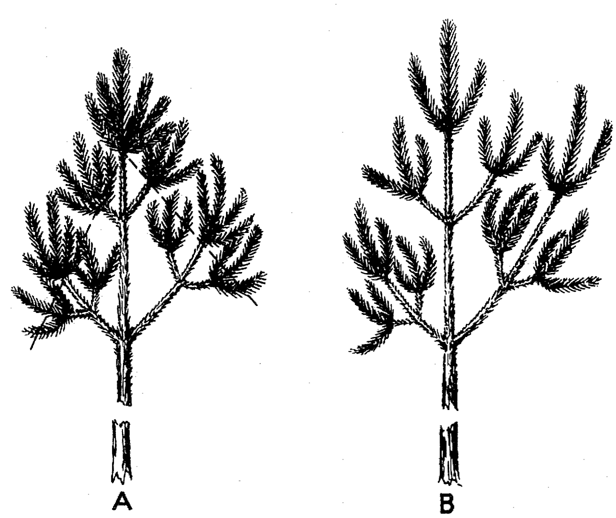
(4) Not more than the lower one-third of the live branches should be cut from any tree. Some prefer to cut no more than the two lower whorls of live branches, but experiments have proved that healthy pines can lose the lower third of their live branches without any reduction in vigor. If more green growth is removed, however, the wood-producing capacity is lowered.

(5) Not more than 150 to 250 trees per acre should be selected for pruning. These are the ones that show promise of growing into sound healthy crop trees, the vigorous well-formed individuals that can successfully compete with their neighbors for growing space.

Another form of pruning, more appropriately called <u>shearing</u>, is done to improve the shape of conifers to be used for <u>Christmas trees</u>. The object is to thicken the foliage and give the tree a dense conical shape. It has been successful with Scotch, red, white, Austrian, and western yellow pine, as well as spruce and fir. The other pines--pitch, jack, and the southern species--because of their indeterminate growth, do not lend themselves to shaping so readily as the pines which grow but one whorl of branches each year.

Pine is pruned after the growth has started in the spring, on the new shoots only, and before the buds at the ends of the new branches are fully developed. About the first week in June in the southern part of the region up to the middle of July in the northern Lake States is the proper time to shear pine. If the cutting is done too early, new growth will continue and no noticable thickening of foliage will result. If done too late, bud formation may not take place.

The cuts can be made anywhere on the new shoots in order to give the tree the desired shape. The following year, several new



(A) Typical shape of a pruned pine whose growth was cut back a year ago, along the dotted line. (B) Normal growth of a pine similar to A, which was not pruned. Note the open character and poor form as compared with the pruned tree.

branches develop at the point of pruning. This serves to thicken the tree and at the same time improves its shape. If wood grown the previous year is cut, only the objective of shaping will be accomplished, because no new buds will be formed at the point of cutting.

Hedge shears are about the best tool to use. However, because there is a tendency to remove too much of the terminal leaders, some growers recommended two operations: Cut terminal leader first with pruning shears, leaving not less than 12 to 15 inches of new growth; later shape the new growth on the lateral branches with hedge shears. Sweeping cuts with a sharp hand sickle also are effective in shearing side branches.

Trees vary in their need for shaping. A few individuals develop into dense conical specimens without attention. Some will be improved by one shearing a year-and-a-half prior to marketing. More frequently, shearing for two or three successive years is necessary to produce a first-class specimen. For such trees the first shearing will start about 3 years after planting and continue annually or as needed.

Spruce and fir also are sheared to develop more compact Christmas Trees. With these species, however, pruning of the long leader or side branches is done in the late summer, fall, or winter. The central leader is cut at a point about 6 to 10 inches above the uppermost whorl of branches. If two or more leaders grow from the point of severance the following year, one can be removed. In pruning laterals, the cut should be made as close as possible to the nearest bud or branchlet in order to avoid a bare branch stub.

Removal of Vines

In addition to improving woodland quality and growth by weeding, thinning, and pruning, there are some pernicious vines to consider. Wild grape, poison ivy, Virginia creeper, and trumpet vine are a serious menace to the growth of trees in many farm woods. Wild grape has a marked capacity to sprout, and the mere cutting of the vine does not insure its destruction. In extremely dense wood land, however, cutting in late June or early July will eliminate the plant, because the sprouts will not develop in complete absence of sunlight. In most farm woods, however, there will be sufficient sunlight to permit sprouts to grow, and the vines will be killed only after repeated cuttings during July and August, over a period of about 3 years. A team or tractor will most effectively eliminate grape vines by removing the root. The vine is severed from the roots, and by fastening a chain or cable to the bulge formed by the roots and the stem, the vital portion of the root system can be pulled from the ground.

REFERENCES

Some Results of Thinning Fifteen-Year-Old Red Pine, Journal of Forestry, Sept. 1945.

Timber Stand Improvement in the Southern Appalachian Region, USDA Miscellaneous Publication 693.

Foundations of Silviculture Upon an Ecological Basis, Toumey. John Wiley & Sons.

Managing the Small Forest, USDA. Farmers' Bulletin 1989.

Managing Small Woodlands, Koroleff. American Forestry Association

Comments on Timber Stand Improvement in the Central States, Central States Forest Experiment Station Note 30.

Woodland Improvement, Wisconsin College of Agriculture Extension Circular 305.

Woodland Management, Bulletin 213, Ohio State University Agricultural Extension Service.

Improvement Cutting and Thinning, Massachusetts Forest and Park Association Bulletin 155.

Results of Forest Cutting Practice in Lake States Timber Types, U.S. Forest Service, Region 9, Milwaukee, Wis.

Knots in Second-Growth Pine and the Desirability of Pruning, USDA Miscellaneous Publication 307.

Pruning Southern Pines, USDA Farmers' Bulletin 1892.

Pruning for Profit, Cline & Fletcher. Massachusetts Forestry Association.

Thinning a Pine Plantation, Wisconsin Conservation Department Publication 515.

Results of Thirty Years Experimentation in Silviculture. Part 1, Lutz and Cline, Harvard Forest, Petersham, 1947.

Trees, USDA Yearbook of Agriculture 1949, pages 120-126.

"Christmas-Tree Farming," Cornell Extension Bulletin 704.

PLANTING

Forest planting, as distinguished from ornamental or windbreak planting, may be defined as an effort to assist Nature in the reestablishment of a complete cover of trees and shrubs. Thus, on a given area to be planted, an attempt is made to establish in a few years a community of woody plants which might otherwise require decades. Success requires reasonably accurate answers to three questions: What to plant? When to plant? How to plant?

What to Plant?

This question must be answered on a local basis. On pages 5 and 7 the various factors of appraising planting sites are stated in general terms. To specifically name species to be planted under any given local condition requires the development of a local planting quide in which the generalized factors are restated to fit local conditions. These guides, in brief, should show what species are adaptable to any given soil, exposure, degree of erosion, etc. There follows a list that can be used as an aid in developing a local planting quide.

Species	*Relative adaptability*
Eastern red cedar	Medium acid to alkaline soils; above pH 5.5.
Jack pine	Most hardy of the northern pines. Wide range of pH adaptability.
Scotch pine	Adaptable to poor soils throughout region. Short lived.
Virginia pine	The eastern counterpart of jack pine.
Pitch pine	Acid soils. Both heavy and light soils.
Shortleaf pine	Fast growing. For dry upland soils.
Western yellow pine	Slow growing. Used mostly in low-rainfall localities.
Loblolly pine	Fastest growing of pines. Used on heavier soils than shortleaf.
Austrian pine	Slightly acid to alkaline soils, pH 6.8 to 8.0. Not commonly planted.
Red pine	Not adapted to soils more alkaline than pH 6.8.
American elm Cottonwood	Adapted to wide variety of moisture conditions; the least demanding of hardwoods. Elm infrequently planted.
Green ash	Dry-land hardwood, widely used in Plains States.
White spruce	Medium acid to alkaline, relatively dry soils. Slower growing than Norway spruce.
White pine	Subject to root rot on heavy, poorly drained sites. Most demanding of pines.
Norway spruce Northern white cedar Balsam	Highest moisture requirements of any conifers. Moderately acid to neutral soils.
Soft maple	For wet, poorly drained areas. Rapid growing.
Bur oak Hickory White oak	Very slow growing. Not frequently planted. Best started from seed.
Osage orange	Often hard to start from seedlings. Heavy or light soils. Needs topsoil.
Red oak	Best started from seed.
Black cherry	Rarely planted.
Red gum	Southern hardwood which tolerates heavy, poorly drained soils.
Black locust	Will start on poor sites, but subject to borer damage unless soil has optimum drainage.
Catalpa	Tolerates heavy soils. Not planted so much as formerly.
White ash	Deep, well-drained soils.
Black walnut	Requires deep, well-drained loams.
Hard maple Basswood Yellow poplar	Although often occur naturally on relatively poor soils, they cannot be successfully established artificially except where there is good drainage, slow evaporation, and low summer soil temperatures. Basswood infrequently planted.

The trees near the top of the list can be established on the drier and generally poorer sites. Species listed further down demand progressively better sites for satisfactory survival and growth.

The arrangement of species indicates that conifers, especially the pines are better adapted to soils of lower "fertility" than are the deciduous trees. For that reason pines are the most widely planted, even in localities where they do not naturally occur. With the exception of Austrian pine, Northern white cedar, and red cedar, the conifers prefer acid soils. Some have a wide range of tolerance to alkalinity but, in general, they develop best on soils which are very acid to neutral in reaction, pH 4.5 to 7.0.

Black locust has been one of the most widely planted species on farms in eastern United States. Its position on the list, however, shows that it requires fairly good sites if it is to succeed.[1] Locust should not be planted except when the subsoil is moist, well-drained, and friable. Dry sands, rocky slopes, poorly drained, and heavy, claypan soils will not produce good black locust trees.

The farther a tree is moved away from its natural climatic range, the better the site must be to insure its survival. Newly planted white pine and spruce will withstand the rigors of exposed sites within their natural range. If the same species are planted in the Central States, however, they should be confined to cool slopes.

If three or more site factors are poor, the prospective planter should begin to question the advisability of planting trees. Many planting failures have resulted from the misconception that trees will grow anywhere a hole could be dug in the ground. The fact remains, however, that there is considerable land on farms which has been so badly misused that tree planting is a highly questionable venture. Land can be submarginal for trees the same as it is submarginal for other farm crops.

Wet, poorly drained areas are not good tree planting sites. They are better adapted to some of the water-tolerant grasses, such as reed canary, or for the development of wildlife.

The planting of exotic species, in general, should be avoided. Of all the foreign species that have been introduced, there is none that has proved eminently successful in forest planting. Norway spruce and Scotch pine are, for certain purposes and in some localities, possible exceptions to this rule. The native species of western United States have not proved useful in eastern reforestation practice. Western yellow pine and Douglas-fir, grown from Rocky Mountain seed, succeed fairly well in the Central and Eastern States, but their growth does not compare favorably with the native conifers.

Plans for tree planting should contemplate the use of at least two, and preferably more, species on any area. A single species in a solid block is an inviting host to insect and disease epidemics. Mixtures to duplicate natural forest development are insurance against future losses.

Trees may be mixed "stem-wise," i.e., alternating the different species in the same row, or else two or three rows of one species can be alternated with the same number of rows of other species. When mixing species, the planter must consider two important factors: how fast the trees will grow and their relative tolerance. As has been previously discussed (p. 8), it would be unwise to plant a slow-growing intolerant species close to a more rapidly growing tree. Stated in another way, the individuals in mixtures must be compatible on the particular site where they are to be grown.

In addition to the kind of trees, the kind of planting stock is an important phase of the question, "What to plant?" Most planting is done with nursery-grown trees. Occasionally, naturally seeded trees, "wildlings," are dug from the woods and set out, and cottonwood from river sand bars has been cheaply and successfully transplanted. With few exceptions, however, wild seedlings usually have poorly developed root systems as compared to nursery-raised trees and are not adapted to large-scale planting.

Forest tree nursery practice attempts to develop planting stock that can be transported and set out in the field with a minimum of labor and little care immediately after planting. If reforestation on a large scale is to be successful, the nursery stock must be inexpensively grown; it must be small enough to be easily handled in quantities and yet sturdy enough to survive handling and planting. Many of the conifers have to be carried several years in the nursery before they are plantable. Other species can be planted after one year in the nursery; and a few may be successfully planted directly from seed or cuttings.

Trees grown direct from seed without transplanting are known as <u>seedlings</u>. If it becomes necessary to transplant the tree in the nursery in order to produce a larger tree, a

[1] Growth of locust can be stimulated on poor sites by placing commercial fertilizer in the hole at the time of planting. Over a period of years, however, this stimulation disappears, and competent observes have reached the conclusions that on good sites fertilizer is unnecessary, and on poor sites pine rather than locust should be planted.

TABLE 2.--*Specifications of nursery stock for farm woodland planting*

Species	Age	Height above ground	Diameter at root collar	Root-top ratio*
	Years	*Inches*	*Inches*	
Spruce .... Douglas-fir White cedar	2-2	6	3/16	40-60
White pine	2-2 or 2-1	7	1/4	40-60
Red pine .... Ponderosa pine Austrian pine	2-1 or 1-2	7	1/4	25-75
Red cedar	2-0, 1-1, or 2-1	6	3/16	40-60
Jack pine .... Scotch pine Virginia pine Pitch pine	2-0 or 1-1	6	3/16	25-75
Shortleaf pine .... Loblolly pine	1-0 or 1-1	7	3/16	25-75
All oaks	1-0	6	3/16	50-50
Other hardwoods	1-0	10	5/16	50-50

*Percent by weight of root and top respectively, including needles of conifers.

more compact root system, and a better balance between the roots and the top, the tree is known as a transplant. In table 2, the column showing age reflects the distinction between seedlings and transplants. The first number represents the number of years in the seedbed, while the second shows the number of years grown as a transplant. The total of the two numbers equals the age of the tree.

Table 2 above indicates the approximate specifications of good nursery stock that can be successfully used for farm-forest planting. Under ideal site and weather conditions, and with good care after planting, smaller stock may be satisfactory. Also, during the early part of the planting season, smaller trees have a better chance of survival than if planted late in the spring. Under average circumstances, however, the sizes and ages shown are the optimum consistent with good survival. Larger stock will be more costly to plant and is likely to have a small root system in proportion to the top, which contributes to poor survival. Smaller stock may be too weak to survive on the eroded sites or in competition with herbaceous vegetation.

Black walnut, the oaks, and other nut-bearing trees also can be established in the field by direct seeding. This method of planting is less costly and, as shown by observations made in Missouri, (table 3) may result in better growth than can be obtained by planting nursery-grown seedlings.

The effectiveness of direct seeding is limited by the possible damage by weevil and rodents.[2] Every effort should be made to plant the nuts in the fall, because fall-planted seeds apparently are less susceptible to theft by squirrels. If not planted then, the seed must be stored in a well-drained, moist medium, like wet sand, over winter. If nuts dry out they will not germinate.

When planting, clear a spot about 2 feet in diameter and work up the soil with a spade or

TABLE 3.--*Comparison of direct seed vs. seedlings*

Size	(Growth 5 years after seeding)			
	Black Walnut	Red Oak	Burr Oak	Pecan
Diameter, root collar:				
Direct seeded..(inches)	2.0	0.8	1.3	0.7
Transplanted...(inches)	1.1	.4	1.1	.3
Height:				
Direct seeded....(feet)	7.2	4.3	5.2	3.3
Transplanted.....(feet)	4.7	2.5	4.4	1.0

[2] The use of discarded tin cans has proved successful in protecting nuts and acorns from squirrels. One end of the can is completely opened; the other end opened with a crossed cut and the four quarters sprung slightly outward for sufficient passage of the shoot, but not enough to permit entrance by squirrels. The can is then pushed down over the already planted seed so the top is flush with the ground. Another method is to "pot" the seed directly in the can and then set the inverted can in a hole. Obviously, no extensive plantings can be made with this method.

grub hoe. Cover the seed with soil to a depth equal to about twice the thickness of the seed.

The only forest trees that are planted directly in the field by means of cuttings are the willows. Under favorable conditions, cottonwood also may be planted by this method, but on most sites nurserygrown stock or 1-year-old wildlings give the best survival.

To give best results, cuttings should be handled as follows:

(1) Make cuttings about 8 inches long and about the thickness of a lead pencil, from 1-year-old, fast-growing wood, any time during dormant season prior to planting.

(2) If cutting is made before the time to plant, store in a cool, moist, but aerated medium; a sand and peat moss mixture is good. Do not let cutting dry out.

(3) Push cutting into soil, top up with one good bud exposed.

(4) Complete planting early, by the time the native willows have burst their buds, if possible.

Planting usually presupposes some future utilization of the trees when they are mature, hence the prospective planter wants to know what use can be made of the various species.

Trees for various uses:

Posts	*Railroad ties*	*Christmas trees*
Osage-orange	Black locust	All pines
Black locust	Oaks	Douglas-fir
Red cedar	Pines (except white)	Spruce
Catalpa		Red cedar

Veneer logs	*Lumber*	*Pulpwood*
Black walnut	All pines	All species except hickory, black locust and Osage-orange.
Oak	Black walnut	
Yellow poplar	Oaks	
Yellow birch	Yellow poplar	
Maple	Cottonwood	
Gum	Ash	
Elm	Red gum	
Cottonwood		

The use of the tree, however, should not be the first consideration in choosing the species. The site is always the limiting factor, and it should be remembered that regardless of the potential value of a species, if it is not adaptable to the site, planting will be futile.

Assuming adaptablility to the site and recovery from the shock of transplanting, the commonly planted trees may be grouped in three classes to indicate their relative rates of height growth the first few years following planting. Later, some species, such as white pine and spruce, develop more rapidly and may overtake some of the fast-growing juveniles.

Relative growth rates of forest trees:

Rapid	*Medium*	*Slow*
Southern pines	White pine	Spruce
Scotch pine	Red pine	Austrian pine
Jack pine	Pitch pine	Western yellow pine
Cottonwood	Virginia pine	Red Cedar
Willow	Black walnut	White cedar
Black locust	Ash	White oak
Yellow poplar	Red oak	Osage-orange

When to Plant?

Forest trees should be planted when the stock is dormant and early enough to insure root establishment before dry weather. In the northern states early spring is the most acceptable planting season. If planted in the fall, the alternate freezing and thawing of the soil causes small trees to be heaved out of the ground.

When the soil is subject to freezing, fall planting will be successful only with large stock on light, sandy soils which are continuously covered with snow throughout the winter months. Mulching around newly planted trees with straw or dead herbaceous material is used as a precaution against heaving. Oftentimes, however, this practice encourages mouse damage (p. 39) and, for that reason, is hazardous. Fall planting if done in the north should be completed before the first half of October, in order to permit root establishment before the ground freezes.

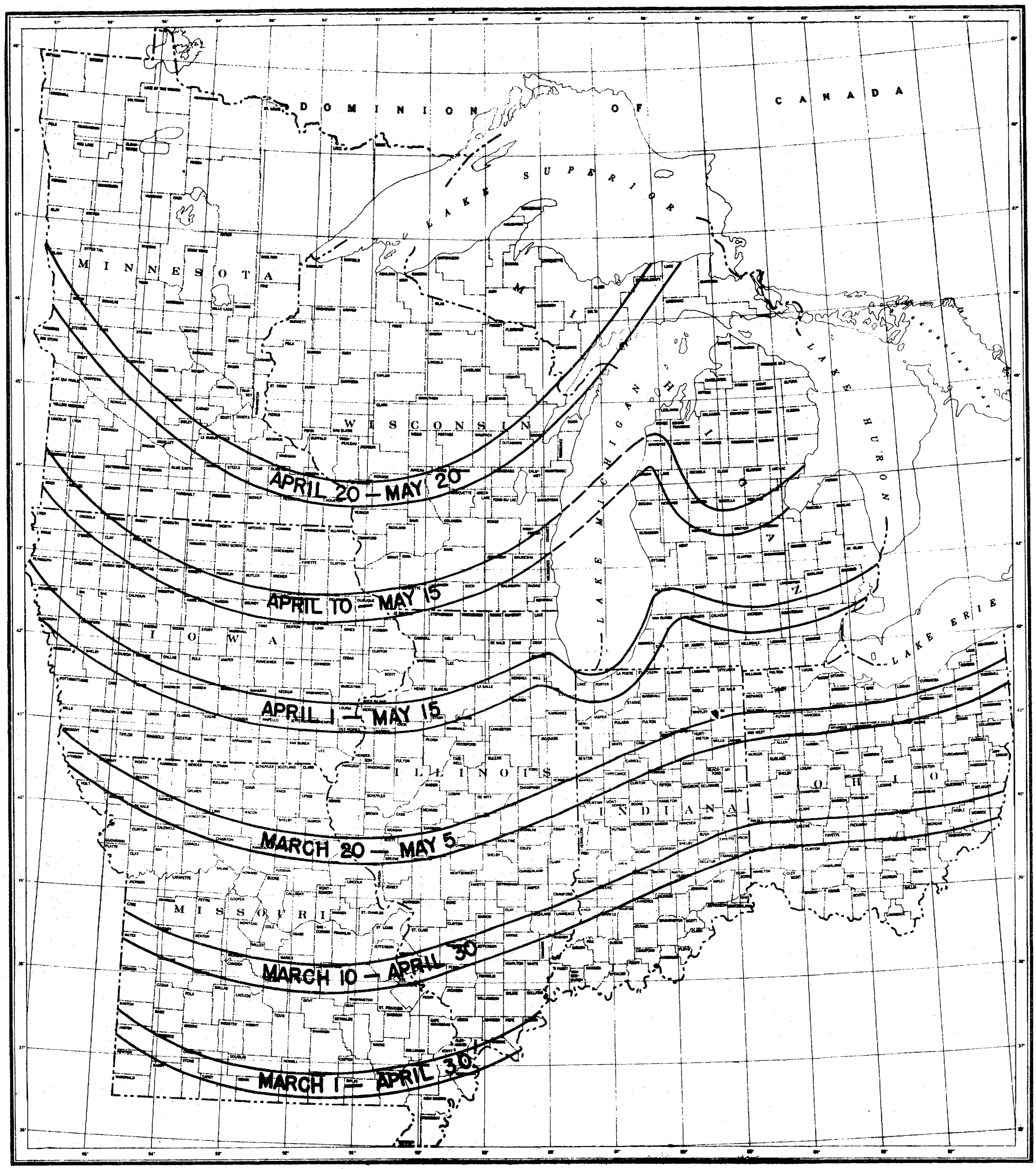
The approximate periods during the spring when tree planting is recommended is given on the following map. The dates, of course, are subject to yearly variations but will be found useful as a year-after-year average.

How to Plant?

Probably more tree planting failures can be attributed to careless handling of stock and improper planting than any other cause. All of the steps listed below should be carefully followed if successful planting is to be assured:

Handling stock:

1. Always keep roots moist. Drying of the fine root hairs of conifers results in hardening of the resin and consequent inability of the tree to grow.
2. Trucks hauling stock should be supplied with tarpaulins for covering the trees.
3. Avoid piling stock too deep, which will result in heating. Tree-tops, particularly of the evergreens, need aeration.
4. Do not permit the roots of nursery stock to freeze, either at digging time or in transit. Black locust, Osage-orange, black walnut, and some conifers are damaged to a point of worthlessness if exposed to temperatures below 25° F.
5. Boxed or baled stock must be removed from containers as soon as received, the bundles cut, and trees "heeled-in" in light, friable soil. If the trees can be planted within a day or two after arrival, heeling-in may be unnecessary. Tightly packed stock that has roots supplied with plenty of moist packing material and tops exposed to the air will not deteriorate if stored in a *cool* place for

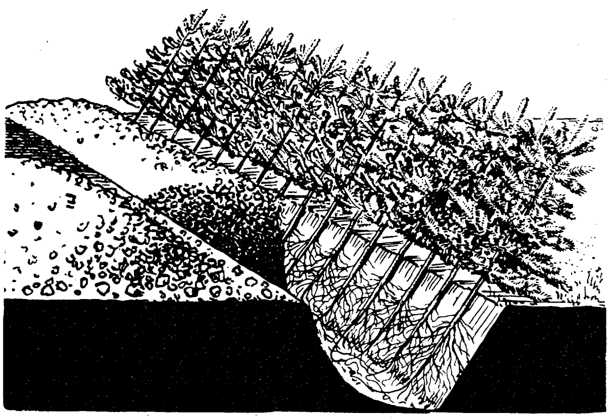


Spring tree-planting periods. Approximate dates between which tree and shrub planting is recommended.

periods up to 1 week. The essential prerequisites are good packing at the nursery and a cool storage place, such as an unheated basement or root cellar.

6. Establish heel-in beds in light or sandy soil in places protected from sun and wind, such as north slopes, under shade frames, north or east of windbreaks, woodlands, or buildings, and with the tops of the trees pointed toward the south.

7. After healing-in, soak well with water.



Heeling In

8. Planting stock also can be held over winter in properly prepared ground. In fact, this practice is desirable where early-spring delivery of trees cannot be assured:

(a) Choose a site as described in (6) above with special attention to the requirement of good drainage. A droughty soil is preferable to a somewhat impervious one.

(b) Dig a pit about 4 feet wide and long enough for the entire shipment. (Allow 8 square feet per thousand seedlings, and 12 square feet per thousand transplants.) The pit should be deep enough to accommodate the roots without bending when the root collar is 1 inch below the ground level. Thus, if the roots average 8 inches long, a 9-inch depth is necessary.

(c) Discard any sod that is removed from the pit, but pile the mineral soil on the sides to be used later in filling around the roots. If there is danger of the ground freezing before the stock is received, this soil should be mulched.

(d) As soon as stock is received, unpack and place close together in rows across the bed, similar to the heeling-in described above, except straight up and down. As each row is placed, work in loose soil around the roots well above the root collar, and pack firmly. Allow 4 to 6 surface inches of soil between each row of trees.

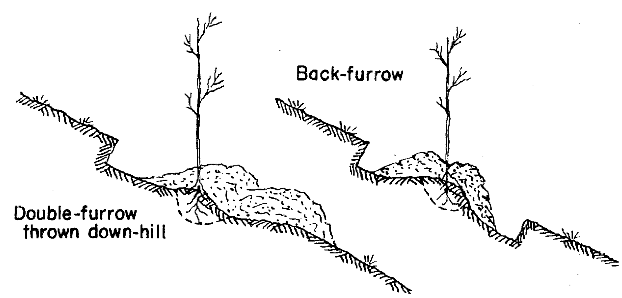
(e) Soak the completed bed with water. Keep soil well-watered until freezing weather.

(f) After frost has hardened the top inch of soil, spread a mulch of straw, leaves, or sawdust between the rows but not over the tops of trees. Application of mulch before that time may result in moulding or heating; if put on after the ground is deeply frozen, no moisture will be available to the trees during the winter. Lay poles on the mulch to prevent removal by wind. Watch for damage by mice if straw is used.

Site preparation and spacing:

1. Never plant in unprepared ground if there is appreciable ground cover. Competing vegetation is the cause of many failures.

2. Plow double furrows about 6 to 8 feet apart on the contour, using a reversible plow, a two-bottom gang plow, or a single walking plow. The plowing should be done in the late summer or early fall preceding the planting season.



Planting trees in contour furrows

3. If plowing is impractical, use a grub hoe to strip sod or ground cover from a spot 18 to 24 inches across. On difficult sites, work up the soil in the spot.

4. In field and gully planting space trees about 6 to 8 feet apart. With fast-growing species in the South and East, and where natural reproduction can be expected, trees may be spaced up to 10 feet apart. Christmas-tree plantings are spaced not less than 4 x 4 nor more than 6 x 6 feet.

5. To determine the number of trees required to plant an acre, divide 43,560 by the product of the spacing, thus: In planting 6 x 8 feet, 43,560 divided by 6 x 8, or 48, gives 907 trees per acre.

6. If the plantation is to be handled intensively, such as for Christmas trees, lanes between every sixth or seventh row of trees should be left unplanted. These lanes may be used as firebreaks, as roadways for the movement of spray equipment, and as places

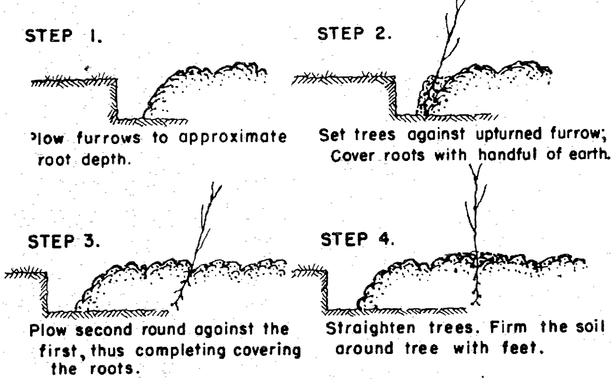
to remove products. The resulting plantation also is more productive of wildlife.

Setting the trees:

1. Carry trees in 12- to 14-quart pails half filled with water, or in boxes containing wet moss or shingle tow.
2. Using a grub hoe, a tile spade, a specially constructed dibble or planting bar, dig holes of ample size to receive all the roots without crowding or doubling back.
3. Take but one tree at a time from the container and leave roots exposed no longer than necessary.
4. Set tree in hole no deeper than it grew in the nursery.
5. Thoroughly tamp loose soil around the roots; eliminate any air pockets.
6. Avoid sod and undecomposed litter in contact with roots.

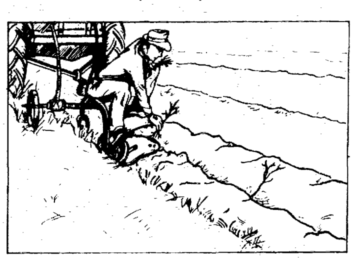
Two methods used in planting trees with a plow are illustrated here. Such methods are useful only on level or somewhat rolling land, and where there is little or no ground cover. Good tamping is very important and can be done by the feet or by driving over the second furrow with the rear tractor wheel. Method 2 is easier if there is a place to sit. An "A" frame made of 2-by-4's and attached to the plow frame with "U" bolts provides for seating as well as a place to carry trees. The plow must be set deep enough to accomodate the full length of the roots.

METHOD I: "PLOWING IN" (1, 2 OR 3-BOTTOM PLOW)



METHOD 2: "RIDING THE PLOW"

First, second and third steps above accomplished in one operation, by setting trees immediately behind the first furrow of a two or three-bottom plow, thus;



Second step same as Step 4 above.

Planting trees with a plow

Various types of tree planting machines have been designed in recent years and can be purchased. They will plant up to 8,000 trees per day with a crew of three men. The cost of the machines precludes their purchase by individual farmers, but a number of soil conservation districts have purchased machines which are available to cooperators at a nominal rental. A few private individuals also own machines which they operate for custom tree planting at a specified rate per thousand.

Care after planting:

1. Cultivation the first summer is necessary if ground cover will overtop or seriously compete with trees. Do not delay until the trees are overtopped and are difficult to find. Sudden exposure of overtopped trees to the hot sun frequently is fatal.
2. In low ground where there is a rank growth of hemp, horseweeds, etc., cultivation the second summer following planting may be necessary. Merely cutting the weeds around the trees and permitting the dead tops to act as a mulch is often substituted for cultivation.
3. A good straw mulch spread in a 12- to 18-inch radius around the trees will often eliminate the necessity of cultivation, and will result in greatly increased growth. Mulch around fall-planted trees, however, often harbors rodents which will girdle and kill the trees.

