UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 285

Contribution from the Forest Service
HENRY S. GRAVES, Forester

Washington, D. C. PROFESSIONAL PAPER October 22, 1915

THE NORTHERN HARDWOOD FOREST: ITS COMPOSITION, GROWTH, AND MANAGEMENT

By

E. H. FROTHINGHAM, Forest Examiner

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INTRODUCTION.

The great hardwood forests of eastern North America separate naturally into two divisions—northern and southern—the one relatively simple, the other varied and rich in composition. What distinguishes the northern from the southern hardwood forest is the presence of yellow birch, white pine, and hemlock and the absence of yellow poplar, red gum, sycamore, and many other southern species. The geographical extent of the northern hardwood forest, in fact, practically coincides with the range of yellow birch (fig. 1, p. 2). It centers about the region in which the white pine lumbering industry was developed.

Early logging in the northern hardwood forests took chiefly the white pine, little hardwood timber being felled except in clearing for settlement. As time went on and demands increased, the cullings extended to spruce, hemlock, and even the more valuable hardwoods. The poorest of the species are now so valuable that stands are often cut clean, and even the tops, branches, and larger undergrowth utilized. There are many reasons why the consumption of hardwoods may be expected to decrease, yet the qualities of these slow-growing trees are so obvious and their woods are so admirably adapted to such a variety of uses that the problem of perpetuating at least a reasonable supply is one of public concern.

It is the aim of this bulletin to outline the extent, general characteristics, and economic importance of the northern hardwood forest; to describe briefly the silvicultural features of the principal species; and to point out the methods of managing hardwood stands which appear best calculated to furnish a continuous supply of these useful woods. There are also given, in the Appendix, a series of volume tables for northern hardwoods for use in estimating the quantity of standing timber.

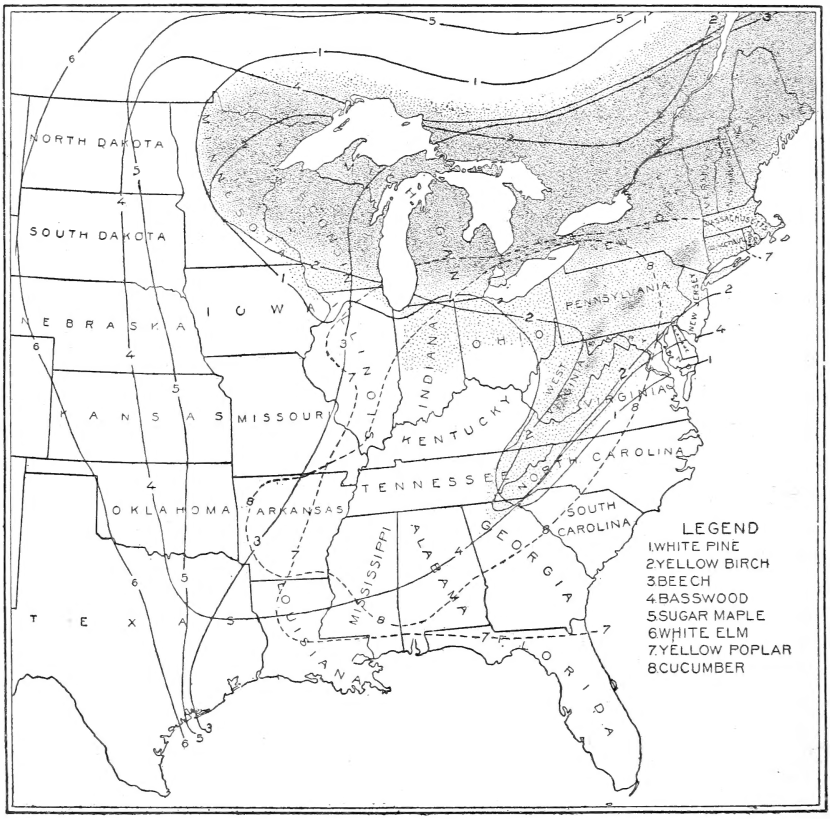

FIG. 1.—Distribution of the northern hardwoods. (The heavy shading represents the region in which the northern hardwoods characterize large areas of forest. The light shading indicates the region of transition from the typical northern to the southern hardwood forest. The numbered lines are the ranges of the species named in the legend. The broken lines are the range limits of two southern hardwoods whose presence largely determines the southward extension of the northern forest. Prepared by Wm. H. Lamb.)

THE NORTHERN HARDWOOD FOREST.

The hardwood forest which is considered in this bulletin occupies the fresh, well-drained, fertile soils of the northern pine region. Its more characteristic hardwoods are sugar maple [1] and yellow birch.

[1] The closely related black maple is not distinguished from sugar maple in this bulletin. Both are commonly referred to as "hard" or "rock" maple.

The term "northern hardwoods" will be used for all stands in this region in which one (or more) of the characteristic species listed on page 7 predominates; for though the type possesses a general uniformity of composition sufficient to distinguish it from other important northern forest types, it varies greatly in different regions.

There are two hardwood forest types that are not considered in the bulletin, although the species which belong to them are often found scattered through the northern hardwood forests. These are the type of the dry sandy plains, in which the chief hardwoods are oaks of various kinds, mixed with hickories and in the east with chestnut, and the type of the swampy places, in which the characteristic hardwoods are black ash, red and silver maples, willows, and alders. The swamp type is not of great extent or importance, and the other type is so much more characteristic of the South that it might be considered only a northern extension of a southern type.

GEOGRAPHICAL EXTENT.

The northern hardwood forest (fig. 1) is found in greater or less abundance within the drainage systems of the St. Lawrence, the Great Lakes, and the upper Mississippi, as far south as southern Minnesota; throughout northern New England, and southward along the northern and southern Appalachian Mountain ranges to extreme northern Georgia. In the North it merges into the spruce and fir and the aspen and birch forests of Canada. Along its southern and lower altitudinal borders it shades into the great "central hardwoods" forest of the Ohio and Mississippi Valleys. In the West it gradually gives place to the prairie of the Great Plains region. On the uplands the "oak openings" supplant it in large measure, until these, too, give way to the prairie. Just how large an area is occupied by northern hardwoods is difficult to estimate. It probably amounts to over 50,000,000 acres, nearly half of which is in the Lake States. The decrease in the total forest area of the Lake States and the northeast—once practically equal to the entire land area—to 60 per cent in New England, 43 per cent in Michigan and Wisconsin, and 35 per cent in New York and Pennsylvania,[1] has undoubtedly been greatest in the softwood forest.

TOPOGRAPHY AND CLIMATE.

Topographically the northern hardwood region separates into two very distinct parts—the eastern mountain ranges and the rolling, glaciated land about the Great Lakes.

The eastern mountain ranges extend from southern Canada southwest to northern Alabama and Georgia. The climatic conditions suitable for the best growth of the northern hardwoods prevail at minimum elevations of from 500 feet in northern New England to 1,000 feet in southern New England and the Adirondacks and 3,500

[1] Forest Service Circular 166, "Timber Supply of the United States," by R. S. Kellogg.

feet in the southern ranges. Above these altitudes the hardwoods give place in large measure to spruce and fir. On northerly slopes the climate suitable for northern hardwoods is often at several hundred feet lower altitude than on southerly exposures.

The soils in the northern hardwood zone are, as a rule, loamy sands, the result of the decay of granite, quartzites, and siliceous gneisses. In the eastern mountains they are partly glacial and partly residual in origin, thin, and of low agricultural value. In the Lake States and through much of the northeast they were deposited by the glaciers in moraines and glacial hills or laid down in beds of varying thickness by glacial streams. Here the hardwoods occupy, for the most part, the water-assorted loams and clays or the unassorted morainal tills, rich in clay, but also thrive on light, sandy soils in localities subject to prevailing moist winds, as in western lower Michigan. In the Appalachians, south of the limit to which the glaciers extended, the soils result entirely from the decomposition of the native rocks. Where schists prevail, fertile loams are the products of decomposition, and these may reach some depth in the coves and broader valleys.

The climatic factors which determine the distribution of forests are moisture and temperature. These differ in relative importance according to the nature of the region. In temperate semiarid regions the determining factor is moisture; in temperate humid regions it is temperature. The northern forest region is distinctly humid, and the composition of the forests is therefore influenced chiefly by temperature. Its western limits, however, are fixed chiefly by moisture factors.

The growing season is approximately five months, from May to September, inclusive.[1] The duration of the season varies within the region, and is shortest in the north and at high altitudes. This factor has undoubtedly a large influence upon the composition of the northern hardwood forests, which is not so much a matter of the sensitiveness of the species to extremes of temperature as it is of optimum temperature.

How moisture and temperature affect the different species in the complexity of the forest environment is still so little known that no positive information can be given. The best that can be done is to compare the available climatic data from observation stations within the northern forest region with corresponding data from stations just outside. Table 1 accordingly gives the average monthly temperature and precipitation during the growing season for adjacent parts of the northern and southern hardwood regions. Similar data for April and October are also given, together with the annual precipitation and depth of snow.

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[1] Raphael Zon, "Meteorological Observations for Purposes of Botanical Geography, Agriculture, and Forestry," Dept. of Agriculture Monthly Weather Review, vol. 42, No. 4, April, 1914; map shows division of the United States on basis of periods of vegetative growth and rest.

CULLED FOREST OF NORTHERN HARDWOODS, SPRUCE, AND HEMLOCK IN THE ADIRONDACKS.

Spruce trees 10 inches and over breasthigh have been removed.

CUT-OVER HARDWOOD LAND IN NORTHERN WISCONSIN LOGGED DURING AN "OFF YEAR" FOR MAPLE LUMBER.

The best maple was taken but much good material was left standing. Lumbermen called this a "clean cutting."

TABLE 1.—*Temperature and precipitation* [1] *within the northern hardwoods and the northern edge of the southern hardwood regions. Based on data from United States Weather Bureau Bulletin Q (1906); observations extending over period of from 5 to 50 years.*

Geographical division and forest region.	Average monthly temperature.							Average temperature for the growing season.
	Apr.	Growing season.					Oct.	
		May.	June.	July.	Aug.	Sept.		
New England and the Adirondacks:	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*
Northern hardwood	41	54	62	66	64	57	46	61
Southern hardwood	44	56	65	70	67	60	48	64
Alleghenies and Southern Appalachians:								
Northern hardwood	46	59	66	69	67	62	50	65
Southern hardwood	50	62	68	72	71	64	54	67
Lake States:								
Northern hardwood	41	53	63	68	64	57	45	61
Southern hardwood	47	58	67	72	70	62	50	66
General average:								
Northern hardwood	42	54	63	67	65	58	46	61
Southern hardwood	47	59	67	71	69	62	51	66

Geographical division and forest region.	Average precipitation.							Average total precipitation.		Average annual snowfall.
	Apr.	Growing season.					Oct.	Growing season.	Annual.	
		May.	June.	July.	Aug.	Sept.				
New England and the Adirondacks:	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Inches.*	*Inches.*	*Inches.*
Northern hardwood	2.4	3.3	3.9	4.4	4.1	3.7	3.3	19.4	42.8	96.1
Southern hardwood	2.9	3.5	3.8	4.1	3.8	3.5	3.6	18.7	44.8	78.1
Alleghenies and Southern Appalachians:										
Northern hardwood	3.4	4.1	5.6	4.9	4.7	3.6	3.8	22.9	49.2	58.5
Southern hardwood	3.1	3.9	4.6	4.7	3.5	3.1	2.5	19.8	41.8	32.4
Lake States:										
Northern hardwood	2.3	3.5	3.8	3.8	3.6	3.4	3.1	18.1	31.1	64.0
Southern hardwood	2.4	3.3	3.8	3.5	3.0	3.0	2.4	16.6	29.9	40.1
General average:										
Northern hardwood	2.5	3.6	4.2	4.2	4.0	3.5	3.3	19.0	38.4	75.5
Southern hardwood	2.9	3.6	4.1	4.2	3.4	3.2	2.8	18.5	39.2	48.4

[1] Monthly averages for the growing season—May to September, inclusive—and for April and October, with average annual precipitation and snowfall.

The stations and altitudes at which the observations were taken are as follows:

Northern hardwoods:

New England— *Feet.*

- Mayfield, Me. 1,000
- Bethlehem, N. H. 1,470
- Stratford, N. H. 950
- Wells, Vt. 1,000
- Jacksonville, Vt. 1,000
- Saranac Lake, N. Y. 1,620
- Number Four, N. Y. 1,571

Alleghenies and Southern Appalachians—

- Le Roy, Pa. 1,400
- State College, Pa. 1,191
- Terra Alta, W. Va. 3,207
- Linville, N. C. 3,800

Lake States—

- Calumet, Mich. 1,246
- Escanaba, Mich. 594
- Grayling, Mich. 1,147
- Ivan, Mich.

Northern hardwoods—Continued.

Lake States—Continued. *Feet.*

- Koepenick, Wis. 1,675
- Medford, Wis. 1,420
- Grantsburg, Wis. 1,095
- Mount Iron, Minn. 1,510
- Sandy Lake Dam, Minn. 1,229
- Park Rapids, Minn. 1,300

Southern hardwoods:

- Lewiston, Me. 210
- Concord, N. H. 280
- Rome, N. Y. 450
- Pittsburgh, Pa. 757
- Elkins, W. Va. 1,920
- Hot Springs, Va. 2,195
- Asheville, N. C. 2,255
- Lansing, Mich. 881
- Madison, Wis. 974
- St. Paul, Minn. 758

COMPOSITION.

THE FOREST AS A WHOLE.

The species commonly found in the northern hardwood forest are separated in Table 2 according to their abundance and distribution; only approximately, however, because there are many subordinate variations which can not be shown. The list does not include several dwarf maples, thorn apples, mountain ash, etc., which are of little or no economic importance.

TABLE 2.—*Hardwoods and conifers grouped according to their prevalence in the northern hardwood forests.*[1]

Region.	Characteristic.	Locally characteristic.	Occasional.
Northeastern States	Yellow birch. Sugar maple. Beech. Red maple. Ironwood. Hemlock. White pine. Red spruce. Balsam fir.	Paper birch. Aspen. Large tooth aspen. Fire cherry. Black birch. Basswood. White elm. White ash. Silver maple. Red oak. White spruce.	Black ash. Slippery elm. Gray birch. Black cherry. Balm of Gilead. Norway pine. Black spruce. Tamarack. Arborvitæ.
Lake States	Sugar maple. Yellow birch. Basswood. White elm. Beech.[2] Ironwood. Hemlock. White pine.	Paper birch. Aspen. Large tooth aspen. Fire cherry. Cork elm. White ash. Red maple. Red oak.	Black ash. Slippery elm. Balm of Gilead. Black cherry. Black birch. Silver maple. White spruce. Black spruce. Balsam fir. Tamarack. Arborvitæ. Norway pine. Jack pine.

[1] In the transition zone between the northern and southern hardwood forest—especially in Pennsylvania and the southern Appalachians—yellow poplar, magnolia, sycamore, black and red gums, and other southern hardwoods not shown in the above list often appear in some abundance among the northern hardwoods.

[2] Beech is not found in Minnesota and only in extreme eastern Wisconsin.

Under the heading "Occasional" are included a number of species which are characteristic either of swamp or of dry-soil types, but are often found among the northern hardwoods as strays. Besides these there are a number of oaks, hickories, walnuts, pines, and birches which occasionally intrude, but being characteristic of other site conditions, can not be considered regular members of the northern hardwood forest. The great bulk of the forest consists of the species listed as "characteristic." The proportions of the species, as will be brought out more fully, vary greatly in different parts of the region. The "locally characteristic" species are found here and there, some rare or of small value, others abundant locally and of considerable importance. Some of these species, especially paper birch and the aspens, form distinct but transitory types on burned-over lands (Pl. VIII), but occur only as widely scattered individuals in old growth stands. They are light-foliaged trees, intolerant of shade, which shelter beneath their crowns the reproduction of maple, beech, hemlock, and other shade-tolerant and heavy-foliaged species. One generation of the intolerant trees is all that is possible under these conditions, for their seedlings can not live in the dense shade of the other undergrowth already started. Survivors of the original temporary stands, however, are often found in the hardwood forest, as well as isolated individuals which have sprung up among old timber where there are accidental openings in the crown cover. Most of the conifers, notably white pine and red spruce, also grow in well-marked types of their own, often in pure stands. Basswood and elm, on the other hand, rarely grow otherwise than as scattered individuals, except in Michigan and Wisconsin, where they sometimes form fully a third of the total stand.

About 15 species of hardwoods are common to the northern and southern forests, and 8 (birches, aspens, fire cherry, and black ash) are found only in the northern. Grouped according to geographical range, north and south, the trees of the northern hardwood forest, excluding a few of the less important, are as follows:

Range northern.

Hardwoods:
- Yellow birch.
- Paper birch.
- Gray birch.
- Aspen.
- Large tooth aspen.
- Balm of Gilead.
- Black ash.
- Fire cherry.

Conifers:
- Red spruce.
- White spruce.
- Black spruce.
- Balsam fir.
- Hemlock.
- White pine.
- Norway pine.
- Jack pine.
- Tamarack.
- Arborvitæ.

Range northern and southern.

Hardwoods:
- Sugar (and black) maple.
- Red maple.
- Silver maple.
- Black birch.
- Beech.
- Basswood.
- White elm.
- Slippery elm.
- Cork elm.
- Ironwood.
- White ash.
- Black cherry.
- Red oak.

The northern forest with about 21 hardwoods is much simpler in composition than the southern, which contains fully 95 of local or general commercial value. It has been still further simplified by selective lumbering. Not only the white pine, spruce, and hemlock, but in many places the better hardwoods also, have been heavily cut, thus increasing the proportion of the less valuable kinds in the culled forests.

REGIONAL VARIATIONS.

The eastern part of the northern hardwood forest is characterized by the abundance and importance of red spruce and balsam fir. These extend south from Canada along the mountains of New England, the Adirondacks, and the southern Appalachians, at increasing elevations. The relatively pure spruce and fir forests occupy higher altitudes than the hardwood forest, but the two are freely intermixed through a broad but not definitely marked altitudinal zone. Though red spruce is the most common spruce associate of the hardwoods, white spruce is sometimes the more abundant locally. The spruce is largely replaced in the Alleghenies by hemlock; and here cucumber (*Magnolia acuminata* Linn.) and yellow poplar, prominent members of the southern hardwood forest, appear in small quantities among the northern hardwoods.

Like the spruce type, the transitory burned-land type of aspen and paper birch is more abundant and of greater perfection in northern New England than in the Lake States. Farther south it becomes less important; paper birch drops out in northern Pennsylvania, and the type loses its identity more and more through the inclusion of other species.

Of the characteristic northern hardwoods, sugar maple is probably the most abundant in the northeastern States at large. Yellow birch, however, is the most abundant in northern New England. It grows in forests of widely different composition, and shares to some extent the habits of paper birch, appearing on burns in small, pure, even-aged stands (Pl. X, fig. 1, and Pl. VII, fig. 2) or in mixed stands with paper birch and aspen, to which it adds an element of permanence. Spruce, maple, and beech, which thrive in the light shade cast by such stands, outlive the paper birch and aspen, and will eventually gain the ascendancy. In the old-growth forests, therefore, yellow birch is found in a great variety of mixtures with spruce, fir, beech, sugar and red maples, white pine, and hemlock, with scattered individuals or groups of other species, notably paper birch and aspen. The old-growth hardwoods in this region are usually very defective, the beech especially. The red maple is usually abundant only as a subordinate growth of little value.

Ash occurs sparsely in New England at low to moderate elevations. Black birch and black cherry become locally abundant in the mountains of southern Vermont and New Hampshire, the Adirondacks, Catskills, and farther south. The northern hardwood forest continues south at gradually increasing altitudes along the southern Appalachian Mountains, becoming more and more restricted to northerly slopes and cool valleys. This region properly belongs to the transition zone between the northern and southern hardwood

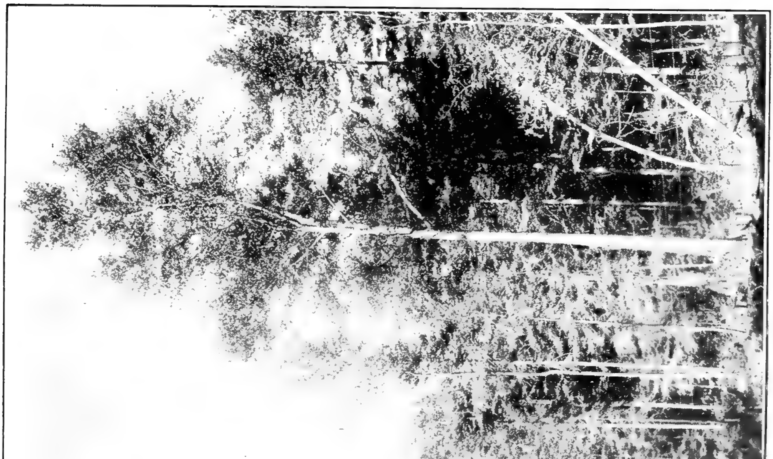

FIG. 1.—BEECH.

FIG. 2.—WHITE ELM.

FIG. 3.—SUGAR MAPLE.

TREE FORMS OF NORTHERN HARDWOODS IN THE FOREST.

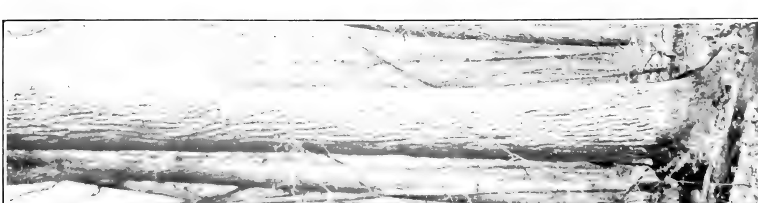

FIG. 1.—WHITE ELM.

FIG. 2.—SHORT-BODIED YELLOW BIRCH.

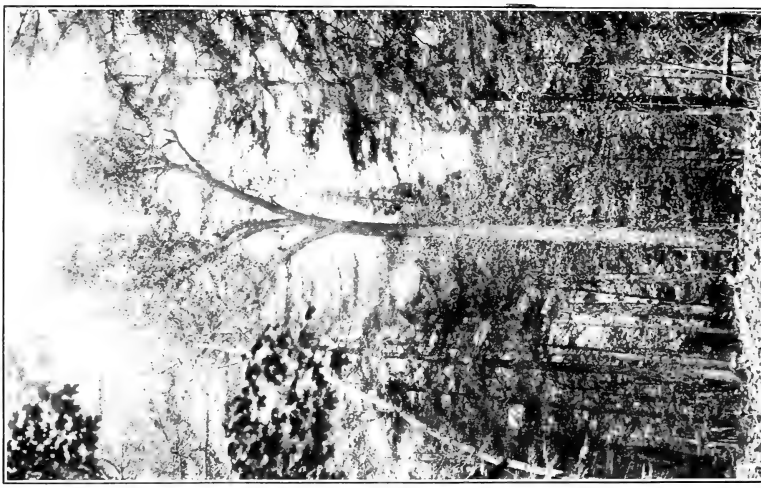

FIG. 3.—LONG-BODIED YELLOW BIRCH.

FIG. 4.—BASSWOOD.

TREE FORMS OF NORTHERN HARDWOODS IN THE FOREST.

regions. In the higher mountains spruce covers the peaks and ridges, especially on northerly slopes, and associates freely with the northern hardwoods along the lower edges of the spruce belt. White pine and hemlock also continue south along the Appalachians, and by mixing with the hardwoods help to maintain the characteristic structure of the northern forest.

Extensive pure stands of beech are found on ridges in southern North Carolina and farther north along the Blue Ridge. The commercial importance of the northern hardwoods is minimized, however, by the abundance of valuable southern timber trees like white oak and yellow poplar.

Elm and basswood as forest trees are more abundant in southern New England than in Maine and northern New Hampshire. These species appear at low altitudes and increase in quantity toward the west and south, their scarcity throughout the east being in marked contrast to the abundance in which they are found in the west. The great abundance of basswood and elm is perhaps the most striking characteristic of the northern hardwood forest in the Lake States. According to estimates compiled by the Bureau of Corporations,[1] basswood forms 12 per cent and elm 9 per cent of all the hardwoods in these States. Maple leads in amount with 35 per cent, birch comprises 24 per cent, beech 4 per cent, and ash 2 per cent of the total hardwood stand. Together these six species make up more than a third of the total stand, hardwoods and softwoods, in the Lake States. Table 3, arranged from a similar table in the Bureau of Corporations report, illustrates the relative importance of the northern hardwoods, individually and collectively, in the Lake States forests during 1910 (the year in which the data were gathered). The estimates do not include publicly owned timber, which, however, does not amount to a large proportion of the merchantable stand.

TABLE 3.—*Privately owned standing timber in the Lake States, by species.*[2]

Species.	Total.	Michigan.	Wisconsin.	Minnesota.
	Board feet.	*Board feet.*	*Board feet.*	*Board feet.*
Total	100,000,000,000	47,600,000,000	29,200,000,000	23,200,000,000
Conifers	58,100,000,000	22,200,000,000	17,100,000,000	18,800,000,000
Hardwoods	41,900,000,000	25,400,000,000	12,100,000,000	4,400,000,000
Maple	14,500,000,000	12,200,000,000	2,300,000,000	
Birch	10,100,000,000	5,100,000,000	4,300,000,000	700,000,000
Basswood	5,100,000,000	2,200,000,000	2,500,000,000	400,000,000
Elm	3,700,000,000	2,100,000,000	1,500,000,000	100,000,000
Beech	1,600,000,000	1,600,000,000		
Ash	1,000,000,000	600,000,000	300,000,000	100,000,000
Poplar (and balm of gilead)	2,000,000,000			2,000,000,000
Oak	700,000,000	200,000,000	300,000,000	200,000,000
Miscellaneous	3,200,000,000	1,400,000,000	900,000,000	900,000,000

[1] Report on the lumber industry, Pt. I, Standing timber.

[2] From Bureau of Corporations, Report on the lumber industry—Standing timber, 1913, p. 78.

Table 3 shows that in the Lake States, as in the East, yellow birch and sugar maple are the most abundant generally, the chief characteristics that distinguish this part of the northern hardwood forest from the northeastern part being the abundance and importance of basswood, elm, hemlock, and white pine, and the absence of red spruce. Here also, however, some spruce extends down from Canada, in this case white spruce being the more important, especially in Minnesota, and black spruce occurring seldom except in the swamps or "muskegs."

In Michigan the stand of sugar maple alone exceeds that of all the other northern hardwoods combined, and amounts to more than a quarter of the total hardwood and softwood stand. The maple in Michigan is of better quality than in many parts of New England, but in Wisconsin much of the maple is very defective (Pl. II). Maple is not abundant in Minnesota, and is as yet of small commercial value; in fact, the hardwoods as a whole are of relatively small importance in this State. Beech is found in Wisconsin only for a short distance inland from Lake Michigan. Yellow birch is especially abundant and important in Wisconsin, and in Minnesota it is the most abundant of the characteristic northern hardwoods. Black birch is found, but much less abundantly than in southern New England. There is more basswood than elm in Michigan; in Wisconsin they are nearly equal in quantity. "Poplar" (aspens) occupies considerable area in all three States, but by far the largest amount is found in Minnesota. In Michigan and Wisconsin the stands are for the most part too young to be of any commercial value.

FOREST RELATIONSHIPS AND THEIR EFFECT ON COMPOSITION.

There are two sets of factors which influence the success of trees in the natural forest, and which must be regarded in silviculture: Physical, including soil and climate, and physiological, including aggressiveness in reproduction, tolerance of shade, rate of growth, form, size, longevity, and resistance to injury and disease. To some extent these factors are interactive, and a deficiency in one or several may be offset by a marked superiority in some other. For instance, rapid growth may compensate for intolerance of shade, air moisture for soil poverty, abundance of seed for low fertility, and longevity and resistance to injury for intolerance and ineffective reproduction. It is therefore profitable to consider the factors more or less in combination. Those of tolerance and reproduction are generally the most important in determining the local distribution and abundance of the species.

Tolerance and reproduction.—Table 4 lists the important species in the northern hardwood forest in the approximate order of their shade tolerance, beginning with the least tolerant, and gives the characteristics of each which influence its reproduction inside and outside of the forest.

These characteristics are subject to variation. Tolerance, for example, is greater in seedlings than in old trees, in the south than in the north, and in fertile than in dry situations. The frequency of seed years and the fertility of the seed produced depend to a large extent on climatic factors, and the amount is influenced by these and by the light supply; even the annual seed bearers do not produce the same amount each year. The extent of seed distribution depends on the height and exposure of the crown, the buoyancy of the seed, and the strength and steadiness of the winds at seed time. Growth of both seedlings and sprouts is influenced by the length of the growing season, the fertility of the soil, and the humidity of the air. All of these variations, by affecting the aggressiveness of particular species in competition with others, modify the composition of the stand. The variations caused by physical factors (soil, precipitation, temperature, etc.), though they do have an influence during the youth of the stand, are active especially in determining the character of the old-growth forest, and are chiefly responsible for differences in its composition at different latitudes, longitudes, altitudes, and exposures. Those caused by physiological factors are especially active in the establishment and subsequent history of temporary stands.

The temporary stands formed by species aggressive outside the forest give way, after they have developed, to species which are aggressive inside the forest. A convenient classification might be based upon this difference in aggressiveness, the trees being called, respectively, extensive or intensive reproducers, according to whether they are more aggressive outside or inside the forest. The separation of the species into these classes would then be made on the basis of the last two columns of Table 4. Extensive reproducers are intolerant of shade, and are generally small, rapid-growing, short-lived, and light-foliaged, and have a tendency to form even-aged stands (Pl. VI). Intensive reproducers are tolerant in tendency, of slow growth and long life, and form uneven-aged stands with dense crown cover (Pl. V). To be sure, these characteristics exist among the different species in all degrees between the extremes, so that a hard and fast line can not be drawn between the extensive and intensive reproducers. Some species even are extensive under certain conditions and intensive under others. Nevertheless the divergent tendencies are perfectly evident and a scale can be drawn the extremes of which are almost exclusively extensive and intensive.

TABLE 4.—*Tolerance and reproduction of hardwoods and conifers in the northern hardwood types.*

Species in order of tolerance (approximately), beginning with the least tolerant.	Seed production.						Seedlings.		Sprouting capacity.	Aggressiveness in reproduction.	
	Periodicity.	Seed crops.		Dispersal.		Per cent fertility.[1]					
		Season.	Amount each seed year.	Extent.	Chief means.		Requirements for rapid growth.	Growth rate.		In the open.	In the forest.
Aspen	Annual	Spring	Immense	Very wide	Wind	Low	Very much light; cool, moist soil and air.	Rapid	Very effective.	Very high.	Very low.
Fire cherry	do	Summer	Large	do	Birds	Very high.	No shade	do	Effective	do	Do.
Gray birch	do	Fall	do	Wide	Wind	Moderate (probably).	do	do	Very effective.	do	Do.
Black cherry	do	Summer	do	Moderate	Birds	High	Much light	do	Effective	High	Low.
Paper birch	do	do	do	Wide	Wind	Rather low	Much light; cool, moist soil and air.	do	Very effective.	Very high.	Do.
White ash [2]	Not annual [3]	Fall	do	do	do	Moderate	Much light;[2] moist, fertile soil.	do	Effective from small stumps.	Moderate	Moderate.
White elm	Annual	Spring	do	do	do	do	Much light; moist air or soil.	do	Unimportant except in youth.	do	Low.
White pine	Not annual	Fall	do	Moderate	do	High	Light shade for first year or two; mineral soil.	Slow	Absent	High	Do.
Basswood	Annual	Early fall	Moderate	do	do	Moderate	Light shade; moist air.	Rapid	Very effective.	Moderate	Moderate.
Yellow birch	do	Fall	Large	Wide	do	do	Cool, moist air and soil; side shade.	Moderate	Effective from small stumps.	do	Do.
Black birch	do	do	do	do	do	Low	do	do	do	do	Do.
Red maple [4]	do	Spring	do	Moderate	do	Moderate	Moist soil and air	Rapid	do	do	Do.
Ironwood	do	Fall	Moderate	do	do	do	Moist air and soil; shade.	Moderate	(?)	Low	High.
Sugar maple	do	do	Large	do	do	do	Moist soil and air	Slow	Effective from small stumps.	Moderate	Do.
Beech	Not annual	do	Rather small	Restricted	Rodents	do	Warmth, humus, shade.	do	Ineffective	Very low	Moderate.
Red spruce	do	do	Large	Moderate	Wind	High	Cool, moist air, mineral soil.	Very slow.	Absent	Moderate	Do.
Hemlock	do	do	do	do	do	Moderate	Shade; moist air, humus soil.	do	do	Very low	High.

[1] Includes abortive seed produced and amount destroyed by insects and fungi while still on the tree. Basswood and beech, for example, lose much seed from these causes.
[2] As a seedling white ash is more tolerant than yellow birch, and will persist for years under fairly heavy shade.
[3] White ash bears some seed annually, but full crops only at intervals of several years.
[4] Red maple is decidedly less tolerant in swamps.

"INTENSIVE" ALL-AGED REPRODUCTION IN A VIRGIN FOREST OF SUGAR MAPLE, BEECH, BASSWOOD, AND HEMLOCK. ROSCOMMON COUNTY, MICH.

"EXTENSIVE" EVEN-AGED REPRODUCTION OF ASPEN AND FIRE CHERRY ON CUT AND BURNED OVER WHITE-PINE LAND IN WISCONSIN.

For the species in Table 4 such a scale is approximately as follows:

Most extensive:
1. Aspens.
2. Gray birch.
3. Paper birch.
4. Fire cherry.
5. Black cherry.
6. White pine.
7. Yellow birch.
8. Black birch.
9. White ash.

Most extensive—Continued.
10. White elm.
11. Red spruce.
12. Basswood.
13. Sugar maple.
14. Red maple.
15. Ironwood.
16. Hemlock.

Most intensive:
17. Beech.

Red spruce and yellow birch are examples of species which though in most respects intensive, are also extensive, under favorable conditions. Both often reproduce in even-aged second-growth stands on clearings, while the spruce, and to a less extent the birch, are able to start seedlings within the forest.

The extensive species are obvioulsy well adpated for quickly reclaiming burned or otherwise cleared land, and not for competition with intensive species. (Pl. VI.) Aspen and paper birch are rapidly displaced by maple, beech, or hemlock, or, in fact, any others of the "characteristic" species of the northern forest whose reproduction may happen to start beneath them.

