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Forest Planting in Illinois.

BY

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CONTENTS.

ILLUSTRATIONS.

FOREST PLANTING IN ILLINOIS.

INTRODUCTION.

During a recent field season the Forest Service carried on in Illinois an extensive study of forest plantations, to determine the kinds of trees best adapted to planting in the prairie sections. Illinois has an area of approximately 56,000 square miles. The field work covered about two-thirds of this area, and was confined chiefly to the central and northern parts of the State, or north of a line drawn through Greene and Coles counties. South of this the prairie gives way to natural forest land, and though much of it is cleared there has been little forest planting. The results of the study contained in this circular, however, are of general application throughout the State, and also to similar situations in Indiana, Missouri, and Iowa.

THE REGION.

Illinois is comparatively level, and contains much true prairie land. This occupies, in general, the central part of the State. In the northern and southern portions the country becomes more rolling.

All variations of soil occur, from deep, black prairie loam to pure sand. Since nearly all of Illinois was once subjected to glacial action, the changes in soil are frequent and often abrupt.

The climate of Illinois is less humid than that of the Atlantic coast, but much more humid than that of the plains. There is a marked increase in precipitation from north to south. This increase, together with the average annual precipitation for each region, is shown in Table 1, compiled from records of the Weather Bureau.

TABLE 1.—*Annual precipitation in Illinois.*

District.	Number of stations.	Length of record.	Precipitation.
		Years.	*Inches.*
Northern	14	20–44	34.58
Central	11	16–32	37.52
Southern	9	17–33	41.73

On the whole, both climatic and soil conditions are favorable to tree growth. This is well illustrated by the fact that there are over 100 native tree species, and that a large number of foreign species which have been introduced are in a thriving condition.

EARLY PLANTING.

Much tree planting was done in Illinois previous to twenty years ago. The early settlers in the prairie regions felt the need of shelter belts and planted them extensively. Some plantations were also established for posts and fuel.

Except silver maple, which, despite its numerous defects, has long been a favorite, the species most widely planted in the early days was black walnut. About 1870, European larch came into favor, and a few years later catalpa was widely planted.

FOREST PLANTATIONS EXAMINED.

NUMBER AND AREA.

In Table 2 are summed up briefly the number of plantations examined, their acreage, the number of trees measured, and the number of sample plots on which volume or stem analyses of sample trees were made.

TABLE 2.—*Summary of plantations examined.*

Species.	Number of plantations.	Acreage.	Number of trees measured.	Number of sample plots on which volume measurements or analyses of sample trees were made.
European larch	16	22	2,000	12
Hardy catalpa	17	32	3,000	12
Black walnut	35	70	4,300	27
Silver maple	12	29	3,000	7
White ash	7	10	700	7
Other species	30	45	9,500	14
Total	117	208	22,500	79

METHODS OF STUDY.

Valuation surveys, usually of not less than one-tenth of an acre, were made on typical areas in the plantations. If conditions in a plantation varied sufficiently to make the results of one valuation survey insufficient to estimate the value of the whole plantation, two valuation surveys were made and their results combined. Small plantations were often measured entire. Diameters were measured at three points on the tree, namely, 1½, 4½, and 7½ feet above ground. The heights of several trees in each plantation were taken, usually with a hypsometer, and the heights of the remaining trees were estimated from these. Stem analyses were made of sample trees wherever possible. In many cases, however, where the owner would not consent to the cutting of trees, volume measurements of the sample trees were taken.

In computing products, the trees were estimated in posts, poles, logs, or cordwood, according to species and size. The estimate of yield in posts, poles, and logs was based upon actual count; that in cordwood upon volumes of sample trees or upon volume-diameter curves constructed for the purpose.[a] All posts and stakes are assumed to be 7 feet in length. Sticks from 2 inches to 2.9 inches in diameter at the top are classed as stakes, from 3 inches to 3.9 inches as second-class posts, from 4 inches to 5.9 inches as first-class posts, from 6 inches to 8.9 inches as two first-class posts each, and from 9 inches to 11.9 inches as four first-class posts each. All poles have a top diameter of 5 inches. Logs have a top diameter of 10 inches or more and are scaled by the Doyle rule. A cord of wood is assumed to contain from 73 to 88 solid cubic feet, according to the size of material.