Wind-Erosion Planting

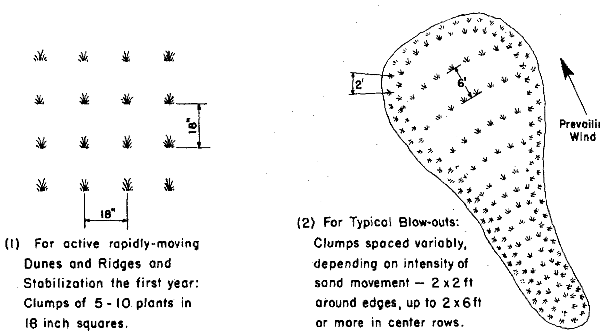
Ordinary field planting methods are ineffective in controlling active sand dunes or blow-outs. Shifting sand first must be stabilized to prevent abrasion, undermining, or covering of newly planted trees. After soil movement has been checked, the hardy species of pine are most frequently used for planting, although on moist sites white pine will grow satisfactorily. Spacing is about 6 x 6 feet.

The three stabilization methods commonly used are "brushing," mulching with straw, and planting of beachgrass (Ammophila breviligulata). All are expensive and alone cannot be considered as permanent methods of control; they merely constitute an essential form of site preparation for tree planting.

Brushing consists of covering the bare sand with any reasonably durable material like cornstalks or brush. The butts should be laid toward the prevailing wind, the tops of each layer overlapping the butts of the preceding layer. Trees are planted immediately afterward.

A cheaper method of stabilization adapted to small blow-outs is to mulch with straw and then roll well with a subsurface or canel packer or a dull disk to give a stubble-mulch effect. The trees are planted immediately afterward in cleared spots in the mulch.

Planting beachgrass is an acceptable method of stabilization when extensive areas of blow sand are involved. The following sketch shows two types of planting. Beachgrass may be planted any time of the year except summer.



Two ways of planting beachgrass

Beachgrass plants should be vigorous and have at least two nodes on their tap roots. Because the tops offer immediate mechanical resistance to reduce air currents, they should be erect, well-developed, and unbroken. Two or more years after the beachgrass has become established, trees are planted in the openings.

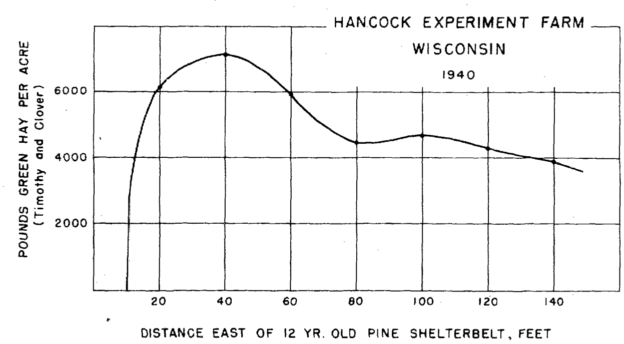
Windbreak and Shelterbelt Planting

A windbreak is generally accepted to mean one or more rows of trees planted to act as protection to a farmstead. Shelterbelts, on the other hand, are planted for the purpose of protection to fields from destructive wind action. Although the two words are used synonymously in some locations, a windbreak as here defined has no direct relation to soil conservation, even though it may add to the livability of farm homes.[3]

The techniques involved in planting trees for windbreaks and shelterbelts are not radically different than for other kinds of field planting; however, species, size of stock, ground preparation, and spacing are somewhat different. Except where there is danger from wind erosion, complete breaking of the ground in the fall before planting is recommended. Regular cultivation after the trees are established is essential for good survival and growth. A good practice is to plant a couple of rows of corn or a row of sunflowers between the rows of newly established trees. This provides for utilizing the land, cultivating the trees, and partially protecting the trees from hot sun and winds, which may be desirable for young conifers.

Conifers, because they give year-round protection, are used more widely than hardwoods and in larger sizes than in field planting. White and Norway spruce, red cedar, and Douglas-fir are favorites, although the pines, particularly on sandy soils and in the southern part of the region, are used most extensively. Mixing of conifers and fast-growing hardwoods is not recommended, because the hardwoods shade out and quickly overtop the slower growing evergreens. Also avoid planting intolerant species on the north side of windbreaks running east and west.

Unwanted snow drifts may result from windbreaks growing too close to farm buildings and roads. In any locality, trees should not be planted nearer than 2 rods windward of buildings or of the edge of a road right-of-way or lane. Frequent heavy snows accompanied by high winds such as occur in sections of Iowa, Minnesota, Wisconsin, and Michigan will pile up drifts 50 to 60 feet to the windward and 100 to 150 feet to the leeward of a solid belt of trees.[4] The proper location of windbreaks in such localities, therefore, requires recognition of drifting both on windward and leeward sides.



Effect of a shelterbelt on a Timothy and clover meadow in central Wisconsin.

[3]A study by the Lake States Forest Experiment Station in North Dakota showed that a windbreak on the north side of a farm home reduced fuel requirements about 25 percent.

[4]If a shelterbelt has sufficient width -- 50 or more feet -- snow will accumulate to the windward and among the trees but not to an appreciable extent to the leeward.

The retention of snow on fields may be beneficial to adjacent crops, especially to the protection of grass and legumes from winter injury. The chart illustrates the effect of a 12-year-old pine shelterbelt on a meadow growing on Plainfield sand in central Wisconsin.

The number of rows of trees and the spacing recommended differ for different States. The following list gives general recommendations. For additional details see State extension service bulletins.

Illinois: Three rows, 12 feet apart; trees 14 feet apart in rows; alternately spaced.

Indiana: At least 3, preferably 4 or 5, rows of evergreens, spaced 10 x 10 feet to 12 x 12 feet. Fast-growing hardwoods, such as green willow, *Salix amygdalina* (also called almond-leaved willow), are commonly used in single rows on much soils. These one-row shelterbelts, with the trees spaced 2 feet apart in the row, are planted at 30- to 40-rod intervals. They use less land, hence are more acceptable than are multiple row barriers at 60- to 80-rod intervals.

Iowa: At least three rows of conifers with the tallest-growing in the middle row. Average spacing for pines and spruce 18 x 18 feet; arbor vitae and red cedar 12 feet apart.

Michigan: Windbreaks: three rows, 8 feet apart; trees 10 feet apart in rows. Shelterbelts: two rows, 8 feet apart, trees 10-14 feet apart in rows.

Minnesota: The "standard" windbreak is 140 to 150 feet wide and is designed for winter protection to farm buildings and feedlots. Two outside rows (north or west), 8 feet apart are planted to shrubs or low-growing trees 6 feet apart; a "snow-trap" or open space about 50 feet wide is left unplanted and used possibly as a garden or calf pasture. The main windbreak of 80 feet consists of eight rows of trees, both hardwoods and conifers, arranged according to height, crown spread, length of life, rate of growth, etc. (See Planting the Standard Windbreak, University of Minnesota, Special Bulletin 168.)

An acceptable type of shelterbelt used on the west and south sides of fields subject to wind erosion in western Minnesota, consists of a row of shrubs planted 4 feet apart; two rows of trees like cottonwood, willow, and green ash, 6 feet apart; and a fourth row of shrubs. The rows are 10 to 12 feet apart which permits cultivation with ordinary farm equipment as well as utilization of the intervening space for corn or other kinds of row crops during the first few years after establishment.

Missouri: Two rows 8 to 12 feet apart; trees 6 to 8 feet apart in rows.

Ohio: Three or five rows 8 feet apart; trees 12 feet apart in rows. The middle row in the 3-row windbreak and the second and fourth rows of the 5-row windbreak are planted to fast-growing conifers like Scotch or jack pine. These so-called filler trees are removed when they begin to interfere with the longer lived spruce or other conifers intended for the permanent windbreak in the remaining rows. The eventual spacing therefore will be 12 x 16 feet.

Wisconsin: Three rows 8 feet apart; trees 6 feet apart in row.

Stripped-Coal-Land Planting

The reforestation of spoil banks resulting from the surface mining of coal or other minerals presents another special tree-planting problem. Aspect, exposure, and competing vegetation affect tree selection for spoil-bank planting in the same manner as in other planting. Dry, exposed slopes and ridges and the frequent sweetclover on alkaline spoils all contribute to difficult planting sites. Spoil acidity and texture of spoil, however, are more variable than of natural soil; hence they must be given more than ordinary attention.

If planting is attempted on newly created spoils, the instability of the banks may also limit success. Three to five years after stripping, however, the banks are sufficiently settled to eliminate this planting hazard.

The texture of the upturned soil, particularly when considered along with the degree to which it is subject to drying (aspect and exposure), is an important site factor in strip-land planting. Texture ranges within wide limits -- from great chunks of limestone and shale to finely divided particles of clay. However, all spoils can be cataloged[5] in one of the six classes shown in the tentative planting guide (table 4).

The material exposed by stripping shovels is extremely variable even on the same acre. Soil tests may show acidity ranges from below pH 3.8 (lethal to most plants) to above pH 8.0, depending on the original overburden and the nature of the stripping. Because of this variability, soil tests by conventional methods do not always give usable results; hence one of the most practical

5 Technical Paper 109, Central States Forest Experiment Station, December 1948.

TABLE 4.--*Suggested planting guide stripped coal land*

Texture of spoil	Acid spoils (pH 4.0 - 6.5)		Slightly acid, neutral, or calcareous spoils (pH 6.5 or more)	
	Depressions; north and east slopes	Ridges; south and west slopes	Depressions; north and east slopes	Ridges; south and west slopes
Loamy: Less than 60% of spoil composed of large rocks.	Red pine White pine Any of the hardwoods	Any of the 2- or 3-needled pines	White pine Any of the hardwoods	Red cedar White ash Cottonwood Black locust
More than 60% composed of large rocks.	Red pine White pine Cottonwood White ash Red oak	Any of the 2- or 3-needled pines	White pine Cottonwood White ash Red oak Black locust	Red cedar Pitch pine Loblolly pine Scotch pine
Clays: Less than 70% of spoil composed of large rocks.	Red pine White pine Loblolly pine Any of the hardwoods	Red pine Loblolly pine	White ash Cottonwood Red gum	Red cedar Pitch pine Loblolly pine Scotch pine
More than 70% composed of large rocks.	Red pine White pine Any of the hardwoods	Pitch pine Scotch pine Virginia pine Loblolly pine	Any of the hardwoods	Red cedar Loblolly pine Pitch pine Scotch pine
Sandy: Less than 50% of spoil composed of large rocks.	Red pine White pine Shortleaf pine White ash Cottonwood	Jack pine Red pine Virginia pine Shortleaf pine	White pine Scotch pine Cottonwood Black locust White ash Red gum Yellow poplar Red oak	Red cedar Pitch pine Scotch pine
More than 50% composed of large rocks (very droughty).	Jack pine Virginia pine Scotch pine Shortleaf pine Red pine	Jack pine Virginia pine Scotch pine Shortleaf pine	White pine Scotch pine Cottonwood Black locust	Red cedar Pitch pine Scotch pine

means of judging acidity is to observe the density and nature of existing ground cover.

Except as influenced by soil moisture, vegetation in general is scant or lacking on extremely acid spots, becomes fairly well established at about pH 5.0, and is heavy and dense on nearly neutral or alkaline banks.[6] Specifically, the presence of certain plants will indicate the degree of acidity about as follows:

Extremely acid (less than pH 4.5)	*Strongly acid (pH 4.5 - 5.5)*
Partridge pea	Partridge pea
Knotweed (smartweed)	Knotweed (smartweed)
Barnyard grass	Barnyard grass
Cinquefoil	Cinquefoil
Sorrell	Goldenrod
(Plants stunted or none, less than pH 3.8)	Foxtail
	Sheep sorrel
	Dewberry
	Hogweed

Moderately acid (pH 5.6 - 6.5)	*Slightly acid to alkaline (above pH 6.6)*
Barnyard grass	Black raspberry
Knotweed (smartweed)	Wild morning glory
Goldenrod	Bindweed
Foxtail	Wild lettuce
Sheep sorrel	Wild strawberry
Dewberry	Wild mustard
Hogweed	Evening primrose
Black raspberry	Kentucky bluegrass
Wild morning glory	Sunflower
Bindweed	Great ragweed
Wild lettuce	Lespedeza
Wild strawberry	Teasel
Wild mustard	Mullein
Evening primrose	Cocklebur
Great ragweed	Pokeweed
Lespedeza	Sweetclover

REFERENCES

Growing and Planting Coniferous Trees on the Farm, USDA Farmers' Bulletin 1453.

Growing and Planting Hardwood Seedlings on the Farm, USDA Farmers' Bulletin 1123.

Seeding and Planting in the Practice of Forestry, Toumey and Korstian, John Wiley and Sons. 2nd Edition

Forest Planting on Illinois Farms, Illinois College of Agriculture Extension Circular 567.

Forest Tree Planting Manual for Illinois, Illinois Department of Conservation.

[6] Revegetation of Illinois Coal-Stripped Lands, W. C. Croxton; Ecology 9 (2), 1928.

Tree Planting Guide, Iowa State College Extension Pamphlet 120.

Planting and Care of Forest Trees, Missouri College of Agriculture Extension Circular 563.

How to Succeed with Forest Plantations, Wisconsin State Conservation Department Publication 506.

Forest Trees and Shrubs - What, When, and How to Plant, Michigan State College Bulletin 264.

How to Plant Forest Trees, Michigan State College Extension Folder F-32.

Woodland Management, Ohio State University Agricultural Extension Bulletin 213.

The Hoosier Tree Planters Manual, Indiana Department of Conservation.

Trees for Reforestation in Indiana, Indiana Agriculture Experiment Station Circular 306.

Forest Plantations, Their Establishment, Growth and Management, Indiana Agricultural Experiment Station Circular 331.

Trees and Tree Planting, Together with a Descriptive Catalog of Common Forest Trees of Minnesota and the Lake States, Anderson, Webb Publication Co.

Reforestion in Ohio, Ohio Agricultural Experiment Special Circular 76.

Extent, Character, and Forestation Possibilities of Land Stripped for Coal in the Central States, Central States Forest Experiment Station Technical Paper 109.

Why Forest Plantations Fail, Journal of Forestry, May 1939.

The Windbreak as a Farm Asset, USDA Farmers' Bulletin 1405.

Windbreaks for Illinois Farmsteads, Illinois Natural History Survey Circular 38.

Tree Windbreaks for Indiana Farms, Purdue University Agricultural Extension Bulletin 226.

Windbreaks for Protecting Muck Soils and Crops, Indiana Agricultural Experiment Station Circular 287. Lafayette.

Evergreen Windbreaks for Iowa Farmsteads, Iowa Agricultural Experiment Station Bulletin P88.

Windbreaks for Field Protection, Minnesota University Agricultural Extension Folder 140.

Planting the Farmstead Shelter Belt, Minnesota University Agricultural Extension Bulletin 196.

Tree Windbreaks for Missouri Farms, Missouri College of Agriculture Extension Circular 343.

Windbreak Planting in Ohio, Ohio State University, [Mimeographed]

Shelterbelts for Windblown Soils, Wisconsin College of Agriculture Extension Circular 287.

Tree Planting in the Central, Piedmont, and Southern Appalachian Regions, USDA Farmers' Bulletin 1994.

PROTECTION

All farm crops have their enemies. Farm operators know they must exercise eternal vigilance against many kinds of pests if farming is to be successful. The wood crop is no exception, although insects and diseases are less destructive to well-managed woodlands than to croplands and orchards. In many farm woods, fire and domestic and wild animals lower the productivity of the woodland more than insects and fungi.

FIRE

In spite of the widespread publicity given to forest-fire damage, farmers as a group have not heeded the warnings. They fail to recognize that small fires slowly burning along the ground are destructive, even though the older trees are not killed. The death of small trees, the destruction of the litter, humus, and the balanced biotic soil conditions essential to the healthy growth of the woodland has escaped their attention. They are aroused against fire only when it gets out of hand, as uncontrolled fires do, and threatens their buildings.

When humus and the ground cover are burned, the sun and the drying winds absorb moisture needed for tree growth. Plant nutrients in the surface soil are lost and the growth rate of the trees is reduced. Fire kills all or part of the young tree growth necessary to replace the trees that are harvested. It burns the outer bark and the cambium layer of older trees, exposing the wood to insects and decay. Fungi causing rot then spreads and ruins the most valuable part of the stem. Even though the tree continues to grow, the effect of the damage will show up when the tree is harvested. In the interim the farmer will have lost much of the earning capacity of the soil which the trees occupied.

Tests conducted over 7- and 9-year periods by the Soil Conservation Service at three different stations reveal the effect of woods fires on runoff and erosion (table 5).

TABLE 5.--*Average annual surface runoff and soil loss*

Location and condition	Surface runoff of rainfall	Soil loss per acre
	Percent	*Tons*
Guthrie, Okla.		
Undisturbed virgin woods	0.1	0.01
Woods burned once annually	4.4	.13
Tyler, Tex.		
Virgin woods, unburned	.3	.05
Woods burned once annually	2.6	.36
Statesville, N. C.		
Virgin woods, unburned	.1	0
Virgin woods, burned annually	9.9	2.6

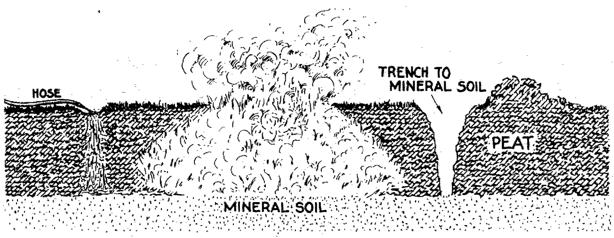
The Central States Forest Experiment Station reports the results of 588 tests on the rate at which moisture would penetrate on seven soil types in the Missouri Ozarks. Half of the tests were made on areas that were burned annually, and the other half on comparable soils unburned for 5 or 6 years. On the unburned plots the penetration was 2.12 inches per hour, whereas on the burned plots it was only 1.32 inches per hour.

The first step toward the control of woods fire is prevention. Enlightened public opinion is the best form of fire prevention. As a rule, the farm woodland is an isolated parcel of timber having a comparatively low fire hazard. Differing from extensive forested areas controlled by the State and Federal Governments and by the lumber companies, it is not so frequently subject to the carelessness of hunters, fishermen, and tourists. Furthermore, it does not or should not include extensive areas of dry tops and branches left from logging operations which create high hazards. Fire in the farm woodland, therefore, is often the result of the farmer's own carelessness. He and his neighbors can prevent most fires if they use the same degree of care exercised around their homes and buildings.

Under hazardous conditions, however, firebreaks are good insurance, especially around coniferous plantations. A satisfactory barrier can be made by plowing a strip about a harrow section wide and keeping it open by subsequent harrowings. One harrowing in the early spring and a second in July or August are usually sufficient to keep weeds in check and the mineral soil exposed. Permanent meadow strips also make effective firebreaks during most of the year.

Even though a farmer is careful, his neighbors and others who cross his land may not be, so fires may start on his land or close to his land that must be put out. Usually he will not have water available and must use the tools and equipment readily obtainable. He will be faced with one or more of the following types of fire: ground fire, crown fire, or surface fires.

Ground fires occur only in peat soils. As implied, the organic soil itself is burned. Although these fires spread very slowly, they are extremely difficult to suppress. Two methods are used to control ground fires: If plenty of water is available, the ground is completely saturated just ahead of the farthest extent of the fire. The other method of control is to dig a trench around the fire. To be effective the trench must go down to mineral soil or to a point where the peat is wet.



Two ways to control ground fires in peat soils.

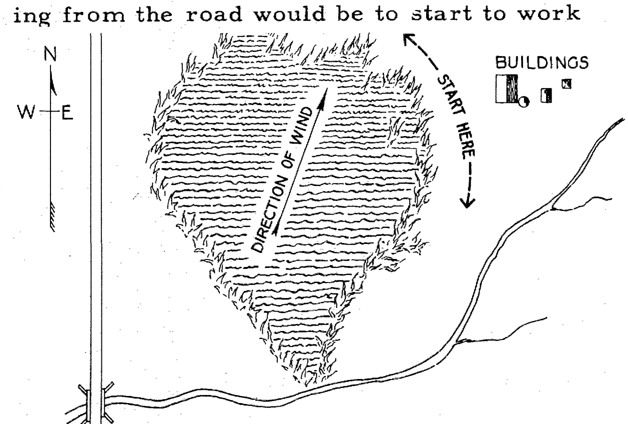
Fortunately, most farmers will not have to fight a crown fire in which the spread is through the tops of the trees. Close-growing coniferous plantations as well as extensive areas of evergreen forests are subject to crown fires. There is little an individual can do to check such fires, because the speed with which they travel and the extensive heat accompanying them defy any ordinary human efforts. Large well-organized fire crews with hose and pumps are needed to cope with crown fires.

The most common type of fire is the one that burns on the surface. At the start its spread is ordinarily slow. But as it gains momentum and generates sufficient heat to create its own draft, progress may be almost as rapid as in crown fires. Surface fires are most frequently controlled by scraping away the flammable debris on the surface of the ground immediately ahead of the fire. Exposing the mineral soil to a width of about 12 inches with a hoe, rake or shovel will create a fire line which will check the spread of the flames.

In open areas and in sod, plowing furrows is the best method of combating surface fires. Wet sacks are also effective in beating out grass and leaf fires when the heat and smoke will permit a direct attack. Loose soil, if available, is also useful to suppress surface fires. It is thrown at the base of the flame with a shovel, in a swinging or swirling motion.

Over-enthusiasm and haste in combating fires result in inefficiency. One does not necessarily start to work at the first point of contact with the fire. The first step in suppressing a woods fire is to determine the direction in which the fire is moving most rapidly. Other factors also bear on the point of initial attack. Where is the most valuable property threatened? Where are the natural barriers like roads, streams and open fields? The illustration will demonstrate some of the principles.

The natural inclination of a man approaching from the road would be to start to work



immediately on the west side of the fire. The fallacy of such a move is obvious. The impending damage is to the east and, furthermore, the fire will stop anyway when it reaches the road. After a line has been made to the stream on the east side, and the buildings secured from danger, the line should progress toward the northwest. If there are two or more men available, one should continue working toward the northwest and the other can then start at the road, working toward the northeast. Only after they have completely controlled the head of the fire should they begin on the southwest.

When fires burn so fiercely that trenching close to the head is impossible, work should start at the flanks and an attempt made to gradually pinch off the head. Regardless of where the start is made, however, there are two important rules to remember: (1) Work as close as possible to the edge of the fire so that all flammable material inside the line is consumed; and (2) don't permit fire to get behind the line. Burning leaves and sparks from dead snags blow over the line, burning cones and logs roll down steep slopes and, unless the trench was started at a natural barrier, there is always the risk of the main fire enveloping the starting end of the line.

Backfiring is used only on extremely hot fires and as the last resort. A trench is dug as usual, but well ahead of the fire. Then the back-fire is started far enough away to consume all flammable material between the trench and the main fire. Stated in another way, the opposite perimeters of the backfire should burn so as to meet the trench and the main fire about the same time.

INSECTS AND DISEASE

Damage from insects and disease as a rule is in direct proportion to the misuse of the woodland. Fire, grazing, and excessive cutting lower the natural resistance of the trees and permit pests to get a foothold. Many other disease and insect depredations to planted trees are the result of the failure to recognize and properly appraise site factors. (See p. 7.) Trees, like every other organism, when growing in an unsuitable environment are weak and become inviting hosts to epidemics. Studies by competent entomologists and pathologists indicate further that insects and diseases are usually secondary in causing decadence in standing timber. Environmental factors, including cumulative deficiencies of rainfall, are the primary causes of death.

Thus, the well-managed, healthy farm woods is relatively free from serious insect and disease injury. Even when epidemics occur, there usually is no practical method of control other than to remove and, if possible, utilize the infested or diseased trees to check the spread. White pine blister rust is an example of an exception; it can be controlled by removing nearby currants and gooseberries. Control measures in natural woodland, therefore, are silvicultural. Spraying schedules such as are used in orchards are not generally feasible.

Artificial control of insects in plantations, however, may be necessary. The establishment of solid blocks of a single tree species or two encourages the development of unnaturally high populations of insects, which must be kept in check by spraying.

Tables 6 and 7 indicate the kind and extent of damage done by the more important and common insects and fungi found in farm woodlands of the Central United States. Appropriate departments at State experiment stations should be consulted for more detailed information.

TABLE 6.--*Common forest tree insects, their host trees, and the character of the damage*

INSECTS BORING UNDER THE BARK AND IN THE WOOD

[Control of the insects in this group by insecticides is impractical. The only recourse is to cut and burn infested parts of trees during the dormant season in hopes of reducing populations.]

Insect	Host trees	Kind and extent of damage
Bark beetles	Pine, hickory	Larvae tunnel between bark and sapwood, scoring the sapwood in fantastic designs. Large numbers of these insects will girdle and hasten the death of trees weakened from other causes.
Bronzed birch borer	Birch, aspen	The death of birch and sometimes aspen is hastened by the larvae which mine shallow criss crossed and winding patterns underneath the bark. Dead branches may be symptoms of attack.
Cottonwood borer	Cottonwood, poplars	A large insect which cuts deep galleries up to an inch in diameter in the trunks and large branches, so weakening the tree that wind causes breakage. Coarse wood-dust at base of tree and holes in bark identify presence.
Locust borer	Black locust	Larvae mine galleries 1/4 inch or more in diameter in stem, causing severe breakage or death. Trees 3 to 15 years old will be attacked, particularly on poor sites. Trees on better sites usually recover. Growth from sprouts appears more resistant than that from seed. (The locust twig borer, which mines in the pith of 1 or 2-year stems and produces irregular swellings 1 to 3 inches long, is not serious and should not be confused with the locust borer.)
Two-line chestnut borer	Oaks	Larvae make wavy, transverse burrows between the bark and wood. Fatal only when tree has been weakened by other agents, such as root rot.
Other borers	Sugar maple, hickory, beech, elm, oak, basswood.	Similar to the cottonwood borer except the galleries are smaller. The species attacking sugar maple is most serious.

INSECTS ATTACKING THE BUDS, SHOOTS, AND SMALL LIMBS

[Insects in this group can be controlled by spraying, provided it is done at the right time of year and is economical.]

Insect	Host trees	Kind and extent of damage
European pine shoot moth	Hard pines, (2-3 needles) especially red pine.	Rusty, orange-red moth having silvery-marked wings, 3/4 inch, that flies in June laying eggs on new needle sheaths. Caterpillars hatch and start boring into twigs about 10 days later and spend rest of summer working inside stem toward the buds, where they overwinter. A crooked or forked tree results from killing the new twigs and buds. Not prevalent where winter temperatures get below -15° F. Use DDT spray as soon as adults are seen and repeat two or three times at weekly intervals. Spraying must catch adults during egg-laying season and before larvae reach the inside of stem.
Gall aphids or lice	Spruce, pines	Small pineapple or conelike growths on stems indicate the work of this insect. No more serious than causing the death of infested twigs.
Nantucket or pine tip moth	Shortleaf, loblolly, red or ponderosa pine.	Larvae work in terminal buds or twigs, similar to European pine shoot moth. Young trees may be killed; if not, they develop a cabbagelike growth that they usually outgrow. Spraying usually is not practical, except in nurseries to control shipment of infested stock.
Oystershell scale.	Ash, cottonwood, maple, elm, birch.	Bark of twigs more or less covered with gray, shell-like bodies, easily detached. Heavy infestation reduces trees' resistance and is sometimes fatal. Other scale insects, notably the European elm scale, act similarly. Contact spray during dormant season.
Pales weevil	Northern pines, spruce.	Dark-brown adult weevils girdle and kill small trees in nurseries and plantations. Larvae inhabit pine stumps and fallen timber, hence only plantations in recently cut over pine will be attacked.
Pine bark aphid.	Pines, especially white pine.	Presence identified by white flocculent growth which develops on the insect's body, giving branches and stems of young trees a white-washed appearance. Not a problem on healthy mature trees but may kill weaklings in plantations. Contact spray.
Pine spittle bug.	All conifers	White frothy masses in spring and early summer identify presence and protect the nymphs. A sap-sucking insect, in both nymph and adult stages, which lower tree's resistance and may be the primary cause of decadence and death. In recent years has been very damaging in the Lake States. Contact spray or dust the spittle masses in spring.
White pine weevil.	White pine, Norway spruce, jack pine, Scotch pine.	Kills terminal shoots. Not usually fatal but results in poorly formed trees. Tiny drops of resin on stem are the first evidence of attack. Spray with lead arsenate in early spring before buds start to swell.

INSECTS ATTACKING LEAVES

[All of the insects in this group can be controlled by stomach sprays applied at the time the insect (larvae, except as noted) begins feeding.]

Cankerworms, measuring worms, or loopers.	Elm, oak	Small grey to dark brown worms. Partial to complete defoliation common in late spring. Rarely fatal unless concurrent with other unfavorable climatic or biotic conditions.
Fall webworm.	Most hardwoods	Dirty webs, sometimes enclosing entire trees, made by this insect are common during the late summer. Defoliation is often complete, but not fatal.
Forest tent caterpillar.	Oak, hard maple, aspen, birch.	Hairy caterpillars with blue head and lines along sides. Feed on leaves in spring and may completely defoliate by June. Common, but not fatal if trees are otherwise healthy.
Other caterpillars.	Oak, elm, aspen, basswood, birch, beech, maple.	Red, orange, yellow, or green-marked, smooth caterpillars, 1½ to 2 inches long, defoliate hardwoods between July and September 1. Not fatal.

Insect	Host trees	Kind and extent of damage
Japanese beetle.	Basswood, chestnut, sassafras, elm, willow, birch, some oaks.	The adult beetle eats the tissue inside the veins of the foliage which results in skeletonized leaf. A serious pest to forest and ornamental trees quickly becoming established throughout the Eastern and Midwestern states. Not as yet serious in farm woodland.
Locust leaf miner.	Black locust	Skeletonized, often transparent foliage, turning brown in summer and early fall are evidence of damage. Not considered serious but repeated attacks are held responsible for the death of locust in parts of Ohio Valley.
Sawflies	All pines, spruce, tamarack.	The small larvae of the several species of this group of insects consume the needles of conifers with similar effect. Trees partially defoliated or even completely defoliated in early summer generally recover. When two and even three broods of larvae hatch, late summer or early fall defoliations are usually fatal.
Spruce bud worm	Spruce, balsam, northern pines, Scotch pine.	In the spring, small, yellow-green, brown-headed caterpillars feed on the new shoots of spruce and balsam and on the flowers of pines. Later the full-grown brown larvae attack mature leaves of spruce and balsam. The base of the needles are gnawed off and the branch covered with silken web. A serious pest where natural stands of balsam and spruce occur.
Walnut caterpillar.	Black walnut	Defoliates trees in late July, August, or September. Seldom fatal.
INSECTS WHOSE ATTACK ABOVE GROUND IS NOT APPARENT		
Ants	Conifers	Mound-building ants gnaw bark at the base of young trees, apparently to eliminate shade from their mounds. Trees are killed as a result of formic acid injected into the wounds made by insect. Surround the mound with a complete barrier of sodium fluoride.
June beetles	All trees	White grubs (larvae) eat roots of newly planted conifers, causing death; common in old pastures, and very damaging in tree nurseries. Occasionally, adults defoliate hardwoods in late spring. No practical control.
Root collar weevil.	Northern, Austrian, and Scotch pines.	White larvae burrow in cambium of young trees just below the ground. Frequently fatal. Outer bark and adjacent soil blackened and scaled with pitch. Pull out and burn infested stumps in fall, winter, or early spring to control spread.