The intensive reproducers hold their ground when once they have gained it; but they differ among themselves in aggressiveness and persistance. Sugar maple is the most generally aggressive reproducer throughout the characteristic beech-birch-maple type. This is undoubtedly due to its combined tolerance and seeding qualities. Beech, which is probably more tolerant, does not bear large seed crops annually, and much of the seed produced is destroyed by animals. Yellow birch, which does bear each year, is less tolerant than maple. Its light-winged seed are so widely dispersed, however, that many fall where the crown shade is light enough to permit the development of seedlings. These are adaptable to a great variety of seed-bed conditions, from sandy soils burned free of humus to duff-covered clay loams, and even moss-covered bowlders, decayed stumps, and logs. Yellow birch thus accomplishes through its reproductive aggressiveness often more than beech can accomplish through its extreme shade endurance. White elm and basswood both require much light for growth and especially for seed production. The elm seeds, with their surrounding wings, are light, thin disks, fitted to be distributed quite widely by the wind; the tree bears annually and abundantly. Basswood seeds are produced in less abundance, and at first glance seem poorly adapted for wind dispersal. They are suspended in clusters of as many as six large spherical fruits beneath a single bract, apparently insufficient in size for a long flight; but when the seed clusters fall the bract becomes an efficient helicopter, which, in a light breeze, may bear its load of seed a hundred yards or more. The seedlings of basswood and elm are able to endure moderate shade for 5 or 6 years, but seedlings of greater age are rare in the virgin forest except where the crown cover is broken.

Forest-grown beech, birch, and maple seedlings which receive but little light develop into extremely slender, whip-like saplings, able to stand erect only through the protection of surrounding trees. If very gradually exposed by frequent, light thinnings these may eventually reach dominant positions; but in silviculture it is probably best in most cases to sacrifice these and secure fresh reproduction under greater light. (Pl. VII, fig. 1, and Pl. XIV, fig. 1.)

Within the ranges of red spruce, fir, and hemlock, the culling of these species from the mixed hardwood and softwood stand reduces the seed supply and thereby the proportion of softwoods in the young growth. Although extremely tolerant, hemlock and spruce seedlings are dwarfed, if not killed, by the heavy shade from an unbroken cover of maple and beech crowns, and can succeed only where the shade is lighter, as may be the case under yellow birch crowns. (Pl. VIII.) This is also true of more or less clear cuttings in these woods, for the softwood seedlings are handicapped by their very slow growth in competition with hardwood sprouts and seedlings and with shade-producing underbrush. In spite of this, the softwood reproduction will usually find enough light here and there to persist and in the course of time reappear in the crown cover. In the mountains, the hardwoods and hemlocks are favored by the relatively warm climate and deep, fertile soils of moderate altitude; at higher altitudes the stands are less dense and reproduction less aggressive, so that spruce and fir assume predominance without much difficulty.

Size, rate of growth, and longevity.—The "intensive reproducers" are, as a rule, larger and longer-lived than the "extensive," and the less tolerant of them owe their presence among shade enduring species in virgin stands largely to these two attributes. They must have started before or at the same time as their tolerant neighbors, and kept a dominant position by faster growth and larger size; or have taken advantage of accidents to trees in the stand and sprung up under the increased light thus admitted. Long-lived trees naturally have more chances to establish reproduction under such conditions than short-lived. White pine, white elm, white ash, and basswood owe their presence among heavy-foliaged species largely to these qualities. In the virgin forest they are almost always taller than the surrounding hardwoods, and this affords them plenty of light for seed bearing. The elm is especially favored by its wide-spreading crown. (Pl. III, fig. 2.) Yellow birch, though of less height, secures crown space and light through the aggressive spread of its slender, flexible twigs and small branches. (Pl. IV, figs. 2 and 3.)

Resistance to various kinds of injury contributes to length of life, and since it varies more or less with climate and soil, it is doubtless at least partly responsible for some regional variations in the composition of the forest. Thus, sugar maple in northern Wisconsin is apt to be inferior to yellow birch in soundness, and is not so abundant. (Pl. II.) Unsoundness does not always influence the forest composition, however. Basswood is extremely unsound, even in the region of its greatest abundance. Its soft wood falls an easy prey to wood-destroying fungi and insects which eat out the hearts of the trees, so that nearly all large basswoods in the old-growth forests are hollow. In spite of this the trees attain great age and size. The reproductive power of large basswoods is apt to be considerably reduced by the breakage of branches in the top, due to snow and wind.

Climate and soil.[1]—Climate has an undoubted selective influence on the composition of these forests, but its precise effect can not easily be disassociated from the other elements determining the composition. In general, however, it appears to restrict the growth of yellow and paper birch and the aspens to the cold, humid air and soil of the north and of fairly high altitudes; the paper birch and aspen extend beyond the Arctic Circle. The wide north and south ranges of most of the hardwoods show that they are less influenced by climate. Some, however, are influenced more than others; for example, in the mountain regions white elm, ash, and basswood are practically confined to warm, lower slopes and sheltered valleys, but beech and sugar maple grow at altitudes as high as those reached by yellow birch. The white elm, ash, and basswood are at their best in the continental climate of the Lake States and southeastern Canada, where they hold their own against the more tolerant beech, maple, and yellow birch. Black birch, though essentially a northern hardwood, is scarce in New England, and its range indicates less hardiness than that of yellow birch. Beech apparently endures greater air dryness than the other northern hardwoods. South of the northern hardwood region it is often a prominent associate of white oak and hickory in relatively dry situations.

As compared with the pines and the hardwoods of the oak-hickory-chestnut types, the northern hardwoods are exacting in their soil requirements. In common with most tree growth they are best suited by deep, fresh, well-drained, fertile loams, mixed with sand or with clay, and kept porous and moist by abundant, well-decomposed humus. It is probable that mycorrhiza and nitrifying soil bacteria

[1] The general climatic conditions within which the northern hardwoods forests grow have been outlined on pp. 3 and 4.

are an important element of fertility in these soils. The northern hardwoods are not confined to rich soils, however. They often thrive on dry or on very shallow soils, but in each case there must be some compensating factor. A shallow soil must be moist, for example, and a dry one deep. In the lower peninsula of Michigan maple, beech, elm, and basswood grow well near the shore of Lake Michigan on deep, dry, fine sand of low agricultural value, while in the eastern part of the State, adjacent to Lake Huron, they are largely replaced on sandy soils by pines or by dry-land hardwoods, principally oaks. The compensating factor here is probably air humidity due to the prevalence of moist winds from Lake Michigan. Under these conditions the growth is more rapid than on heavier, more fertile soil, no farther north, in Wisconsin. Beech is the least exacting species with reference to soil moisture and quality. In Ohio [1] it grows well in limestone soils in mixture with white oak, red oak, hickory, and white ash, and also on well-drained sandy clay moraines with white oak and hickory. It is rather sensitive to changes in the ground-water level through draining, however, as well as by the opening up of the forest crown cover. White elm, basswood, sugar maple, and ash, though apparently less sensitive to such changes, are somewhat more exacting, and in dry climates require a larger amount of soil moisture for their best growth.

The species differ in the ability of their root systems to adapt themselves to soils of different depths and moisture content, but as yet little is known of their capacities in this respect. The soil conditions in which they are found indicate that probably the root systems of sugar maple and yellow birch are the least and those of beech, basswood, and elm the best adapted to draw moisture from a deep but only slightly moist soil. Where the soil and air humidity are ample, the tendency of all the species is in the direction of shallow-rootedness, and vice versa.

FORM.

Tables 50 to 53 (Appendix) show the taper of trees of different species and size, and Tables 5 and 6 give the comparative lengths and breadths of crown of beech, sugar maple, yellow birch, and basswood trees. These figures are average measurements of the crowns of forest trees felled to obtain the growth measurements given in Tables 7 to 9, together with the measurements of the sample trees from the second-growth plots described on pages 21 to 27. No regular variation between crown classes was distinguishable, but practically all the trees measured belonged to the upper crown classes. Both the length and the breadth of the crowns are greatest in the most tolerant and smallest in the least tolerant species, though this

[1] O. E. Baker, in "The forest problem in a rich agricultural county of Ohio," Forestry Quarterly, vol. 1, No. 2, pp. 138–150 (1908).

FIG. 1.—YOUNG TREES IN AN OLD FOREST.

These would probably not survive the removal of the large timber. See Plate XIV, figure 1.

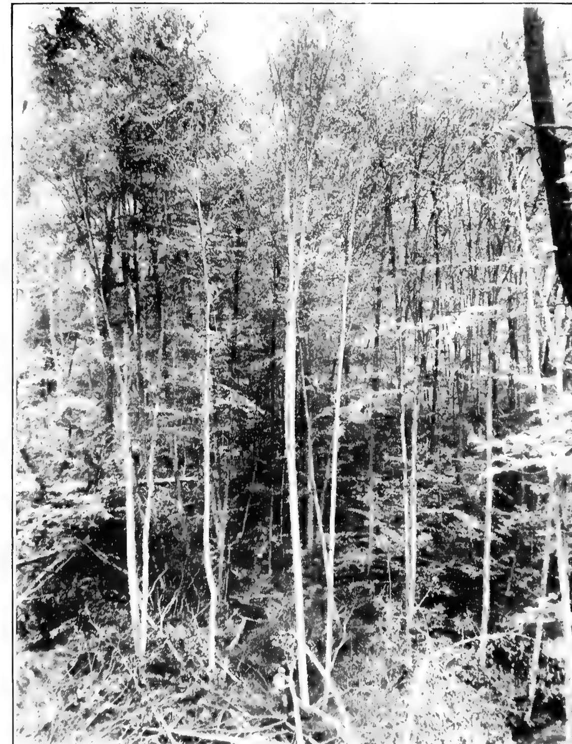

FIG. 2.—A 70-YEAR-OLD STAND, 75 FEET HIGH, WHICH GREW FROM THE START IN THE OPEN.

YELLOW BIRCH IN OLD-GROWTH AND SECOND-GROWTH FORESTS.

RED SPRUCE REPRODUCTION FILLING AN OPENING IN A SECOND-GROWTH STAND OF SUGAR MAPLE AND YELLOW BIRCH NEW HAMPSHIRE.

generalization can not be applied to all species. White elm, for example, may have a wider crown than beech, which is much more tolerant.

TABLE 5.—*Comparative crown widths of northern hardwoods based on diameter breast high.*

Diameter breast high.	Average width of crown.				Diameter. breast high.	Average width of crown.			
	Beech.	Sugar maple.	Yellow birch.	Bass-wood.		Beech.	Sugar maple.	Yellow birch.	Bass-wood.
Inches.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1	3	3	3	3	15	31	27	23	20
2	5	5	5	5	16	32	28	25	20
3	8	8	7	8	17	33	29	26	20
4	10	10	9	10	18	34	30	27	21
5	13	13	11	12	19	34	31	28	21
6	15	14	12	14	20	35	32	29	22
7	18	16	14	15	21	36	34	30	22
8	20	18	15	16	22	36	35	31	23
9	22	19	16	17	23	37	36	33	24
10	24	21	18	18	24	37	37	34	24
11	26	22	19	18	25	38	38	35	25
12	28	23	20	19	26	39	39	36	26
13	29	25	21	19					
14	30	26	22	19	Basis, trees	82	67	42	195

TABLE 6.—*Comparative crown lengths of northern hardwoods based on total height of tree.*

Total height of tree.	Average length of crown.				Total height of tree.	Average length of crown.			
	Beech.	Sugar maple.	Yellow birch.	Bass-wood.		Beech.	Sugar maple.	Yellow birch.	Bass-wood.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
5	3	2	2	3	70	42	33	31	27
10	6	5	4	5	75	45	36	34	28
15	8	7	6	7	80	48	38	37	29
20	11	9	8	10	85	51	40	40	31
25	14	12	10	12	90	54	43	43	32
30	17	14	12	14	95	56	45	....	33
35	20	16	14	16	100	59	47	....	34
40	23	19	17	18	105	62	50	....	35
45	26	21	19	19	110	65	52	....	36
50	29	24	21	21	115	....	54	....	37
55	32	26	24	23	120	....	57	....	39
60	35	28	26	24					
65	39	31	29	25	Basis, trees	87	72	47	253

GROWTH.

The rate of growth of a given species depends on the soil, the climate, and especially sunlight. Theoretically the growth per acre is the same whether there are few or many trees, provided the supply of light is completely utilized by a continuous crown cover. The northern hardwood forest in its virgin condition was characterized by extreme crown density, caused not only by the large number of trees which the fertile soil produced, but also by the difference in shade endurance. Under the light-needing crowns of the tall pines, elms, or basswoods, the tolerant birch, beech, and maple grew without much difficulty, providing an efficient, wood-producing "lower story" of foliage. The total amount of wood produced was very large.

But, on the other hand, the individual trees grew with extreme slowness, especially the more tolerant. Many of the trees which ultimately became dominant did so only after a long struggle upward toward the light, during which their growth was suppressed by shade almost to the point of extinction. Evidence of this struggle is found when old-growth forest trees are cut, in the great and irregular variation in the width of the annual rings. These irregularities are not, it is true, wholly due to variations in the light supply; climatic fluctuations and the drain caused by heavy seed crops undoubtedly have their effect. But the aggregations of fine rings represent chiefly the periods of suppression by shade, while the wider rings represent the more rapid growth under increased light. In dominant trees, therefore, the rings are apt to be narrower near the heart than elsewhere, and in trees which have long been suppressed they may all be very narrow.

Most of the "intensive" trees of the northern forest retain to a great age their power of recovery from moderate suppression, and this is as true of the less as of the more tolerant. In consequence, a graphic curve based on the growth of an individual virgin forest tree is exceedingly irregular, and bears little resemblance to that of an open-grown tree, in which the growth is at first slow, rapidly reaches a maximum, and then gradually decreases. An average curve representing the growth of many forest trees is commonly almost a straight line.

It is worthy of notice that the fine rings next the bark of large, old trees may be due not to insufficient light, but to the great circumference about which the season's layer of wood must be spread. At the top of the tree, where the circumference is smaller, the growth of the same year will show a much wider ring on cross section.

Tables 7, 8, and 9 show the growth of most of the important "intensive" trees of the northern hardwood forest in the Lake States. They are based on decade measurements of selected, well-formed, sound trees, and represent a growth slightly greater than the average rate.[1] The small number of white elm trees measured (14) was insufficient for thoroughly representative tables; but since the trees were dominant the figures given show fairly well what may be expected of vigorous white elm in unmanaged forests. The principal inference from the table is that the growth rate is more or less in proportion to the tolerance of the species, and that basswood is considerably more rapid growing than any of the others.

[1] The maximum and minimum figures do not indicate extremes, but only averages of maxima and minima. All the measurements were separated into three equal parts, representing maxima, averages, and minima, and each part was averaged (graphically) by a curve. The absolute maxima or minima can be found by halving the difference between the figures given in the "maximum" or "minimum" columns and those given in the "average" column for any desired year, and then increasing the average maximum or decreasing the average minimum by this amount.

TABLE 7.—*Growth in diameter, breasthigh, of northern hardwoods and hemlock in the Lake States.*[1]

Age.	Average growth.						Maximum growth.						Minimum growth.					
	Sugar maple.	Beech.	Yellow birch.	Hemlock.	White elm.	Basswood.	Sugar maple.	Beech.	Yellow birch.	Hemlock.	White elm.	Basswood.	Sugar maple.	Beech.	Yellow birch.	Hemlock.	White elm.	Basswood.
Years.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
20	0.5	0.7	1.1	0.7	0.9	2.2	1.2	1.3	2.1	2.0	2.8	3.3	.....	0.3	.....	0.3	0.1	1.3
30	1.2	1.5	1.7	1.3	1.7	3.6	2.3	2.3	3.3	3.9	4.3	5.1	.....	.7	0.2	.6	.4	2.2
40	1.9	2.3	2.3	2.1	2.5	5.0	3.6	3.3	4.6	5.7	5.7	6.9	0.2	1.1	.4	.9	.7	3.1
50	2.7	3.0	3.0	2.9	3.3	6.5	4.9	4.4	5.8	7.6	7.0	8.8	.5	1.6	.7	1.3	1.0	4.1
60	3.5	3.8	3.8	3.8	4.1	7.9	6.3	5.4	7.1	9.4	8.2	10.7	.8	2.2	1.1	1.6	1.3	5.2
70	4.3	4.6	4.6	4.7	4.9	9.4	7.6	6.5	8.4	11.1	9.3	12.5	1.1	2.8	1.5	2.0	1.6	6.3
80	5.2	5.4	5.6	5.7	5.7	10.9	9.1	7.5	9.8	12.8	10.4	14.3	1.5	3.4	2.1	2.4	1.9	7.4
90	6.1	6.3	6.6	6.7	6.5	12.4	10.5	8.6	11.2	14.5	11.5	16.0	1.9	4.0	2.7	2.7	2.3	8.5
100	7.0	7.1	7.7	7.8	7.3	13.8	11.9	9.6	12.5	16.1	12.6	17.6	2.4	4.7	3.4	3.1	2.7	9.5
110	8.0	8.1	8.9	9.0	8.1	15.1	13.2	10.6	13.9	17.7	13.8	19.0	2.9	5.4	4.2	3.4	3.2	10.7
120	9.0	8.9	10.1	10.0	8.9	16.3	14.5	11.6	15.2	19.4	14.9	20.3	3.5	6.1	5.0	3.8	3.7	11.7
130	10.0	9.8	11.2	11.2	9.7	17.5	15.8	12.6	16.5	21.0	16.0	21.6	4.1	6.9	5.8	4.3	4.2	12.8
140	10.9	10.7	12.3	12.3	10.5	18.5	17.0	13.6	17.8	22.6	17.0	22.9	4.7	7.6	6.7	4.8	4.8	13.8
150	11.9	11.5	13.4	13.4	11.4	19.5	18.2	14.6	19.1	24.2	18.1	24.1	5.4	8.3	7.6	5.3	5.4	14.7
160	12.9	12.4	14.5	14.5	12.2	20.6	19.4	15.5	20.3	25.7	19.2	25.3	6.1	9.1	8.5	5.9	6.0	15.7
170	13.9	13.2	15.6	15.5	13.2	21.5	20.5	16.4	21.6	27.2	20.2	26.4	6.8	9.9	9.5	6.6	6.7	16.6
180	14.8	14.1	16.7	16.5	14.1	22.6	21.5	17.3	22.9	.....	21.3	27.5	7.5	10.6	10.5	7.3	7.5	17.5
190	15.7	14.9	17.8	17.5	15.1	23.6	22.6	18.2	21.1	.....	22.3	28.6	8.3	11.3	11.4	8.0	8.2	18.4
200	16.7	15.7	18.8	18.4	16.0	24.6	23.6	19.1	25.2	.....	23.4	29.7	9.0	12.1	12.2	8.7	9.0	19.3
210	17.6	16.5	19.8	.....	17.0	25.5	24.7	20.0	26.3	.....	24.4	30.7	29.7	12.9	13.1	.....	9.8	20.1
220	18.5	17.3	20.8	.....	17.9	26.5	25.7	20.9	27.5	.....	25.5	31.7	10.5	13.8	13.9	.....	10.7	21.1
230	19.3	18.1	21.8	.....	18.9	27.5	26.7	21.8	28.6	.....	26.5	32.7	11.3	14.6	14.8	.....	11.6	22.0
240	20.3	19.0	22.7	.....	19.9	28.4	27.5	22.7	29.7	.....	27.5	33.8	12.1	15.4	15.5	.....	12.5	22.9
250	21.1	19.9	23.7	.....	20.9	29.4	28.4	23.6	30.8	.....	28.5	34.8	13.0	16.2	16.3	.....	13.5	23.8

[1] Based on the following data: Sugar maple, 80 trees, Charlevoix and Kalkaska Counties, Mich., Price and Iron Counties, Wis.; beech, 74 trees, Charlevoix and Kalkaska Counties, Mich.; yellow birch, 27 trees, Charlevoix and Kalkaska Counties, Mich., Price and Iron Counties, Wis.; hemlock, 186 trees Leelanaw County, Mich.; white elm, 14 trees, Charlevoix and Kalkaska Counties, Mich., Price and Iron Counties, Wis.; basswood, 75 trees, Charlevoix and Kalkaska Counties, Mich., Price and Iron Counties, Wis.

TABLE 8.—*Growth in height of northern hardwoods and hemlock in the Lake States.*[1]

Age.	Average growth (total height).						Maximum growth (total height).					Minimum growth (total height).				
	Sugar maple.	Beech.	Yellow birch.	Hemlock.	White elm.	Basswood.	Sugar maple.	Beech.	Yellow birch.	Hemlock.	Basswood.	Sugar maple.	Beech.	Yellow birch.	Hemlock.	Basswood.
Years.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
20	10	13	20	8	21	23	18	19	30	18	32	.....	8	.....	6	16
30	18	21	26	12	28	34	29	28	39	31	44	.....	13	8	7	23
40	25	28	31	16	34	43	39	35	48	42	54	7	17	11	8	30
50	32	33	37	20	40	52	48	42	54	53	63	10	22	15	10	37
60	38	39	43	25	45	59	55	48	60	62	70	14	27	20	11	45
70	44	44	48	30	49	66	61	54	64	70	75	17	32	24	13	51
80	49	48	53	35	53	71	67	59	68	76	80	21	36	30	14	57
90	54	53	58	40	57	75	71	64	71	82	83	25	40	35	15	62
100	58	57	62	44	61	78	75	68	73	85	85	29	44	40	17	66
110	62	62	66	49	64	81	78	72	75	88	87	34	48	45	18	70
120	66	65	69	53	67	83	81	75	77	91	89	38	52	50	20	73
130	70	69	71	57	71	85	83	78	79	94	90	43	56	54	21	76
140	72	72	73	60	73	87	85	81	80	96	92	46	59	58	23	78
150	75	75	75	63	76	88	87	83	81	98	93	50	63	61	25	80
160	77	78	76	66	78	89	89	84	82	100	94	54	66	64	27	82
170	80	80	78	68	81	90	90	85	83	102	95	57	69	67	29	84
180	81	82	79	70	83	91	92	86	83	.....	96	61	72	70	31	85
190	83	83	80	72	85	92	93	87	84	.....	97	64	74	71	33	87
200	85	84	81	74	87	93	94	87	85	.....	97	66	77	73	35	88
210	86	85	81	.....	90	94	96	88	86	.....	98	69	79	74	.....	89
220	87	86	82	.....	92	95	97	89	86	.....	98	71	81	75	.....	90
230	89	87	83	.....	93	96	98	90	87	.....	99	73	83	77	.....	91
240	90	87	83	.....	95	96	99	90	87	.....	100	75	84	77	.....	92
250	91	88	84	.....	97	97	100	91	88	.....	100	78	85	78	.....	93

[1] Based on same data as Table 7. The measurements for white elm were too few to warrant maximum and minimum curves.

TABLE 9.—*Growth in volume (cubic) of northern hardwoods and hemlock in the Lake States.*[1]

Age.	Average growth.					Maximum growth.					Minimum growth.				
	Sugar maple.	Beech.	Yellow birch.	Hemlock.	Basswood.	Sugar maple.	Beech.	Yellow birch.	Hemlock.	Basswood.	Sugar maple.	Beech.	Yellow birch.	Hemlock.	Basswood.
Years.	*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.*	*Cu.ft.*
20	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
30	......	......	......	......	......	......	......	......	......	2.1	......	......	......	......	......
40	......	......	......	......	1.5	......	......	2.4	2.2	6.4	......	......	......	......	......
50	......	......	......	......	4.8	2.5	1.8	5.0	6.6	13.0	......	......	......	......	0.8
60	......	1.0	1.0	......	9.2	5.6	3.6	8.1	12.4	22.0	......	......	......	......	2.2
70	1.5	2.2	2.4	......	15.5	9.5	5.9	12.1	20.0	33.0	......	......	......	......	4.5
80	3.0	3.7	4.3	1.8	23.0	14.7	8.7	17.2	29.0	46.0	......	......	......	......	7.5
90	5.0	5.5	6.8	3.6	32.0	21.0	12.1	24.0	39.0	59.0	......	1.1	......	......	11.4
100	7.3	7.8	10.0	5.9	41.0	29.0	16.5	31.0	50.0	73.0	......	2.4	......	......	16.3
110	10.3	10.5	13.8	9.2	51.0	37.0	21.0	40.0	64.0	87.0	......	3.8	1.5	......	22.0
120	14.0	13.8	18.3	12.5	61.0	47.0	27.0	49.0	78.0	101.0	......	5.3	3.0	......	28.0
130	18.3	17.6	24.0	17.1	72.0	58.0	34.0	60.0	94.0	115.0	1.1	7.0	4.8	......	35.0
140	23.0	22.0	30.0	22.0	82.0	69.0	40.0	71.0	112.0	130.0	2.3	9.0	6.8	......	42.0
150	29.0	27.0	37.0	28.0	93.0	81.0	47.0	82.0	131.0	145.0	3.6	11.5	9.3	1.0	49.0
160	35.0	32.0	44.0	34.0	104.0	93.0	55.0	93.0	152.0	161.0	5.1	14.3	12.3	1.8	57.0
170	42.0	38.0	53.0	40.0	115.0	107.0	62.0	106.0	174.0	177.0	7.0	18.6	16.0	2.6	65.0
180	49.0	44.0	61.0	47.0	126.0	121.0	71.0	119.0	......	193.0	9.0	21.0	20.0	3.4	73.0
190	57.0	50.0	70.0	54.0	138.0	136.0	79.0	133.0	......	210.0	11.3	25.0	25.0	4.6	81.0
200	66.0	56.0	79.0	61.0	151.0	151.0	89.0	147.0	......	228.0	14.1	30.0	30.0	5.9	90.0
210	75.0	63.0	88.0	......	165.0	168.0	98.0	161.0	......	247.0	17.3	36.0	35.0	......	99.0
220	84.0	71.0	98.0	......	178.0	184.0	109.0	176.0	......	267.0	21.0	42.0	40.0	......	109.0
230	94.0	79.0	108.0	......	192.0	201.0	120.0	191.0	......	288.0	25.0	48.0	46.0	......	119.0
240	104.0	87.0	118.0	......	207.0	218.0	132.0	205.0	......	311.0	30.0	54.0	52.0	......	130.0
250	115.0	95.0	128.0	......	221.0	235.0	143.0	220.0	......	335.0	35.0	61.0	58.0	......	141.0

[1] Based on same data as Table 7.

SECOND GROWTH.

Before lumbering began young growth of the intensive species was practically confined to individuals and groups of various ages within the virgin forest. Fires, windfall, and other accidents to the stand undoubtedly resulted in some even-aged reproduction over small areas, but only a small amount as compared with the reproduction of the extensive species. In 1825, for example, fires denuded an area in New Brunswick and northern Maine estimated at more than 5,000,000 acres, over the greater part of which aspen and paper-birch thickets sprang up. In the shade of these the more intensive species came in irregularly, producing relatively uneven-aged stands.

As a result of widespread logging operations and the fires which have followed them, even-aged second-growth stands of the intensive species have become fairly numerous, especially in the rough eastern part of the northern hardwood region, where more of the land has been allowed to revert to forest. It is common for these stands to be of mixed species, one or two of which predominate over the others in number and size. Over small areas a single species may grow in almost pure stands. Yellow birch is the most frequent example

FIG. 1.—A CLUMP OF MERCHANTABLE BASSWOOD SPROUTS FROM A SINGLE STUMP. TENNESSEE.

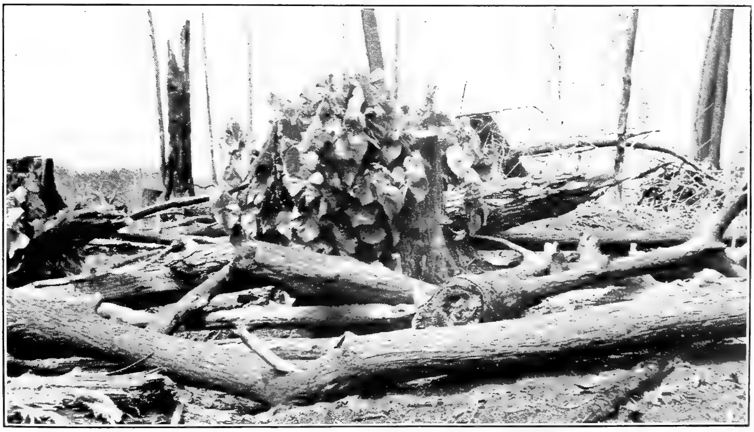

FIG. 2.—THREE MONTHS AFTER A FIRE, CLUMPS OF BASSWOOD SPROUTS WERE PRACTICALLY THE ONLY LIVING VEGETATION. NORTHERN WISCONSIN.

BASSWOOD, NEXT TO CHESTNUT, IS THE BEST SPROUTER.

FIG. 1.—AN 80-YEAR-OLD STAND OF YELLOW BIRCH IN PENNSYLVANIA.

Illustrates plot No. 9, p. 24.

FIG. 2.—A 95-YEAR-OLD BEECH STAND IN NEW HAMPSHIRE.

Illustrates plot No. 13, p. 25.

EVEN-AGED SECOND-GROWTH HARDWOOD STANDS. "OLDER THAN THEY LOOK."

within its geographical range. Substantially pure, even-aged yellow birch stands are especially abundant in the eastern mountains from Maine to Pennsylvania. (Pl. X, fig. 1.) Pure, even-aged stands of sugar maple or of beech are uncommon (Pl. X, fig. 2), and basswood and elm hardly ever predominate in the second-growth except in small groups among other species.

The following measurements of second-growth hardwood stands made in the course of the study illustrate the growth and composition of young forests of various ages and species. The measurements were made in small sample plots, the sizes of which are given; and the volumes and ages were determined by means of sample trees representing arbitrarily fixed diameter groups.[1] The volumes are on an acre basis. As a matter of fact, the composition represented by a sample plot was in most cases less than an acre in extent, the plot representing that portion of the second-growth stand in which the desired species was most abundant. The stands were selected at random and show about the average growth, in cubic feet and cords, for the mountain lands.[2] The volume measurements were of merchantable fuel wood material in trees 3 inches and over in breast-high diameter to a minimum diameter limit of about 2 inches. The cubic-foot volumes were reduced to cords by dividing by 85. The crown density is shown in tenths, perfect density being 1. The crown density of birch stands, however, is rarely greater than 0.9, which may be considered perfect.

BIRCH PLOTS.

NEW HAMPSHIRE.

Plot No. 1.—Age, 43 years; yield, 24.2 cords per acre; height of dominant trees, 55 to 60 feet.

Species.	Proportion based on volume.	Number of trees per acre.	Diameter breast-high.		Volume per acre.	Average annual growth per acre.
			Average.	Extremes.		
	Per cent.		*Inches.*	*Inches.*	*Cubic feet.*	*Cubic feet.*
Yellow birch	88.0	496	5.8	2 to 10	1,806	45.15
Paper birch	8.0	40	6.1	3 to 10	166	4.15
Sugar maple	2.2	24	4.2	2 to 5	46	1.15
Fire cherry (dead)	1.8	16	4.5	3 to 5	38	.95
Total	100.0	576			2,056	51.40

Benton township, Grafton County, N. H., near Glencliff; western slope of Mount Moosilauke; altitude 1,500 feet; slope 25 per cent west by north; soil rather shallow, loamy sand with 3 inches of humus; plot one-eighth acre, representing one-fourth acre stand surrounded by uneven-aged growth; density 0.8; reproduction, sugar and red maple, abundant.

[1] This method is described in H. S. Graves's "Forest mensuration," pp. 229–231, 1906.

[2] The yield of mixed second-growth hardwood stands in Vermont is given in Vermont Agricultural Experiment Station Bulletin 176, "The management of second-growth hardwoods in Vermont."

Plot No. 2.—Age, 75 to 80 years; yield, 22.9 cords per acre; height of dominant trees, 50 to 55 feet.

Species.	Proportion based on volume.	Number of trees per acre.	Diameter breast-high. Average.	Diameter breast-high. Extremes.	Volume per acre.	Average annual growth per acre.
	Per cent.		*Inches.*	*Inches.*	*Cubic feet.*	*Cubic feet.*
Yellow birch	78.2	360	6.1	2 to 12	1,519	19.00
Beech	14.7	328	3.5	1 to 7	286	3.58
Sugar maple	7.1	456	2.2	1 to 6	138	1.73
Total	100.0	1,144			1,943	24.31

Milan Township, Coos County, N. H., 3 miles east of west Milan; altitude 1,300 feet; slope 5 per cent north; soil fine, fresh, brown loam, very stony, medium depth, humus 2 inches deep; plot one-eighth acre in strip of second-growth 2 chains wide at south end of an old hardwood stand; density 0.9; reproduction, beech and sugar maple seedlings quite abundant, no birch; numerous maple seedlings killed by shade.

Plot No. 3.—Age, 88 years; yield, 38.6 cords per acre; height of dominant trees, 60 to 65 feet.

Species.	Proportion based on volume.	Number of trees per acre.	Diameter breast-high. Average.	Diameter breast-high. Extremes.	Volume per acre.	Average annual growth per acre.
	Per cent.		*Inches.*	*Inches.*	*Cubic feet.*	*Cubic feet.*
Yellow birch	63.9	368	6.8	2 to 14	2,097	23.83
Paper birch	30.6	128	7.6	2 to 13	1,005	11.42
Beech	4.5	52	4.9	1 to 10	147	1.67
Sugar maple	.6	4	6.5	2 to 9	21	.24
Aspen	.4	2	7.0		13	.15
Red spruce		416	2.2	1 to 6		
Balsam fir		36	2.2	1 to 3		
Total	100.0	1,006			3,283	37.31

Benton Township, Grafton County, N. H., near Glencliff; west slope of Mount Moosilauke; altitude 2,000 feet; slope 17 per cent; exposure northwest; soil fairly deep sandy loam with 3 to 4 inches of humus; plot one-half acre, in stand running largely to paper birch; density 0.9; reproduction, red spruce, heavy, of very slow growth.

NEW YORK.

Plot No. 4.—Age, 20 years; yield, 10.8 cords per acre; height of dominant trees, 35 to 40 feet.

