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STEPHEN A. FORBES, *Chief*

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A Manual of Woodlot Management

BY

C. J. TELFORD

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After Threshing Comes Sawmilling

A MANUAL OF WOODLOT MANAGEMENT

C. J. TELFORD

This manual is addressed to those landowners who have woodlots or idle land. It is assumed that they appreciate the intangible benefits accruing from the woodlot as a refuge for wild life, as a local modifier of dry and cold winds, as a protection to the sources of local water supply, as a means of enhancing the beauty of the landscape, and as a place for recreation; and that they also appreciate the service to the nation rendered by productive forests. Our purpose is to define the true forest lands in Illinois, to outline the methods for the proper management of the woodlot, and to give the general returns to be derived from the managed production of wood. The point of view throughout is the growing of a wood crop as a producer of revenue. The broad essentials of woodlot management are outlined briefly, the methods which are adapted to the growing of timber under different conditions of site and market are discussed at some length, and the methods of measuring and marketing the product are described in detail.

Summary of General Measures in the Management of Natural Woodlots

The broad essentials of woodlot management may be summarized as follows:

(1) Put the soil in condition to support the best growth by developing and maintaining a good leaf mulch. Since fire, grazing, wind, and sunshine destroy this mulch, keep out fire by eternal vigilance, stock by fencing, wind by leaving a dense wall of bushes on the borders and small trees within the woods, and sunshine by growing enough trees to provide a complete shade.

(2) Stock the area with the most rapidly growing species suited to the products in view. In Table VIII (page 118) are listed the species recommended for the specified products under definite soil conditions. Work out the worthless trees, such as decayed, broken-topped, crooked- or short-boled, very limby ones of all species, and all trees of those species classed as weed trees and listed on page 118. Observe the seed bed conditions which favor the seeding in of trees of the species desired—shade or sunlight, leaf litter, humus or mineral soil—and create such

conditions at the time when the desired species promises to bear good seed crops. If suitable restocking can not be attained naturally, plant seeds or small trees where reenforcement is necessary.

(3) Develop and maintain light conditions favoring the rapid growth of trees of good form. Enough trees should be grown so that tall clear-boled trees are produced. This type is secured when the trees during their early stages of development get direct sunlight only from overhead and none on the lower branches. This crowding, intended to force the tree to discard the lower limbs, must be done when the trees are young. The naturally pruned tree should be so developed as to show a tall straight stem, with the crown bunched at the top when it has attained a diameter of 6 to 10 inches and is passing the period of most rapid height growth. After this period, there will be progressively less stem added to the top from which branches can grow, and continued crowding cramps the crown. At this stage, therefore, thinnings should be initiated to supply space for lateral crown expansion. Such thinnings should be light, removing just enough live trees to give the select trees the space which they will fill up in five or six years. When crowding again occurs, another thinning is made. In even-aged stands, these thinnings can be done somewhat systematically at regular intervals. In an all-aged stand containing trees of different sizes, the process of regeneration, the crowding of immature trees to improve their form, thinnings to give additional space to the crowns of select trees, and cuttings incident to harvesting the crop, are carried on simultaneously.

Very frequently one operation can be carried out only by sacrificing some of the rules outlined. If a raw mineral soil is necessary for seedling regeneration, obviously the heavy leaf mulch can not be retained; if undesirable trees have usurped a large part of the area, these can not be removed without letting in sunlight; if the underbrush consists of weed trees, its removal gives access to the wind. In forest management, judgment rather than rules must be followed.

LAND CLASSIFICATION

Land is classified according to its suitability for certain uses. The guiding principle usually is that lands should be put into the most productive group to which they lend themselves. Permanent classification is impossible—the swamp of yesterday, if drained, becomes productive cropland to-day, and may be the site of a town to-morrow—but at present almost nine-tenths of the area of Illinois is given over to the business of farming, so that a classification based upon the use of land for farming applies to practically all of the State.

The farm owner generally classifies his land by answering two questions: (1) Does the land lie so that cropping is possible? (2) Is the quality of the soil good enough to raise paying crops? Any part of the farm which seems unlikely to produce crops at a profit is left in forest or is considered waste land. Some areas are undeveloped because they do not lie so that cropping is possible. The slopes may be too steep for tillage or they may be badly gullied. Similarly, rock-strewn fields discourage cultivation. Other areas are not farmed because the quality of the soil is not good enough to raise paying crops. This class includes extremely compact hardpan soils, extremely loose sandy soils, worn-out croplands, and soggy bottomlands. Some of this non-cropped land is potential cropland in the sense that by terracing, by draining, or by soil treatment it can be developed to produce crops, but there is no reason to believe that the economic conditions which have forced a decrease in the cropland area in Illinois during the past 15 years will improve enough to make profitable the immediate redemption of these marginal lands. The steep hillsides, gullied, rocky, or worn-out fields, sands, hardpan soils, swamps, and flood bottoms, it is generally agreed, should be in forests.

From the viewpoint of the production of wood at a profit, this definition of the true forest lands is inaccurate. There are lands in the above list which can not produce any kind of wood crops at a profit, and there are certain lands now returning a profit in crops which would show a higher profit from forests. The farmer can not get a profitable wood crop from all lands too poor for general crops, nor does he need to confine his woodlot to areas unsuited to other crops.

Considering, first, the lands listed above as unsuited to ordinary farm crops, we find that the revenue to be derived from either natural or planted forests on the hardpan soils (post oak flats) is less than the cost of management; that sands can usually produce acceptable timber crops only when planted to conifers; that the loams on steep slopes and on gullied, rocky, or worn-out fields usually prove acceptable for either native hardwoods or conifers; and that the floodlands are well suited to hardwoods.

Considering, next, the arable lands which are commonly considered as true croplands, we find that wood production is financially justifiable on such lands only when the sustained net returns from wood crops equal or exceed those from other crops which can be produced on them. There is very little conflict between wood crops and other farm crops on high-grade arable land. Aside from very limited areas devoted to fence post or Christmas tree plantations, such land can not produce returns from wood crops comparable to those from the ordinary farm crops, and it should not be in woods. Low-grade arable land and unimproved pasture return net revenues comparable to those from productive forests. The net returns from the rough hillside pasture averages about $1.25 per acre annually. The same kind of land in well-stocked hardwood forests yields a net return up to $1.60 per acre annually. Certainly, there is no economic justification for developing a pasture or low-grade cropland where woods are already well established and will give a better return, but, if they are once cleared, the very considerable cost of forest restoration more than offsets the higher revenue accruing from the forest. Keep such forested land in forest. The time has not yet come in Illinois when land already cleared, suitable for and devoted to untilled pasture, will give sufficiently greater returns if restored to forest to justify the change; and such land, therefore, should be kept in pasture.

The detailed classification of farm land to determine the area of true forest land is most important and often difficult. Very steep hillsides or frequently flooded bottomland can readily be classified as forest land, just as well-located, fertile prairie loams fall into the division of true arable soils. The need of information which can be used in classifying the marginal soils between these extremes becomes apparent in the survey of the farm.

Should any of the improved lands be given over to forest? A proper system of accounting will show if the field in question is giving a net return. Lacking such records the classification becomes a matter of guesswork and is seriously liable to error.

What slopes are too steep for cultivation? The erosion of a given area is dependent upon the volume of water passing over it, the velocity which the water attains, and the character of the soil. The amount of water is influenced by the area drained and by the structure of the soil and soil cover, and the velocity is determined by the gradient. Heavy, compact clays absorb but little water and, when stripped of cover, readily wash at gradients as low as 6° in Hardin County. The open, absorbent, deep loess soils in parts of Jackson County produce alfalfa on slopes greater than 20° without eroding; yet the open mixed sand and loess soils in parts of Whiteside County gully seriously when cleared.

These instances are advanced to show that no fixed ruling about degree of slope can be given*. If erosion has developed to such an extreme stage that gullies are forming, the land is true forest land; but areas may be in this class where erosion has not reached the gully phase. Actually less loss to farm soils results from gullying than from a general surface washing resulting in the steady removal of the surface soil particles, the consequent impoverishment of the soil, and the relegation of the area to the worn-out crop-land class. The effect on the soil of this surface washing is much more ruinous than is generally appreciated and reduces the fertility of soils to a greater degree than the demands of the crops for plant food. Thus arable slopes which do not gully may become true forest areas because they no longer produce profitable crops, and the classification is dependent upon crop records and costs.

Total Area of Woodlot

Careful classification of the land on a given farm may show both wooded areas and cleared areas which should be forested. The total of these areas of true forest land naturally varies for individual farms. If the woodlot comprises all non-arable parts of the farm, it is evident that its size may bear little relation to the needs of the farm. The first aim in woodlot management, however, should be to supply the farm with those products which can be grown in the woodlot. In many instances the woodlots will also produce a surplus, and they must be managed with a view to marketing this surplus in the most profitable form.

THE WOODLOT AS A SOURCE OF SUPPLY FOR THE FARM

The wood consumed on farms in Illinois consists largely of fuelwood, posts, and lumber; it averages, as standing timber, 704.8 cubic feet per farm annually. The average rate of growth for fully-stocked stands is estimated at 41.1 cubic feet per acre annually, and the area of the woodlot required to supply this wood to an average farm is 17.1 acres.

Considering these three major forms of wood used, the woodlot should in all cases supply the posts used on the farm; it should in most cases furnish the lumber; and it should supply the fuelwood only when this can be secured by utilizing tops and other materials which can serve no higher purpose. White oak fence posts cost on an average $0.24 each, and an average acre should produce 38 posts annually, a total value of $9.12. The farm woodlot can usually supply all the rough lumber used on the farm. The operator will be dependent upon outside sources for the bulk of the surfaced lumber; for, although the woodlands of Illinois will produce crops of pine and other woods suitable for

* For a discussion of erosion see Circular No. 290, "Saving Soil by Use of Mangum Terraces", and Bulletin No. 207, "Washing of Soils and Methods of Prevention", University of Illinois Agricultural College and Experiment Station.

finished lumber, the process of manufacturing into siding, flooring, ceiling and similar finished products requires equipment not available to the woodlot owner. The fully-stocked average acre in Illinois should produce an average of 180 board feet of hardwoods annually, having a gross value of $8.10. The production of fuelwood as the chief crop is not an economical use of forests. To supply annually wood equivalent to one ton of coal requires nearly 2½ acres of average woodland. With an average cost of coal of $6.60 per ton, the gross returns from such woodland devoted to cordwood are but $2.71 per acre annually. No greater mistake is commonly made than converting into cordwood the timber which is suitable for higher uses.

The following information is given for the benefit of the woodlot owner who wishes to compute the woodlot area required to supply his farm. He may calculate from Table I the number of posts which will be needed annually to keep up his fences.

TABLE I

REQUIRED RENEWALS OF UNTREATED POSTS *

Species	Number of untreated posts that must be renewed annually in each 100 posts in fence	Species	Number of untreated posts that must be renewed annually in each 100 posts in fence
Osage orange ..	2½	White oak	10
Mulberry	5	Sassafras	11
Black locust	5	Elm	16⅔
Catalpa	6⅔	Black or red oak	20
Cedar	6⅔	Ash	20
Burr oak	8	Maple	22⅕
Post oak	9	Cottonwood	28½
Walnut	9	Willow	28½

* From *Second Report on a Forest Survey of Illinois.* State Natural History Survey Bulletin Vol XV, Art. III (1924).

Each post is equivalent to 1.08 cubic feet in the standing tree. To get the total cubic feet required for posts, find from Table I the number required annually and multiply by 1.08. To get the total cubic feet required for rough lumber,divide the annual board feet requirements by 4.4. There will be approximately one cord of fuelwood in the tops for each 1000 B. F. of lumber taken out.

If additional fuel wood is cut, the amount in cubic feet is found by multiplying by 80 the number of additional cords required.

The average annual growth in peeled stems for fully-stocked woodlots is as follows:

	Cubic feet per acre
Upland	
Hardpan	15.8
Sands	28.6
Loams	36.4
Bottomland	
Oak, hickory, elm, ash	45.0
Sycamore, soft maple, cottonwood, sweet gum, locust	100.0

To find the approximate number of acres required to supply the farm, first find the total number of cubic feet required and then divide by the average annual growth per acre of the type in question.

Example: Assume that the farm has 135 acres with a total of 844 posts. If the posts are white oak, there are required for renewals 10 posts for each 100 in service (Table I), or 85 posts yearly. Each post is equivalent to 1.08 cubic feet of standing timber, so that the annual drain on the woodlot *for post material* is 85×1.08, or 92 cubit feet.

Assuming that the consumption of rough lumber on the farm is 1000 B. F. annually, and that there are 4.4 B. F. in each cubic foot of the standing tree, then the drain on the woodlot *for lumber* is 1,000 divided by 4.4 or 228 cubic feet.

Assume that, in addition to the cord of fuelwood in the tops of the trees cut for sawlogs, there are cut 4 more cords per year. Each cord is equivalent to 80 cubic feet; hence, this drain *for fuelwood* equals 4 times 80, or 320 cubic feet.

The total annual drain is then to be calculated thus:

Lumber	228	cubic feet
Fuel	320	" "
Posts	92	" "
Total	640	" "

If the woodlot is entirely on the hardpan soils, only fuel and posts can be produced. To supply the 412 cubic feet needed for these, requires $\frac{412}{15.8}$, or 26.1 acres.

If the woodlot is on sands, the fuel, lumber, and post requirements of 640 cubic feet can be supplied by $\frac{640}{28.6} = 22.4$ acres.

Similarly, on the upland loams the requirements will be met by using $\frac{640}{36.4} = 17.6$ acres; the oak, hickory, elm, ash bottomland type, by using $\frac{640}{45} = 14.2$ acres; the sycamore, soft maple, cottonwood, locust, sweet gum type, by using $\frac{640}{100} = 6.4$ acres. The gross value of the 1,000 B. F. of lumber, 5 cords of wood, and 85 posts is approximately $92, so that the woodlot on sand gives a gross return of $4.10 per acre annually, the upland loam type $5.23, the slow-growing bottomland type $6.48, the rapidly-growing bottomland type $14.38.

GRAZED WOODLOT.

Young trees cleaned out, ground covered with turf.
Natural replacement impossible.

WOODLOT PROTECTION

The method of establishing and of harvesting a stand usually differ in even-aged and all-aged forests, but the same degree of protection must be given to each against grazing, fire, and attacks of insects and diseases.

Grazing. The injury done to the Illinois woodlots by using them for pasture is greater than injury from all other sources. Throughout central and northern Illinois, woodland is not only being injured; it is being converted to cleared land by grazing.

To appreciate the damage resulting from grazing, we must understand that grasses and trees are conflicting kinds of vegetation. A very slight agency in this region is able to upset the balance between them and determine whether a forest or a sod shall hold the contested site. The forest's defenses against grass consist in shade and in a leaf mulch completely covering the earth. This blanket of leaves and partly-decayed vegetable matter serves the very vital purpose of readily absorbing moisture and checking evaporation; in addition, it serves to cultivate and fertilize the ground, as it supports bacteria which are the agents for chemical reactions of the greatest importance in building up the soil fertility. The first effect of grazing is the injury to the small trees. A grazed woodlot is strikingly free from underbrush. More sunlight reaches the ground, and sunlight is as effective as fire in destroying the leaf mulch. Its destruction, coupled with the increased sunlight striking the forest floor, paves the way for the occupation of the site by grasses; and the formation of a sod, in addition to effectively preventing tree seedlings from becoming established, uses up the moisture. The effect of the very variable moisture conditions which result from the destruction of the mulch of humus and the compacting of the soil by the trampling of stock, is shown as the larger trees begin to die at the top and eventually drop out. First, the grazed woodlot becomes clear of underbrush, then grasses appear and a sod forms, the tops of the large trees die, eventually these trees drop out, and the area is cleared. If you wish to retain any area wooded, you must keep out live-stock. Grazing and wood production can not be practiced on the same area except to the material disadvantage of each and the lessening of total returns received from the area.

Fire. It is universally understood that fire is very destructive to our forests. The ordinary farm woodlot in Illinois is relatively small, usually isolated from extensive woodland, and can readily be protected by the owner. The reasons why fire protection is imperative are much the same as those given under grazing. The smaller trees are usually killed outright, and the larger trees suffer wounds which offer ingress to rot fungi, but the greatest injury comes in the destruction of the leaf mulch. A single burning may destroy the accretion of years, and repeated burnings, like grazing, result in the formation of a sod.

Insects and fungous diseases. The application of insecticides and fungicides and other measures feasible for the protection of valued ornamental and fruit trees are not ordinarily practicable in the woodlot. If a disease or insect attack takes on the proportions of an epidemic, the woodlot owner as an individual usually can not successfully combat it. Such epidemic conditions occur throughout the country both as disease infections and insect infestations. The attacks of a particular disease or insect are generally limited to a certain tree species or genus; they vary in intensity, and in an extreme form they may affect every tree of the species in the region. Disease epidemics on native chestnut are spreading throughout the range of this species so completely that native chestnut seems sure to disappear from our forests. No successful method has been found to combat it. In sections of the Northeast, Lake States, and Northwest where the white pine blister rust has caused serious loss, organized protective measures have been adopted. Insect epidemic conditions are also common and often destructive. In the Northeastern States losses through infestations of the brown-tail and gypsy moths have reached millions of dollars; throughout the range of eastern larch, periodic epidemics of the larch sawfly eliminate this species from the forest; in the West and South, the devastation of bark beetles destroys immense acreages of pines. In Illinois diseases have not reached such destructive intensity as to eliminate completely any important species. Insect damage, however, has been serious enough to restrict the use of certain affected species. The black locust borer is so universally destructive that the use of black locust for post production is advisable only under exceptional conditions. Trees of the black oak group are being killed by a flat-headed borer. Ash and cottonwood are dying in large numbers as a result of the attacks of scale and bark-boring insects. Where marked disease and insect injury are present in our woodlots, it is usually a result of poor forest conditions. The remedies lie in practicing forest hygiene and in destroying diseased trees and those which harbor borers. It should be the rule to remove trees as soon as they show evidences of weakness and stagnation. If bark borers are present in a living tree, it should be cut and peeled, and the bark and tops burned.

Identification of diseases and recommendation of remedial measures will be made upon receipt of a specimen by the pathologist of the Natural History Survey, Room 219, Natural History Building, Urbana, and of insects by the entomologist at the same address.

ADAPTATION OF TREES TO SOIL

To get the highest production from the woodlot, it is essential not only that the trees should be given protection so that they can be carried to harvesting maturity but also that they should be suited to the site and market demands. The average growth rates of different species of trees vary greatly, even when they are growing under similar conditions. Once the choice has been made as to what form the output of the woodlot should take, the woodlot should be managed with the object of favoring those most rapidly growing species which are suitable for the manufacture of these products. Studies of growth rates correlated with soil types made by the Natural History Survey,* show the relative values of the commoner soil types for tree growth and the relative growth rates of the species commonly found on each soil type.

The best soils for timber production in this region are the bottomland sandy loams, followed by the bottomland heavy loams, the upland loams, the sands, and finally the very compact loams or hardpan soils. If we give the least productive—hardpan soils—a rating of 1, the relative productiveness of the other soils for unmanaged tree growth characteristic of each soil type is in about the following ratio: sands, 1.8; upland loams, 2.3; bottomland clay loams, 2.8; bottomland sandy loams 6.3. The above ratings, representative of unmanaged forests stocked with species whose presence in the stand is the result of natural forces, are probably very conservative for stands under management. In the latter, only the more rapidly growing species will be permitted to grow. The growth rates on the poorer soils are uniformly low, but with improved soil conditions not only do the growth rates increase, but there is also an increased number of the more rapidly growing species from which to choose. The prospects of raising the production on the hardpan soils through management of the woodlot are not encouraging, but on all other soils the managed woodlot is clearly capable of producing much better returns than the unmanaged.

Tables II, III, IV, V, VI and VII show the average growth rates on these five general soil groups at 20-year periods in Illinois. The growth rates are indicated by the diameter inside the bark on the stump, by the height, and by the cubic feet of stem exclusive of bark. In a managed woodlot the growth rates should be more comparable to the even-aged figures as shown in these tables than to the all-aged figures.

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* Bulletin Vol. XVI, Art. I, *Third Report on a Forest Survey of Illinois.* (1926.)

TABLE II.

AVERAGE GROWTH RATES ON UPLAND SANDY LOAMS IN ILLINOIS

A and E indicate all-aged and even-aged stands, respectively

Species		20 years			40 years			60 years			80 years			100 years		
		D. i. b., In.	Height, Ft.	Volume, Cu. Ft.	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.
Black walnut	A	4.8	31	1.3	11.2	71	17.4	16.8	87	51.5						
Tulip	A	7.4	19	2.1	13.4	39	13.2	17.8	62	37.5	21.9	83	78.8	25.4	94	120.1
Black oak	E	4.4	26	1.1	9.3	50	9.9	13.8	67	26.7	18.1	81	57.5	20.9	90	74.6
	A	2.2	25	.4	4.6	45	2.1	7.8	62	8.0	11.6	73	21.6	16.4	80	46.6
White oak	E	5.5	22	1.1	10.5	44	8.7	14.0	60	23.5	17.2	70	43.6			
	A	2.6	24	.6	6.2	48	3.4	10.2	69	15.0	13.4	86	33.6	17.0	91	64.5
Red oak	A	2.2	24	.3	4.4	45	1.9	8.6	61	9.8	14.2	74	32.8	18.6	84	63.2
Basswood	A	2.4	19	.4	5.7	37	2.1	10.0	55	11.2	15.0	68	32.9	20.0	80	70.6
Ash	A	1.9	21	.4	4.6	43	2.0	8.2	65	9.4	12.3	83	27.4	15.0	95	45.1
Hard maple	A	2.1	17	.2	5.1	35	1.8	7.6	55	6.4	10.6	70	20.3	15.1	81	40.1
Hickory	A	1.4	25	.2	3.4	48	1.6	6.2	66	5.6	9.0	78	14.0	12.2	86	27.9
Elm	A	1.9	24	.4	4.0	44	1.7	6.5	60	5.4	8.8	72	13.0	12.0	82	25.9
Beech	A	1.6	15	.1	3.2	29	.8	5.3	42	2.4	8.4	56	8.0	11.6	69	21.3

Table 111.