Some standard insecticides used to control forest tree insects are:

Lead Arsenate is used as a stomach spray in solutions as strong as 1 pound to 2.5 gallons of water for white pine weevil, up to 1 pound to 20 gallons of water for leaf-eating insects. Commercial wetting or spreading agents are usually added according to manufacturers' directions for better distribution of the spray. One ounce of linseed oil per gallon of water insures better adherence of the spray.

Nicotine Sulfate is the most generally used contact spray and is the base of most commercial insecticides for control of sucking and soft-bodied insects. It is diluted at the rate of about 1 fluid ounce per 6 gallons of water, to which is added 2 heaping tablespoons of soap flakes per gallon of solution.

DDT is both a stomach and a contact poison. It can be used as a dust or a spray. Futhermore, it is not so violent a poison to warm-blooded animals as lead arsenate or nicotine sulfate and its effects appear to last longer after application. Dusts and wettable powders are most used in forest-insect control, but since the DDT content of commercial preparations will vary, the manufacturers' directions should be followed. Two to three pounds of wettable 50 per cent DDT powder per 100 gallons of water is a common dosage against forest-tree insects.

TABLE 7.--*Common forest fungi, their host trees, and the character of the damage*

Fungi	Host Trees	Kind and Extent of Damage
Shoestring fungus	All species	This fungus spreads through soil by black, shoestring-like strands of mycelium, attacking the roots and spreading upward into the trunk. Generally fatal, especially when present with the two-lined borer or other weakening factors. Presence not easily determined except in advanced stage; then honey-colored toadstools appear on trunk or exposed roots.
Root rot	All conifers	Pines, white in particular, if planted on heavy, poorly drained soils, are subject to attacks of root-rotting fungi. No easy means of identifying presence, but the short, yellowish needles, thin crowns, and sometimes the leaning trunks of trees in older plantations grown on heavy soils are indicators. Underground spread is slow, but trees attacked are generally wind thrown.
Leaf rusts, leaf spots.	Pines	Blisters on pine needles produce bright orange or yellow dust (spores) in the spring. They occur principally in plantations and are not serious. There are also large numbers of fungi causing spots and blisters on the leaves of other trees; none should be the object of concern.
Needle casts	Conifers	Old needles turn brown from the tips back and shed prematurely. Frequently cause alarm because of striking effect. Usually not serious.
Strumella and nectria cankers.	Most hardwoods	Start in living or dead branch stubs, gradually spreading to form target-like "catfaces" in the trunk. Not immediately fatal but result in a poorly formed tree subject to damage by other causes.
Antropellis canker	Pitch, Scotch, loblolly, and slash pines	Cankers occur on twigs and small branches; wood beneath is stained blue. Rarely fatal.
Tympanis canker	Red pine	In crowded plantations south of its natural range, red or Norway pine is subject to a disease that enters through dead branches. Heavily infected trees die. Presence shown by black cankers on bark around branch whorls; affected wood beneath is depressed.
White pine blister rust	White pine	Orange or yellow blister on bark. Eventually fatal. Dependent on gooseberries or currants *(Ribes)* to spread from tree to tree, inasmuch as these shrubs act as alternate hosts.
Sweet fern rust	Scotch pines, pitch pines	Similar to white pine blister rust except alternate host is sweet fern. Infected trees are misshapen. Occasionally fatal.
Cedar apple rust	Eastern red cedar, apples	Unimportant to the cedar. Spots on apples result in degrading of fruit. No practical importance except within ¼ mile of commercial orchards; here cedar should not be planted.
Cedar blight	Red cedar	Leaves of seedlings and transplants turn yellow-brown and plant dies. Fatal only to new plantings and in nursery stock.

Fungi	Host Trees	Kind and Extent of Damage
Oak wilt	Oaks, especially red oak	Leaves begin to turn yellow any time during summer from May on. Within a few weeks tree is dead. A newly isolated and very serious organism for which no control methods are known other than to quickly cut and remove dead trees.
Heart rots	All species	All heart or butt rots are similar. Spores of the fungi gain entrance in fire scars, branch stubs, or other exposed wood, and the resulting decay spreads at an average rate of about 2 inches per year throughout the heartwood. Infected wood is reduced to a punky, useless state.
Chestnut blight	Chestnut	Cankerous growth affects cambium on trunk and branches until tree is killed. Has practically eliminated the American chestnut from eastern woodland. No control methods are known.
Dutch elm disease	Elm	Kills weakened and unhealthy elms by spreading in the sapwood and cambium where the spores are carried by the elm bark beetle. A serious disease of street trees in the east. Partial control by cutting and burning infected trees.
Elm necrosis	White Elm	Although not known to affect trees in woodland, this virus disease causes the death of Midwest street trees. Identified by yellowing, falling leaves, and yellow to light-brown inner bark which gives off a wintergreen odor. No known control.

DOMESTIC ANIMALS

Intensive grazing in woodland on livestock and dairy farms probably causes more damage to tree growth than any other destructive agent. Livestock browse on the leaves and shoots of the small trees, trample them underfoot, and break or deform them by rubbing or riding them down. The destruction of the young trees eliminates the possibility of any future tree crop to take the place of the older trees as they are cut or die.

Confinement to restricted areas lacking sufficient forage will force livestock to feed on almost any species of plant. Nutritional deficiencies will even impel the chewing the bark of trees. The extent to which livestock will damage young trees depends not only on the palatability of species but also on the degree to which the stock is underfed. Purdue Agricultural Experiment Station recorded the extent to which cattle browsed various kinds of trees. The fact that cows have a general preference for the more economically desirable tree species indicates that woodland grazing of ordinary intensity will reduce the quality as well as the quantity of reproduction. The relative frequency of browsing on forest trees, based on percentage of browsing on reproduction over 6 inches high is as follows:

Relished under all conditions	*Browsed under light grazing (10 acres or more per cow)*	*Browsed under Moderate grazing (4-10 acres per cow)*
White ash	American elm	Beech
Sugar maple	White oak	Black locust
Basswood	Red oak	Sassafras
Red elm	Tulip poplar	Black oak
		Hickory
		Sycamore
		Honey locust
		Kentucky coffee tree
		Burr oak
		Black cherry

Browsed only under heavy grazing (2-4 acres per cow)	*Rarely browsed even under very heavy grazing (less than 2 acres per cow)*
Dogwood	Red cedar
Black walnut	Blue beech
Hawthorn	Hop hornbeam
	Paw paw
	Persimmon

Trampling by livestock damages the surface feeding roots and compacts the soil, reducing its water absorptive capacity, thus adversely affecting the rate of tree growth. There is less litter and humus accumulated, and the ground surface dries out faster because of the sun and wind. Table 8 summarizes the results of a study by Cornell University of the extent to which grazing affected site factors on 18 grazed and 18 ungrazed woodlands.

TABLE 8.--*Comparison of 18 grazed and 18 ungrazed woodlands in central New York*

Site factor	Grazed	Ungrazed
Soil organic matter-------*(percent)*	6.40	8.50
Volume weight-------------*(pounds)*	1.15	.90
Soil moisture(Dry weight) *(percent)*	10.60	14.40
Average air temperature---*(°C.)*	27.10	25.00
Soil temperature----------*(°C.)*	23.60	20.10
Percent of full sunlight--*(percent)*	21.00	3.03
Relative humidity---------*(percent)*	53.60	67.70

Soil losses and the amount of water that runs off the land following rain were measured at the Soil Conservation Experiment Station, La Crosse, Wis. The table 9 gives the results of 6 years of measurements on three separate watersheds having the same soil type.

TABLE 9.--*Soil loss and runoff from watersheds with different covers*

Cover	Runoff		Soil loss per acre
	Inches	*Percent*	*Pounds*
Watershed A (grazed woods)	2.31	1.17	2,126
Watershed B (protected woods)	.05	.02	19
Watershed G (open pasture)	.79	.40	866

Watershed A: 2.67 acres of second-growth hardwoods. Slope, 15-28 percent. Grazed to optimum carrying capacity.
Watershed B: 11.5 acres of second-growth hardwoods. Slope, 25-50 percent. Neither grazed nor burned.
Watershed G: 5.85 acres cleared of second-growth timber in 1932. Slope, 25-35 percent. Grazed to optimum carrying capacity.

Livestock grazing in woodland, therefore, adversely affects more than the growth of the trees. Community and national interests have an enormous stake in the control of floods which are caused by uncontrolled water and silt-clogged stream channels. Anything that contributes to the loss of soil and to a reduction in its water-holding capacity is inimical to general public welfare.

Ungrazed, unburned woodland has long been recognized as the form of land use best suited to the conservation of soil and moisture on sloping land. In that respect, woodland in relation to other types of land use was demonstrated at the Soil Conservation Experiment Station, Zanesville, Ohio. The soil and water losses from three watersheds receiving an average annual precipitation of 37 inches were measured over a 9-year period. The soil and the slope (14 percent) were comparable in all watersheds. Table 10 summarizes the results of this experiment.

TABLE 10.--*Annual soil and water losses from land in different uses*

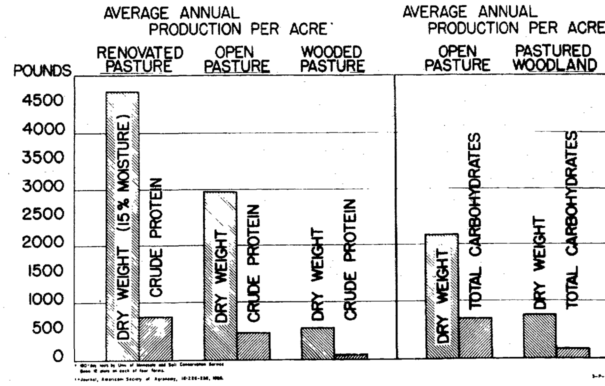
Land Use	Soil loss per acre	Water loss of rainfall
	Tons	*Percent*
Cultivated in rotation of corn-grain-hay	17.18	20.6
Pasture, fertilized bluegrass	.10	13.8
Woodland, unburned, ungrazed second-growth	.01	3.2

In general, the farmer uses woodland for pasture at a loss to himself and to the livestock State agricultural experiment stations have repeatedly demonstrated that forage grown in woodland is poorer both in quantity and quality than that produced in open pastures. The Wisconsin Agricultural Experiment Station measured the total yield of dry matter from three types of pasture. The improved grass-and-legume pasture produced over 11 times, and the unimproved open bluegrass 5 times, the forage grown in the woodland. Over a 5-year period the average annual yield of dry matter per acre for each type of pasture was as follows:

Renovated, grass and legume - - 3210 lbs.
Open bluegrass, unimproved - - 1453 lbs.
Woodland pasture - - - - - - - - 276 lbs.

In Indiana, studies of the ground cover in grazed woodland showed a preponderance of low-value forage. In the same State, other experiments proved that attempts to carry beef cattle in woodland without supplemental feed resulted in a loss of weight of the animals.

Similar evidence, available from observation and experiments in Minnesota and Ohio, is shown graphically in the following figure.



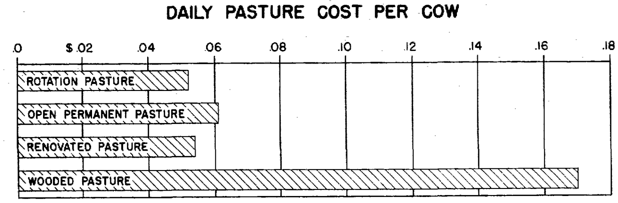
Adjusting these studies to the grazing capacity of various types of pastures, the area needed to sustain a cow for 180 days is as follows:

Kind of Pasture:	*Acres per cow*
Dense woods pasture	9 plus
Average woods pasture	4.5 to 9.0
Open woods pasture	3.0 to 4.5
Steep open pasture	2.3 to 3.6
Bluegrass on rolling land	1.4 to 2.3
Bottom land pasture	1.1 to 1.4
Improved or legume pasture	.75 to 1.4

Northern farmers require 5 to 10 times the acreage of wooded pasture to support their livestock because of the failure to improve their open pastures. This waste of land resource is reflected in lower yields of milk and meat and increased costs of fence maintenance. In short, it costs the farmer more per cow to carry stock on poor pasture than on good pasture.

Studies by the Soil Conservation Service in cooperation with the Wisconsin Agricultural Experiment Station show that the daily pasture cost per cow is greater in woodland pastures. The study considered taxes and other charges against the land, fencing, costs of establishment, and acres required per cow. The results are shown in the following graph.

DAILY PASTURE COST PER COW



If the farm woods produces maple sirup, the loss incurred by grazing the woodland is also very pronounced. In northeastern Ohio, a study of maple-sirup yields on an ungrazed and an adjacent grazed woods over a 5-year period showed that grazing lowers the flow of maple sap. The average annual production of sirup per acre on the ungrazed tract was 21.9 gallons. The grazed tract produced 16.2 gallons per acre, or a difference of 5.7 gallons. Based on sirup prices current at the time the study was made, the operation of the grazed wood produced $10.67 less sirup per acre annually to gain a comparatively few cents worth of livestock forage.

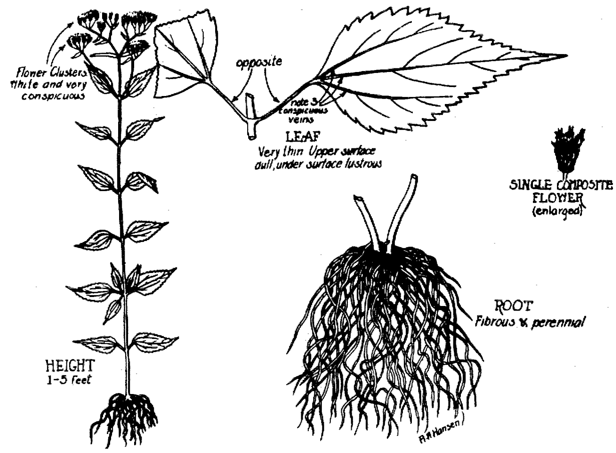
The quality of the woodland pasture may have even more serious aspects than merely small amount and small nutritional value of the forage. Many of the weeds as well as some of the trees that occur in farm woodland are poisonous to the livestock. Here again, the farmer who grazes woodland risks the loss of stock worth several thousands of dollars in order to get some poor quality forage. The following list includes those species common in eastern United States which are poisonous at some time during the grazing season. It includes only typically woodland plants; species such as corn cockle, green sorghum, and others which grow in open fields are not listed.

Woodland plants poisonous to livestock:

Common name	*Scientific name*
Black cherry	(*Prunus serotina*)
Buttercup	(*Ranunculus sp.*)
Common brake	(*Pteris aquilina*)
Dutchman's breeches	(*Discentra cucullaria*)
Great laurel	(*Rhododendron maxima*)
Kentucky coffeetree	(*Gymnacladus dioica*)
Larkspur	(*Delphinium sp.*)
Nightshade	(*Solanum nigrum*)
Oak	(*Quercus sp.*)
Ohio buckeye	(*Aesculus glabra*)
Pokeberry	(*Phytolacca decandra*)
Water hemlock	(*Cicuta maculata*)
White snakeroot	(*Eupatorium urticaefolium*)
Whorled milkweed	(*Asclepias verticillata*)

There are a few exceptions to the rule that livestock and trees are not compatible. In order to get natural establishment of coniferous reproduction in the North, controlled grazing may be advisable. The stock keep the undesirable but more aggressive hardwoods in check until the less palatable but more valuable conifers are started. See also recommendations for preventing damage by rodents.

Cattle and other domestic animals commonly range in the pine forests of the South without serious damage to the wood crop. Because the stock is permitted to roam at large and since pine is less palatable than much of the associated vegetation, there is a



White snakeroot, one of the most poisonous plants in eastern farm woodland. Farmers suffer heavy losses from cattle, sheep, horses, mules, and goats eating this weed.

negligible loss of tree growing stock. Furthermore, by keeping the ground cover down, livestock serves to eliminate fuel for hot destructive surface fires.

In fact, pine forests generally suffer less than hardwoods from domestic livestock. As a rule, the pines naturally exist on the lighter sandy soils which are not subject to the same degree of compaction as loam or clay soils. On light soils where the regeneration of conifers is desired, intensive and carefully controlled grazing may be an inexpensive reforestation measure.

Fencing

The protection of woodland from livestock necessitates building a fence between the pasture and the woodland. Fencing methods are throroughly covered in previously issued instructions, as well as the following publications:

"Farm Fence Handbook," Guise. Republic Steel Corp., Chicago, Rev. 1942.
"Range Pasture and Field Fencing," Soil Conservation Service EP-17, November 1939.

The important consideration to be given in fencing farm woodland is cost (see table 11). On many small tracts this may be so great as to absorb a large part of any anticipated returns from the woods. Incidentally, there is no good reason why the cost of fencing should not be charged against the livestock enterprise rather than the woodland. Regardless of where it is charged, nowever, these are a few suggestions to keep cost to a minimum:

(1) The smaller and more irregular the area, the greater the cost per acre of complete fencing. Therefore, the fence should include as large and as regular an area as possible.

(2) Wire may be fastened to poorly formed live trees along the margin of the woods to cut costs and to insure permanence. Do not, however, fasten wire to straight, well-formed trees which later may be processed; stapling to a 2 x 4 which is fastened to the trunk of good trees will prevent injury.

(3) It is not usually necessary to build fences between woodland and cultivated fields and meadows. The relatively short period that livestock will have access to the woods, and the small damage they may do will not, as a rule, justify the cost of building and maintaining the fence. Think of fences as a means of confining livestock in pastures, not of keeping stock out of the woods.

TABLE 11.--*Approximate cost per rod of fence for labor and materials, assuming wood posts one rod apart*

Kind of fence	Labor: two-man-crew-day[1]		Cost of material[2]	
	Line posts driven	Line posts set[3]	Wire, etc.	Posts
	Days	*Days*		
Barbed wire:				
2 strands, 2 pt.	0.012	0.015	$ 0.14	$ 0.30
3 strands, 2 pt.	.014	.020	.21	.30
4 strands, 2 pt.	.017	.025	.28	.30
5 strands, 2 pt.	.020	.033	.35	.30
Woven wire only (60 inch)	.018	.030	.95	.30
Woven + barbed:				
32-inch woven + 2 strands	.022	.035	.85	.30
47-inch woven + 1 strand	.022	.035	.90	.30

[1] Thus, two men will set line posts and build a 4-strand barbed wire fence at the rate of 40 rods per day (1 day ÷ 025) If labor is worth $10.00 for the two men, the labor expense per rod is 25 cents (10.00 x .025).

[2] Average quality materials, 1945 prices.

[3] Will require about 3 hours for 2 men to set corner and brace posts (wood).

Living fences recently have been given renewed attention. Osage-orange and multiflora rose are used in Ohio, Indiana, Missouri, Illinois, and much of Iowa as natural fences with or without a supplementary wire or two. Red cedar, hawthorn (C. crusgalli), and orange bark willow are about the only promising species for such use in Michigan, Wisconsin, and Minnesota, anticipating that protection must be given until the trees are large enough to support the necessary wire.

Eliminating of Woody Plants in Pastures

Farmers permit livestock to graze in woodland either because of indifference or because they feel they need the forage in the woodland to augment that in the open pasture. Most farms are short of palatable forage, especially in the summer, hence the prevention of woodland grazing must necessarily start by the improvement of the pasture.

Although the following material cannot rightly be classed under the subject of woodland protection, the elimination of woody plants in pastures has an indirect bearing on the farm woods. Where power machinery is available, pulling stumps and grubbing roots is the quickest and most satisfactory method. Power saws operating from a tractor and special sickle bars for cutting brush are available for keeping sprout growth in check. Continued mowing, plus fertilizer treatment and seeding with adapted grasses and legumes, eventually will result in the exclusion of sprouts.

Grazing alone is not a satisfactory method of eliminating brush. A sufficient concentration of stock to make inroads on the woody vegetation means underfeeding of the animals, and a consequent loss against the livestock investment. At best, grazing is merely supplemental to other methods of clearing.

A single or occasional cutting also is unsatisfactory. Most hardwoods and shrubs have marked sprouting capacity, and so long as they are permitted to produce enough leaves to manufacture plant food they will continue to send up new growth. Cutting in midsummer, June to August, is preferable to fall, winter, or early spring. The important consideration, however, is not when to do the cutting, but how frequently. Little permanent benefit will be derived unless tops are cut at least twice during the summer and cutting is continued year after year until there is no food supply left in the roots.

Fire is another favored method of brush disposal; but the problem of getting a "clean" burn, together with the dangers of the fire getting out of control, make it unsatisfactory except as a supplement to other methods.

In the absence of heavy equipment and sufficient power to pull and uproot all woody vegetation, a combination of cutting, grazing and fire, continued over a 4-year period is an inexpensive and fairly efficient method. In late summer or early fall, all small trees and brush are cut and left where they fall. Follow with a heavy seeding of forage grasses, such as equal parts of timothy, orchard grass, redtop, and alsike. After the grass is well established in the spring, stock is turned in at the rate of about 3 animal-units per acre. Grazing is continued for about 4 years, during which time the larger trees are cut and hauled away. Also it may be necessary to hand-clear some sprout growth resulting from previous cutting.

In the summer of the fourth year the stock is removed and the grass permitted to grow to maturity. After the frost has killed the grass during a dry time in the late fall or early winter the grass is set on fire. Usually this fire is hot enough to consume the down brush and small logs. Many of the stumps will be partially rotted and burned and can be pulled the next spring, following which a good disking and seeding can be repeated.

Chemicals are also used to kill woody vegetation and prevent sprouting. For small trees and shrubs under 7 feet high, or for new sprouts from large trees, herbicides such as 2, 4-D and ammonium sulfamate ("Ammate") are most frequently used. Solutions made according to the manufacturers' directions are sprayed on the full-grown leaves in June or July. Complete coverage of the leaf surface is necessary for a satisfactory kill. Ammate, though more expensive than 2, 4-D, appears to be more potent. Neither is poisonous. Ammate, however, is corrosive to metal, and spray equipment should be thoroughly cleaned after using.

For larger trees, methods other than leaf spraying are necessary for a complete kill. Some violently poisonous and dangerous chemicals, such as caustic soda, arsenic trioxide, and sodium chlorate, have been used in the past, but now have been replaced by the safer Ammate.

Trees up to 8 to 10 inches can be completely killed by placing Ammate in "cups" in the trunk near the ground. Cups are made by chopping two downward axe cuts, one about an inch above the other, and prying out the chip. Two or three cups are enough for 3 to 6-inch trees; an additional cup is needed for each 2-inch increase in diameter. One heaping tablespoon of dry Ammate crystals is put in each cup immediately after cutting. Trees less than 3 inches high can be cut off completely, leaving a V-shaped stump, and the crystals put into the V. Spring or summer is the best time to apply this method.

Instead of dry crystals, solution of Ammate (4 pounds per gallon of water) can be applied to a row of axe-cuts made completely around the stem of the tree. Make single downward-slanting cuts with an axe, spud, or other sharp tool, well into the sapwood, near the ground. The solution can be poured into the girdle with a long-spouted oil can or a watering can the nozzle of which is plugged with a perforated cork. Treatment should be made in the spring or early summer and the solution applied before the exposed sapwood dries out. Trees should stand at least a year, so that full effects of the treatment may be realized.

Ammate is not always effective in killing the larger bottom land hardwoods or some of the more persistent sprouters. Observations indicate that sodium arsenite is a more effective herbicide. It can be used in the dry form as described above or in solution (1 pound per 3 pints of water). In common with all arsenic compounds, this one is deadly poison. If used, the following precautions should be rigidly observed:

1. Don't breathe the dust or fumes from the chemicals
2. Wash hands and clothing after handling.
3. Label containers conspicuously.
4. Don't permit livestock in the poisoned area until the spring following treatment.
5. Avoid spattering chemicals on skin.
6. If the poisoned wood is burned, avoid breathing the smoke.
7. Screen off the poisoned areas if valuable game and fur animals are present in the community.

PROTECTION

WILD ANIMALS

Plantations of most species, often up to 10 years of age, are subject to serious damage by mice during the winter. The common field mouse is the worst offender, and high populations can be expected in 4-year cycles. Any small, heavily sodded area in which the rodents from surrounding fields and pastures invariably concentrate is in a hazardous position. When the mouse population is heavy and the snow is deep, every tree in a plantation may be girdled, and even the bark from the stems and branches will be consumed. Scotch pine is a favored host; spruce, jack pine, and white oak are among those usually not harmed.

One way to prevent such losses is to turn livestock into the area for a few days before freezing weather in the fall. Some damage to the trees can be expected from trampling and browsing, but for the week or two that stock have access to the plantations, damage by livestock will be small compared to what the mice would do otherwise.

Pocket gophers may kill trees in young plantations by chewing off the roots under the surface of the ground. Complete control can be obtained by placing poisoned carrots in burrows. See Pocket Gopher Control, USDA Farmer's Bulletin 1709.

In years of peak population, rabbits or snowshoe hares also will damage newly planted stands in the Northern States. They nip off terminal buds and stems, thus tending to deform trees and retard growth. Trapping and hunting are the best controls.

The protection of deer and beaver afforded by State game laws sometimes results in local concentrations of these two animals.

Deer browse trees and shrubs particularly in the winter. Under ordinary conditions their damage to commercial tree species can be ignored. Heavy populations of deer on overstocked ranges, however, result in severe injury to northern conifers particularly white cedar, white and jack pine, and balsam. Yellow poplar is highly palatable to deer in the southern part of the region. Deer can be controlled by hunting, but before any radical measures are taken, the value of the wildlife resource should be carefully weighed against the damage to the tree crop.

Beaver feed on the bark of many hardwoods obtained by cutting the standing trees. This direct killing of timber, however, is not so serious as is the indirect damage caused by their dams in streams. By backing up water and flooding lowlands, they may kill hundreds of acres of timber. Most States permit trapping the beaver and the destruction of their dams where they threaten valuable property. State conservation departments should be consulted for recourse.

Birds are distinctly beneficial to the trees, the one exception being the yellow-bellied sapsucker. This bird, which looks and acts like a woodpecker, drills a series of holes completely around the trunks and large limbs of pine, basswood, maple, and some of the other hardwood trees. The exotic conifer Scotch pine is a favorite host. Rather than attempting to kill the birds, it is better to accept the deformities in the trees, and perhaps avoid planting the more susceptible species.

Squirrels occasionally and porcupines regularly eat the succulent inner bark from the branches of living trees. While their operations retard the development of the trees and furnish a point of entrance for destructive insects and diseases, generally the loss is small. If porcupines become so numerous as to kill many trees, they can be readily controlled by shooting.

REFERENCES

Managing the Small Forest, USDA Farmers' Bulletin 1989.

Principles of Forest Entomology, Graham. McGraw-Hill.

Destructive and Useful Insects, Metcalf and Flint. McGraw-Hill.

Common Diseases of Important Shade Trees, USDA Farmers' Bulletin 1987.

Butt Rot in Unburned Sprout Oak Stands, USDA Technical Bulletin 684.

Insects Injurious to Deciduous Shade Trees and Their Control, USDA Farmers' Bulletin 1169.

Protecting Shade Trees from Insect Damage, Illinois Agricultural Experiment Station Circular 509.

Reducing Losses from Tree Diseases in Eastern Forests and Farm Woodlands, USDA Farmers' Bulletin 1887.

Stand Improvement of Northern Hardwoods in Relation to Diseases in the Northeast, Allegheny Forest Experiment Station. Paper 5.

Woodland Management, Ohio State University Agricultural Extension Bulletin 213.

Pathology in Forest Practice, Baxter. John Wiley & Sons.

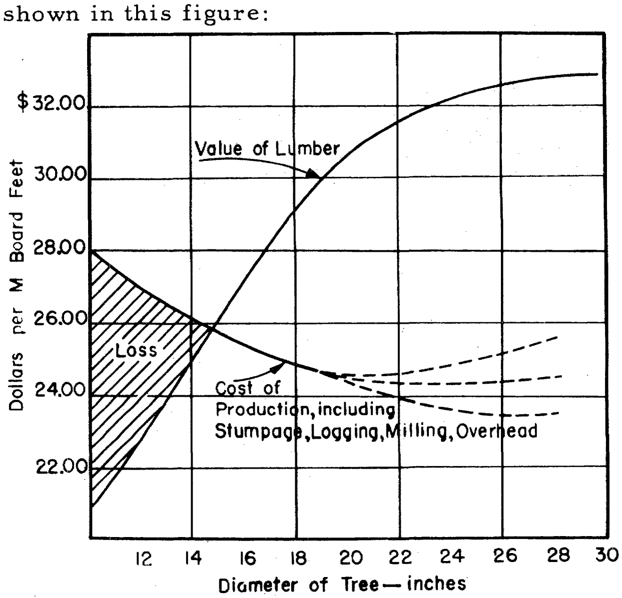
WOODLAND PRODUCTS

The farm woods should be handled in a manner similar to cropland and meadows. Like any other crop, the woodland products are harvested, used on the farm, or sold. The requisites for conducting this harvest are (1) the recognition of various products in the trees, (2) a knowledge of the specifications of the products and how they are measured, and (3) an idea of how to market and harvest the products. The farmer will be interested principally in the following products:

SAW TIMBER

Logs or timber intended for sawing into boards, planks, or other construction material are known as saw timber. Practically all species which grow to sufficient size are usable, the more important being pine, black walnut, cottonwood, ash, the oaks, red elm, yellow poplar, aspen, basswood, hard maple, beech, yellow birch, soft maple, black cherry, hickory, gum, hemlock, and cypress.

Except as taken in improvement cuttings, trees to be cut for saw logs should be a minimum of 16 inches d.b.h. (diameter, breast high), be at least 16 feet to nearest branch of appreciable size, and be reasonably straight and sound. The cutting of small trees for saw logs does not pay. Based on logging and milling studies in both pine and hardwoods, a typical comparison of costs represented in the utilization of trees of different sizes is shown in this figure:



Comparison of production costs of trees of different size

Saw timber is sold by the thousand board feet (M bd. ft.), a board foot being a unit of volume 1 inch x 12 inches x 12 inches. After the tree has been felled, it is cut into logs, 8, 10, 12, 14, or 16 feet in length plus an additional 2 to 4 inches for trimming and squaring the ends of the resulting boards. In absence of a specified length, foresters assume a log to be 16 feet.

The board foot contents of sound logs can be determined with fair accuracy by measuring the average diameter inside the bark of the small end, obtaining the length, and referring to a table indicating the board feet (Appendix C). Where many logs are to be measured, scale sticks or log rules giving readings direct in board feet are used. If logs are defective, the board foot contents are reduced accordingly.[7]

There are no uniformly established grades for sawlogs. In fact, much saw timber is purchased from farmers on a lump sum or lot basis. In a few localities, however, log grades are fairly well recognized, and by knowing exactly the specifications of the grades, the seller may be assured of a fair price for his product. When graded, the diameter of the log, the length, and the number and size of visible defects influence whether it is a No. 1, 2, or 3 log. See figure on page 44 for specifications of a No. 1 log in one locality.