Species.	Proportion based on volume.	Number of trees per acre.	Diameter breast-high. Average.	Diameter breast-high. Extremes.	Volume per acre.	Average annual growth per acre.
	Per cent.		*Inches.*	*Inches.*	*Cubic feet.*	*Cubic feet.*
Yellow birch	56.2	2,288	2.1	1 to 4	518	25.90
Black birch	15.0	336	2.4	1 to 4	138	6.90
Sugar maple	14.2	288	2.4	1 to 4	131	6.55
Fire cherry	11.1	80	3.4	3 to 4	102	5.10
Red maple	3.5	48	2.7	2 to 3	32	1.60
Beech		320	1.0			
Service berry		32	1.6	1 to 2		
Total	100.0	3,392			921	46.05

Colchester Township, Delaware County, N. Y.; altitude 1,300 feet; slope 10 per cent northwest; soil very scant; fresh, loamy sand with thin humus layer, over large, flat, loose sandstone fragments; plot one-eighth acre, in stand of 2 or 3 acres, varying in composition; density 0.9; reproduction absent.

Plot No. 5.—Age, 42 years; yield, 25.8 cords per acre; height of dominant trees, 55 to 60 feet.

Species.	Proportion based on volume.	Number of trees per acre.	Diameter breast-high.		Volume per acre.	Average annual growth per acre.
			Average.	Extremes.		
	Per cent.		*Inches.*	*Inches.*	*Cubic feet.*	*Cubic feet.*
Yellow birch	54.1	360	5.2	2 to 8	1,185	28.21
Red maple	26.9	160	5.4	3 to 9	588	14.00
Black birch	17.8	104	5.6	4 to 7	390	9.29
Beech	1.2	96	2.4	1 to 4	26	.62
Sugar maple		16	2.0			
Total	100.0	736			2,189	52.12

Colchester Township, Delaware County, N. Y.; altitude 1,300 feet; slope 5 per cent west; soil very scant fresh, brown, loamy sand with thin humus layer, over large, flat, loose sandstone fragments; plot one eighth acre, in 2 or 3 acre stand of second growth with scattered old trees; density, 0.7 to 0.8; reproduction beech and sugar maple, numerous.

PENNSYLVANIA.

Plot No. 6.—Age, 25 years; yield, 11.5 cords per acre; average height of dominant trees, 40 feet.

Species.	Proportion based on volume.	Number of trees per acre.	Diameter breast-high.		Volume per acre.	Average annual growth per acre.
			Average.	Extremes.		
	Per cent.		*Inches.*	*Inches.*	*Cubic feet.*	*Cubic feet.*
Fire cherry	48.3	312	3.9	2 to 6	470	18.80
Yellow birch	42.7	1,368	2.4	1 to 6	416	16.64
Black birch	8.4	440	1.9	1 to 4	82	3.28
Striped maple	.6	56	1.9	1 to 3	6	.24
Beech		184	1.2	1 to 2		
Sugar maple		80	1.2	1 to 2		
Total	100.0	2,440			974	38.96

Near Austin, Potter County, Pa.; altitude 1,600 feet; slope 15 per cent north; soil shallow, fresh, clay loam, over small, flat, shale fragments; humus 3 inches deep; plot one-eighth acre, in similar stand of 60 to 80 acres, following lumbering and fire on hemlock land; density 0.9; reproduction absent; many dead fire cherries still standing indicate rapid elimination of this species. Stand apparently thinning itself rapidly; birch largely sprouts.

Plot No. 7.—Age, 40 years; yield, 21.1 cords per acre; average height of dominant trees, 55 feet.

Species.	Proportion based on volume.	Number of trees per acre.	Diameter breast-high.		Volume per acre.	Average annual growth per acre.
			Average.	Extremes.		
	Per cent.		*Inches.*	*Inches.*	*Cubic feet.*	*Cubic feet.*
Yellow birch	49.1	420	4.3	2 to 8	881	22.02
Black birch	37.0	332	4.2	2 to 7	664	16.60
Red maple	8.1	100	3.9	1 to 7	146	3.65
Sugar maple	2.4	96	2.4	1 to 6	44	1.10
Black cherry	1.3	8	5.0	5	23	.58
Service berry	1.2	16	3.6	2 to 6	21	.53
Ironwood	.9	56	2.2	1 to 5	16	.40
Beech		156	1.0	1 to 2		
Blue beech		4	1.0	1		
Hemlock		8	1.0	1		
Total	100.0	1,196			1,795	44.88

Near Costello, Potter County, Pa.; altitude 1,600 feet; slope 25 per cent northwest; soil scant, gray loam, dry and crumbly, in interstices of small, fine grained standstone fragments; humus 3 inches thick; density 0.9; reproduction, beech and sugar maple, numerous; a few hemlock seedlings.

Plot No. 8.—Age, 50 years; yield, 10.9 cords per acre; average height of dominant trees, 45 feet.

Species.	Proportion based on volume.	Number of trees per acre.	Diameter breast-high.		Volume per acre.	Average annual growth per acre.
			Average.	Extremes.		
	Per cent.		*Inches.*	*Inches.*	*Cubic feet.*	*Cubic feet.*
Yellow birch	76.4	672	3.4	2 to 5	709	14.18
Black birch	21.5	272	2.8	2 to 5	200	4.00
Service berry	1.3	8	4.0	4	12	.24
Cucumber	.8	8	3.0	3	7	.14
Total	100.0	960			928	18.56

Endeavor, Forest County, Pa.; altitude 1,200 feet; slope 5 per cent north; soil, shallow, rich, residual clay loam, over flat shale fragments; humus heavy, rich, well decomposed; plot one-eighth acre, in second-growth stand of less than one-fourth acre; density 0.85; reproduction scant; scattered hemlock, white ash, sugar and red maple, white oak and birch.

Plot No. 9.—Age, 80 years; yield, 42.2 cords per acre; average height of dominant trees, 75 feet.

Species.	Proportion based on volume.	Number of trees per acre.	Diameter breast-high.		Volume per acre.	Average annual growth per acre.
			Average.	Extremes.		
	Per cent.		*Inches.*	*Inches.*	*Cubic feet.*	*Cubic feet.*
Yellow birch	85.4	324	7.4	5 to 11	3,062	38.28
Black birch	8.2	32	7.3	5 to 10	296	3.70
Hemlock	4.6	68	5.7	1 to 9	164	2.05
Beech	.8	84	3.0	1 to 6	29	.36
Sugar maple	.6	24	3.1	1 to 6	20	.25
Red maple	.4	20	3	3	16	.20
Total	100.0	552			3,587	44.84

Homer Township, Potter County, Pa.; altitude 1,600 feet; slope 30 per cent west; soil very scant, rich, fresh, residual clay, over talus of flat shale fragments; humus heavy, moist, well decomposed; plot one-fourth acre, in similar stand of more than 10 acres; density 0.9; reproduction scant; beech, red maple, hemlock. (See Pl. X, fig. 1.)

MAPLE PLOTS.

NEW YORK.

Plot No. 10.—Age, 39 years; yield, 28 cords per acre; average height of dominant trees, 68 feet.

Species.	Proportion based on volume.	Number of trees per acre.	Diameter breast-high.		Volume per acre.	Average annual growth per acre.
			Average.	Extremes.		
	Per cent.		*Inches.*	*Inches.*	*Cubic feet.*	*Cubic feet.*
Sugar maple	77.9	712	4.4	1 to 9	1,852	47.49
Yellow birch	8.3	56	5.1	4 to 6	198	5.08
Fire cherry	7.6	32	6.3	5 to 8	181	4.64
Service berry	2.8	16	5.5	5 to 6	66	1.69
Ironwood	1.8	32	3.3	3 to 4	42	1.08
Basswood	1.6	8	6.0	6	39	1.00
Total	100.0	856			2,378	60.98

Cooks Falls, Delaware County, N. Y.; altitude 1,300 feet; slope 15 per cent east by north; soil moist, sandy loam, relatively deep; humus 1 inch thick; plot one-eighth acre in similar stand of 2 or 3 acres; density 1; reproduction, sugar maple and beech; maple very abundant but badly suppressed; an "old field" stand of seedling origin.

MICHIGAN.

Plot No. 11.—Age, 42 years; yield, 16.2 cords per acre; height of dominant trees, 45 to 50 feet.

Species.	Proportion based on volume.	Number of trees per acre.	Diameter breast-high. Average.	Diameter breast-high. Extremes.	Volume per acre.	Average annual growth per acre.
	Per cent.		*Inches.*	*Inches.*	*Cubic feet.*	*Cubic feet.*
Sugar maple	53.2	2,224	2.2	1 to 6	731	17.40
White ash	19.5	128	4.5	2 to 7	267	6.36
Ironwood	19.3	72	5.8	2 to 8	265	6.31
Beech	5.4	40	4.2	1 to 7	74	1.76
Service berry	2.6	32	3.5	2 to 5	36	.86
Total	100.0	2,496			1,373	32.69

Glen Haven, Leelanau County, Mich., one-half mile from Lake Michigan; altitude 600 feet; slope level; soil fine, wind transported, lake sand, blackish near surface; humus thin; produces fair corn crops, but difficult to get a "grass catch," due to wind; plot one-eighth acre, in similar stand of several hundred acres; density 0.8. This stand contained from 5 to 20 red oak trees per acre, conspicuously larger than the surrounding trees, and often 10 or 12 inches in diameter. The situation is much better adapted for red oak or white pine than for northern hardwoods.

BEECH PLOTS.

NEW HAMPSHIRE.

Plot No. 12.—Age, 70 years; yield, 22.9 cords per acre; average height of dominant trees, 55 feet.

Species.	Proportion based on volume.	Number of trees per acre.	Diameter breast-high. Average.	Diameter breast-high. Extremes.	Volume per acre.	Average annual growth per acre.
	Per cent.		*Inches.*	*Inches.*	*Cubic feet.*	*Cubic feet.*
Beech	58.0	952	3.4	1 to 8	1,129	16.13
Sugar maple	33.1	208	5.1	2 to 9	644	9.20
Paper birch	8.9	32	6.4	4 to 8	174	2.49
Yellow birch		16	2.0	2		
Striped maple		8	2.0	2		
Total	100.0	1,216			1,947	27.82

Shelburne Township, Coos County, N. H.; altitude 1,400 feet; slope 20 per cent east; soil rather shallow, fresh, sandy loam, from decomposition of granite; humus 3 inches deep, well decomposed; plot one-eighth acre, a fair sample of at least 5 acres, containing some red oak; density 0.85 to 0.9; reproduction almost exclusively beech seedlings and root sprouts, slender and suppressed; about 10 spruce seedlings per acre. This stand evidently sprang up after a fire in a stand containing beech and hemlock, of which a few decayed stubs are still standing.

Plot No. 13.—Age, 95 years; yield, 33.1 cords per acre; average height of dominant trees, 55 feet.

Species.	Proportion based on volume.	Number of trees per acre.	Diameter breast-high. Average.	Diameter breast-high. Extremes.	Volume per acre.	Average annual growth per acre.
	Per cent.		*Inches.*	*Inches.*	*Cubic feet.*	*Cubic feet.*
Beech	91.5	524	4.4	1 to 9	2,571	27.06
Red maple	4.6	24	4.7	1 to 6	130	1.37
Paper birch	3.9	4	10.0	10	109	1.15
Hemlock		12	1.0	1		
Total	100.0	564			2,810	29.58

Near Intervale, N. H.; altitude 1,000 feet; slope 8 per cent, north; soil fresh, sandy loam, gravelly and rocky, with 1½ inches of well-decomposed humus; plot one-eighth acre, in stand of 10 or 15 acres, containing a few larger red oak and red maple; density 1.0; reproduction principally striped maple and beech, with clumps of hemlock; some sugar and red maple and scattered small white pine seedlings. This is an unusually pure stand of beech on soil better fitted for raising red oak, white pine, and other rapid growing species. (See Pl. X, fig. 2.)

MIXED PLOTS.

NEW YORK.

Plot No. 14.—Age, 18 years; yield, 7.8 cords per acre; average height of dominant trees, 34 feet.

Species.	Proportion based on volume.	Number of trees per acre.	Diameter breast-high.		Volume per acre.	Average annual growth per acre.
			Average.	Extremes.		
	Per cent.		*Inches.*	*Inches.*	*Cubic feet.*	*Cubic feet.*
Yellow birch	27.4	496	2.5	1 to 4	182	10.11
Basswood	25.3	360	2.8	1 to 5	168	9.33
Sugar maple	19.7	936	2.1	1 to 5	131	7.28
White ash	10.7	80	3.4	1 to 7	71	3.94
Fire cherry	9.9	64	3.8	1 to 6	66	3.67
Ironwood	3.3	152	2.1	1 to 4	22	1.22
Beech	2.6	144	1.6	1 to 5	17	.94
Aspen	1.1	8	3.0	3	7	.39
Striped maple		32	1.8	1 to 2		
Total	100.0	2,272			664	36.88

Cooks Falls, Delaware County, N. Y.; altitude 1,300 feet; slope 20 per cent, east by south; soil very shallow, fine, crumbly loam, fresh and rich, very full of flat sandstone fragments; humus 2 inches deep, well decomposed; plot one-eighth acre in similar stand of 8 or 10 acres, which contains scattered older trees. The trees are mostly of sprout origin. Basswood and ash, especially, grew in clumps of numerous sprouts, from small stump. Density 0.9; reproduction, a few unthrifty sugar-maple seedlings.

Plot No. 15.—Age, 32 years; yield, 19.8 cords per acre; average height of dominant trees, 48 feet.

Species.	Proportion based on volume.	Number of trees per acre.	Diameter breast-high.		Volume per acre.	Average annual growth per acre.
			Average.	Extremes.		
	Per cent.		*Inches.*	*Inches.*	*Cubic feet.*	*Cubic feet.*
Red maple	27.4	632	3.4	1 to 6	692	21.62
Black cherry	25.3	176	4.7	2 to 7	391	12.22
Aspen	19.7	120	4.7	3 to 7	318	9.94
White ash	10.7	80	3.7	1 to 6	104	3.25
Beech	9.9	1,624	1.5	1 to 4	84	2.62
Yellow birch	3.3	32	3.6	1 to 5	41	1.28
Service berry	2.6	56	2.8	1 to 4	41	1.28
Sugar maple	1.1	216	1.5	1 to 3	8	.25
Total	100.0	2,936			1,679	52.46

Cooks Falls, Delaware County, N. Y.; altitude 1,300 feet; slope 10 per cent, south; soil very shallow, fresh, sandy loam, very full of rock fragments; humus rather dry, 1½ inches deep; plot one-eighth acre, representative of more than 10 acres of second growth, containing scattered larger trees; density 1, but south exposure permits golden rod among the ground cover. The beech are mostly root sprouts 1 and 2 inches in diameter, and most of these are badly suppressed, many dying, and some dead. The dead and dying were not counted. Reproduction occasional aspen, red maple, and cherry seedlings; none of beech. This plot is in the same stand as the thinned plot described last in this list.

Plot No. 16.—Age, 42 years; yield, 30.6 cords per acre; average height of dominant trees, 70 feet.

Species.	Proportion based on volume.	Number of trees per acre.	Diameter breast-high.		Volume per acre.	Average annual growth per acre.
			Average.	Extremes.		
	Per cent.		*Inches.*	*Inches.*	*Cubic feet.*	*Cubic feet.*
Yellow birch	50.8	288	5.8	3 to 10	1,323	31.50
Red maple	30.1	88	7.5	2 to 12	785	18.69
Beech	15.1	136	4.8	1 to 10	394	9.38
Sugar maple	4.0	16	6.5	2 to 9	103	2.45
Total	100.0	528			2,605	62.02

Colchester Township, Delaware County, N. Y.; altitude 1,300 feet; slope 20 per cent, east by south; soil very scant, fresh, brown, loamy sand with thin humus layer, over large, flat, loose sandstone fragments; plot one-eighth acre, surrounded by mixed second-growth containing scattered older trees; density 0.9; reproduction, a few larger seedlings of yellow birch and red and sugar maples.

Plot No. 17.—Age, 45 years; yield, 24.9 cords per acre; height of dominant trees, 55 to 60 feet.

Species.	Proportion based on volume.	Number of trees per acre.	Diameter breast-high.		Volume per acre.	Average annual growth per acre.
			Average.	Extremes.		
	Per cent.		*Inches.*	*Inches.*	*Cubic feet.*	*Cubic feet.*
Red maple	40.5	228	5.5	1 to 10	856	19.02
Yellow birch	26.9	348	4.0	1 to 9	570	12.67
Black birch	26.4	124	5.9	2 to 9	558	12.40
Sugar maple	4.1	96	3.0	1 to 7	86	1.91
Beech	1.1	116	2.1	1 to 4	24	.53
Fire cherry	.5	8	3.8	1 to 5	11	.24
Service berry	.3	20	2.6	1 to 4	7	.16
Ironwood	.2	8	2.3	1 to 3	4	.09
Total	100.0	948			2,116	47.02

Colchester Township, Delaware County, N. Y.; altitude 1,400 feet; slope 20 per cent, northwest; soil very scant, fresh, brown, loamy sand in interstices of loose sandstone fragments; humus thin; plot one-fourth acre, in similar stand covering 1 or 2 acres; density 0.9; reproduction very scanty; a few small sugar maple and birch seedlings, and an occasional hemlock sapling; most of the red maples and beeches are sprouts; the birches are mostly seedlings.

THINNED PLOT.

[Originally similar to plot No. 15 in composition and yield.]

Plot No. 18.—Age, 32 years; yield, 9.7 cords per acre; average height of dominant tree, 50 feet.

Species.	Proportion based on volume.	Number of trees per acre.	Diameter breast-high.		Volume per acre.	Average annual growth per acre.
			Average.	Extremes.		
	Per cent.		*Inches.*	*Inches.*	*Cubic feet.*	*Cubic feet.*
White ash	44.7	200	4.2	2 to 6	370	11.56
Red maple	43.8	104	5.8	4 to 8	262	11.31
Black cherry	9.0	16	6.5	6 to 7	74	2.31
Basswood	2.5	8	5.0	5	21	.66
Red maple sprout clumps, 3 years old		560				
Total	100.0	888			827	25.84

Cooks Falls, Delaware County, N. Y.; altitude 1,300 feet; slope 10 per cent, south; soil very shallow, fresh, sandy loam, full of rock fragments; humus scanty; plot one-eighth acre, representative of 5 or 6 acres similarly thinned. The stand was heavily thinned 3 years before, when from 10 to 15 cords per acre of 4-foot wood were removed. The material removed was chiefly yellow and black birch, sugar maple, red maple, beech, and ironwood. Density 0.7; reproduction, heavy sprout reproduction of red maple, averaging about 8 feet high. Numerous 1-year-old seedlings of black cherry and red maple, and unthrifty breech sprouts. (See Pl. XV, fig. 1.)

ECONOMIC IMPORTANCE.

GENERAL UTILITY.[1]

In the amount and total value of their products the northern hardwoods have always been overshadowed by the softwoods, particularly white pine. They have in the past contributed but little to the purposes which require wood in large quantities, like general construction, box making, and paper making, so that the hardwood-lumber cut of the country has been less than a quarter of the total lumber cut. On the other hand, the average value of hardwood

[1] An account of the characteristics and uses of the wood of beech and various species of maple and birch is given in Department of Agriculture Bulletin No. 12, "Uses of commercial woods of the United States: Beech, birches, and maples," 1913.

lumber in 1912 exceeded that of softwood by 25 per cent. Hardwoods are indispensable for hundreds of uses none the less important because they demand a relatively small supply. Among them are finishing, flooring, furniture, turnery, "novelties," woodenware, handles, shuttles, bobbins, spools, vehicles, veneer boxes and baskets, and many others, none of which use much, but which in the aggregate consume a great and increasing quantity of hardwood material. In certain regions hardwoods now compete actively with softwoods in box making and to some extent in construction. They furnish the greater part of the wood used for fuel in the hardwood region. The manufacture of wood alcohol and charcoal is supported by maple, beech, and birch (Pls. XI and XII), and practically all the northern hardwoods are now used in paper production (Pl. XIII).

ANNUAL CUT.

The annual cut in 1912 of the principal northern hardwoods is shown in Table 8, prepared from the census report for that year.[1] The proportion of these species, individually and collectively, contained in the total hardwood cut in each of the States and in the whole northern hardwood region is also given.

TABLE 8.—*Annual lumber cut (1912) of the principal hardwoods of the northern hardwood forest, with the proportion of each in the total hardwood cut of the States and the United States.*

[Compiled from data in Census Bureau circular, "Forest products: Lumber, lath, and shingles, 1912."]

Species.	Maine.		New Hampshire.		Vermont.		New York.	
	Quantity.	Per cent of all hardwoods cut.	Quantity.	Per cent of all hardwoods cut.	Quantity.	Per cent of all hardwoods cut.	Quantity.	Per cent of all hardwoods cut.
	Mft. b. m.		*Mft. b. m.*		*Mft. b. m.*		*Mft. b. m.*	
Maple	11,423	12.5	11,256	18.3	30,435	31.4	76,891	30.7
Birch	51,110	55.8	18,132	29.4	31,551	32.5	31,395	12.5
Beech	7,264	8.0	8,986	14.6	13,144	13.5	40,761	16.3
Basswood	5,499	6.0	1,493	2.4	7,957	8.2	28,513	11.4
Elm	407	.4	350	.6	1,348	1.4	13,684	5.5
Total	75,703	82.7	40,217	65.3	84,435	87.0	191,244	76.4

Species.	Pennsylvania.		Michigan.		Wisconsin.		Minnesota.	
	Quantity.	Per cent of all hardwoods cut.	Quantity.	Per cent of all hardwoods cut.	Quantity.	Per cent of all hardwoods cut.	Quantity.	Per cent of all hardwoods cut.
	Mft. b. m.		*Mft. b. m.*		*Mft. b. m.*		*Mft. b. m.*	
Maple	81,617	16.0	453,110	60.7	118,765	27.1	1,255	2.2
Birch	17,666	3.5	55,350	7.4	140,071	32.0	6,452	11.4
Beech	49,686	9.7	92,106	12.3	2,913	.7	117	.2
Basswood	10,925	2.1	53,533	7.2	79,389	18.1	13,713	24.3
Elm	2,994	.6	52,757	7.1	50,608	11.6	12,245	21.7
Total	162,888	31.9	706,856	94.7	391,746	89.5	33,782	59.9

[1] Bureau of the Census: Forest products—Lumber, lath, and shingles, 1912.

FIG. 1.—A BRANCH WHICH WILL BE TAKEN FOR DISTILLATION.

Such material was formerly left in the woods to rot.

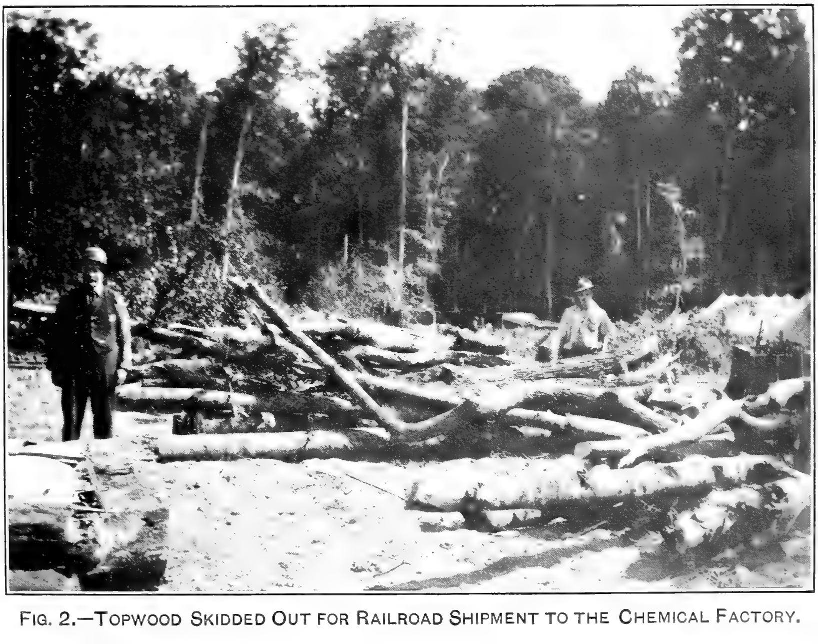

FIG. 2.—TOPWOOD SKIDDED OUT FOR RAILROAD SHIPMENT TO THE CHEMICAL FACTORY.

UTILIZING CROOKED HARDWOOD TOPS AND BRANCHES FOR CHEMICAL DISTILLATION. MICHIGAN.

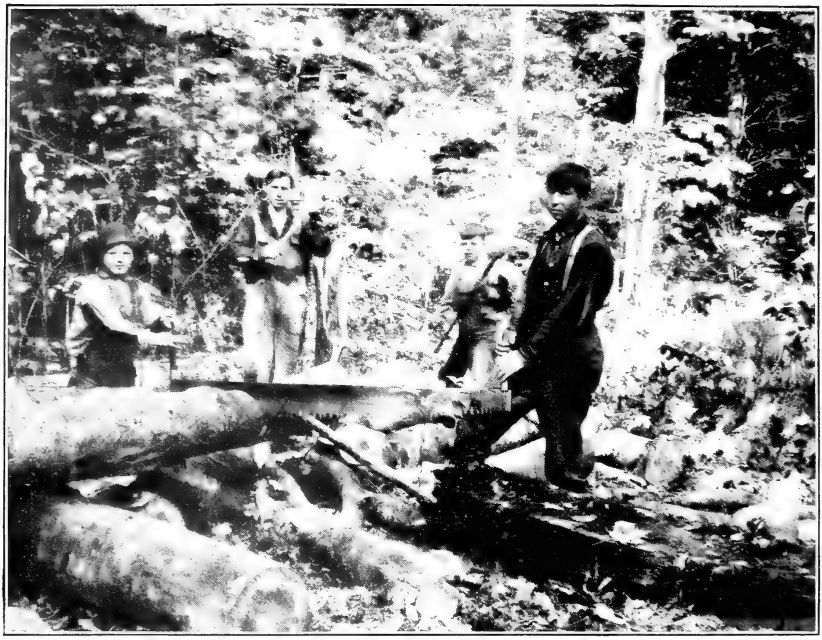

FIG. 1.—A WOODS CREW SAWING UP AND SPLITTING LARGE BEECH TREES INTO CHEMICAL WOOD.

FIG. 2.—MORE THAN A CORD OF 4-FOOT WOOD FROM A SINGLE SUGAR-MAPLE TREE.

LOG TIMBER TO BE BURNED FOR CHEMICALS AND CHARCOAL. PENNSYLVANIA.

TABLE 8.—*Annual lumber cut (1912) of the principal hardwoods of the northern hardwood forest, with the proportion of each in the total hardwood cut of the States and the United States*—Continued.

Species.	Total for the northern hardwood region.			Total for the United States.		
	Quantity.	Per cent of all hardwoods cut.	Per cent of total lumber cut in this region.	Quantity.	Per cent cut in northern hardwoods region.	Per cent of total lumber cut (soft and hard).
	Mft. b. m.			*Mft. b. m.*		
Maple	784,752	34.8	10.5	1,020,864	76.9	2.6
Birch	351,727	15.6	4.7	388,272	90.6	1.0
Beech	214,977	9.5	2.9	435,250	49.4	1.1
Basswood	201,022	8.9	2.7	296,717	67.7	.8
Elm	134,393	6.0	1.8	262,141	51.3	.7
Total	1,686,871	74.9	22.5	2,403,244	70.2	6.2

In per cent of the total lumber cut (soft and hard) in each State the combined cut of the five hardwoods was as follows:

Maine	8.6	New York	38.1	Wisconsin	26.1
New Hampshire	8.4	Pennsylvania	16.6	Minnesota	2.4
Vermont	35.8	Michigan	47.5		

The figures given for maple, birch, and elm each cover more than one species, as no distinction of species is made by the census. Commercial maple is principally "hard" (sugar) maple, but includes some "soft" (red and silver) maple. Commercial birch in the Lake States is almost entirely yellow birch, but in New England includes also some "white" (paper) birch, and in New York and Pennsylvania some "cherry" (sweet) birch; heart lumber is known as "red" birch. Elm lumber is made, in the north, from three species—white, slippery or "red," and cork or "rock" elm. Much the greater part is undoubtedly white elm, which is known on the market as "gray" or "soft" elm. Much rock elm has been cut in the past, but the remaining supply is small. Some slippery or "red" elm is cut in the Lake States and the northeast, but it is impossible to tell how much of the total elm cut it forms.

Table 8 does not tell the whole story. An immense amount of northern hardwood is used for house fuel. According to estimates for 1908 secured by the Forest Service (Circular 181), the total fuel wood consumption of the Northeastern and Lake States was 16,400,000 cords, of which probably a third was northern hardwoods. About 1,150,000 cords were consumed in 1909 for wood distillation,[1] and as this industry has been extended from New York and Pennsylvania into the Lake States, the amount now used annually for distillation is undoubtedly much greater. Paper-pulp manufacture consumed 31,390 cords of beech alone in 1909 (loc. cit.).

[1] Forest products of the United States, 1909. Bureau of the Census. Compiled in cooperation with the Forest Service.

The census figures for 1909 show the following amounts of the various hardwoods used for making veneers in the northern hardwood region:

	Board feet.
Maple	29,219,000
Birch	23,064,000
Basswood	12,119,000
Elm	11,951,000
Beech	6,700,000
Total	83,053,000

The consumption for slack cooperage stave manufacture for the same year was as follows:

	Staves.	Equivalent in board feet.
Beech	249,761,000	83,253,667
Elm	138,761,000	46,253,667
Maple	107,969,000	35,989,667
Birch	78,224,000	26,074,667
Basswood	62,720,000	20,906,666
Total	637,435,000	212,478,334

In terms of lumber, the aggregate annual consumption for all purposes of these five hardwoods in the Northeastern and Lake States alone is probably 5,500,000,000 board feet. Including the amount not usable, and therefore left in the woods, or burned as refuse or mill fuel, it undoubtedly exceeds 6,000,000,000 board feet, or 12,000,000 cords.

The depreciation both in extent and quality of the northern forests through lumbering, fire, decay, insects, and other causes has already been mentioned. Concurrent with the decrease in softwood timber there has occurred a relative increase in hardwood exploitation, and a similar increase in the cut of inferior hardwoods. From 1899 to 1912 the recorded annual lumber cut of northern hardwoods increased from less than 10 to more than 22 per cent of the total lumber cut. The increase in the several States is shown in Table 9:

TABLE 9.—*Increase in proportion of northern hardwoods in the aggregate lumber cut of all species, from 1899 to 1912.*

State.	Proportion of northern hardwoods cut to total cut.		
	1899	1912	Increase.
	Per ct.	*Per ct.*	*Per ct.*
Maine	7.3	8.6	1.3
New Hampshire	1.1	8.4	7.3
Vermont	11.2	35.8	24.6
New York	15.7	38.1	22.4
Pennsylvania	4.9	16.4	11.5
Michigan	19.5	47.5	28.0
Wisconsin	10.9	26.1	15.2
Minnesota	.8	2.4	1.6
Average [1]	9.8	22.5	12.7

[1] Based on actual lumber cut figures; not on the percentages above listed.

The amount of increase serves indirectly as an index to the States in which large supplies of conifers yet remain. Spruce in Maine and white pine in Minnesota still hold first place. The relatively small increase in the northern hardwoods cut in Pennsylvania is due partly to the influence of the large hemlock cut, and partly to that of the southern hardwoods, especially oak.

PRESENT SUPPLY.

There is little hope of finding out the amount of standing northern hardwoods except within a very wide "limit of error." The estimates are given in Table 10, therefore, merely as rough approximations. They are based on estimates of the total forest areas in the different States, the proportions occupied by northern hardwoods, and the probable average stand per acre (from 1,000 to 3,000 board feet). Each of these factors is, of course, subject to wide error, and there is the further error arising from differences in the closeness of utilization and in the prevalence of defect.

TABLE 10.—*Estimated stand of hardwood timber in the northern hardwood forest.*[1]

State.	Stand.	State.	Stand.
	Board feet.		*Board feet.*
Maine	7,000,000,000 to 15,000,000,000	Southern Appalachian States	10,000,000,000 to 15,000,000,000
New Hampshire	4,000,000,000 to 5,000,000,000	Lake States	30,000,000,000 to 30,000,000,000
Vermont	4,000,000,000 to 5,000,000,000		
New York	10,000,000,000 to 20,000,000,000		
Pennsylvania	10,000,000,000 to 20,000,000,000	Total	75,000,000,000 to 110,000,000,000

[1] Acknowledgment is made to State Foresters A. F. Hawes, E. C. Hirst, and C. R. Pettis for assistance received in the preparation of these estimates. For the Lake States estimates compiled by the Bureau of Corporations in 1910 and published in its report on standing timber (1913) were used. These were brought down to date by deducting an equivalent of five years lumber cut.

VALUE OF STANDING TIMBER.

There is normally a wide range in the stumpage value of any species, the price depending not only upon the accessibility and quality of the timber, but also upon the condition of the market, the exigency of the sale, and other matters common to all property exchange. Since, however, the remaining virgin timber in the Northeastern and Lake States is roughly uniform as to accessibility (a result of fairly similar logging and trade conditions) stumpage values for a given species tend to approach a standard market value. Statistics of this nature were obtained by the Forest Service through a canvass of timberland owners in 1907, and again in 1912. The averaged results, with reference only to the principal species of the northern hardwood forest, are given in Tables 11 and 12.

TABLE 11.—*Comparative stumpage values per 1,000 board feet of the more important species of the northern hardwood region: 1912.*

[From reports of sales collected by the Forest Service, Office of Industrial Investigations.]

Species.	North-eastern States.[1]	Lake States.[2]	Southern States.[3]	Species.	North-eastern States.[1]	Lake States.[2]	South-ern States.[3]
Maple	$5.98	$4.58	$3.45	Elm	$8.40	$5.87	$3.41
Birch	5.61	4.85	3.33	Ash	9.03	5.82	6.16
Beech	4.38	3.67	2.86	White pine	8.44	10.39	3.91
Basswood	8.40	6.30	4.92	Hemlock	6.28	3.78	2.62

[1] Maine, New Hampshire, Vermont, Massachusetts, New York, and Pennsylvania.
[2] Minnesota, Wisconsin, and Michigan.
[3] Maryland, Virginia, West Virginia, Kentucky, Tennessee, and North Carolina.

While the figures in Table 11 are based on many reports of actual sales of stumpage, they are of practical value only in showing the general tendency of prices in these regions.