Average Growth Rates on Upland Yellow and Yellow-Gray Silt Loams in Illinois

A and E indicate all-aged and even-aged stands, respectively

Species		20 years			40 years			60 years			80 years			100 years		
		D. i. b., In.	Height, Ft.	Volume, Cu. Ft.	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.
White pine	E	8.6	29	4.6	18.0	64	40.1	22.3	85	79.7	24.4	97	10.76			
Tulip	A	5.6	30	1.8	10.4	57	11.3	14.0	63	23.3	18.0	85	55.0	21.4	91	82.8
Red oak	E	2.6	22	.33	6.8	42	4.2	11.4	60	16.8	15.6	70	38.2			
	A	2.8	24	.38	6.6	45	4.3	11.9	61	18.7	17.2	73	47.0	21.6	82	83.6
Black oak	E	3.2	25	.7	7.4	47	4.9	11.6	63	17.8	14.6	72	33.0			
	A	2.8	24	.5	6.6	45	3.7	10.2	61	13.4	13.0	72	30.3	17.2	76	48.9
Shingle oak	E	3.0	19	.5	6.6	41	3.3	10.2	58	12.5	13.8	68	28.0			
Ash	E	3.9	25	.9	7.9	44	5.1	11.6	58	15.9	14.7	68	31.5			
	A	1.5	15	.1	3.7	33	1.1	7.3	52	5.5	10.2	68	15.3	12.8	80	28.8
Hickory	E	2.4	12	.1	5.4	27	1.4	8.5	42	5.6						
	A	1.7	22	.1	4.2	40	1.6	6.8	52	4.8	9.6	63	12.0	12.3	72	23.8
Hard maple	A	1.8	18	.1	3.6	38	1.2	6.1	52	3.8	8.7	63	10.1	10.8	72	18.2
White oak	E	3.4	20	.5	7.2	40	3.8	10.8	55	12.2	13.8	65	25.5			
	A	2.4	20	.4	4.8	34	1.6	7.0	45	4.1	9.8	53	9.6	12.2	60	17.8

TABLE IV.

AVERAGE GROWTH RATES ON SAND IN ILLINOIS

A and E indicate all-aged and even-aged stands, respectively

Species	20 years			40 years			60 years			80 years		
	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.
White pine ......E	4.1	26	1.2	8.3	47	7.3	11.0	62	16.6			
Black locust ......E	5.5	38	2.2	11.4	60	16.1	17.1	73	46.5			
Black oak ......E	3.4	25	.7	7.6	46	5.1	10.8	54	13.6	14.0	57	22.7

Table V.

Average Growth Rates on Hardpan in Illinois

A and E indicate all-aged and even-aged stands, respectively

Species		20 years			40 years			60 years			80 years			100 years		
		D. i. b., In.	Height, Ft.	Volume, Cu. Ft.	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.
Black oak	E	3.2	25	.7	6.8	41	3.5	10.8	49	11.0						
Post oak	E	2.8	15	.3	5.8	32	2.0	9.0	42	6.1	12.0	54	18.8			
	A	2.4	14	.2	5.2	30	1.6	7.2	42	4.0	9.8	56	10.4	11.8	57	15.4

TABLE VI.

AVERAGE GROWTH RATES ON BOTTOMLAND LIGHT SOILS IN ILLINOIS

A and E indicate all-aged and even-aged stands, respectively

Species	20 years			40 years			60 years			80 years			100 years		
	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.
Cottonwood .....E	17.2	96	56.2	24.2	108	122.9									
Sycamore .....A	8.8	67	10.0	17.2	96	56.2	21.8	100	94.3	25.8	101	132.6			
Soft maple .....E	.....	43	.....	.....	78	53.0									
Elm .....A	2.2	24	.4	4.0	44	1.7	5.2	60	3.6	6.4	70	6.5	9.1	74	13.4

TABLE VII.

AVERAGE GROWTH RATES ON BOTTOMLAND HEAVY SOILS IN ILLINOIS

A and E indicate all-aged and even-aged stands, respectively

Species	20 years			40 years			60 years			80 years			100 years		
	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.	D. i. b., In.	Height, Ft.	Volume, Cu. Ft.
Water locust .....A	7.5	47	5.0	14.6	65	25.2	18.0	80	47.9						
Honey locust .....A	5.6	33	2.0	13.4	65	21.2	20.0	82	61.1	26.6	87	116.3			
Sofe maple .....A	5.0	34	1.7	11.2	63	16.6	17.8	80	55.0	22.4	90	98.1			
Pin oak.....E	5.8	34	2.2	13.8	62	21.4	19.8	83	60.6	24.2	88	97.6			
Pin oak.....A	4.0	27	.9	10.0	53	10.2	16.0	80	38.0	21.6	86	75.5	23.8	95	103.5
Ash .....A	3.8	25	.8	8.8	48	7.3	12.4	69	23.2	16.2	82	46.9	16.8	91	54.6
Schneck's oaks .....E	3.1	24	.4	8.3	47	6.1	15.0	68	28.0	21.4	82	70.2			
Swamp .....E	3.4	23	.7	7.6	46	5.1	11.2	61	15.9	14.2	67	29.0			
Spanish oak .....A	3.0	24	.6	6.2	45	3.3	9.0	60	10.1	14.0	70	30.0			
Hackberry .....A	2.3	26	.4	6.0	48	3.3	9.6	61	11.8	13.6	70	28.4	16.2	86	48.6
Elm .....A	2.8	22	.5	6.6	41	3.3	10.0	58	11.9	13.1	68	25.2	15.8	73	39.9
Tupelo .....A	3.0	19	.3	6.0	35	2.5	8.6	47	6.5	12.0	58	15.7	13.4	65	21.2
Hickory .....A	1.8	18	.1	3.8	35	1.2	6.6	53	4.6	9.8	67	13.9	12.0	75	23.8

An inspection of these growth measurements emphasizes the importance of eliminating the slow-growing species. The following list contains those slow-growing or otherwise undesirable species which are least suited to a place in the Illinois woodlot.

WEED TREES

Box elder	Hackberry	Black gum	Elm
Hard maple	Redbud	Hop hornbeam	Ailanthus
Buckeye	Dogwood	Shortleaf pine	Jack pine
Shadbush	Persimmon	Aspens	Crabapple
Pawpaw	Beech	Scrub oak	Tupelo gum
Birch	Butternut	Cypress	
Hickory	Red cedar	Arbor vitae	

Table VIII is a compilation of those species which are recommended because they have high growth rates and have the mechanical properties necessary for the production of the given product. The fastest growing species are listed first.

TABLE VIII

LIST OF SPECIES RECOMMENDED FOR SPECIFIC SOIL CONDITIONS AND PRODUCTS

FOR BOTTOMLAND			
Flooded for long periods		Not flooded for long periods	
Light Soils	Heavy soils	Heavy soils	Light soils
For Production of High-Grade Veneer Logs			
Red Oaks White oaks	Red oaks White oaks	Black walnut Red oaks White oaks	White oaks Red oaks
For Production of Posts			
Catalpa White oaks	Catalpa White oaks	Catalpa Mulberry Black walnut White oaks Sassafras	Catalpa Mulberry White oaks

FOR BOTTOMLAND—Continued.

Flooded for long periods		Not flooded for long periods	
Light Soils	Heavy soils	Light soils	Heavy soils
For Production of Piling			
Pin oak	Pin oak	Pin oak	Pin oak
Red gum	Red gum	Sycamore	Sycamore
Sycamore	Sycamore	Red oak	Red oak
Red oak	Red oak	White oak	White oak
White oak	White oak	Black oak	Black oak
Black oak	Black oak	Shingle oak	Shingle oak
Shingle oak	Shingle oak	Ash	Ash
Ash	Ash		
For Production of Ties			
Sycamore	Sycamore	Sycamore	Sycamore
Ky. Coffee tree	Ky. Coffee tree	Black walnut	Ky. Coffee tree
Honey locust	Honey locust	Ky. Coffee tree	Honey locust
Pin oak	Pin oak	Honey locust	Pin oak
Red oak	Red oak	Pin oak	Red oak
White oaks	White oaks	Red oak	White oak
Black oak	Black oak	White oak	Black oak
Shingle oak	Shingle oak	Black oak	Shingle oak
Ash	Ash	Sassafras	Sassafras
		Shingle oak	Mulberry
		Mulberry	Ash
		Ash	
For Production of Lumber			
Cottonwood	Water locust	Cottonwood	Sycamore
Water locust	Sycamore	Sycamore	Soft maple
Sycamore	Soft maple	Black walnut	Coffee tree
Soft maple	Coffee tree	Soft maple	Honey locust
Ky. Coffee tree	Honey locust	Coffee tree	Pin oak
Honey locust	Red gum	Honey locust	Red oak
Red Gum	Pin oak	Tulip	White oak
Pin oak	Red oak	Pin oak	Black oak
Red oak	White oak	Red oak	Ash
White oak	Black oak	White oak	Shingle oak
Black oak	Ash	Basswood	
Ash	Shingle oak	Black oak	
Shingle oak		Ash	
		Shingle oak	

FOR BOTTOMLAND—Concluded.

Flooded for long periods		Not flooded for long periods	
Light Soils	Heavy soils	Light soils	Heavy soils
For Production of Mine Timbers			
Sycamore	Sycamore	Sycamore	Sycamore
Coffee tree	Coffee tree	Coffee tree	Coffee tree
Catalpa	Catalpa	Catalpa	Catalpa
Honey locust	Honey locust	Honey locust	Honey locust
Red gum	Red gum	Red gum	Red gum
Pin oak	Pin oak	Black walnut	Pin oak
Red oak	Red oak	Pin oak	Red oak
Black oak	Black oak	Red oak	Black oak
White oaks	White oaks	Mulberry	White oak
Shingle oak	Shingle oak	Black oak	Shingle oak
Ash	Ash	White oak	Ash
		Shingle oak	
		Ash	
For Production of Slack Cooperage and Average Veneer Logs			
Cottonwood	Sycamore	Cottonwood	Sycamore
Sycamore	Water locust	Sycamore	Soft maple
Water locust	Soft maple	Soft maple	Coffee tree
Soft maple	Red gum	Coffee tree	Honey locust
Coffee tree	Honey locust	Honey locust	Ash
Honey locust	Coffee tree	Willow	
Red gum	Ash	Tulip	
Willow		Basswood	
Ash		Ash	
For Production of Cordwood			
Cottonwood	Sycamore	Cottonwood	Sycamore
Sycamore	Water locust	Sycamore	Soft maple
Water locust	Soft maple	Soft maple	Coffee tree
Soft maple	Coffee tree	Coffee tree	Honey locust
Coffee tree	Honey locust	Honey locust	Pin oak
Honey locust	Red gum	Black walnut	Red oak
Red gum	Pin oak	Pin oak	White oak
Pin oak	Red oak	Red oak	Black oak
Red oak	White oak	Willow	Shingle oak
Willow	Black oak	Tulip	Ash
White oak	Ash	Magnolia	
Black oak	Shingle oak	Basswood	
Ash		Black oak	
Shingle oak		White oak	
		Shingle oak	
		Ash	

Table VIII—(Continued)

List of Species Recommended for Specific Soil Conditions and Products

FOR UPLAND

Sandy Loams	Silt Loams	Sand	Hardpan
For Production of High-Grade Veneer Logs			
Black walnut	Black walnut		
Black cherry	Red oaks		
Red oaks	White oaks		
White oaks	Black cherry		
For Production of Posts			
Catalpa	Catalpa	Sassafras	Post oak
Mulberry	Mulberry	Black locust	
Black walnut	Black walnut	Osage orange	
White oaks	White oaks		
Sassafras	Sassafras		
Black locust	Black locust		
For Production of Piling			
White oak	White oak		
For Production of Ties			
Black walnut	Black walnut	Red oak	
Ky. Coffee tree	Ky. Coffee tree	Black oak	
Honey locust	Honey locust	Black locust	
Cherry	Cherry		
Red oak	Red oak		
Black oak	Black oak		
Shingle oak	Shingle oak		
White oak	White oak		
Sassafras	Sassafras		
Mulberry	Mulberry		
Black locust	Black locust		
Ash	Ash		
For Production of Lumber			
White pine	White pine	White pine	
Black walnut	Black walnut	Red oak	
Tulip	Tulip	Black oak	
Magnolia	Magnolia		
Black cherry	Black cherry		
Coffee tree	Coffee tree		
Honey locust	Honey locust		
Red oak	Red oak		
White oaks	White oaks		
Black oaks	Black oaks		
Basswood	Basswood		
Ash	Ash		
Shingle oak	Shingle oak		

FOR UPLAND—Concluded.

Sandy Loams	Silt Loams	Sand	Hardpan
	For Production of Mine Timbers		
Black walnut	Black walnut	Red oak	Red oak
Coffee tree	Coffee tree	Black oak	Black oak
Honey locust	Honey locust	Sassafras	Post oak
Catalpa	Catalpa	Black locust	
Sassafras	Sassafras		
Red oak	Red oak		
Black oak	Black oak		
White oaks	White oaks		
Mulberry	Mulberry		
Ash	Ash		
Black locust	Black locust		
	For Production of Slack Cooperage and Average Veneer Logs		
Coffee tree	Coffee tree		
Honey locust	Honey locust		
Tulip	Tulip		
Magnolia	Magnolia		
Basswood	Basswood		
Ash	Ash		
	For Production of Cordwood		
Black walnut	Black walnut	Sassafras	Red oak
Coffee tree	Coffee tree	Red oak	Black oak
Honey locust	Honey locust	Black oak	Post oak
Tulip	Tulip	Black locust	
Magnolia	Magnolia		
Black cherry	Black cherry		
Sassafras	Sassafras		
Red oak	Red oak		
Black oak	Black oak		
White oak	White oak		
Mulberry	Mulberry		
Basswood	Basswood		
Ash	Ash		
Black locust	Black locust		

EVEN-AGED SYSTEM OF SILVICULTURE

A silvicultural system is a broad plan of management under which a forest is reproduced and developed. The two general types of forests which can be developed are even-aged and all-aged. Even-aged forests contain trees of approximately uniform size, all of which reach harvesting maturity and are cut at approximately the same period; all-aged forests, as the name implies, contain trees of varying ages and sizes. No system based upon the idea of clear cutting is well suited to our Illinois woodlots. One important function of the woodlot is to supply the farm requirements for certain wood products. A clear-cutting system results in the formation of an even-aged stand, incapable of yielding any products until it has passed through the sapling stage. The returns from the even-aged stands are periodic, and the interval between periods of returns is so long that the interest compounded on the maintenance costs—protection, taxes, cleanings—may completely absorb all proceeds. To illustrate the influence of compound interest where returns are deferred: if taxes of $0.50 per acre per year are paid for 30 years while the stand is going through the sapling stage, the actual outlay for taxes totals $15, but the interest on these payments compounded at the rate of 5 per cent totals $18.44. On the average upland soils, at least 60 years are required to produce hardwood trees large enough for ties or small sawlogs. At $0.50 a year, the total outlay for taxes is $30 per acre, but the interest on this amount, when compounded over this period at 5 per cent totals $146.79. On this basis of calculation, only trees of exceptionally rapid growth and high value can show a profit when grown in even-aged stands. A discussion of the even-aged system follows.

Even-aged woodlots are common throughout central and northern Illinois. The economic conditions by virtue of which such stands originated and developed are rapidly altering and should force the complete clearing of these stands on the high-grade agricultural land and should lead to their alteration to all-aged stands on the true forest lands. During the three decades prior to rail transportation when the tide of immigrants settled the prairies, there was a tremendous drain upon the local forests, amounting almost to clear cutting. The plow at the same time stopped the sweep of destructive fires, and the removal of the old forest and the cessation of fire was closely followed by the natural reestablishment of young trees. With the advent of the railroad, these young trees were permitted to grow, since construction materials and fuel requirements were supplied from other regions. Pressure for cleared land has subsequently resulted in clearing arable areas occupied by this second growth, thus incidentally supplying the farm with certain wood products, but very little cutting has been done in the stands which remain. The majority of these even-aged stands grow on upland sites and are between 60 and 90 years in age, and the diameters fall between 8 and 18 inches.

EVEN-AGED STAND OF YOUNG WHITE OAK.

Ground carpeted with leaves and well shaded by heavy stand of trees.

As the timber famine becomes more acute, the farmer will draw upon these woodlots for his requirements, gradually changing them to all-aged woodlots. But since the even-aged type usually follows clear cutting or the natural and planted reforestation of abandoned fields, there will always be stands of this character.

The practice of growing wood crops in even-aged stands is more applicable to bottomland than to upland regions. On the bottomlands subject to inundation, natural regeneration after a clear cutting is a certainty, although it is very difficult to control the kinds which seed in, because the floodwaters deposit seeds from outside sources and carry away seed from local sources. Plant growth on such bottomlands is usually rank—weeds, vines, and worthless trees are very aggressive—and under an all-aged, or selection, system constant work is necessary to prevent the useless species from suppressing the useful. The unbroken canopy of the even-aged stand offers less favorable conditions for climbing vines. Certain useful bottomland species have very rapid growth rates; yet these trees are often intolerant of shade, developing better in even-aged stands. Finally, tall straight stems suitable for piling can best be developed in even-aged bottomland stands. Under these conditions it may be expedient to use an even-aged system.

The management of even-aged stands is less complex in many respects than that of all-aged stands. The process may be divided into (1) development of the crop, (2) harvesting, and (3) reestablishing of a new crop. The proper development of the crop is attained through protecting the area so that an abundance of trees may grow and through the judicious use of the axe so that the maximum growth may be concentrated on the trees which are carried to the final harvest. The natural reestablishment of a new crop can usually be secured by observing a few rules at the time of harvesting the old crop.

Development of an Even-aged Stand

The stand on the well-stocked acre starts with several thousand small trees. In a few years these become a thicket of saplings. The struggle for light at this stage is very intense, as each tree races upward in the effort to overtop its neighbor. When the polewood stage is reached, there are approximately 400 trees per acre, ranging in diameter from 2 to 10 inches. The increasing height brings added difficulty in transporting supplies from root to crown, and the height growth slows down. At this stage, trees must have room to expand laterally in order to make the best growth; hence, thinnings should be made. This is the opportunity to insure the representation of desirable trees in the final crop by cutting into the following classes: (1) undesirable species (see p. 118), and (2) trees of desirable species but poor form. The forest tree should be tall and straight with a relatively short crown and a long stem. The thriftier trees of the desirable species which should be carried to maturity

are less than half the number present, but the rule should be to thin lightly, cutting only those trees which are directly interfering with the development of the select trees. In general, not more than a quarter of the trees should be taken out in any thinning, and the crowns of the trees left should close the canopy in 5 or 6 years. All material which can not be utilized should be left on the ground to decay. It should not be burned except in the emergency of insect or disease attacks. When it is evident that the trees are again suffering from crowding, other thinnings should be made. The average numbers of trees per acre on unmanaged even-aged stands at different decades are shown in Table IX.

The heavy mulch of leaves and humus, a characteristic of good forest conditions, can not be maintained if excessive thinnings occur. The appearance of grass and weeds in abundance after a thinning is evidence that it was excessive. Even-aged stands are often free from an understory of bushes and shrubs, and if not, the owner considers it good practice to clear them out. *Such an understory should not be cleaned out.* It protects the forest floor by its shade and retards the movements of drying air. Indeed, it is advisable to provide a thicket of bushes along the southern and western borders of the woodlot exposed to dry winds prevailing from these points.

Harvesting the Crop

Under the even-aged system a stand may be harvested in a single operation or by a series of cuttings. Such cuttings should not be extended over too long an interval—more than 20 years—since young trees usually appear after each cutting and the succeeding stand loses its even-aged character.

Reestablishment

Following the removal of an even-aged stand, the area may be restocked by sprouts or seedlings or both, or restocking may fail completely; therefore, a knowledge of conditions favorable to regeneration is essential to intelligent management.

REGENERATION FROM SPROUTS

Common Illinois hardwoods show a capacity to send out sprouts when trees are cut under certain conditions. These sprouts grow rapidly for several years, but trees developing from them do not eventually attain the dimensions of trees grown from seedlings, and rot commonly enters the sprout through the decay of the stump to which it is attached. The sprouting capacity weakens and is lost as the tree matures. For these reasons, stands of sprout origin are not well suited to the development of trees for the larger logs, nor can stands be renewed through sprouts from these larger stumps.

This method of regeneration is, however, silviculturally suited to stands handled on a short rotation for the production of posts, cordwood, and mine timbers. The trees should be cut during the dormant season;

Table IX. Average Yields from Even-aged Stands in Illinois

Age Years	No. of trees per acre	Height of dominant trees Feet	D. B. H. of average trees Inches	Basal area per acre Sq. Ft.	Yields per acre in peeled stems Cu. Ft.	Average annual increment Cu. Ft.
	(Upland) Post Oak Type. (Based on 14 Plots)					
20	1,025	22	2.8	45	250	12.5
30	775	29	3.6	56	420	14.0
40	605	35	4.4	63	610	15.2
50	470	40	5.1	67	775	15.5
60	360	43	5.9	69	950	15.8
70	285	46	6.8	71	1,150	16.4
80	235	49	7.5	73	1,360	17.0
90	195	51	8.4	75	1,550	17.2
100	170	52	9.1	77	1,780	17.4
	(Upland) Scrub Oak Type. (Based on 23 Plots)					
20	1,035	25	2.9	47	450	22.5
30	670	36	4.0	59	775	25.8
40	400	46	5.6	68	1,075	26.9
50	260	54	7.3	75	1,400	28.0
60	180	61	9.1	81	1,750	29.2
70	120	67	11.6	88	2,075	29.7
80	90	72	13.8	93	2,375	29.7
90	75	74	....	...	2,650	29.4
100	65	77	....	...	2,920	29.2
	(Upland) Upland Hardwood Type. (Based on 34 Plots)					
20	1,010	36	3.6	72	810	40.5
30	630	47	4.8	79	1,175	39.2
40	400	55	6.5	84	1,520	38.0
50	250	61	8.1	89	1,870	37.4
60	185	66	9.5	94	2,175	36.2
70	155	70	11.0	99	2,500	35.7
80	130	73	12.5	103	2,825	35.3
90	110	75	13.9	106	3,125	34.7
100	100	78	15.6	109	3,425	34.2
	(Bottomland) Rapidly-Growing Species. (Based on 8 Plots) Cottonwood, Sycamore, Soft Maple, Honey Locust, Sweet Gum					
20	450	75	6.0	87	2,450	122
30	290	82	8.6	118	3,400	113
40	230	87	10.2	130	4,180	104
50	205	90	10.9	137	4,930	99
60	190	92	11.7	143	5,600	93
70	165	94	12.7	146	6,150	88
	(Bottomland) Slow-Growing Species. (Based on 11 Plots) Oak, Elm, Ash, Hickory					
20	1,100	42	3.5	74	1,075	54
30	530	53	5.4	84	1,560	52
40	330	62	7.1	92	2,000	50
50	250	69	8.5	98	2,375	47.5
60	200	76	9.7	104	2,675	45
70	170	81	10.8	109	2,950	42
80	145	85	12.0	113	3,225	40
90	125	88	13.0	116	3,500	39
100	110	91	14.0	118	3,750	37.5

the stumps should be low, and it is preferable to cut the top of the stump on a slant to allow water to drain off. Trees cut during the growing season exhibit a weakened sprouting capacity, and the sprouts are frequently killed by the autumn frosts before the tender tissues harden. Sprouts from low stumps are usually more vigorous, and conditions are less favorable to the decay of stems than in trees growing from high stumps. The sprouting capacity varies for different species, but, in general, stumps should not be more than a foot in diameter for good results. It usually happens that too many sprouts develop and a thinning becomes necessary. This should be made in the early sapling stage when the crowns are closing and crowding each other. The object is to leave plenty of thrifty stems to form the stand but to cut out the less desirable ones which are crowding the others. Frequently the thinning is cheapened by lopping off the tops of undesirables with a machéte or a bush hook sufficiently to check them and permit the desirables to get above them.