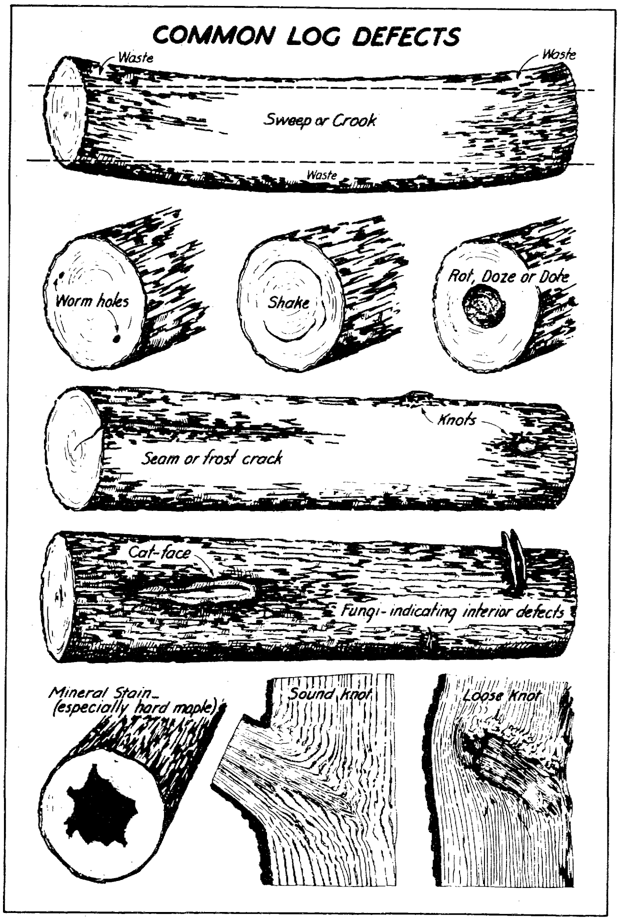
Lumber

Boards 1 inch or more in thickness and in random widths and lengths sawed from logs are known to the trade as lumber. Thicker pieces sawed to specific dimensions, such as 2 by 4's, are called dimension stock.[8] Further remanufacture produces trim, flooring, and other finished products for special uses. Lumber sizes are designated by thickness, width, and length respectively. Thus, 1 x 6 x 14 indicates a board 1 inch thick, 6 inches

---

[7]To scale out defect: (a) measure in inches the end dimensions of a rectangle that will be wasted in sawing; (b) measure the length of the defect in feet; (c) multiply the three dimensions and divide by 15. Thus $\frac{W'' \times H'' \times L'}{15}$ board feet to be deducted. This reduction in scale is not made for sound knots, stain, or small worm holes.

[8]In hardwoods, any small piece cut to specific size for special use also is called dimension stock.



wide, and 14 feet long. Thickness is also designated in quarter inches: 4/4 is 1-inch lumber; 6/4 is 1-1/2 inch lumber, etc.

There are a dozen or more lumber-grading rules in use in the United States to specify quality. In fact, some species are graded under several different rules, depending on the use to which the material is to be put. No one person is intimately familiar with all the rules, but their common denominator is the amount of defect present in an individual board, or stated in another way, the amount of clear material obtainable.

Generally, hardwood lumber can be placed in one of five grades, each grade determined by the proportion of the board that can be cut into clear (without knots or defect) pieces of a minimum size. The names of the grades and the approximate specifications for each are as follows.

Grade and minimum size of board:	*Approximate percent of surface to yield clear pieces*	*Minimum size of clear pieces after cutting defects*
FAS (Firsts and seconds) 6" wide, 8' long	85	4" x 5' or 3" x 3'
SELECT.................. 4" wide, 6' long	One side (face) of board to meet FAS specifications and the other to meet No. 1 Common.	
No. 1 COMMON............ 3" wide, 4' long	67	4" x 2' or 3" x 3'
No. 2 COMMON............ 3" wide, 4' long	50	3" x 2'
No. 3 COMMON............ 3" wide, 4' long	33	3" x 2'

No. 3 Common is further divided into A and B, B requiring only 25 percent of the surface to yield sound pieces, each piece to contain at least 36 square inches.

The average hardwood logs from poorly managed farm woodland will produce only about 10 percent of FAS and Select lumber, and about 30 percent in each of the three lower grades. Well-managed woodland should produce logs which will yield about 20 percent in each of the five grades.

Softwood lumber or dimension stock is classified into three major groups depending on intended use: (1) Yard lumber for general building and construction, (2) Structural material or "timber", graded primarily according to its strength, and (3) Shop and factory lumber which, similar to hardwood lumber, is intended for re-manufacture. Each group has its individual grades, and yard lumber, for example, recognizes the following nine grades.

Grades of softwood yard lumber:

	Principal requirements
A Select...... B Select	Suitable for natural finishes. A is essentially free from any defect. B admits not over two minor defects such as small, tight knots, worm holes, or pitch pockets.
C Select...... D Select	Suitable for paint finishes that will cover any defects. C admits four minor defects such as pin knots, etc. D admits any number that will not detract from the appearance when painted.
No. 1 Common...	Admits sound, tight knots 1¼ to 3 inches in diameter, depending on width of board. Water-tight material.
No. 2 Common...	Admits sound, tight knots 2½ to 4 inches in diameter depending on width of board, plus other coarse defects which permit its use in construction without waste.

Grades of softwood yard lumber: (Cont)

	Principal requirements
No. 3 Common...	Admits loose knots and knot holes not exceeding one in boards 10 feet or less, and three in 16 feet or longer boards. 25 percent poorer than No. 2.
No. 4 Common...	Same as No. 3 except to a greater degree.
No. 5 Common...	Admits all defects, provided the board is strong enough to hold together under careful handling.

Black Walnut

If walnut timber will not yield logs that approximately meet specifications for veneer logs, it is worth but little more than any other timber. In larger trees, however, there may be exceptional values, and farmers should recognize the factors that make one tree more valuable than another (table 12).

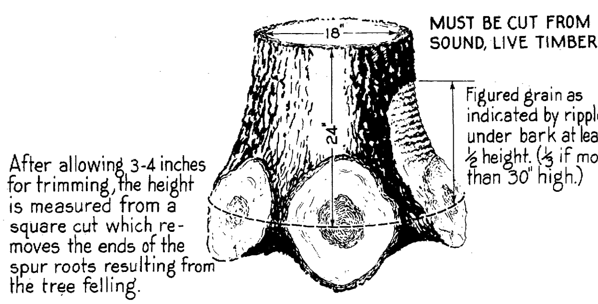
TABLE 12.--*Board-foot contents of walnut stumps of various top diameters and heights*

Diameter (inches)	Length 24 inches	30 inches	36 inches
	Board-feet	*Board-feet*	*Board-feet*
18	24	30	37
20	32	40	48
22	40	50	61
24	50	62	75
26	60	75	91
28	72	90	108
30	84	105	127
32	98	122	147

Most good walnut is sold as stumpage (standing trees, on the stump) and is cut by men who are skilled in obtaining the highest valued products from each tree. This is as it should be and is an exception to the general recommendation that farmers can get a higher labor return if they cut their own timber. In many cases the owner can get more for a good standing walnut than he can for the same tree after it has been improperly cut and made into logs.

To bring premium prices, walnut logs should have the following characteristics: Butt logs must be more than 12 inches inside bark at small end and 8 feet or more in length (6- to 7-foot lengths acceptable only if 16 inches or more in diameter). Logs other than butt cuts must exceed 16 inches at small end and be 8 feet or more in length. All logs must be cut from live timber and be sound, straight, and free of all defects and of excessive sapwood; must be 4 inches over specified length. Walnut is usually scaled by the Doyle rule (Appendix C).

Large, sound walnut trees having bell-shaped bases are commonly cut off below the ground line so that the stump can be utilized to obtain valuable figured veneer. The stump is left attached to the first log, but its characteristics are considered separately. If the stump will not meet the minimum specifications shown in the figure it should be ignored, for it will not be worth the extra labor involved in grubbing it out.



Minimum specifications for walnut stumps.

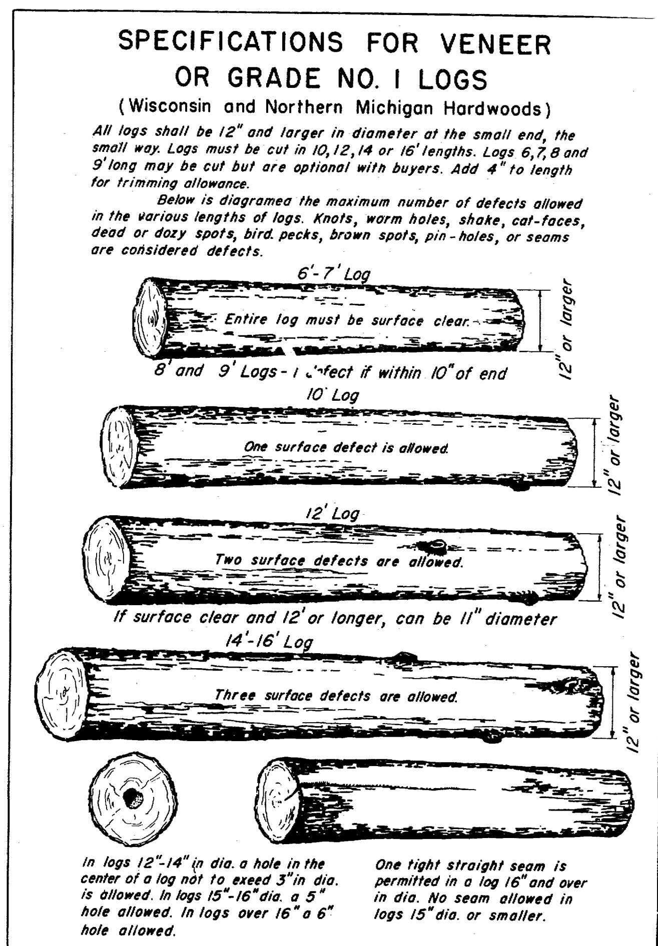
VENEER

Usually the best grade of timber will bring the highest price if sold to veneer manufacturers. Veneering, the cutting, slicing, or sawing of timber into thin sheets, is not a new process. Veneered caskets and plywood furniture have been found in the tombs of Egptians who lived 1,500 years before Christ. Since then, improved machinery, modern waterproof glues, and new methods of laminating have greatly expanded the use of veneer to many fields of construction.

Because of the wide variety of uses, most species in large-sized bolts are usable for some purpose. The more common are black walnut, the oaks, birch, yellow poplar, basswood, cottonwood, elm, maples, gums, sycamore, and pine. The fact that manufacturers want clear, unbroken pieces of veneer emphasizes their demands for large logs without defects. Trees below 16 inches in diameter, or logs that have visible knots, rot, wormholes, and shake, ordinarily are not marketable for veneer.

Logs are sold by the board foot the same as saw timber, even though manufactured veneer is sold by the square foot of surface.

Specifications for veneer logs vary according to locality and species. The accompanying illustration shows the maximum number of defects allowed in various sizes of veneer logs in Wisconsin and northern Michigan. Although standards in the Southern and Eastern States are somewhat higher, the same principles are applicable.



RAILROAD TIES

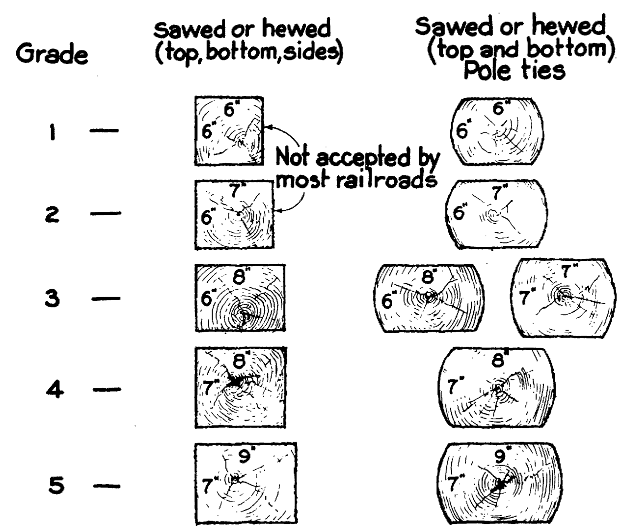
The relative suitability of various species of wood used for ties depends on (1) strength, (2) wearing qualities, (3) susceptibility to preservative treatment, and (4) natural resistance to decay. No single species has all these favorable characteristics, but the oaks and hard pines (two- and three-needled) are used in the greatest numbers by eastern railroads. Species are commonly grouped together, as follows:

Group U-a	*Group T-a*
Black locust (heartwood) White oak (heartwood) Black walnut (heartwood)	Ash Hickory Honey locust Red and black oaks Any of U-a group with sapwood
Group U-b	*Group T-b*
Hard pines (heartwood) Larch (heartwood)	Same as U-b and U-c except with sapwood
Group U-c	*Group T-c*
Cedars (heartwood) Cypress (heartwood)	Beech Birch Cherry Gum Hard maple
Group U-d	*Group T-d*
Catalpa (heartwood) Mulberry (heartwood) Sassafras (heartwood)	Any of U-d group with sapwood Butternut Elm Hackberry Poplar Sycamore

These groups, when considered with the various sizes (grades), dictate the acceptability and value of the product. Group U ties may be used untreated, group T ties require treatment.

The minimum standard railroad tie length is 8 feet, although many roads demand 8 1/2-foot or 9-foot ties. The minimum diameter of a tie cut is about 12 inches outside the bark at the small end, although it will be seen from the diagram of grades that this may be variable, depending on the size which the market accepts. Trees must be reasonably straight, sound, and free from decay and large knots. Many tie operators purchase tie cuts in diameters from 12 inches up at a flat rate regardless of diameter. When they get a 20-inch bolt, they can cut two #5 ties or three #3 ties plus 35 to 45 board feet of additional side lumber. (See Appendix I for tables.)

The demands by different railroads are variable in respect to grades of ties. However, the grades shown in the illustration are standard, and it remains only for the seller to determine grades that the market will accept.



Grades of railroad ties

ROUND TIMBER

Piling

Oak and pine are most commonly used for piling. The market, however, is variable and irregular in its demands, and for many purposes, sound straight trees of any species are acceptable.

Sizes also are variable, depending on special uses. Soundness, freedom from crook and excessive sweep, and gradual taper from butt to tip always are essential requisites for good piling. Sizes range from 15 to 60 or more feet in length, and between 6-inch tip and 20-inch butt. Table 13 gives the specifications established by one State highway department.

TABLE 13.--*Specifications for first-class piling (oak, peeled) established by a Midwestern State highway department*

Length (feet)	Diameter 6 feet from butt		Diameter of tip
	Minimum	Maximum	Minimum
	Inches	*Inches*	*Inches*
Less than 30	12	18	10
30 to 40	12	18	9
More than 40	12	18	8

Poles

Treated pine is the most widely used species, although tamarack, untreated cedar and some of the more decay-resistant hardwoods are used locally when available. Both poles and piling are sold by the linear foot.

As shown in the table 14, there are 10 classes of poles, based on top diameter and length. The first 7 classes also specify minimum circumference of the butt. Freedom from short crooks, excessive sweep, decay, cracks, and bird holes are required in addition to size. Shakes and checks are also considered as defects if located at the top or above the butt of the pole, and prior to treatment the surface must be free from bark and projecting limb stubs.

Table 14 gives the classes of southern pine poles and their minimum dimensions, as specified by the American Telephone and Telegraph Company.

TABLE 14.--*Specifications for southern pine telephone poles*

Length of pole	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10
	MINIMUM TOP DIAMETER									
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Any length...	8.6	8.0	7.3	6.7	6.0	5.4	4.8	5.7	4.8	3.8
	MINIMUM CIRCUMFERENCE AT 6 FEET FROM BUTT [1]									
16 feet	.....	.....	.....	.....	21.5	19.5	18.0	No butt requirement	No butt requirement	No butt requirement
18 feet	.....	.....	26.5	24.5	22.5	21.0	19.0			
20 feet	31.5	29.5	27.5	25.5	23.5	22.0	20.0			
22 feet	33.0	31.0	29.0	26.5	24.5	23.0	21.0			
25 feet	34.5	32.5	30.0	28.0	26.0	24.0	22.0			
30 feet	37.5	35.0	32.5	30.0	28.0	26.0	24.0			
35 feet	40.0	37.5	35.0	32.0	30.0	27.5	25.5			
40 feet	42.0	39.5	37.0	34.0	31.5	29.0	27.0			
45 feet	44.0	41.5	38.5	36.0	33.0	30.5	28.5			
50 feet	46.0	43.0	40.0	37.5	34.5	32.0	29.5			
55 feet	47.5	44.5	41.5	39.0	36.0	33.5				
60 feet	49.5	46.0	43.0	40.0	37.0	34.5				
65 feet	51.0	47.5	44.5	41.5	38.5					
70 feet	52.5	49.0	46.0	42.5	39.5					
75 feet	54.0	50.5	47.0	44.0						
80 feet	55.0	51.5	48.5	45.0						
85 feet	56.5	53.0	49.5							
90 feet	57.5	54.0	50.5							

[1] To reduce to diameter breast height of standing trees, divide circumferences by 2.76. Thus a tree 50 feet above the stump to an 8-inch top diameter, must be 15.6 inches d.b.h. (43.0 ÷ 2.76) to produce a Class 2 pole. On the same basis, if a tree of that height is in excess of 16.6 inches d.b.h., it will produce a Class 1 pole, etc.

FUELWOOD

Although any reasonably well seasoned species may be used as fuel, its value for heating purposes is roughly equivalent to its dry weight, i.e., specific gravity (see Appendix H.) This relationship is shown by figures supplied by the United States Forest Products Laboratory, giving the weight per cord (80 cu. ft. of solid wood) of air-dried wood (20 percent moisture content) and the gross fuel value in b. t. u. 's.

TABLE 15.--*Weight of air-dried fuelwood and gross fuel value (U.S. Forest Products Laboratory)*

Species	Weight per cord	Total heat value per cord
	Pounds	*B. t.u.*
Shagbark hickory	4,240	24,600,000
White oak	3,920	22,700,000
Beech	3,760	21,800,000
Sugar maple	3,680	21,300,000
Red oak	3,680	21,300,000
Birch	3,680	21,300,000
Ash	3,440	20,000,000
Red maple	3,200	18,600,000
American elm	2,960	17,200,000
Shortleaf pine	2,900	18,500,000
Red pine	2,880	18,200,000
White pine	2,080	13,300,000
Aspen	2,160	12,500,000

For comparison with other fuel, the range of values for bituminous coal produced in Indiana, Illinois, Iowa, Missouri, and Ohio is between 18,000,000 and 30,000,000 B.t.u.'s per ton, and an average grade of fuel oil furnishes 120,000 B.t.u.'s per gallon. Hence, roughly speaking, a cord of good dry wood is about equal to one ton of coal or 200 gallons of fuel oil, assuming comparable efficiency of the heating units.

A ton of hardwood burns to about 60 pounds of ash; hard coal, 200 to 300 pounds; and soft coal, up to 1,000 pounds of ash per ton.

The above values are for seasoned wood -- wood cut for 6 to 12 months and properly dried. Green wood of some species like aspen and elm may burn with only 60 percent of this heating value, depending on the amount of natural moisture in the cells. However, the fact that the heartwood of other species like white ash, beech, pignut and shagbark hickory, black locust, Osage-orange, red pine, and tamarack is naturally dry, such species will improve but little on drying.

There are no standard grades or specifications for fuel or cord wood. It is sold by the cord or rick. State laws in Illinois, Ohio, and Minnesota define a cord as 128 cubic feet, and even though local usage is commonly indefinite, the courts, in absence of statutes, have upheld the dictionary definition which says a cord is a pile of wood 4' x 4' x 8', or 128 cubic feet. A rick of wood (sometimes called a short or face cord) generally designates fuel or fireplace lengths, 4 feet high and 8 feet long.

MAPLE SIRUP

Where hard or sugar maple grows in considerable quantities there is a possibility of adding to the farm income by utilizing the sap of this tree. (Soft maple also yields satisfactory sap, but it does not contain a large enough percentage of sugar to make a worthwhile operation.) Although the evaporating and other equipment necessary for such an enterprise represents an additional investment over the usual farm equipment, a study of 130 maple groves in Maryland showed annual net profits per acre as good or better than from other farming operations. Unless sap can be pooled and evaporated at a central point, an operation involving less than 500 buckets probably would not be economical as a commercial enterprise.

Best yields of sap come from ungrazed woodland. The probable reason for this increase is that the flow of sap is dependent on available moisture in the soil. When the ground is frozen, as it commonly is in grazed woods, the soil moisture is bound up. In protected woods, however, good leaf litter and persistent snow depths keep the ground from freezing. In general, production depends to a large extent on climatic conditions. Cool nights, warm days in the spring, moist but well-drained sites and a heavy snowfall during the months preceding the tapping are conducive to highest yields.

It is not economical to tap trees less than 10 inches in diameter. Large, full-crowned, thrifty trees are the best producers. The number of buckets hung per tree varies. Some experienced operators in Ohio use one bucket for trees under 15 inches and add a bucket for every 5-inch increase in diameter with a maximum of four. In other localities two buckets are the maximum per tree, and then only on those 24 inches or more.

Trees should be tapped on all sides. The difference of sap flow in favor of the south side of the tree is too small to warrant a concentration of holes on that side.

From 30 to 60 gallons of sap will evaporate to 1 gallon of sirup, the average being around 50. Sirup production is estimated on the basis of number of buckets hung during the season. The average figure is between 3 and 5 buckets per gallon. In poor seasons and in grazed woods, however, this may run higher.

The product is sold mostly as sirup. Some sugar is manufactured, but it is generally consumed locally. One gallon of sirup will yield 8 pounds of sugar. Eleven pounds per Standard U.S. gallon is the standard for the four grades under which sirup usually is sold. All except the lowest grade must be free from any trace of fermentation, sappiness, or cloudiness. The lighter the color, the higher the grade.

Table 16 itemizes the income and expenses of twelve farm woodlands whose principal production was maple sirup. The records cover 1 to 4 years of operation, 1942-45, in Ohio, northern Indiana, and southern Michigan. They reflect above-average sirup prices, but to offset this, expenses also were higher. Furthermore, the 1945 season was one of the poorest in volume production that operators ever experienced.

TABLE 16.--*Average annual income and expense from maple sirup operations*

Item		Average of four high-income woods	Average of four medium-income woods	Average of four low-income woods
		Dollars	*Dollars*	*Dollars*
Home-use income:				
Posts		12.50	--	0.78
Lumber		8.30	15.00	40.22
Fuel		50.37	129.37	160.22
Other		21.22	7.50	19.95
Total		92.39	151.87	221.17
Income from sales:				
Posts		--	--	--
Logs and lumber		11.75	13.77	90.82
Fuel and other		25.00	--	120.40
Maple sirup		1,071.16	77.48	281.67
Total		1,107.91	788.25	492.89
Stumpage sales		--	60.69	289.82
Total gross income		1,200.30	1,000.81	1,003.88
Noncash expense:				
Labor		174.06	183.06	48.69
Team		61.56	53.62	18.43
Equipment operation		--	6.26	22.35
Equipment depreciation		29.00	26.25	25.65
Total		264.62	269.19	115.12
Cash expense				
Labor		10.12	28.44	97.25
Tools and equipment		--	--	2.76
Processing		19.69	16.12	9.19
Materials		51.64	38.99	16.32
Total		81.45	83.55	125.52
Taxes		11.27	40.94	16.25
Interest at 3%		118.50	141.75	56.80
Total expense		475.84	535.43	513.69
Net income		724.46	465,38	490.19
Total farm area	....*acres*.....	136	119	657
Area in managed woods	....*acres*.....	30	43	101
Capital value, woodland and equipment	....*dollars*...	3,950.00	4,725.00	8,560
Net return per acre of woods	....*dollars*...	24.15	10.82	4.85
Rate of interest earned on capital	....*percent*...	21.3	12.9	8.7
Return per hour of labor hours of labor	.....*number*...	(368)	(423)	(389)
	....*dollars*...	2.47	1.45	0.89

CHRISTMAS TREES

Christmas trees can be raised and marketed at a good profit on most any farm. Many northern and eastern woodland owners raise them with little, if any, care, and at intervals simply sell the thinnings from plantations or natural woodland. The highest returns, however, are made by men who are accessible to metropolitan centers, where they sell on the retail market. They plant and harvest their trees on regular rotations of from 6 to 10 years. (See page 21 for recommendations on spacing and arrangement of plantations.)

Any well-shaped evergreen produces an acceptable Christmas tree. The spruces, Douglas-fir, and Scotch and Norway pines are the species most commonly planted, although locally, red cedar and most of the other pines are marketable. Balsam fir is an ideal tree, but except on cool sites in the North and East its establishment is difficult.

The shape and not the species is the most important factor in marketing. Some farmers develop symmetrical-shaped trees by pruning and have found that the increased value of a well-shaped tree gives them good returns on the extra labor involved. Spruce should be pruned in late summer; pine as soon as the new needles have reached their full size, or about June 1 to July 15, depending on latitude This stimulates the development of a large number of new buds, which in turn insures compact as well as symmetrical growth. (See page 14.)

Trees are acceptable from 2 to 10 feet in height, the most popular being those about 6 to 8 feet high. Symmetrical specimens, with full foliage from the lower branches to the top, are desirable. Conversely, trees with long, terminal shoots and few needles and trees that have been exposed to hot sun with the resulting dying back of branches are not so readily marketable.

CHARCOAL

Under ordinary demands commercial charcoal kilns produce sufficient quantities for a market with which the average farmer is unable to compete. With a good market, however, and a knowledge of its manufacture, farmers can get a fair labor return from the reduction of low-grade wood. Charcoal is the carbon residue of partially burned wood. During the making, enough air is admitted to burn the gasses driven off by the burning wood, but not enough to consume the residue. Because of the necessity of controlling the burning with loose soil, charcoal cannot be made in the Northern States during the winter when the ground is frozen.

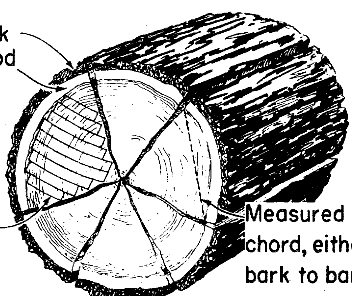
Any sound wood will make acceptable charcoal. Heavy, hard species yield greater amounts per cord and produce stronger coal. Small trees taken from improvement cuttings, limb wood, or any odd-sized pieces from 2 to 4 feet long and up to 6 inches in diameter may be used. The only essential requirements are that the billets used are uniformly dry and not rotten.

The larger and harder the resulting pieces, the better. Charcoal which does not hold together with handling is not in demand. One cord of hardwood will yield about 40 bushels of charcoal; 1 bushel weighs about 18 to 20 pounds.

STAVE BOLTS (COOPERAGE)

Stave bolts are utilized in two ways: as slack cooperage or as tight cooperage, depending on whether the resulting barrel is to be used for dry material or liquids. Mills producing staves for tight cooperage are active wherever there is a sufficient quantity of large, sound, straight-grained oak. The discussion that follows applies only to tight cooperage, because this product yields the highest returns to the farm-woodland owner.

The white oaks are used, although for some types of barrels the other oaks, white ash, and even red gum and elm are acceptable. Sections of varying lengths, but usually between 30 to 39 inches depending on the kind of barrel, are cut from strictly sound, straight-grained trunks of trees 18 inches or more d.b.h. The sections are then split radially to the size acceptable to the local market, 6 inches being the smallest size generally taken. The resulting bolts are measured by the chord-foot.



How barrel staves are cut

Inasmuch as the splitting of stave bolts requires considerable skill to obtain most efficient utilization, farmers should not be encouraged to work up trees unless they are thoroughly familiar with the operation. If the disposal of trees as stumpage is contemplated, however, the owner should carefully compare the values offered as staves against prices obtainable for veneer or high-grade sawlogs, keeping in mind that there is an enormous amount of waste in trees (50 to 70 percent) if only stave bolts are taken.

PULPWOOD

Any wood intended for conversion into paper products is known as pulpwood. The manufacture of some plastics and rayon also requires pulpwood. Farmers within reasonable shipping distance of pulp mills (paper mills do not necessarily convert trees to pulp) can take advantage of a market for small-sized trees cut from thinnings and small material from tops.

Pine, hemlock, spruce, balsam, aspen, and cottonwood are the species most used, although yellow poplar, basswood, maple, gum, and most of the other hardwoods except hickory, Osage-orange, black locust, and black walnut also can be pulped. The kinds of wood in demand by any pulp mill depend on the reduction process in use by the particular mill, and like any other product, the users' specifications should be well known and closely adhered to.

Pulpwood is sold by the cord and in the Northern States most commonly is cut in 100-inch lengths, but sometimes in 50- or 48-inch lengths. A stack of 100-inch wood 4 feet high and 4 feet wide is sold as a "cord." In the Southern States, wood is cut in 5-foot lengths; hence a "cord" or unit contains 160 cubic feet. Pieces free from rot or charred surfaces, with closely trimmed limbs, and having minimum diameters sometimes as low as 3 inches, are acceptable. Often buyers require that pieces be over 9 inches in diameter by split; others accept diameters as large as 20 inches.

Pulpwood is purchased as "rough" or "peeled," i.e., with or without the bark. Peeled wood can be economically produced only during the peeling season which is normally the first 2 months of the growing season. Peeled wood contains about 15 percent more solid material per cord than does rough wood and should command a correspondingly higher price. Most buyers of peeled wood insist that all inner bark be removed completely.

OTHER PRODUCTS

Local industries demand many other forest products which may be marketed under certain local specifications: Fence posts; bolts for handles, bowling pins, etc.; mine timbers; Christmas greens; excelsior wood; edible nuts; cabin logs.

MARKETING

Unlike other products grown on the farm, the market for wood in many farming communities is not always well established. Buyers are often itinerant and take advantage of the fact that the average farmer does not have any accurate idea of the value of standing timber. Furthermore, a farmer with but a small amount of material is at a disadvantage to find buyers who can regularly and efficiently process and handle the relatively few trees he has to sell. In spite of apparent marketing difficulties, however, the problem has several possible solutions.

In the first place the farm itself is the best outlet for wood products. Fuelwood, fence posts, rough lumber, poles, and other farm uses annually consume large quantities of wood (table 17). In fact, home consumption each year on many of the farms in the more highly developed agricultural areas exceeds the annual wood production. Table 18 shows the results of a survey made in 1941-42 in a typically agricultural county.

TABLE 17.--*Wood products used annually on average farm*

State	Area of Average farm	Fence posts	Fuelwood	Lumber
	Acres	*Number*	*Standard cords*	*Board feet*
Illinois	140	75	5	1,000
Indiana	130	75	9	900
Iowa	150	80	12	1,200
Michigan	125	60	12	850
Minnesota	155	110	15	1,000
Missouri (except Ozarks)	190	112	13	800
Ohio	120	100	8	1,000
Wisconsin (western)	145	145	15	1,200

If there is a surplus to sell, the farmer is not compelled to put his product on the market each year. If the price is not right, he can leave his trees standing in the woods until it is; he can "store them on the stump." Except in emergencies, sound, immature, well-formed trees should not be cut. Differing from livestock which may have to be sold because of feed shortage, standing timber can be carried without direct cost. Sound trees in well-managed woods do not deteriorate, in fact young, thrifty trees will treble in value every 15 to 20 years. Many of the so-called marketing problems are the result of attempts to dispose of low-grade products, which in turn are the result of mismanaged farm woods. Selling fire-scarred, partly rotten, and crooked trees is as difficult as an attempt to market moldy grain, skim milk, or cull livestock.