TABLE 12.—*Average stumpage values of northern hardwoods for 1907 and 1912.*

Species and year.	Northeastern States.						North Central States.		
	Aver-age of five States.	Maine.	New Hamp-shire.	Ver-mont.	New York.	Penn-syl-vania.	Aver-age of two States.	Ohio.	Indi-ana.
Maple:									
1907	$4.37[174]	$4.30[25]	$4.46[25]	$3.22[32]	$4.84[28]	$4.74[64]	$7.55[89]	$7.19[35]	$7.79[54]
1912	**5.34**[209]	**4.84**[56]	**5.21**[33]	**4.28**[29]	**6.00**[91]	**5.37**[100]	**7.68**[169]	**7.42**[86]	**7.94**[83]
Birch:									
1907	4.90[161]	4.78[30]	4.50[26]	3.52[31]	5.63[24]	5.70[50]	6.50[4]	....	6.50[4]
1912	**5.44**[261]	**4.89**[65]	**5.67**[38]	**4.81**[27]	**6.14**[69]	**5.38**[62]	**4.05**[11]	**4.70**[5]	**3.50**[6]
Beech:									
1907	3.67[147]	4.38[21]	3.39[22]	2.72[25]	3.02[25]	4.25[54]	5.80[94]	5.36[38]	6.10[56]
1912	**4.28**[253]	**4.31**[52]	**4.31**[31]	**3.50**[29]	**4.55**[77]	**4.28**[71]	**6.10**[163]	**6.15**[78]	**6.06**[85]
Basswood:									
1907	6.68[127]	5.80[20]	6.25[18]	4.96[27]	8.31[21]	7.59[41]	10.21[54]	9.59[27]	10.83[27]
1912	**7.68**[245]	**6.04**[48]	**7.56**[23]	**6.90**[25]	**8.51**[58]	**8.14**[61]	**11.43**[102]	**11.59**[59]	**11.22**[43]
Elm:									
1907	4.74[76]	3.00[7]	4.65[10]	4.07[15]	5.07[14]	5.35[30]	7.42[89]	7.11[37]	7.64[52]
1912	**5.40**[133]	**3.71**[26]	**5.25**[8]	**4.25**[12]	**6.17**[56]	**5.93**[31]	**8.59**[154]	**9.43**[76]	**7.78**[78]
Ash:									
1907	7.99[154]	6.38[26]	8.20[22]	6.29[28]	8.91[23]	9.15[55]	14.19[89]	13.01[39]	15.11[50]
1912	**8.35**[253]	**6.60**[56]	**9.85**[26]	**7.48**[23]	**8.97**[77]	**8.80**[71]	**15.54**[159]	**15.87**[78]	**15.23**[81]

Species and year.	Southern Appalachian States.						
	Average of six States.	Mary-land.	Vir-ginia.	West Vir-ginia.	Ken-tucky.	Tennes-see.	North Caro-lina.
Maple:							
1907	$2.87[103]	$3.14[7]	$2.71[14]	$1.99[26]	$3.41[29]	$3.05[15]	$3.25[12]
1912	**3.68**[138]	**5.31**[16]	**2.70**[5]	**2.78**[9]	**4.01**[57]	**3.84**[22]	**3.09**[49]
Birch:							
1907	2.47[53]	3.17[3]	2.75[8]	2.42[26]	2.25[4]	2.30[5]	2.29[7]
1912	**2.81**[70]	**4.05**[9]	**3.00**[7]	**2.86**[7]	**3.00**[15]	**2.31**[8]	**2.70**[24]
Beech:							
1907	2.24[105]	3.90[5]	2.61[9]	1.67[35]	2.41[33]	2.36[16]	2.00[2]
1912	**2.72**[141]	**3.38**[13]	**2.12**[8]	**1.83**[9]	**3.34**[49]	**2.45**[38]	**2.27**[24]
Basswood:							
1907	3.75[73]	4.50[3]	3.33[6]	3.91[43]	4.46[3]	4.04[12]	1.67[6]
1912	**4.16**[82]	**4.50**[4]	**6.33**[3]	**4.11**[9]	**4.62**[25]	**4.22**[18]	**3.30**[23]
Elm:							
1907	3.04[53]	4.50[2]	2.17[6]	2.19[8]	3.82[24]	2.29[13]	....
1912	**3.51**[79]	**4.56**[8]	**2.67**[3]	**3.00**[1]	**4.09**[29]	**2.80**[33]	**3.70**[5]
Ash:							
1907	5.08[152]	6.42[6]	4.51[20]	5.05[39]	6.38[28]	4.91[27]	3.23[22]
1912	**5.50**[168]	**7.39**[9]	**6.06**[3]	**3.85**[7]	**5.98**[45]	**6.01**[53]	**4.23**[46]

FIG. 1.—CARLOADS OF SPLIT BODY WOOD AND SMALL ROUND WOOD.

FIG. 2.—PEELING STEAMED HARDWOOD BOLTS.

Practically all the species are used except the oaks, hickories, chestnut, and white ash.

NORTHERN HARDWOODS FOR PAPER MANUFACTURE IN PENNSYLVANIA.

TABLE 12.—*Average stumpage values of northern hardwoods for 1907 and 1912*—Contd.

Species and year.	Lake States.								
	Average of three States.	Michigan.				Wisconsin.			Minnesota.
		State average.	Upper peninsula.	Lower peninsula.	Southern tier of counties.	State average.	Northern counties.	Southern counties.	
Maple:									
1907	$3.63[156]	$4.17[92]	$1.91[22]	$4.55[64]	$8.50[6]	$2.71[60]	$2.61[57]	$4.67[3]	$5.13[4]
1912	**5.41[208]**	**6.75[84]**	....	....	....	**3.48[104]**	....	....	**9.86[20]**
Birch:									
1907	4.50[167]	4.95[89]	3.24[23]	5.49[64]	7.29[2]	3.94[66]	....	....	4.29[12]
1912	**5.44[194]**	**6.34[61]**	....	....	....	**4.86[111]**	....	....	**5.84[22]**
Beech:									
1907	3.02[82]	3.11[75]	1.42[6]	2.89[63]	7.17[6]	2.00[7]	....	....	....
1912	**4.54[92]**	**4.79[78]**	....	....	....	**3.17[14]**	....	....	....
Basswood:									
1907	7.42[163]	8.26[88]	5.61[23]	8.95[59]	11.67[6]	6.59[65]	....	....	5.50[10]
1912	**8.02[247]**	**9.57[86]**	....	....	....	**7.12[122]**	....	....	**7.41[39]**
Elm:									
1907	6.10[172]	7.49[87]	4.03[19]	8.34[62]	9.67[6]	4.72[76]	....	....	4.22[9]
1912	**6.61[227]**	**8.77[82]**	....	....	....	**5.01[112]**	....	....	**6.70[33]**
Ash:									
1907	6.49[156]	7.24[90]	4.64[21]	7.67[63]	11.83[6]	5.43[59]	....	....	5.79[7]
1912	**6.85[195]**	**8.72[71]**	....	....	....	**5.38[99]**	....	....	**7.36[25]**

NOTE.—These figures are averages of estimates by timberland owners. The small numerals indicate the number of reports on which the averages are based. In the case of Michigan and Wisconsin, stumpage values in different parts of the States are shown for 1907 to indicate the effect of differences in accessibility upon stumpage values. Similar data were not obtained for 1912. The 1907 data are, of course, obsolete, and illustrate nothing except tendencies. Averages of actual sales of stumpage in 1912 are shown for these regions in Bulletin 152, "The Eastern Hemlock," Table 10.

MANAGEMENT.

THE PLACE OF THE NORTHERN HARDWOODS IN FOREST MANAGEMENT.

The practice of forestry by private owners is practicable in the case of certain quick-growing, valuable species, or, where wood in small sizes is in steady demand, for slower-growing species under short rotations, or on estates maintained for recreation, hunting, or park purposes, in which the cost of maintenance is not charged against the stumpage value. In the case of the northern hardwoods, however, management is, for the present at least, largely a matter of Federal, State, or municipal, rather than of private, concern. The need for such a supply can hardly be questioned. Softwoods will, of course, always be in greater demand, but for furniture, flooring, and finish, veneer, distillation, "novelties," and other uses for which the various northern hardwoods are peculiarly fitted, there will undoubtedly always be a market. The use of substitutes for wood and the importation of foreign hardwoods may retard increase in value; but in spite of a decrease in per capita consumption, the total demand may be expected to tax the capacity of a reduced forest area to supply it.

The agricultural value of much of the land now in hardwoods will cause it eventually to be cleared and tilled. This is especially true in the gentle topography of the Lake States. But the progress of development is a gradual one, and in the meantime the soil might profitably be kept in timber. Ultimately the forests, especially those of northern hardwoods, will be rather closely confined to mountain regions. The hardwood forests of the future will probably share with spruce and fir the narrow mountain valleys and slopes at moderate altitudes, where they will serve at once for steam-flow protection and timber supply. Ridge tops and higher altitudes in the mountain and dry, poor, sandy soils elsewhere are better fitted for softwood than for hardwood management.

Large bodies of old-growth northern hardwoods still remain under private ownership. From the standpoint of growth these represent idle capital, since they have long passed the age of rapid volume increment, and in many cases their growth is offset by decay. The holding of these for increase in stumpage value is of doubtful wisdom in view of deterioration, fire risk, insect damage, etc., and especially the rapidly accumulating interest and tax charges. The owner has, therefore, every incentive to cut his timber and dispose of the land. With very little trouble such lands, when not put into farms, could be protected from fire and allowed to restock with "active capital" in the form of vigorous young growth. Under Federal and State action fire protection is rapidly becoming effective in many parts of the region and thrifty stands of second-growth now occupy soils which in earlier years would have been charred and barren.

OBJECTS OF MANAGEMENT.

The northern hardwood forest region includes such a wide variety of species, markets, climate, and topography that nearly all the recognized systems of management have their place, and none is generally applicable. For any particular tract the system used will depend also upon the object of management. This is often twofold, as when the forest affords both watershed protection and a timber supply.

Ideally, forest management aims to secure the heaviest possible sustained yield of the best species. Practically, it can approach this ideal only so closely as is warranted by the cost of logging and the value of the product. The degree of the compromise varies with these two factors, and the possibilities are therefore greater in some regions than in others. Just as the rise in stumpage value warrants the private holding of timber as an investment under certain conditions, it may also, in extreme cases, warrant the public holding of forests until the time is ripe for more intensive management.

Two considerations, however, point to the general advisability of the early removal of the old-growth timber. These are (1) the risk of loss by fire, insects, decay, wind, or other cause, of the stored-up growth of centuries, and (2) the advantage of placing the stand on an active, producing, instead of an idle, nonproducing basis. The problem of management then becomes how best to dispose of the old growth so as to secure the most desirable composition of the ensuing stand of young growth. Before making cuttings the species which are to be favored in securing reproduction must be decided upon.

CHOICE OF SPECIES.

Wherever possible, a mixture of hardwoods and conifers is desirable. Mixed forests produce heavier yields of better quality, are more effective for watershed protection, and present less risk of total loss from various sources than pure forests. From the standpoint of aggressiveness conifers are not as a rule a menace to the supremacy of hardwoods on fertile soils. To secure natural softwood growth among hardwoods is, in fact, usually a difficult matter, requiring a high degree of technical skill. Red spruce, hemlock, and white pine are the best species to grow among hardwoods.

Of the hardwoods, white ash, basswood, elms, black birch, yellow birch, and red oak are to be favored when in mixture with the more tolerant beech and sugar maple. Beech is usually the least valuable of the species, commercially, so that where possible it should be eliminated and its place given to better species. Its silvicultural value is high, but so closely resembles that of sugar maple that ordinarily no object is gained in keeping it in stands containing both. Sugar maple is the easiest of the intensive species to perpetuate in management. Its reproductive aggressiveness is such that in many regions it will probably be necessary to discourage it in favor of softwoods and preferred hardwoods. The birches are of great present and prospective value, commercially, and their forest value is hardly less than that of beech and maple. Their maintenance in the stand should, therefore, be one of the objects of silviculture wherever the climate and soils are favorable. In the Lake States and at lower altitudes in the mountains the intolerant species—ash, basswood, elm, and red oak—should be given every advantage. As in the natural forest, these will require a commanding position in the crown cover.

The most desirable composition of the stand will be determined chiefly by the climate and market conditions. In general it will comprise a shady, tolerant understory and an intolerant overstory of the most valuable species, hard and soft. The understory will consist largely of sugar maple, but with as much yellow or black birch as can be secured, and possibly a subordinate growth of red spruce or hemlock. The overstory will be of ash, basswood, white pine, or elm, or of any combination of these that the climate permits and the local demand indicates. Where black cherry, red oak, walnut, or other valuable intolerant species are available, these should be favored. Together with ash they are best managed in small, exclusive groups among the other species.

SILVICULTURAL METHODS.

It is impracticable to discuss in detail all the possible methods of management. The method to be chosen depends not only upon the kind of timber present, but also upon the kind of logging, the market conditions, etc. Any method would probably have to conform to local logging practice. In every case the management should follow in general some definite, if elastic, plan prepared in advance. While every stand presents its own problems, there are certain generally applicable procedures which are dealt with in the following discussion from a strictly silvicultural point of view, the many economic factors being neglected.

The most marked differences in silviculture are in the methods employed in old-growth and "second-growth" forests.

Old growth.—The aim of silviculture in old-growth stands, as has already been pointed out, is to replace mature and unproducing with immature, producing timber in such a way as to maintain a sustained periodic (though not necessarily annual) yield, and, at the same time, improve the composition of the stand in the direction indicated under "Choice of species," page 35. This implies a more or less gradual removal of the mature stand. For silvicultural as well as economic reasons, however, the removal must often be accomplished in a single cutting. The management will, therefore, approach two extremes: Clear cutting, after which the management will be that applied to second-growth stands; and the selection system, which is the nearest to nature's method of general replacement in virgin stands. Between these extremes are the seed tree and the shelterwood systems.

Clear cutting is justified silviculturally when there is good promise of seedling or sprout reproduction of desired species. The season in which the cutting is done is, therefore, of importance. Thus by cutting during a heavy seed year of a preferred and an "off" year of an undesirable species it may be possible to control or modify the character of the reproduction. This may also be done by cutting early or late in the year, to avoid or take advantage of the season's seed crop of a given species. Clear cutting may extend over a large area in a single season, the stand supplying its own seed for reproduction, or be confined to a strip along the border of the stand, whence the area is seeded down. In stands containing basswood, clear cutting is usually followed by a vigorous growth of basswood sprouts which far outstrip all other vegetation (Pl. IX). Since basswood will sprout, and apparently with success, from very large stumps, clear cutting seems well adapted to the perpetuation of basswood, even in the virgin stands. It is the simplest and easiest method, as well as the cheapest, from the standpoint of logging; but it converts the forest immediately from an uneven-aged old growth to an even-aged young growth form, which may not be desirable if it is planned to perpetuate the stands on a long rotation basis, and especially if it is to serve partially for soil or stream-flow protection.

To provide against failure of the reproduction because of fire or for some other reason, seed trees may be left. The ordinary rules regarding the selection of seed trees should be observed. These should be thrifty specimens of the desired species, well rooted to lessen danger from windthrow. Short trees with full crowns have correspondingly large root systems, and such should therefore be left for seed supply. Where more slender trees are chosen, they should be left in groups for mutual protection. The number left per acre depends upon the species and the location. To secure an immediate heavy seeding, two or three individuals or small groups of the light-seeded species (birch, elm, ash, etc.) should be left per acre; more trees are necessary for basswood, oak, etc.

The plan of management may contemplate either the abandonment of the seed trees, in which case their stumpage value must be charged against the cost of the natural reproduction established, or their removal in a subsequent logging operation. It may even be planned to leave them as "standards," until the succeeding crop of "second growth" is logged. The risk from wind, insects, disease, etc., makes it advisable in any event to charge the value of the seed trees against the cost of reproduction. The unavoidable damage to young growth caused by removing the seed trees may be an item of some importance. Furthermore, the stumpage value of the seed trees may be close to the cost of planting the area with some desirable species. The alternative of planting should always, therefore, be considered before deciding to leave seed trees.

The selection method is very well adapted to hardwood forests from a silvicultural but not from a logging point of view. The removal of carefully selected trees uniformly throughout the stand affords an excellent means of controlling the subsequent composition, and insures a sustained yield of increasing quality. But the trees removed will at first be of inferior value, probably too low to pay logging costs. Only a small percentage of the total volume of the stand will be removed at one time, and the trees will be so scattered that many roads will be necessary and handling charges will be very heavy. At the same time, this system is a difficult one to operate, requiring technical attention of a high grade. In its ideal form, therefore, the selection system is not yet applicable in this country to large tracts of hardwood timber, except when the management involves some other object than money returns.

A practical modification of the selection system which has been recommended for northern hardwood management involves a cutting to a minimum diameter limit, which is not fixed but varies according to the average size of the timber and is higher for preferred and lower for inferior species. To make logging financially possible, the cutting must be rather heavy and at rather long intervals. It is thus impossible to control the species in the reproduction by regulating the light supply. On the other hand, this compromise is about the only one by which a sustained periodic yield could be at once provided for.

Under many conditions the selection group method is the best that could be practiced. This is true particularly for stands containing intolerant species, whose reproduction may be favored by removing small groups of trees in the vicinity of the seed trees. Groups of intolerant seedlings, already started, may be freed in this way. White ash is a species well fitted for management by this method.[1]

Two important considerations in management are the material which it is aimed to produce and the rotation necessary to produce it. Under silviculture the volume growth per acre may be expected to be much greater than the average in the virgin forest, equal at least, to the maximum shown in Tables 7 to 9. To ascertain what might be expected of beech under management, the most rapid diameter-growth rates for each one-half inch in radius of the beech trees on which the growth values in Tables 7 to 9 are based were selected and averaged by a curve.[2] The resulting "selective" growth rate, with the per cent by which it exceeds the maximum, is shown in Table 13.

TABLE 13.—*Selective maximum diameter growth of Michigan beech.*

Age.	Diameter breast-high. Composite of maximum decades.	Diameter breast-high. Excess over maximum in Table 7.	Age.	Diameter breast-high. Composite of maximum decades.	Diameter breast-high. Excess over maximum in Table 7.
Years.	*Inches.*	*Per cent.*	*Years.*	*Inches.*	*Per cent.*
10	0.5		70	13.1	102
20	1.9	46	80	15.2	103
30	3.8	65	90	17.3	101
40	5.9	79	100	19.1	99
50	8.3	89	110	20.8	92
60	10.7	98			

Somewhat similar results are obtainable for other species. Trees in the open undoubtedly grow even faster than this, but it is at the expense of the long, clear log lengths of forest-grown trees. This accelerated growth represents an ideal to be approached under management in which each tree would receive from youth up just the

[1] See Department of Agriculture Bulletin 299. "The ashes: Their characteristics and management," by W. D. Sterrett.

[2] This process was devised and applied by W. B. Barrows.

right amount of light for the most rapid growth consistent with good trunk development and the complete utilization of all sunlight by the aggregate crown cover. In the selection forest, growth at this rate can not be expected for all the trees all the time. Thinnings, heavy enough to permit rapid growth of the younger trees, would sacrifice a great deal of immediate volume increment per acre of the larger timber. In fairly even-aged timber managed under the shelter-wood system, however, the accelerated growth might be more nearly maintained for all individuals by judicious thinning.

Young growth under virgin stands must usually be sacrificed in logging. There is little use in attempting to save it, since much of it has been so suppressed by shade that it is less vigorous than a new growth would be. If left exposed by the removal of much of the large timber, it would probably suffer great damage from wind, snow, and ice (Pl. XIV, fig. 1). Moreover the logging operations and the subsequent hauling break down a large proportion of the smaller trees, either killing them outright or causing them to lead a crippled existence, occupying valuable space to the exclusion of better trees. It is therefore advisable, in most virgin stands, to cut as cleanly and utilize to as small sizes as possible, thus clearing the way for a vigorous reproduction from the seed trees which are left.

Culled forest.—By culled forest is here meant a forest which has been culled of its best trees, but in which, usually, at least half of the original stand remains (Pl. I). Among the trees commonly culled from hardwood forests are white pine, red spruce, hemlock, bird's-eye maple, curly birch, "whitewood" or yellow poplar, cucumber, cherry, basswood, etc. Forests are often culled several times, a different species being removed each time to fill a special demand. This tends to simplify the composition of the forest, and also to decrease its value, while the power of the more highly prized species to compete with the others in the second growth is curtailed by the decrease in their seed supply.

The openings left by the removal of the scattered trees or groups of trees admit sunlight to the soil, and the openings soon become filled with young trees. These patches of young growth, when fairly abundant, form the basis for the management of the stand. All logging should be conducted with special reference to preserving and extending the stand of young growth. The merchantable timber should not all be removed at a single cutting, but enough of it should be left to warrant a second cutting at a later date. The trees left standing will serve to seed down the soil and fill up most of the gaps between the already existing groups of reproduction. The increased light which the remaining large trees receive will not only increase their seed production, but will accelerate their growth. The second cutting should be made after from 5 to 10 years, when the ground is well stocked with a thrifty reproduction, plentiful enough to be mutually protective.

Care should be taken to remove at the first cutting: (1) Trees of species not wanted in the reproduction, such as beech when in mixture with yellow birch, sugar maple, and other more valuable species; (2) damaged trees, liable to depreciate before a second cutting, and (3) heavy-foliaged, limby trees which shade the ground too thoroughly for successful reproduction and would be apt to damage young growth when removed. Where the reproduction groups are numerous, it will often be necessary to fell trees toward each other so that the damage from their fall may be reduced to a minimum.

As a result of the first cutting, there will thus be left a uniform but rather open stand of sound, well-shaped trees of the best species, interspersed with groups of well-started young growth. The increased light and root space stimulate growth in both the old and the young trees, prepare the soil for seed, and increase the seed supply from the large timber. Within 5 or at most 10 years the reproduction may be expected to be complete over all well-lighted spots. The remaining merchantable trees, now considerably larger owing to their growth since the first cut, are then felled with the greatest care to minimize the damage to the reproduction. If the felling and removal of the first crop is carefully done, such gaps as remain in the reproduction will not be large, and will, in most cases, result in increased growth of the adjacent stand due to the abundant light thus admitted.

Second-growth.[1]—Under this title are included all young hardwood stands, whether they result from the removal of older stands, from fire, or from any other cause. In composition such young stands vary even more greatly than those which preceded them, for they contain great quantities of small, weedlike species, like fire cherry, dwarf maple or "moose maple," aspen, etc., which, on account of their short lives or intolerance of shade, do not remain long in the stand.

Sprouts commonly form a large proportion of the second-growth after logging. They spring abundantly from most hardwood stumps, large or small, but those from large stumps are rarely thrifty, except in the case of basswood and chestnut (Pl. IX). Among them appear various small annual weeds, like "fireweed" (*Erechtites hieracifolia* and *Eupatorium* sp.), blackberry briers, fire cherry and other small trees, and finally forest-tree seedlings. Though not always the last in this succession, seedlings of the desired kinds often find difficulty in growing up through the tangled masses of vegetation which follow clearing (Pl. VI). Thus yellow birch must come in, if at all, within a few years after the land is cleared, or other vegetation will be apt

[1] The management of second-growth hardwoods is discussed in Bulletin 176 of the Vermont Agricultural Experiment Station, Burlington, Vt.

FIG. 1.—PARTIAL CUTTING IN OLD-GROWTH HARDWOODS. MCKEAN COUNTY, PA.

Too much of the stand was taken, and the slender trees left were bent or uprooted by snow and ice the following winter. Either more trees should have been left or the stand should have been clear cut, as in fig. 2.

FIG. 2.—CLEAR CUTTING IN SECOND-GROWTH HARDWOODS. CATSKILL MOUNTAINS, N. Y.

TWO WAYS OF CUTTING NORTHERN HARDWOODS FOR CHEMICAL DISTILLATION.

FIG. 1.—HEAVY THINNING IN A 32-YEAR-OLD STAND OF MIXED HARDWOODS.
Slow-growing species were cut and sold for fuel, leaving cherry, ash, and red maple. This is plot No. 18, p. 27.

FIG. 2.—LIGHTLY THINNED YELLOW BIRCH STAND IN NEW HAMPSHIRE; ABOUT 45 YEARS OLD.

THINNINGS IN SECOND-GROWTH STANDS.

to forestall it and shade it out; beech and maple, however, are less exacting. To induce sprout production, the cutting should be done during the season of vegetative rest, from late fall to early spring, and the stumps should be cut low.

In respect to the ultimate size and quality which they attain, seedlings are much superior to sprouts. In beech, as has been seen, sprouts rarely or never attain merchantable size in the North. Maple and birch sprouts, however, like most of the other common hardwoods, often grow rapidly and well to a moderate size, suitable for cordwood. Only the small stumps, 6 inches or less in diameter, should be chosen for sprout production, and wherever possible all but one of the many sprouts which appear on each stump should be removed. Such a thinning will result in the vigorous and rapid growth of the remaining sprout. Basswood is second only to chestnut in sprouting capacity, and sprouts of log size are often found springing from stumps 2 or 3 feet in diameter. (Pl. IX.)

Aside from the cutting of sprouts, the young stand will need little attention for 5 or 10 years. During this time it will have succeeded in killing out most of the blackberry and other competing shrubs, while many of the fire cherry and other short-lived, light-needing species, and even some of the maple and beech saplings, will have been choked out. At this period in its life the young growth commonly forms a dense thicket of slender saplings, 8 or 10 feet high, in which growth is quite slow, owing to the intense crowding. If from one-third to one-half of the young trees are now removed, so as to give more light and growing space to those which remain, the survivors will at once put on foliage and begin to grow vigorously until their crowns once more crowd each other. (Pl. XV, figs. 1 and 2.) The first thinning, which takes out entirely useless material, can be expected to pay for itself only in the increased growth of the stand, hastening the time at which it may be properly cut. Subsequent thinnings, however, besides resulting in rapid growth, produce a merchantable yield which may not only pay for the thinning, but may also give a small profit.

The aim in all thinnings should be to remove enough trees to prevent danger of crowding for several years to come, and at the same time to leave enough trees to utilize fully the increased light and to prevent the growth of grass and weeds on the soil beneath them. Damaged, poorly formed, and small trees should be removed in preference to the more vigorous ones, and the quality of the stand should also be improved by removing the least desirable species.

Wood-distillation factories in the East (notably in the Catskills) have already taken steps toward the management of second-growth hardwoods, and have bought mountain lands in quantities sufficient to supply them perpetually on an estimated yield per acre basis.

The stands are unthinned and are customarily cut clear, the largest timber being the first cut. (Pl. XIV, fig. 2.) With the introduction of thinnings and possibly of the shelterwood system of reproduction cuttings, both the yield and the composition of these stands could be materially improved. In the case of the thinned stand illustrated (Pl. XV, fig. 1) as plot No. 18 (p. 27) the owner realized a substantial profit in addition to a good stumpage value for his thinnings, and at the same time left the stand in a very much better condition as to species and growing space. With improving tax laws and increasing stumpage values, the opportunities for intensive management of second-growth hardwoods can not fail to extend.

APPLICATION OF PRINCIPLES OF MANAGEMENT IN TIMBER-SALE PRACTICE.

The method of applying the principles governing management in any particular region is illustrated in the following provisional schedule of instructions proposed for timber-sale practice on Federal land in the White Mountains of New Hampshire.

Principles Governing the Marking of Northern Hardwoods in National Forest Timber-Sale Practice in the White Mountains.

OBJECTS OF MARKING:

In general, the objects of marking will be:

(1) To secure a reproduction of desirable species.

(2) To remove a practicable cut for the operator under the actual local conditions as to marketable products.

(3) To improve existing stands through the removal for utilization of (*a*) large mature timber; (*b*) smaller trees when decayed, insect infested, or otherwise defective; and (*c*) trees of the less valuable species; and through thinnings to increase the growth of preferred species.

The markings will vary in detail according to the composition of the forest type, the topography, aspect, etc. In general, the following variations in composition may be distinguished:

OLD-GROWTH YELLOW BIRCH, BEECH, AND HARD MAPLE:

(*a*) With mixture of spruce, balsam, or hemlock.
(*b*) With mixture of white pine or tamarack.
(*c*) With mixture of ash, elm, basswood, or red oak.
(*d*) With mixture of paper birch or aspen.
(*e*) With beech predominating.
(*f*) With yellow or black birch predominating.
(*g*) With sugar maple predominating.

YOUNG-GROWTH HARDWOODS (EVEN-AGED):

(*a*) Pure or mixed stands of yellow birch, beech, and maple with and without mixture of conifers, ash, elm, basswood, and oak.

(*b*) Pure or mixed stands of paper birch and aspen, with subordinate conifers or hardwoods.

MARKING IN OLD-GROWTH HARDWOODS:

(*a*) *With mixture of spruce, balsam, or hemlock:*

Wherever practicable, conifers should be encouraged among the hardwoods, to increase the value and size of the future yield and, on watersheds, the protective value of the forest. With tolerant conifers this should be attempted by selection cuttings among the hardwoods, aimed to free the crowns of the conifers. On steep slopes and in exposed situations the cuttings, if done at all, should be very light. Where danger from windthrow is slight the hardwoods should be marked heavily, but the stand should be left sufficiently dense to afford reasonable protection from the wind. The severity of the cutting should be expressed in terms of the crown classes and species to be removed. If preferred, the approximate percentage of the merchantable timber corresponding to the species and crown classes designated for removal may be added. When even-aged groups of small hardwoods or conifers occur among older timber they will be thinned, provided marketable material can be obtained. In groups of small yellow birch, for example, considerable hub and bobbin stock may be available, but care must be taken not to thin too heavily. The same care should be used in thinning groups of small softwoods for pulpwood, etc. Not more than a third of the trees comprising the dominant stand should be removed, together with all the subordinate trees that are merchantable.

Brush should be lopped and scattered.

(*b*) *With mixture of white pine and tamarack:*

As a rule, only widely scattered seedlings of pine or tamarack can be expected to succeed under hardwood shade or in competition with hardwood reproduction. Mature trees of these species should therefore be removed in the first selection or shelterwood cutting. Small or oppressed individuals should be freed and left for increment and whatever scattered reproduction they may succeed in starting.

Brush should be lopped and scattered.

(*c*) *With mixture of ash, elm, basswood, or red oak:*

The light requirements of ash, elm, basswood, and red oak prevent their successful reproduction under heavy shade. Where these species occur in the stand, however, their reproduction should be the main object of management. This can best be accomplished by local shelterwood cuttings. These should remove the stand in two cuttings separated by a period of 10 or 20 years. The first cutting should be heavy, reducing the crown cover fully one-half, removing the trees of all the lower crown classes, and leaving large-crowned trees of the more valuable, less tolerant species to restock.

Brush should be lopped and scattered.

(*d*) *With mixture of paper birch or aspen:*

Where trees of these species occur individually among old-growth hardwoods, they should be removed in the selection cutting in favor of the longer lived species, if a market exists, except where they are not competing strongly, in which case they may, if thrifty, be left for a subsequent cutting. Where birch and aspen form pure groups among hardwoods they may be thinned, if practicable, and the most promising individuals left for a subsequent cutting. If promising reproduction is beneath them, however, such stands should be cut as clean as the possibilities of utilization will permit.

Brush should be lopped and scattered.

(*e*) *Old-growth with beech predominating:*

The object of management should be eventually to replace the beech with some species of greater promise, except on steep slopes, where the cuttings necessary to accomplish this might cause serious erosion. The shelterwood method is best adapted, approaching the clear-cutting-with-seed-trees method where the stand runs especially heavy to beech. If it can be done without loss to the operator, all merchantable beech shall be removed, together with only those trees of other species which are defective or whose presence is unnecessary to preserve the uniformity of the shelterwood, or to serve as seed trees. Where possible, the logging should precede rather than follow a heavy production of beech seeds.

Brush should be lopped and scattered so as to lie close to the ground.

(*f*) *Old-growth with yellow birch predominating:*

The shelterwood method is applicable in stands running largely to birch. The first cutting should remove about 50 per cent of the upper crown cover. The remaining half of the upper crown cover should include the crowns of thrifty yellow birches and less tolerant species like ash, elm, oak, or bass wood, whose reproduction is desirable. Where groups of thrifty young growth of mixed species exist these should be lightly thinned and left for subsequent cutting. The subordinate stand should be removed if merchantable, except that especially thrifty small and large poles, well situated as to light and protection from wind, may be left for a later cut, in the discretion of the marker.

The brush should be lopped and scattered.

(*g*) *Old-growth with sugar maple predominating:*

According to the composition of the stand, the management should follow the principles laid down in (*a*), (*b*), (*c*), or (*d*). In general, the management should aim (1) to eliminate beech and other species of lesser value, (2) to perpetuate sugar maple, or (3) in the presence of more valuable species, to increase their proportion in the stand at the expense of the maple. Provisions aiming to secure (1) and (3) are given above. Maple is the most aggressive reproducer in the forest, of the northern hardwoods. To perpetuate it either the selection or the shelterwood method may be used. The severity of the selection cutting should be expressed in terms of the crown classes and species to be removed. If preferred, the approximate percentage of the merchantable timber corresponding to the species and crown classes to be removed may be added. Unless it increases the danger of windthrow or results in loss to the operator, marking will be lighter in stands containing a large proportion of thrifty young and middle-aged timber, and heavier in stands containing a large proportion of mature and overmature timber; except that on steep slopes the cutting should be very light. When crowded groups of small trees occur among older timber they will be thinned, provided they contain marketable material.

Brush should be lopped and scattered.

Young-growth hardwoods (even-aged):

In young hardwoods, cuttings should be restricted to (1) improvement and increment thinnings in stands of the tolerant, longer-lived species, and in immature stands of intolerant, short-lived species (aspen and paper birch), wherever merchantable material can be removed practicably; and (2) to clear cuttings of aspen and paper birch which have reached physical maturity.

(1) The thinnings should remove (*a*) merchantable defective trees, (*b*) merchantable trees of the less valuable species in the stand, (*c*) not over 50 per cent of the trees comprising the dominant, codominant, and intermediate crown classes, and (*d*) all merchantable trees of the subordinate crown classes. The degree of thinning should depend upon the stem density of the stand and the consequent degree of windfirmness which the individuals will be likely to possess when the stand is opened up. This must be judged on the ground by the person conducting the marking.

Brush should be lopped and scattered.