REGENERATION FROM SEED

In case the stand is carried past the period of vigorous sprouting—about 60 years for most species—, provision should be made for seedling reproduction or for replanting. The two different methods of securing natural seedling regeneration are as follows:

1. When the old crop is removed in a single cutting, the operation should take place after the trees have matured a heavy seed crop. Since heavy seed years vary somewhat for different species, best results are attained by selecting the species which is sufficiently well represented to insure the proper amount of seed production and which is the most desirable tree to grow, and then by clear cutting the area immediately after this species has matured a heavy seed crop. The layer of leaves which covers the ground under normal forest conditions is very favorable to the establishment of heavy-seeded trees, such as the oaks and other nut trees; it is unfavorable to the seeding in of elm, ash, tulip, and other light-seeded trees. In logging the area, the ground will be torn up somewhat, making spots favorable for the establishment of seedlings. The device of burning this leaf carpet will secure excellent results for light-seeded species *if a favorable seed year is followed by a moist growing season;* but this combination can not be assured. Therefore, as a failure to re-establish the forest under natural seeding is irrevocable after the seed trees have been cut, *a burning is not recommended.*

2. In order to positively insure the satisfactory restocking from the trees of the crop to be harvested, the stand can be harvested in two operations. The first cutting removes about 40 per cent of the total number of trees and, by opening up the stand, creates light and heat conditions favorable to the establishment of seedlings. The trees removed in this first cutting are those of undesirable species or form; the 60 per cent left should give character to the succeeding stand. When seedlings appear abundantly in the openings, these remaining trees are removed. Since

all seed trees are not cut until seedlings are established, this is the safest method of securing seedling regeneration from an even-aged stand. Under this system a light burning previous to the falling of the seed crop is justified where the leaf litter is heavy and where it is desired to secure seedlings from light-seeded species.

Application of the Even-aged System

Species suitable for production of piling

Temporary piling includes any sound timber that will stand driving, such as ash, beech, birch, cherry, sap cypress, sap white oak, red oaks, maple, black gum, and sycamore. In the application of the even-aged system to the production of piling, the object is to grow tall straight trees. Trees of this form can best be produced on fertile bottomland sites. Red gum, pin oak, and sycamore, especially in youth, develop a long narrow crown, and the main stem continues to the top. A great number of trees of this form can be grown per acre; consequently, for piling production these species rate high.

Planting, or artificial regeneration, is not economically justifiable; hence, dependence must be placed upon natural regeneration. An abundance of seedlings can be secured on cleared bottomlands if light and soil conditions are favorable; a full stand is assured on all cleared, unsodded floodlands, but usually the stand is a mixture of many species. To produce tall straight stems, the trees should crowd each other during the sapling and polewood stage, so that no heavy side branches are formed. Thinnings can usually begin when the larger trees of the stand are a foot in diameter breast high (12 inches D. B. H.).

Pin oak on fertile bottomlands produces a 30′ to 35′ pile in forty years, and unmanged stands contain as many as 60 trees to the acre suitable for piling.

Intolerant species, exemplified by cottonwood

Those tree species which are not shade-enduring are classed as "intolerant". Sycamore and soft maple belong in this class, but the Carolina poplar, or cottonwood, is the outstanding example of a rapidly-growing intolerant tree which should be grown in even-aged stands. Cottonwood trees make phenomonal growth on all but the heaviest bottomland soils, the logs find a ready market at excellent prices at mills specializing in fruit and egg containers, and the cordwood furnishes 50 per cent of the pulpwood grown in Illinois. Cottonwood has been successfully grown in plantations by the prairie farmer, has been developed into a profitable commercial project in South America, and is being developed commercially on Illinois bottomlands. There is no wood crop in Illinois which promises better returns than this species.

Cottonwood seeds in naturally on bottomlands where the moist mineral soil is exposed to full sunlight. It does not seed in on ground covered with a layer of leaves or a heavy growth of weeds, nor will it survive if planted under the shade of other trees. Pure stands have come in naturally on river bars and similar deposits and on patches of abandoned plowland. The embankments of levees and drainage ditches are quickly marked by a line of cottonwoods. This species grows best on the alluvial sandy-silt loams; it grows well on alluvial sands and loams, but poorly on ill-drained alluvial clays. Although well able to grow on the floodlands subjected to repeated inundations, cottonwood does not grow in swamps where water stands continually or on the very poorly drained clays otherwise well above water level.

Cottonwood matures an abundant crop of seed practically every year during the latter part of May and the early part of June, but these seeds must find favorable seed-bed conditions immediately, for they begin to lose their vitality within a week and are dead within a month. The pistillate, or seed-producing, flowers are borne on different trees from the staminate flowers. At maturity the pods open and liberate immense quantities of tiny brown seeds. Each seed is provided with a tuft of long silky hairs which enables it to be readily carried long distances by the wind. Ripening at a period when the larger rivers are at flood, the seeds are also transported long distances by water; but floods may also submerge an area past the germinating period of the seed, thus effectually keeping cottonwood out. This, together with the aggressiveness of weeds on open bottomland areas, has led to the practice of *planting* such areas to cottonwood rather than depending upon a natural seeding. The methods of planting are outlined on pp. 152-154.

When light and soil conditions have chanced to be just right, cottonwood has come in on bottomland sites in immense numbers; but since it is a tree which requires abundant sunlight throughout its life, only a very few of the most vigorous trees survive the sapling stage; the stand then opens up, and less valuable but more tolerant trees grow as an understory. A bad cutting practice of harvesting all trees above a merchantable diameter has been developed to conform with market conditions. A few years later some of the survivors have reached a merchantable size and are cut. Meanwhile, the shade has been sufficient to keep out cottonwood seedlings, but insufficient to keep out elm, soft maple, hackberry, and other less valuable trees. This cutting practice should be changed to a single clear cutting followed by a fire which thoroughly cleans off the ground cover in order to create seed bed conditions favorable for another crop of cottonwood.

SELECTION SYSTEM OF SILVICULTURE

The system generally best suited to the woodlot is termed the selection system. It consists in harvesting trees singly or in small groups and in regulating the cuttings so as to bring the stand to produce about the same number of mature trees in each cutting period. In the fully-stocked woodlot the total amount cut at any time should balance the total amount grown since the previous cutting was made. Under intensive management the mature trees are harvested annually; hence, the total amount of wood per acre removed should equal the annual growth of the acre. The usual practice is to fix a minimum diameter limit and to cut each year all trees which attain this limit, carrying on at the same time such cuttings in the lower-diameter classes as may be necessary to facilitate the growth of the trees to be carried to maturity and to free the stand from undesirable trees. Under this method the woodlot contains trees of many sizes; thus the diverse requirements of the farm can at all times be supplied. Since some trees are harvested annually, the value of these can be balanced against the annual maintenance costs—protection, taxes, cleanings—, and there is no compounding of interest over long periods.

General Cultural Measures

Whether the woodlot be managed for the production of the small products, such as cordwood, posts and mine timbers, the intermediate products, such as ties, piling, ordinary sawlogs, or the large products, such as veneer logs, the general cultural measures are similar. The first concern should be to insure proper conditions for regeneration. This means, first of all, the absolute protection of the area from fire and grazing. Under natural forest conditions, where fires and live-stock are kept out, the layer of leaves gives place to a rich, moist layer of partly-decayed organic matter, under which is the mineral soil. Small seeds to some extent sift through the layer of leaves; the sprouting acorn or nut can push through to the rich humus and finally to the mineral soil. The removal of this layer of leaves and the exposure of the humus or bare mineral soil is usually highly conducive to the establishment of seedlings, but the leaves should not be removed, because satisfactory regeneration can usually be established with the leaves present and because the injury to the soil through the destruction of leaves and humus outweighs all benefits.

Where fires have repeatedly run through the woodland or cattle have freely grazed, the conditions are quite different. Instead of a mellow moist soil, there is hard dry surface or, if sufficient sunlight, a sod. Keeping fire and cattle out will usually bring back the forest trees if there is no sod; but, if a sod has formed, more intensive measures are

ALL-AGED, OR SELECTION, TYPE.

Ground carpeted with leaves. Abundance of trees.

necessary to restore the forest, as germinating seeds can not establish themselves under such conditions. Any agency which breaks up the sod, be it harrow or hogs, is useful; but the best means and often the only sure method of securing regeneration is to plant seed or seedlings in spots from which the sod has been removed. Where the woodlot is managed for the production of small products, satisfactory regeneration can be secured largely from sprouts. When managed for the production of medium and large products, this method can not be depended on, as the larger stumps do not sprout vigorously and the trees which develop from sprouts, although growing rapidly until the polewood stage is reached, do not develop into mature trees as large as those from seedlings.

After the woodlot has been managed under the selection system for a period long enough to secure good forest conditions, abundant natural reproduction is a practical certainty, and management will consist largely in trying to insure the establishment in sufficient numbers of the most desirable species. The rather common practice of marketing the valuable species from the woodlot without taking any positive steps to reestablish a valuable successor has resulted in a two-fold evil. The unmerchantable or low-grade species practically dominate the mature classes and deluge the area with seed. Thus the trees remaining in the woodlot have a low value, and these inferior species will perpetuate themselves and make up the succeeding stands. Management aims to correct this condition by weeding out the inferior species, thus lessening the seed supply and decreasing their representation in the reproduction, and by securing the establishment of desirable species, even resorting to planting when natural reproduction is not wholly successful.

Since, under the selection system, the aim is to manage the woodlot so as to bring about the same number of trees to cutting maturity each year, the area occupied by each age class should be approximately the same. If the average time required to grow trees suitable for mine timbers, cordwood and posts is 40 years, then each age class would occupy one-fortieth of the area. In actual practice this exact adjustment of age classes can not be attained, because of irregularity in regeneration and variation in growth rates, and because the annual yields from small areas often are insufficient to justify an annual cut. Although in theory the area occupied by each age class is the same, the number of trees in each age class is not. On average upland loams there will be something like 42 one-year-old trees and but 10 forty-year-old trees on the acre. In the case of such small products as mine timbers, cordwood, and posts requiring 40 years, only 400 out of 1000 trees are brought to maturity. In the case of sawlogs requiring 80 years, there are 600 trees per acre, 130 of which are carried to maturity. In the case of veneer logs requiring up to 150 years, only 80 would be carried to maturity out of a total of 367 trees. Since from 60 to 80 per cent of the total number of trees fail to reach maturity, it is not necessary to have more than half the reproduction of desirable species. Thus, for small products, it would be

considered satisfactory regeneration if 20 trees per acre of a desirable species were established annually; for logs, 4 trees; and for high-grade veneer, one tree of a desirable species per acre properly located will suffice. The young trees of the desirable species should, of course, be located in the openings formed by the removal of the older trees. Frequently, well-located young trees, which have become established before the older trees are removed, provide satisfactory successors to the matured trees. Commonly, young trees in abundance will appear in any opening; but if these are wholly of undesirable species or if, as in rare cases, reproduction fails, it is advisable to plant seed or seedlings. Methods of planting seed and young trees are described on pages 138-142.

The establishment of desirable trees in sufficient numbers is half of silviculture; the other half consists in creating light conditions such that the trees to be carried to maturity will require the shortest time consistent with the production of trees of good form. Openings will always be made in the forest by the removal of mature trees and of other trees of undesirable species, but one of the cardinal principles of cuttings should be to make as few openings as possible where the direct sunlight can reach the forest floor. Although from 60 to 80 per cent of the trees which start will not be carried to maturity, these trees perform the useful service of shading the forest floor and preserving moisture conditions decidedly beneficial to soil enrichment as well as to tree growth; and, in addition, by lateral crowding of the select trees during their immaturity, these others force them to rapid height growth and development into trees of good form. On the other hand, the competition for growing space between all trees is keen, and, if unaided by thinnings, many of the desirable species will be crowded out by less desirable ones. Hence it is advisable to let all trees grow until such a time that the proper development of the select trees can not continue because of lack of crown space, and then to cut the undesirable trees which are competing with the select ones. The number of trees per acre or the regularity of spacing of the trees does not indicate whether the stand should be thinned, but rather the growing space available to the crown is the factor determining the necessity of a thinning. The critical examination is overhead. The rule should be to make light cuttings often rather than to depend upon heavy thinnings at longer intervals. Only through experience can the individual develop the skill and judgment by which he determines when crowding ceases to be a stimulus to height growth and becomes a check to proper development. Unutilized tops of felled trees should not be piled and burned, unless burning must be resorted to in order to check insects and fungous diseases. The brush should be scattered to lie close to the ground in order to facilitate decay. In woodlots managed for the production of cordwood, posts, and mine timbers, such thinnings would give products of little value; but in woodlots managed for the production of ties and logs, these thinnings should provide posts, cordwood and mine timbers.

Fixing the Diameter Limit

The diameter of a standing tree is customarily taken outside the bark and at a point 4½ feet from the ground. This is known as the diameter breast high, or D.B.H, and affords a convenient basis of classification. If the stand is kept fully stocked in the smaller-diameter classes, and if the area occupied by each class is approximately the same, then, by fixing a diameter to which the select trees must grow before they are harvested, equal quantities can be harvested each year, yet the cut is automatically balanced by growth.

Not only are there certain products which give higher returns than others, but also the returns per acre, even for a given product, vary with the diameters of the trees harvested. The individual tree is unmerchantable for a definite period of its immaturity; after it attains merchantable dimensions, the value increases rapidly as the tree increases in size. The higher value is due to the added growth and to the higher quality of growth. This increase in value continues as long as the tree remains sound and continues growth. Offsetting this increase in value as the individual tree gains in size is the fact that fewer large trees can be grown per acre. A refinement of management consists in fixing the diameter limit at the size which gives the greatest returns per acre.

The accurate defining of the correct diameter limit for any given product and region requires a knowledge of the average time required to grow a tree to each diameter, the number of trees of any given diameter which can be grown on an acre, the quantities of the product which are produced per tree and per acre for each diameter class, and, finally, the net value of the product. The problem is further complicated by the constant increase in the value of forest products, an increase which often justifies holding trees beyond the time dictated by factors of natural growth. The local influence of market conditions, together with the variation in the composition of different stands, permits the application of only very general statements to individual woodlots. It is a fact, however, that the smallest diameter at which a tree becomes merchantable almost never corresponds to the diameter at which the tree would give the best returns. It is not wise to cut thrifty trees of the lower-diameter classes which may be merchantable.

ADVANTAGE OF LARGER DIAMETERS

The rapid increase in value of the individual tree after it enters the merchantable class is brought out in studies of black oak on upland loam in Illinois Such a tree having a D. B. H. of 10″ averages one tie worth $0.50; a 12″ tree averages two ties worth $1.60; a 14″ tree, four ties worth $3.80; a 16″ tree, four ties worth $4.90; an 18″ tree, five ties worth $5.70. It takes 52 years to grow

the tree producing the $0.50 tie, and 103 years for the tree producing the $5.70 value. If the 10-inch tree is cut, the gross annual returns per tree approximate one cent; if the tree is allowed to grow to 18 inches, these returns are approximately 5½ cents per tree.

No information exists as to the number of trees per acre which can be grown to 10" D. B. H. in 52 years under the selection system, or to 18" D. B. H. in 103 years. In the absence of reliable data on the average number of trees per acre of a given diameter which can be matured yearly where the selection system has been practiced, recourse must be had to the data collected from fully-stocked even-aged plots. Table X gives data for such plots on upland loams in this State, the tabulation being in terms of the average D. B. H. of the stand. The average D. B. H., made up from all trees on the plot, includes trees of several diameters, and the yields assume that all trees which have attained a merchantable diameter will be cut, whereas in the selection system only those trees which reach the diameter limit chosen as the most desirable will be harvested. In order to make the data from even-aged stands directly applicable to a selection cutting, the rather doubtful assumption must be made that the number of trees on the even-aged plot of a given age and average D. B. H. is equal to the number of trees actually brought to this diameter in a selection forest over the same period.

The number of ties which can be harvested from the larger tree until the 15-inch class is reached more than makes up for the decrease in the number of trees per acre. Above this diameter the increase in the number of ties per tree is not enough to offset completely the decrease in the number of trees per acre, and the total tie yield per acre decreases. Converted to gross returns, however, it often happens that the increase in value due to the higher quality of ties which can be secured from the larger-diameter classes may carry optimum gross returns into a larger-diameter class than that for the maximum number of ties. The interplay of quantities and quality, as measured by gross annual returns per acre for ties shown in column 6, indicates that under average conditions of growth the upland woodlots give the highest gross returns on a 15-inch diameter limit. At this diameter these returns per acre are 1.65 times those when a 10-inch diameter limit is used.

The same general principle, that it is not profitable to cut the low-diameter classes merely because there happens to be a market for them, holds for other products. Rather limited studies of black walnut on sandy loams in this State indicate that 1.58 trees averaging 14 inches on the stump can be matured per acre annually. Such trees average 50 years in age, and the average annual yield per acre is 63 B. F. of lumber logs worth $3.15 at the mill. If trees are carried until they attain a 26-inch diameter, only .57 trees per acre can be matured annually, and such trees average 140 years in age, but the average annual yield *per acre* is increased to 214 B. F. of veneer logs and 16 B. F. of lumber logs, totaling $23.54 at the mill. Thus the acre managed on the 26-inch diameter limit gives a gross return of 7.47 times that from the acre on the 14-inch diameter limit.

Table X.

Yield of Ties per Acre on Upland Loam under Various Diameter Limits

Diameter Limit	Height of Dominant Tree	Age	No. of trees annually reaching diam. limit per A.	No. of ties annually harvested per A.	Av. annual gross return per A.	Av. annual gross return per tree
Inches	Feet	Years				
10	67	63	2.78	2.78	$2.28	$.013
11	70	70	2.21	3.24	2.89	.018
12	72	77	1.75	3.64	3.29	.024
13	74	84	1.43	3.83	3.55	.030
14	76	91	1.21	3.98	3.73	.034
15	77	97	1.06	4.02	3.76	.036
16	78	104	0.95	3.92	3.70	.039
17	78	111	0.86	3.80	3.60	.042
18	79	117	0.80	3.73	3.50	.044

PLANTING TO REENFORCE HARDWOOD STANDS

Up to this point in the discussion of woodlot management, it has been assumed that natural reproduction is possible and advantageous, but there are conditions where planting must be resorted to. Tree planting on the farm may be divided into two classes: (1) reenforcement planting within the woodlot, and (2) planting of cleared areas. The first of these will be discussed here, and the second on pages 143-163.

The principle to be followed in reenforcement planting within the woodlot is to use those species which are not only adjusted to local soil and climatic conditions but which are also able to compete successfully with the associated native trees and to reproduce naturally under forest conditions. The conifers do not qualify for reenforcement planting among all-aged hardwoods in Illinois, because those having a sufficiently high rate of growth and value are intolerant of shade and are not well suited to woodlot conditions, nor will they reproduce and hold their place in a hardwood mixture. Black walnut, basswood, and red oak are recommended for woodlot reenforcement on those soils and sites adapted to these species as shown in Table VIII, p. 118. To these may be added tulip poplar in the southern part of the State.

Black Walnut

Black walnut is by far the best native hardwood for reenforcement planting. The tree can easily be grown from nuts, the wood is suitable for farm requirements, and the growth rate is relatively rapid. Logs of black walnut command a price virtually double that of any other native hardwood, and good markets are accessible. A large percentage of the walnut now being marketed is coming from open-grown trees, and the practice is general of leaving seedlings which spring up in vacant places along fences or in pastures. Farm owners have found that walnut trees set out in plantations on high-grade arable land do not give returns at all comparable to those from ordinary crops, but that trees standing individually or in groups along roads, fences, streams, and hollows, or scattered about in the permanent pasture, are a source of revenue and warrant the slight positive effort necessary to increase their representation in such waste places. A walnut takes up no more room than an elm or hackberry and has a much higher market value.

Black walnut is rather exacting as to soil requirements. It grows best on deep, fertile, well-drained loams with a stable moisture supply, such as are found along the flood-plains of the smaller streams, or in hollows and sheltered coves receiving the wash from adjacent uplands. It makes exceptionally rapid growth on sandy loams. It grows well on the moderately fertile, yellow and yellow-gray, silt loams characteristic of the

rolling uplands of the timbered regions, and on well-drained, dark, prairie loams. It does not grow on sands or hardpan soils where acidity is high and moisture conditions are variable, nor on swampy areas.

This species is also somewhat exacting as to light requirements. The seedling can persist under an overwood but requires full overhead light to develop; therefore, in reenforcement planting in a hardwood stand, walnut should be started in openings large enough to insure such light. This species should be used to supplant other trees which are removed, but there is a limit to the number which should be grown on an acre. It is a space-demanding tree, for the long branches extend almost at right angles to the axis. The canopy is also relatively open, so much so that in pure walnut stands enough light comes through to support grass. It can be grown in groups, but not more than half of the stand should be of walnut if proper forest conditions are retained.