There is also a possibility of cooperative marketing of forest products. Many other farm crops are sold through a centralized agency which represents the farmers themselves, thus eliminating the disadvantages of attempting to move and process small lots of material. Products from farm woods are well adapted to such a form of processing and marketing, particularly through already existing cooperatives.

TABLE 18.--*Total annual wood used in Allamakee County, Iowa, 1941-42*

[Population: 10402 on farms; 6,782 in towns]

Where used	Fence posts	Fuel-wood	Lumber: Home sawed	Lumber: Im-ported	Coal
	Number	*Cords*	*1,000 Bd. ft.*	*1,000 Bd. ft.*	*Tons*
Towns and villages (6)	......	3,605		538	10,100
Creameries (6)	......	145			270
Churches & rural schools (115)	......	415			1,850
Farms (2,088)	302,760	22,970	1,044	640	3,550
Total	302,760	27,135	1,044	1,178	15,770

Many farmers lose income from their woods by selling standing trees (stumpage) instead of utilizing their labor and equipment to further carry on the processing. This is similar to selling standing hay or corn, in that only a part of the value of the crop is recovered. The diagram on page 54 shows the approximate percentage of the total value of rough lumber and ties represented at various stages of production. If rough lumber, for example, is worth $60 per thousand board feet, the farmer would receive only about 20 percent or $12 if he sold standing trees only. If, however, he cut and hauled his timber to the mill, he could expect about 60 percent or $36 per thousand as a return on his labor and equipment.

TABLE 19.--*Harvesting and marketing hardwoods: Approximate time and expense factors*

Operation[1]	Saw logs per M bd.ft. Mill Tally[2]	Cross ties per average sawed tie	Fuelwood per cord 4'x4'x8'	Fence posts per 100, average split and round	Shipping cost per 1,000 pound carload lot		
					Logs	Lumber	Fuelwood
Cut - fall and buck:							
10 - 12 inches d.b.h. .....man hours	6.0	--	--	--			
14 - 20 inches d.b.h. .....man hours	5.5	0.2	--	--			
22 - 30 inches d.b.h. .....man hours	5.0	--	--	--			
Average, all sizes ....man hours	5.6	--	8	12			
Skid and yard:							
10 - 12 inches d.b.h. .....man and team hours	6.0	--	--	--			
14 - 20 inches d.b.h. .....man and team hours	3.5	.2	--	--			
22 - 30 inches d.b.h. .....man and team hours	3.0	—	--	--			
Average, all sizes ....man and team hours	4.0	--	5	6			
Load and unload:							
Truck or wagon ....man hours	1.0	.07	1.5	2.0			
Load:							
Railroad cars ....man hours	3.7	.07	.8	1.0			
Haul 1-way loaded mile[3]:							
1½ ton truck, graded dirt dollars	.35	.008	.18	.15			
1½ ton truck, gravel ......dollars	.27	.006	.16	.12			
1½ ton truck, surfaced ....dollars	.18	.005	.15	.10			
Processing[4]:							
Sawing ....dollars	6-9	.15-.20					
Planing lumber ....dollars	3-5						
Sheathing and siding manufacturers ....dollars	6-8						
Flooring manufacturing 1,000 linear feet ....dollars	12-15						
Freight[5]:							
50 miles ....dollars					0.45	1.20	0.45
75 miles ....dollars					.55	1.60	.55
100 miles ....dollars					.60	1.90	.60
125 miles ....dollars					.70	2.20	.65
150 miles ....dollars					.75	2.30	.70
200 miles ....dollars					.80	2.70	.80

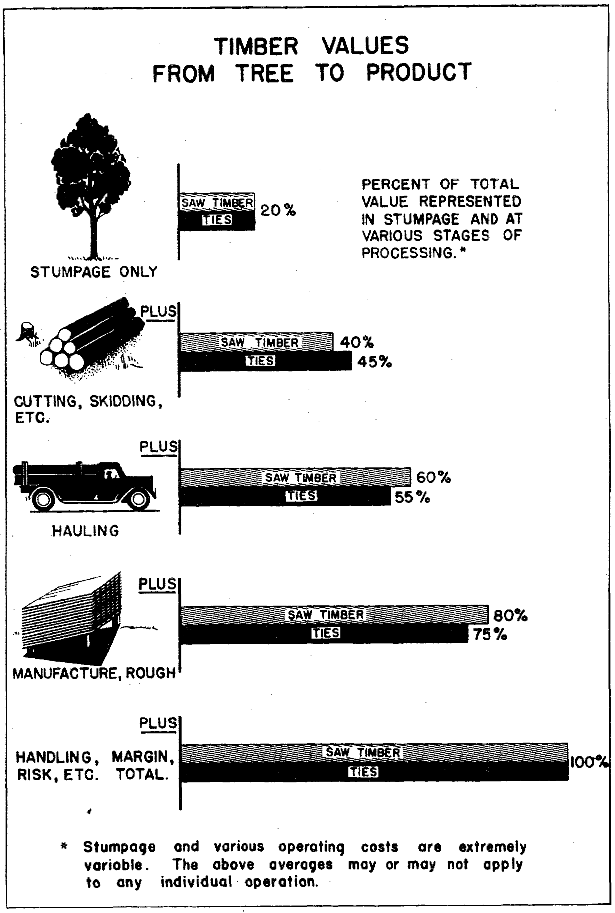
[1] With good equipment and reasonably experienced operators.

[2] Mill tally conforms approximately to the International rule for logs after deducting for rot, cracks, checks, or other defects.

[3] Assumes trucks with usual beds loaded to about double rated capacity, (see also Appendix I). Also assumes fair hauling conditions from woods to public road. For example, if it is 10 miles to destination, the expense per M of hauling a load of 800 bd. ft. of logs over a gravel road is about $2.16 (10 x .27 x .8).

[4] A standard portable type sawmill, working efficiently, is capable of producing about 1,500 bd. ft. of lumber and 50 ties per hour of actual running time. The usual mill, running 8 hours per day will produce about 8 to 10 M bd. ft. of lumber and 250 to 325 cross ties.

[5] Shipping weight varies with species and whether green or dry. See Appendix H for log, lumber, cord, and minimum carload weights. Values shown are mileage rates which are higher than special commodity rates frequently in effect between certain shipping points. Check locally.



Competition among buyers should be encouraged, and, if possible, timber should be sold direct to the user instead of to agents. This is one of the advantages offered by marketing through a cooperative. Timber should not be cut until a market is located and an agreement made as to its disposal. Finally, the responsibility of the purchaser should be investigated, and in transactions involving sizable amounts, a written contract should be drawn up to include the following items:

(a) Date of agreement, and names and addresses of the seller and buyer.

(b) Description of place where the timber or product is located.

(c) Description of the product and approximate amount in terms of pieces, board feet, cords, etc., giving the log rule used, or otherwise specifically defining the unit of measurement.

(d) Amount to be paid per unit of product; and time of such payment(s).

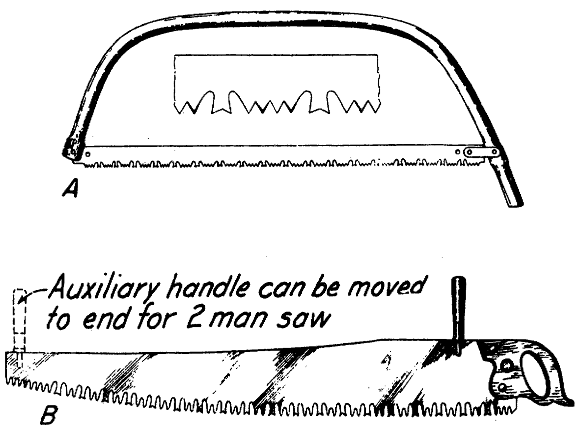
(e) Time when cutting or removal shall start, and when to be completed.

(f) Other optional clauses such as: Penalties for infraction of agreement, waiving or posting a bond, protection of young trees, limits of utilization, disposal of slash, ingress and egress.

(g) Signatures of each party, and witnesses and seals if necessary.

HARVESTING

The older generations of American farmers needed no instructions regarding the cutting of timber. The era of clearing up timberland for farming has passed, however, and except for cutting an occasional tree and clearing brush, many of the present-day farmers have not had the opportunity to exercise the skill possessed by their forefathers. Harvesting timber involves less skill than many other farm operations, and with good tools and equipment any able-bodied farmer and an extra man can do a creditable job.

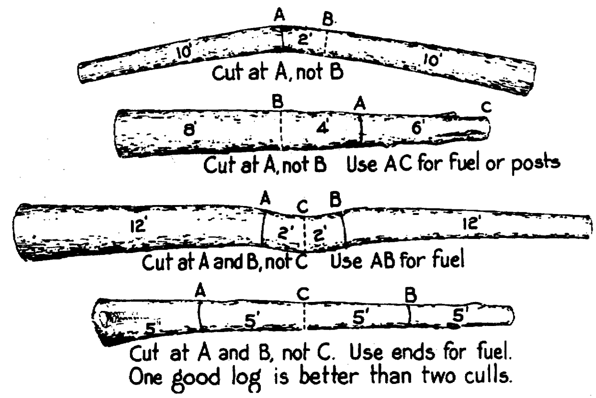


Frame or bow saws (A) and one-man cross-cut saws (B) are useful in small timber.

The essential tools for harvesting are simple and inexpensive. Any equipment needed already is available on the farm or can be purchased or home-made at small expense. Axes, saws, wedges, and sledges are all that are required for felling trees and cutting into lengths. Axes should be about 3 1/2 pounds in weight with 30 to 32 inch handles. Cross-cut saws for logs should be less than 5 feet in length. Heavier axes or longer saws should be avoided. Medium weight axes with fairly short handles can be directed with greater accuracy than large axes, whereas long saws require unnecessary work in filing and setting.[9]

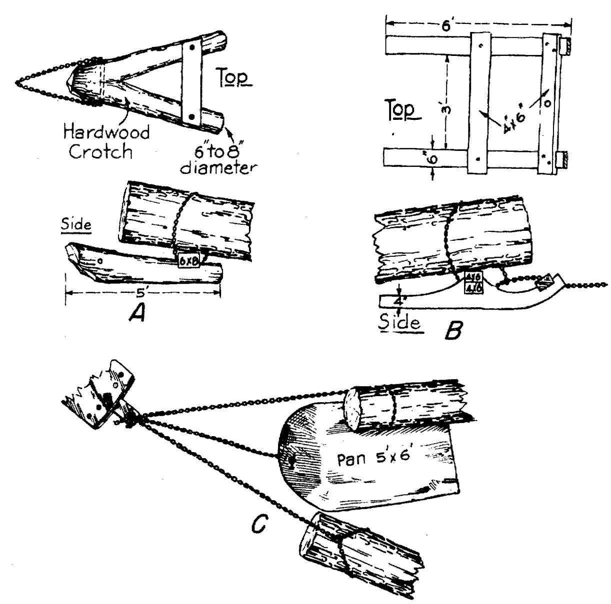
Power-chain saws are rapidly finding their place in farm-woods work. Although they make the harvesting job much easier, their high initial cost and subsequent maintenance make them uneconomical except in large operations.

All logs should be cut as long as possible, up to 16 feet. Defects in the tree, however, frequently modify this general rule, and the following figure illustrates a few common principles to be observed in getting the highest values from log-making.



Eliminating defects in logs

After logs are cut, a simple type of drag or sled will lessen the power required to pull the logs to a loading point. Many modifications of the three types shown in the following figure can be made at home. Type C is especially good behind tractors. A flat piece of boiler plate is flared up in front to form a pan, which is chained to the draw bar. When one or more logs are secured to the same source of power, the forward movement of the tractor draws the logs on the pan.



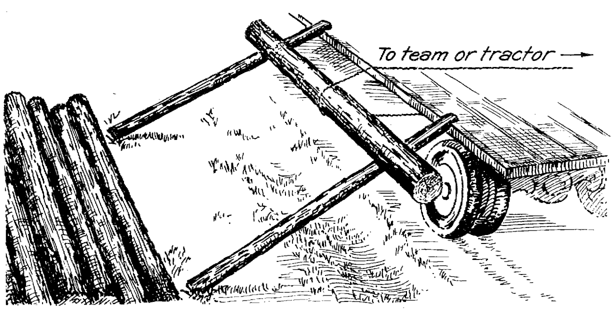
Skidding devices for moving logs in the woods

---

[9] Manuals of instruction for filing cross-cut saws are available from any saw manufacturer.

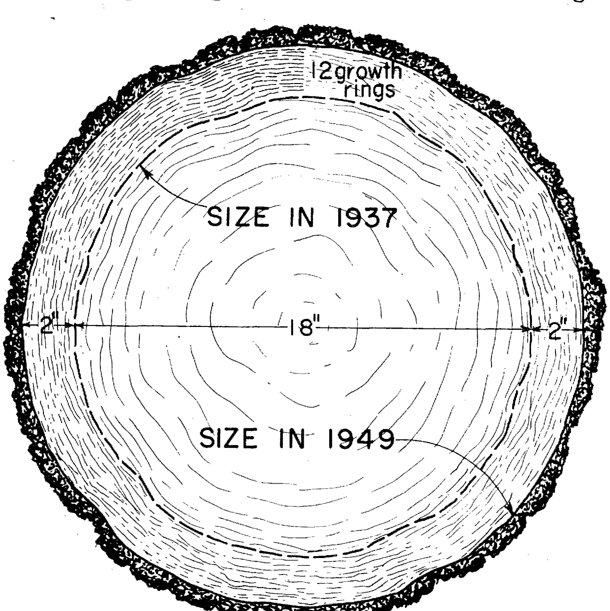
Log chains are useful for many different woods operations. They should be about 14 feet long and have links 3/8 inch thick. A grab hook on one end and an open hook with swivel on the other are desirable features of such chains.

The cross-haul is the almost universally employed method of loading logs on trucks or wagons. One end of a chain or cable is attached to the underside of the vehicle to be loaded. The other end goes under the log and over the vehicle to a team or tractor. Two poles, large enough to bear the weight of the log and notched on the ends to fit the edge of the truck bed, are placed as shown in the figure below.



The cross-haul, a simple method of loading logs or vehicles

All harvesting should be done with an eye toward good silviculture. The immature, full-crowned trees of desirable species should be undamaged by the cutting operations. Whenever a tree is cut, the questions asked on page 11 should be answered. Especially important are the fast-growing trees–the interest-bearing trees.



The addition of a few inches in diameter results in surprisingly large increases in board feet. For example, the diagram below represents a section through the stem, at breast height, of a 22-inch tree having 40 feet of merchantable height. When cut in 1949 it contained 344 board feet, Doyle rule (Appendix J).

The tree had been growing at the rate of 6 rings per inch; hence it was adding an inch in diameter every 3 years. Thus, 12 years before, in 1937, the diameter was only 18 inches, and it had an assumed 32 feet of merchantable height. By referring to the volume tables, Appendix J, such a tree would scale about 164 board feet, Doyle rule. In 12 years, therefore, the volume more than doubled, to say nothing about increase in quality. Stated in another way, the tree was producing about 15 board feet of high quality lumber annually.

This principle can be readily demonstrated to farmers by counting rings on stumps or logs. On small trees, growth can be projected into the future to prove that cutting small thrifty timber for sawlogs is poor business. Obviously, good growth is a prerequisite to the demonstration. If the tree in the above diagram had grown 20 rings per inch (10 years per inch of diameter), the 4-inch increase would have taken 40 years. Good business, therefore, would have dictated its prior removal in order to make room for a thrifty tree.

Because forest products are bulky and their movement puts a big strain on the ordinary farm equipment, roads should be planned so the products move downhill. Farmers should remember that commercial loggers go many miles out of their way to avoid steep grades.

Harvesting is best done in the late fall, winter, and early spring. Teams, tractors, and farm labor are not so busy; the weather is better suited to chopping, sawing, felling, and skidding timber; the timber itself saws and splits and seasons better. When the product is to be peeled as in piling and pulpwood, spring is the most satisfactory season for harvesting. Trees cut in summer are subject to damage by stain and insects; hence, summer-cut logs should be disposed of immediately.

Under most conditions no provisions are necessary for the disposal of limbs and tree tops left after harvesting. In the East and North most hardwood slash decomposes rather rapidly. Any tops left in southern woodland are quickly disposed of by fungi and termites. Coniferous slash in northern woodland, however, may present a fire hazard, and along highways or railroads, piling and burning of tops is good fire insurance.

REFERENCES

Managing the Small Forest, USDA Farmers' Bulletin 1989.

How Lumber Is Graded, USDA Department Circular 64.

Growing Walnut For Profit, American Walnut Manufacturer's Association, Chicago.

How to Grade Hardwood Sawlogs, Purdue Agricultural Extension Bulletin 346.

Production of Maple Sirup and Sugar, USDA Farmers' Bulletin 1366.

Production of Maple Sirup in Michigan, Michigan State College Agricultural Experiment Station Circular Bulletin 213. 1949.

Woodlands in the Farm Plan, USDA Farmers' Bulletin 1940.

Logging Farm Forest Crops in the Northeast, USDA Farmers' Bulletin 2008.

Cooperative Management and Marketing for the Woodland Owner, USDA Farmers' Bulletin 1927.

Equipment and Methods for Harvesting Farm Woodland Products, USDA Farmers' Bulletin 1907.

Operating Small Sawmills in Wartime, USDA Miscellaneous Publication 509.

Marketing Crossties and Piling in Southern Indiana, Indiana Agricultural Experiment Station Bulletin 395.

Marketing Timber in the North Central Area of Indiana, Indiana Agricultural Experiment Station Bulletin 477.

Marketing Illinois Forest Products, Illinois Agricultural Experiment Station Circular 361.

Use of Home-Grown Timber on the Farm, Michigan State College Extension Folder F-30.

Market for Forest Products Grown on Minnesota Farms, Minnesota University Agricultural Extension Pamphlet 69.

Marketing Missouri Farm Timber Crops, Missouri Agricultural Experiment Station Bulletin 460.

Ohio Farm Woods a Neglected Crop, Ohio State University Agricultural Extension Bulletin 142.

Timber Marketing in Eastern Ohio, Ohio Agricultural Experiment Station Bulletin 666.

Woodland Improvement, Wisconsin College of Agriculture Extension Circular 305.

Marketing and Harvesting Farm Timber, Wisconsin College of Agriculture Agricultural Extension Service. [Mimeographed.]

Trees, USDA Yearbook of Agriculture 1949, pages 173-176, 237-254.

WOOD USE ON THE FARM

The operation of a farm is less expensive and much more convenient because of the availability of wood products. Many farmers in the Northern States burn 25 to 30 cords of wood per year, thus saving a considerable fuel bill. A dairy or livestock farm may use at the rate of 100 or more fence posts and 1,000 board feet of lumber annually. As a class, farmers are the country's biggest users of wood products. (See p. 52)

The farm woodland should be large enough and good enough to supply home needs. If the operator has to pay retail prices for his wood products, his costs include expensive transportation charges plus a wholesale and retail profit-taking. In effect, he is hiring men to cut and manufacture the timber and still other men to market and transport it to him. All of these hired hands demand a higher wage than the labor he can employ on the farm.

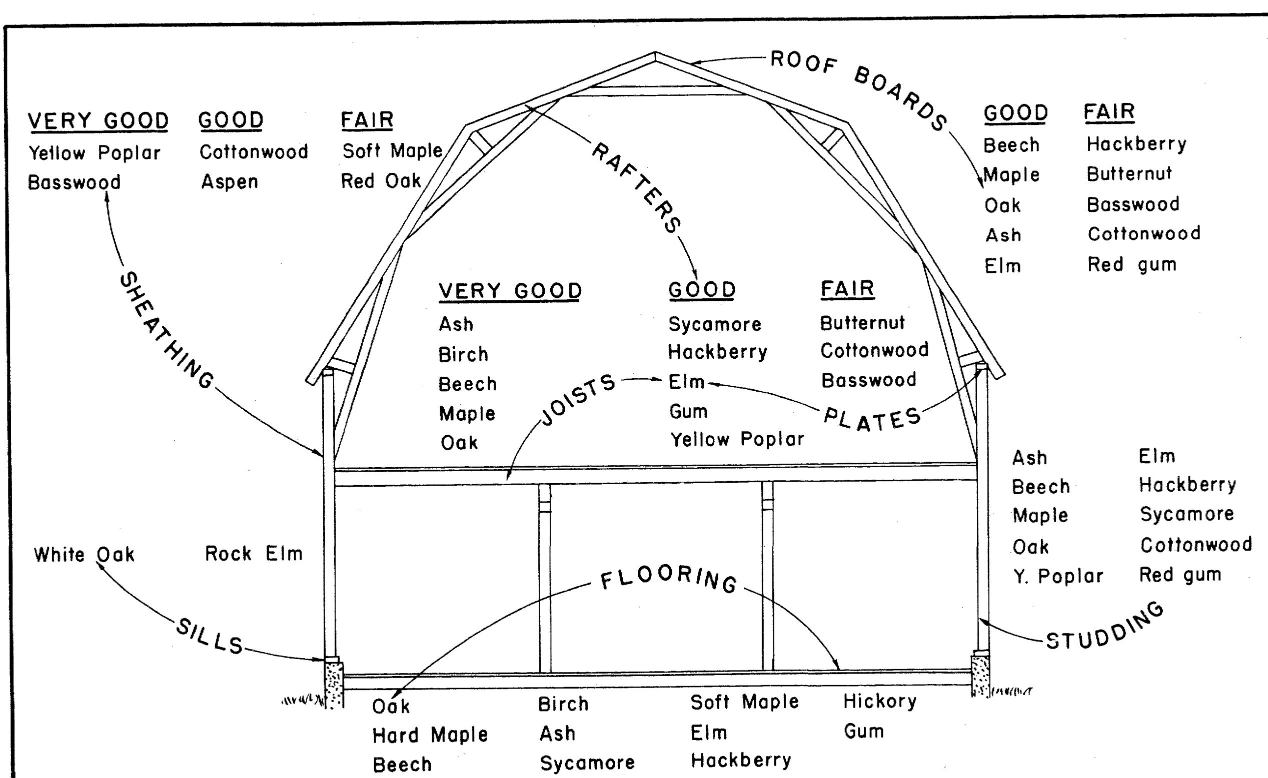
In order to efficiently use home-grown timber, however, the farmer should have a knowledge of its adaptability in construction and its durability and information on methods of wood preservation to extend its usefulness.

LUMBER FOR CONSTRUCTION

The farm woodland containing pine or other conifers can supply the owner with lumber which is ideally suited for construction purposes. Only Douglas-fir, the leading commercial timber of the West Coast, can equal pine in adaptability. Ease of manufacture, seasoning, and working, and strength in proportion to weight and ability to take paint and preservative treatment are factors that favor the softwoods over the hardwoods for general construction.

The terms "softwoods" and "hardwoods" describe products from coniferous and broadleaf trees respectively. This convenient separation is not literally accurate because some southern pines and tamarack (softwoods) actually may be harder than aspen or yellow poplar which are called hardwoods.

In spite of the advantages of softwoods, locally processed hardwoods are available to farmers at considerably less cost and are as well adapted to many farm uses as the usually more expensive coniferous species. In fact, white oak for sills and any of the oaks,



hard maple, birch, or beech for flooring are superior to the softwoods. The drawing on page 59 shows the relative adapatibility of some of the more common hardwoods to farm building construction, and suggests where some of the so-called less desirable species can be used for rough construction.

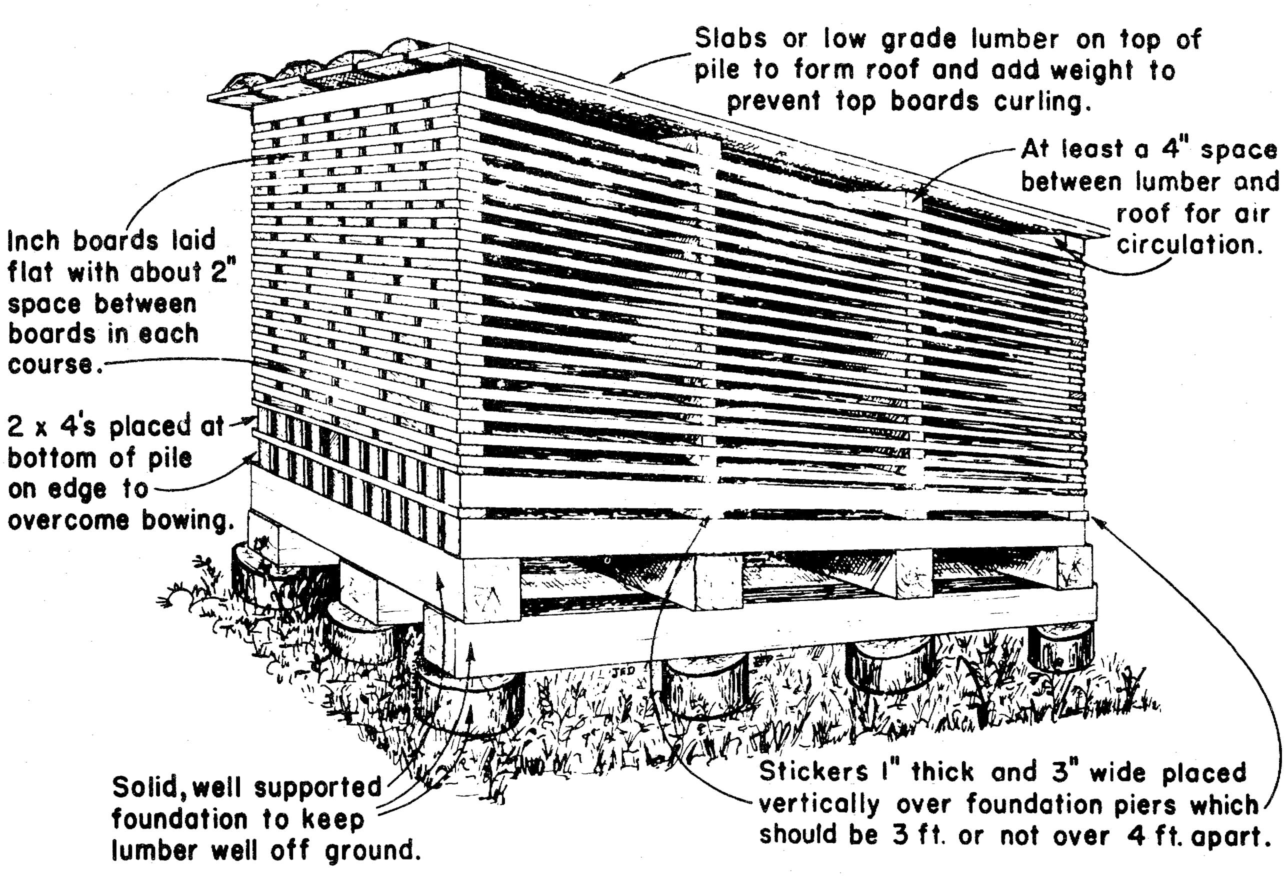
Home-grown hardwood lumber in framing, siding, and roofing of buildings does not exhaust the possible uses of wood on the farm. There are many other everyday needs such as bridge planks, stalls and stanchions, wagon boxes and tongues, bolsters, eveners, and dozens of minor uses. Every farmer knows the convenience of having a stock of seasoned material on hand for the repairs of buildings and equipment in emergencies. When there is hay to get in or grain to be threshed, there usually is not time to go to town to buy material for repairs.

Because of the commercial practice of specifying that lumber be cut from "sound, live trees," the idea has developed that material cut from dead trees is unusable. The fact that the tree was dead when cut is immaterial; the important consideration is whether the wood is free from decay or other defects which render it unsuitable for use. Sound lumber cut from trees killed by insects, disease, fire, or windfall is as good for most structural purposes as that cut from live trees, provided it is not decayed or badly checked.

If lumber cannot be used within a few days after it is sawed from the log, it must be properly piled to prevent warping and twisting. Much locally-sawed lumber is unfit for use because of improper handling. Hardwoods are especially subject to warping, and because the sawyer or the consumer has piled it improperly, home-produced hardwood lumber has not had a good reputation.

The principles illustrated in the accompanying figure will eliminate many of the mistakes that are made in curing green lumber. Good piling takes more care and time, but it more than pays its way in quality of product. Future time-saving and convenience also can be assured by making separate piles for different species and varying lengths, because a board from the top of a pile is much easier obtained than one from the bottom.

The amount of time required to thoroughly air-dry lumber varies by species, thickness, and local climatic conditions. When lumber has lost all but 15 to 20 percent of its



moisture, it is said to be "air-dry" and is a stable product under average conditions in the eastern United States. The time required to air dry 1 inch boards (properly piled) is as follows:

	Days
White oaks................	240-300
Red oaks, cypress.........	180-240
Birch, beech, maple, cherry hickory	150-200
Red gum, black walnut......	100-160
Ash, elm, chestnut.........	80-120
White pine, hemlock........	60-120
Yellow poplar, cottonwood, southern pine...........	40- 80
Basswood..................	30- 60

The best commercially kiln-dried lumber has but 6 to 8 percent moisture, but after the lumber has been nailed in place for a short period, there is no difference in the strength as a result of the method of drying.

Piling and seasoning are unnecessary for many purposes of rough construction, provided the lumber can be used as soon as it is sawed and is not permitted to get out of shape. Hog houses, sheds, cribs, and other outbuildings are commonly put up with green lumber. The vertical members of barns also can be used green, and there is no great objection to unseasoned joists, provided they are given support and bracing until they are dry. Seasoning is essential, however, for any construction that requires a tight match, such as flooring and siding.

One of the biggest advantages of using hardwoods before seasoning is the ease of nailing. Dense heavy lumber is difficult to nail satisfactorily when dry, not only because the nails are harder to drive, but also because the lumber has a tendency to split and to warp. Nailing difficulties in hardwoods can be minimized by several methods: Using blunt-pointed nails, placing warped boards so as to obtain maximum bearing surface at the point of nailing, using a wedge or shim to furnish a temporary bracing when nailing at the point of warp, and waxing nail points so they will drive easier.

After lumber has been seasoned there is no difference between the strength of the sapwood and the heartwood. In fact, the strength of all wood is roughly in proportion to its specific gravity. The width of the growth rings also furnish an indication of strength. In a given species of hardwoods, the wider the annual rings, the greater the strength. But the reverse is true in softwoods; here wide rings indicate weakness and the strongest timbers are those from slow-growing trees.

Although farm buildings usually are constructed by following detailed plans and specifications, frequently it is desirable to estimate the lumber requirements of different types of buildings. Table 20 adapted from material furnished by the Missouri Extension Service, will be found helpful in obtaining the approximate number of board feet required to construct specific kinds of farm buildings.

TABLE 20.--*Conversion factors to be multiplied by cubic contents to obtain board feet* [1]

Type of building	Construction lumber	Finished lumber
Two-story general-purpose barn (55,000 cu. ft.)	0.41	0.063
Hay and feeding barn (64,000 cu. ft.)	.39	.034
Two-story dairy barn (58,000 cu. ft.)	.49	.048
Sheds -- sheep, machine, cattle (10,000 cu. ft.)	.45	.026
Double corn crib (2,000 bu. -- 11,000 cu. ft.)	.55	.016
Granary (2,000 bu. -- 3,000 cu. ft.)	.90	.380
Garage (1 car -- 2,200 cu. ft.)	.46	.720
Milk house (2 room -- 1,500 cu. ft.)	.61	1.03

[1] For the 3 barns: For every 10 percent increase in cubic contents, decrease lumber by 2 percent and vice versa. For the other types: For every 10 percent increase in cubic contents, decrease lumber by 4 percent and vice versa.