(2) To reproduce these stands *in situ* early spring clear cutting should be practiced. Aspen root suckers and birch stump sprouts which result will probably grow rapidly enough to take care of themselves if the competing hardwood growth is not too abundant. Where a desirable reproduction of conifers or hardwoods exists, all merchantable birch and aspen should be removed, with care to prevent damage to the reproduction.

Brush should be lopped and scattered.

SPECIES MENTIONED IN THIS BULLETIN.

Alders	*Alnus* sp.
Arborvitæ	*Thuja occidentalis* Linn.
Ash, black	*Fraxinus nigra* Marsh.
Ash, white	*Fraxinus americana* Linn.
Aspen	*Populus tremuloides* Michx.
Aspen, large tooth	*Populus grandidentata* Michx.
Balm of Gilead	*Populus balsamifera* Linn.
Balsam fir. (See Fir.)	
Basswood	*Tilia americana* Linn.
Beech	*Fagus atropunicea* (Marsh) Sudworth.
Birch, black ("sweet," "cherry")	*Betula lenta* Linn.
Birch, gray ("white")	*Betula populifolia* Marsh.
Birch, paper ("white," "canoe")	*Betula papyrifera* Marsh.
Birch, yellow ("gray," "red," "silver")	*Betula lutea* Michx. f.
Cherry, black	*Prunus serotina* Ehrh.
Cherry, fire ("pin," "wild red")	*Prunus pennsylvanica* Linn. f.
Chestnut	*Castanea dentata* (Marsh) Borkh.
Cucumber tree	*Magnolia acuminata* Linn.
Elm, cork ("rock," "hard")	*Ulmus racemosa* Thomas.
Elm, slippery ("red")	*Ulmus pubescens* Walt.
Elm, white ("gray," "soft")	*Ulmus americana* Linn.
Fir, balsam	*Abies balsamea* (Linn.) Mill.
Gum, black ("sour")	*Nyssa sylvatica* Marsh.
Gum, red ("sweet")	*Liquidambar styraciflua* Linn.
Hemlock	*Tsuga canadensis* (Linn.) Carr.
Hickory	*Hicoria* sp.
Ironwood ("hornbeam")	*Ostrya virginiana* (Mill.) Koch.
Magnolia	*Magnolia* sp.
Maple, black	*Acer saccharum nigrum* (Mich. f.) Britton.
Maple, red	*Acer rubrum* Linn.
Maple, silver	*Acer saccharinum* Linn.
Maple, striped ("moosewood")	*Acer pennsylvanicum* Linn.
Maple, sugar	*Acer saccharum* Marsh.
Oak, red	*Quercus rubra* Linn.
Oak, white	*Quercus alba* Linn.
Pine, jack	*Pinus divaricata* (Ait.) Du Mont de Cours.
Pine, norway ("red")	*Pinus resinosa* Ait.
Pine, white	*Pinus strobus* Linn.
Poplar, yellow ("tulip")	*Liriodendron tulipifera* Linn.
Poplar. (*See* Aspens and Balm of Gilead).	
Spruce, black	*Picea mariana* (Mill.) B. S. P.
Spruce, red	*Picea rubens* Sargent.
Spruce, white	*Picea canadensis* (Mill.) B. S. P.
Sycamore	*Platanus occidentalis* Linn.
Tamarack ("larch")	*Larix laricina* (Du Roi) Koch.
Walnut	*Juglans* sp.
Willows	*Salix* sp.

APPENDIX.[1]

VOLUME TABLES.

BOARD-FOOT VOLUMES.

The following tables give the average volumes in board feet of forest-grown beech, basswood, yellow birch, and sugar maple trees of different sizes, in terms of the number of possible 16-foot logs and half logs in the tree. Since among trees of the same size some will be straight and usable to a small diameter at the top, while others break up into branches at considerably larger diameters, the Lake States measurements were separated on this basis, and appear in three tables, headed maximum, average, and minimum utilization. The tables from the other regions represent only the average utilization.

The tables were prepared by the Scribner Decimal C rule, and show in each case the stump height, top diameter limit, and number of trees on which they are based. "Diameter breast-high" is the diameter at a height of 4½ feet. The tables are based on measurements of sound trees of normal shape only.

TABLE 14.—*Yellow birch in New Hampshire,*[1] *volumes in board feet.*

Diameter breast-high.	Number of 16-foot logs.							Diameter inside bark of top.	Stump height.	Basis.
	½	1	1½	2	2½	3	3½			
	Volume—board feet in tens.									
Inches.								*Inches.*	*Feet.*	*Trees.*
7	1	1	2	3	......	......	......	6	2.1	2
8	1	2	2	3	4	......	......	6	2.1	8
9	1	2	3	4	5	......	......	7	2.2	24
10	2	3	4	5	6	......	......	7	2.2	43
11	2	4	5	6	8	......	......	8	2.2	44
12	3	5	6	8	9	......	......	8	2.2	45
13	3	6	8	9	11	......	......	9	2.2	36
14	4	7	9	11	13	14	......	9	2.3	35
15	4	8	11	13	15	16	......	10	2.3	47
16	5	10	13	15	17	18	......	11	2.3	40
17	6	11	15	18	20	21	......	11	2.4	32
18	7	13	17	20	23	25	......	12	2.4	38
19	8	14	20	23	26	28	......	13	2.4	36
20	9	16	22	26	30	33	36	13	2.5	39
21	10	18	25	30	34	37	41	14	2.5	28
22	11	20	27	33	38	42	47	15	2.6	21
23	13	23	30	36	42	48	53	15	2.6	24
24	14	25	33	40	47	53	59	16	2.7	21
25	15	27	36	44	51	58	64	16	2.7	23
26	......	30	40	48	56	63	70	17	2.8	17
27	......	33	44	52	61	69	76	18	2.9	14
28	......	36	48	57	66	74	82	18	2.9	17
29	......	......	52	62	71	80	88	19	3.0	7
30	......	......	57	67	77	86	95	20	3.0	....
31	......	......	......	72	82	92	101	20	3.1	5
32	......	......	......	78	88	98	108	21	3.1	5
										651

[1] Grafton County.

Logs scaled as cut, 10 to 16 feet long, by Scribner Decimal C rule. Utilization as close as form of tree allowed.

[1] Credit is due to W. B. Barrows, of the Forest Service, for the working up from field data of all the tables in the Appendix not credited to other sources.

TABLE 15.—*Yellow birch in the Lake States,*[1] *volumes in board feet.*

AVERAGE TOP DIAMETERS.

Diameter breast-high.	Number of 16-foot logs.					Diameter inside bark of top.	Basis.
	1½	2	2½	3	3½		
	Volume—board feet.						
Inches.						*Inches.*	*Trees.*
8	23	37	....	....	....	6	11
9	30	45	....	....	....	6	17
10	36	54	72	92	....	6	26
11	43	63	84	100	....	6	17
12	50	73	97	120	....	7	27
13	57	83	110	140	170	7	20
14	65	94	130	160	190	7	16
15	73	110	140	180	210	8	8
16	82	120	160	200	240	8	16
17	....	140	180	230	270	9	15
18	....	160	210	260	300	9	15
19	....	180	230	290	340	10	13
20	....	200	270	330	380	10	9
21	....	230	300	370	430	11	6
22	....	260	340	410	490	12	3
23	....	290	380	460	550	12	5
24	....	330	430	510	610	13	4
25	....	360	470	570	680	14	4
26	....	400	520	630	750	15	2
27	....	440	570	690	830	15	....
28	....	480	620	760	900	16	1
29	....	520	670	830	980	17	2
30	....	560	720	900	1,050	17	....
							237

[1] Gogebic and Wexford Counties, Mich.; Marinette and Vilas Counties, Wis.

Scaled from taper curves by Scribner Decimal C rule; mostly in 16.3-foot logs, with a few shorter logs where necessary. Stump height, 1 foot. Average utilization.

TABLE 16.—*Yellow birch in the Lake States,*[1] *volumes in board feet.*

MINIMUM TOP DIAMETERS.

Diameter, breast-high.	Number of 16-foot logs.						Diameter inside bark of top.	Basis.
	2	2½	3	3½	4	4½		
	Volume—board feet.							
Inches.							*Inches.*	*Trees.*
8	32	43	55	....	....	....	6	11
9	40	52	66	....	....	....	6	17
10	49	62	78	95	....	....	6	26
11	58	73	90	110	....	....	6	17
12	69	85	100	130	140	....	6	27
13	81	98	120	140	160	....	6	20
14	94	110	130	160	180	....	6	16
15	....	130	150	180	210	240	6	8
16	....	150	170	200	230	270	6	16
17	....	....	190	230	260	300	6	15
18	....	....	220	250	290	330	6	15
19	....	....	240	280	330	370	6	13
20	....	....	270	320	360	410	6	9
21	....	....	310	360	410	460	7	6
22	....	....	350	400	450	510	7	3
23	....	....	390	450	500	560	8	5
24	....	....	440	500	560	620	8	4
25	....	....	480	550	620	690	9	4
26	....	....	540	610	690	760	10	2
27	....	....	590	670	760	840	10	....
28	....	....	650	740	830	920	11	1
29	....	....	710	820	920	1,010	12	2
30	....	....	780	890	1,010	1,100	13	....
								237

[1] Gogebic and Wexford Counties, Mich.; Marinette and Vilas Counties, Wis.

Scaled from taper curves by Scribner Decimal C rule; mostly in 16.3-foot logs, with a few shorter logs where necessary. Stump height 1 foot. Close utilization.

TABLE 17.—*Yellow birch in the Lake States,*[1] *volumes in board feet.*

MAXIMUM TOP DIAMETERS.

Diameter, breast-high.	Number of 16-foot logs. 1	1½	2	Diameter inside bark of top.	Basis.
	Volume—board feet.				
Inches.				*Inches.*	*Trees.*
8	23	....	....	7	11
9	28	....	....	7	17
10	33	51	....	8	26
11	39	62	....	8	17
12	45	75	110	9	27
13	52	87	120	10	20
14	60	100	140	10	16
15	68	120	150	11	8
16	78	130	170	12	16
17	88	150	190	12	15
18	98	170	210	13	15
19	110	190	240	14	13
20	120	210	260	14	9
21	140	240	290	15	6
22	150	270	320	16	3
23	170	300	360	17	5
24	190	330	400	17	4
25	210	360	450	18	4
26	230	400	500	19	2
27	260	440	550	19	....
28	280	480	600	20	1
29	310	520	650	21	2
30	340	570	710	22	....
					237

[1] Gogebic and Wexford Counties, Mich.; Marinette and Vilas Counties, Wis.

Scaled from taper curves by Scribner Decimal C rule; mostly in 16.3-foot logs, with a few shorter logs where necessary. Stump height 1 foot. Poor utilization.

TABLE 18.—*Beech in New Hampshire,*[1] *volumes in board feet.*

Diameter, breast-high.	Number of 16-foot logs. ½	1	1½	2	2½	3	3½	Diameter inside bark of top.	Stump height.	Basis.
	Volume—board feet in tens.									
Inches.								*Inches.*	*Feet.*	*Trees.*
7	1	1	2	......	......	......	......	6	1.8	1
8	1	2	3	......	......	......	......	6	1.8	3
9	2	3	4	5	......	......	......	7	1.9	4
10	2	4	5	6	......	......	......	8	1.9	11
11	3	4	6	8	9	......	......	8	2.0	24
12	3	6	8	9	11	......	......	9	2.0	35
13	4	7	9	11	13	15	......	10	2.0	45
14	5	8	11	13	16	18	......	11	2.1	41
15	6	10	13	16	19	21	24	11	2.1	45
16	......	11	15	19	22	26	29	12	2.1	43
17	......	13	17	22	26	30	34	13	2.2	37
18	......	......	20	26	30	35	39	13	2.2	28
19	......	......	23	30	35	40	44	14	2.2	10
20	......	......	......	34	39	44	49	15	2.2	18
21	......	......	......	38	44	49	54	15	2.2	11
22	......	......	......	42	48	53	59	16	2.3	11
23	......	......	......	46	52	58	64	17	2.3	8
24	......	......	......	49	56	62	69	17	2.3	1
										376

[1] Grafton County.

Logs scaled as cut, 10 to 16 feet long, by the Scribner Decimal C rule. Utilization as close as form of tree allowed.

TABLE 19.—*Beech in Pennsylvania,*[1] *volumes in board feet.*

Diameter, breast-high.	Number of 16-foot logs.					Diameter inside bark of top.	Basis.
	2	2½	3	3½	4		
	Volume—board feet.						
Inches.						*Inches.*	*Trees.*
10	47	67	87	110	....	6	14
11	52	77	100	130	....	7	6
12	61	91	120	150	170	7	6
13	74	110	140	170	200	7	8
14	92	130	170	200	230	8	11
15	120	160	200	230	270	8	5
16	150	190	230	270	310	9	13
17	180	220	270	310	360	9	10
18	220	260	310	350	410	10	10
19	....	290	350	400	460	11	11
20	....	330	390	450	510	11	5
21	....	370	430	500	570	12	6
22	....	400	470	560	640	13	2
23	....	440	520	610	710	14	5
24	....	490	570	670	780	15	2
25	....	530	620	740	870	16	1
26	....	....	670	810	960	17	1
27	....	....	720	890	1,050	18	....
28	....	....	780	960	1,150	19	....
29	....	....	830	1,040	1,260	20	1
30	....	....	880	1,120	1,370	21	1
							118

[1] McKean County.

Height of stump, 1.5 to 3.3 feet. Scaled by the Scribner Decimal C rule.

TABLE 20.—*Beech in Michigan,*[1] *volumes in board feet.*

AVERAGE TOP DIAMETERS.

Diameter, breast-high.	Number of 16-foot logs.								Diameter inside bark of top.	Basis.
	1	1½	2	2½	3	3½	4	4½		
	Volume—board feet.									
Inches.									*Inches.*	*Trees.*
6	16	25	34	43	53	....	....	....	6	2
7	17	27	37	48	62	....	....	....	6	13
8	18	29	41	55	71	89	....	....	6	20
9	20	32	46	63	81	100	....	....	6	11
10	22	37	52	72	93	110	130	....	6	23
11	24	42	60	83	110	130	160	....	6	22
12	26	47	69	96	120	150	180	210	7	30
13	28	53	80	110	140	180	210	240	7	19
14	30	60	93	120	160	200	240	280	7	25
15	33	68	110	140	180	230	270	310	8	26
16	36	77	120	160	210	250	300	350	8	28
17	....	85	140	190	240	290	340	400	9	14
18	....	95	160	210	270	320	390	450	9	14
19	....	110	180	240	310	370	430	500	10	9
20	....	....	200	280	350	420	490	560	10	6
21	....	....	220	320	390	470	550	630	11	7
22	....	....	250	360	440	530	620	710	12	8
23	....	....	....	400	500	600	690	800	12	4
24	....	....	....	440	560	670	780	890	13	3
25	....	....	....	....	620	740	860	1,000	14	1
26	....	....	....	....	680	820	960	1,110	15	....
										285

[1] Wexford County.

Scaled from taper curves, by the Scribner Decimal C rule, mostly in 16.3-foot logs, with a few shorter logs. Stump height, 1 foot. Average utilization.

TABLE 21.—*Beech in Michigan,*[1] *volumes in board feet.*

MINIMUM TOP DIAMETERS.

Diameter, breast-high.	Number of 16-foot logs.									Diameter inside bark of top.	Basis.
	1	1½	2	2½	3	3½	4	4½	5		
	Volume—board feet.										
Inches.										*Inches.*	*Trees.*
6	16	25	34	......	......	......	......	......	......	6	2
7	17	27	37	......	......	......	......	......	......	6	13
8	18	29	41	55	......	......	......	......	......	6	20
9	19	31	44	60	77	......	......	......	......	6	11
10	20	33	48	66	86	100	......	......	......	6	23
11	21	35	54	73	96	120	140	......	......	6	22
12	22	38	60	81	110	130	160	210	......	6	30
13	......	40	66	89	120	150	190	230	......	6	19
14	......	43	73	98	130	170	210	260	......	6	25
15	......	......	81	110	150	190	230	280	330	6	26
16	......	......	90	120	170	210	260	310	360	6	28
17	......	......	......	130	180	230	290	340	390	6	14
18	......	......	......	140	200	260	320	370	430	6	14
19	......	......	......	......	230	300	360	420	470	6	9
20	......	......	......	......	250	340	410	470	530	6	6
21	......	......	......	......	......	390	460	530	600	7	7
22	......	......	......	......	......	450	520	600	670	7	8
23	......	......	......	......	......	520	590	670	750	8	4
24	......	......	......	......	......	590	670	760	850	8	3
25	......	......	......	......	......	660	750	850	950	9	1
26	......	......	......	......	......	750	850	940	1,040	10	......
											285

[1] Wexford County.

Scaled from taper curves, by the Scribner Decimal C rule, mostly in 16.3-foot logs, with a few shorter logs. Stump height, 1 foot. Close utilization.

TABLE 22.—*Beech in Michigan,*[1] *volumes in board feet.*

MAXIMUM TOP DIAMETERS.

Diameter, breast-high.	Number of 16-foot logs.					Diameter, inside bark of top.	Basis.
	1	1½	2	2½	3		
	Volume—board feet.						
Inches.						*Inches.*	*Trees.*
6	20	27	......	......	......	6	2
7	22	32	41	......	......	6	13
8	24	37	52	68	......	7	20
9	27	44	63	83	110	7	11
10	32	53	75	97	120	8	23
11	36	63	88	110	140	8	22
12	42	74	100	130	160	9	30
13	48	87	120	150	190	10	19
14	56	100	140	180	210	10	25
15	65	120	160	200	250	11	26
16	75	130	180	230	280	12	8
17	87	150	210	270	330	12	14
18	98	170	240	300	370	13	14
19	130	190	270	340	420	14	9
20	140	220	300	380	470	14	6
21	......	240	340	430	520	15	7
22	......	270	380	480	580	16	8
23	......	300	420	530	650	17	4
24	......	......	460	590	730	17	3
25	......	......	500	660	820	18	1
26	......	......	540	730	920	19	......
							285

[1] Wexford County.

Scaled from taper curves, by the Scribner Decimal C rule, mostly in 16.3-foot logs, with a few shorter logs. Stump height, 1 foot. Poor utilization.

TABLE 23.—*Sugar maple in New Hampshire,*[1] *volumes in board feet.*

Diameter, breast-high.	Number of 16-foot logs. ½	1	1½	2	2½	3	3½	4	Diameter, inside bark of top.	Height of stump.	Basis.
	Volume—board feet in tens.										
Inches.									*Inches.*	*Feet.*	*Trees.*
7	1	1	2	......	......	......	......	......	6	2.0	1
8	1	2	2	3	......	......	......	......	6	2.0	3
9	2	2	3	4	5	......	......	......	7	2.0	3
10	3	3	4	5	6	7	......	......	7	2.0	13
11	4	4	5	7	8	9	......	......	8	2.1	18
12	4	5	7	8	9	11	12	......	8	2.1	25
13	5	7	8	10	11	13	14	......	9	2.1	24
14	6	8	9	11	13	15	17	......	10	2.1	19
15	......	9	11	13	16	18	21	24	10	2.1	22
16	......	11	13	15	18	21	24	27	11	2.2	32
17	......	13	15	18	21	24	27	31	11	2.2	19
18	......	14	17	21	24	27	31	35	12	2.2	28
19	......	16	20	23	27	30	34	39	13	2.3	23
20	......	18	23	27	30	34	38	43	13	2.3	22
21	......	......	26	30	34	38	42	47	14	2.4	16
22	......	......	30	34	38	42	47	51	14	2.4	21
23	......	......	34	38	42	47	51	56	15	2.4	18
24	......	......	39	43	47	52	57	61	16	2.5	15
25	......	......	43	48	52	57	62	67	16	2.5	9
26	......	......	48	52	57	63	67	73	17	2.6	6
27	......	......	......	57	63	68	73	79	18	2.6	6
28	......	......	......	63	68	74	79	85	18	2.7	6
29	......	......	......	68	74	80	86	92	19	2.8	4
30	......	......	......	73	79	86	92	99	20	2.9	3
31	......	......	......	78	85	92	98	106	20	2.9	3
32	......	......	......	84	91	97	104	113	21	3.0	1
											360

[1] Grafton County.

Logs scaled as cut, 8 to 16 feet long, by the Scribner Decimal C rule. Utilization as close as form of tree allowed.

TABLE 24.—*Sugar maple in Pennsylvania,*[1] *volumes in board feet.*

Diameter, breast-high.	Number of 16-foot logs. 2½	3	3½	4	Diameter, inside bark of top.	Basis.
	Volume—board feet.					
Inches.					*Inches.*	*Trees.*
10	63	90	....	....	6	4
11	74	100	....	....	7	3
12	86	120	....	....	7	2
13	99	130	....	....	8	2
14	110	150	210	....	8	2
15	130	170	230	....	8	2
16	150	190	260	320	9	4
17	....	220	290	360	10	7
18	....	250	330	410	10	5
19	....	280	370	460	11	1
20	....	320	410	510	11	3
21	....	360	460	570	12	2
22	....	400	510	640	13	....
23	....	440	560	710	13	....
24	....	480	620	780	14	1
25	....	530	680	850	15	....
26	....	580	740	920	15	....
27	....	630	810	1,000	16	2
28	....	680	880	1,070	16	1
						41

[1] McKean County.

Height of stump, 1.8 to 3.2 feet. Logs scaled by the Scribner Decimal C rule.

TABLE 25.—*Sugar maple in the Lake States,*[1] *volumes in board feet.*

AVERAGE TOP DIAMETERS.

Diameter, breast-high.	Number of 16-foot logs.						Diameter, inside bark of top.	Basis.
	1½	2	2½	3	3½	4		
	Volume—board feet.							
Inches.							*Inches.*	*Trees.*
8	25	31	38	....	....	....	6	21
9	30	40	50	....	....	....	6	35
10	37	47	62	76	94	....	6	23
11	43	59	76	93	110	....	6	26
12	50	70	91	110	140	170	7	25
13	57	82	110	130	160	190	7	20
14	65	95	130	160	190	220	7	22
15	73	110	150	180	220	250	8	16
16	83	120	170	210	250	290	8	22
17	93	140	190	240	280	330	9	7
18	100	160	220	270	320	380	9	13
19	....	180	240	300	370	430	10	6
20	....	200	270	340	410	490	10	9
21	....	220	300	380	460	550	11	7
22	....	250	340	420	520	620	12	7
23	....	280	370	470	580	690	12	6
24	....	310	410	520	640	770	13	2
25	....	340	460	570	710	840	14	6
26	....	370	500	630	780	930	15	1
27	....	....	550	690	860	1,020	15	2
28	....	....	600	760	940	1,110	16	....
29	....	....	650	820	1,020	1,210	17	....
30	....	....	690	890	1,110	1,300	17	2
								278

[1] Gogebic and Wexford Counties, Mich.; Marinette and Vilas Counties, Wis.

Scaled from taper curves by Scribner Decimal C rule; mostly in 16.3-foot logs, with a few shorter logs where necessary. Stump height, 1 foot. Average utilization.

TABLE 26.—*Sugar maple in the Lake States,*[1] *volumes in board feet.*

MINIMUM TOP DIAMETERS.

Diameter, breast-high.	Number of 16-foot logs.							Diameter, inside bark of top.	Basis.
	2	2½	3	3½	4	4½	5		
	Volume—board feet.								
Inches.								*Inches.*	*Trees.*
8	28	38	48	....	....	....	....	6	21
9	36	49	60	....	....	....	....	6	35
10	44	60	74	....	....	....	....	6	23
11	53	73	89	....	....	....	....	6	26
12	63	86	100	120	150	....	....	6	25
13	74	100	120	140	170	....	....	6	20
14	86	110	140	160	190	220	260	6	22
15	98	130	160	190	210	250	290	6	16
16	110	140	180	210	240	280	330	6	22
17	120	160	200	240	270	320	370	6	7
18	140	180	220	260	300	360	420	6	13
19	....	....	240	290	340	400	470	6	6
20	....	....	270	320	380	450	520	6	9
21	....	....	290	360	430	500	590	7	7
22	....	....	320	390	480	560	660	7	7
23	....	....	360	440	530	630	730	8	6
24	....	....	390	480	590	700	820	8	2
25	....	....	430	530	650	770	910	9	6
26	....	....	480	590	720	860	1,000	10	1
27	....	....	530	650	800	950	1,120	10	2
28	....	....	590	720	890	1,050	1,230	11	....
29	....	....	650	810	980	1,160	1,360	12	....
30	....	....	720	900	1,080	1,280	1,500	13	2
									278

[1] Gogebic and Wexford Counties, Mich.; Marinette and Vilas Counties, Wis.

Scaled from taper curves by the Scribner Decimal C rule; mostly in 16.3-foot logs, with a few shorter logs where necessary. Stump height, 1 foot. Close utilization.

TABLE 27.—*Sugar maple in the Lake States,*[1] *volumes in board feet.*

MAXIMUM TOP DIAMETERS.

Diameter, breast-high.	Number of 16-foot logs. 1	1½	2	2½	Diameter, inside bark of top.	Basis.
	Volume—board feet.					
Inches.					*Inches.*	*Trees.*
8	18	50	....	....	7	21
9	24	57	....	....	7	35
10	30	65	....	....	8	23
11	37	73	....	....	8	26
12	44	84	110	130	9	25
13	51	95	120	150	10	20
14	59	110	140	170	10	22
15	68	120	160	190	11	16
16	77	130	180	220	12	22
17	88	150	210	250	12	7
18	99	170	230	290	13	13
19	110	190	260	320	14	6
20	130	210	290	370	14	9
21	140	230	330	410	15	7
22	160	260	360	460	16	7
23	180	290	410	510	17	6
24	200	320	450	560	17	2
25	220	360	500	620	18	6
26	240	400	540	680	19	1
27	270	440	590	740	19	2
28	300	480	640	800	20	....
29	330	520	690	850	21	....
30	360	570	740	910	22	2
						278

[1] Gogebic and Wexford Counties, Mich.; Marinette and Vilas Counties, Wis.

Scaled from taper curves by the Scribner Decimal C rule; mostly in 16.3-foot logs, with a few shorter logs where necessary. Stump height, 1 foot. Poor utilization.

TABLE 28.—*Basswood in the Lake States,*[1] *volumes in board feet.*

AVERAGE TOP DIAMETERS.

Diameter breast-high.	Number of 16-foot logs. Volume—board feet. 2	2½	3	3½	4	4½	Diameter inside bark of top.	Basis.
Inches.							*Inches.*	*Trees.*
8	30	47	60	....	....	....	6	6
9	36	53	69	....	....	....	6	9
10	44	60	79	100	130	....	6	7
11	53	70	90	110	140	....	6	8
12	63	80	100	130	160	....	7	7
13	75	94	120	150	180	220	7	9
14	89	110	140	170	200	240	7	7
15	100	130	160	190	230	270	8	17
16	120	150	180	220	260	300	8	17
17	....	170	210	250	290	340	9	20
18	....	190	240	280	330	380	9	18
19	....	210	270	320	370	430	10	14
20	....	240	300	360	420	480	10	31
21	....	270	340	400	470	540	11	21
22	....	300	380	450	520	600	12	14
23	....	340	420	500	580	670	12	17
24	....	380	470	560	650	750	13	19
25	....	410	520	620	720	830	14	14
26	....	450	570	680	790	920	15	17
27	....	500	620	750	870	1,010	15	8
28	....	540	680	820	960	1,100	16	9
29	....	590	740	890	1,040	1,190	17	6
30	....	640	800	970	1,130	1,290	17	4
31	....	690	870	1,050	1,220	1,400	18	8
32	....	750	940	1,130	1,310	1,500	18	3
33	....	810	1,010	1,210	1,410	1,610	19	3
34	....	870	1,080	1,290	1,500	1,720	20	4
35	....	940	1,150	1,380	1,600	1,830	20	1
36	....	1,010	1,240	1,470	1,700	1,950	21	....
37	....	1,080	1,320	1,560	1,800	2,060	22	1
38	....	1,150	1,410	1,650	1 900	2,180	22	....
39	....	1,220	1,490	1,750	2,000	2,300	23	....
40	....	1,300	1,570	1,850	2,100	2,420	24	....
								319

[1] Charlevoix and Kalkaska Counties, Mich.; Iron and Price Counties, Wis.

Height of stump, 1 foot, scaled from taper curves, by the Scribner Decimal C rule; mostly in 16.3-foot logs, with a few shorter logs where necessary. Average utilization.

TABLE 29.—*Basswood in the Lake States,*[1] *volumes in board feet.*

MINIMUM TOP DIAMETERS.

Diameter, breast-high.	Number of 16-foot logs.										Diameter inside bark of top.	Basis.
	1½	2	2½	3	3½	4	4½	5	5½	6		
	Volume—board feet.											
Inches.											*Inches.*	*Trees.*
8	16	24	......	......	......	......	......	......	......	......	6	6
9	18	28	46	......	......	......	......	......	......	......	6	9
10	23	34	52	67	86	......	......	......	......	......	6	7
11	29	42	61	78	97	120	......	......	......	......	6	8
12	38	52	73	91	110	140	170	190	......	......	6	7
13	49	66	87	110	130	160	190	210	......	......	6	9
14	63	82	100	120	150	180	210	240	260	......	6	7
15	80	100	120	140	170	200	230	260	290	......	6	17
16	100	120	140	160	190	220	250	290	320	350	6	17
17	......	......	160	180	210	250	280	320	350	390	6	20
18	......	......	180	200	240	280	310	360	390	440	6	18
19	......	......	......	230	270	310	350	400	440	490	6	14
20	......	......	......	250	310	350	390	440	490	540	6	31
21	......	......	......	......	340	390	430	490	550	610	7	21
22	......	......	......	......	380	430	480	540	610	680	7	14
23	......	......	......	......	430	480	530	610	680	760	8	17
24	......	......	......	......	470	530	590	680	760	850	8	19
25	......	......	......	......	520	580	660	750	850	950	9	14
26	......	......	......	......	570	640	720	820	940	1,050	10	17
27	......	......	......	......	620	700	790	900	1,030	1,160	10	8
28	......	......	......	......	670	760	870	990	1,130	1,270	11	9
29	......	......	......	......	730	830	950	1,080	1,240	1,390	12	6
30	......	......	......	......	780	900	1,030	1,180	1,340	1,510	12	4
31	......	......	......	......	840	970	1,120	1,280	1,460	1,640	13	8
32	......	......	......	......	910	1,040	1,210	1,390	1,580	1,770	13	3
33	......	......	......	......	970	1,120	1,300	1,500	1,700	1,900	14	3
34	......	......	......	......	1,040	1,200	1,400	1,610	1,830	2,040	14	4
35	......	......	......	......	1,110	1,290	1,500	1,730	1,960	2,190	15	1
36	......	......	......	......	1,180	1,370	1,610	1,850	2,090	2,340	16	......
37	......	......	......	......	1,260	1,460	1,710	1,980	2,230	2,490	16	1
38	......	......	......	......	1,340	1,560	1,830	2,110	2,380	2,640	17	......
39	......	......	......	......	1,420	1,660	1,940	2,230	2,530	2,800	17	......
40	......	......	......	......	1,500	1,760	2,060	2,360	2,680	2,950	18	......
												319

[1] Charlevoix and Kalkaska Counties, Mich.; Iron and Price Counties, Wis.

Height of stump, 1 foot, scaled from taper curves, by the Scribner Decimal C rule; mostly in 16.3-foot logs, with a few shorter logs where necessary. Close utilization.

TABLE 30.—*Basswood in the Lake States,*[1] *volumes in board feet.*

MAXIMUM TOP DIAMETERS.

Diameter, breast-high.	Number of 16-foot logs. ½	1	1½	2	Diameter inside bark of top.	Basis.
	Volume—board feet.					
Inches.					*Inches.*	*Trees.*
8	7	17	....	....	7	6
9	10	23	....	....	7	9
10	14	28	....	....	8	7
11	17	35	....	....	8	8
12	21	43	74	100	9	7
13	26	51	85	120	10	9
14	31	61	97	140	10	7
15	....	73	110	150	11	17
16	....	86	130	170	12	17
17	....	100	150	190	12	20
18	....	120	170	220	13	18
19	....	130	190	240	14	14
20	....	150	210	270	14	31
21	....	170	240	300	15	21
22	....	190	260	340	16	14
23	....	210	290	380	17	17
24	....	230	330	420	17	19
25	....	250	360	470	18	14
26	....	270	390	520	19	17
27	....	290	430	570	19	8
28	....	320	470	620	20	9
29	....	340	500	670	21	6
30	....	370	540	720	22	4
31	....	390	580	770	22	8
32	....	420	620	830	23	3
33	....	450	660	880	24	3
34	....	480	710	940	24	4
35	....	510	750	1,000	25	1
36	....	540	800	1,060	26	....
37	....	570	840	1,120	26	1
38	....	600	890	1,180	27	....
39	....	630	940	1,240	28	....
40	....	670	990	1,310	28	....
						319

[1] Charlevoix and Kalkaska Counties, Mich.; Iron and Price Counties, Wis.

Height of stump, 1 foot, scaled from taper curves by the Scribner Decimal C rule; mostly in 16.3-foot logs, with a few shorter logs where necessary. Poor utilization.

CUBIC-FOOT VOLUMES.

These tables give the average volumes in cubic feet of forest-grown yellow birch, beech, sugar maple, and basswood trees of different sizes. They are based on stem and branch taper measurements of the trees from which the preceding board-foot tables were made. The volumes are shown separately for "logs" and "topwood." The cubic-foot volume of "logs" includes the stem of the tree between the same stump heights and top diameters as for the board-foot tables, except that for the Lake States tables only the "average" top diameters were used. The volume of "top" is for the portion of the main stem above the upper diameter given, plus the solid volume of all branches suitable for cordwood to a minimum diameter of about 2 inches outside bark at the middle of a 5-foot stick, except for basswood, the branches of which were measured to a minimum middle diameter of 4 inches.

The tables for the Lake States also give the per cent of bark based on the cubic volume of the stem with bark. For basswood and beech the per cent of bark varied consistently with breasthigh diameter; for birch and maple there was no consistent variation.

Table 37 gives the cubic volume of red maple on the Harvard Forest, Petersham, Mass.