When grown in the open, the tree has a short trunk and wide-spreading crown. A tree developing a long clear bole can be produced by pruning off the lateral branches close to the trunk while the tree is in the sapling stage, or by pinching off the new lateral shoots as they develop during spring.

Tulip Poplar and Basswood

Tulip poplar and basswood are not valuable for ordinary farm requirements but are special-purpose woods, and should be grown in those woodlots tributary to a market. Good markets for tulip logs exist in southern Illinois and for basswood logs in both southern and northern Illinois. The natural range of tulip is limited to the southern part of the state, while basswood is of state-wide occurrence. Tulip is slightly more exacting as to soil and light requirements, but both species occur on all but extremes of sands and hardpan soils, and each can naturally establish itself and grow in hardwood mixtures. Tulip must have direct overhead light, being very similar to walnut in this respect. Basswood is rather shade-enduring, and can grow on heavier clays and wetter situations than tulip or walnut, commonly being found on the stream banks as well as on the uplands.

It is not advisable to plant basswood or tulip seed directly in the woodlot, because the germination of the former is often delayed until the second year and the germination of the latter is uncertain. Other less desirable seedlings meanwhile establish themselves. Seeds should be planted in a seed bed as described on pp. 141-142. The proper time for sowing is in the fall. The proper number of seeds per foot of row is shown in Table XI (p. 142). In order to produce sturdy stock well able to compete in the woodlot, it is advisable to let the young trees grow two seasons in the seedbed, after which they can be transplanted to the woodlot.

OAKS

Red oak, although it is a wood of only medium value for either farm or market purposes, is recommended as a sort of general-purpose tree, because it is one of the most rapidly growing oaks, because it can be easily grown on a wide range of soil conditions, and because its wood has so many uses that markets exist everywhere in the State. It is subject to destruction through the attacks of a flat-headed borer and should not be used in those localities where this insect is killing the black and red oaks. Reenforcement can be made by planting acorns during the spring.

METHODS OF PLANTING

The term reenforcement planting has been used for planting done in openings where natural reproduction is not assured. On such blanks, once the desirable species is planted, there is but little danger that reproduction of undesirables will crowd it out. But woodlot improvement does not stop with the operation of filling up the blanks with seedlings of valuable species. Such seedlings can be established where an abundance of reproduction of an undesirable kind exists. In this case the undesirable reproduction must be cleaned away from the valuable in order that the latter may properly develop. Such a cleaning should occur at the time when the planting is made and be repeated at any stage of the competition when the undesirables overtop the planted trees.

When the nut trees and oaks are used, the better method consists in planting the seed where the trees are needed. For basswood, tulip, and other light-seeded trees, the better method is to transplant seedlings where trees are needed.

The acorns of the white oaks germinate in the fall and must be planted at this season; spring is the best time to plant acorns or nuts of the other oaks and nut-bearing trees, as fall-planted seeds are subject to rodent destruction. The seed should be collected in the fall. It is a good plan to place acorns in a vessel of water and discard those which float buoyantly, as this minimizes the number ruined by insects. To store nuts or acorns over winter, place them outdoors in a small heap on a slight elevation where water will not stand, and preferably on well-drained sandy soil. Place a layer of straw or leaves over them and then throw dirt on this, but leave places where the straw ends project out at the side of the mound to insure ventilation. Freezing does not injure them, but as soon as the frost leaves the ground in the spring they must be planted, because acorns especially will quickly sprout at this time. Most of the black walnuts sprout the first year, but some walnuts will carry over and sprout the second year. In planting, two or three

nuts are placed in a slight excavation where the tree is to be grown, and about 2 inches of soil packed over them. If squirrels are troublesome, it is advisable to make several seed spots where ultimately but a single tree may stand, or to protect the nuts by covering each one with a tin can from which the lid has been removed. A crisscross incision in the bottom of the can is made with an axe, the can is placed upside down over the planted nut, and the tree grows through the hole punched in the bottom. The can rots away before the tree attains a large diameter.

Growing Hardwood Planting Stock

Customarily those trees which have small seeds are raised in a seedbed during the first year and transplanted to the woodlot as seedlings. Elm, soft maples, willows, and cottonwoods ripen their seeds between April and June, and since these seeds are relatively perishable they should be planted immediately. The seeds of virtually all other native hardwoods can be planted in the fall. The ideal soil is a well-drained, mellow, sandy-loam, garden soil. It should be tilled until the soil is thoroughly pulverized, then raked level, and the seeds should be sown in rows to a depth two or three times the thickness of the individual seed. The rows should be about one foot apart for hand cultivation or three feet if horse cultivation is used. The object is to secure a seedling for every four-fifths of an inch of the row, and to do this requires a knowledge of the germinating capacities of seeds of the species used. See Table XI.

For fall-sowed seed, a mulch consisting of two or three inches of leaves is advisable, but this should be removed before the seeds germinate

Table XI.

Number of Seeds to Sow to Secure 15 Seedlings to the Foot

Hardwoods

*Species	No. of seed to sow per foot of row	Species	No. of seed to sow per foot of row
Yellow poplar	150	Honey locust	23
Sycamore	50	Catalpa	20
Basswood	30	Black locust	23
Maple	30	Elm	23
Mulberry	30	Cherry	20
Ash	25	Hackberry	20
Coffee Tree	25	Osage orange	20
Red gum	25		

* Based on Table 8, U. S. Dept. Agr. Bulletin 1123.

in spring. The same weeding and cultivation should be given as is practiced to insure the success of garden crops. One growing season in the seed bed produces stock of the size most convenient to handle. Stock can be left in the seed bed over winter without mulching. Transplanting should be done in spring as early as possible after the frost is out of the ground. In lifting seedlings from the bed, care must be taken to minimize root injury; the trees should never be pulled up but should be turned out by a spade. They should be transplanted immediately and the roots kept moist while out of ground by covering with wet sacking, moss, or other moisture—retaining matter.

GULLIED, WORN-OUT, LOW-GRADE SOILS SHOULD BE PLANTED TO TREE CROPS.

PLANTING CLEARED AREAS

Two disturbing consequences of forest and land exploitation are forcing a consideration of tree planting on cleared areas. As the forests diminish, the prices of forest products go up until eventually they reach such a height that wood can be grown as a crop at a profit. This is the commercial aspect of reforesting cleared areas. But also, following the development of a region into farm lands, soils from the upland fields wash and are deposited over the choice bottomlands, or sands are blown over adjacent fields, so that the protective aspect of reforesting becomes important. In most instances where protective forests are needed, it is possible to use species which promise commercial returns as well.

COMMERCIAL ASPECTS OF REFORESTING CLEARED LAND

The chief deterrent to landowners undertaking the project of planting their waste lands to forests is the long interval which must elapse between planting and harvesting the crop. In an analysis of the project of tree plantations as profitable crops, it is necessary to recognize the tremendous accumulative effect of compound interest when carried over a long period, and to draw a general comparison between the trend in lumber prices as compared to all other commodities.

In computing returns from forest plantations as an investment, the practice is to regard all money spent for land purchase and plantation development as entitled to a rate of interest which the owner can readily secure by investing in other common phases of business, and, since the period between disbursement and realization extends over several years, to compound the interest. The use of interest calculations permits the owner to establish the value of an acre of land for growing timber and to compare this with the value of other crops which could be secured from the same land. It also enables him to measure the present value of a sum to be received in the future. The rate customarily used in computing farm values is 5 per cent. At this interest rate and with average yields and stumpage values, upland soils of average fertility in Illinois have a value of $13.25 an acre when devoted to pine plantations. Land in annual crops needs to net but $0.66 per acre yearly to give this soil value. But the forest plantation is in the nature of a savings account which draws 5 per cent interest and which is permitted to run for a long period, say 50 years, at compound rates. In such an account, the sum of the "deposits" consists of $13.25 an acre for land, $12.00 for planting, and $20.00 for taxes paid at the rate of $0.40 yearly. These deposits are considered to earn 5 per cent interest compounded annually, so that at the end of 50 years when the deposits total $45.25, the accumulated interest is $314.75, and the account amounts to $360.00.

It should be pointed out that while such an accounting is a fair basis for planting projects where land must be purchased and where capital has the choice of other fields of investment, the case of the farm owner is somewhat different. Farms are acquired as units, embracing both good and poor areas. The owner can not separate out and dispose of the waste areas, since no market exists for disconnected fragments of land of this type. He is committed to owning the waste-land and carrying the taxes on it in order to possess that part of the farm from which he gets his revenue. He is already two-thirds in the business, and the decision left for his judgment is whether the cost of the other third of the project—establishing and carrying the trees—will be amply rewarded. When he considers that plantations in 50 years repay the cost of establishing approximately 30 fold, amounting to an average of $7.00 per acre yearly, he is more likely to decide in favor of planting than if he considers compound interest on the land values and taxes.

In approaching the problem of the practicality of devoting areas now cleared to growing wood, it is important, also, to thoroughly appreciate the fact that the present is a period intermediate between a former period of abundant and cheap supplies of high-grade virgin timber and a future period of inadequate supplies of wholly second-growth origin, and that forest crops have increased and should continue to increase in value more rapidly than other commodities. Since 1865 the average price of lumber in the United States has risen 300 per cent while the average prices of other commodities have risen but 40 per cent. The use of current stumpage values in computing the value of a crop which matures in 50 years injects a very conservative element into the computation. The prices of wood products have now reached a level where with certain species the Illinois plantation can return a profit on all but the poorest soil.

PLANTATIONS FOR PRODUCTION OF SAW-LOGS

Plantations for the production of saw-logs offer a profitable use for low-grade lands, but only those species can yet be profitably used which have an exceptionally high growth-rate and value. The native hardwoods are not profitably used for restocking denuded upland areas. Even under natural seeding to hardwood and with no planting cost incurred, the long period required to produce hardwood saw-logs and the small yields per acre result in decidedly low returns. Recent studies of growth rates in this State place the average yield of well-stocked even-aged stands of native hardwoods on upland loams at 60 years as 6,144 B. F. to the acre. The stumpage value scarcely totals $75 an acre. Pine plantations on similar sites produce 30,000 B. F. in 50 years, or a stumpage value of $360 per acre. If planting is necessary in each case, the cash outlay on an acre of hardwood is $12 planting cost and $24 taxes; on pine, $12 plant-

ing cost and $20 taxes. The hardwood pays an average of $0.65 per year over money spent for taxes and planting; the pine returns ten times as much, or $6.50. The interest rates earned on these costs properly compounded over the period represent slightly better than 1½ per cent for hardwood and slightly better than 6 per cent for pine.

Growing Coniferous Planting Stock

In those States which have developed tree nurseries, suitable planting stock can usually be secured cheaper than it can be raised. This State is just developing such nurseries, and the supply from private concerns is uncertain and expensive; consequently, the Illinois landowner must grow his own. (Tree seeds can be purchased from concerns listed on p. 183.)

The seedbed should preferably be located at a point convenient to work and where water can readily be supplied in dry periods. A sandy loam is best, and almost any fertile soil is acceptable, but the land should not be fertilized with fresh manure or lime. The seedbed should be thoroughly tilled and the soil pulverized and leveled off in beds. A convenient width of the beds is about 4 ft. This allows access from the margin and is suitable for the adjustment of shading frames. About 500 trees per running foot of bed can be raised in beds of this width.

Fall sowing is preferable to spring sowing, because the germination of seeds which have been in moist soil over winter is higher. If, however, planting is done in spring, germination can be increased by soaking the seeds in water for about a week before sowing. The seeds can be sowed in rows spaced about 5 inches apart and running crosswise of the bed. The drills should be about one-half inch deep, and the number of fresh seed to be sowed per linear foot of drill is shown in Table XII.

Table XII.

Number of Seeds to Sow to Secure 100 Seedlings per Square Foot

Conifers

Species*	No. of seeds per lb.	No. of seedlings 1 lb. of seed will produce	No. of seed per running foot of drill to produce 100 seedlings per sq. ft.
Eastern red cedar	17,000	6,000	120
European larch	60,000	5,000—10,000	331
Jack pine	150,000	15,000—35,000	276
Red pine	54,000	20,000—30,000	83
Eastern white pine	26,000	8,000—14,000	98
Norway spruce	60,000	14,000—35,000	103

* Based on Table 2, Farmers Bulletin 1453, U. S. Dept. Agr.

PLANTATION FOR THE PRODUCTION OF SAW LOGS.

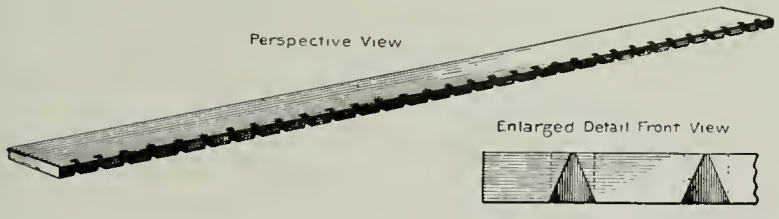
White pine on dune sand. Age 20 years.

The seeds should be covered with one-fourth to one-half inch of pulverized soil and this in turn with a mulch of straw leaves, or burlap. The mulch must be removed in spring as soon as seedlings appear, and shade should be provided for most coniferous seedlings at this stage. A good framework to support the shading material consists of two-by-fours driven into the ground at the corners of the bed, so that about 20 inches projects above ground, and connected by one-by-four strips nailed near the top of each stake. This forms a support across which can be placed the brush, boards, or lath used to supply shade. By this arrangement the layer of shading material will be about 20 inches above the seed bed. Shading is essential from the time the seedling emerges until well into the first summer. Complete shading, however, should never be supplied, but the material should shut off only about half of the sunlight. After the first year the trees should stand full sunlight. The beds should be kept free from weeds, and during dry periods they must be watered, although the ground should never be kept water-soaked.

Transplanting

The trees can be left in the seed bed during two growing seasons, then either planted directly in the plantation or set out in transplant beds. Spruce develops so slowly that it is usually advisable to set it in transplant beds for one or two growing seasons. On such adverse sites as pure sands, loams where a rank weed and grass growth prevails, or gullied uplands where bare soil is exposed to the drying effects of sun and wind, pine *transplants* should be used; but on the ordinary upland loamy cleared fields pine *seedlings* can be successfully used.

Transplanting from seedling bed to transplant bed may be done after either the first or second season's growth. The soil of the transplant beds should be well tilled. The beds can be 6 feet wide, the trees are spaced 2 inches apart in a row, and the rows are 6 inches apart. Such a bed contains 72 plants for each linear foot of bed. Transplanting is facilitated by using an inch board 6 inches wide and 6 feet long, with notches cut two inches apart along one edge to hold the seedlings. (See figure.) A row of holes one-fourth inch in diameter is bored one-half



Transplant board *

* From U. S. Dept. Agr. Bull. 1453.

inch from the edge, two inches apart. Wedge-shaped slots are cut from the edge to the holes, the base of the wedge at the underside of the board being three-fourths of an inch and the apex on the top side having a width about the same as the one-fourth inch hole.

Transplanting may be done either in fall or spring. If dry, both seed bed and transplant bed should be well soaked in order to soften the soil. Carefully lift plants by inserting a spade fork between the rows, thrusting it deeply under the roots, and, as the handle is forced back, pulling gently on the tops. If too much force is used, the roots will be so damaged that the seedlings will die. The roots should be kept constantly moist until replanted. The trees can be placed in a basket and the roots well wrapped with wet burlap or moss. It is not advisable to place the roots in water, as it should be the aim to retain as fully as possible the soil particles which surround roots when the trees are lifted from the bed. Poor specimens should be discarded, and the rest immediately transplanted. The transplanting board is placed across the bed, the unnotched edge serving as a marker. The trench is dug along this edge to a depth of at least 6 inches, the spade being thrust vertically down along the edge of the board and the excavated earth placed directly in front of the trench. The board is now reversed so that the notched edge is over the trench and the back of the notch is flush with the vertical side of the trench. The seedlings are then placed one to a notch in a vertical position. The lower leaves hold the crown above the board and the trench is now filled with earth which is tramped firmly about the roots. To remove the board, grasp the unnotched edge and pivot it forward on the notched edge and draw it slowly backward. Repeat the process for each row. Before finishing for the day, water the plants set out that day. The beds should be kept free from weeds and in periods of unusual drought should be watered. Trees carried over the winter in transplant beds do not need to be mulched.

The trees may be removed from the seed bed or transplant bed to the plantation either in fall after the conclusion of the season's growing period or in spring before growth starts. On sandy sites there is a slight advantage in fall planting; but on heavy soils fall-planted stock is often heaved by frost, so that spring planting is preferable. On the ordinary upland loams it becomes more a matter of convenience. If the site is so unfavorable as to require transplants, it is advisable to use stock which has been in the seed bed one year and in the transplant bed two years, that is, stock about 6 inches high, but it is rarely economical to use stock which is a foot or more high.

A discussion of the methods of establishing plantations and the kinds of trees which are recommended for the different soils follows.

CONIFER PLANTATIONS ON SANDS

Red pine *(P. resinosa)* and white pine *(P. strobus)* will grow well on most Illinois sands; but if the site is exceptionally dry and exposed,

Jack pine (*P. banksiana*) should be used. Either red or white pine produces very excellent lumber. Probably preference should be given to red pine on sandy sites as it grows naturally under these conditions and is not susceptible to insect and disease damage to the same degree as white pine. Yet there is no reason why white pine should not be used, as it has demonstrated its ability to produce good yields on Illinois dune sand, and effective control can readily be secured if the white pine blister rust becomes established in Illinois. Spruce and tamarack are not adapted to sand.

On areas where the sand drifts, it is advisable to establish a windbreak on the windward side of the area to be planted. The ordinary cottonwood, or Carolina poplar, has the required adaptability, as it sends out roots from the parts of the tree which become buried by sand drift. This species also grows with relative vigor on dune sands. A windbreak of three rows of poplar with the trees spaced 8 by 8 feet usually suffices to stop the sand particles. Rooted cuttings (described on p. 154) may be used. On sandy areas the sparse grass cover is not an impossible barrier to transplants. If the plow can be used, a single furrow should be plowed, and the planters should follow this immediately and plant the trees in the furrow. The soil should not have time to dry between the plowing and planting. Transplants rather than seedlings should be used, and the proper safeguards should be taken to prevent root drying when the plants are out of the ground.

The furrows should parallel each other at 6-foot intervals, and the trees should be planted at 6-foot intervals in the furrow. This spacing of 6 feet by 6 feet makes a total of 1,210 trees required for an acre. Spacing can be measured by pacing. In planting, the tree is held in one hand in a vertical position and the roots properly spread; then with the other hand the most fertile soil is spread about the roots and packed firmly, care being taken to remove all leaves and sticks from contact with the roots. The tree should be planted fully as deep as it stood in the nursery. Lastly, some loose sand or litter should be thrown over the topsoil as a protective mulch. If the sand is liable to drift, the furrow should not be deep, as the tree will be covered and die. If the plow can not be used, planting is usually done by two-man teams, one man digging the hole with a grub hoe or mattock, the other following closely and planting the trees. The man digging holes maintains an even spacing between lines (if necessary, by placing a stick to serve as a foresight at the end of the row and 6 feet from the last row planted) and maintains even spacing between trees within the line by pacing. The earth is scooped out and deposited in a heap at the edge of the hole. If a sod interferes, it should be torn up, making a bare spot about 16 inches square. The planter places the trees properly, as in furrow-planting. Two men in this way plant an acre in a day. Trees respond to cultivation, but usually no further treatment after planting is given the young plantation on sand excepting the replanting necessary in the following year to replace trees which die.

CONIFER PLANTATIONS ON LOAMS

Practically all of the common conifers used in plantations in this region are suited to loams, but the pines are most satisfactory for lumber production, and white pine should probably be given preference over red pine on the heavier loams. Larch and spruce grow well, and a special discussion of spruce for Christmas trees will be given. The loams in Illinois are comparatively fertile, and a plantation can easily be established on unsodded fields. Two-year-old seedlings can safely be used. When a sod occupies the site to be planted, special measures are necessary, as small conifers can not compete with the heavy grass which covers loams in this region. If the area can be plowed, the sod should be broken up by plowing a couple of furrows for each row of trees. On heavy soils it is preferable to do this in the fall, leaving the upturned soil exposed to frost and air over winter, and planting the following spring by plowing a single furrow in the center of the double furrow. In this method transplants should be used. The planter should be particularly careful to work the more fertile topsoil against the roots. If the area can not be plowed, the man digging holes should clear a spot about 16 inches square and dig the hole in the center of this. Once the trees become established and the canopy closed—about 10 years after planting—the sod is shaded out and a carpet of needles soon furnishes typical forest conditions.

Conifer plantations for profit should not be attempted under other trees, nor in spots where shade from brush or weeds is dense, nor on heavy, sour, light-colored hardpan soils locally known as post-oak flats, nor on bottomlands subject to inundation.

CHRISTMAS TREE PLANTATIONS

The species most used for Christmas trees are spruce and fir. Of these, Norway spruce is best adapted to handling in plantations. A sandy loam is best, but the ordinary yellow and yellow-gray silt loams of the rolling uplands are entirely satisfactory. The brown prairie loams can be used if well drained. The soil should not be pure sand or a heavy hardpan. A north or east slope not too steep for tillage is preferred, but trees can be grown even on dry southwest exposures which have suitable soils. Cultivation hastens the early growth of all kinds of trees in plantations, and the business of growing Christmas trees warrants the use of land which can be cultivated, although it need not be high-grade crop land. To secure the best returns, the soil should be put in good tilth by plowing and harrowing. Sodded areas should be thoroughly broken, and it is a good plan to raise a crop on such land before planting trees in order to thoroughly work and disintegrate the sod. However, Christmas trees can be raised on land too rough for cultivation.

Trees may be planted either in autumn or spring on light soils; on heavy soils it is preferable to plant in spring. Four-year-old spruce transplants are recommended. Such trees will be from 10 to 18 inches high and will be ready to develop rapidly. Younger transplants and even seedlings can be used, but such trees require from one to three additional years before good height growth begins. The trees are spaced in the formation of a triangle three feet on a side, and regular spacing is desirable where later cultivation is applied. This spacing is attained by plowing parallel furrows spaced 31 inches apart, planting the trees every three feet in the furrow and at a point half-way between the trees of the adjacent furrow. For such a three-foot triangular spacing, there are required 5600 trees per acre.