An example of the practical application of this table would be the case of a farmer who wanted to know if he had enough standing timber to build a two-story general purpose barn, 34 by 60 feet, and 16 feet to the eaves. Thus, the cubic contents of such a barn are about 50,000 cubic feet, including the gambrel roof. Then,

50,000 x .41 = 20,500 bd. ft. of construction lumber, and 50,000 x .063 = 3,150 bd. ft. of finished lumber, or a total of 23,650 bd. ft.

However, this barn has 10 percent less cubag than the one to which the converting factor applies; hence, it is necessary to add 2 percent of the indicated total, making a total in excess of 24,000 board feet. The prospective builder then could answer his question by estimating the board foot contents of his standing timber (page 65), and comparing against his needs.

DURABILITY OF WOOD

Decay in wood is caused by fungi, which feed upon cellulose or lignin and gradually succeed in breaking down the wood structure. Four conditions are necessary for fungus growth: Air, warmth, moisture and the food supply which all species of wood furnish to a greater or lesser degree. Wood, therefore, will not decay if kept uniformly dry or continuously cold or submerged in a liquid. Under ordinary conditions of use there is always sufficient air, and during most of the year sufficient heat; hence, moisture is the greatest influence on fungus action.

The sapwood, of all kinds of timber, has low resistance to decay. The durability of heartwood is extremely variable, depending on the species, density (weight), temperature, available moisture, and the kind of fungus. With all these variables affecting decay it will be recognized that the comparison given in the table is relative. In fact, variations within the same species are so great that the groupings overlap, hence, the necessity of placing some kinds of wood in two groups.

Comparative durability of heartwood under conditions favoring decay (alphabetical -- not in order of durability):

Group I (very durable)	*Group II (intermediate)*	*Group III (nondurable)*
Catalpa	Elm, red	Aspen
Cedars	Douglas-fir	Basswood
Chestnut	Larch	Cottonwood
Cypress	Pine, white	Willow
Locust, black	Pine, southern	
Mulberry	Red gum	
Osage-orange		
Redwood		
Walnut, black		

Group I or II	*Group II or III*	
Douglas-fir (dense)	Ash	Maple
Locust, honey	Birch	Oak, red and black
Oak, white and bur	Elm, white	Yellow poplar
Pine, southern (dense)	Hickory	Spruce
	Sycamore	

The decay resistance of posts is of special interest to farmers because of the labor involved in maintaining fences. From experience farm operators generally are familiar with the wide range of decay resistance in the various kinds of wood. The effects of seasoning, time of cutting, and peeling posts on durability are not so well known. Here are some comparative figures on the durability of untreated fence posts.

Comparative durability of untreated fence posts:

	Years		Years
Osage-orange	30	Cherry	10
Black locust	25	Ash	7
Red cedar	20	Red elm	7
N. white cedar	15	Red and black oak	6
Catalpa	15	Willow	5
Mulberry	15	Aspen and cottonwood	4
Chestnut	15	Jack and Scotch pine	4
Bur oak	15	Red pine	4
White oak	12	Shortleaf pine	4
Walnut	10	Hickory	4
Sassafras	10	Sugar maple	3
Tamarack	10	Birch	3

Contrary to the popular belief, peeled unseasoned fence posts placed in the ground as soon as cut are as durable as seasoned posts. This is understandable from the fact that the amount of moisture eventually contained in the post will depend on the amount in the ground. A seasoned post will absorb ground moisture and a green post will give off moisture. Within a few months both posts will contain the same amount, regardless of their original condition.

Peeling posts is desirable with the less durable species. The bark allows moisture to collect, thus creating conditions favorable to decay. The amount of moisture in freshly cut heartwood does not vary appreciably by seasons. Nevertheless, it is preferable to cut posts and other round material in the fall and winter rather than in late spring and summer; there is less checking and less fungus and insect activity during cool weather.

Although there is no scientific evidence showing that rate of growth has a significant bearing on resistance to decay, numerous observations indicate that posts from fast growing trees with wide annual rings are less decay-resistant than posts from slower growing trees.

WOOD PRESERVATION

The rate of decay in wood can be greatly reduced by impregnating the cells with a preservative. In principle, the preservative oil or salt simply poisons the food supply of the fungus which would cause the wood to decay. The strength of the wood is not affected by the treatment.

There are many kinds of preservative oils and salts, and as many methods of getting them into the wood cells. Commercial treating plants load railroad ties, piling, or other timbers on special trucks, run them into large tanks, and force the preservative into the tanks under pressure. Regardless of the preservative used, or the many variations of this process, wood so handled is known as "pressure treated."

Less elaborate methods, such as those outlined below, are the only ones that find application on farms, even though the depth to which the preservative will penetrate with nonpressure methods is not so great as with pressure treatments. In considering the desirability of any home treatment, however, first recognition must be given to the degree which various species of trees will absorb the preservative.

The heartwood of most species, except the pines, is relatively impenetrable by nonpressure methods. The degree of penetration, therefore, depends on the amount of sapwood and the rate at which it will absorb the preservative. An attempt to home-treat the species having a poor rate of sapwood penetration would meet with questionable success.

Relative penetration of preservatives, sapwood only:

Good	*Moderate*	*Poor*
Beech	Aspen	Ash
Elm, red	Birch	Basswood
Red gum	Black gum	Balsam fir
Red oaks	Cherry	Butternut
Pines	Cottonwood	Green ash
Sycamore	Elm, white	Hemlock
Tupelo gum	Hackberry	Hard maple
	Hickory	Yellow poplar
	Soft maple	Spruce
	White oaks	Tamarack
	Willow	

Hot and cold bath. The material to be treated is heated in coal-tar creosote in an open tank to temperatures ranging from 180° to 220° F. for 2 hours or more, depending on species. The heating causes some of the air and moisture in the wood cells to be driven off, but in itself does not give the desired penetration of preservative.

The wood is then removed and placed into another tank containing cold creosote, although the word "cold" is used only in a relative sense. Actually, the temperature should be about 80° to 100 °F., or high enough to result in thinning the oil. This cooling process permits the preservative to fill the wood cells from which air and moisture have been eliminated. The wood should be left in the cool bath about the same length of time as in the hot. Equal parts of fuel oil and creosote can be used in the cold bath for economy. Where only a small amount of wood is to be treated, the process can be done in one tank. The posts are left in the tank overnight and permitted to cool gradually. The fire can be rekindled the following day, a new batch treated, and again allowed to cool.

Wood treated by this process must be entirely free of bark, which means that with posts, peeling, to be economical, must be done on freshly cut material in May or early June. Also, penetration will be deeper and more complete if the wood is thoroughly seasoned. Assuming good penetration, three round posts, butt-treated only, will absorb about one gallon of creosote.

A relatively new preservative, pentachlorophenol, promises to be a good substitute for creosote. It is a crystalline organic compound used in about 5 percent solution with petroleum oils, like kerosene or fuel oil. It is available in solution under various trade names. Penetration is equal to creosote; in fact, cold soaking for 48 to 72 hours appears to give a satisfactory degree of absorption for species listed under "good" in the table above.

The osmose process compares favorably with other nonpressure methods, according to tests with the southern pines. Sodium fluoride and sodium or potassium carbonate are the basic ingredients which are applied to green and freshly cut material in the form of a thin paste. The wood is then closely piled and covered with watertight paper, in which state it is left for 2 weeks to 3 months, depending on the thickness of the wood. During that period the salts in the paste gradually diffuse with the water in the wood cells by osmosis.

The preservative has been used commercially in the United States since 1930, and is sold under proprietory names by at least two companies. Its desirable features are easy application with no special equipment, no fire hazard, and the treated wood is left odorless, paintable, and clean.

Tire-tube method. This method is adapted primarily for fence posts or other round material which can be treated green with the bark intact. A water-soluble preservative such as zinc chloride is used at the rate of about 1 pound of dry salt per post. The principle involves the replacement of the living sap in the tree by the salt solution; later evaporation through seasoning leaves the salt deposited in the wood cells. The expected life of species such as aspen, birch, or pine can be extended by 10 to 15 years. The details of the method are described in a leaflet, Tire-tube Method of Fence Post Treatment, Forest Products Laboratory, Madison, Wis.

Where water-soluble preservatives are used, the steeping process is probably as effective as any and is generally simpler. Seasoned material is submerged and soaked, with or without heating, in the preservative solution for about 1 week. See Preservation of Timber by the Steeping Process, Forest Products Laboratory, Madison, Wisconsin.

REFERENCES

Selection of Lumber for Farm and Home Building, USDA Farmers' Bulletin 1756.

Selecting, Seasoning, and Using Home-Grown Lumber, Wisconsin College of Agriculture Extension Service Special Circular, [Mimeographed.]

Piling and Seasoning Iowa Native Lumber, Iowa State College Extension Service.

Using Home-Grown Timber for Farm Buildings, Minnesota University Agricultural Extension Bulletin 238.

Better Lumber Through Good Piling, Minnesota University Agricultural Extension Folder 104.

How to Pile and Season Native Lumber, Purdue University Agricultural Extension Bulletin 300.

Preserve Your Posts with Penta, Illinois College of Agriculture Extension Circular 636.

The Durability of Fence Posts, Missouri Agricultural Experiment Station Bulletin 312,

The Preservative Treatment of Farm Timbers, USDA Farmers' Bulletin 744.

Longer Durability for Fence Posts and Farm Timbers, Iowa State College Extension Bulletin 109.

For complete technological discussion of wood in construction, see "Wood Handbook," prepared by U. S. Forest Products Laboratory. Available from Superintendent of Documents, Washington, D. C., 25 cents.

WOODLAND MANAGEMENT

Stripped of all its technical implications, woodland management on the farm is simply the wise use of the woods. If a farmer is protecting his woodland from fire and grazing, if he is practicing good silviculture, and if he is harvesting products to get the most out of his timber, he has already taken the first and most important steps toward good management. There is no reason, therefore, to introduce the word "management," except as it covers some additional information required for orderly cropping. An inventory of the standing timber which is important in harvesting and marketing, an estimate of the amount of wood products produced annually, and a simple plan for annual or periodic harvests, are further requirements for the intelligent handling of merchantable wood products.

MEASUREMENT OF STANDING TIMBER

Before orderly management can be applied to any type of land, property, or business, an inventory of the physical conditions, products, or assets should be available. In the farm woods an essential part of such an inventory is an estimate of the amount of timber on the land. The inventory is expressed in board feet, cords, cubic feet, or pieces of some specified product per acre. It also may be designated in total square feet of basal area[10] of all trees per acre. A breakdown of numbers of trees into species and diameter classes usually is made.

At best, any timber inventory is an estimate. The lack of uniformity of trees, species, and growing conditions in different parts of the woods makes it impossible to get an exact figure unless each tree is measured. Furthermore, the unit of measurement itself is frequently expressed in terms of a product which requires processing before the exact volume is known.

Methods of estimating timber are many and varied. The early day timber estimator simply walked through the woods, and with little, if any, recording made a mental estimate of the amount of timber on the land. His experience permitted him to make a comparison with previously logged tracts from which the volume had been measured after cutting. Based on experience in previous years, his method was the same as used by farmers in anticipating the yield of corn and grain per acre.

Present-day estimating methods with valuable species may be detailed to the extent that every merchantable tree is examined and recorded. Experienced timber buyers can visualize the number and length of logs that will be cut from a standing tree, and estimate the diameter inside the bark of the small end of each log. Then by consulting a table showing the contents of logs of different sizes (Appendix C), they arrive at the total volume.

Unless there are exceptionally high values involved, however, the timber inventory or cruise most often is made by measuring and recording the trees standing on a number of mechanically selected plots. By applying the volume recorded on the sampled areas to the total acreage of woodland, the gross volume can be obtained. Table 21 furnished by the Lake States Forest Experiment Station will give the recommended percentage of cruise, in accordance with the woodland area and the percentage of accuracy desired.

TABLE 21.--*Recommended percent of cruise*

Acres to be estimated	Sampling error (percent) 2	3	4	5	6	10	15	20	25
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
10	--	--	--	70	44	33	18	11	8
20	--	73	61	50	29	20	10	6	--
40	76	58	44	33	16	11	5	3	--
80	61	41	29	20	9	6	3	--	--
160	44	26	16	11	5	--	--	--	--
320	30	15	9	6	2	--	--	--	--
640	20	8	5	3	--	--	--	--	--

Thus, if one-fifth-acre plots are to be used to estimate the volume of timber on a 40-acre woodland, with a sampling error of 10 percent, the above table indicates that 11 percent of the woodland should be sampled. The value of the product to be estimated should guide the accuracy desired. A woodland containing valuable products should be estimated with a sampling error of 5 percent; one consisting of small-sized, low-grade timber might be sampled with an error of 20 percent or more

One of the most common estimating procedures is known as the "line-plot" method.

[10] Basal area: The area in sq. ft. represented by the cross-section of the stem of a tree, 4½ feet (breast high) from the ground. (D^2 in inches x .00545.)

This method is relatively simple to execute, is adapted to any kind of timber, and permits one man, if necessary, to work alone. Its essential steps are outlined below:

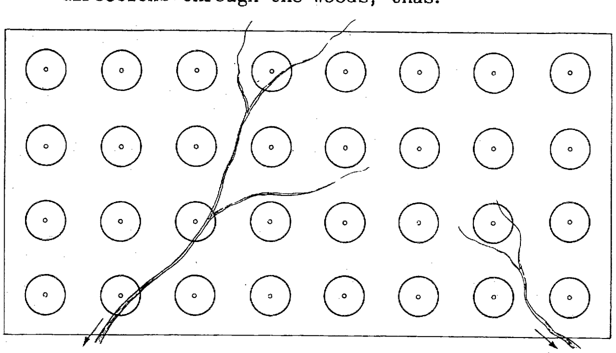
(1) The following material is required:

(a) Outline map of the woodland to be cruised.
(b) A compass to keep directions.
(c) Measuring tools to get tree diameters and heights.
(d) Pencil.
(e) Engineers' or surveyors' scale.
(f) Paper in a stiff-backed pad or holder.
(g) Measuring tape if ground distances cannot be paced accurately.

(2) Determine the total woodland area from the map and decide on the size of the circular sample plots. One-fifth acre plots are more convenient, although quarter-acre plots are commonly used in open woodland and in large timber. (See Appendix A for plot dimensions.)

(3) Determine the number of plots necessary to give the desired accuracy. Table 21 will be helpful if one-fifth acre plots are used. For example, if the table shows that 16 percent of a 40-acre woodland should be sampled, it means that 32 one-fifth acre plots should be taken (.16 x 40 x 5).

(4) Plot the location of each sample on the outline map, so that the plots will be regularly distributed over the woodland. The plots should be uniformly spaced, and generally lined up in cardinal directions through the woods, thus:



(5) Locate a convenient starting point on the border of the woodland. With the compass determine the direction the first line of plots is to follow.

(6) Scale off the distance from the starting point to the center of the first plot, and by measuring or pacing this distance along the line established in (5), mark the center of the first plot.

(7) Measure the diameter at breast height (4½ feet, known as d.b.h.) and the merchantable height of each tree growing within the radius of the plot. Merchantable height is that part of the stem, above the stump, which is usable for the product being estimated.

(8) Record the diameter and height of each tree separately by species, in 2 inch classes, on a form similar to the following. Heights also are designated in 16-foot log lengths. Sixteen-inch trees, for example, are any whose diameters measure from 15.0 inches to 16.9 inches.

d.b.h. inches	Species and merchantable heights																	
	Pine						White and red oak						Others					
	16	24	32	40	48	56	16	24	32	40	48	56	16	24	32	40	48	56
12																		
14																		
16																		
18																		
20																		
22																		
24																		
26																		
28																		
30																		

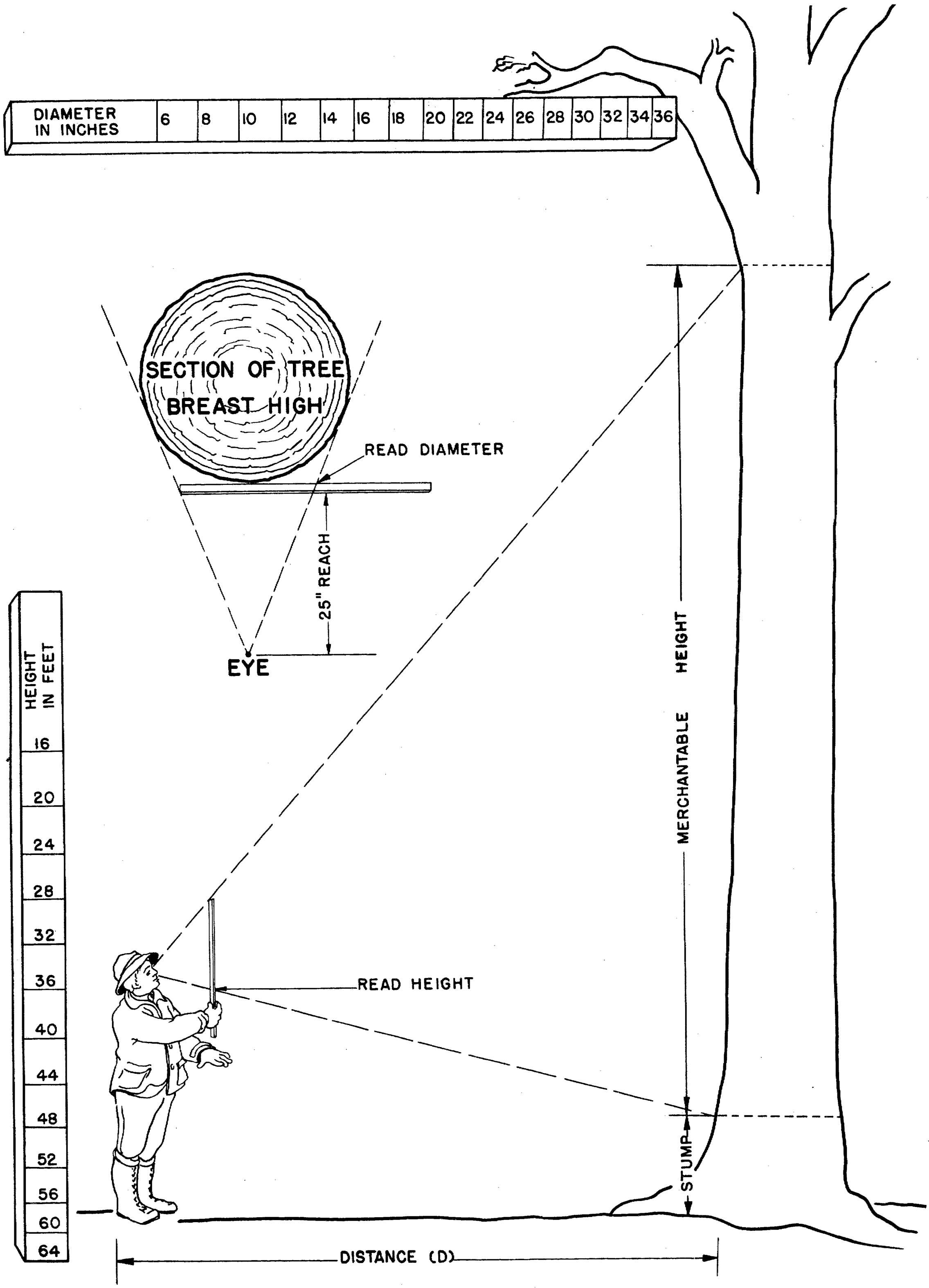
One form for keeping tree measurements. Each tree is recorded by a dot or a dash in the square corresponding to its breast-high diameter (d.b.h.), and its merchantable height.

(9) When all trees on the first plot have been measured, continue on the line established in (5), and repeat steps (7) and (8) for all the remaining plots.

(10) After all plots have beem measured, the volumes of the trees are determined by means of a volume table (Appendix J), which gives the contents of standing timber of known diameters and heights. Having the volumes of the trees on the plots, and the percentage of the total area the plots represent, the total volume of the woodland can be readily calculated.

Steps (8) and (10) may be modified if cumulative tally sheets are available. These forms are designed to permit recording directly in board feet or cords and make the use of volume tables unnecessary. They are available with instructions for use from a number of State and Federal forestry agencies.

A simple tool, known as a cruiser stick, sometimes called a Biltmore stick, is very handy for measuring tree heights and diameters. Some State extension foresters supply them through county agents, they can be purchased, or can be home-made by graduating any straight stick to read diameters on one side and heights on the other (table 22). The principles governing the use of this tree-measuring tool are showin in the illustration.



Illustrating the use of a cruiser stick to measure diameters and heights of standing timber.

TABLE 22.--*Markings for cruiser stick (25-inch reach)*

Tree diameter (inches)	Mark on stick	Tree height (feet)	Mark on stick	
			For 60 feet	For 66 feet
	Inches		*Inches*	*Inches*
6	5 3/8	16	6 5/8	6 1/8
8	7	20	8 1/4	7 1/2
10	8 1/2	24	10	9 1/8
12	9 7/8	28	11 5/8	10 3/4
14	11 1/4	32	13 3/8	12 1/4
16	12 1/2	36	15	13 3/4
18	13 3/4	40	16 3/4	15 1/4
20	14 7/8	44	18 3/8	16 7/8
22	16	48	20	18 1/2
24	17 1/8	52	21 5/8	20
26	18 1/4	56	23 1/4	21 1/2
28	19 1/4	60	25	23 1/8
30	20 1/4			
32	21 1/8			
34	22 1/8			
36	23			
38	24			
40	24 3/4			

If other reaches or distances are desired, the correct markings can be computed from the following formulae:

$$\text{Diameter scale} = \sqrt{\frac{ad^2}{a+d}} = \text{inches from end of stick.}$$

$$\text{Height scale} = \frac{Ha}{D} = \text{inches from end of stick.}$$

In which:

a -- Reach in inches
d -- Tree diameter, inches
H -- Tree height, feet
D -- Distance from tree, feet.

If cruiser sticks are to be home-made, the maker will recognize that the calibrations are dependent on the length of the arm or reach. Commercially manufactured sticks assume an arm's length as 25 inches. On the height side of the stick, the marking also will depend on the distance from the tree.

Like many other woodland practices, the theory of estimating timber is simple. The inexperienced estimator, however, cannot expect to obtain truly accurate results. First of all, the degree to which the tree is to be utilized must be known. In the case of lumber this requires a knowledge of saw-milling practices in the region. Then, there are hidden defects in most trees which can be recognized only by experienced timbermen. Even though care in measuring and recording has been taken, the estimator has to make deduction for the rotten, checked, or otherwise unusable portion of the gross volume. This deduction is known as the cull percent, which may run as high as one-third of the total estimated volume.

The volume tables used are another source of error. Those included in Appendix J are averages of thousands of measurements obtained from trees that had been cut. If they are applied to single trees that differ from the average, they commonly will indicate volumes that are inaccurate. These inaccuracies are primarily the result of differences in the taper of tree trunks. Short-stemmed, rapidly tapering trunks actually contain less volume than the tables indicate. Long-bodied trees, whose top diameters are but little less than the d. b. h. will contain more board feet or cords than shown in the tables.

DETERMINATION OF CUT

A farmer's woodland is similar to other forms of invested capital. The growing stock of trees is the principal; what it produces each year in growth is the interest or increment. The object of management is to manipulate the capital or principal so as to obtain the maximum interest. Manipulation of the capital or growing stock means building it up in quantity and quality so as to utilize the capacity of the soil to produce the most wood. Like any other investment, the capital must be maintained if interest is to be permanent.

If a 30-acre farm woods is growing at an annual rate of 60 cubic feet per acre, the farmer theoretically can harvest 1,800 cubic feet in sawlogs, poles, pulpwood, fuel, or other products, per year. Actually, in any one year he might choose to cut more or less than this amount, depending on the farm needs, the outside market, the available farm labor and equipment, the silvicultural condition of the woods, and perhaps other factors. Over a period of years, however, cutting in excess of growth will reduce the growing stock (capital) and consequently, the increment (interest). Cutting less than the annual growth will not yield maximum interest on his capital. In order to avoid overcutting or undercutting -- in short, to maintain efficient production year after year indefinitely -- the woodland owner should know the volume of timber that is being produced annually.

For a given type (kind) of timber, the productive capacity of woodland is primarily dependent on three factors: (1) Soil condition, particularly depth and character of subsoil. (2) Aspect or exposure which influences the soil moisture. (3) Density of the trees or the degree of stocking, which may be measured in terms of basal area per acre.

With a knowledge of these three factors, a rough estimate of what a given farm woodland will produce annually can be obtained from table 23. It will be found sufficiently accurate for general application in woodland where the principal species are upland hardwoods or northern conifers.

Where other species predominate, the table is not applicable without adjustment. On bottom lands or wet flats supporting soft maple, red gum, or other moisture-tolerant species, yields will be comparable to, or better than, the best loams. A considerable amount of tulip poplar (25-50 percent) will increase the figures shown by one-half. Fifty percent or more of cottonwood may double the best production shown in the table. Thinnings cut from

TABLE 23.--*Approximate annual production of upland hardwoods per acre*

Soil	Northeast, north, and northwest slopes or flats[1]: Degree of stocking			Southeast, south, and southwest slopes: Degree of stocking		
	Good	Medium	Poor	Good	Medium	Poor
	Cubic feet	*Cubic feet*	*Cubic feet*	*Cubic feet*	*Cubic feet*	*Cubic feet*
Loams:						
Pervious A and B horizons, 5 feet or more deep.	70	52	35	55	40	25
Somewhat impervious B horizon; 2 to 5 feet deep.	50	37	25	30	22	15
Very impervious B horizon;[1] or less than 2 feet deep.	30	22	15	20	15	10
Sands:[2]						
Relatively moist during growing season.	60	45	30	40	30	20
Dry; very little sub-surface moisture during growing season.	30	22	15	15	12	8
Rocky soils:						
Deep, pervious. Large rock fragments do not occupy more than 25 percent of soil.	60	45	30	40	30	20
2 to 5 feet deep. Large rocks occupy 25 to 75 percent of soil volume.	40	30	20	20	15	10
Very shallow. Large rock fragments comprise more than 75 percent of soil.	20	15	10	10	5	0

[1] Flat land includes all slopes under 15 percent. Consider highly impervious soils on flat land as south slopes.
[2] If impervious material is close to surface, yields will be reduced proportionately to those shown for loams.

small trees and tops from logging are excess and are not charged against growth.

An example of the use of the table: A mixed-oak woodland lies on a generally south-facing slope and is growing in a moderately compact loam. It is well stocked with trees over 4 inches in diameter, (over 75 square feet basal area per acre). The table shows an approximate annual production of 30 cubic feet of wood. This is equivalent to 150 board feet, 0.39 cord, 30 fence posts, or 6 ties. (Appendix B.)

The conversion of cubic feet to other units of volume requires some judgment and an application of common sense. If a farm woods had an indicated production of 50 cubic feet per acre annually, one would not recommend a yearly cut of 250 board feet (50 x 5) per acre if the trees were too small to be used as sawlogs. In fact, if a converting factor of 5 is used, a considerable part of the cut would have to come from trees of 20 inches or more in diameter. (See explanation, Appendix B.)

Similar reasoning must be exercised in converting to cords. Straight smooth pieces 6 to 12 inches in diameter have approximately 90 cubic feet of solid wood; crooked limb wood, less than 6 inches in diameter may have only 60 cubic feet per cord.

With the many variables affecting rate of growth in woodland, it is apparent that these generalized figures assume no high degree of accuracy. Applicable local yield tables are seldom available for farm woodland, and in absence of better information, table 23 will serve to guard against unrestrained and promiscuous cutting. Furthermore, it demonstrates the relative importance of site and stocking as related to timber growth.

REGULATION OF CUT

By definition, regulation is the development of a woodland in order that it can produce an annual, sustained income. By application to a farmer's woods, regulation is no different than the field arrangements made on cropland meadows, and pasture so as to provide uniform amounts of corn, grain, hay, or pasture each year. It is merely a part of good farm management.

Regulation modifies utilization and is inseparable from silviculture. All members of the triumvirate are interrelated in their practical application. Thus, the three steps for continued economical management of any woodland are:

(1) Silviculture: Eliminates worthless trees or weeds; gives good trees sufficient growing space; encourages reproduction of desirable species. (Note the interrelation of silviculture with utilization in the definition of "worthless," "good," and "desirable.")

(2) Utilization: Salvages merchantable portions of trees that are misformed and show decay; takes thinnings for fuel, posts, pulp, and props; harvests marketable trees of sizes and species that bring the highest value. (Note again how silviculture is involved.)

(3) Regulation: Provides for continuous wood crops indefinitely, through the right kind of silviculture and utilization.

The first obvious requisite of a farm woods capable of producing a regular income is a reasonably good distribution of sizes of trees. If all the trees are too small to utilize, it is apparent that no income will be derived until they are large enough to cut. If most of the trees are old, heavy cutting will result in a depletion of the growing stock sometime in the future, because of an absence of younger trees to replace them.

Table 24 will furnish a guide to what may be considered as a well-stocked average acre[11] of woodland having a good distribution of sizes.

[11] Intolerant species, p.8, tend to grow in approximately even-aged stands, hence any single acre never would develop in the manner shown. The table attempts to depict an *average* acre over the woodland as a whole and not a specific plot.

Stands of Virginia pine, jack pine, and the northern swamp species which do not attain the larger diameters shown in the table will have proportionally greater numbers of trees in the lower diameters.

Not many farm woods will duplicate this distribution; in fact, exact duplication is both impossible and unnecessary. The diameter classes in the well-managed southern Michigan woodland shown in the figure on page 11, will vary considerably from the above. The fractional difference is unworthy of concern.

TABLE 24.--*Number of trees by diameters on a well-stocked average acre*

Diameter (inches)	Trees	Basal Area
	Number	*Square feet*
4	60	5.2
6	40	7.8
8	30	10.5
10	20	10.9
12	15	11.8
14	10	10.7
16	7	9.8
18	5	8.8
20	3	6.5
22	2	5.3
24	1	3.1
26	1	3.7
Total	194	94.1

Any woodland which has 75 to 100 square feet of basal area per acre and roughly approximates this range of sizes may be considered satisfactory. Unmanaged woods show heavy concentrations in a few size classes and deficiencies in others. The objective of regulation is accomplished by taking the allowable annual cut from the age groups that are high, and cutting but little material from those that are deficient. When sizes are well-distributed, and when good silviculture and utilization are being practiced, regulation in the farm woods becomes more or less automatic with regular harvests of the periodic growth.

MANAGEMENT PLANS

A woodland management plan is a cropping plan for the farm woods. In addition to the universal requirements of protection, it may cover recommendations for silvicultural treatment. It may give a sequence of cutting, how much should be cut, suggestions as to size and kind of trees to be harvested. Above all, it should be brief. Elaborate typewritten plans which are handed to the farmer with the expectation that he will read and apply the recommendations have proved ineffective.

The extent and degree to which management recommendations are pertinent depend on the character of the woodland. For purposes of management, any farm woodland will fall in one of five classes:

(1) Small patches of woodland (less than 10 acres), that cannot permanently supply even the home needs. Recommendations should cover only protection and close utilization so as to insure production as long as possible. How much is growing is important only to the extent that it will indicate that growth is less than home requirements, and that the farm needs more woodland or restricted use, if annual cutting and growth are to balance.