TABLE 31.—*Yellow birch in the Lake States,*[1] *volumes in cubic feet.*

Diameter, breasthigh.	Total height of tree—feet.												Diameter, inside bark of top.	Basis, trees.	
	40		50		60		70		80		90				
	Volume [2] including bark—cubic feet.														
	Logs.	Top.	Logs.	Top.	Logs.	Top.	Logs.	Top.	Logs.	Top.	Logs.	Top.		Logs.	Top.
In.													*In.*		
4	......	0.8	......	0.9	......	......	......	......	......	......	......	......	......	......	......
5	......	1.1	......	1.3	......	1.4	......	......	......	......	......	......	......	......	6
6	......	1.4	1.0	1.6	1.1	1.8	1.2	2.0	......	......	......	......	......	4	4
7	......	1.7	4.5	1.9	4.8	2.0	5.1	2.3	5.4	2.3	......	......	......	12	12
8	......	1.9	7.5	2.1	7.9	2.3	8.5	2.6	9.2	2.6	10.1	2.6	6	11	11
9	......	......	9.9	2.4	10.5	2.6	11.6	2.9	12.8	2.9	14.3	2.9	6	17	17
10	......	......	12.6	2.7	13.4	3.0	15.1	3.2	16.8	3.2	18.7	3.2	6	26	26
11	......	......	15.6	3.1	16.6	3.4	18.9	3.7	21.0	3.7	24.0	3.7	6	17	17
12	......	......	18.6	3.6	20.0	4.0	23.0	4.2	26.0	4.2	29.0	4.2	7	27	27
13	......	......	22.0	4.3	24.0	4.7	28.0	4.9	31.0	4.9	34.0	4.9	7	20	20
14	......	......	25.0	5.1	28.0	5.5	32.0	5.9	36.0	5.9	40.0	5.9	7	16	17
15	......	......	......	......	33.0	6.6	38.0	7.1	42.0	7.1	46.0	7.1	8	8	8
16	......	......	......	......	38.0	8.0	43.0	8.4	48.0	8.4	52.0	8.4	8	16	14
17	......	......	......	......	44.0	9.6	49.0	9.9	54.0	9.9	58.0	9.9	9	15	15
18	......	......	......	......	50.0	11.3	56.0	11.5	61.0	11.5	65.0	11.5	9	15	15
19	......	......	......	......	56.0	13.2	62.0	13.3	67.0	13.3	72.0	13.3	10	13	12
20	......	......	......	......	63.0	15.2	69.0	15.2	74.0	15.2	79.0	15.2	10	9	7
21	......	......	......	......	......	......	75.0	17.2	81.0	17.2	87.0	17.2	11	6	5
22	......	......	......	......	......	......	82.0	19.6	88.0	19.6	95.0	19.6	12	3	2
23	......	......	......	......	......	......	88.0	22.0	96.0	22.0	103.0	22.0	12	5	5
24	......	......	......	......	......	......	95.0	25.0	103.0	25.0	111.0	25.0	13	4	4
25	......	......	......	......	......	......	102.0	29.0	111.0	29.0	120.0	29.0	14	4	4
26	......	......	......	......	......	......	109.0	32.0	119.0	32.0	129.0	32.0	15	2	2
27	......	......	......	......	......	......	116.0	36.0	127.0	36.0	138.0	36.0	15	......	......
28	......	......	......	......	......	......	124.0	40.0	135.0	40.0	147.0	40.0	16	1	1
29	......	......	......	......	......	......	131.0	44.0	144.0	44.0	156.0	44.0	17	2	2
30	......	......	......	......	......	......	138.0	48.0	152.0	48.0	165.0	48.0	17	......	......
														253	253

[1] Gogebic and Wexford Counties, Mich.; Marinette and Vilas Counties, Wis.

[2] The "log" volume is the solid contents of wood and bark between a stump height of 1 foot and the "diameter inside bark of top" shown in the 14th column. The volume of "top" is that contained in the stem above this point, and in addition all branches suitable for cordwood having a diameter, outside bark, of 2 inches or more at the middle of a 5-foot stick. The entire volume of trees too small to yield a 6-inch log is considered topwood. Bark comprises about 13 per cent of the total volume; there was no consistent variation with the size of the tree.

TABLE 32.—*Beech in Michigan,*[1] *volumes in cubic feet.*

Diameter, breast-high.	Height of tree—feet.														Diameter, inside bark of top.	Per cent of bark.	Basis, trees.	
	40		50		60		70		80		90		100					
	Volume [2] including bark—cubic feet.																	
	Logs.	Top.	Logs.	Top.	Logs.	Top.	Logs.	Top.	Logs.	Top.	Logs.	Top.	Logs.	Top.			Logs.	To
In.															*In.*			
4	....	0.7	....	0.9	....	....	....	....	....	....	....	....	....	....	6	8.1	....	3
5	....	.9	....	1.1	....	1.4	....	....	....	....	....	....	....	....	6	8.0	....	3
6	1.0	1.0	1.3	1.3	1.7	1.6	2.4	1.9	....	....	....	....	....	....	6	7.9	2	5
7	2.9	1.3	3.5	1.6	4.7	1.9	6.2	2.2	....	....	....	....	....	....	6	7.8	14	16
8	4.9	1.5	5.9	1.8	7.4	2.2	9.6	2.5	10.4	2.8	12.4	3.1	....	....	6	7.7	20	15
9	7.1	1.7	8.2	2.1	10.0	2.4	12.3	2.8	13.9	3.2	16.5	3.5	....	....	6	7.6	11	15
10	9.4	1.9	10.7	2.3	12.7	2.7	15.4	3.1	17.8	3.5	21.0	3.9	24	4.3	6	7.6	23	23
11	11.8	2.2	13.4	2.6	15.3	3.0	18.8	3.5	22.0	3.9	26.0	4.3	29	4.7	6	7.5	22	29
12	14.4	2.4	16.3	2.9	18.1	3.4	23.0	3.8	27.0	4.3	31.0	4.8	35	5.2	7	7.4	30	25
13	....	....	19.3	3.2	21.0	3.7	27.0	4.2	32.0	4.8	36.0	5.3	41	5.8	7	7.3	19	18
14	....	....	22.0	3.5	24.0	4.1	31.0	4.7	37.0	5.3	42.0	5.9	48	6.5	7	7.2	25	25
15	....	....	25.0	3.9	27.0	4.5	35.0	5.2	43.0	5.9	49.0	6.6	54	7.3	8	7.1	26	23
16	....	....	27.0	4.3	30.0	4.9	40.0	5.6	49.0	6.5	56.0	7.5	62	8.5	8	7.0	28	21
17	....	....	....	....	34.0	5.4	45.0	6.3	55.0	7.3	63.0	8.5	70	9.7	9	6.9	14	14
18	....	....	....	....	37.0	5.9	51.0	7.0	62.0	8.3	71.0	9.6	78	11.0	9	6.8	14	10
19	....	....	....	....	....	....	56.0	8.1	69.0	9.6	79.0	11.1	87	12.6	10	6.7	9	6
20	....	....	....	....	....	....	62.0	9.5	76.0	11.2	87.0	13.0	96	14.8	10	6.6	6	5
21	....	....	....	....	....	....	69.0	11.6	84.0	13.5	96.0	15.4	105	17.3	11	6.5	7	8
22	....	....	....	....	....	....	75.0	14.8	92.0	16.6	104.0	18.3	115	20.0	12	6.4	8	4
23	....	....	....	....	....	....	81.0	18.1	100.0	20.0	113.0	21.7	125	23.0	12	6.3	4	1
24	....	....	....	....	....	....	....	....	....	....	123.0	25.0	135	27.0	13	6.2	3	....
25	....	....	....	....	....	....	....	....	....	....	132.0	29.0	145	31.0	14	6.1	1	....
26	....	....	....	....	....	....	....	....	....	....	142.0	33.0	156	35.0	15	6.0	....	....
																	286	239

[1] Wexford County.
[2] The "log" volume is the solid contents of wood and bark between a stump height of 1 foot and the "diameter inside bark of top" shown in the sixteenth column. The volume of "top" is that contained in the stem above this point, and in addition all branches suitable for cordwood, having a diameter, outside bark, of 2 inches or more at the middle of a 5-foot stick. The entire volume of trees too small to yield a 6-inch log is considered topwood.

TABLE 33.—*Beech in Pennsylvania,*[1] *volumes in cubic feet.*

Diameter, breast-high.	Total height of tree—feet.					Volume of top wood.	Diameter, inside bark of top.	Basis.
	70	80	90	100	110			
	Volume [2] of logs including bark—cubic feet.							
Inches.						*Cu. ft.*	*Inches.*	*Trees.*
8	8.8	10.1	11.3	....	....	2.8	6	2
9	11.4	13.0	14.6	....	....	3.3	6	6
10	14.3	16.4	18.4	20	....	4.1	6	8
11	17.7	20.0	23.0	25	....	5.0	7	6
12	21.0	24.0	28.0	31	34	5.9	7	6
13	26.0	29.0	33.0	37	40	7.1	7	8
14	30.0	34.0	39.0	43	47	8.8	8	11
15	35.0	40.0	45.0	50	55	10.9	8	5
16	....	46.0	52.0	57	63	13.4	9	13
17	....	52.0	58.0	65	71	16.4	9	10
18	....	58.0	65.0	72	80	19.8	10	10
19	....	64.0	72.0	80	88	23.5	11	11
20	....	70.0	79.0	88	96	27.3	11	5
21	....	....	86.0	95	105	31.1	12	6
22	....	....	92.0	103	113	35.0	13	2
23	....	....	99.0	110	122	39.0	14	5
24	....	....	106.0	118	130	43.0	15	2
25	....	....	113.0	125	138	47.0	16	1
26	....	....	....	133	146	51.0	17	1
27	....	....	....	141	155	55.0	18	....
28	....	....	....	149	164	59.0	19	....
29	....	....	....	157	173	63.0	20	1
30	....	....	....	164	181	68.0	21	1
								120

[1] McKean County.
[2] The "log" volume is the solid contents of wood and bark between an average stump height of 2.4 feet and the "diameter inside bark of top" shown in the eighth column. The volume of "top" is that contained in the stem above this point, and in addition all branches suitable for cordwood having a diameter, outside bark, of 2 inches or more at the middle of a 50-inch stick.

TABLE 34.—*Sugar maple in Pennsylvania,*[1] *volumes in cubic feet.*

Diameter, breast-high.	Total height of tree—feet.					Volume of top wood.	Diameter, inside bark of top.	Basis.
	70	80	90	100	110			
	Volume[2] of logs including bark—cubic feet.							
Inches.						*Cu. ft.*	*Inches.*	*Trees.*
10	13.6	15.6	17.5	19.5	....	5.3	6	4
11	16.7	19.1	21.0	24.0	....	5.4	7	3
12	20.0	23.0	26.0	29.0	32	5.5	7	2
13	24.0	27.0	31.0	34.0	37	6.1	8	2
14	28.0	32.0	36.0	40.0	44	7.2	8	2
15	32.0	37.0	42.0	46.0	51	9.0	8	2
16	....	43.0	48.0	53.0	59	11.8	9	4
17	....	49.0	55.0	61.0	67	15.5	10	7
18	....	55.0	62.0	69.0	76	20.0	10	5
19	....	62.0	70.0	78.0	85	24.7	11	1
20	....	69.0	78.0	87.0	95	29.0	11	3
21	....	....	89.0	96.0	106	32.4	12	2
22	....	....	96.0	106.0	117	35.3	13	....
23	....	....	104.0	116.0	128	37.6	13	....
24	....	....	113.0	126.0	139	39.6	14	1
25	....	....	122.0	136.0	149	41.1	15	....
26	....	....	....	145.0	160	42.5	15	....
27	....	....	....	155.0	171	43.9	16	2
28	....	....	....	164.0	181	45.1	16	1
								41

[1] McKean County.

[2] The "log" volume is the solid contents of wood and bark between an average stump height of 2.4 feet and the "diameter inside bark of top" shown in the eighth column. The volume of "top" is that contained in the stem above this point, and in addition all branches suitable for cordwood, having a diameter, outside bark, of 2 inches or more at the middle of a 50-inch stick.

TABLE 35.—*Sugar maple in the Lake States,*[1] *volumes in cubic feet.*

Diameter, breast-high.	Total height of tree—feet.												Diameter inside bark of top.	Basis, trees.	
	50		60		70		80		90		100				
	Volume[2] including bark—cubic feet.														
	Logs.	Top.	Logs.	Top.	Logs.	Top.	Logs.	Top.	Logs.	Top.	Logs.	Top.		Logs.	Top.
Inches.													*Inches.*		
6	0.6	1.8	0.7	2.2	0.8	2.6	1.0	3.0	......	......	......	......	......	9	10
7	3.4	1.9	4.2	2.3	5.0	2.7	5.7	3.2	......	......	......	......	......	18	17
8	6.5	2.0	7.4	2.5	8.4	2.9	9.4	3.3	......	......	......	......	6	21	22
9	9.8	2.2	10.4	2.7	11.6	3.0	13.1	3.5	......	......	......	......	6	35	34
10	13.1	2.4	13.8	2.9	15.2	3.3	17.2	3.7	19.4	4.2	......	......	6	23	24
11	16.7	2.6	17.4	3.1	19.3	3.5	22.0	4.0	25.0	4.5	......	......	6	26	26
12	21.0	2.8	21.0	3.4	24.0	3.8	27.0	4.4	30.0	4.9	34	5.4	7	25	25
13	......	......	26.0	3.7	28.0	4.2	32.0	4.8	36.0	5.4	41	6.0	7	20	20
14	......	......	30.0	4.1	33.0	4.8	37.0	5.4	42.0	6.0	48	6.7	7	22	22
15	......	......	35.0	4.7	38.0	5.4	43.0	6.1	49.0	6.8	55	7.5	8	16	16
16	......	......	40.0	5.4	43.0	6.3	50.0	7.0	56.0	7.8	64	8.5	8	22	22
17	......	......	......	......	49.0	7.2	56.0	8.0	64.0	8.9	72	9.6	9	7	7
18	......	......	......	......	54.0	8.4	63.0	9.4	72.0	10.2	81	11.0	9	13	13
19	......	......	......	......	60.0	9.8	70.0	11.0	80.0	11.8	89	12.6	10	6	5
20	......	......	......	......	66.0	11.5	77.0	12.7	88.0	13.5	99	14.4	10	9	8
21	......	......	......	......	72.0	13.4	85.0	14.6	97.0	15.5	108	16.5	11	7	6
22	......	......	......	......	79.0	15.6	92.0	16.9	105.0	17.8	118	19.0	12	7	7
23	......	......	......	......	85.0	18.3	100.0	20.0	114.0	21.0	128	22.0	12	6	6
24	......	......	......	......	92.0	21.0	108.0	23.0	124.0	25.0	138	26.0	13	2	2
25	......	......	......	......	......	......	116.0	27.0	133.0	30.0	149	32.0	14	6	6
26	......	......	......	......	......	......	125.0	33.0	142.0	36.0	160	40.0	15	1	1
27	......	......	......	......	......	......	134.0	38.0	152.0	42.0	171	47.0	15	2	......
28	......	......	......	......	......	......	142.0	44.0	163.0	48.0	182	54.0	16	......	......
29	......	......	......	......	......	......	152.0	50.0	173.0	55.0	194	61.0	17	......	......
30	......	......	......	......	......	......	161.0	55.0	184.0	61.0	206	68.0	17	2	......
														305	299

[1] Gogebic and Wexford Counties, Mich.; Marinette and Vilas Counties, Wis.

[2] The "log" volume is the solid contents of wood and bark between a stump height of 1 foot and the "diameter inside bark of top" shown in the fourteenth column. The volume of "top" is that contained in the stem above this point, and in addition all branches suitable for cordwood having a diameter, outside bark, of 2 inches or more at the middle of a 5-foot stick. The entire volume of trees too small to yield a 6-inch log is considered topwood.

Bark comprises about 17 per cent of the total volume; there was no consistent variation with the size of the tree.

TABLE 36.—*Basswood in the Lake States,*[1] *volumes in cubic feet.*

Diameter, breast-high.	Total height of tree—feet. Volume [2] of logs including bark—cubic feet. 40	50	60	70	80	90	100	110	120	Volume of topwood.	Diameter inside bark of top.	Per cent of bark.	Basis, trees. Logs.	Top.
Inches.										*Cu. ft.*	*Inches.*			
8	3.9	5.4	7.0	8.3	9.3	.....	.....	.....	.....	2.2	6	22.1	6	6
9	5.7	8.1	10.3	12.3	13.9	.....	.....	.....	.....	2.4	6	21.7	9	7
10	7.8	10.7	13.5	16.1	18.2	19.8	.....	.....	.....	2.6	6	21.2	7	6
11	.....	13.5	17.1	20.0	23.0	25.0	.....	.....	.....	2.8	6	20.8	8	7
12	.....	16.6	21.0	25.0	28.0	30.0	33	.....	.....	3.2	7	20.5	7	5
13	.....	.....	25.0	30.0	33.0	36.0	39	.....	.....	3.7	7	20.1	9	10
14	.....	.....	30.0	35.0	39.0	43.0	46	49	.....	4.3	7	19.7	7	6
15	.....	.....	34.0	41.0	46.0	49.0	53	56	.....	5.2	8	19.4	17	16
16	.....	.....	40.0	47.0	52.0	56.0	60	64	68	6.2	8	19.1	17	15
17	.....	.....	.....	.....	58.0	63.0	68	72	76	7.5	9	18.8	20	18
18	.....	.....	.....	.....	65.0	70.0	75	80	85	9.0	9	18.6	18	13
19	.....	.....	.....	.....	72.0	78.0	83	89	94	10.9	10	18.3	14	15
20	.....	.....	.....	.....	79.0	85.0	91	97	103	13.1	10	18.0	31	28
21	.....	.....	.....	.....	86.0	92.0	99	106	112	15.6	11	17.8	21	20
22	.....	.....	.....	.....	93.0	100.0	107	114	121	18.6	12	17.5	14	12
23	.....	.....	.....	.....	101.0	108.0	115	122	131	22.0	12	17.3	17	17
24	.....	.....	.....	.....	109.0	116.0	123	131	140	26.0	13	17.1	19	17
25	.....	.....	.....	.....	116.0	124.0	132	140	150	30.0	14	16.9	14	12
26	.....	.....	.....	.....	124.0	132.0	140	149	159	34.0	15	16.7	17	15
27	.....	.....	.....	.....	132.0	140.0	149	159	169	39.0	15	16.5	8	10
28	.....	.....	.....	.....	140.0	149.0	158	168	180	45.0	16	16.3	9	9
29	.....	.....	.....	.....	148.0	158.0	170	179	191	52.0	17	16.1	6	6
30	.....	.....	.....	.....	156.0	167.0	177	189	202	59.0	17	15.9	4	4
31	.....	.....	.....	.....	.....	176.0	187	199	214	67.0	18	15.7	8	8
32	.....	.....	.....	.....	.....	185.0	197	211	226	77.0	18	15.5	3	1
33	.....	.....	.....	.....	.....	195.0	208	222	238	88.0	19	15.4	3	3
34	.....	.....	.....	.....	.....	205.0	219	234	251	98.0	20	15.2	4	4
35	.....	.....	.....	.....	.....	215.0	230	247	265	109.0	20	15.1	1	1
36	.....	.....	.....	.....	.....	.....	242	260	279	121.0	21	14.9	.....	.....
37	.....	.....	.....	.....	.....	.....	255	274	293	131.0	22	14.7	1	.....
38	.....	.....	.....	.....	.....	.....	268	288	308	142.0	22	14.6	.....	.....
39	.....	.....	.....	.....	.....	.....	280	302	323	153.0	23	14.4	.....	.....
40	.....	.....	.....	.....	.....	.....	294	317	338	163.0	24	14.3	.....	.....
													319	291

[1] Charlevoix and Kalkaska Counties, Mich., Iron and Price Counties, Wis.

[2] The "log" volume is the solid contents of wood and bark between a stump height of 1 foot and the "diameter inside bark of top" shown in the twelfth column. The volume of "top" is that contained in the stem above this point, and in addition all branches suitable for cordwood having a diameter, outside bark, of 4 inches or more at the middle of a 5-foot stick.

TABLE 37.—*Volume of red maple in cubic feet,*[1] *Harvard Forest, Petersham, Mass., 1910–11.*

[Revised and enlarged in 1915.]

Diameter, breast-high.	Total height of tree—feet. Merchantable volume, including bark—cubic feet. 20	30	40	50	60	70	80	Basis.
Inches.								*Trees.*
2	0.25	0.35	0.55	.....	.....	.....	.....	59
3	.60	.71	1.00	1.2	.....	.....	.....	51
4	1.00	1.30	1.65	2.0	.....	.....	.....	36
5	.....	2.15	2.40	3.0	3.6	.....	.....	38
6	.....	.....	3.45	4.3	5.2	6.2	.....	42
7	.....	.....	4.70	5.9	7.1	8.4	.....	25
8	.....	.....	6.05	7.8	9.4	10.8	11.8	39
9	.....	.....	7.65	10.1	12.0	13.5	14.8	28
10	.....	.....	.....	12.7	15.0	16.7	18.2	20
11	.....	.....	.....	15.6	18.5	20.5	22.0	23
12	.....	.....	.....	18.9	22.5	24.8	26.4	10
13	.....	.....	.....	22.6	26.8	29.7	31.4	9
14	.....	.....	.....	26.8	31.6	35.0	36.7	8
15	.....	.....	.....	31.5	37.0	40.7	42.7	3
16	.....	.....	.....	36.6	43.2	47.0	49.7	4
17	.....	.....	.....	.....	.....	.....	58.4	2
								397

[1] See "A Volume Table for Red Maple on the Harvard Forest," by E. E. Carter; Bulletin of the Harvard Forestry Club, Vol. II, 1913, pp. 1–8.

The volumes are for stem and branch wood to a minimum diameter, outside bark, of about 2 inches at the middle of a 4-foot length. The measurements were taken in a wide variety of types, including bottom or swale, pine slope, swamp, and birch and maple coppice. Most of the trees more than 6 inches in diameter breast-high were of seedling origin.

CORDWOOD VOLUMES.

So many factors affect the compactness of piled wood that it is impracticable to include volume tables showing the contents in stacked cords[1] of northern hardwood trees of different sizes. Experiments performed in the course of this study showed that the solid contents per cord varied a great deal more with the amount of branchwood and the straightness of the split and round bodywood sections than with the size of the trees alone. The solid contents per cord averaged about 71 cubic feet, but ranged from less than 60 cubic feet for large, spiral-grained, branchy trees, to over 90 cubic feet for small, well-formed trees with few branches.

For use in average old-growth stands of northern hardwoods the following converting factors will give fairly reliable results when applied to the cubic volumes in the preceding tables: 90 cubic feet per cord for tall, slender, straight trees with few large branches; 60 cubic feet per cord for large, spiral-grained, branchy trees; and 75 cubic feet per cord for trees which fall between these extremes. This is for the closeness of utilization described in the footnotes to Tables 31–37.

Cordwood cut from small trees is apt to lie straighter and pile more compactly than that from large timber. Consequently, cordwood tables are more practicable for small than for large trees. Table 38 gives cordwood volumes for red maple on the Harvard Forest, Petersham Mass.[2] They are based on the cubic-foot volumes for red maple given in Table 37 and on the same number of trees, except for those of the 2-inch class, omitted in these tables. Red maples of good height for their diameters should run about as follows:

Diameter, breast-high.	Number of trees per cord.	Diameter, breast-high.	Number of trees per cord.
Inches.		*Inches.*	
4	50	10	6
6	20	12	4
8	9	14	3

TABLE 38.—*Volume of red maple in standard cords of 128 cubic feet, Harvard Forest Petersham, Mass., 1910–11.*

[Revised and enlarged in 1915.]

Diameter, breast-high.	Total height of tree—feet.						
	20	30	40	50	60	70	80
	Merchantable volume—cords.						
Inches.							
3	0.009	0.011	0.015	0.018	....	....	....
4	.015	.019	.024	.029	....	....	....
5	....	.031	.034	.043	0.051	....	....
6	....	....	.048	.060	.072	0.081	....
7	....	....	.063	.079	.095	.113	....
8	....	....	.078	.101	.122	.140	0.153
9	....	....	.095	.125	.149	.168	.184
10	....	....	....	.151	.179	.199	.217
11	....	....	....	.179	.212	.235	.252
12	....	....	....	.210	.251	.276	.294
13	....	....	....	.246	.292	.324	.343
14	....	....	....	.286	.338	.374	.392
15	....	....	....	.332	.390	.430	.450
16	....	....	....	.383	.451	.491	.565
17	....	....	....	....	....	....	.607

[1] A standard cord is a pile 8 feet long by 4 feet high and 4 feet broad. Contractors usually require about 3 inches additional height to allow for settling. Where wood is intended for distillation a length of 50 inches is commonly specified. This influences the converting factor but little, compared with the other variables.

[2] See "A volume Table for Red Maple on the Harvard Forest," by E. E. Carter; Bulletin of the Harvard Forestry Club, Vol. II, 1913, pp. 1–8.

TABLE 39.—*Per cent of wood in piles of red maple cordwood, based on 9 piles of from 2 to 4 cord feet each, Harvard Forest, Petersham, Mass., 1910–11.*

Diameter, breast-high of trees cut and piled.	Per cent of wood in piles.	Diameter, breast-high of trees cut and piled.	Per cent of wood in piles.	Diameter, breast-high of trees cut and piled.	Per cent of wood in piles.	Diameter, breast-high of trees cut and piled.	Per cent of wood in piles.
Inches.		*Inches.*		*Inches.*		*Inches.*	
3	52.5	7	58.0	11	68.0	15	74.0
4	53.6	8	60.2	12	70.0	16	74.6
5	54.9	9	62.8	13	71.5	17	75.0
6	56.2	10	65.5	14	73.0		

GRADED LOG SCALE TABLES.

Tables 40, 41, 42, are taken, with slight modification in arrangement, from "Graded volume tables for Vermont hardwoods," by Irving W. Bailey and Philip C. Heald, Forestry Quarterly, Volume XII, No. 1, pages 5–23. These give the contents in graded lumber of a large number of logs of yellow birch, hard maple, and beech, from hardwood stands on lower slopes and foothills of the Green Mountains in southern Vermont. The logs were run through a single-action band saw cutting a one-eighth inch kerf, and the lumber from each was graded according to the grading rules of the Northern Hardwood Lumber Association, the results being averaged by a curve. The lumber was mostly 1 inch stock, sawed 1⅛ inches thick to allow for shrinkage. The mill crew were men of average skill, experienced in hardwood mills in other regions.

The merchantable length of the trees was seldom over 32 feet; practically no logs were taken above the first branches. The percentage of 1, 2, and 3 log trees was as follows:

	Birch.	Maple.	Beech.
1-log trees	23	22	37
2-log trees	62	60	58
3-log trees	15	18	5

Nearly one-half of the logs cut were defective or abnormal in some particular.[1] The following defects were noted in regard to their influence in decreasing the volumes of the logs: Butt defects, top defects, crook, sweep, knots, seams, shake, miscellaneous. For yellow birch a comparison was made of the contents of nondefective butt logs, nondefective top logs, and the average of all logs. This showed that the difference in volume due both to defect and position in the tree was negligible for logs under 12 inches in diameter at the small end, while for logs 12 inches and over in diameter it amounted to about 9 per cent of the volume of the sound butt logs. It was less than 6 per cent for logs from 12 to 16 inches in diameter, and a little less than 11 per cent for 21 to 24 inch logs. The difference due to position in the tree between sound normal top and butt logs varied from about 3 per cent of the volume of the 12 to 16 inch butt logs to about 10 per cent of the 21 to 24 inch butt logs.

In the table for yellow birch it will be noted that the 10-foot logs show a greater proportion of the poorer grades than do the longer logs. This is particularly noticeable in the No. 1 common red and the No. 2 common grades, and is due especially to the fact that the majority of the 10-foot logs were top logs and hence knotty and of inferior quality.

While they can be applied with substantial accuracy only to conditions similar to those under which they were made, these tables may perhaps be used in other regions

[1] The percentages of defective logs were: Birch 43 per cent, maple 45 per cent, beech 51 per cent.

by carefully studying and comparing defects, methods of utilization, etc., and applying suitable converting factors. With these precautions graded volume tables can be constructed by combining the graded log tables here given with Tables 43, 44, and 55, which show the average taper of trees measured in the Lake States.

For graded volume tables actually constructed from these tables and for additional information relative to the latter the reader is referred to the article by Messrs. Bailey and Heald.

TABLE 40.—*Yellow birch log scale,*[1] *Windham County, Vt.*

Diameter at small end.	10-foot logs. Grade of lumber.							Diameter at small end.	14-foot logs. Grade of lumber.						
	1sts and 2ds red.	1 C. red.	1sts and 2ds.	1 C.	2 C.	3 C.	Total.		1sts and 2ds red.	1 C. red.	1sts and 2ds.	1 C.	2 C.	3 C.	Total.
	Volume—board feet.								Volume—board feet.						
Inches.								*Inches.*							
7	....	....	....	....	10	10	20	7	......	....	......	5	15	10	30
8	....	....	....	....	10	10	20	8	......	....	......	10	15	15	40
9	....	....	....	....	15	15	30	9	......	....	......	10	15	15	40
10	....	....	....	10	15	15	40	10	......	....	5	15	15	15	50
11	....	....	5	10	20	15	50	11	......	....	10	20	20	20	70
12	....	....	5	15	20	20	60	12	......	5	10	25	20	20	80
13	....	....	10	20	20	20	70	13	5	5	20	25	20	25	100
14	....	5	10	20	20	25	80	14	10	5	25	25	20	25	110
15	5	5	15	20	20	25	90	15	15	5	35	30	20	25	130
16	10	10	20	25	20	25	110	16	15	10	40	35	20	30	150
17	10	15	20	30	20	25	120	17	20	15	50	35	20	30	170
18	15	15	25	30	20	25	130	18	35	15	55	35	20	30	190
19	25	20	30	30	20	25	150	19	45	20	70	35	20	30	220
20	30	20	30	30	20	30	160	20	60	20	75	35	20	30	240
21	35	25	35	30	25	30	180	21	75	25	80	35	25	30	270
22	45	30	40	30	25	30	200	22	90	25	90	30	25	30	290
23	60	30	45	30	25	30	220	23	105	25	95	40	25	30	320
24	70	30	55	35	25	35	250	24	120	25	95	40	25	35	340

	12-foot logs.								16-foot logs.						
7	....	....	....	....	10	10	20	7	......	....	......	5	15	10	30
8	....	....	....	5	10	15	30	8	......	....	......	10	15	15	40
9	....	....	....	10	15	15	40	9	......	....	......	15	20	15	50
10	....	....	5	15	15	15	50	10	......	....	5	15	20	20	60
11	....	....	5	20	15	20	60	11	......	....	10	20	20	20	70
12	....	5	10	20	15	20	70	12	5	5	15	25	20	20	90
13	5	5	15	20	15	20	80	13	5	5	20	30	25	25	110
14	5	5	20	25	15	30	100	14	10	5	35	30	25	25	130
15	10	5	25	25	15	30	110	15	15	10	45	30	25	25	150
16	15	10	30	30	15	30	130	16	25	10	55	35	25	30	180
17	25	10	40	30	15	30	150	17	30	15	60	40	25	30	200
18	30	15	45	30	20	30	170	18	40	15	70	40	25	30	220
19	40	15	50	30	15	30	180	19	55	20	80	40	25	30	250
20	50	15	55	30	20	30	200	20	70	25	90	40	25	30	280
21	60	20	60	30	20	30	220	21	90	25	100	40	25	30	310
22	70	25	65	35	20	35	250	22	110	25	110	40	25	30	340
23	85	30	70	30	20	35	270	23	130	25	115	40	25	35	370
24	90	30	70	35	25	40	290	24	145	25	120	40	25	35	390

Based on mill tally of lumber from 1,530 logs.

TABLE 41.—*Beech log scale,*[1] *Windham County. Vt.*

CURVED.

Diameter at small end.	10-foot logs. Grade of lumber. 1sts and 2ds.	1 C.	2 C.	3 C.	Total.	Diameter at small end.	14-foot logs. Grade of lumber. 1sts and 2ds.	1 C.	2 C.	3 C.	Total.
	Volume—board feet.						Volume—board feet.				
Inches.						*Inches.*					
8	......	......	5	25	30	8	......	......	5	25	30
9	......	......	10	20	30	9	......	5	10	25	40
10	......	10	10	20	40	10	......	10	10	30	50
11	......	10	15	25	50	11	......	20	15	35	70
12	......	15	15	30	60	12	5	20	15	40	80
13	5	20	15	30	70	13	15	25	20	40	100
14	10	25	15	30	80	14	20	30	20	40	110
15	15	25	15	35	90	15	25	35	20	50	130
16	20	30	20	40	110	16	35	40	25	50	150
17	30	35	20	45	130	17	45	45	25	55	170
	12-foot logs.						16-foot logs.				
8	......	......	5	25	30	8	......	......	10	30	40
9	......	5	10	25	40	9	......	10	10	30	50
10	......	10	10	30	50	10	......	10	15	35	60
11	......	15	15	30	60	11	......	20	20	40	80
12	5	15	15	35	70	12	5	25	20	40	90
13	10	20	15	35	80	13	15	30	20	45	110
14	15	25	15	35	90	14	20	35	25	50	130
15	20	30	20	40	110	15	30	40	25	55	150
16	30	35	20	45	130	16	40	45	25	60	170
17	40	40	20	50	150	17	55	55	25	65	200

[1] Based on mill tally of lumber from 631 logs.

TABLE 42.—*Sugar maple log scale,*[1] *Windham County, Vt.*

CURVED.