In all planting operations, precautions are essential to prevent the drying of roots when trees are out of the ground. As each tree is put in place, the roots must be well spread and in contact with moist fertile soil. The soil must be firmly packed about the roots, and loose soil finally scattered over it to serve as a mulch. The plantation should be cultivated during the first two years.

The variation in height growth is very pronounced in young spruce. The heights commonly in demand are from 4 to 8 feet, and the time required to grow spruce to such sizes runs from 4 to 10 years. The usual system is to cut out the larger trees as they become merchantable rather than to attempt to carry the entire plantation until most trees are merchantable and then clear the area. A small per cent will attain 4 feet or more after four growing seasons, and 90 per cent should reach this height before the eighth growing season. No special irrigation or fertilization is desirable, as trees growing more than one foot a year do not have the compact form desired in Christmas trees.

Christmas tree plantations should prove profitable when located near a market, especially when the production is carried on with sufficient regularity to assure dealers a sustained supply.

The cost of vigorous four-year-old transplants when purchased from private nurseries is prohibitive for plantation stocking, and since Illinois has not yet perfected a state-owned nursery, the planter must grow his own stock from seed. The methods are described on pp. 145-148. The trees should be left two years in the seedbed and two years in the transplant bed. Seed costs approximately $2.50 per pound, and one pound should produce 25,000 seedlings—at least enough transplants for 3 acres of plantation. The disadvantage is that eight years are required to produce marketable trees from seed. In most States suitable transplants can be secured from the state nurseries at rates up to $15 per thousand, and at such rates this stock is profitably used. The returns begin

after four growing seasons, and at an average price of $0.50 per tree the acre shows the following gross returns:

Year*	No. of trees harvested	Gross value
4th	1000	500
5th	1000	500
6th	2000	1000
7th	940	470
Total	4940	$2470

* An allowance of 12 per cent, or 660 trees, is made to cover loss in growing stock and trees which fail to attain a merchantable size in 7 years.

These returns of $2470 per acre are based on the wholesale price to the retailer, on the assumption that the owner of the plantation will deliver his trees direct to the retailer. Trees can be cut, bundled, and delivered within a reasonable distance, for 15 cents each, netting $1729 per acre. Against these receipts must be balanced the costs of plowing and subsequent cultivation, which average $12; of transplants, $84; of planting, $35; and taxes at $1.50 annually carried seven years to the maturity of the project. Where a 5 per cent interest rate is used in all computations, the entire project gives an annual return of $208.80 per acre for the use of the land.

Cottonwood Plantations on Bottomland

As stated above (p. 130), cottonwood grown in plantations on bottomlands yields larger quantities of wood in a shorter period than any other native tree. The area to be planted must be as completely cleared of brush and weeds as for field crops. Planting stock is of three kinds: (1) direct cuttings, (2) seedlings, and (3) rooted cuttings.

Direct cuttings are used on the more fertile, mellow, bottomland soils where a good supply of moisture is available. Cuttings are taken from vigorous trees growing in the neighborhood, preferably from the top of the tree. The growth of the preceding year is best, and that of the second year is acceptable, but good results can not be secured by using wood older than two years. The branches are cut during the dormant season and should be subdivided into lengths averaging about 18 inches by cuts made at a 45° angle with a sharp knife. These cuttings are tied in bundles of 50 or 100, with the tops all one way. Care should be exercised to avoid breaking off the buds. If made in autumn, these cuttings should be buried over winter below the frost line in moist sand, and they should not be allowed to dry out whether cut in spring or fall. It is also advisable to bury spring-cut stock for 2 or 3 weeks in moist sand, with the large end but an inch or two from surface. This process facilitates the callousing of the cut surface from which roots are sent out.

The method of planting consists merely in sticking the larger end of these cuttings into the ground to a depth of about a foot. No preliminary plowing or digging is done as the cuttings can usually be pushed directly into the soil. When the soil is not loose, it may be necessary to make a hole with a stick or iron rod. This is the cheapest planting method commonly employed and is well suited to fertile, mellow, moist soils free from weeds and brush. The cuttings should be planted as soon as the frost leaves the ground in spring. When this is done in a wet period, excellent stocking results.

Seedlings are recommended for intermediate sites, where soil or moisture conditions are neither exceptionally favorable nor adverse. Wild stock can be collected, or seedlings can be grown. In collecting wild stock, one-year-old seedlings average 12″ to 18″ in height should be lifted in spring before growth starts. In favorable circumstances this stock can be turned out with a plow, but ordinarily a spade can be used to advantage. Collecting should be done while the ground is soft and moist, and precautions must be taken to keep the roots moist until replanted.

If seedlings are to be grown, a seed bed of rich loam should be selected and the soil thoroughly worked, pulverized, and then rolled smooth. Small branches heavily laden with seed catkins are cut from the seed tree just before the pods open. At this time it may be necessary to cover the beds with paper or any material which will hold the buoyant seed on the plot. When the pods open, shake seed out on a calm day. The bed should be evenly covered with a very thin layer of cottony seed, then just enough dry soil sifted over this to hide the cotton from view. Next, thoroughly saturate the seedbed, using a spray. Cover the moistened surface with paper until the seedlings appear. After this the paper should be removed, but the bed should be kept moistened, as the surface soil must not become dry before the tiny seedlings have developed deep taproots. If the stock seeds in thicker than 20 trees to the square foot, it should be thinned. This stock should be taken up and planted the following spring before growth begins. It will then be about 2 feet tall. It is important to keep the roots moist during the interval between lifting from the bed and replanting.

Seedlings are planted as follows: a hole about 6 inches wide and fully a foot deep is dug with a narrow spade, the roots of the seedling are well spread, and the loose earth is packed firmly about them. The seedling should be set fully as deep as it stood in the bed.

Rooted cuttings are recommended for sites where soil and moisture conditions are not well suited to the establishment of cottonwood. This stock is bulky, costing more to handle than either calloused cuttings or seedlings. On sandy or gravelly soils where the water table is not close to the surface, or on fertile sites where vigorous weed growth is not

controlled, rooted cuttings are necessary to insure the establishment of a fully-stocked plantation. For growing this stock, branches should be cut into lengths of about 1 foot and set in a well-tilled sandy-loam bed to a depth of 9 inches. At least one good bud should project above ground. Space 6 inches in a row with a foot between rows. Keep free from weeds and well moistened during the growing season. Plant the following spring before growth begins. Planting requires digging the hole for each tree as for seedlings, but the process can be cheapened by the use of a plowed furrow on those areas where a plow can be used. The spacing for all forms of planting stock should be 10 feet by 10 feet when logs are to be produced, and 8 feet by 8 feet for pulpwood. This is 440 and 680 trees per acre, respectively.

The exceptional growth and unusual intolerance of cottonwood results in an early struggle for light and the early suppression of all but the most vigorous trees. Pure stands of cottonwood open up at an early age, creating light conditions favorable for less-exacting trees and weeds. Cottonwood responds to increased light conditions resulting from a thinning, but after the sapling stage the canopy of a pure stand opens up so much naturally that the benefits of increased growth on the trees left in a thinned stand are somewhat nullified by the increase in weeds and brush which follows such a thinning. When thinnings are made they should be light. The main crop should be harvested in a single cutting, all brush and under-growth being cleaned out at the same time, and the area should be immediately restocked with cottonwood before a heavy growth of other species makes clearing costs prohibitive. An idea of the number of trees naturally found at different ages on fully-stocked cottonwood stands can be had from an inspection of column 2 in Table XIII (p. 155).

Planting an understory of soft maple and elm has been practiced as a means for utilizing all the light for tree growth and for keeping out the weeds. On floodlands a well-shaded forest floor is not essential to the maintenance of soil fertility, since such fertility is renewed by repeated soil deposits rather than by the decay of forest litter. The growth of the understory must be cleared off at the time that the overwood is harvested if a new stand of cottonwood is to be established; and since such growth is relatively slow and is not of merchantable size, growing an understory is a questionable practice in managed cottonwood stands on floodlands. Weeds and trees which seed in naturally, do not greatly influence the development of a crop of cottonwood on fertile bottomlands after it is well started.

The yields given in Table XIII can be secured from cottonwood plantations on the floodlands of the Wabash, Ohio, and Cache, and on the Mississippi up to about Alton. On Mississippi bottomland in Union County a yield of 5,174 B. F. per acre harvested for veneer logs from 18-year-old trees compares very favorably with the 4,100 B. F. yield in the table. Yields on the Kaskaskia, Illinois, and upper Mississippi bottomlands are somewhat lower.

Logs delivered at the mills average about $25 per thousand (Doyle Rule). The 1924 price for logs delivered on the river bank at a landing in southern Illinois was $17 per thousand. The trees are grown on the floodlands outside the levees; consequently, the haul is short and $5 per thousand is a fair logging cost. Table XIII shows the yields and the returns received at these values.

Table XIII

Yield per Acre for Fully-stocked Cottonwood Stands at Ages from 12 to 50 Years in Illinois

Age Yrs.	No. of trees per A.*	B. F. yield per A. (Doyle Rule)*	Gross value of logs per A. at $17 per M.	Cost of logging per A. at $5 per M.	Accumulated tax and planting cost per A. An. Tax $0.40. Planting $9.08. Interest 5% compounded	Returns per A. above logging, planting, and tax costs	Maximum to be spent for buying and clearing lands at 5% compound interest
1	2	3	4	5	6	7	8
12	452	200	3.40	1.00	22.68	—20.28	.....
13	375	700	11.90	3.50	24.20	—15.80	.....
14	320	1,300	22.10	6.50	25.82	—10.22	.....
15	276	1,900	32.30	9.50	27.51	—4.71	.....
16	243	2,600	44.20	13.00	29.28	1.92	1.62
17	217	3,300	56.10	16.50	31.15	8.45	6.54
18	195	4,100	69.70	20.50	33.10	16.10	11.44
19	178	4,900	83.30	24.50	35.16	23.64	15.48
20	163	5,700	96.90	28.50	37.32	31.08	18.80
21	150	6,500	110.50	32.50	39.59	38.41	21.50
22	140	7,500	127.50	37.50	41.96	48.04	24.95
23	130	8,400	142.80	42.00	44.46	56.34	27.20
24	121	9,500	161.50	47.50	47.08	66.92	30.07
25	114	10,700	181.90	53.50	49.84	78.56	32.92
26	106	12,000	204.00	60.00	52.72	91.28	35.72
27	99	13,400	227.80	66.00	55.77	106.03	38.80
28	92	15,100	256.70	75.50	58.95	122.25	41.86
29	86	17,100	290.70	85.50	62.30	132.90	42.65
30	80	19,200	326.40	96.00	65.81	169.59	49.59
31	75	21,400	363.80	107.00	69.50	187.30	52.94
32	70	23,500	399.50	117.50	73.38	208.62	55.41
33	66	25,300	430.10	126.50	77.45	226.15	56.49
34	62	26,600	452.20	133.00	81.73	237.47	55.83
35	59	27,500	467.50	137.50	86.21	243.79	53.98
36	57	28,200	479.40	141.00	90.92	247.48	51.64
37	53	28,700	487.90	143.50	95.87	248.53	48.91
38	51	29,100	494.70	145.50	101.06	248.14	46.07
39	50	29,300	498.10	146.50	106.52	245.08	42.96
40	49	29,300	498.10	146.50	112.24	239.36	39.63
50	32	29,400	499.80	147.00	187.86	164.94	15.75

* From U. S. Dept. of Agr. Bulletin No. 24, "Cottonwood in the Mississippi Valley".

PERIOD FOR MOST PROFITABLE HARVEST

Table XIII has been worked out in detail in order to show the importance of the time element on both the amount of wood grown and the net returns received. The annual tax of $0.40 per acre and the planting cost of $9.08 both approach maximum costs for the unprotected floodlands used for this purpose in Illinois. Where money is spent for taxes and planting costs and when returns are deferred for a period of years, compound interest at 5 per cent has been charged.

The stand first contains trees of a merchantable size at the age of 12 years, when the yield is 200 B. F. per acre, as shown in column 3. The merchantable contents added thereafter increase yearly until the amount of merchantable contents grown in the 31st year (2200 B. F.) is more than four times that grown in the 13th year (500 B. F.); after the 31st year the rate of increment decreases rapidly, and virtually no increase in yields occurs after 40 years. The folly of cutting a stand of 20-year-old cottonwood for a yield of 5,700 B. F. per acre becomes apparent when it is seen that an additional growth of 13,500 B. F. can be secured if the stand is allowed to grow another ten years. Expressed in money the wood grown in the first 20 years has an average gross value of $4.84 per acre annually, but in the next ten years the wood grown has an average gross value of $22.95 per acre annually.

The rapid increase in carrying costs, due to compounding the interest on money actually expended, is apparent in column 6. At 18 years approximately half of these costs, or $16.28, is actual disbursement, and the rest, or $16.82, is interest; at 33 years the interest amounts to 71 per cent ($55.17) of the carrying costs ($77.45); and at 39 years, the interest has climbed to $82.02, or 77 per cent of the carrying costs. This rapid increase fixes the period for most profitable harvest well in advance of the time when the volume of wood in the stand reaches its maximum amount. Thus, according to column 8, in which land cost, planting cost, and tax cost are calculated, with 5 per cent compound interest, the most profitable time at which to cut the stand is at 33 years, although the maximum merchantable content of the stand does not occur before 39 years, as shown in column 3. In other words, under the approximately average yields and costs shown in this table, cottonwood reaches its financial maturity at 33 years, paying 5 per cent interest compounded on a total investment of $78.77 per acre for land, planting, and taxes.

PLANTATIONS FOR POST PRODUCTION

The farm owner who is considering the advisability of establishing a plantation of trees to supply his posts is confronted with this problem: he can consider one of the five durable species each of which has at least one serious limitation, or he can decide to treat his posts with a preservative and grow any of a half-dozen species well suited to this purpose because of rapid growth rates, insect immunity, and ease of culture.

The five durable species commonly used are catalpa, black locust, Osage orange, mulberry, and red cedar. Although very rapid growth produces posts of low durability, yet posts from these species have an average durability of 15 years or more. Red cedar, although it will grow on thin sterile soils, is scarcely to be considered because of its slow growth*. Mulberry requires a fertile soil, freezes back in winter, and develops a bushy form not suited to post production. Osage orange is very durable and has been freely planted as a hedge, but develops both poorly and slowly when planted in groves. Black locust has all the qualities of durability, rapid growth rate, adaptability to a wide range of soils, and proper form, but it has two insect enemies which have discounted its usefulness. Catalpa has a rapid growth rate, durability, and suitable form, but requires a fertile soil, and has one serious insect enemy.

CATALPA

Most failures in catalpa plantations in Illinois can be traced either to planting the trees on soils not suited to the species, to the use of the wrong species, or to insect attacks. Catalpa plantations show excellent returns, but only on high-grade fertile soils. The upland locations where catalpa will succeed are limited to deep, well-drained, fertile soils. It grows well on fertile prairie loams, but it is not recommended for ordinary light-colored soils of the upland, and it should never be planted on extreme types, such as sands or clays. On bottomlands the tree grows well over a wider range of soils, and can be used on both heavy and light loams, but not on extremes of sands or clays. It is not injured by flooding but is susceptible to frost injury on bottomland sites in the northern part of the State. When grown in pure plantations, it is also defoliated from 2 to 3 years out of 5 by larvae of the catalpa sphinx moth.

In spite of its exacting soil requirements, liability to frost injury, and probability of insect damage, this tree is recommended because in Illinois under proper conditions it produces more high-grade posts in a given period than any other species. It should not be considered for pole or tie products, as it tends to rot freely after the post size is passed. The average service of posts is 16 years. From 12 to 15 years are usually required to produce posts in plantations, and the average yearly yield approximates 100 per acre.

The use of a hybrid of the native catalpa *(Catalpa speciosa)* and the southern catalpa *(Catalpa bignonoides)* has invariably resulted in trees of unsatisfactory form. In ordering nursery stock, insist upon *Catalpa speciosa*.

It is preferable to select a spot protected from the prevailing winds, because in exposed plantations the trees on the south and west sides are usually distorted and less thrifty. Catalpa should not be planted

* Studies based on 200 trees in southern Illinois indicate that approximately 50 years are required for cedar to grow to post size.

FIFTEEN-YEAR-OLD CATALPA PLANTATION FOR PRODUCTION OF POSTS

under other trees nor in small openings in native hardwood forest. The cleared area should be plowed, as catalpa planted in a sod develops very slowly. After plowing, furrows should be run every six feet, and the trees planted three feet apart in these furrows. The roots should be well spread in the bottom, loose moist earth placed over them and packed firmly with the foot. After the furrows have been planted, they should be plowed full of earth. This spacing requires 2420 trees per acre.

The plantation should be cultivated and kept clean of weeds until the trees attain a size sufficient to form a closed canopy—at least two years. Proper tillage shortens by several years the time required to grow posts.

Catalpa does not naturally develop the straight smooth stem suited to post material. The terminal bud is frequently winter-killed or injured by insects, resulting in a crook in the stem as a lateral branch replaces the terminal. Also, the dead side branches hang to the tree long after they have been shaded out. In order to correct these conditions, the young trees frequently are cut back to the ground during the dormant season after their second year's growth. As sprouts develop, only the most vigorous one on each stump is permitted to grow. This sprout often grows nearly to the same height the first year as the seedling attained in the previous two years, and it forms a straight stem. There is a very good chance, however, that the vigorous sprouts bearing their large leaves will be ruined by storms or distorted by sheer weight. The same injury also follows a pruning off of the live lateral branches for the purpose of forcing the stem to vigorous height growth, and this practice is not recommended. The trees should be planted close together to insure active height growth, and on fertile land to support such growth; *as the lateral branches are shaded out and die*, they should be pruned off as close to the stem as possible.

At about eight or ten years after the plantation has been set out, it will need thinning. The smaller trees should be cut, taking out between one-fifth and one-third of the total number. The plantation on good soil should produce posts after 12 years. The higher yields are secured between 12 and 18 years, and an acre should average 100 posts per year since planting. Because catalpa posts are not easily split from larger diameters but must be sawed, it is usually preferable to cut the trees before they develop large diameters. Some success in reestablishing a new plantation from sprouts is secured if the rows are cut clean in the dormant season. In order to minimize wind injury, it is a good plan to cut rows on the north or east side first and to work south or west in successive years as posts are needed. The old plantation then forms a windbreak. Only one sprout to each stump is usually allowed to grow, but as this practice often results in a very tall shoot unable to support its heavy crown of leaves, it may be advisable to let all sprouts grow during the first season and to knock off all but the best one the following winter.

The plan of management of a catalpa plantation must include control of the catalpa sphinx. This is practical, as an arsenical spray can be applied to the crowns with a hand pump in those years when the worms are abundant. The normal defoliations of three years out of five will utterly kill an unsprayed plantation. The effective mixture consists of 4 pounds of lead arsenate to 50 gallons of water, and it should be applied upon the first evidence of the larvae in the plantation.

BLACK LOCUST

Black locust stock can be purchased cheaply, is easily transplanted, makes rapid growth, and produces very durable posts. The tree develops a very fibrous root system capable of producing new trees from root sprouts. Black locust is one of the legume family and has the nitrifying merits of this family. Perhaps its best quality, however, is its ability to grow on thin, sandy, or eroded soils; as an agent in the reclamation of sterile gullied hillsides or loose sand, it is superior to any other tree. Even though the borers distort or kill the stem, the roots grow vigorously and bind the soil, sending out sucker shoots freely and developing a soil cover as well as enriching the soil with nitrogen.

There are conditions under which black locust plantations are not destroyed by attacks of the borer. Trees which are growing with pronounced vigor seem not to offer suitable conditions for borer infestation in epidemic intensity. Although such trees are usually attacked, the infestation does not gain such momentum as to destroy them. It is possible for entire plantations to be brought to profitable yields of posts in spite of the locust borer. Pure locust plantations are successfully grown on fertile, well-drained loams, but they are generally destroyed when located on sterile sands or thin loams. On such intermediate sites as gullied uplands or crop-worn fields, special measures will often result in a growth vigorous enough to enable the plantation to resist a borer attack. Alternate the locust with another species, and cultivate the plantation as long as it is possible to drive between the rows.

Black locust should never be planted under an overwood, but it will grow as groups in openings of the forest. It produces posts in about 15 years. A good mixture for the reclamation of gullied uplands or of sand hills and for the production of posts consists of sassafras and locust, planted alternately, as the sassafras offers a certainty of some posts even if the locusts are destroyed. Spacing should be about 6 feet by 6 feet, thus requiring 1210 trees per acre.

Plantation for the Production of Posts.

Twenty-year-old black locust on gullied land.

OSAGE ORANGE

Osage orange is less exacting in soil requirements than catalpa and more exacting than locust. It will produce posts on sandy and loamy soils which are deep and well-drained, but it is not suited to extremely heavy, thin, or sterile soils, and it suffers winter injury on bottomlands.

Although Osage Orange posts excell in durability, the growth rate is less than that of either locust or catalpa, and the trees have a pronounced habit of forking close to the ground and producting much-branched and crooked stems. This defect can be corrected by pruning, but the tree has too slow a growth rate to recommend it for extensive plantation work. Osage orange can grow well in situations exposed to drying winds, and the very qualities which bar it from use in plantations make it a very excellent hedge tree. The much-branched form is trimmed to make a living fence, or the trees are allowed to develop full height growth, making a tall hedge which serves as a windbreak. Leaders from the trimmed hedge may be permitted to grow and provide posts at intervals of about three feet.

This species was formerly freely planted about the fields, not only because it served as an excellent fence and provided excess post material, but also because a windbreak was considered a necessity for high crop yields in all sections of the prairie regions. The influence of windbreaks upon crops in adjoining fields is injurious within the zone reached by the shade of the trees and may be injurious over a somewhat wider zone because their roots compete with crops for moisture; for a distance beyond this the influence is generally beneficial. The balance measured in crop yields is entirely in favor of windbreaks in more arid regions but not enough so in Illinois to justify decisively their general use. The past decade has witnessed a transformation in farm management involving the general use of tractors, organized campaigns against weeds and insects, and the effort to utilize fully the crop-producing areas. As a consequence, hedges are in disrepute and during the past few years their removal has been actively carried on; yet many landowners are still interested in growing such hedges.