(2) Woodland on farms where home use is unimportant, such as in coal producing centers, where no periodic harvest is contemplated, and no good markets exist for wood products. The interest of the farmer in such a woodland is confined to use of the products for posts and rough lumber. Probably he cuts posts only as needed, and logs for rough lumber at indeterminate intervals to replace or repair farm buildings. In other words, there is no regular cropping and the woodland's place in farm economy is simply as a reservoir for materials needed in an emergency. Protection and the efficient utilization of species are the only subjects that require consideration.

(3) Probably the most common class of farm woods; the best timber has been removed and most of the remaining trees are culls or are otherwise undesirable. A plan of management for such woodland does not involve rates of growth or suggest the cutting of any particular size of trees. The first recommendation would be to make improvement cuttings as rapidly as possible, putting the land and growing stock in a condition to produce both quantity and quality. Present growth rates and regulation will have no place in this class of woods for a number of years to come.

(4) Woodlands where there are more trees per acre than should be present to insure the best growth as, for example, trees ranging from 16 to 30 inches in diameter, totaling over 120 square feet of basal area per acre. Here again, present growth rate is unimportant. The farmer, to get maximum yields, should first remove the surplus trees which will mean cutting heavier than the indicated productive rate. Overstocked woods may be unproductive as woods that are proportionally understocked.

(5) Woodland that is well-stocked, but not overstocked, with usable trees and large enough to supply at least home needs. The farmer has sufficient interest and knowledge to follow a plan of regular or periodic harvest. Only for this class are complete and detailed management plans involving regulated cutting based on growth applicable.

No great amount of written material is necessary under any of the above conditions. A few paragraphs covering the principal recommendations, plus a supplementary map as a reminder of what the farmer should do in his woods, is all that is needed. The map can be tacked up in a conspicuous place in the barn or toolshed for future guidance.

The sample map and plan shown here is of a woodland in class 5. The farmer, Mr. Olson, for whom this plan was made had been cutting timber for his own fuel and posts for the past 10 years. He had completely covered his 44 acres and had confined his harvest to misshapen and poorly formed trees of the less desirable species; he has been practicing good silviculture. With the help of a forester, he made a cruise of the timber and from the information obtained, the following facts were considered in developing the management plan:

(a) More efficient harvesting operations could be done by working on a small area each winter. The topography indicated ten natural blocks, ranging from 3.5 to 5.5 acres each (5 to 12 blocks would have been equally acceptable). By cutting in one block each year, thus getting over his entire woods in 10 years, he would be handling his wood crop on a 10-year rotation.[12]

(b) The inventory of the average acre in Olson's woodland showed the following distribution of tree diameters:

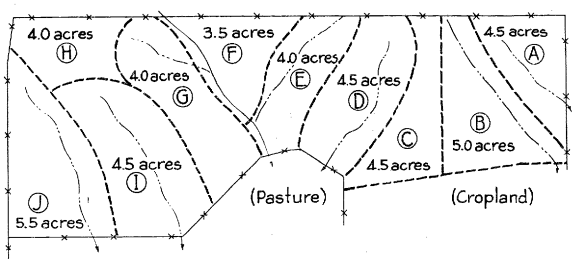
Diameter	*Number of Trees*	*Diameter*	*Number of Trees*
4	16	16	4
6	17	18	4
8	15	20	1
10	30	22	1
12	25	24	1
14	15		

From table 24 there are too many trees in the 10-, 12-, and 14-inch classes, and too few in the smaller and larger diameter groups. The recommendation, therefore, was to cut heaviest in those classes where there was an excess, thereby increasing the proportion of trees in those sizes which were deficient.

[12] Foresters will recognize the word *rotation* as used here should read *cutting cycle*. The operation described corresponds to what is defined in agriculture as a rotation, hence no attempt was made to introduce a new term.

WOODLAND HARVEST PLAN

(JOHN OLSON)
(44 ACRES)



1945-1946 - Cut 15 cords fuelwood (60-70 trees) from Block "A"
1946-1947 - Cut 15 cords fuelwood (60-70 trees) from Block "B"
---and so on each year until entire woodland is covered.

FUEL WOOD - Take from poorly formed trees 10"-14" in diameter. (additional fuelwood from tops of saw log trees, dead trees and thinnings)

FENCE POSTS - Take anywhere as needed for home use.

LOGS - Take when needed or when market is good from oak 16" or more in diameter, at rate of 4,000 bd. ft. per year. It is recommended that this annual growth be permitted to accumulate for about 5 years at which time 20,000 bd. ft. can be cut. (About five 18"-20" trees equal 1,000 bd. ft.

PROTECT FROM FIRE AND LIVESTOCK

(c) The woodland is producing at an annual rate of 50 cubic feet per acre(table 23), or 2200 cubic feet for the 44 acres. Mr. Olson cuts 21 cords of fuel and about 120 posts annually for use on the farm. Reduced to cubic feet (Appendix B), this home consumption amounts to 1800 cubic feet.

(d) Apparently, if Mr. Olson is to cut no more than current growth, there is but 400 cubic feet or 2,000 board feet in excess of home needs. The forester pointed out, however, that there is over one cord of limbs--topwood--for every 1,000 board feet of sawlogs, and another cord or more of fuelwood in each block that can be taken from dead trees and thinnings. These are not chargeable to the growth, hence the annual cutting budget will look about like this:

	Cubic feet
Fuelwood (21 cords):	
15 cords from poorly formed trees	1,200
5 cords from topwood	400
1 cord from dead trees, thinnings	80
Fence posts (120)	120
Sawlogs (4,400 bd. ft.)	880
Total cut	2,680
Topwood, dead trees, and thinnings not chargeable to growth	480
Net growth	2,200

(e) Mr. Olson had no previous experience with sawtimber and did not think of trees in terms of board feet. Neither did he pile his fuelwood and hence did not measure it in cords. The indicated cut, therefore, was given in numbers of trees as well as in volume.

The principles applied to the development of this sample plan are applicable to many other farm woodlands, yet the details of any single plan are bound to be different. No two woods are exactly alike, nor are the farmers who work in them. To be usable the plan must fit the land, fit the timber, fit the farm labor, the needs of the farm and the market possibilities.

WOODLAND ECONOMICS

VALUATION

Most farmers, as well as other private owners, have thought of woodland only in terms of cash value of the standing timber on the land. Not enough attention has been directed to the fact that woodland is capable of producing a wood crop indefinitely in a manner similar to the corn or grain crops on properly managed cropland.

Trees grow and add new wood each year. Once the wood capital has been built up, the source of income can be sustained indefinitely, simply by harvesting the annual growth. A tract of land capable of producing a net income of $2.50 per acre per year is, assuming interest at 5 percent, worth $50 per acre. Therefore, if a purchaser is satisfied with 5 percent on his investment, he can afford to pay $50 per acre for land producing $2.50 annually, whether it be in standing timber, grain crops, or pasture.

Thus, farm woodland as a unit of the farm business is subject to the same economic forces as other parts of the farm. Misused cropland, misused pasture, or misused woodland all deteriorate in value because they are incapable of maintaining a high sustained annual production. The landowner's judgment of land use and value is in direct proportion to his understanding of productive capacity of that land.

A measure of the return possible from handling farm timber as a crop is shown by the records that were kept by woodland owners in Indiana, Iowa, Michigan, Minnesota, and Ohio. Eighty-nine of these records, covering from 2 to 6 years operation, 1940-1945, are summarized (table 25). The three columns represent the average annual return per farm from 25 woods ranging from $3.86 to $66 per acre (high-income group), 25 woods returning from -$3.70 to $0.37 (low-income group), and 39 woods ranging from $0.39 to $3.83 per acre medium-income group.

The accounting procedures used in keeping and summarizing the records were as follows: Income values for products consumed at home were credited in amounts equal to their cost if purchased by the farmer. Noncash expense, which includes the operator's or family labor, team, tractor, and annual depreciation on equipment, were charged at current rates for comparable services. Cash expenses represent actual out-of-pocket costs as a result of the woods operation; similarly, cash income reflects actual returns from sales.

Buzz saws and maple sirup evaporators are the only equipment capitalized, because they are the only types used exclusively in woodland work. Only the operating costs of tractors and machinery purchased primarily for use in other farming enterprises are charged against the woodland. Capital charges also include interest on present value of the land and standing timber. This may be a questionable charge in accounting, when the usual practice is to compute annual interest on the basis of original costs of the property rather than present worth. The justification for departure from the standard practice in farm woodland accounting is that the original cost of the land seldom took the timber values into account. As a rule, the considerations involved in the actual transfer of farm land are based on values for producing annual and forage crops.

In any accounting procedure, inventory increases or decreases must be taken into consideration. With a woodland property, where an owner might show a high return as the result of an overcut of his growing stock, inventory changes are especially pertinent. If the woods capital is stable, as it is under good management practices, there is no drastic change in inventory, hence the necessity of considering volume differences in the growing stock is eliminated. The records summarized, therefore, reflect only regulated timber harvests. If an individual account book showed an exceptionally heavy cut, either the record was discarded entirely or else the returns and the expenditures were adjusted to cover the accounting period.

Stumpage sales require separate consideration in calculating labor return. Obviously, if a farmer sells stumpage with little or no expended labor, his labor return per hour should not reflect the income from stumpage. This explains the reason why stumpage is handled as a separate item of income, later to be deducted from the net profit when computing the labor return.

Three commonly accepted methods of showing monetary returns from agricultural use of land are: (1) Annual net profit per acre or per farm, (2) rate of interest earned by the investment, and (3) operator's return per hour of labor.

The first two consider the farm as a business and consequently are adapted to commercial agriculture. They appeal to the owner of a tenant-operated farm. In the woodland phase of the farming operation, however, the third method has some advantages over the other two.

TABLE 25.--*Average annual income and expense of 89 farm woodlands, Indiana, Iowa, Michigan, Minnesota, and Ohio*

Item	High-income woods (25)	Medium-income woods (39)	Low-income woods (25)
	Dollars	*Dollars*	*Dollars*
1. Home-use income:			
(a) Posts	5.99	5.96	9.93
(b) Lumber	50.58	49.56	28.02
(c) Fuel	93.83	85.33	69.11
(d) Other	5.74	1.49	.57
Total	156.14	142.34	107.63
2. Income from sales:			
(a) Posts	2.80	2.56	2.96
(b) Logs and lumber	25.50	6.05	1.44
(c) Fuel	55.95	6.10	3.91
(d) Other	350.17	2.25	6.31
Total	434.42	16.96	14.62
3. Stumpage sales	103.46	24.66	2.60
4. Total gross income	694.02	183.96	124.85
5. Noncash expense:			
(a) Labor	102.04	43.43	48.70
(b) Team	23.58	6.68	7.24
(c) Equipment operation	11.69	5.00	4.34
(d) Equipment depreciation	13.69	2.11	2.00
Total	151.00	57.22	62.28
6. Cash expense:			
(a) Labor	25.71	7.61	7.68
(b) Tools and Equipment	.67	.12	.20
(c) Processing	15.78	14.39	7.86
(d) Materials	17.99	1.88	4.16
Total	60.15	24.00	19.90
7. Taxes	14.21	8.13	10.01
8. Interest (capital value @ 3 percent)	111.54	37.08	46.27
9. Total expense	336.90	126.43	138.46
10. Net income[1]	357.12	57.53	-13.61
11. Area in average farm--acres	246	192	272
12. Area in managed woods--acres	42	30	58
13. Capital value, woodland, growing stock and equipment--dollars	3,718.00	1,236.00	1,542.00
14. Net return per acre[2]--dollars	8.50	1.92	-0.23
15. Rate of interest earned on capital[3]--percent	12.6	7.6	2.1
16. Return per hour of labor[4]--dollars	1.33	.67	.26

[1] Line 4 minus line 9.
[2] Line 10 divided by line 12.
[3] (Line 8 plus line 10) x 100, divided by line 13.
[4] Sum of lines 10, 5a and 6a minus line 3, divided by total man-hours of labor as follows: High income, 287 man-hours; medium income, 125 man-hours; low income, 153 man-hours:

For example, as a means of selling farm-woods management, it is more convincing to say, "For every hour you work in your woods, Mr. Farmer, you earn $1.35," than to tell him he earned 12 percent on his investment. It is something tangible, something understandable to anyone who has worked for wages. Also, a dairy farmer who obtains 75 percent of his net income from operations connected with the sale of milk, but only 8 percent from his woodland products, will not be impressed with the woods enterprise. This same farmer's record shows, however, that he nets only $1.00 per hour from his dairy operations as against $1.75 for the time he spends in the woods.

In spite of favorable factors of hourly returns, agricultural accountants recognize that woods work and the labor income therefrom is supplemental to the labor of other farm operations. It competes only as the use of land competes and it is impossible for a farmer to be productively employed during the entire year in a small patch of woods.

In final analysis, therefore, woodland management will be sold on the basis of giving the highest return for the use of certain land. That this land generally consists of the least productive soil of the farm, plus the fact that woods work can be done at any time of year to supplement other income, also serves to demonstrate the value of woodland in the farm economy.

INCOME AS REFLECTED BY MANAGEMENT

A study of table 25 discloses extensive variation in efficiency of operation and managerial ability. This can be expected in the farm woodland when the skills and equipment required to handle timber are not uniform. Every farmer is able to plow and harvest corn and milk cows in a reasonably satisfactory manner and has, as a rule, at least fairly good equipment to handle such operations. The same is not always true in harvesting the wood crop. Because of poor or inadequate equipment, the net return may be negative. Training farmers to efficiently handle their woodland crop, therefore, is an important phase of agricultural extension.

Low returns, however, do not always indicate a lack of skill. A farmer who starts treating his woodland as a crop oftentimes takes over a rundown piece of timber. Because of past misuse, uneconomical silvicultural measures must precede the thought of any immediate income. The situation is similar to rebuilding a badly depleted and weed-infested field: the investment in labor and materials during the first few years may be greater than the income.

Even though the income summary shows the capital value per acre of the three groups to be consistent with income--about $80, $40, and $25--a correlation between income and site is not always evident. The adjectives high, medium, and low, therefore, should not be construed as describing the productive capacity of the woodland. Some very ordinary farm woods in terms of species, size, and stocking produce surprisingly high returns when the operator fully utilizes his own labor in getting out wood products. On the other hand, good quality timber sold as stumpage does not always show a high net income.

In spite of the sound presumption that a good site will produce more wood per acre annually than a poor one, an analysis of the returns indicates that site is sometimes overrated as an income factor. Growing wood is important but its utilization is equally so. Cords or board feet grown per acre per year do not show up as financial gains until they are cut and brought to a good market. The outstanding deduction that can be drawn from the records is that when farmers harvest posts, logs, fuel, and other products for sale, they make the highest income; if they do not, they frequently lose money, site notwithstanding.

The apparent relation between high valuation per acre and income also is misleading as it affects inventories. Often the carrying of a large inventory of wood on the stump is costly, and one of the best records covered a farm where the owner makes heavy cuts each year. In financial terms, he does not permit unused capital to accumulate; in the language of foresters, he keeps the merchantable material cut down to the annual growth. Such a woodland likewise will tend to be perpetuated in event of a change in ownership. The lack of a concentration of ripe and overripe timber will not encourage clear-cutting either by the subsequent owner or a stumpage buyer.

Many operators do not work in their woods each year, another factor which reduces their income. An examination of the summary shows that the average farmer in the high-income group worked at the rate of 6.8 hours per acre annually, whereas those in the medium and low groups spent 4.1 and 2.6 hours respectively per acre per year. The truism, the more one works the more one earns, applies to farm woodland management as well as to other enterprises.

Where a farmer attempts to operate more woodland than his labor can handle efficiently, he has but two courses of action: either he can sell stumpage, or he can let the growth accumulate. Neither alternative is productive of high returns. Although not immediately evident from the income summary, the size of the farm woodland apparently is correlated with income. Eighty-eight[13] of the woodlands recorded in the table ranged from 4 to 185 acres in size. When these are divided into the three groups based on area, it is evident that the annual net income per acre decreases as the size of the woods increases (table 26).

TABLE 26.--Relation between size of woodland and net income per acre

Size of woodland (acres)	Number in group	Average net income per acre
4 - 20	33	$4.07
21 - 40	31	3.70
41 - 185	24	3.21

[13]The eighty-ninth woodland is one of 239 acres on a 1,400 acre farm. This farm is a commercial enterprise, operated by a salaried manager, and the woods is used as an outlet for the hired labor in slack seasons. As such it contributes a net income of $4.90 per acre, returns 12.5 percent interest on the investment, and for 4 years had a labor return of $1.00 per man-hour.

DEFERRED RETURNS

Sometimes the returns from forest management are not always determinable on an annual basis. If the income is deferred until some future date, a fair consideration of values necessitates the use of compound instead of simple interest. Specific examples to illustrate the use of a few common formulae are given:

Example 1: A plantation established 30 years ago cost a farmer $20 per acre, including planting stock, labor, and protection (fencing). What is his present investment per acre, considering only the first cost and interest at 4 percent?

$$Cn = C_o\ (1.0p^n)^1$$
$$= 20\ (1.04^{30})$$
$$= 20\ (3.24)$$
$$= \$64.80$$

Example 2: A badly misused woodlot must be given complete protection for 10 years before a cut can be made. Total cost of fencing amounts to $150. What must the first harvest net the owner in order that he can break even on the fencing costs, with interest at 3 percent?

$$Cn = 150\ (1.03^{10})$$
$$= 150\ (1.34)$$
$$= \$201.00$$

Example 3: With interest at 5 percent, what is the value of a managed woodland producing crop of sawlogs every 5 years, the logs having a net value of $150?

$$C_o = \frac{a}{(1.0p^n-1)}$$
$$= \frac{150}{(1.05^5 - 1)}$$
$$= \frac{150}{(1.28\ -1)}$$
$$= \$535.71$$

Example 4: The farmer in example 2 has yearly taxes of 25 cents per acre to pay on his woodland, in addition to the fencing cost. What will be his total investment in taxes per acre at the end of the 10-year period?

$$Cn = \frac{a\ (1.0p^n-1)}{(1.0p\ -1)}$$
$$= \frac{.25\ (1.03^{10}-1)}{.03}$$
$$= \frac{.25\ (.34)}{.03}$$
$$= \$2.82$$

(Note that after the woods is producing an income each year, taxes will be paid out of earnings, and compound interest need not enter into the calculations.)

Example 5: What rate of interest was earned from an Osage-orange hedge which 20 years after establishment produced fence posts valued at $300 net, considering the land it occupied was worth (cost) $80, total cost of establishment was $20, and taxes and maintenance were $1.00 per year?

$$1.0p^n = \frac{Cn}{C_o}$$ (Obtained by transposing formula used in example 1.)

but, $Cn = [Yn$ (yield in dollars) + S_s (sale value of land + E)]

and, $C_o = [C$ (cost of establishment) + S_c (cost of land (soil) + E)]

"E" being a capital fund which will yield sufficient interest to pay annual expenses. In this case, annual expense was $1.00, hence $E = \left(\frac{1.00}{.05}\right)$ or $20.00

then - $1.0p^{20} = \frac{300 + 80 + 20}{20 + 80 + 20}$

$$= 3.33$$

therefore p = 6% (plus) (from interest tables, Appendix D.)

---

[1] C_o - Initial capital; original cost or investment; income value.
n - Number of years or number of payments.
Cn - Final capital; future value; end cost or value of investment after (n) years.
p - Rate of interest chargeable or earned.
a - One of a series of equal periodic amounts of money, either income or outgo.
$(1.0p^n)$ - Consult compound interest tables (Appendix D) for numerical values.

COMPARISON WITH OTHER FARM ENTERPRISES

The income derived from the products of the farm woods compares favorably with other farm products. Specialized crops like tobacco planted on the best land and requiring a large investment in fertilizer and labor yield much higher returns per acre, while some of the commonly produced small grains like oats frequently net considerably less than wood products.

But the woodland also has its specialized crops, such as Christmas trees and maple sirup. Any readily marketable product like these, which can be processed by farm labor up to the point of retail consumption, can be grown, harvested, and marketed with good financial success.

Although the concept of wood as an annual crop generally has not been introduced in farm accounting procedures, a comparison of income from woodland with total income from other crops is possible. Table 27, summarizing 1944 farm-account records from 78 farms in Wisconsin whose principal income was derived from livestock and dairying, gives an opportunity to make such a comparison. Farm prices during that year are comparable to those reflected by the accounts in table 24, and the type of farming is similar to those farms summarized in the woodland records.

TABLE 27.--*Farm business reports, central and western Wisconsin, 1944*

Item	Average of 25 farms on heavy soils	Average of 53 farms on light soils
Income	*Dollars*	*Dollars*
Home use	644.00	629.00
Sales and other	6,020.00	4,969.00
Inventory increases	--	251.00
Total gross income	6,664.00	5,849.00
Expenses		
Cash and noncash	3,677.00	3,545.00
Taxes	168.00	132.00
Interest on investment	877.00	680.00
Total expense	4,722.00	4,357.00
Net income	1,942.00	1,492.00
Area per farm--acres	162	263
Return per acre--dollars	11.98	5.29
Interest on capital--percent	12	11
Return per hour--dollars	0.58	.48

Because of the greater investment in land, building, machinery, and livestock, the average returns per acre and interest on investment from cultivated crops and livestock is greater than farm-wood products. Table 27 includes products from the best land on the farms. The woodland income, on the other hand, reflects returns principally from rough, steep, or poorly drained land which would permanently produce little in grain, hay, or pasture. Current government subsidies for crop production also augmented the income on the Wisconsin farms.

The labor income from woods work, however, is greater than in many other farm pursuits. As was previously emphasized, farmers who work in their woods receive a good wage rate, even though the woodland income is small as measured against the total farm income.

How much farm labor will the woods profitably employ? Obviously this question has no single answer. The 89 woodlands previously referred to consumed 1 to 36 man-hours of labor per acre annually. The operator of a Christmas-tree business might expend 5 or 6 days per acre every year in planting, shearing, and harvesting his crop. According to Preston,[14] experience in other regions shows that with a reasonably good piece of woods, one-half to one man-day per acre is a satisfactory average figure to use in estimating annual labor requirements of woodland management.

[14] "Farm Wood Crops," John F. Preston, McGraw-Hill, 1949.

INTEGRATION WITH OTHER FARM ACTIVITIES

There are no sound physical or economic reasons why woodland management cannot be integrated with the management of cropland, pastures, and livestock. An accurate determination of the capabilities of the farm land will delineate those portions best suited to cultivated crops, to pasture, and to woodland. Economically, returns for the labor spent in woods work are favorable in comparison with other activities.

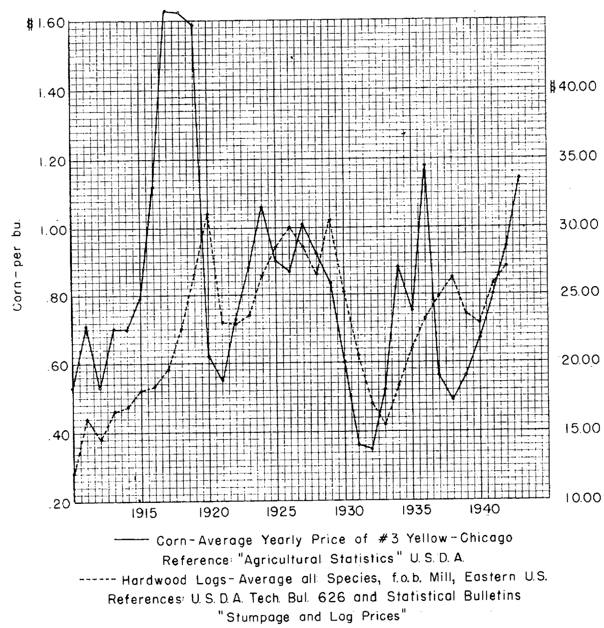
The reasons why good management of woodland is not generally practiced by more farmers are largely ones of concept, attitudes, and a lack of woods appreciation on the part of operators. Until there is a general appreciation of what constitutes good land use, until trees and their products are looked upon as agricultural commodities, and until the farmer takes the same degree of interest in his woodland that he does in the rest of his cropland, the farm woods will continue to be fenced into the pasture and he will sell a few merchantable trees to the first buyer of stumpage that comes along.

Many farmers adopt the attitude that they do not have time to work in the woods. This attitude is more valid with dairying than with other types of farming because there is greater competition for land and labor. Many dairymen have limited pasture and feel they must carry livestock on every available acre, including the woodland. The dairy farmer's chores and milking are year-round activities as compared to the cash grain or general farm which has a light work load during the winter.

The one very desirable feature of the wood crop as compared with others is that it does not become mature at any special time. Timber harvesting is not compulsory on any particular day, week, or year, and no losses will result if it is left until the press of other farm work is at a minimum. In that respect it is an excellent outlet for unemployed labor and even with dairying, there are parts of days in the winter when the farmer is not doing chores. From about 10:00 a. m. to 4:00 p. m., with the exception of spreading manure, making repairs, and going to town, are hours which are not always consumed in useful activities. In that connection, working in the woods can become a habit the same as going to town.

Distaste for woods work plus the overemphasized dangers of working in the timber also contribute to the reasons why the wood crop is given a low priority on so many farms. Much of this distaste may be the result of poor tools and equipment, because pulling a poorly fitted saw through a large log or attempting to chop with a dull axe is hard work. National Safety Council statistics support the fact that woods work is dangerous. In all types of accidents it is the careless person and not the novice who is recorded in the statistics. Good tools, reasonable precautions, and a few easily acquired woods techniques make timber work no more arduous or dangerous than many other farm operations.

Marketing problems frequently are suggested as reasons why farmers are not interested in their timber crops. This has been discussed pre-



Comparison of yearly price fluctuations of corn and hardwood logs, 1910 - 43.

viously and it was shown that marketable products, an understanding of the value of products, and perhaps some centralized organization through which to pool the products, will eliminate many of the difficulties experienced by farmers.

The stability of the timber market has been as good as most other commodities. In the chart it can be seen that the fluctuation in hardwood logs during 1910-43 was less than it was for corn. If farm woods are managed to produce wood products continuously, even greater stability of log prices should result. And when the farm owner sells his logs as he does his grain, milk, and livestock instead of something to be moved from the land once in a lifetime, the curve for prices of logs will show an upswing.

"The man who has a piece of woodland where during the winter months he cuts his firewood and fencing and a few logs for the repair of buildings and implements, and during certain years when prices are high cuts some logs for the neighboring sawmill, but at the same time looks after the piece of woods, clears it of dead timber and other rubbish, thus keeping out fire and insects, and otherwise makes an effort to keep the land covered with forest--such a man practices forestry. His forest may be small or large, his ways of doing may be simple and imperfect, the trees may not be the best kind for the particular locality and soil, they may not be as thrifty as they should and could be; but nevertheless here is a man who does not merely destroy the woods nor content himself with cutting down whatever he can sell, but one who cares for the woods as well as uses them, one who sows as well as harvests. He is a forester, and his work in the woods is forestry."

FILIBERT ROTH,

Teacher, philosopher
and pioneer American
forester

APPENDIX

APPENDIX A

UNIT CONVERSION FACTORS

LENGTH

Inches	Links	Feet	Yards	Rods	Chains[1]	Mile
1	0.126	0.083	0.028	0.005	-	-
7.92	1	.66	.22	.04	0.01	-
12.	1.515	1	.33	.06	.015	-
36.	4.55	3.	1	.18	.045	0.0005
198.	25.	16.5	5.5	1	.25	.0031
792.	100.	66.	22.	4.	1	.0125
-	-	5280.	1760.	320.	80.	1

[1]Surveyor's Chain - 66 feet in length.

AREA

Square inches	Square links	Square feet	Square yards	Square chains	Acres
1	0.016	0.007	-	-	-
62.72	1	.435	-	-	-
144.	2.295	1	0.111	0.0002	-
1296.	20.66	9.	1	.002	.0002
-	10,000	4,356	484.	1	.1
-	-	43,560	4840.	10.	1

DIMENSIONS OF PLOTS

Area	Feet		Rods		Chains	
	Side of square	Radius of circle	Side of square	Radius of circle	Side of square	Radius of circle
1 acre	208.7	117.7	12.65	7.14	3.16	1.78
1/2 acre	147.6	83.3	8.94	5.05	2.24	1.26
1/4 acre	104.3	58.9	6.32	3.57	1.58	.89
1/5 acre	93.3	52.7	5.66	3.19	1.41	.80
1/10 acre	66.0	37.2	4.00	2.26	1.00	.56

APPENDIX B

APPROXIMATE EQUIVALENTS, FOREST PRODUCTS

	Cu. ft.	*Bd. ft*	*Cord*	*Post*	*Tie*
1 cubic foot (in the round)	--	5	0.013	1.	0.20
1 bd. ft.(1' x 1' x 1" solid wood)	.20	--	.0025	.20	.033
1 cord (stacked wood 4' x4' x8')	80.	400	--	80.	20.
1 post (5" x 7')	1.	5	.013	--	.20
1 tie (6"x8"x8')	5.	30	.05	5.	--

Forest products are not subject to absolute conversion. For example, a cubic foot is equal to 12 board feet in theory, but in actual practice a cubic foot as represented in a tree produces only about 5 board feet, because of loss in slabs, edgings, and processing waste. For trees less than 16 inches in diameter there are only 3 to 4 board feet per cubic foot; for trees above 20 inches, the ratio may be 6 or more, increasing as the diameter increases. See also the following table, adapted from Lake States Forest Experiment Station data, for variation in the contents of a cord.

SOLID CONTENTS OF STACKED CORD OF UNPEELED HARDWOODS

Kind of 4-foot wood	*Sticks less than 6 inches in diameter*	*Sticks 6 to 12 inches in diameter*	*Sticks more than 12 inches in diameter*
Straight and smooth	200 bd. ft. 85 cu. ft.	400 bd. ft. 91 cu. ft.	500 bd. ft. 98 cu. ft.
Slightly crooked and rough	75 cu. ft.	82 cu. ft.	89 cu. ft.
Crooked and rough including branches	60 cu. ft.	70 cu. ft.	75 cu. ft.

APPENDIX C

BOARD FOOT CONTENT OF LOGS

Diameter inside bark small end	LENGTH OF LOG IN FEET															
	Scribner decimal C rule (in tens) [1]						Doyle rule [2]					International rule [3]				
(inches)	6	8	10	12	14	16	8	10	12	14	16	8	10	12	14	16
	Bd. ft.	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*
6	0.5	0.5	1	1	1	2	2	3	3	4	4	10	10	15	15	20
7	.5	1	1	2	2	3	5	6	7	8	9	10	15	20	25	30
8	1	1	2	2	2	3	8	10	12	14	16	15	20	25	35	40
9	1	2	3	3	3	4	13	16	19	22	25	20	30	35	45	50
10	2	3	3	3	4	6	18	23	27	32	36	30	35	45	55	65
11	2	3	4	5	5	7	25	31	37	43	49	35	45	55	70	80
12	3	4	5	6	7	8	32	40	48	56	64	45	55	70	85	95
13	4	5	6	7	8	10	41	51	61	71	81	55	70	85	100	115
14	4	6	7	9	10	11	50	63	75	88	100	65	80	100	115	135
15	5	7	9	11	12	14	61	76	91	106	121	75	95	115	135	160
16	6	8	10	12	14	16	72	90	108	126	144	85	110	130	155	180
17	7	9	12	14	16	18	85	106	127	148	169	95	125	150	180	205
18	8	11	13	16	19	21	98	123	147	172	196	110	140	170	200	230
19	9	12	15	18	21	24	113	141	169	197	225	125	155	190	225	260
20	11	14	17	21	24	28	128	160	192	224	256	135	175	210	250	290
21	12	15	19	23	27	30	145	181	217	253	289	155	195	235	280	320
22	13	17	21	25	29	33	162	203	243	284	324	170	215	260	305	355
23	14	19	23	28	33	38	181	226	271	316	361	185	235	285	335	390
24	15	21	25	30	35	40	200	250	300	350	400	205	255	310	370	425
25	17	23	29	34	40	46	221	276	331	386	441	220	280	340	400	460
26	19	25	31	37	44	50	242	303	363	424	484	240	305	370	435	500
27	21	27	34	41	48	55	265	331	397	463	529	260	330	400	470	540
28	22	29	36	44	51	58	288	360	432	504	576	280	355	430	510	585
29	23	31	38	46	53	61	313	391	469	547	625	305	385	465	545	630
30	25	33	41	49	57	66	338	423	507	592	676	325	410	495	585	675

In the eastern United States the board foot contents of logs are measured by one of three different log rules or scales.