Diameter at small end.	10-foot logs. Grade of lumber. 1sts and 2ds.	1 C.	2 C.	3 C.	Total.	Diameter at small end.	14-foot logs. Grade of lumber. 1sts and 2ds.	1 C.	2 C.	3 C.	Total.
	Volume—board feet.						Volume—board feet.				
Inches.						*Inches.*					
7	......	......	5	15	20	7	......	......	10	20	30
8	......	......	10	20	30	8	......	5	10	25	40
9	......	......	10	20	30	9	......	10	10	20	40
10	......	10	10	20	40	10	......	15	10	25	50
11	5	15	10	20	50	11	5	20	10	25	60
12	5	20	15	20	60	12	10	25	15	30	80
13	10	25	10	25	70	13	15	30	15	30	90
14	15	25	15	25	80	14	25	35	20	30	110
15	25	30	15	30	100	15	35	40	20	35	130
16	35	30	15	30	110	16	50	40	20	40	150
17	50	30	15	35	130	17	60	40	20	40	160
18	60	30	15	35	140	18	80	40	20	40	180
19	75	35	15	35	160	19	100	45	20	45	210
20	90	40	15	35	180	20	120	45	20	45	230
	12-foot logs.						16-foot logs.				
7	......	......	5	15	20	7	......	......	10	20	30
8	......	5	5	20	30	8	......	5	10	25	40
9	......	10	10	20	40	9	......	10	15	25	50
10	......	10	10	20	40	10	......	15	15	30	60
11	5	15	10	20	50	11	5	20	15	30	70
12	10	20	15	25	70	12	10	30	20	30	90
13	15	25	15	25	80	13	20	35	20	35	110
14	20	30	15	25	90	14	30	40	20	40	130
15	30	35	15	30	110	15	45	45	20	40	150
16	45	35	15	35	130	16	60	45	20	45	170
17	60	35	15	40	150	17	75	50	20	45	190
18	70	35	15	40	160	18	90	50	25	45	210
19	85	40	15	40	180	19	100	50	25	45	230
20	100	40	20	40	200	20	140	55	25	50	270

[1] Based on mill tally of lumber from 943 logs.

FORM TABLES.

The following tables give diameters inside bark at different heights for average birch, beech, maple, and basswood trees in Michigan and Wisconsin. Above breast-height, the distance from the ground are in units of 8.15 feet above a 1-foot stump. These units represent the half of a 16.3-foot log. The practical use of these tables is to permit scaling trees of given size in terms of any desired log rule, but they also serve as a basis for comparing the species with regard to form. (See similar tables in Bulletin 152, "The Eastern Hemlock.")

TABLE 43.—*Form of yellow birch in the Lake States.*[1]

Diameter, breast-high.	Height above ground—feet.											Basis.
	1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	49.9	58.05	
	Diameter inside bark—inches.											
50-FOOT TREES.												
Inches.												*Trees.*
4	4.5	4.1	3.9	3.8	3.4	3.0	2.4	......	......	......	......	....
5	5.8	5.2	4.9	4.7	4.3	3.7	3.1	......	......	......	......	5
6	7.1	6.3	6.0	5.7	5.2	4.7	3.9	......	......	......	......	1
7	8.6	7.5	7.0	6.7	6.1	5.5	4.7	......	......	......	......	2
8	10.1	8.7	8.1	7.6	6.9	6.3	5.5	......	......	......	......	1
9	11.7	9.9	9.1	8.6	7.9	7.2	6.2	......	......	......	......	2
10	13.4	11.1	10.0	9.6	8.7	8.0	7.0	......	......	......	......	....
												11
60-FOOT TREES.												
4	4.8	4.2	3.9	3.6	3.1	2.7	2.4	1.9	1.3	......	......	....
5	6.1	5.3	4.9	4.6	4.2	3.7	3.3	2.6	1.9	......	......	1
6	7.4	6.5	5.9	5.6	5.1	4.6	4.0	3.3	2.3	......	......	2
7	8.8	7.6	6.9	6.6	6.1	5.5	4.8	4.0	2.9	......	......	6
8	10.2	8.7	7.9	7.6	6.9	6.3	5.5	4.6	3.3	......	......	7
9	11.7	9.8	9.0	8.6	7.9	7.2	6.3	5.3	3.9	......	......	6
10	13.0	10.9	9.9	9.5	8.7	7.9	7.0	5.9	4.3	......	......	9
11	14.4	12.0	11.0	10.5	9.5	8.7	7.7	6.5	4.9	......	......	5
12	15.8	13.0	11.9	11.3	10.3	9.3	8.3	7.0	5.3	......	......	3
13	17.2	14.1	12.9	12.3	11.1	10.0	9.0	7.6	5.9	......	......	....
14	18.6	15.3	13.9	13.2	11.8	10.7	9.6	8.2	6.3	......	......	1
												40
70-FOOT TREES.												
6	7.8	6.5	5.9	5.6	5.2	4.8	4.3	3.5	2.7	1.9	1.1	1
7	9.1	7.5	7.0	6.6	6.0	5.5	5.0	4.2	3.3	2.4	1.5	4
8	10.3	8.6	8.0	7.5	7.0	6.3	5.7	4.9	4.0	2.9	1.8	3
9	11.6	9.7	8.9	8.5	7.7	7.1	6.5	5.7	4.6	3.4	2.1	8
10	12.9	10.8	10.0	9.5	8.7	7.9	7.1	6.1	5.2	4.0	2.5	15
11	14.2	11.8	11.0	10.4	9.5	8.7	7.9	7.0	5.9	4.5	2.7	9
12	15.5	12.9	11.9	11.4	10.4	9.5	8.7	7.7	6.5	5.0	3.0	15
13	16.8	14.1	13.1	12.3	11.3	10.3	9.5	8.5	7.2	5.5	3.4	11
14	18.1	15.1	14.0	13.3	12.1	11.1	10.2	9.2	7.9	6.1	3.9	5
15	19.5	16.3	15.1	14.1	13.0	11.8	10.9	9.9	8.5	6.7	4.2	2
16	20.9	17.4	16.1	15.1	13.9	12.6	11.7	10.6	9.2	7.3	4.6	5
17	22.3	18.5	17.1	16.0	14.7	13.4	12.3	11.3	9.9	7.8	4.8	2
18	23.7	19.7	18.0	16.9	15.6	14.3	13.2	12.0	10.5	8.4	5.3	3
19	25.2	20.7	18.9	17.8	16.3	14.9	13.8	12.6	11.2	8.9	5.6	2
20	26.7	21.9	20.0	18.7	17.2	15.7	14.5	13.3	11.8	9.5	6.1	1
21	28.1	23.0	20.9	19.6	18.0	16.3	15.1	13.9	12.5	10.1	6.5	1
22	29.8	24.2	21.8	20.6	18.8	17.1	15.7	14.7	13.1	10.7	6.9	1
23	31.2	25.3	22.8	21.5	19.7	17.8	16.5	15.3	13.8	11.3	7.3	....
24	32.9	26.5	23.7	22.4	20.5	18.5	17.2	16.0	14.5	11.9	7.8	1
25	34.3	27.6	24.7	23.1	21.3	19.3	17.8	16.5	15.1	12.5	8.3	1
26	36.2	29.1	25.9	24.0	22.3	20.2	18.5	17.5	15.9	13.1	8.8	....
												90

[1] Gogebic and Wexford Counties, Mich.; Marinette and Vilas Counties, Wis.

TABLE 43.—*Form of yellow birch in the Lake States*—Continued.

80-FOOT TREES.

Diameter, breast-high.	Height above ground—feet.													Basis.
	1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	49.9	58.05	66.2	74.35	
	Diameter inside bark—inches.													
Inches.														*Trees.*
8	10.3	8.7	8.0	7.6	7.1	6.5	6.1	5.4	4.7	3.7	2.7	1.7	......	......
9	11.7	9.7	9.1	8.6	8.0	7.3	6.9	6.3	5.4	4.3	3.1	2.0	......	1
10	12.9	10.8	10.0	9.5	8.9	8.2	7.6	6.9	6.0	4.8	3.6	2.3	......	2
11	14.3	11.9	11.0	10.4	9.7	8.9	8.3	7.7	6.8	5.4	4.0	2.5	......	3
12	15.6	13.1	12.1	11.3	10.5	9.6	9.1	8.4	7.4	6.0	4.5	2.8	......	9
13	17.0	14.1	13.0	12.3	11.4	10.3	9.7	9.1	8.1	6.6	4.9	3.1	......	9
14	18.4	15.3	14.0	13.2	12.2	11.1	10.4	9.7	8.7	7.3	5.4	3.5	......	10
15	19.7	16.3	15.1	14.1	13.1	11.8	11.2	10.5	9.4	7.9	5.9	3.7	......	6
16	21.1	17.5	16.1	15.1	13.9	12.7	11.9	11.1	10.1	8.4	6.3	4.0	......	11
17	22.5	18.6	17.1	16.0	14.8	13.4	12.6	11.8	10.7	8.9	6.8	4.4	......	413
18	24.0	19.8	18.1	16.9	15.6	14.2	13.3	12.5	11.3	9.6	7.3	4.7	......	12
19	25.4	20.9	19.1	17.8	16.4	14.9	13.9	13.1	11.9	10.1	7.8	5.0	......	9
20	27.0	22.2	20.2	18.8	17.3	15.6	14.7	13.7	12.5	10.7	8.3	5.4	......	5
21	28.5	23.4	21.2	19.7	18.1	16.4	15.3	14.3	13.1	11.3	8.7	5.6	......	2
22	30.2	24.6	22.2	20.6	19.1	17.2	16.0	14.9	13.7	11.8	9.2	6.0	......	1
23	31.8	26.0	23.2	21.5	19.7	17.8	16.6	15.5	14.2	12.3	9.7	6.4	......	2
24	33.5	27.4	24.1	22.4	20.5	18.5	17.3	16.1	14.7	12.9	10.2	6.8	......	1
25	35.3	28.9	25.3	23.3	21.3	19.3	18.0	16.8	15.3	13.4	10.6	7.0	......	2
26	37.0	30.3	26.3	24.2	22.1	20.0	18.7	17.4	15.9	13.8	11.0	7.3	......	1
27	38.7	31.8	27.3	25.1	23.0	20.8	19.3	17.9	16.4	14.3	11.4	7.6	......	......
28	40.5	33.4	28.3	26.0	23.7	21.5	20.0	18.5	17.0	14.8	11.8	7.9	......	......
29	......	34.9	29.3	26.9	24.6	22.3	20.7	19.1	17.5	15.4	12.3	8.1	......	1
30	......	36.6	30.3	27.8	25.3	23.0	21.3	19.7	18.0	15.9	12.7	8.5	......	......
														100

90-FOOT TREES.

Diameter, breast-high.	1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	49.9	58.05	66.2	74.35	Basis.
16	20.6	17.7	16.4	15.1	13.9	12.9	12.1	11.3	10.3	9.3	7.9	6.3	4.3	......
17	22.3	18.9	17.4	16.1	14.7	13.5	12.7	11.9	11.0	9.8	8.4	6.6	4.5	......
18	24.0	20.0	18.4	16.9	15.6	14.3	13.4	12.5	11.6	10.4	8.9	7.1	4.8	......
19	25.6	21.3	19.4	17.9	16.3	15.0	14.1	13.2	12.2	11.0	9.4	7.5	5.1	2
20	27.3	22.6	20.5	18.8	17.2	15.7	14.7	13.8	12.8	11.5	9.9	7.8	5.3	3
21	29.0	24.0	21.5	19.8	18.1	16.5	15.5	14.6	13.5	12.1	10.4	8.1	5.5	3
22	30.6	25.3	22.6	20.7	18.9	17.2	16.1	15.2	14.1	12.7	10.9	8.5	5.7	1
23	32.5	26.7	23.6	21.7	19.7	17.9	16.8	15.9	14.8	13.3	11.3	8.9	6.0	3
24	34.2	28.1	24.7	22.7	20.6	18.7	17.5	16.5	15.4	13.9	11.8	9.3	6.3	2
25	36.0	29.6	25.6	23.6	21.4	19.5	18.2	17.2	16.1	14.5	12.3	9.6	6.5	1
26	37.6	31.0	26.6	24.5	22.2	20.3	18.9	17.9	16.8	15.1	12.9	10.1	6.8	1
27	39.6	32.6	27.7	25.5	23.2	21.1	19.6	18.6	17.4	15.7	13.3	10.5	7.1	......
28	41.7	34.2	28.8	26.5	24.0	21.9	20.4	19.3	18.1	16.2	13.8	10.9	7.3	1
29	......	35.9	29.9	27.5	24.9	22.7	21.1	19.9	18.8	16.9	14.3	11.2	7.6	1
30	......	37.5	30.9	28.6	25.8	23.5	21.8	20.7	19.5	17.5	14.9	11.7	7.9	......
														18

TABLE 44.—*Form of beech in Michigan.*[1]

Diameter, breast-high.	Height above ground—feet.									Basis.
	1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	
	Diameter inside bark—inches.									
40-FOOT TREES.										
Inches.										*Trees.*
2	2.5	2.2	2.1	1.9	1.7	1.3	......	......	......	....
3	3.5	3.2	3.1	2.8	2.5	2.0	......	......	......	3
4	4.6	4.1	4.0	3.8	3.4	2.7	......	......	......	3
5	5.7	5.1	4.9	4.7	4.2	3.4	......	......	......	2
6	6.8	6.1	5.8	5.6	5.1	4.2	......	......	......	....
7	7.9	7.1	6.8	6.5	5.9	4.9	......	......	......	....
8	9.0	8.0	7.7	7.4	6.8	5.7	......	......	......	....
										8
50-FOOT TREES.										
4	4.6	4.1	4.0	3.8	3.5	3.0	2.5	1.8	......	....
5	5.9	5.3	5.1	4.8	4.4	3.8	3.1	2.2	......	2
6	7.2	6.4	6.0	5.7	5.3	4.5	3.7	2.7	......	1
7	8.6	7.5	7.0	6.7	6.2	5.3	4.3	3.2	......	5
8	10.0	8.6	8.0	7.7	7.1	6.0	4.9	3.7	......	3
9	11.5	9.7	9.0	8.7	8.0	6.7	5.5	4.1	......	2
10	12.9	10.8	9.9	9.6	8.9	7.4	6.1	4.6	......	1
11	14.3	11.9	10.9	10.5	9.7	8.3	6.8	5.1	......	....
12	15.6	12.9	11.8	11.5	10.6	9.0	7.4	5.5	......	....
										14
60-FOOT TREES.										
4	5.5	4.5	4.2	3.8	3.7	3.3	2.8	2.3	1.7	....
5	6.6	5.6	5.2	4.8	4.6	4.1	3.6	3.0	2.3	....
6	7.7	6.6	6.1	5.7	5.5	4.8	4.3	3.6	2.8	1
7	8.8	7.6	7.1	6.7	6.3	5.6	4.9	4.2	3.2	8
8	10.0	8.6	8.1	7.7	7.1	6.3	5.7	4.8	3.7	12
9	11.2	9.7	9.1	8.6	7.9	7.0	6.3	5.4	4.1	4
10	12.4	10.7	10.0	9.8	8.7	7.7	7.0	5.9	4.5	5
11	13.6	11.8	11.0	10.6	9.4	8.4	7.6	6.4	4.9	3
12	14.9	12.9	12.1	11.5	10.2	9.0	8.2	6.9	5.3	2
13	16.2	13.9	13.0	12.5	11.0	9.7	8.7	7.3	5.6	....
14	17.5	15.0	14.1	13.5	11.7	10.3	9.2	7.7	6.0	....
15	18.6	16.2	15.1	14.4	12.5	10.9	9.8	8.2	6.3	....
16	20.1	17.3	16.1	15.4	13.2	11.5	10.3	8.6	6.5	....
17	21.5	18.4	17.2	16.4	14.0	12.1	10.8	9.0	6.9	....
18	22.9	19.5	18.2	17.3	14.7	12.7	11.3	9.5	7.2	1
										36

[1] Wexford County.

TABLE 44.—*Form of beech in Michigan*—Continued.

Diameter, breast-high.	Height above ground—feet.												Basis.
	1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	49.9	58.05	66.2	
	Diameter, inside bark—inches.												
70-FOOT TREES.													
Inches.													*Trees.*
6	7.7	7.0	6.5	6.0	5.7	5.3	5.1	4.6	3.5	2.0	0.9	......	....
7	8.9	7.9	7.4	6.9	6.4	6.1	5.8	5.2	4.0	2.5	1.2	......	1
8	10.1	8.9	8.3	7.8	7.2	6.7	6.3	5.7	4.5	3.0	1.6	......	2
9	11.3	9.8	9.2	8.7	8.0	7.4	7.0	6.3	5.1	3.6	1.9	......	5
10	12.6	10.9	10.2	9.7	8.8	8.0	7.7	6.9	5.7	4.1	2.2	......	9
11	13.9	11.9	11.2	10.6	9.6	8.8	8.2	7.4	6.3	4.7	2.7	......	10
12	15.3	13.0	12.2	11.6	10.4	9.5	8.9	8.0	6.8	5.3	3.2	......	8
13	16.7	14.0	13.2	12.6	11.3	10.2	9.5	8.6	7.4	5.9	3.6	......	6
14	18.2	15.1	14.2	13.5	12.1	11.0	10.2	9.1	7.9	6.4	4.0	......	6
15	19.6	16.2	15.2	14.4	13.0	11.7	10.9	9.7	8.5	6.8	4.4	......	6
16	21.1	17.3	16.2	15.4	13.8	12.5	11.5	10.3	9.0	7.3	4.8	......	3
17	22.6	18.4	17.2	16.4	14.7	13.3	12.2	11.0	9.6	7.8	5.2	......	2
18	24.1	19.6	18.3	17.4	15.5	14.0	12.9	11.6	10.1	8.3	5.5	......	2
19	25.6	20.8	19.3	18.4	16.5	14.9	13.5	12.2	10.6	8.7	5.8	......	1
20	27.2	22.0	20.4	19.4	17.3	15.6	14.3	12.7	11.1	9.2	6.1	......	....
													61
80-FOOT TREES.													
8	10.4	8.7	8.3	7.7	7.3	6.8	6.5	5.9	5.0	4.1	2.9	1.7	....
9	11.8	9.7	9.3	8.7	8.2	7.6	7.2	6.6	5.7	4.7	3.5	2.0	3
10	13.1	10.8	10.2	9.6	9.0	8.4	7.9	7.3	6.4	5.4	3.9	2.4	6
11	14.6	11.8	11.2	10.6	9.9	9.1	8.7	8.0	7.1	6.0	4.4	2.7	6
12	15.9	12.9	12.2	11.6	10.7	9.9	9.4	8.8	7.8	6.5	4.9	3.1	12
13	17.4	14.0	13.2	12.5	11.6	10.7	10.1	9.4	8.5	7.3	5.5	3.4	8
14	18.8	15.1	14.2	13.4	12.4	11.5	10.8	10.1	9.1	7.8	5.9	3.7	7
15	20.2	16.2	15.2	14.4	13.3	12.2	11.6	10.9	9.9	8.5	6.4	4.1	13
16	21.6	17.4	16.2	15.4	14.1	13.0	12.3	11.6	10.6	9.1	7.0	4.5	9
17	23.0	18.5	17.3	16.3	15.0	13.8	13.1	12.3	11.3	9.8	7.6	4.9	9
18	24.4	19.7	18.3	17.3	15.9	14.6	13.7	13.0	11.9	10.5	8.1	5.3	3
19	25.8	20.8	19.4	18.3	16.8	15.4	14.5	13.7	12.7	11.1	8.7	5.8	2
20	27.2	22.0	20.5	19.2	17.6	16.2	15.2	14.4	13.3	11.7	9.3	6.3	3
21	28.5	23.2	21.6	20.2	18.4	16.9	15.9	15.1	14.0	12.4	9.9	6.6	1
22	29.9	24.4	22.6	21.2	19.2	17.7	16.6	15.7	14.7	13.0	10.4	7.2	....
													82

TABLE 44.—*Form of beech in Michigan*—Continued.

Diameter, breast-high.	Height above ground—feet.														Basis.
	1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	49.9	58.05	66.2	74.35	82.5	
	Diameter inside bark—inches.														
90-FOOT TREES.															
Inches.															*Trees.*
8	12.1	8.7	8.3	7.8	7.4	7.0	6.6	6.2	5.6	4.7	3.8	2.5	1.5	.....	....
9	13.3	9.8	9.3	8.8	8.3	7.8	7.4	6.9	6.4	5.6	4.4	3.1	1.9	.....	....
10	14.5	10.8	10.3	9.7	9.2	8.6	8.1	7.6	7.1	6.3	5.0	3.6	2.3	.....	1
11	15.7	11.8	11.2	10.7	10.0	9.4	8.9	8.4	7.8	6.9	5.6	4.2	2.7	.....	4
12	16.9	13.0	12.3	11.6	10.9	10.2	9.6	9.1	8.5	7.5	6.2	4.7	3.2	.....	6
13	18.1	14.0	13.3	12.6	11.8	11.0	10.4	9.9	9.2	8.2	6.8	5.3	3.6	.....	7
14	19.4	15.2	14.3	13.5	12.6	11.8	11.1	10.6	9.9	8.8	7.4	5.9	4.1	.....	9
15	20.6	16.3	15.3	14.5	13.5	12.7	11.9	11.3	10.6	9.5	8.1	6.5	4.5	.....	8
16	21.9	17.3	16.3	15.4	14.4	13.4	12.7	12.0	11.3	10.1	8.7	7.0	5.0	.....	11
17	23.2	18.5	17.3	16.4	15.3	14.2	13.5	12.8	12.0	10.8	9.3	7.6	5.4	.....	8
18	24.5	19.6	18.4	17.3	16.2	15.0	14.2	13.6	12.7	11.4	10.0	8.2	5.9	.....	6
19	25.7	20.8	19.3	18.3	17.0	15.8	15.0	14.3	13.4	12.1	10.6	8.7	6.3	.....	7
20	26.9	21.9	20.3	19.3	17.9	16.6	15.7	15.0	14.1	12.8	11.2	9.3	6.7	.....	3
21	28.2	23.0	21.4	20.2	18.7	17.3	16.4	15.7	14.8	13.5	11.9	9.9	7.2	.....	3
22	29 5	24.1	22.3	21.2	19.6	18.2	17.1	16.4	15.5	14.1	12.5	10.4	7.6	.....	2
23	30.7	25.2	23.4	22.2	20.5	18.9	17.9	17.1	16.1	14.8	13.2	11.0	8.0	.....	2
24	32.0	26.3	24.3	23.1	21.4	19.7	18.6	17.8	16.8	15.4	13.9	11.6	8.4	.....	....
25	33.3	27.4	25.4	24.1	22.3	20.5	19.4	18.5	17.5	16.1	14.5	12.2	8.8	.....	1
26	34.5	28.5	26.3	25.1	23.2	21.3	20.1	19.3	18.2	16.7	15.1	12.7	9.3	.....	....
															78
100-FOOT TREES.															
10	15.0	10.7	10.3	9.8	9.4	9.0	8.6	8.2	7.6	6.8	5.8	4.7	3.7	2.7	....
11	16.2	11.8	11.4	10.7	10.2	9.8	9.4	8.9	8.3	7.5	6.4	5.3	4.2	3.0	....
12	17.3	12.9	12.3	11.7	11.0	10.5	10.1	9.6	9.0	8.2	7.1	5.8	4.6	3.3	....
13	18.5	14.0	13.4	12.6	11.9	11.4	10.9	10.4	9.7	8.9	7.7	6.4	5.1	3.6	....
14	19.8	15.1	14.3	13.5	12.7	12.1	11.6	11.1	10.4	9.6	8.3	6.9	5.5	3.9	1
15	21.0	16.2	15.4	14.5	13.6	12.9	12.4	11.9	11.1	10.2	9.0	7.5	5.9	4.2	1
16	22.2	17.3	16.3	15.4	14.5	13.7	13.2	12.6	11.8	10.9	9.6	8.1	6.3	4.5	2
17	23.4	18.5	17.3	16.4	15.3	14.5	14.0	13.4	12.6	11.6	10.3	8.7	6.9	4.8	....
18	24.7	19.7	18.3	17.3	16.1	15.3	14.7	14.1	13.3	12.3	11.0	9.3	7.3	5.1	....
19	25.9	20.8	19.4	18.3	17.0	16.1	15.5	14.9	14.0	13.0	11.6	9.9	7.8	5.5	....
20	27.1	22.0	20.4	19.2	17.9	16.9	16.3	15.7	14.7	13.7	12.3	10.5	8.2	5.8	....
21	28.4	23.2	21.5	20.2	18.8	17.7	17.1	16.4	15.5	14.4	13.0	11.1	8.7	6.2	3
22	29.6	24.4	22.6	21.2	19.6	18.5	17.8	17.2	16.2	15.0	13.6	11.7	9.2	6.5	3
23	30.9	25.6	23.7	22.2	20.5	19.2	18.6	17.9	16.9	15.7	14.3	12.3	9.6	6.8	3
24	32.1	26.8	24.8	23.2	21.4	20.0	19.3	18.7	17.6	16.4	14.9	12.8	10.0	7.1	2
25	33.4	28.1	25.9	24.2	22.4	20.8	20.1	19.4	18.3	17.1	15.7	13.5	10.5	7.4	1
26	34.6	29.4	27.0	25.2	23.3	21.6	20.8	20.2	19.1	17.8	16.2	14.0	11.0	7.7	....
															16

TABLE 45.—*Form of sugar maple in the Lake States.*[1]

Diameter, breast-high.	Height above ground—feet.									Basis.
	1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	
	Diameter inside bark—inches.									
50-FOOT TREES.										
Inches.										*Trees.*
4	4.9	4.3	3.9	3.7	3.4	2.8	2.1	1.3	....	....
5	5.9	5.2	4.8	4.6	4.3	3.7	2.9	2.0	....	1
6	6.8	6.1	5.7	5.4	5.1	4.5	3.6	2.7	....	4
7	7.8	7.0	6.6	6.3	5.9	5.3	4.5	3.5	....	7
8	8.7	7.9	7.4	7.2	6.8	6.1	5.3	4.3	....	1
9	9.7	8.8	8.3	8.0	7.6	6.9	6.1	5.1	....	1
10	10.6	9.7	9.3	8.9	8.5	7.8	7.0	5.9	....	1
11	11.6	10.7	10.1	9.8	9.3	8.6	7.8	6.7	....	....
12	12.5	11.5	11.0	10.6	10.1	9.4	8.7	7.5	....	....
										15
60-FOOT TREES.										
4	4.7	4.2	3.8	3.6	3.4	2.9	2.4	1.8	1.3	....
5	5.7	5.2	4.8	4.5	4.2	3.7	3.2	2.6	1.8	1
6	6.7	6.1	5.7	5.4	5.1	4.6	4.0	3.3	2.3	5
7	7.7	7.0	6.6	6.3	6.0	5.4	4.8	4.0	2.9	11
8	8.7	7.9	7.5	7.2	6.9	6.3	5.6	4.7	3.5	11
9	9.7	8.9	8.4	8.1	7.7	7.1	6.3	5.5	4.0	11
10	10.7	9.8	9.3	9.0	8.6	7.9	7.2	6.1	4.5	3
11	11.8	10.8	10.3	9.9	9.5	8.7	8.0	6.9	5.1	1
12	12.8	11.7	11.1	10.7	10.3	9.6	8.8	7.7	5.7	4
13	13.9	12.7	12.0	11.6	11.1	10.4	9.6	8.5	6.2	1
14	14.9	13.6	12.9	12.5	11.9	11.1	10.4	9.1	6.8	....
15	16.0	14.5	13.8	13.3	12.7	11.9	11.2	9.9	7.4	....
16	16.9	15.4	14.6	14.2	13.6	12.7	12.0	10.7	7.9	....
17	18.0	16.3	15.5	15.1	14.4	13.5	12.8	11.4	8.5	....
18	19.0	17.3	16.4	15.9	15.2	14.3	13.5	12.1	9.0	....
										48

[1] Gogebic and Wexford Counties, Mich.; Marinette and Vilas Counties, Wis.

Table 45.—*Form of sugar maple in the Lake States*—Continued.

Diameter, breast-high.	Height above ground—feet.												Basis.
	1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	49.9	58.05	66.2	
	Diameter inside bark—inches.												
70-FOOT TREES.													
Inches.													*Trees.*
6	6.7	6.1	5.7	5.3	5.0	4.6	4.3	3.8	2.9	1.8	0.9	......	....
7	7.7	7.0	6.5	6.3	6.0	5.5	5.1	4.5	3.5	2.3	1.2	......	....
8	8.9	7.9	7.4	7.2	6.9	6.3	5.9	5.2	4.1	2.7	1.5	......	8
9	9.9	8.9	8.3	8.1	7.7	7.1	6.6	5.8	4.6	3.2	1.9	......	18
10	11.1	9.8	9.2	9.0	8.6	8.0	7.4	6.5	5.2	3.7	2.2	......	12
11	12.3	10.8	10.2	9.9	9.5	8.8	8.1	7.2	5.9	4.3	2.6	......	12
12	13.6	11.7	11.2	10.8	10.3	9.6	8.9	7.9	6.5	4.9	3.0	......	14
13	14.7	12.7	12.1	11.7	11.1	10.3	9.5	8.5	7.1	5.5	3.4	......	5
14	16.0	13.7	13.1	12.7	12.0	11.1	10.2	9.1	7.7	6.0	3.8	......	5
15	17.3	14.7	14.1	13.6	12.7	11.8	10.9	9.7	8.2	6.6	4.3	......	5
16	18.8	15.6	15.1	14.5	13.6	12.7	11.6	10.3	8.9	7.2	4.8	......	5
17	20.2	16.7	15.9	15.3	14.4	13.3	12.2	10.9	9.4	7.7	5.0	......	....
18	21.8	17.9	17.0	16.3	15.1	14.1	12.9	11.5	10.0	8.1	5.3	......	1
19	23.4	18.9	17.9	17.1	15.9	14.7	13.5	12.1	10.5	8.7	5.6	......	1
20	24.9	19.8	18.9	18.1	16.8	15.5	14.1	12.7	11.1	9.1	5.9	......	1
21	26.6	20.9	19.9	19.0	17.5	16.1	14.7	13.2	11.6	9.5	6.2	......	1
22	28.3	22.0	21.0	19.9	18.3	16.9	15.4	13.8	12.1	10.1	6.6	......	....
23	30.0	23.1	21.9	20.8	19.0	17.6	16.1	14.4	12.7	10.6	7.0	......	....
24	31.6	24.1	23.0	21.8	19.8	18.2	16.7	15.1	13.3	11.1	7.3	......	....
													88
80-FOOT TREES.													
8	8.9	8.0	7.6	7.4	7.0	6.5	6.0	5.5	4.7	3.6	2.5	1.5	1
9	10.1	8.9	8.5	8.3	7.8	7.3	6.9	6.2	5.3	4.4	3.1	1.9	5
10	11.4	9.9	9.5	9.1	8.7	8.0	7.5	6.9	6.1	5.0	3.6	2.1	6
11	12.7	10.9	10.4	10.0	9.5	8.9	8.3	7.6	6.7	5.7	4.0	2.4	13
12	14.1	12.0	11.3	11.0	10.4	9.7	9.0	8.3	7.5	6.3	4.5	2.8	7
13	15.5	13.0	12.4	11.9	11.2	10.5	9.8	9.0	8.1	6.9	5.1	3.1	11
14	16.8	14.0	13.3	12.7	12.1	11.3	10.5	9.7	8.9	7.5	5.5	3.4	14
15	18.2	15.0	14.3	13.7	12.8	12.0	11.2	10.4	9.5	8.2	6.1	3.7	6
16	19.6	16.1	15.3	14.6	13.7	12.8	11.9	11.1	10.2	8.9	6.6	4.0	13
17	21.1	17.1	16.3	15.5	14.5	13.5	12.7	11.7	10.9	9.5	7.1	4.4	5
18	22.5	18.3	17.3	16.4	15.3	14.3	13.4	12.5	11.5	10.1	7.6	4.7	3
19	24.0	19.3	18.3	17.3	16.1	15.0	14.0	13.1	12.2	10.7	8.1	5.0	2
20	25.5	20.5	19.4	18.3	16.8	15.7	14.7	13.7	12.9	11.3	8.7	5.3	3
21	26.9	21.6	20.4	19.2	17.7	16.4	15.3	14.4	13.5	11.9	9.1	5.7	2
22	28.5	22.7	21.4	20.1	18.5	17.1	15.9	15.0	14.1	12.5	9.7	6.0	1
23	30.0	23.9	22.5	21.1	19.3	17.7	16.6	15.7	14.7	13.0	10.2	6.3	....
24	31.5	25.1	23.6	22.1	20.2	18.5	17.2	16.3	15.3	13.6	10.7	6.6	....
25	33.0	26.3	24.7	23.1	21.0	19.1	17.8	16.9	15.9	14.2	11.2	7.0	1
26	34.5	27.5	25.8	24.1	21.8	19.8	18.5	17.5	16.5	14.7	11.8	7.3	....
27	36.1	28.8	26.9	25.1	22.6	20.4	19.1	18.1	17.1	15.3	12.3	7.7	1
28	37.6	29.9	28.0	26.1	23.5	21.2	19.7	18.7	17.7	15.8	12.7	7.9	....
29	39.2	31.3	29.1	27.2	24.3	21.8	20.3	19.4	18.3	16.3	13.3	8.3	....
30	40.6	32.5	30.2	28.2	25.1	22.5	20.9	20.0	19.0	16.9	13.8	8.7	....
													94

TABLE 45.—*Form of sugar maple in the Lake States*—Continued.