Seedlings can be easily grown on the farm. Gather the hedge apples in fall and place them in water until the pulp becomes rotten, and then wash out the seeds. Plant the seeds in spring in well-tilled garden soil and, when the seedlings appear, thin so that they stand about three inches apart. Keep free from weeds and transplant to the field in fall or early the following spring. One growing season in the seed bed is ample. For hedges, a two-foot spacing is recommended; for windbreaks, three-foot. If a plantation is the object, plow the area and set the seedlings in rows seven feet apart and five feet in the row. The area should

be cultivated until the growth of the branches impedes this work—about two years. The trees should also be pruned, as this species has a habit of developing forks and persistent side branches. If pruning is properly done between the second and fifth years, post production is materially increased. The trees require at least 15 years to grow to post size.

Summary of Points on Seed and Tree Planting

Reenforcement planting in under-stocked natural stands.—Use rapidly-growing native hardwoods rather than conifers. For oaks and other large-seeded species, plant the seeds where trees are needed. Trees having small seeds are customarily first started in a seed bed and the young trees transplanted where needed after the first growing season in the bed. Transplant during spring before the leaves appear and in spots cleared of bushes and sod, packing fine, moist soil about roots and mulching with litter.

Planting cleared areas.—For saw timber, conifers should be used on upland sites and broadleaved species on bottomlands. Conifers are grown from 2 to 4 years in the nursery before transplanting in the field. If such trees can not be bought for a cent a piece, they should be grown on the farm. Plant thickly—6 feet by 6 feet—to develop trees of good form, and begin thinnings when the lower branches have been shaded out and the plantation reaches the polewood stage—trees from 3 to 8 inches in diameter and 20 years or older.

In plantations for posts, the relatively durable species recommended are: catalpa for fertile uplands, or for bottomlands except in the northern quarter of the State, and black locust mixed with larch or sassafras on the less fertile soils. For hedge fencing, nothing equals Osage orange.

MEASURING AND MARKETING WOODLOT PRODUCTS

In general, the woodlot owner should undertake the marketing of his own products. In so doing, in addition to providing employment for teams and men at a season when farm work is slack, he gets for himself a knowledge of timber values and woodlot management, which is the best guarantee for a permanent and profitable woodlot. Woodlot owners are usually ignorant of the products and grades into which trees can be cut, do not know of the many markets for woodlot products, and are unable to estimate standing timber. For these reasons they frequently sell standing timber for a lump sum below its real value, or turn into cheap products much timber which is suitable for high-grade products. It is a good plan to investigate the markets and estimate the contents of standing timber, even if it is to be sold for a lump sum. Selling by the piece or by board-foot unit rather than for a lump sum is generally more satisfactory, especially if it is possible to get a reliable check on the amount taken.

While it is usually desirable to harvest systematically at regular intervals, as previously explained, yet this practice should be modified when necessary to take advantage of periods of favorable market conditions. Timber holds a unique position as a crop, inasmuch as, within certain limits, it increases in volume and value if not harvested. When market conditions are poor, it should be allowed to grow.

CHOICE OF PRODUCTS

There are eight principal products grown on Illinois woodlots: cordwood, mine timbers, cross ties, lumber, cooperage and veneer logs, piling, and posts. All forest soils in the State can produce at least three of these products, and most forest soils are generally fit for the production of all eight. Since some of them are much more profitable than others, it is best to choose those from which the highest returns may be had.

Before any comparison of returns can be made, these different products must be reduced to a common unit, for different products are measured by different units: cordwood, by the cord; mine timber, cross ties, piling, and posts, by the piece; logs and lumber, by board feet. These may all be reduced to cubic feet. The average cord contains 80 cubic feet of wood; the average mine timber, 0.606; cross tie, 3.0; pile, 22.3; post, 0.8; and 1,000 B. F. in the log is equivalent to 166.7 cubic feet; 1000 B. F. of lumber to 83.3 cubic feet. Again, in converting the tree into the different products, the owner should consider what portion of it is usable in each case. The amount of stem which appears in the product varies from 32.5 per cent in lumber to 100 per cent in cordwood. The amount of wood to the acre is best expressed as total cubic feet in the entire stems, and the annual growth, or accretion, as the number of cubic feet annually added. Therefore, in order to express the money value of the annual growth worked up into the differ-

ent products, their value must be computed per cubic foot of total stem rather than per cubic foot of manufactured product. This has been done in Table XV (p. 167).

The choice of the product or combination of products, in any given case, depends upon the following considerations: (1) per cent of the tree which enters into the salable product, (2) relative costs of converting the tree into different products, (3) relative cost of shipping products to market, and (4) relative sale values at market.

(1) The per cent of the total amount of wood in the bole of a tree which enters into the salable product averages as follows: cordwood 100, piling 85, mine timber and posts 74, cooperage and veneer logs 65, cross ties 49, and lumber 32.5. It is evident that, if the sale price is similar, the greater returns will come from those forms of product which utilize the greater part of the tree.

(2) The average costs of converting a tree into the different products, *in terms of cubic feet of wood in the bole or stem*, are as follows: veneer or cooperage logs $0.0509 per cubic foot, cordwood $0.0518, piling $0.0794, cross ties $0.0796, mine timbers $0.0808, posts $0.0932, and lumber $0.0996. Thus the greatest cost of conversion (into lumber) is 95 per cent greater than the lowest cost (into veneer logs), both being measured in cubic feet of the entire stem.

(3) The freight rates vary with the product and the distance. Customarily, cordwood pays the least per hundred pounds, mine timbers slightly more, while rates on piling, logs, posts, and lumber are yet higher. The effect of these transportation costs is to limit definitely the area within which forest products can be shipped. When the costs of manufacture and transportation equal the sale price, the operator has given his product away. At the average sale price of $5.06 per cord, cordwood can not be shipped at all. The other products can be shipped distances varying from 100 miles for ordinary logs up to 500 miles for average lumber produced in Illinois. (See Table XIV.)

(4) Rates of growth per acre and per cents of possible utilization determine the quantities of the different products which can be produced; the respective manufacturing and shipping costs determine the expense of putting the various products from tree to market; and, finally, the respective sale values determine the choice of the product. The average cost of manufacturing, the average sale price, and the margin left for profit *per cubic foot of product* are shown in Table XIV, and from these elements can be computed the shipping zones; but the determination of the *relative profit* in growing these different products is not based solely upon the cubic feet of product, but involves also relative per cents of the total growth which can be utilized in making these products. In Table XV this variable degree of utilization has been taken into account by converting all values per cubic foot of the different products into values *per cubic foot of the total contents of the standing tree*, and the data are tabulated to show stumpage values per cubic foot of the standing tree for timber which is marketed at average prices (1) with no freight cost, (2) with a 25-mile haul, and (3) with a 100-mile haul. This table, giving weight to degree of utilization as well as costs, more nearly expresses the ratings of the different products from the viewpoint of the producer.

TABLE XIV

SHIPPING DISTANCES DETERMINED BY THE MARGIN BETWEEN AVERAGE SALE PRICE AND AVERAGE MANUFACTURING COST

Product	Unit	No. of cu. ft. per unit	Sale price per cu. ft. of product	Cost of mfg. per cu. ft. of product	Margin left for transportation and profit	Freight rates per cu. ft.		Shipping zone
						25 Mi.	100 Mi.	Miles
Mine timber..	Props	.83						
	Bars & legs..	1.91						
	Mine ties....	.70						
	Average..	.85	$.183	$.1092	$.0738	$.018	$.0301	250
Cross ties.....	Tie	3.0	.300	.1611	.1389	.0337	.0585	250
Piling.....	Pile	22.3	.230	.0934	.1366	.0337	.0585	250
Cooperage.....	M. B. F.....	166⅔	.150	.0783	.0717	.0337	.0585	150
Veneer								
Average.....	M. B. F.....	166⅔	.150	.0783	.0717	.0337	.0585	150
Highgrade..	M. B. F.....	166⅔	.300	.0783	.2217	.0337	.0585	400
Lumber.....	M. B. F.....	83⅓	.504	.3061	.1979	.0337	.0585	500
Posts.....	Post	.8	.300	.1260	.174	.0337	.0585	300
Cordwood.....	Cord	80.	.0633	.0518	.0112	.0146	.0225	...

Table XV

Net Returns per Acre as Influenced by Kind of Product and Shipping Distance

Product	Sale price per cu.ft. of stem	Cost of mfg. per cu. ft. of stem	Freight rates per cu. ft. of stem		Value of stumpage per cu. ft. of tree at specified shipping distances			Net returns per acre from upland loam woodlots averaging 36.4 cu. ft. growth annually, at specified shipping distances		
			25 mi.	100 mi.	0 mi.	25 mi.	100 mi.	0 mi.	25 mi.	100 mi.
Mine timber	$.1345	$.0808	$.0133	$.0223	$.0546	$.0413	$.0323	$1.99	$1.50	$1.18
Cross ties	.1482	.0796	.0165	.0289	.0686	.0521	.0397	2.50	1.90	1.45
Piling	.1955	.0794	.0287	.0497	.1161	.0874	.0664	4.23	3.18	2.42
Cooperage	.0975	.0509	.0219	.0380	.0466	.0247	.0086	1.70	.90	.31
Veneer										
Average	.0975	.0509	.0219	.0380	.0466	.0247	.0086	1.70	.90	.31
High-grade	.1950	.0509	.0219	.0380	.1441	.1222	.1061	5.25	4.45	3.86
Lumber*	.1638	.0996	.0219	.0380	.0642	.0423	.0262	2.34	1.54	.95
Posts	.2220	.0932	.0250	.0433	.1288	.1038	.0855	4.69	3.78	3.11
Cordwood	.0633	.0518	.0146	.0225	.0115	.....	.....	.42		

* Cost of sawmilling averages $7 per M. B. F. and sale prices at destination average $42 per M. B. F.

Thus Table XIV, in terms of *cubic feet of product*, shows the margin left for profit and transportation of the different products in the following order: (1) high-grade veneer logs, (2) lumber, (3) posts, (4) ties, (5) piling, (6) mine timber, (7) cooperage and average veneer logs, and (8) cordwood. Table XV, containing the same data but also including the quantity utilized, rates the different products as follows: (1) high-grade veneer logs, (2) posts, (3) piling, (4) ties, (5) lumber, (6) mine timber, (7) cooperage and average veneer logs, and (8) cordwood. This is the more accurate index of the relative average value of the different products from the producer's viewpoint.

High-grade veneer, posts and piling, are in general the most profitable products; the average net returns from woodlots yielding these are roughly twice as great as for those yielding ties, lumber, mine timber, or average veneer and cooperage logs, and ten times as great as those yielding cordwood. It is necessary to emphasize the fact that, while these are average statewide figures, yet the presence of local markets will modify these ratings, and the woodlot owner producing for the market must know the market conditions locally. For instance, cordwood sells for $8.00 a cord in Chicago and $3.00 in Johnson County. These are sale prices of $0.10 and $0.0375 per cubic foot, respectively. The cost of manufacturing is $0.0518 per cubic foot. Woodlot owners near Chicago supplying this market find cordwood giving higher returns than either mine timbers or cooperage and average veneer logs, while those in Johnson County fail by $0.0143 per cubic foot, or $1.14 per cord, to get the average labor cost for producing it.

SAWLOGS

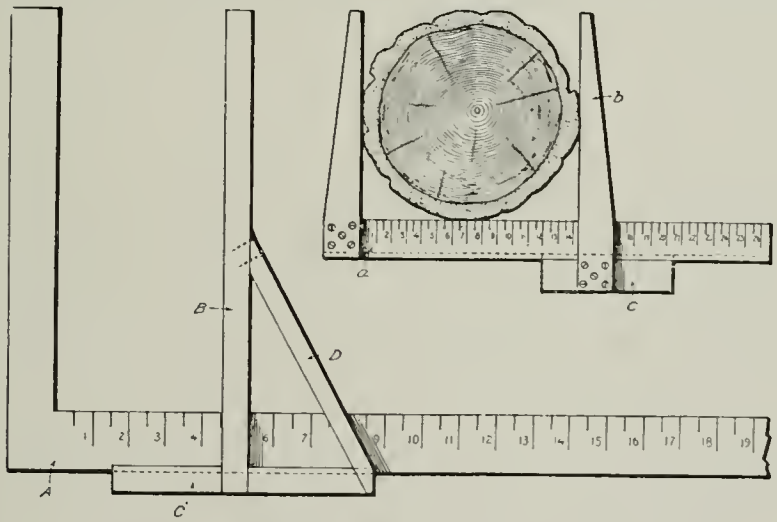
Estimating standing timber

Logs for veneer, cooperage, and lumber are measured by the thousand board feet (M. B. F.). The amount of lumber in a standing tree is estimated by judging the number of logs which would be cut from the given tree and estimating the length and top diameter inside the bark of each log. The estimator requires a stick of lumberman's crayon (red) for marking trees, calipers for getting the diameter of the tree, a pencil, and a notebook. A convenient form for recording log lengths and diameters by species is shown on the following page.

Calipers may be purchased from a dealer in instruments of precision, or may be made from an ordinary carpenter's square by attaching an arm sliding along the beam and at right angles to it (see figure). If large timber is to be measured, the beam should be 36 inches long; in second growth, an 18- or 24-inch beam suffices. The sliding arm is made by cutting a half-inch strip about two inches wide, two inches longer than the short arm of the square. Next, get a strip of tongue-and-groove material six inches long and an inch and a half wide, shave off the tongue and mortise the first strip at right angles through the center of this 6-inch strip in such a way that when the beam of the carpenter's square is placed in the groove the mortised arm will be parallel

to the fixed arm of the square. A brace, as shown in the figure, is necessary to strengthen the movable arm. When in use, the movable arm must be parallel to the fixed arm of the square.

Species	Log length	Diameter inside the bark at small end of log																			
		10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ash	8																					
	10																					
	12																					
	14																					
	16																					
Basswood	8																					
	10																					
	12																					
	14																					
	16																					
Elm	8																					
	10																					
	12																					
	14																					
	16																					

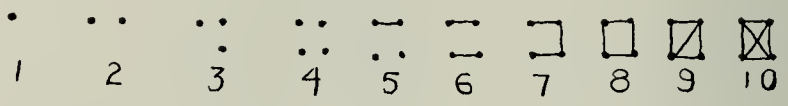


A simple homemade instrument, or calipers, for measuring the diameters of trees *

* Taken from U. S. Dept. Agr. Farmers' Bulletin No. 1210.

The contents of large timber tracts are frequently estimated by measuring a percentage of a tract and applying the results to the entire tract. In ordinary woodlot work involving small areas, the contents of each tree should be estimated.

Usually two work together. The estimator begins at a convenient side of the tract and estimates the trees in a strip 50 or 100 feet in width extending across the woodlot. He first measures the average diameter of the tree outside the bark at a point 4½ feet from the ground. This is usually called the "diameter breast-high" (D. B. H.). This serves as a check and helps to estimate correctly the diameters of the logs into which he mentally divides the tree. He also marks the tree with the crayon at a given place where it will be visible as he works on the next strip. He then steps back to where he can get a clear view of the bole and lays off with his eye a log length (8, 10, 12, 14, or 16 feet from the assumed stump) and estimates the diameter *outside the bark* at the upper end of the log. With a knowledge of average bark thicknesses for trees of a given species and size, he mentally deducts the double bark thickness (D. B. T.), so as to get the diameter inside the bark (D. i. b.). See Table XVI for bark thickness of oaks, which can be used for most species. He then calls the record to his companion; for example, "white oak, 14 feet, 18 inches." The tallyman places a single dot in the proper place on the form shown on page 83, to indicate a white oak log 14 feet long and 18 inches in diameter inside the bark at the small end. Succeeding logs are recorded by dots and lines until ten complete the figure, as follows:



The estimator continues, mentally, to divide up the bole and estimate the log lengths and diameter of each log inside the bark at the small end, until he reaches a point in the crown where the material is unmerchantable. A ten-inch top is commonly taken as the minimum diameter for a log, but in large hardwoods the heavy limbs may prevent the economical use of logs of a diameter as small as this. Thus, in turn, all trees in the strip are estimated, and with succeeding strips the entire woodlot is covered.

The next step consists of computing the board-feet contained in the logs. For this, it is necessary to have a log rule. A log rule is a statement of the number of board feet contained in logs of different lengths and diameters. It may be marked on a stick or printed as a table.

Add up the total number of logs of each species having the same diameter and length, and multiply by the board-foot contents as shown for a log of this given length and top diameter inside the bark (D. i. b.). The summation for all logs gives the total for the woodlot.

The many different log rules in use give quite different readings. The theory has been to construct a rule giving the number of board feet which could be sawed out of logs of a given region and under rather fixed marketing conditions. The early rules were made to fit conditions then in force, such as an abundance of large, defective trees and a demand for high-quality material, and such rules do not give the quantity which is now cut from second-growth logs for a market using material formerly unmerchantable. Since they give a decided advantage to the buyer, these old rules have been retained in many instances. Thus, in Illinois practically all logs are scaled with the Doyle Rule. A comparison of the values for the Doyle and the International Rules, Table XVII, shows that the latter gives fully one-third greater amounts for 12-inch logs. In general, it may safely be said that there is sawed from ordinary-size timber 20 per cent more material than is scaled under the Doyle Rule.

If logs are to be sold, the buyer usually insists upon using the Doyle Rule; if the logs are to be sawed by the owner, a closer approximation of the yield can be secured by using the International Rule.

Table XVI

Average Thickness of Bark for Black Oak Trees of Diameters up to 30 Inches

Diameter breast-high (D. B. H.)	Double bark thickness (D. B. T.)	D. B. H.	D. B. T.	D. B. H.	D. B. T.
1	.1	10	.9	21	1.8
2	.1	11	1.0	22	1.9
3	.2	12	1.1	23	2.0
4	.3	13	1.2	24	2.0
5	.4	14	1.2	25	2.1
6	.5	15	1.3	26	2.2
7	.6	16	1.4	27	2.3
8	.7	17	1.5	28	2.4
9	.8	18	1.6	29	2.5
		19	1.6	30	2.6
		20	1.7		

Scaling logs

The process of scaling cut logs consists in measuring the average diameter inside the bark at the small end, noting the log length, and looking up in a log rule the board-foot contents for a log of this diameter and length. The record can be kept in a form as shown on p. 169. Where much scaling is done, a stick is used from which can be read the contents of a log of specified length and diameter. When the average diame-

ter does not fall on the even inch, it is rounded off to the nearest inch class; thus, 10.5 to 10 inches, 10.6 to 11 inches, etc. The values are for sound, straight logs, and if defects are present, a certain per cent is usually discounted. This rarely runs beyond 10 per cent, even for old-growth hardwood.

Markets, Specifications, and Quotations

Logs are valued according to species, size, and freedom from defects. Large, sound logs of a species suitable for high-grade veneer bring twice as much as those used for ordinary lumber, cooperage, or low-grade veneer such as goes into fruit containers and egg crating.

The leading species used in high-grade veneers are black walnut, white oak, and red oak; and to a lesser extent tulip poplar, black cherry, and basswood are used. Sound logs of these species, with a D. i. b. of 16 inches and up, bring $50 or more per M. B. F. at the points of consumption.

TABLE XVII

BOARD-FOOT CONTENTS FOR LOGS OF GIVEN DIAMETERS AND LENGTHS AS SCALED BY THE INTERNATIONAL RULE (I) AND BY THE DOYLE RULE (D)

Top diameter Inches	Length of the log in feet									
	8		10		12		14		16	
	I	D	I	D	I	D	I	D	I	D
6	10	2.0	10	2.5	15	3.0	15	3 5	20	4.0
7	10	4.5	15	5.0	20	7.0	25	8 0	30	9.0
8	15	8.0	20	10.0	25	12 0	35	14.0	40	16.0
9	20	12.0	30	16.0	35	19.0	45	22.0	50	25.0
10	30	18.0	35	22.0	45	27.0	55	31.0	65	36.0
11	35	24.0	45	31 0	55	37 0	70	43.0	80	49.0
12	45	32.0	55	40.0	70	48.0	85	56 0	95	64.0
13	55	40.0	70	51.0	85	61.0	100	71.0	115	81.0
14	65	50.0	80	62.0	100	75.0	115	87.0	135	100.0
15	75	60.0	95	76.0	115	91.0	135	106.0	160	121.0
16	85	72.0	110	90.0	130	108.0	155	126.0	180	144.0
17	95	84.0	125	106.0	150	127.0	180	148.0	205	169.0
18	110	98.0	140	122.0	170	147.0	200	171.0	230	196 0
19	125	112.0	155	141.0	190	169.0	225	197.0	260	225.0
20	140	128.0	175	160.0	210	192 0	250	224.0	290	256.0
21	155	144.0	195	181.0	235	217.0	280	253.0	320	289.0
22	170	162.0	215	202.0	260	243.0	305	283.0	355	324 0
23	185	180.0	235	226.0	285	271.0	335	316.0	390	361.0
24	205	200.0	255	250.0	310	300.0	370	360.0	425	409.0
25	220	220.0	280	276.0	340	331.0	400	386 0	460	441.0
26	240	242.0	305	302.0	370	363.0	435	423.0	500	484.0
27	260	264.0	330	331.0	400	397.0	470	463.0	540	529.0
28	280	288.0	355	360.0	430	432.0	510	504.0	585	576.0
29	305	312.0	385	391.0	465	469.0	545	547.0	630	625.0
30	325	338.0	410	422.0	495	507 0	585	591.0	675	676 0
31	350	364 0	440	456.0	530	547.0	625	638.0	720	729.0
32	375	392.0	470	490.0	570	588.0	670	686.0	770	784.0
33	400	420.0	500	526.0	605	631.0	715	736.0	820	841.0
34	425	450.0	535	562.0	645	674.0	760	787.0	876	900.0
35	450	480.0	565	601.0	686	721.0	805	841.0	925	961.0
36	475	512.0	600	610.0	725	768.0	855	896.0	980	1024.0

Where local markets do not exist, it pays to market such logs at distant points. The prospective returns can be approximated by getting specifications and quotations from buyers of the kind of logs in question. A list of dealers and consumers is given in appendix C. Get from the local freight agent the rates per 100 pounds on logs in carload lots to the markets in question. The number of pounds per M. B. F. of logs for various species is given in Table XVIII. The transportation cost per M. B. F. is found by multiplying the rate per 100 pounds by the number of hundred-weights shown in the table, and thus the best market may be determined. Full carload lots should be shipped to minimize the freight charge. Frequently it is advisable for several woodlot owners to cooperate in making carload shipments. From 4,000 to 7,000 B. F. (Doyle Rule) can be shipped per average car of 60,000-pound capacity.