[1] *The Scribner Rule* is based on diagrams which intend to show the actual board feet that can be sawed from logs of varying lengths and diameters.

The original rule was published over a century ago, but subsequently the last digit was dropped and the figures rounded off to the nearest 10 board feet. The rule is in general use in Wisconsin and Minnesota and in national forests. It is now known as "Decimal C" as given above.

[2] *The Doyle Rule* is based on the formula $\left(\frac{D-4}{4}\right)^2 \times L =$ Board feet, in which D is the diameter of the small end of the log, inside the bark in inches, and L is the length in feet. In spite of its inaccuracies when applied to small logs, this rule is used almost exclusively in scaling hardwoods of the Mississippi and Ohio Valleys, and in the southern pine region. It underscales average-sized logs by about 30 board feet.

[3] *The International Rule* is the most accurate rule yet devised but unfortunately does not have the widespread use of the others. The figures given will come quite close to actual board feet that can be derived from sound logs by saws which cut 1/4 inches of kerf (saw-dust). It has been adopted by statute in Michigan. The formula, .8D (D-2) will give values closely approximating the board feet in 16-foot logs.

APPENDIX D

COMPOUND INTEREST TABLE

Values of $1.0p^n$

Number of years (n)	When interest rate, p, equals									
	2	2½	3	3½	4	4½	5	5½	6	6½
1	1.02	1.02	1.03	1.03	1.04	1.04	1.05	1.05	1.06	1.06
2	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12	1.13
3	1.06	1.08	1.09	1.11	1.12	1.14	1.16	1.17	1.19	1.21
4	1.08	1.10	1.13	1.15	1.17	1.19	1.22	1.24	1.26	1.29
5	1.10	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37
6	1.13	1.16	1.19	1.23	1.26	1.30	1.34	1.38	1.42	1.46
7	1.15	1.19	1.23	1.27	1.32	1.36	1.41	1.45	1.50	1.56
8	1.17	1.22	1.27	1.32	1.37	1.42	1.48	1.53	1.59	1.66
9	1.19	1.25	1.30	1.36	1.42	1.49	1.55	1.62	1.69	1.76
10	1.22	1.28	1.34	1.41	1.48	1.55	1.63	1.71	1.79	1.87
20	1.48	1.63	1.80	1.98	2.19	2.41	2.65	2.92	3.21	3.52
30	1.81	2.09	2.42	2.80	3.24	3.74	4.32	4.98	5.74	6.62
40	2.20	2.68	3.36	3.95	4.80	5.81	7.04	8.51	10.29	12.42
50	2.69	3.43	4.38	5.58	7.10	9.03	11.46	14.54	18.42	23.33
60	3.28	4.39	5.89	7.87	10.51	14.02	18.67	24.84	32.99	43.82
70	3.99	5.63	7.91	11.11	15.57	21.78	30.42	42.43	59.08	83.80
80	4.87	7.20	10.64	15.67	23.04	33.93	49.56	72.48	--	--
90	5.94	9.22	14.30	22.11	34.11	52.53	80.73	--	--	--
100	7.24	11.81	19.21	31.19	50.50	81.58	--	--	--	--

APPENDIX E

APPROXIMATE NUMBER OF TREES REQUIRED TO YIELD SPECIFIC UNITS OF MATERIAL

Tree diameter (inches)	1 cord[1] fuelwood	1 unit[2] pulpwood	1 tie[3] 6" x 8"	1 fence post 4 inch top	1,000 board feet lumber[4]		
					Medium-height hardwoods	Tall hardwoods	Pine
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
6	20	27	-	0.50	-	-	-
8	10	12	-	.25	-	-	-
10	6	7	-	.10	-	-	19.
12	4	3	1.	.06	20	15	10.
14	3	2	.75	.04	12	8	6.2
16	2	-	.50	-	9	6	4.3
18	1.5	-	.33	-	7	4	3.
20	1.3	-	-	-	6	3.5	2.5
22	1	-	-	-	5	3	1.8
24	-	-	-	-	4	2	1.5
26	-	-	-	-	2.5	1.5	1.2
28	-	-	-	-	2	1.3	1.0

[1] 3 inch sticks and larger.

[2] 160 cu. ft. of unpeeled stacked wood -- southern pine.

[3] Side lumber taken from larger bolts in addition to ties, (see Appendix I). Also, 1 cord of topwood and 1/3 cord of slabs are obtainable for every 10 ties.

[4] See volume tables (Appendix J) for more accurate tables. About 1 cord of slabs is available from every 1,000 bd. ft. of lumber sawed. In addition, the tops of heavy-crowned trees with short merchantable lengths will yield up to 4 cords of fuelwood per 1,000 bd ft. of sawlogs; tall forest-grown trees will yield 1 cord or less in topwood per 1,000 bd. ft.

APPENDIX F

AREA OF CIRCLES (BASAL AREA)

Diameter class (inches)	Number of trees												
	1	2	3	4	5	6	7	8	9	10	20	30	40
	Sq. ft.	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*
4	0.09	0.17	0.26	0.35	0.44	0.52	0.61	0.70	0.79	0.87	1.7	2.6	3.5
6	.20	.39	.59	.79	.98	1.2	1.4	1.6	1.8	2.0	3.9	5.9	7.8
8	.35	.70	1.0	1.4	1.7	2.1	2.4	2.8	3.1	3.5	7.0	10.5	14.0
10	.55	1.1	1.6	2.2	2.7	3.3	3.8	4.4	4.9	5.5	10.9	16.4	21.8
12	.79	1.6	2.3	3.1	3.9	4.7	5.5	6.3	7.1	7.9	15.7	23.6	31.4
14	1.1	2.1	3.2	4.3	5.3	6.4	7.5	8.5	9.6	10.7	21.4	32.1	42.8
16	1.4	2.8	4.2	5.6	7.0	8.4	9.8	11.2	12.6	14.0	27.9	41.9	55.9
18	1.8	3.5	5.3	7.1	8.8	10.6	12.4	14.1	15.9	17.7	35.3	53.0	70.7
20	2.2	4.4	6.5	8.7	10.9	13.1	15.3	17.5	19.6	21.8	43.6	65.4	87.3
22	2.6	5.3	7.9	10.6	13.2	15.8	18.5	21.1	23.8	26.4	52.8	79.2	-
24	3.1	6.3	9.4	12.6	15.7	18.8	22.0	25.1	28.3	31.4	62.8	-	-
26	3.7	7.4	11.1	14.7	18.4	22.1	25.8	29.5	33.2	36.9	73.7	-	-
28	4.3	8.5	12.8	17.1	21.4	25.7	29.9	34.2	38.5	42.8	-	-	-
30	4.9	9.8	14.7	19.6	24.5	29.4	34.4	39.3	44.2	49.1	-	-	-
32	5.6	11.2	16.8	22.3	27.9	33.5	39.1	44.7	50.3	55.8	-	-	-
34	6.3	12.6	18.9	25.2	31.5	37.8	44.1	50.4	56.7	63.0	-	-	-
36	7.1	14.1	21.2	28.3	35.3	42.4	49.5	56.5	63.6	70.7	-	-	-
38	7.9	15.7	23.6	31.5	39.4	47.3	55.1	63.0	70.8	78.7	-	-	-
40	8.7	17.4	26.2	34.9	43.6	52.3	61.5	69.8	78.5	87.3	-	-	-

By substituting feet in length for number of trees this table also gives cubic-foot contents of cylinders. Thus, a log 8 ft. long having an average diameter of 20 in. contains 17.5 cu. ft.

APPENDIX G

BOARD MEASURE

Size (inches)	Length of piece in feet							
	6	8	10	12	14	16	18	20
	Bd. ft.	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*
1x3	1.5	2	2.5	3	3.5	4	4.5	5
1x4	2	2.6	3.3	4	4.6	5.3	6	6.6
1x6	3	4	5	6	7	8	9	10
1x8	4	5.3	6.6	8	9.3	10.6	12	13.3
1x10	5	6.6	8.3	10	11.6	13.3	15	16.6
1x12	6	8	10	12	14	16	18	20
2x4	4	5.3	6.6	8	9.3	10.6	12	13.3
2x6	6	8	10	12	14	16	18	20
2x8	8	10.6	13.3	16	18.6	21.3	24	26.6
2x10	10	13.3	16.6	20	23.3	26.6	30	33.3
2x12	12	16	20	24	28	32	36	40
2x14	14	18.6	23.3	28	32.6	37.3	42	46.6
3x6	9	12	15	18	21	24	27	30
3x8	12	16	20	24	28	32	36	40
3x10	15	20	25	30	35	40	45	50
3x12	18	24	30	36	42	48	54	60
3x14	21	28	35	42	49	56	63	70
4x4	8	10.6	13.3	16	18.6	21.3	24	26.6
4x6	12	16	20	24	28	32	36	40
4x8	16	21.3	26.6	32	37.3	42.6	48	53.3
4x10	20	26.6	33.3	40	46.6	53.3	60	66.6
4x12	24	32	40	48	56	64	72	80
6x6	18	24	30	36	42	48	54	60
6x8	24	32	40	48	56	64	72	80
6x10	30	40	50	60	70	80	90	100
6x12	36	48	60	72	84	96	108	120
8x8	32	42.6	53.3	64	74.6	85.3	96	106.6
8x10	40	53.3	66.6	80	93.3	106.6	120	133.3
8x12	48	64	80	96	112	128	144	160
10x10	50	66.6	83.3	100	116.6	133.3	150	166.6
10x12	60	80	100	120	140	160	180	200
12x12	72	96	120	144	168	192	216	240

APPENDIX H

APPROXIMATE WEIGHTS OF COMMERCIALLY IMPORTANT WOODS[1]

Species	Cubic foot		Cord 4' x 4' x 8' [2]		Lumber per 1,000 board feet [3]		Logs--per M[4] Bd.Ft. "green"		
	Green	Air dry	Green	Air dry	Green	Air dry	12"	18"	24"
	Pounds	*Pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*
Ash, white	48	41	4.3	3.7	4.0	3.4	11.0	7.7	6.6
Aspen	43	26	3.9	2.3	3.6	2.2	10.8	7.6	6.4
Basswood	42	26	3.8	2.3	3.5	2.2	9.5	6.6	5.6
Beech	54	43	4.9	3.9	4.5	3.7	12.7	8.9	7.5
Birch, yellow	57	43	5.1	3.9	4.8	3.5	13.2	9.2	7.8
Birch, white	50	38	4.5	3.4	4.2	3.2	-	-	-
Cedar, red	37	33	3.3	3.0	3.1	2.7	-	-	-
Cedar, northern white	28	22	2.5	2.0	2.3	1.8	-	-	-
Cherry, black	45	35	4.0	3.2	3.8	2.9	10.5	7.3	6.2
Cottonwood	49	28	4.4	2.5	4.1	2.3	10.7	7.5	6.3
Elm, white, red	55	36	5.0	3.2	4.6	3.0	12.0	8.2	7.0
Gum, red, black	50	34	4.5	3.0	4.2	2.8	10.5	7.3	6.2
Hackberry	50	37	4.5	3.3	4.2	3.1	11.3	7.9	6.7
Hemlock	50	28	4.5	2.5	4.2	2.3	11.0	7.8	6.5
Hickory	63	51	5.7	4.6	5.3	4.2	14.7	10.3	8.7
Locust, black	58	48	5.2	4.3	4.8	4.0	13.4	9.3	-
Maple, hard	59	42	5.3	3.8	4.6	3.6	12.9	9.0	7.6
Maple, soft	47	35	4.3	3.2	3.9	2.8	11.0	7.8	6.5
Oak, red	63	44	5.7	4.0	5.2	3.7	14.8	10.3	8.8
Oak, white	62	46	5.6	4.1	5.2	3.9	14.4	10.0	8.5
Pine, Norway (red)	42	31	3.8	2.8	3.5	2.6	9.7	6.8	5.7
Pine, shortleaf	52	36	4.7	3.2	4.3	3.0	10.4	7.2	6.1
Pine, white	36	25	3.2	2.3	3.0	2.1	9.0	6.3	5.3
Poplar, yellow (tulip)	38	28	3.4	2.5	3.2	2.3	8.8	6.1	5.2
Spruce	34	28	3.0	2.5	2.8	2.3	7.7	5.4	4.6
Sycamore	52	34	4.7	3.0	4.3	2.9	11.9	8.3	7.1
Tamarack (larch)	47	37	4.2	3.0	3.9	3.1	-	-	-
Walnut, black	58	38	5.2	3.4	4.8	3.2	11.9	8.3	7.1

[1] From USDA Farmers' Bulletin 1210, and "Wood Handbook," Forest Products Laboratory. Values for green wood may vary up to 20 percent due to lack of definition of what is "green." Air-dry values assume 15 percent moisture and will not vary over 10 percent; add or subtract 1/2 percent weight of wood for every 1 percent change in moisture content.

[2] Derived by multiplying cubic foot weights by 90, giving approximate weight of a stacked cord.

[3] Full-sized pieces; reduce proportionally for finished lumber which is not full dimension.

[4] Doyle log rule; diameter inside bark, small end.

TRANSPORTATION ITEMS

1 1/2-ton truck, standard chassis will haul: 1 to 1 1/2 standard cords of wood; 500 to 1,000 board feet of logs, depending on size, species, etc., 35 to 45 crossties. All assumes a load of double-rated capacity.

Railroad: Roughly 6,000 board feet sawlogs per gondola or flat car; 16,000 to 20,000 board feet lumber, 18 to 20 cords of wood, or 300 to 350 ties per box car. Minimum carload weights are 34,000 lbs. for lumber, 50,000 lbs. for logs. Car capacities: 45,000 to 60,000 lbs.

APPENDIX I

RAILROAD TIES

Ties and additional side lumber obtainable from bolts of various diameters - 8 to 8 1/2 feet long

Log diameter-- inside bark, small end (inches)		Cross ties		Side lumber-- minimum boards 4 inches wide
		Number	*Grade*	*Board feet*
9		1	1	Little or no side lumber
	or	1	2	
10		1	3	5
	or	1	4	5
11		1	4	10
	or	1	5	5
12		1	5	15
13		1	5	20
14		2	3	15
15		2	3	35
		1	5	
	or	1	3	20
16		1	5	
		1	3	20
	or	2	4	25
17		2	5	30
18		2	3	
		1	5	30
	or	3	3	35
	or	2	5	45
19		2	4	
	or	1	5	30
20		4	3	40
		1	4	
	or	2	5	45
	or	3	5	45
21		3	5	50
22		2	3	
		1	5	55
	or	5	3	25
23		4	4	60
		3	3	
	or	2	5	30
24		4	5	70
25		7	3	30
	or	5	5	45

Based on diagrams, with values checked by a tie sawyer. Values are maximum which could be derived from cylindrical, straight, sound logs. Probably will not run so high under usual milling conditions.

RAILROAD TIES AND ADDITIONAL SIDE LUMBER OBTAINABLE FROM STANDING TREES OF VARIOUS DIAMETERS AND HEIGHTS [1]

D. B. H. (inches)	1 cut [2]			2 cuts [2]			3 cuts [2]		
	Cross ties		Add. side lumber	Cross ties		Add. side lumber	Cross ties		Add. side lumber
	Number	Grade		Number	Grade		Number	Grade	
12	1	3	8	1 1	2 3	8	1 1 1	1 2 3	8
13	1	4	6	1 1	3 4	12	1 1 1	2 3 4	12
14	1	5	15	1 1	4 5	21	1 1 1	3 4 5	27
15	1	5	15	2	5	23	1 2	4 5	29
16	1	5	30	2	5	41	3	5	49
17	2	3	21	2 1	3 5	48	2 2	3 5	57
18	1 1	4 3	22	1 1 1	3 4 5	49	1 1 2	3 4 5	64
19	2	4	34	2 2	3 4	56	2 2 1	3 4 5	83
20	2	5	41	1 3	3 5	63	1 4	3 5	90
21	2 1	3 5	30	2 3	3 5	55	4 3	3 5	65
22	1 2	3 5	33	1 4	3 5	58	2 1 4	3 4 5	82
23	1 2	3 5	50	3 3	3 5	83	4 4	3 5	108
24	1 2	4 5	50	2 4	3 5	83	2 6	3 5	111
25	4	4	41	1 4 2	3 4 5	91	4 4 2	3 4 5	115
26	2 2	3 5	40	2 5	3 5	79	4 6	3 5	113

[1] Based on diagrams. Values are maximum which can be derived from cylindrical, straight, sound logs with optimum efficiency of sawing and milling. Upper diameters determined from form class taper of mixed hardwoods in Lake States.

[2] 1 tie cut equals 9 ft. above stump; 2 cuts - 17 ft.; 3 cuts - 26 ft.

APPENDIX J

VOLUME TABLES

The first three tables in this appendix are adapted from Tables for Estimating Board-Foot Volume of Timber, Form class 78, by Mesavage and Girard, United States Forest Service, 1946. They are for use in obtaining the approximate gross board foot contents of standing trees by each of three rules -- International, Scribner, and Doyle (Appendix C). Diameters are measured outside the bark at breast height, 4 1/2 feet from the ground (d.b.h.). Merchantable height is that part of the main trunk above the stump, as limited by large branches, small diameter, or deformity which prohibits use as saw timber (see p. 68).

The tables give approximate volumes for tree trunks of average taper, i.e., the diameter at breat height is about 20 percent greater than the diameter at 16 feet. For tall, columnar trunks with only 10 to 15 percent difference between the breast high diameter and the diameter at 16 feet, multiply by 1.25. For comparatively short-stemmed trees having 25 to 30 percent difference between d.b.h. and diameter at 16 feet, multiply by 0.80.

Because of the characteristic form of beech and hemlock, modification also should be made if applied to these two species:

Beech - multiply by 1.2
Hemlock - multiply by 0.85

Rule of Thumb

If tables are not available, approximate volume (Scribner) can be obtained in terms of d.b.h. by applying the simple formula:

Board feet (Scribner) = d (d + x), in which

d = d.b.h. in inches,
and x = +3 for 3½ log trees (56 feet merchantable height)
= 0 for 3 log trees (48 feet merchantable height)
= -3 for 2½ log trees (40 feet merchantable height)
= -6 for 2 log trees (32 feet merchantable height)
= -9 for 1½ log trees (24 feet merchantable height)

In other words:
For 3 log trees, squaring the diameter gives board feet, Scribner.
For 3½ log trees, *add* 3 to d.b.h. and multiply by d.b.h.
For 2½, 2, or 1½-log trees, *subtract* 3, 6, or 9, respectively, from d.b.h. and multiply by d.b.h.

VOLUME PER TREE -- INTERNATIONAL RULE

Tree diameter (inches)	Merchantable height in feet										
	16	24	32	40	48	56	64	72	80	88	96
	Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.
10	36	48	59	66	73	--	--	--	--	--	--
11	46	61	76	86	96	--	--	--	--	--	--
12	56	74	92	106	120	128	137	--	--	--	--
13	67	90	112	130	147	158	168	--	--	--	--
14	78	105	132	153	174	187	200	--	--	--	--
15	92	124	156	182	208	225	242	--	--	--	--
16	106	143	180	210	241	263	285	--	--	--	--
17	121	164	206	242	278	304	330	--	--	--	--
18	136	184	233	274	314	344	374	--	--	--	--
19	154	209	264	311	358	392	427	--	--	--	--
20	171	234	296	348	401	440	480	511	542	--	--
21	191	262	332	391	450	496	542	579	616	--	--
22	211	290	368	434	500	552	603	647	691	--	--
23	231	318	404	478	552	608	663	714	766	--	--
24	251	346	441	523	605	664	723	782	840	--	--
25	275	380	484	574	665	732	800	865	930	--	--
26	299	414	528	626	725	801	877	949	1,021	--	--
27	323	448	572	680	788	870	952	1,032	1,111	--	--
28	347	482	616	733	850	938	1,027	1,114	1,201	1,280	1,358
29	375	521	667	794	920	1,016	1,112	1,210	1,308	1,398	1,488
30	403	560	718	854	991	1,094	1,198	1,306	1,415	1,517	1,619
31	432	602	772	921	1,070	1,184	1,299	1,412	1,526	1,640	1,754
32	462	644	826	988	1,149	1,274	1,400	1,518	1,637	1,762	1,888
33	492	686	880	1,053	1,226	1,360	1,495	1,622	1,750	1,888	2,026
34	521	728	934	1,119	1,304	1,447	1,590	1,727	1,864	2,014	2,163
35	555	776	998	1,196	1,394	1,548	1,702	1,851	2,000	2,156	2,312
36	589	826	1,063	1,274	1,485	1,650	1,814	1,974	2,135	2,298	2,461
37	622	873	1,124	1,351	1,578	1,752	1,926	2,099	2,272	2,444	2,616
38	656	921	1,186	1,428	1,670	1,854	2,038	2,224	2,410	2,590	2,771
39	694	976	1,258	1,514	1,769	1,968	2,166	2,359	2,552	2,744	2,937
40	731	1,030	1,329	1,598	1,868	2,081	2,294	2,494	2,693	2,898	3,103

VOLUME PER TREE -- SCRIBNER RULE

Tree diameter (inches)	Merchantable height in feet										
	16	24	32	40	48	56	64	72	80	88	96
	Bd. ft.	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*
10	28	36	44	48	52	--	--	--	--	--	--
11	38	49	60	67	74	--	--	--	--	--	--
12	47	61	75	85	95	100	106	--	--	--	--
13	58	76	94	107	120	128	136	--	--	--	--
14	69	92	114	130	146	156	166	--	--	--	--
15	82	109	136	157	178	192	206	--	--	--	--
16	95	127	159	185	211	229	247	--	--	--	--
17	109	146	184	215	246	268	289	--	--	--	--
18	123	166	209	244	280	306	331	--	--	--	--
19	140	190	240	281	322	352	382	--	--	--	--
20	157	214	270	317	364	398	432	459	486	--	--
21	176	240	304	358	411	450	490	523	556	--	--
22	194	266	338	398	458	504	549	588	626	--	--
23	214	294	374	441	508	558	607	652	698	--	--
24	234	322	409	484	558	611	665	718	770	--	--
25	258	355	452	534	617	678	740	799	858	--	--
26	281	388	494	585	676	745	814	880	945	--	--
27	304	420	536	636	736	811	886	959	1,032	--	--
28	327	452	578	686	795	877	959	1,040	1,120	1,190	1,261
29	354	491	628	746	864	953	1,042	1,132	1,222	1,306	1,389
30	382	530	678	806	933	1,028	1,124	1,224	1,325	1,421	1,517
31	411	571	731	871	1,011	1,117	1,223	1,328	1,434	1,541	1,648
32	440	612	784	936	1,089	1,206	1,322	1,432	1,543	1,661	1,779
33	469	654	838	1,001	1,164	1,289	1,414	1,534	1,654	1,783	1,912
34	498	695	892	1,066	1,239	1,373	1,507	1,636	1,766	1,906	2,046
35	530	742	954	1,141	1,328	1,473	1,618	1,757	1,896	2,044	2,192
36	563	789	1,015	1,216	1,416	1,572	1,728	1,877	2,026	2,182	2,338
37	596	836	1,075	1,290	1,506	1,670	1,835	1,998	2,160	2,324	2,488
38	629	882	1,135	1,366	1,596	1,769	1,942	2,118	2,295	2,466	2,637
39	666	935	1,204	1,449	1,694	1,881	2,068	2,251	2,434	2,616	2,799
40	703	988	1,274	1,532	1,791	1,993	2,195	2,384	2,574	2,768	2,961

VOLUME PER TREE -- DOYLE RULE

Tree diameter (inches)	Merchantable height in feet										
	16	24	32	40	48	56	64	72	80	88	96
	Bd. ft.	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*
10	14	17	20	21	22	--	--	--	--	--	--
11	22	27	32	35	38	--	--	--	--	--	--
12	29	36	43	48	53	54	56	--	--	--	--
13	38	48	59	66	73	76	80	--	--	--	--
14	48	62	75	84	93	98	103	--	--	--	--
15	60	78	96	108	121	128	136	--	--	--	--
16	72	94	116	132	149	160	170	--	--	--	--
17	86	113	140	161	182	196	209	--	--	--	--
18	100	132	164	190	215	232	248	--	--	--	--
19	118	156	194	225	256	276	297	--	--	--	--
20	135	180	225	261	297	322	346	364	383	--	--
21	154	207	260	302	344	374	404	428	452	--	--
22	174	234	295	344	392	427	462	492	521	--	--
23	195	264	332	388	444	483	522	558	594	--	--
24	216	293	370	433	496	539	582	625	668	--	--
25	241	328	414	486	558	609	660	709	758	--	--
26	266	362	459	539	619	678	737	793	849	--	--
27	292	398	505	594	684	749	814	877	940	--	--
28	317	434	551	650	750	820	890	961	1,032	1,096	1,161
29	346	475	604	714	824	902	980	1,061	1,142	1,218	1,294
30	376	517	658	778	898	984	1,069	1,160	1,251	1,339	1,427
31	408	562	717	850	983	1,080	1,176	1,273	1,370	1,470	1,570
32	441	608	776	922	1,068	1,176	1,283	1,386	1,488	1,600	1,712
33	474	654	835	994	1,152	1,268	1,385	1,497	1,609	1,734	1,858
34	506	700	894	1,064	1,235	1,361	1,487	1,608	1,730	1,866	2,003
35	544	754	964	1,149	1,334	1,472	1,610	1,743	1,876	2,020	2,163
36	581	808	1,035	1,234	1,434	1,583	1,732	1,878	2,023	2,173	2,323
37	618	860	1,102	1,318	1,534	1,694	1,854	2,013	2,172	2,332	2,492
38	655	912	1,170	1,402	1,635	1,805	1,975	2,148	2,322	2,491	2,660
39	698	974	1,250	1,498	1,746	1,932	2,118	2,298	2,479	2,662	2,844
40	740	1,035	1,330	1,594	1,858	2,059	2,260	2,448	2,636	2,832	3,027

PULPWOOD VOLUME [1](NORTHERN CONIFERS) [2]

D. B. H. (inches)	Usable height in feet							
	8	16	24	32	40	48	56	64
	Cords	*Cords*	*Cords*	*Cords*	*Cords*	*Cords*	*Cords*	*Cords*
4	0.004	0.008	--	--	--	--	--	--
5	.010	.018	0.027	--	--	--	--	--
6	.018	.030	.043	0.058	--	--	--	--
7	.025	.039	.056	.074	0.093	--	--	--
8	.032	.050	.070	.092	.116	0.138	--	--
9	.040	.061	.085	.112	.140	.168	--	--
10	.049	.074	.101	.132	.167	.200	0.239	0.270
11	.059	.087	.119	.155	.195	.233	.280	.320
12	.070	.100	.138	.180	.225	.271	.324	.365
13	.082	.116	.158	.206	.257	.310	.370	.417
14	.095	.134	.179	233	291	.351	.419	.472
15	--	--	.200	.260	.325	.393	.469	.528
16	--	--	.222	.290	.361	.437	.521	.587
17	--	--	.245	.320	.399	.483	.577	.650
18	--	--	.270	.350	.439	.531	.634	.715
19	--	--	.295	.382	.480	.581	.693	.781
20	--	--	.321	.416	.522	.632	.755	.851
21	--	--	--	.452	.566	.685	.818	.922
22	--	--	--	.490	.612	.739	.883	.995
23	--	--	--	--	.659	.796	.950	1.07
24	--	--	--	--	--	.855	1.02	1.15
25	--	--	--	--	--	.914	1.09	1.23

[1] Volume above a 1-foot stump in standard unpeeled cords. Usable 8-foot bolts to a variable top diameter not less than 4 inches inside the bark.

[2] From Technical Note No. 241, Lake States Forest Experiment Station.

PULPWOOD VOLUME [1](SOUTHERN PINE)[2]

D. B. H. (inches)	Usable height in feet													
	12	16	20	24	28	32	36	40	44	48	52	56	60	64
	Cu. ft.	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*
6	1.6	2.2	2.7	3.2	3.8	4.3	4.8	--	--	--	--	--	--	--
8	--	3.6	4.6	5.5	6.4	7.3	8.3	9.1	10.1	11.0	--	--	--	--
10	--	--	6.8	8.2	9.5	10.8	12.3	13.6	14.9	16.3	17.7	19.0	20.4	--
12	--	--	--	11.2	13.0	14.9	16.7	18.6	20.5	22.3	24.2	26.0	27.9	29.8
14	--	--	--	--	16.8	19.3	21.7	24.0	26.5	28.9	31.3	33.7	36.1	38.5
16	--	--	--	--	--	23.8	26.9	29.8	32.8	35.8	38.8	41.7	44.7	47.7

[1] Volume above stump in *cubic feet*, by 4-foot lengths to a variable top diameter of 5 inches outside the bark.

To obtain cords or units of wood divide sum of cubic volumes above by: 90 for a 128 cu. ft. cord, 102 for a 144 cu. ft. cord, and 113 for a 160 cu. ft. cord.

This table also will give approximate cubic feet contents of any species of trees whose diameters at one-half merchantable height range from 73 to 83 percent of the diameter at breast height.

[2] Adapted from tables prepared by Southern Forest Experiment Station.

APPENDIX K

VOLUME IN TREE TOPS (HARDWOODS)

Fuelwood above merchantable stem [1 & 2]

D. B. H. (inches)	Height above merchantable stem in feet (Total height minus merchantable height)					
	20	30	40	50	60	70
	Cords	*Cords*	*Cords*	*Cords*	*Cords*	*Cords*
12	---	---	1/10	1/10	1/6	1/6
14	---	1/10	1/6	1/6	1/4	1/4
16	1/10	1/10	1/6	1/4	1/3	1/3
18	1/10	1/6	1/4	1/3	1/3	1/2
20	1/10	1/4	1/3	1/2	1/2	2/3
22	1/6	1/4	1/3	1/2	2/3	3/4
24	1/6	1/3	1/2	2/3	3/4	1
26	1/4	1/2	2/3	3/4	1	1 1/6
28	1/3	1/2	3/4	1	1 1/6	1 1/4
30	1/3	2/3	3/4	1	1 1/4	---

[1] For estimating *approximate* volume of stacked fuelwood in tops and branches above merchantable height. Merchantable height is the distance above the stump to an 8 inch top or where the merchantable stem is otherwise limited by large branches or defects.

[2] Adapted from "Timber Cruising," Girard and Gevorkiantz, U. S. Forest Service, 1939, using converting factor of 67 cubic feet per cord.

INDEX