Diameter, breast-high.	Height above ground—feet.														Basis.
	1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	49.9	58.05	66.2	74.35	82.5	
	Diameter inside bark—inches.														
	90-FOOT TREES.														
Inches.															*Trees.*
10	11.6	10.0	9.5	9.3	8.8	8.3	7.7	7.1	6.5	5.8	4.7	3.3	1.9	.....	1
11	13.0	11.0	10.5	10.2	9.6	9.0	8.5	7.9	7.3	6.5	5.3	3.7	2.2	.....	
12	14.5	12.1	11.4	11.1	10.5	9.8	9.2	8.7	8.1	7.2	5.8	4.1	2.5	.....	....
13	15.9	13.2	12.4	11.9	11.2	10.6	10.0	9.4	8.8	7.9	6.4	4.6	2.8	.....	3
14	17.4	14.3	13.4	12.8	12.1	11.4	10.8	10.2	9.6	8.6	7.0	5.1	3.1	.....	3
15	18.8	15.3	14.3	13.7	12.9	12.2	11.5	10.9	10.3	9.2	7.6	5.5	3.4	.....	4
16	20.3	16.5	15.4	14.7	13.7	12.9	12.3	11.7	11.1	9.9	8.2	6.0	3.7	.....	4
17	21.7	17.5	16.5	15.5	14.6	13.5	12.9	12.5	11.8	10.6	8.8	6.4	4.0	.....	2
18	23.1	18.7	17.5	16.5	15.4	14.3	13.6	13.1	12.5	11.3	9.4	6.9	4.3	.....	7
19	24.5	19.7	18.5	17.4	16.3	15.2	14.5	13.8	13.2	11.9	9.9	7.3	4.6	.....	3
20	25.9	20.9	19.5	18.3	17.1	16.0	15.2	14.6	13.9	12.5	10.5	7.8	4.9	.....	2
21	27.3	22.0	20.5	19.2	17.9	16.7	15.9	15.2	14.5	13.1	11.1	8.3	5.2	.....	4
22	28.7	23.1	21.5	20.2	18.8	17.5	16.5	15.9	15.2	13.8	11.6	8.7	5.5	.....	3
23	30.1	24.2	22.5	21.2	19.5	18.2	17.3	16.5	15.8	14.4	12.1	9.1	5.8	.....	3
24	31.5	25.4	23.6	22.1	20.4	19.0	18.0	17.2	16.4	15.0	12.7	9.5	6.1	.....	2
25	32.8	26.5	24.5	23.1	21.3	19.7	18.7	17.7	17.0	15.6	13.1	10.0	6.4	.....	3
26	34.2	27.6	25.6	24.1	22.1	20.5	19.3	18.4	17.6	16.2	13.7	10.4	6.7	.....	1
27	35.5	28.8	26.7	25.1	22.9	21.2	20.1	19.1	18.1	16.8	14.3	10.8	7.0	.....	....
28	37.0	29.9	27.7	26.1	23.7	22.0	20.7	19.7	18.8	17.3	14.9	11.3	7.3	.....	....
29	38.3	31.1	28.7	27.1	24.7	22.7	21.5	20.3	19.3	18.0	15.3	11.7	7.7	.....	....
30	39.7	32.3	29.8	28.2	25.5	23.5	22.1	21.0	20.0	18.6	15.9	12.1	8.0	.....	....
															45
	100-FOOT TREES.														
12	15.8	12.5	11.7	11.1	10.5	9.9	9.5	9.1	8.5	7.7	6.7	5.5	4.0	2.7	....
13	17.0	13.5	12.7	11.9	11.3	10.6	10.2	9.8	9.3	8.4	7.4	6.0	4.5	3.0	....
14	18.3	14.5	13.8	12.9	12.2	11.5	11.0	10.6	10.0	9.1	8.0	6.5	4.9	3.3	....
15	19.6	15.7	14.8	13.8	13.0	12.3	11.9	11.4	10.8	9.9	8.7	7.1	5.3	3.6	1
16	21.0	16.8	15.7	14.7	13.9	13.1	12.6	12.2	11.5	10.6	9.3	7.7	5.8	3.9	....
17	22.1	17.9	16.8	15.6	14.7	13.9	13.5	13.0	12.3	11.4	10.0	8.2	6.3	4.2	....
18	23.5	19.0	17.8	16.5	15.6	14.8	14.3	13.7	13.0	12.1	10.6	8.8	6.7	4.4	2
19	24.7	20.1	18.8	17.5	16.4	15.5	15.0	14.5	13.8	12.8	11.3	9.3	7.1	4.8	....
20	26.1	21.1	19.7	18.4	17.3	16.3	15.7	15.1	14.5	13.5	11.9	9.9	7.5	5.1	3
21	27.4	22.1	20.7	19.3	18.1	17.1	16.5	15.9	15.1	14.1	12.5	10.3	7.9	5.4	....
22	28.8	23.2	21.7	20.3	19.0	17.9	17.2	16.5	15.7	14.7	13.0	10.8	8.3	5.7	3
23	30.0	24.3	22.6	21.3	19.8	18.7	17.9	17.1	16.5	15.5	13.7	11.3	8.7	6.0	3
24	31.5	25.4	23.6	22.2	20.7	19.5	18.7	17.9	17.1	16.1	14.3	11.9	9.2	6.2	....
25	32.8	26.4	24.5	23.1	21.5	20.3	19.4	18.5	17.7	16.7	14.8	12.5	9.7	6.5	2
26	34.2	27.5	25.5	24.1	22.4	21.0	20.0	19.1	18.3	17.3	15.5	12.9	10.0	6.7	....
27	35.5	28.6	26.5	25.1	23.2	21.8	20.8	19.8	19.0	17.9	16.1	13.3	10.3	7.1	1
28	36.9	29.7	27.4	26.0	24.0	22.5	21.5	20.5	19.6	18.5	16.6	13.9	10.8	7.3	....
29	38.1	30.7	28.3	27.0	24.8	23.3	22.2	21.1	20.2	19.1	17.3	14.5	11.2	7.5	....
30	39.6	31.8	29.3	27.9	25.7	24.1	22.9	21.7	20.7	19.6	17.9	15.1	11.5	7.7	2
															17

TABLE 46.—*Form of basswood in the Lake States.*[1]

Diameter, breast-high.	Height above ground—feet. 1	2	3	4.5	9.15	17.3	25.45	Basis.
	Diameter inside bark—inches.							
30-FOOT TREES.								
Inches.								*Trees.*
2	2.1	2.0	1.9	1.7	1.5	....	....	....
3	3.1	3.0	2.8	2.6	2.3	....	....	2
4	4.1	3.9	3.8	3.5	2.9	....	....	2
5	5.2	4.9	4.6	4.4	3.7	....	....	....
6	6.3	5.9	5.6	5.3	4.4	....	....	1
7	7.5	6.9	6.5	6.2	5.2	....	....	....
8	8.6	7.9	7.4	7.1	5.8	....	....	....
								5
40-FOOT TREES.								
2	2.1	2.0	1.9	1.7	1.5	1.3	....	....
3	3.1	3.0	2.8	2.6	2.3	1.8	....	....
4	4.1	3.9	3.8	3.5	3.1	2.5	....	....
5	5.2	4.9	4.6	4.4	3.9	3.0	....	2
6	6.3	5.9	5.6	5.3	4.7	3.6	....	....
7	7.5	6.9	6.5	6.2	5.5	4.2	....	....
8	8.6	7.9	7.4	7.1	6.2	4.8	....	....
9	9.9	8.9	8.4	8.0	7.1	5.5	....	....
10	11.3	9.9	9.4	9.0	7.9	6.1	....	....
								2
50-FOOT TREES.								
2	2.1	2.0	1.9	1.7	1.6	1.4	1.1	....
3	3.1	3.0	2.8	2.6	2.4	2.1	1.8	....
4	4.1	3.9	3.8	3.5	3.2	2.8	2.4	....
5	5.2	4.9	4.6	4.4	4.0	3.5	3.0	2
6	6.3	5.9	5.6	5.3	4.8	4.2	3.5	2
7	7.5	6.9	6.5	6.2	5.6	4.9	4.1	3
8	8.6	7.9	7.4	7.1	6.5	5.6	4.7	....
9	9.9	8.9	8.4	8.0	7.3	6.3	5.3	....
10	11.3	9.9	9.4	9.0	8.1	7.1	6.0	....
11	12.7	11.0	10.4	10.0	8.9	7.8	6.6	....
12	14.2	12.1	11.4	10.9	9.8	8.5	7.1	....
								7

[1] Charlevoix and Kalkaska Counties, Mich.; Iron and Price Counties, Wis.

TABLE 46.—*Form of basswood in the Lake States*—Continued.

Diameter, breast-high.	Height above ground—feet.											Basis.
	1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	49.9	58.05	
	Diameter inside bark—inches.											
60-FOOT TREES.												
Inches.												*Trees.*
4	4.1	3.9	3.8	3.5	3.2	3.0	2.7	2.3	1.8	......	......	....
5	5.2	4.9	4.6	4.4	4.1	3.8	3.4	2.9	2.1	......	......	....
6	6.3	5.9	5.6	5.3	4.9	4.5	4.0	3.4	2.6	......	......	....
7	7.5	6.9	6.5	6.2	5.8	5.2	4.8	4.0	3.0	......	......	....
8	8.6	7.9	7.4	7.1	6.6	6.1	5.4	4.6	3.4	......	......	5
9	9.9	8.9	8.4	8.0	7.4	6.8	6.1	5.2	3.9	......	......	4
10	11.3	9.9	9.4	9.0	8.2	7.6	6.8	5.8	4.4	......	......	2
11	12.7	11.0	10.4	10.0	9.2	8.3	7.6	6.5	4.9	......	......	3
12	14.2	12.1	11.4	10.9	10.0	9.1	8.3	7.1	5.4	......	......	1
13	15.8	13.2	12.4	11.8	11.0	9.9	9.0	7.7	5.9	......	......	....
14	17.4	14.4	13.5	12.8	11.8	10.6	9.6	8.3	6.4	......	......	....
15	19.1	15.6	14.5	13.7	12.7	11.4	10.4	9.0	6.9	......	......	1
16	20.8	16.8	15.5	14.7	13.6	12.2	11.1	9.7	7.4	......	......	....
												16
70-FOOT TREES.												
6	6.3	5.9	5.6	5.3	5.1	4.7	4.3	3.8	3.3	2.6	1.8	....
7	7.5	6.9	6.5	6.2	5.9	5.5	5.1	4.5	3.9	3.2	2.2	....
8	8.6	7.9	7.4	7.1	6.7	6.3	5.8	5.2	4.5	3.7	2.5	1
9	9.9	8.9	8.4	8.0	7.5	7.0	6.5	5.8	5.1	4.3	2.9	4
10	11.3	9.9	9.4	9.0	8.4	7.8	7.2	6.5	5.7	4.8	3.3	4
11	12.7	11.0	10.4	10.0	9.2	8.6	7.9	7.1	6.3	5.4	3.6	4
12	14.2	12.1	11.4	10.9	10.0	9.2	8.6	7.8	6.9	5.8	4.0	....
13	15.8	13.2	12.4	11.8	10.9	10.0	9.3	8.5	7.5	6.4	4.4	5
14	17.4	14.4	13.5	12.8	11.7	10.7	9.9	9.1	8.3	7.0	4.8	2
15	19.1	15.6	14.5	13.7	12.5	11.5	10.7	9.8	8.8	7.6	5.1	4
16	20.8	16.8	15.5	14.7	13.3	12.2	11.3	10.4	9.4	8.1	5.5	2
17	22.6	18.1	16.5	15.6	14.0	12.8	12.1	11.0	10.0	8.7	6.0	4
18	24.3	19.4	17.5	16.6	14.9	13.7	12.7	11.7	10.7	9.3	6.4	5
19	26.0	20.8	18.5	17.5	15.7	14.3	13.4	12.3	11.3	9.9	6.8	....
20	27.6	22.0	19.5	18.5	16.5	15.1	14.0	13.0	11.9	10.4	7.3	1
21	29.1	23.3	20.5	19.4	17.3	15.7	14.7	13.6	12.6	11.0	7.7	....
22	30.6	24.5	21.6	20.3	18.0	16.5	15.3	14.4	13.3	11.6	8.2	....
23	32.1	25.7	22.6	21.2	18.8	17.1	16.0	14.9	13.9	12.2	8.6	....
24	33.4	26.8	23.6	22.2	19.5	17.9	16.7	15.6	14.5	12.8	9.2	....
												36

TABLE 46.—*Form of basswood in the Lake States*—Continued.

80-FOOT TREES.														
Diameter, breast-high	Height above ground—feet.													Basis.
	1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	49.9	58.05	66.2	74.35	
	Diameter inside bark—inches.													
Inches.														*Trees.*
8	8.6	7.9	7.4	7.1	6.8	6.3	5.9	5.4	4.9	4.3	3.6	2.5	1.1	....
9	9.9	8.9	8.4	8.0	7.6	7.1	6.6	6.1	5.5	4.9	4.1	2.8	1.3	1
10	11.3	9.9	9.4	9.0	8.5	7.9	7.4	6.7	6.1	5.4	4.5	3.2	1.4	1
11	12.7	11.0	10.4	10.0	9.3	8.6	8.1	7.5	6.8	6.1	5.0	3.5	1.6	1
12	14.2	12.1	11.4	10.9	10.2	9.4	8.7	8.1	7.4	6.6	5.5	3.8	1.7	3
13	15.8	13.2	12.4	11.8	11.1	10.1	9.5	8.8	8.1	7.2	5.9	4.2	1.9	1
14	17.4	14.4	13.5	12.8	11.8	10.9	10.2	9.5	8.7	7.8	6.4	4.6	2.1	2
15	19.1	15.6	14.5	13.7	12.7	11.7	11.0	10.2	9.3	8.4	6.9	4.9	2.3	6
16	20.8	16.8	15.5	14.7	13.5	12.3	11.5	10.7	10.0	9.0	7.4	5.3	2.5	7
17	22.6	18.1	16.5	15.6	14.3	13.1	12.3	11.5	10.6	9.6	7.9	5.7	2.7	8
18	24.3	19.4	17.5	16.6	15.1	13.8	12.9	12.1	11.2	10.1	8.4	6.1	2.9	5
19	26.0	20.8	18.5	17.5	16.0	14.5	13.6	12.7	11.8	10.7	8.9	6.6	3.2	7
20	27.6	22.0	19.5	18.5	16.6	15.2	14.2	13.3	12.4	11.3	9.5	7.0	3.5	7
21	29.1	23.3	20.5	19.4	17.5	15.9	14.9	14.0	13.0	11.9	10.0	7.5	3.7	5
22	30.6	24.5	21.6	20.3	18.2	16.6	15.5	14.6	13.6	12.5	10.5	7.9	4.0	4
23	32.1	25.7	22.6	21.2	19.0	17.3	16.2	15.2	14.2	13.1	11.0	8.3	4.1	7
24	33.4	26.8	23.6	22.2	19.7	18.1	16.8	15.7	14.8	13.7	11.6	8.7	4.4	3
25	34.8	28.0	24.7	23.1	20.6	18.7	17.4	16.3	15.4	14.3	12.2	9.2	4.6	4
26	36.1	29.2	25.8	24.1	21.3	19.5	18.1	16.9	15.9	14.8	12.7	9.6	4.8	2
27	37.4	30.3	26.8	25.0	22.2	20.2	18.7	17.6	16.6	15.4	13.3	10.2	5.2	....
28	38.7	31.5	27.9	26.0	22.8	20.8	19.3	18.0	17.1	16.0	13.9	10.6	5.5	....
29	40.0	32.6	29.0	26.9	23.7	21.5	20.0	18.6	17.6	16.5	14.4	11.1	5.7	1
30	41.2	33.8	30.0	27.9	24.4	22.2	20.5	19.1	18.1	17.1	14.9	11.5	6.0	1
31	42.6	34.9	31.1	28.8	25.2	22.9	21.2	19.8	18.8	17.7	15.5	12.1	6.3	....
32	43.8	36.0	32.1	29.8	25.9	23.6	21.8	20.3	19.4	18.2	15.9	12.4	6.7	....
33	45.2	37.2	33.2	30.7	26.9	24.3	22.4	20.9	20.0	18.8	16.5	13.0	7.1	....
34	46.5	38.4	34.2	31.7	27.6	25.1	23.0	21.5	20.5	19.3	17.0	13.4	7.4	....
35	47.9	39.5	35.2	32.6	28.4	25.7	23.7	22.1	21.1	19.9	17.6	13.9	7.5	....
36	49.3	40.6	36.3	33.6	29.2	26.5	24.3	22.7	21.7	20.4	18.0	14.4	8.0	....
37	50.7	41.8	37.3	34.5	30.0	27.2	24.9	23.3	22.2	20.9	18.7	14.9	8.2	....
38	52.0	43.0	38.4	35.4	30.8	27.9	25.5	23.8	22.8	21.5	19.1	15.3	8.4	....
39	53.4	44.1	39.5	36.4	31.7	28.5	26.1	24.4	23.4	22.0	19.7	15.8	8.7	....
40	54.7	45.3	40.5	37.3	32.4	29.3	26.7	25.0	23.9	22.5	20.2	16.3	9.0	....
														76

TABLE 46.—*Form of basswood in the Lake States*—Continued.

90-FOOT TREES.

Diameter, breast-high.	Height above ground—feet.														Basis.
	1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	49.9	58.05	66.2	74.35	82.5	
	Diameter inside bark—inches.														
Inches.															*Trees.*
10	11.3	9.9	9.4	9.0	8.5	8.0	7.5	7.1	6.6	5.9	5.2	4.4	3.2	1.7	......
11	12.7	11.0	10.4	10.0	9.4	8.8	8.3	7.7	7.2	6.6	5.7	4.8	3.6	1.9	......
12	14.2	12.1	11.4	10.9	10.3	9.5	8.9	8.4	7.8	7.1	6.2	5.3	3.9	2.0	2
13	15.8	13.2	12.4	11.8	11.1	10.2	9.6	9.1	8.5	7.7	6.8	5.8	4.3	2.2	3
14	17.4	14.4	13.5	12.8	12.0	11.0	10.3	9.8	9.1	8.3	7.4	6.2	4.5	2.3	2
15	19.1	15.6	14.5	13.7	12.8	11.8	11.0	10.4	9.8	9.0	7.9	6.7	4.9	2.5	2
16	20.8	16.8	15.5	14.7	13.6	12.5	11.7	11.1	10.4	9.6	8.5	7.2	5.2	2.6	7
17	22.6	18.1	16.5	15.6	14.4	13.2	12.4	11.7	11.0	10.2	9.0	7.6	5.6	2.8	5
18	24.3	19.4	17.5	16.6	15.2	13.9	13.0	12.3	11.6	10.8	9.6	8.0	5.9	3.0	4
19	26.0	20.8	18.5	17.5	16.0	14.6	13.7	12.9	12.2	11.3	10.1	8.5	6.3	3.1	4
20	27.6	22.0	19.5	18.5	16.8	15.3	14.3	13.6	12.8	11.9	10.6	9.1	6.6	3.2	20
21	29.1	23.3	20.5	19.4	17.6	16.0	15.0	14.2	13.4	12.4	11.1	9.5	7.0	3.4	12
22	30.6	24.5	21.6	20.3	18.2	16.7	15.7	14.8	14.0	13.0	11.7	9.9	7.2	3.6	6
23	32.1	25.7	22.6	21.2	19.2	17.4	16.3	15.4	14.5	13.6	12.2	10.4	7.6	3.7	7
24	33.4	26.8	23.6	22.2	19.9	18.1	17.0	16.0	15.2	14.2	12.8	10.9	7.9	3.9	8
25	34.8	28.0	24.7	23.1	20.7	18.8	17.6	16.6	15.8	14.9	13.3	11.4	8.3	4.0	4
26	36.1	29.2	25.8	24.1	21.5	19.5	18.3	17.2	16.4	15.4	14.0	11.9	8.7	4.3	6
27	37.4	30.3	26.8	25.0	22.2	20.2	18.9	17.9	16.9	15.9	14.4	12.3	9.1	4.6	3
28	38.7	31.5	27.9	26.0	23.0	20.8	19.6	18.5	17.5	16.5	15.0	12.8	9.6	4.9	2
29	40.0	32.6	29.0	26.9	23.8	21.6	20.2	19.1	18.1	17.1	15.5	13.3	9.9	5.2	3
30	41.2	33.8	30.0	27.9	24.5	22.4	20.9	19.7	18.7	17.7	16.0	13.7	10.4	5.5	1
31	42.6	34.9	31.1	28.8	25.4	23.0	21.5	20.2	19.3	18.3	16.6	14.2	10.8	5.7	3
32	43.8	36.0	32.1	29.8	26.1	23.7	22.1	20.9	19.9	18.8	17.1	14.7	11.2	6.0	......
33	45.2	37.2	33.2	30.7	27.0	24.4	22.8	21.4	20.5	19.3	17.6	15.1	11.6	6.2	2
34	46.5	38.4	34.2	31.7	27.7	25.2	23.5	22.1	21.1	20.0	18.2	15.7	12.0	6.4	2
35	47.9	39.5	35.2	32.6	28.6	25.9	24.1	22.7	21.7	20.5	18.7	16.2	12.4	6.6	......
36	49.3	40.6	36.3	33.6	29.4	26.7	24.8	23.3	22.3	21.1	19.2	16.7	12.8	6.9	......
37	50.7	41.8	37.3	34.5	30.2	27.4	25.4	23.8	22.9	21.7	19.7	17.2	13.3	7.1	......
38	52.0	43.0	38.4	35.4	30.9	28.1	26.1	24.5	23.5	22.2	20.3	17.7	13.7	7.5	......
39	53.4	44.1	39.5	36.4	31.8	28.8	26.7	25.1	24.0	22.7	20.7	18.2	14.1	7.7	......
40	54.7	45.3	40.5	37.3	32.6	29.5	27.4	25.8	24.7	23.3	21.3	18.6	14.6	8.0	......
															108

100-FOOT TREES.

Diameter, breast high.	Height above ground—feet.															Basis.
	1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	49.9	58.05	66.2	74.35	82.5	90.65	
	Diameter inside bark—inches.															
In.																*Trees.*
12	14.2	12.1	11.4	10.9	10.4	9.7	9.1	8.5	8.0	7.4	6.7	5.9	4.8	3.5	1.9	1
13	15.8	13.2	12.4	11.8	11.2	10.4	9.8	9.2	8.7	8.1	7.3	6.4	5.3	3.8	2.0	......
14	17.4	14.4	13.5	12.8	12.0	11.1	10.4	9.8	9.2	8.6	7.8	6.9	5.7	4.1	2.3	1
15	19.1	15.6	14.5	13.7	12.9	11.9	11.2	10.5	9.9	9.3	8.4	7.3	6.1	4.5	2.4	4
16	20.8	16.8	15.5	14.7	13.7	12.6	11.9	11.2	10.5	9.9	9.0	7.9	6.5	4.8	2.7	1
17	22.6	18.1	16.5	15.6	14.5	13.4	12.6	11.8	11.2	10.5	9.6	8.4	6.9	5.1	2.9	2
18	24.3	19.4	17.5	16.6	15.3	14.0	13.3	12.5	11.8	11.1	10.2	9.0	7.4	5.5	3.1	3
19	26.0	20.8	18.5	17.5	16.1	14.8	14.0	13.2	12.4	11.7	10.8	9.6	7.8	5.7	3.2	3
20	27.6	22.0	19.5	18.5	16.9	15.6	14.6	13.9	13.1	12.3	11.3	10.0	8.2	6.0	3.3	3
21	29.1	23.3	20.5	19.4	17.8	16.3	15.3	14.5	13.7	12.9	11.8	10.5	8.7	6.3	3.5	4
22	30.6	24.5	21.6	20.3	18.5	17.0	15.9	15.1	14.3	13.5	12.4	11.0	9.1	6.6	3.6	3
23	32.1	25.7	22.6	21.2	19.3	17.7	16.6	15.7	14.9	14.1	12.9	11.5	9.5	6.9	3.8	3
24	33.4	26.8	23.6	22.2	20.1	18.5	17.3	16.4	15.5	14.6	13.4	12.0	9.9	7.2	4.0	7
25	34.8	28.0	24.7	23.1	20.9	19.0	17.9	16.9	16.1	15.3	14.0	12.5	10.4	7.5	4.1	6
26	36.1	29.2	25.8	24.1	21.7	19.8	18.5	17.5	16.7	15.8	14.6	13.0	10.8	7.7	4.2	7
27	37.4	30.3	26.8	25.0	22.6	20.4	19.2	18.1	17.4	16.5	15.2	13.5	11.2	8.0	4.3	1
28	38.7	31.5	27.9	26.0	23.2	21.2	19.8	18.8	18.0	17.0	15.7	14.1	11.6	8.2	4.5	4
29	40.0	32.6	29.0	26.9	24.0	21.9	20.5	19.4	18.5	17.6	16.2	14.5	12.1	8.6	4.6	2
30	41.2	33.8	30.0	27.9	24.7	22.7	21.1	20.0	19.2	18.1	16.8	15.0	12.4	8.9	4.8	2
31	42.6	34.9	31.1	28.8	25.5	23.3	21.8	20.6	19.8	18.8	17.4	15.6	12.9	9.1	4.9	3
32	43.8	36.0	32.1	29.8	26.2	24.1	22.4	21.2	20.4	19.3	17.9	16.1	13.4	9.5	5.2	2
33	45.2	37.2	33.2	30.7	27.0	24.7	23.1	21.9	21.0	20.0	18.6	16.6	13.8	9.9	5.4	1
34	46.5	38.4	34.2	31.7	27.8	25.5	23.7	22.4	21.6	20.5	19.0	17.1	14.3	10.3	5.7	1
35	47.9	39.5	35.2	32.6	28.6	26.1	24.4	23.1	22.2	21.2	19.6	17.6	14.8	10.7	5.9	......
36	49.3	40.6	36.3	33.6	29.3	26.9	25.0	23.7	22.7	21.6	20.1	18.1	15.2	11.1	6.2	......
37	50.7	41.8	37.3	34.5	30.1	27.5	25.7	24.4	23.5	22.4	20.7	18.7	15.7	11.4	6.4	......
38	52.0	43.0	38.4	35.4	30.9	28.3	26.4	25.0	24.1	22.9	21.3	19.2	16.2	11.9	6.6	......
39	53.4	44.1	39.5	36.4	31.6	28.9	27.0	25.6	24.7	23.6	21.9	19.7	16.6	12.1	6.7	......
40	54.7	45.3	40.5	37.3	32.4	29.7	27.7	26.2	25.3	24.1	22.5	20.3	17.1	12.5	6.9	......
																64

TABLE 46.—*Form of basswood in the Lake States*—Continued.

110-FOOT TREES.

Diameter, breast high.	Height above ground—feet. 1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	49.9	58.05	66.2	74.35	82.5	90.65	98.9	Basis.
	Diameter inside bark—inches.																
Inches																	*Trees.*
14	17.4	14.4	13.5	12.8	12.1	11.3	10.7	10.2	9.6	8.9	8.1	7.3	6.4	5.2	3.8	2.2	......
15	19.1	15.6	14.5	13.7	12.9	12.0	11.5	10.9	10.3	9.5	8.7	7.9	6.9	5.7	4.0	2.3	......
16	20.8	16.8	15.5	14.7	13.7	12.7	12.0	11.5	10.9	10.1	9.3	8.4	7.4	6.0	4.2	2.4	......
17	22.6	18.1	16.5	15.6	14.6	13.5	12.8	12.2	11.5	10.8	9.9	9.0	7.9	6.5	4.4	2.6	1
18	24.3	19.4	17.5	16.6	15.4	14.2	13.4	12.8	12.1	11.4	10.6	9.6	8.4	6.8	4.7	2.7	1
19	26.0	20.8	18.5	17.5	16.3	14.9	14.1	13.5	12.8	12.0	11.2	10.1	8.9	7.2	4.9	2.8	......
20	27.6	22.0	19.5	18.5	17.0	15.6	14.8	14.1	13.4	12.6	11.7	10.7	9.3	7.5	5.2	2.9	......
21	29.1	23.3	20.5	19.4	17.9	16.4	15.5	14.7	14.0	13.2	12.3	11.2	9.8	7.9	5.5	3.1	......
22	30.6	24.5	21.6	20.3	18.7	17.1	16.1	15.3	14.6	13.8	13.0	11.8	10.3	8.2	5.8	3.3	1
23	32.1	25.7	22.6	21.2	19.5	17.8	16.9	16.1	15.2	14.5	13.5	12.3	10.7	8.6	6.1	3.5	......
24	33.4	26.8	23.6	22.2	20.3	18.5	17.5	16.6	15.9	15.1	14.1	12.9	11.2	9.0	6.4	3.6	1
25	34.8	28.0	24.7	23.1	21.0	19.2	18.1	17.2	16.5	15.7	14.7	13.4	11.6	9.3	6.6	3.9	......
26	36.1	29.2	25.8	24.1	21.8	19.9	18.8	17.9	17.1	16.3	15.3	14.0	12.1	9.7	7.0	4.1	1
27	37.4	30.3	26.8	25.0	22.6	20.6	19.5	18.5	17.7	17.0	15.8	14.5	12.6	10.0	7.1	4.2	4
28	38.7	31.5	27.9	26.0	23.4	21.3	20.1	19.1	18.3	17.5	16.4	15.0	13.0	10.3	7.5	4.3	3
29	40.0	32.6	29.0	26.9	24.1	22.0	20.8	19.7	18.9	18.2	17.0	15.5	13.5	10.7	7.7	4.4	......
30	41.2	33.8	30.0	27.9	24.9	22.7	21.4	20.3	19.6	18.8	17.6	16.0	13.9	11.1	8.0	4.7	......
31	42.6	34.9	31.1	28.8	25.7	23.4	22.1	21.0	20.2	19.4	18.1	16.6	14.3	11.4	8.2	4.8	2
32	43.8	36.0	32.1	29.8	26.3	24.2	22.7	21.6	20.8	19.9	18.7	17.1	14.8	11.7	8.5	4.9	1
33	45.2	37.2	33.2	30.7	27.3	24.8	23.4	22.3	21.4	20.5	19.3	17.7	15.3	12.1	8.7	5.0	......
34	46.5	38.4	34.2	31.7	27.9	25.6	24.0	22.9	22.0	21.1	19.9	18.3	15.8	12.5	9.0	5.2	1
35	47.9	39.5	35.2	32.6	28.7	26.3	24.8	23.6	22.7	21.8	20.5	18.8	16.3	12.9	9.2	5.4	......
36	49.3	40.6	36.3	33.6	29.4	27.1	25.3	24.2	23.4	22.5	21.2	19.4	16.9	13.3	9.5	5.6	......
37	50.7	41.8	37.3	34.5	30.3	27.7	26.1	24.9	24.0	23.0	21.7	20.0	17.3	13.7	9.8	5.7	1
38	52.0	43.0	38.4	35.4	31.1	28.5	26.7	25.5	24.7	23.7	22.3	20.5	17.9	14.1	10.0	5.9	......
39	53.4	44.1	39.5	36.4	32.0	29.2	27.5	26.3	25.3	24.2	22.8	21.1	18.4	14.6	10.4	5.9	......
40	54.7	45.3	40.5	37.3	32.7	30.0	28.1	26.9	26.0	24.9	23.5	21.7	19.0	15.0	10.6	6.1	......
																	17

120-FOOT TREES.

Diameter, breast high.	Height above ground—feet. 1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	49.9	66.2	58.05	74.35	82.5	90.65	98.8	106.95	Basis.
	Diameter inside bark—inches.																	
In.																		*Trees.*
16	20.8	16.8	15.5	14.7	13.7	13.0	12.4	11.7	11.1	10.4	9.7	8.9	8.0	6.9	5.5	4.0	2.5	......
17	22.6	18.1	16.5	15.6	14.6	13.6	13.0	12.4	11.8	11.1	10.3	9.4	8.5	7.3	5.8	4.2	2.6	......
18	24.3	19.4	17.5	16.6	15.4	14.5	13.7	13.0	12.4	11.7	10.9	10.0	9.0	7.7	6.1	4.4	2.7	......
19	26.0	20.8	18.5	17.5	16.3	15.1	14.3	13.7	13.1	12.3	11.5	10.5	9.5	8.1	6.3	4.6	2.8	......
20	27.6	22.0	19.5	18.5	17.1	15.9	15.0	14.3	13.6	12.9	12.1	11.1	9.9	8.5	6.5	4.7	2.9	......
21	29.1	23.3	20.5	19.4	18.0	16.5	15.6	14.9	14.3	13.6	12.7	11.7	10.5	8.9	6.8	4.9	3.0	......
22	30.6	24.5	21.6	20.3	18.8	17.3	16.2	15.6	15.0	14.3	13.3	12.3	10.9	9.2	7.1	5.1	3.2	......
23	32.1	25.7	22.6	21.2	19.6	18.0	17.0	16.2	15.6	14.8	13.9	12.8	11.5	9.7	7.3	5.3	3.3	......
24	33.4	26.8	23.6	22.2	20.4	18.7	17.6	16.9	16.2	15.4	14.5	13.4	12.0	10.1	7.6	5.5	3.4	......
25	34.8	28.0	24.7	23.1	21.2	19.4	18.3	17.5	16.9	16.0	15.1	14.1	12.6	10.5	8.0	5.8	3.5	......
26	36.1	29.2	25.8	24.1	21.9	20.2	18.9	18.2	17.5	16.7	15.7	14.6	13.0	10.8	8.4	6.1	3.7	1
27	37.4	30.3	26.8	25.0	22.7	20.8	19.7	18.8	18.1	17.3	16.3	15.2	13.6	11.3	8.7	6.3	3.8	......
28	38.7	31.5	27.9	26.0	23.5	21.5	20.3	19.5	18.7	17.9	16.9	15.8	14.1	11.6	9.0	6.6	4.0	......
29	40.0	32.6	29.0	26.9	24.4	22.2	21.0	20.1	19.3	18.6	17.5	16.3	14.6	12.1	9.4	6.8	4.2	......
30	41.2	33.8	30.0	27.9	25.1	23.0	21.6	20.8	20.0	19.1	18.1	16.9	15.1	12.4	9.8	7.1	4.3	......
31	42.6	34.9	31.1	28.8	25.9	23.6	22.4	21.4	20.7	19.8	18.7	17.5	15.6	12.9	10.0	7.3	4.5	......
32	43.8	36.0	32.1	29.8	26.6	24.3	23.0	22.1	21.3	20.4	19.3	18.0	16.1	13.2	10.4	7.5	4.6	......
33	45.2	37.2	33.2	30.7	27.4	25.0	23.7	22.8	21.9	21.0	19.9	18.6	16.6	13.7	10.7	7.7	4.8	......
34	46.5	38.4	34.2	31.7	28.1	25.8	24.3	23.3	22.5	21.6	20.5	19.2	17.1	14.1	11.0	8.0	4.9	......
35	47.9	39.5	35.2	32.6	29.0	26.5	25.1	24.1	23.3	22.3	21.1	19.7	17.6	14.5	11.3	8.1	5.0	1
36	49.3	40.6	36.3	33.6	29.7	27.3	25.8	24.8	23.8	22.8	21.7	20.3	18.1	14.9	11.7	8.5	5.2	......
37	50.7	41.8	37.3	34.5	30.5	27.9	26.5	25.4	24.5	23.5	22.3	20.9	18.6	15.4	12.0	8.7	5.3	......
38	52.0	43.0	38.4	35.4	31.1	28.8	27.2	26.1	25.2	24.1	22.9	21.5	19.2	15.8	12.3	9.0	5.5	......
39	53.4	44.1	39.5	36.4	32.0	29.4	28.0	26.9	25.9	24.8	23.5	22.1	19.7	16.2	12.6	9.2	5.6	......
40	54.7	45.3	40.5	37.3	32.7	30.3	28.7	27.5	26.5	25.4	24.2	22.7	20.2	16.6	12.9	9.4	5.7	......
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