Logs should be cut in lengths of 8, 10, 12, 14, and 16 feet, and an allowance of from 3 to 6 inches should be made for irregular saw-cut in working the tree up into logs. It is advisable to make long logs where possible, but the aim should be to get the most from the tree by making cuts so as to get the maximum amount of high-grade material.

Logs suitable for low-grade veneers used in the manufacture of containers for fruit, eggs, and vegetables, or for ordinary lumber, bring from $15 to $30 per M. B. F. at points of consumption. Specifications vary, but logs with a minimum diameter of 12 inches are usually accepted. The manufacturers of fruit and vegetable containers use tulip poplar, sweet gum, tupelo gum, black gum, sycamore, cottonwood, willow, elm, cypress, birch, cucumber, hackberry, soft and hard maples. Egg crates are made chiefly from tupelo gum, sweet gum, and cottonwood. Local sawmills or wood-using industries in many regions offer a market for logs of practically all species listed above, as well as for ordinary oak and hickory. Prices paid usually range between $15 and $30 per M. B. F.

LUMBER

The efficient manufacture of lumber for special industries requires knowledge, experience, and capital not ordinarily at the command of the woodlot owner; consequently, he finds it difficult to manufacture to special sizes, grades, and quantities to meet the requirements of wood-using industries. The woodlot owner who decides to operate a sawmill will usually find a local market for oak and hickory bridge plank and for limited amounts of mill-run rough lumber and dimension stock. This, with the tie market, usually furnishes the chief outlet for such mills, but a better market can be developed for sound timber of the larger diameters. Markets should be investigated even before the trees are cut, in order to determine the lengths and diameters required; and, if possible, contracts should be secured for the product before cutting a stick.

TABLE XVIII

APPROXIMATE WEIGHTS OF VARIOUS WOOD PRODUCTS*

Species	Lumber (per 1,000 board feet).			Logs (per 1,000 board feet) (Doyle Rule)						Cordwood bolts, butts, etc., per cord	
				12 inches diameter		18 inches diameter		24 inches diameter			
	Air-dry	Green	Rough (classed as 1 inch thick) "shipping dry"	Green	Dry	Green	Dry	Green	Dry	Green	Dry
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Ash, white	3,500	4,000	3,800	11,100	9,700	7,700	6,800	6,600	5,700	4,300	3,800
Basswood	2,100	3,400	2,500	9,500	5,900	6,600	4,100	5,600	3,500	3,700	2,300
Beech	3,600	4,600	4,000	12,700	10,100	8,900	7,000	7,500	6,000	5,000	3,900
Cherry, black	3,000	3,800	3,800	10,500	8,300	7,300	5,800	6,200	4,900	4,100	3,200
Cottonwood	2,200	3,600	2,800	10,700	6,300	7,500	4,400	6,300	3,700	4,200	2,500
Elm, white	2,900	4,000	3,100	11,300	7,800	7,900	5,500	6,700	4,600	4,400	3,100
Elm, slippery	3,300	4,600	4,000	12,600	9,200	8,800	6,400	7,400	5,500	4,900	3,600
Gum, black	3,000	3,700	2,800	10,400	8,300	7,200	5,800	6,100	4,900	4,000	3,200
Gum, red (sweet)	2,800	3,900	3,300	10,600	8,100	7,400	5,600	6,300	4,800	4,200	3,100
Hackberry	3,500	4,400	3,200	11,300	8,900	7,900	6,200	6,700	5,200	4,400	3,500
Hickory	4,300	5,200	4,500	14,700	11,900	10,300	8,300	8,700	7,000	5,700	4,600
Locust, black	4,100	4,800	.....	13,400	11,300	9,300	7,900	7,900	6,700	5,200	4,400
Maple, sugar	3,600	4,700	3,900	12,900	10,000	9,000	7,000	7,600	5,900	5,000	3,900
Maple, red	3,000	4,300	3,300	11,900	8,200	8,300	5,700	7,100	4,900	4,700	3,200
Maple, silver	2,800	3,800	3,300	10,500	7,800	7,300	5,400	6,200	4,600	4,100	3,000
Oak, red	3,600	5,400	4,000	14,800	10,400	10,300	7,300	8,800	6,200	5,800	3,900
Oak, white	4,000	5,200	4,000	14,400	10,900	10,000	7,600	8,500	6,500	5,600	4,300
Poplar, yellow (tulip)	2,400	3,200	2,800	8,800	6,500	6,100	4,500	5,200	3,800	3,400	2,500
Sycamore	3,000	4,300	3,000	12,000	8,300	8,400	5,800	7,100	4,900	4,700	3,200
Walnut, black	3,000	4,300	3,800	11,900	8,200	8,300	5,700	7,100	4,900	4,700	3,200
Willow	2,100	4,300	2,800	11,800	6,000	8,200	4,200	7,000	3,500	4,600	2,300

* Table taken from U. S. Dept. of Agr. Farmers' Bulletin No. 1210.

Grading hardwoods requires experience. The number of grades into which a given species is divided varies with different manufacturers, ranging from six to twenty or more grades for a single species. A description of the more standardized grades is given in grading rules which can be secured from the National Hardwood Lumber Association, McCormick Building, Chicago.

The weight of lumber per M. B. F. is given in Table XVIII. From 15 to 20 M. B. F. can be loaded to the car.

POSTS

A great many posts are marketed locally to farmers or to retail lumber dealers. The steam and electric lines also use large numbers and will furnish the specifications and quotations upon request. Some consumers limit purchases to the few so-called durable woods; others use a greater variety. Ordinarily the specifications call for straight, sound, round posts having a top diameter ranging between 4 and 6 inches D. i. b. and a length of 7 feet, cut square on both ends.

TIES

To estimate the number of ties in a tract of standing timber, there are required calipers, chalk, notebook, and pencil, as for estimating saw-logs. The following form is convenient.

D.B.H. inches	Black Oak Height in feet				White Oak Height in feet				Maple Height in feet				Elm Height in feet			
	50	60	70	80	50	60	70	80	50	60	70	80	50	60	70	80
10																
11																
12																
13																
14																
15																
16																
17																
18																

When two work together, the estimator calipers each tree about 4½ feet from the ground, marks it, and estimates the total height, calling out, for instance, "white oak, 14 inches, 70 feet." His companion places a dot or line in the proper place on the form to record a white oak D. B. H. 14 inches, total height 70 feet. The usual system of placing dots and lines as shown on p. 170, so that the closed figure records ten, is followed.

The total height can be estimated with the eye after a little practice, but at first the eye should be checked by measuring standing trees. A fairly accurate

and simple method consists in using a straight stick having a length of about five feet. The estimator takes a position at a point he judges to be distant from the tree about the total height of the tree and on approximately the same level as the tree. He grasps the stick in the right hand and standing with his right side toward the tree holds the stick vertically at arm's length between his body and the tree and pivots it until the tip comes to his right eye. The stick is pivoted back again and held vertically at a full arm's length toward the tree, so that a line from the eye to the pivotal point of the stick cuts the base of the tree. He then advances or retreats until the tip of the stick and the tip of the tree are in line with his right eye, while the line from eye to hand cuts the base. The distance to the tree from the point where he now stands, equals the total height of the tree. With practice, this distance can be measured by pacing.

Heights should be recorded in the nearest height class, i. e., 55 feet in the 50 feet class, and 56 feet in the 60 feet class. When the field work is completed, the number and grades of ties can be approximated by reference to Table XIX.

TABLE XIX

YIELD IN TIES OF VARIOUS GRADES (No. 1-5) FOR TREES OF GIVEN DIAMETER AND HEIGHT

Based on studies of black oak

D.B.H. inches	Total height in feet																				
	50					60					70					80				
	No. 1	2	3	4	5	No. 1	2	3	4	5	No. 1	2	3	4	5	No. 1	2	3	4	5
10	.....	..	..	..	..	1	..	..	..	..	1	..	..	..	..	1				
11	1	..	..	..	..	2	..	..	..	..	1	1	..	..	..	1	1			
12	1	..	1	..	..	.....	1	1	..	..	1	1	1	..	..	2	1			
13	.....	1	..	1	..	1	..	1	1	..	.....	1	1	1	..	1	1	..	2	
14	....	1	..	..	1	.....	1	..	1	1	.....	1	1	1	1	1	1	..	1	2
15	1	..	..	1	1	.....	..	1	1	1	.....	1	..	1	2	1	..	1	1	2
16	1	..	..	..	2	1	..	..	1	2	.....	..	..	1	3	.....	1	..	1	3
17	.....	..	..	..	2	1	..	..	..	3	1	..	..	1	3	.....	..	1	..	4
18	.....	..	1	..	2	.....	1	..	..	3	.....	1	..	..	4	1	..	..	1	4

Ties are graded according to species and size. There is a slight variation in required length, some specifications calling for 8½ feet, others for 8 feet. Also, some roads use a wider range of species than others, or have special rules governing the cutting period and methods of delivery. For these reasons, it is advisable to get specifica-

tions and quotations from the railroad where ties are to be marketed. This information can be secured through the local agent or by writing to the general purchasing agent. The quotations in Table XX give a general idea of the relative values of the different species and grades.

Table XX

Values of Ties (Based on Average Quotations)

Grade No.	Thickness In.	Width In.	"U A" Black locust, White oaks, Black walnut	"U D" Catalpa, Red mulberry, Sassafras	"T A" Ashes, Hickories, Honey locust, Red oaks	"T C" Beech, Birch, Cherry, Hackberry, Hard maple	"T D" Gums, Soft maples, Sycamore, White walnut
1	6	6	$0.55	$0.20	$0.45	$0.30	$0.20
2	6	7	0.75	0.30	0.65	0.50	0.40
3	7 / 6	7 / 8	1.00	0.50	0.90	0.75	0.55
4	7	8	1.25	0.65	1.15	1.00	0.65
5	7	9	1.35	0.75	1.25	1.10	0.75

The steam railroads readily absorb grades 4 and 5 but frequently local traction companies provide a better market for the smaller ties.

PILING

Trees suitable for piling must be straight and must carry a long clear bole with relatively little taper. The woodlot owner who has tall straight trees ranging in diameter between 14 and 22 inches D. B. H. should investigate the possibilities of this market. Dealers in piling are given in the list in Appendix C, but in many cases the owner can market directly to consumers, such as railroad companies or contractors along the water front. Specifications vary, depending on the conditions under which the pile is to be used. The common sizes are 30, 40, and 50 feet in length with a minimum top diameter of 9, 8, and 7 inches, respectively, and with a maximum butt diameter of 20 inches and a minimum of 12 inches. Prices depend not only upon the size but also upon the species, the more durable kinds, such as white oak, bringing a higher price. Species generally used are: black locust, white oaks, red gum, ash, beech, birch, cherry, elm, hickory, honey locust, maple, red oaks, and black gum. The approximate weights are given in Table XXI.

To estimate the number of piles in a woodlot, there are required calipers, crayon, pencil, and notebook. A convenient form for recording material is given below:

Species	Length of pile in feet						
	30	35	40	45	50	55	60
White oak...							
Red oak.....							
Ash							
Elm							

The estimator first determines if the tree has the required form, straightness, and size. Trees which have a D. B. H. between 14 and 22 inches are commonly acceptable. He then marks the tree and estimates the maximum length which can be secured conforming with the top diameter requirements. The rule is to allow two inches for bark thickness. Consequently, for piling with a 7-inch top, a point in the stem must he selected which has a diameter of 9 inches outside the bark. The estimator then jndges the distance from the stump to this point as the length of pile which can be cut. Some experience in estimating diameters and lengths is essential to accurate work. The tree is recorded by the dot-and-line system as for sawlogs.

TABLE XXI

APPROXIMATE WEIGHTS OF PILING OF DIFFERENT SIZES, GREEN AND DRY, FOR DIFFERENT KINDS OF WOOD*

Length	White Oak		Black Oak		Sugar Maple		White Elm		Black Gum	
	Green	Air dry	Green	Air dry	Green	Air dry	Green	Air dry	Green	Air dry
Feet	Weight in pounds									
20	610	470	610	440	550	430	480	340	440	350
25	770	590	770	550	690	530	600	430	550	450
30	920	700	920	660	820	640	710	510	660	530
35	1080	820	1080	770	960	750	840	600	770	620
40	1580	1200	1590	1140	1410	1100	1230	880	1130	920
45	1780	1360	1790	1280	1590	1240	1390	990	1270	1030
50	1980	1500	1980	1420	1770	1370	1540	1090	1410	1140

* From Farmers' Bulletin 1210, U. S. Dept. Agr., Washington, D. C.

MINE TIMBERS

The Illinois coal mines provide a market for large quantities of both rough and sawed wood. Wood in the round is used for props, legs, and bars. For ties, a face is hewed or sawed on one or more sides. For caps, inch boards about one foot square are used, and large quantities of sawed material are used in the buildings at the surface. The requirements in sizes and lengths vary for the different seams mined, so that a list of specifications should be obtained from accessible markets before cutting such timber. The latest coal report can be secured upon request at the Department of Mines and Minerals, Springfield, Illinois, which shows the location and tonnage produced from the operating mines. The list in appendix C contains the addresses of most mine timber dealers and consumers.

Sticks, either split or round, such as are used for supporting the roof in temporary openings, are termed props. They are cut square at the ends from any hardwood, and the bark is left on. The minimum top diameter accepted usually varies between 4 and 7 inches. The mines in the LaSalle region require lengths from 3½ to 7 feet; in Fulton County, 5 feet; in Sangamon County, 6 to 7 feet; and in Williamson County, 7½ to 10 feet.

Legs are the upright posts used, together with the bar across the top, to support the roof and walls in more permanent openings. For this work, white oak is usually demanded in lengths from 8 to 16 feet and in diameters from 6 to 9 inches.

Main-line, or motor, ties are usually oak from 4 to 6 feet long with a face of 4 inches and a thickness of 5 inches. Room ties are usually lighter, having a face and diameter an inch less. Prices for props at the mine range from 2 to 3 cents per running foot, legs average 4 cents, and bars from 4 to 10 cents. Motor ties bring about 25 cents each, and room ties from 8 to 16 cents. Mine timbers at these prices and under average costs of production (see Table XIV, p. 166) can be shipped up to 250 miles before all profit vanishes. Approximately 1200 mine ties constitute a carload, or from 800 to 1200 props, legs, or bars, depending upon the sizes. This market offers a very satisfactory outlet for the utilization of small materials such as usually come from thinnings or remain in the tops after a sawlog or railroad tie operation. The estimating of the amounts of mine timber per acre is complicated by the variety of products and specifications. No tables have been made to cover this material, but the general statement can be made that usually from one-fourth to one-half carload is cut per acre and that its requires an exceptionally well-stocked stand of thrifty polewood growth to produce a carload to the acre.

CORDWOOD

Fuelwood and pulpwood are measured and marketed by the cord. Ordinarily the market price of cordwood does not justify any rail shipment. Local markets may be found among neighboring farmers, fuel dealers, bakers, and consumers of open-fireplace fuel. The meat packers offer a somewhat limited market for good hardwood at excellent prices, as they consume more than 5,000 cords annually. Charcoal plants in Johnson, Pulaski, Alexander, and Jersey counties furnish markets for cordwood located within short hauling distances. Limited amounts of pulpwood are also marketed from Illinois to Ohio.

The standard cord is a stack which measures 8 by 4 by 4 feet and contains 128 cubic feet. Usually the stack of green wood is piled 3 inches higher than 4 feet to allow for shrinkage in drying. An approximate estimate of the amount of cordwood in standing timber can be secured by calipering each tree in the plot and referring to Table XXII for the number of trees of each diameter required to yield one cord.

TABLE XXII

NUMBER OF TREES REQUIRED TO YIELD ONE CORD*

Diameter of tree breast-high	Number of trees	Diameter of tree breast-high	Number of trees
2	170	13	3.4
3	90	14	3.0
4	50	15	2.5
5	25	16	2.2
6	17	17	2.0
7	13	18	1.8
8	9	19	1.5
9	7	20	1.3
10	6	21	1.2
11	5	22	1.1
12	4	23	1.0
		24	.9

* Taken from Farmers' Bulletin No. 1210, United States Department of Agriculture.

The markets should be investigated before cutting. The requirements of the meat packers vary, but such species as oak and hickory in diameters between 4 and 8 inches are generally preferred. Quotations fall between $6 and $16 per cord for wood f. o. b. destination. For wood pulp, the sticks must be 54 inches in length, peeled, and of cottonwood, soft maple, or box elder. Sticks down to a 3-inch diameter are accepted, and the prices approximate $6.50 per cord f. o. b. shipping point. Wood used in stoves and open fireplaces is usually cut into 16-inch lengths and marketed locally by the short cord or by the pound, retailing in cities for about $7 per short cord. A cord of air-dried hardwood weighs 4,000 pounds, and a box car holds from 15 to 18 cords.

Appendix A

Preservative Treatment of Fence Posts

The practice of treating fence posts with preservatives permits the use of virtually all species. Posts which ordinarily would give service of from 3 to 10 years can be treated so as to serve 20 years or more, so that species which have rapid growth rates and immunity from destructive insect attacks may be chosen for post production. Cottonwood, silver maple, willow, and honey locust are very satisfactory post trees. Cottonwood will produce posts in five years on good bottomland soils, is a very suitable tree on upland prairie loams, makes growth acceptable for posts on upland sands, but does not make acceptable growth on hardpan soils. The cost of treatment increases with increase in the size of the post, and for this reason posts having a diameter under five inches are preferable to larger ones. Split posts when properly treated have practically the same durability as round posts. The cost of treatment runs up to 20 cents per post.

Posts with a high percentage of sapwood, such as usually require preservative treatment, often check if cut in the summer, and for this reason it is preferable, although not essential, to cut them in the dormant season. They should be peeled, and it is important to carefully remove the inner as well as the outer bark. The posts should then be piled off the ground in such a manner as to give free air circulation. They should be left in this condition two or three months in order to season properly before being treated.

The application of preservatives to the surface is not effective; hence, the slight increase in durability secured by brush or dipping treatments of tars and paints does not warrant the expense. An effective treatment, practical for farm use, is called the open-tank process.

The simplest equipment for this process is a single tank set over a fire pit. The tank should be deep enough to insure submergence of fully half the length of the post at a dipping. A large oil drum* has a capacity of 25 posts per day. Care should be exercised in selecting a location away from buildings. The pit should be partly below ground level in order to keep the top of the tank as low as possible. It can be walled in with brick, hollow tile, or rock, leaving an aperture for the flue and an opening to stoke the fire. In a temporary

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* A tank with a 3-foot diameter and 4-foot depth made from 20 gauge iron with angle iron reinforcements, all joints riveted and rivet holes soldered.

set-up where cement is not used, earth should be banked about the outside of the foundation. Three or four lengths of ordinary stove pipe can be used for a flue. Four iron bars are laid across the top of the foundation as a support for the tank. Earth placed against the sides of the tank serves to hold the heat in the pit, while the opening in front and the flue furnish ample draft. Enough coal-tar creosote is placed in the tank so that with its charge of posts the tank is full. The creosote is heated to a temperature of at least 180° F. but should not be heated above 200° F., as there is then a loss of the oils through evaporation. The posts are placed in position with the larger end down, with at least 3 to 3½ feet submerged, and held in creosote at the above temperatures, as follows: Soft maple and cottonwood, 2 hours; willow, 4 hours. The butt treatment of yellow poplar and sycamore requires about the same time as cottonwood, while fully 6 hours are required for good impregnation of white ash, elm, hackberry, hickory, hard maple, and black oak. The preservative should go into the wood at least a half-inch. The amount of creosote absorbed averages half a gallon per post. Keep the creosote at a uniform level by adding more as posts absorb it. The posts should be left in the tank until the creosote cools, and the creosote should be kept at a uniform depth for this time also.

The tops should next be treated by inverting the posts so that all wood not previously reached is submerged, and leaving them in the tank while the creosote is being heated up to 180° F. The posts should then be put in open piles. The excess creosote in the tank can be put back into a barrel and stored until needed again. It is important, in setting posts thus treated, that the top line of the butt treatment should be at least 6 inches *above* the ground line.

Where the number of posts to be treated justifies the installation of more elaborate equipment, a second tank* of cold creosote is used. After the butt treatment in the hot creosote, the posts are immediately transferred to the tank of cold creosote. These are held in the cold creosote until the posts are thoroughly cooled, and by this process the preservative is drawn into the heated portion of the butt. The coating which the top receives is enough to safeguard it against ordinary decay.

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* The best type of tank for the cold creosote is a 2½ x 2½ x 8 foot stock tank. It should have ample capacity to hold completely submerged all posts from the hot tank.

Appendix B

Concerns Dealing in Tree Seedlings and Transplants*

D. Hill Nursery, Dundee, Illinois.
Onarga Nursery Company, Onarga, Illinois.
Naperville Nurseries, Naperville, Illinois.
Betsie River Nursery, Thompsonville, Michigan.
Northeastern Nursery Company, Cheshire, Connecticut.
F. W. Kelsey Nursery Co., 50 Church Street, New York City.
Evergreen Nursery Company, Sturgeon Bay, Wisconsin.
Forest Nursery Co., Inc., McMinnville, Tennessee.

Tree Seed Dealers*

T. Meehan Sons, Dresher, Pennsylvania.
Thomas J. Lane, Dresher, Pennsylvania.
Conyers B. Fleu, Jr., Germantown, Pennsylvania.
Otto Katzenstein, 6 Cone St., Atlanta, Georgia.
J. M. Thorburn, 32 Barclay Avenue, New York City.
The Barteldes Seed Co., Lawrence, Kansas.
L. E. Williams, Exeter, New Hampshire.
The American Forestry Co., Pembine, Wisconsin.
Frank N. Graass, Sturgeon Bay, Wisconsin.

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* These lists have been carefully prepared for the convenience of woodlot owners, but the State Natural History Survey does not vouch for their completeness nor guarantee the responsibility of the concerns here named.

Appendix C

LIST OF CONSUMERS AND DEALERS*

ADAMS COUNTY

Lumber

Electric Wheel Co., Quincy. Buy graded oak and hickory cut to special sizes.
Collins Plow Co., Quincy. Buy graded elm and oak.
Henry Knapsheide Wagon Co., Quincy. Buy graded oak.
Quincy Show Case Works, Quincy. Buy black walnut, oak and rough local lumber.

ALEXANDER COUNTY

Logs

Peterson-Miller Box Co., Cairo. Buy cottonwood, sycamore, willow, and red gum.
Singer Mfg. Co., Cairo. Buy black walnut, white and red oak, and red gum.

Lumber

Vehicle Supply Co., Cairo. Buy oak and hickory cut to special sizes.

Ties

Solomon Tie & Timber Co., Cairo. Buy ties.

Piling

Solomon Tie & Timber Co., Cairo. Buy piling.

Cordwood

Solomon Tie & Timber Co., Cairo. Buy cordwood at Tamms.
Alabama Charcoal Co., Kansas City, Mo. Buy cordwood at Cache and Olive Branch.

Sawdust

E. Bucher Packing Co., Cairo. Buy hardwood sawdust.

Standing timber

Solomon Tie & Timber Co., Cairo.

BOONE COUNTY

Logs

National Sewing Machine Co., Belvidere. Buy walnut.

BUREAU COUNTY

Mine timbers

Spring Valley Coal Co., No. 3. Springvalley.
Saint Paul Coal Co., No. 2, Cherry.

CHRISTIAN COUNTY

Mine timbers

Penwell Coal Mining Co., Pana.
Springside Coal Co., Pana.
Pana Coal Co., No. 1 and 2, Pana.
Peabody Coal Co., No. 7, Kincaid.
Peabody Coal Co., No. 8, Tovey.
Peabody Coal Co., No. 9, Taylorville.
Peabody Coal Co., No. 21, Stonington.

* The Natural History Survey does not vouch for the completeness of this list nor guarantee the responsibility of the concerns named here.

Clinton County

Mine timbers

Breese-Trenton Mining Co., Beckemeyer.
W. W. Smith, Keyesport.

Cook County

Logs

R. S. Bacon Veneer Co., 213 N. Ann st., Chicago. Buy walnut.
Adolph Sturm Co., 542-44 W. Washington St., Chicago. Buy dogwood and persimmon.

Lumber

Pullman Car & Mfg. Corp., Pullman. Buy graded car stock.
Yellow Cab Mfg. Co., Chicago. Buy graded ash.
Marsh & Truman Lumber Co., 332 S. Mich. Ave., Chicago. Buy car stock crossing plank, etc.
L. D. Leach & Co., 5 N. Wabash, Chicago. Buy locally sawed lumber.
Chicago Mill & Lumber Co., Conway Bldg., Chicago. Buy locally sawed lumber.
Frank B. Stone, Maller's Bldg., Chicago. Buy local lumber.
Anguera Lumber & Tie Co., 111 W. Washington, Chicago. Buy local lumber.

Posts, Ties, and Piling

L. D. Leach & Co., 5 N. Wabash, Chicago. Buy piling and ties.
Chicago Mill & Lumber Co., Conway Bldg., Chicago. Buy piling poles and posts.
W. W. and A. J. Schultz, 1235 Colony Bldg., 37 W. Van Buren St., Chicago. Buy piling.
Ozark Timber Co., 833 W. Washington, Chicago. Buy ties.
Frank B. Stone, Maller's Bldg., Chicago. Buy piling and ties.
Anguera Lumber & Tie Co., 111 W. Washington, Chicago. Buy ties.
Bay, DeNouquet Co., 80 E. Jackson Bldv., Chicago. Buy ties.
W. B. Crane Co., 22nd and Sangamon Sts., Chicago. Buy ties.
Marsh & Truman Lumber Co., 332 S. Michigan Ave., Chicago. Buy ties.
Lake Superior Piling Co., 22nd and Morgan St., Chicago. Buy piling.
C. B. & Q. R. R. Co., Burlington Bldg., Chicago. Buy ties and piling.
C. M. & St. Paul Ry., Exchange Bldg. Chicago Buy piling, ties, and posts.

Cordwood and Sawdust

Swift & Co., Union Stock Yards, Chicago. Buy cordwood and sawdust.
Armold Bros., Inc., 660 W. Randolph St., Chicago. Buy hardwood sawdust.
Jourdan Packing Co., Chicago. Buy hardwood sawdust.
Cudahy Packing Co., 111 W. Monroe St., Chicago. Buy oak hickory cordwood and sawdust.
Omaha Packing Co., 2320 W. Halsted St., Chicago. Buy oak hickory cordwood and sawdust.
Roberts & Oaks, 45th and Racine Ave., Chicago. Buy oak hickory cordwood and sawdust.
Hately Bros. Co., 37th and Halsted Sts., Chicago. Birch, maple, oak, hickory cordwood and sawdust.
William Daviess Co., Inc., Union Stock Yards, Chicago. Birch, maple, oak, hickory cordwood and sawdust.
Armour & Morris, Union Stock Yards, Chicago. Oak wood, oak and maple sawdust.
Libby, McNeil & Libby, Union Stock Yards, Chicago. Oak and hickory wood and sawdust.
Beiersdorf & Bros., 932 W. 38th Place, Chicago. Buy oak, hickory, wood and sawdust.

COOK COUNTY—(Continued)

Covey Durham Co., 431 S. Dearborn St., Chicago. Buy cordwood and standing timber.
Illinois Fuel Co., 39 S. LaSalle St., Chicago. Fuelwood retailer.
Northern Wood Fuel Co., 310 S. Mich. Ave., Chicago. Fuelwood retailer.
W. A. Davis Hardwood Co., 122 S. Mich. Ave., Chicago. Fuelwood retailer.
Buesing Homan Coal Co., 2151 N. Lincoln St., Chicago. Fuelwood retailer.
Chicago Wood & Coal Co., 4900 W. Chicago Ave., Chicago. Fuelwood retailer.
Wilson & Co., 4100 S. Ashland Ave., Chicago. Maple and hickory wood and sawdust.
Chicago Butchers Packing Co., 216-222 N. Peoria St., Chicago. Buy maple and hickory wood and sawdust.
G. H. Hammond Co., Union Stock Yards, Chicago. Buy elm, maple, oak, hickory wood and sawdust.
Reliable Packing Co., 1446-1452 W. 47th St., Chicago. Buy hardwood sawdust.

Miscellaneous

Hartwell Handle Co., 146th and Lincoln Ave., Harvey. Use sapling hickory.
H. R. Mosnat, 10, 910 Prospect Ave., Morgan Park, Chicago. Buy walnut kernels.

DEWITT COUNTY

Cordwood

Clinton Coal Co., Clinton.
C. E. Crang, Clinton.

EDGAR COUNTY

Logs

T. A. Foley, Paris. Buys black walnut, cherry and high grade logs.

Lumber

Cummings Car & Coach Co., Paris. Buys car stock.

EFFINGHAM COUNTY

Lumber

John Boos, Effingham. Buys specially sawed soft maple.

Mine timbers

C. E. Hershey & Co., Effingham.

FAYETTE COUNTY

Mine timbers

Sholmier Timber Co., Vandalia.

FRANKLIN COUNTY

Mine timbers

Valier Coal Co., Valier.
Franklin County Coal Co. No. 7, Royalton.
Franklin County Coal Co., No. 5, Herrin.
Franklin County Mining Co., Benton.
Old Ben Coal Corp. Nos. 8, 9, 19, West Frankfort.
Old Ben Coal Corp. Nos. 10, 11, 12, Christopher.
Old Ben Coal Corp. No. 14, Buckner.
Old Ben Coal Corp. No. 15, Ezra.
Old Ben Coal Corp. No. 16, Sesser.
C. W. & F. Orient No. 2, West Frankfort.
C. W. & F. Orient No. 1, Orient.
Peabody Coal Co., No. 18, West Frankfort.
Bell & Zoller Mining Co., No. 2, Zeigler.

Fulton County
Mine timbers
Canton Coal Co., Canton.
Buckheart Coal Co., Canton.
Rawal Coal Co., Canton.
Murphy & Loftus, Canton.

Grundy County
Mine timbers
Wilmington Star M. Co., Coal City.

Henry County
Mine timbers
Shuler Coal Co., Alpha.

Jackson County
Logs
Merchants Basket & Box Co., Grand Tower. Buy elm, gum, etc., logs 16" and up.
Ties
Ayer & Lord Tie Co., Carbondale.
Mine timbers
DeSoto-Peacock Coal Co., DeSoto.
Harsha & Floyd, Vergennes.
Rector Bros., Murphysboro.
H. M. Sellers, 800 S. Forest St., Carbondale.

Jersey County
Cordwood
Equitable Powder Mfg. Co., E. Alton. Use bottomland and hardwoods in charcoal plant at Grafton.

Johnson County
Cordwood
Berger Bros., 1176 Cherry Ave., Chicago. Charcoal plant at Belknap.

Kane County
Logs
Westgate Walnut Co., Aurora. Buy black walnut.
Lumber
Appleton Mfg. Co., Batavia. Buy graded oak.

LaSalle County
Lumber
King & Hamilton Co., Ottawa. Graded oak.
Ties
Northwestern Timber Co., Mendota. Also buy standing timber.
Mine timbers
LaSalle County Carbon Coal Co., Union.

McLean County
Logs
J. O. Wheadon, Bloomington. Buys walnut logs, standing timber, ties, lumber, mine props and cordwood.
Lumber
Paul O. Moratz, Bloomington. Buys log run oak and hard maple lumber.

Macon County
Cordwood
Danzeisen Packing Co., Decatur. Buy oak hickory wood.

MACOUPIN COUNTY
Mine timbers
Madison Coal Corp. No. 5, Mt. Olive.

MADISON COUNTY
Lumber
American Car Foundry Co., Madison. Buy car stock.
Illinois Glass Co., Alton. Buy cottonwood lumber.

MARION COUNTY
Mine timbers
L. S. Gray, Centralia.

MARSHALL COUNTY
Mine timbers
F. A. Barr, Lacon.

MASON COUNTY
Lumber
Havana Metal Wheel Co., Havana. Buy graded oak, ash, hickory.

MASSAC COUNTY
Logs
E. C. Artman Lumber Co., Metropolis.
Roberts Liggett Co., Metropolis.
Ties
E. C. Artman Lumber Co., Metropolis.
Bennett-Field Tie Co., Tie plant at Brookport.
Mine timbers
Bennett-Field Tie Co., Brookport (main office 1406 Fisher Bldg., Chicago).

MONTGOMERY COUNTY
Mine timbers
Hillsboro Coal Co., Hillsboro.

MORGAN COUNTY
Cordwood and sawdust
Powers Begg & Co., Packers, Jacksonville. Buy hardwood and sawdust.
Walton & Co., Jacksonville, cordwood retailers.
Rogerson & Co., Jacksonville, cordwood retailers.
J. A. Paschall, Jacksonville, cordwood retailers.

PEORIA COUNTY
Logs
National Cooperage & Woodenware Co., Peoria. Buy red and white oak.
Moschell & Whitfield, Marshall Block, Pekin. Buy black cherry and walnut logs.
Mine timbers
Crescent Coal Co., No. 6, Peoria.
Neusau Bros. Coal Co., Glasford.
Crescent Coal Co., No. 1, Peoria.
Hanna City Mining Co., Hanna City.
Bartonville Coal Co., Peoria.
Cordwood and sawdust
Wilson Provision Co., Peoria. Buy maple, oak, hickory wood and sawdust.
Godel & Sons, Peoria. Buy oak, hickory wood.

Perry County

Mine timbers

Crear Clinch Coal Co., DuQuoin.
Willis Coal & Mining Co., No. 7. Sparta.

Pulaski County

Logs

O. L. Bartlett, Mound City. Buys elm, gum, hackberry, maple, ash, and sycamore.
Geo. L. Kannapell, Mound City Veneer Mills. Buys tulip and gum.
Portsmouth Veneer & Panel Co., Mound City. Buy oak, poplar and gum.
Inman Veneer & Panel Co., Mound City. Buy poplar, gum, and oak.
Main Bros. Box & Lumber Co., Karnak. Buy softwood logs locally.

Cordwood

B. E. Moses, Perks.
J. E. Black Charcoal Co., Ullin.

Putnam County

Mine timbers

Barney Ernst, Granville.
A. Hecht, Magnolia.

Randolph County

Mine timbers

Madison Coal Corp., Tilden.

Rock Island County

Lumber

Strombeck-Becker Mfg. Co., Box 74, Moline. Buy locally sawed basswood.

St. Clair County

Logs

W. L. Fletcher, Ill. Walnut Co., E. St. Louis. Buys walnut.

Mine timbers

B. B. Coal Co., Belleville.
Prairie Coal Co., O'Fallon.
Mulberry Hill Coal Co., Freeburg.
Southern Coal, Coke & M. Co., Nos. 1, 6, 7, 8. Belleville.
Aluminum Ore Co., E. St. Louis.
Groom Coal Co., Belleville.
Lou Nash Coal Co., Freeburg.

Cordwood and sawdust

Armour and Co., E. St. Louis. Buy hickory wood, hardwood sawdust.
Swift and Co., E. St. Louis. Buy hickory wood, hardwood sawdust.

Saline County

Mine timbers

Dodds Coal Co., Carriers Mills.
Harrisburg Coal M. Co. B. B., Harrisburg.

Sangamon County

Mine timbers

Madison Coal Corp., Divernon.
West End Coal Co., Springfield.
Sangamon Coal Co., No. 2, Spriugfield.
New Staunton Coal Co., Livingston.
C. W. & F. Coal Co., No. 1, Thayer.

SANGAMON COUNTY—(Continued)
Peabody Coal Co., No. 6, Sherman.
Peabody Coal Co., No. 51, Auburn.
Peabody Coal Co., No. 52, Riverton.
Peabody Coal Co., No. 53, Springfield.
Peabody Coal Co., No. 54, Auburn.
Peabody Coal Co., No. 55, Springfield.
Castleman Bros. Timber Co., 401 Ridgley, Springfield. Buys ties, standing timber, mine timber.
Standard Tie & Timber Co., Reisch Bldg., Springfield.

SHELBY COUNTY
Mine timbers
Moweaqua Coal M. Co., Moweaqua.
J. J. Patterson, Trowbridge, R. R. 1

TAZEWELL COUNTY
Mine timbers
Groveland Coal M. Co., Pekin.
Ubben Coal Co., Pekin.

UNION COUNTY
Logs
H. A. DuBois, Cobden. Buys gum, sycamore, maple, poplar, cottonwood, willow, elm, and hackberry.
Julius Rendelman, Alto Pass. Buys poplar, gum, beech, sycamore, etc.
Ed. Karraker, Jonesboro. Buys poplar, gum, beech, sycamore, etc.
C. M. Sampson, Jonesboro. Buys oak and poplar veneer logs.
R. L. Lawrence, Cobden. Buys basket veneer logs.
Dongola Box Factory, Dongola. Buy softwood and oak logs.
Fruit Growers Package Co., Jonesboro. Buy maple, beech, sycamore, etc.
Ties
C. M. Sampson, Jonesboro.

VERMILION COUNTY
Logs
Pierson-Hollowell Walnut Co., 520 Section St., Danville. Buy walnut.
Mine timbers
Peabody Coal Co., No. 24, Danville.

WARREN COUNTY
Lumber
Western Stoneware Co., Monmouth. Buy rough local lumber.
Mine timbers
Dennis Howard, Monmouth.

WASHINGTON COUNTY
Logs
J. J. Pool, Richview. Buy cooperage stock.

WHITE COUNTY
Mine timbers
C. A. Fitch, Norris City.

WHITESIDE COUNTY
Logs
Illinois Refrigerator Co., Morrison. Buy ash, basswood, elm, maple logs and lumber.

Will County

Logs

Federal Match Corp., Joliet. Basswood logs.

Williamson County

Mine timbers

Sincerity Coal Co., Marion.
Crear Clinch Coal Co., Herrin.
Sincerity Coal Co., Carterville.
Crear Clinch Coal Co., Johnson City.
St. Louis Coal & Iron Co., No. 1, Johnson City.
Consolidated Coal Co., No. 7, Herrin.
Freeman Coal M. Co., Herrin.
Old Ben Coal Corp. No. 18, Johnson City.
Old Ben Coal Corp. No. 20, Herrin.
C. W. & F. Mining Co., Mine A, Herrin.
Peabody Coal Co., No. 3, Marion.
Southern Timber Co., Marion.

Winnebago County

Logs

Litton Veneer Co., Rockford. Buy walnut, basswood, and elm.
Illinois Veneer Co., Rockford. Buy walnut, basswood, and elm.

Lumber

Rockford Furniture Co., Rockford. Buy walnut and basswood.
Illinois Sewing Machine Co., Rockford. Buy walnut and basswood.
Old Colony Chair Co., Rockford. Buy walnut.
Continental Desk Co., Rockford. Buy cedar.
Rockford Eagle Furniture Co., Inc., Rockford. Buy red cedar.
Rockford Reed & Fibre Co., Rockford. Buy rock elm.
Rockford Cedar Furniture Co., Rockford. Buy red cedar.

Woodford County

Mine timbers

Banta Bros., Lowpoint.
Rudolph Durst., Metamora.

Appendix D

UNITED STATES DEPARTMENT OF AGRICULTURE

PUBLICATIONS RELATING TO WOODLOT MANAGEMENT AND ORNAMENTAL TREE CULTURE

For the following publications, address the U. S. Department of Agriculture, Washington, D. C.

Trees for shade and ornament

Planting and care of street trees. (Farmers' Bulletin 1209) 5 cents.

Street trees—kinds, description, culture, and care. (Department Bulletin 816) 15 cents.

Tree Surgery. (Farmers' Bulletin 1178) 5 cents.

Trees for town and city streets. (Farmers' Bulletin 1208) 5 cents.

Planting the roadside. (Farmers' Bulletin 1481).

Trees for roadside planting. (Farmers' Bulletin 1482).

Beautifying the farmstead. (Farmers' Bulletin 1087).

Insects injurious to deciduous shade trees and their control. (Farmers' Bulletin 1169) 15 cents.

Trees for wood production

Cottonwood in the Mississippi Valley. (Department Bulletin 24) 10 cents.

Protection from the locust borer. (Department Bulletin 787) 5 cents.

White pine under forest management. (Department Bulletin 13) 15 cents.

Black walnut for timber and nuts. (Farmers' Bulletin 1392) 5 cents.

Black walnut, its growth and management. (Department Bulletin 933) 20 cents.

Selling black walnut timber. (Farmers'Bulletin 1459.)

Basket willow culture. (Farmers' Bulletin 622) 5 cents.

Basket willow, with chapter on insects injurious to basket willow. (Forest Bulletin 46) 15 cents.

Farm forestry

Care and improvement of the farm woods. (Farmers' Bulletin 1177) 5 cents.

Cooperative marketing of woodland products. (Farmers' Bulletin 1100) 5 cents.

Forestry and farm income. (Farmers' Bulletin 1117) 5 cents.
Forestry lessons on home woodlands. (Department Bulletin 863) 15 cents.
Measuring and marketing farm timber. (Farmers' Bulletin 1210) 5 cents.
Preserving treatment of farm timbers. (Farmers' Bulletin 744) 5 cents.
Machinery for cutting firewood. (Farmers' Bulletin 1023) 5 cents.
Use of wood for fuel. (Department Bulletin 753) 10 cents.
Wasteland and wasted land on farms. (Farmers' Bulletin 745).
Second-growth hardwoods in Connecticut. (Forest Service Bulletin 96) 15 cents.
Growing and planting hardwood seedlings on the farm. (Farmers' Bulletin 1123).
Growing and planting coniferous trees on the farm. (Farmers' Bulletin 1453).

Appendix E

Illinois State Natural History Survey
Publications on Forestry

Sent free upon request

Hall, R. C., and Ingall, O. D.
1911. Forest conditions in Illinois. Vol. IX, Art. 4.
Forbes, S. A.
1920. Concerning a forestry survey and a forester for Illinois. Forestry Circular No. 1.
Miller, Robt. B.
1920. Fire prevention in Illinois forests. Forestry Circular No. 2.
1923. First report on a forestry survey of Illinois. Vol. XIV, Art. 8.
Chapman, Herman H., and Miller, Robert B.
1924. Second report on a forest survey of Illinois. The economics of forestry in the state. Vol. XV, Art. 3.
Telford, C. J.
1926. Third report on a forest survey of Illinois. (A woodland inventory, including growth and yield studies). Vol. XVI, Art. 1.
1926. Brownfield Woods: a remnant of the original Illinois forest. Forestry Circular No. 3.
1926. Wood as a crop in Illinois. Forestry Circular No. 4.

Appendix F

SERVICES OFFERED TO WOODLAND OWNERS IN ILLINOIS

The Natural History Survey, as a branch of the State Government, is prepared to help farmers and other woodland owners in the following ways:

(1) Instruction through correspondence, or by personal visit if necessary, in proper methods of thinning and developing natural woodlands to their highest productive capacity.

(2) Advice as to cutting trees to the best advantage for various purposes.

(3) Information on means of marketing wood products from any point in the State to such users as furniture factories, veneer plants, railroads, mines, car shops, pulpwood factories, companies using piling, dealers in cordwood, and others.

(4) Estimation of costs of manufacturing various wood products and costs of transportation to various markets.

(5) Identification of tree diseases and insect enemies, when specimens are sent to the Natural History Survey, and advice on methods of eradicating pests.

(6) Advice through correspondence, or by personal visit if necessary, to those who desire to plant waste lands, as to the proper species of trees suited to the soils and to the special purposes of the plantations.

(7) Suggestions for solving problems in the protection of woodlands against fire.

(8) Co-operation with other State agencies in all matters related to forestry.

In this connection, the Natural History Survey also pursues the following aims:

(a) To take account of the value of woodlands, existing or proposed, for recreational uses, not only by the inhabitants of the larger cities of the State, but also by the country people and the inhabitants of the smaller towns, whose home surroundings are often oppressively monotonous.

(b) To consider the uses of forests as preserves of the primitive life of the State, of great interest and value to the student of science and his teacher and to the lovers of wild life.

(c) To co-ordinate the forest policy of the State with the movement for the establishment of a system of State parks.

Address inquiries to: Forester,
State Natural History Survey,
Urbana, Illinois.