The prices assigned to the various products were determined by comparison with the prevailing prices of similar material of other species, together with estimates of quality and durability. The prices are purposely made low in order that the conclusions drawn from the study might be conservative. The price of native white or bur oak posts in Illinois ranges from 8 to 15 cents. The cost of cutting such posts is usually from 2 to 2½ cents each. The market price of the native woods ranges from $3 to $6 per cord, according to location and quality. The cost of cutting is about $1 per cord.

DETERMINING THE VALUE.

In the tables the stand, yield, and value of the products are reduced to the basis of 1 acre throughout. Stumpage prices are assigned to the various classes of products. The cost of establishing each plantation is figured at 3 per cent compound interest for as many years as the plantation is old, and this amount is deducted from the gross value of the plantation to determine its present net value. The figure under the heading "Annual income at 3 per cent" is the sum which, if placed at 3 per cent compound interest during each successive year from the date of planting, would at present amount to the net value of the plantation. The value of the plantation is computed in this way in order that the profit from forest planting may easily be compared with that from farm crops.

In consequence of this method, also, the price of land and taxes do not enter into the calculations. For example, if a certain piece of land has on it a catalpa plantation which at the end of twenty years shows an annual income of $8 per acre at 3 per cent compound interest, when the annual income from ordinary farm crops on the

[a] These curves show how the volume of a tree is related to its diameter, so that for trees of all diameters the corresponding volumes are known.

same land for the same length of time averages not more than $6 per acre, it is evidently more profitable to devote the land to trees than to wheat or corn, whether its value be $20 or $100 per acre. Thus, if the comparison proves that forest planting is the more profitable, silviculture in this region becomes a legitimate form of agriculture.

SPECIES STUDIED.

HARDY CATALPA.

In estimating the value of the products from the plantations of hardy catalpa, first-class posts are assumed to be worth 12 cents each and second-class posts 8 cents each. The material left after the posts have been taken is estimated as cordwood and assumed to be worth $2 per cord. The cost of establishing a catalpa plantation is placed at $15 per acre.

TABLE 3.—*Hardy catalpa.*

Plantation No.	County.	Age.	Area of plantation.	Original spacing.	Number of trees per acre.	Average size of dominant trees.		Products per acre.			Net value per acre.	Annual income per acre at 3 per cent.	Condition.
						Diameter breasthigh.	Height.	Posts.		Firewood.			
								1st class.	2d class.				
		Yrs.	*Acres*	*Feet.*		*In.*	*Ft.*			*Cords*			
1	Whiteside...	15	0.63	4 by 4	1,010	2.8	21	.....	.....	.....	.....	.....	Poor; injured by fungi.
2	Marshall....	18	.73	.....	800	5.4	35	520	610	5	$95.67	$4.10	Fair; pastured.
3	Hancock....	18	.27	6 by 8	534	6.3	....	830	260	5	104.87	4.49	Good; slight injury by fungi.
4	Lee.....	20	.35	4 by 8	309	5.9	32	400	210	2	41.71	1.55	Very poor; trees grown from stump sprouts.
5	Marshall....	20	.63	.....	1,229	5.3	35	2,955	1,350	7	449.51	16.70	Excellent; see text.
6	Marion(Mo.)	20	8.00	4 by 8	392	7.5	47	1,515	320	2	184.31	6.85	See text.
7	.....do.....	20	1.25	4 by 8	616	7.0	55	1,930	540	2	251.71	9.35	Do.
8	Logan.....	21	3.50	.....	1,300	4.8	28	630	830	5	124.10	4.32	Best trees cut out; remainder poor and neglected.
9	Sangamon..	21	2.90	4 by 4	850	5.7	33	830	650	4	131.70	4.60	Do.
10	.....do.....	21	3.00	4 by 5	800	5.3	32	940	840	5	162.10	5.66	Similar to No. 9 on same farm.
11	.....do.....	21	1.10	4 by 5	730	4.8	25	390	500	7	72.90	2.54	Similar to No. 9 on same farm; much fungus.
12	Christian....	21	4.00	4 by 13	760	4.9	32	790	465	5	114.10	4.10	Very poor; spacing too wide.
13	Livingston..	22	.40	9 by 9	275	7.3	35	675	160	5	75.06	2.46	Good; 50 per cent of stand cut out.
14	Mason.....	23	2.50	.....	460	7.3	33	.....	.....	.....	.....	.....	Poor; best trees cut out.
15	Hancock....	23	1.40	5 by 6	744	6.5	40	1,710	610	3	230.39	7.10	Good; slight injury by fungi.
16	McLean.....	25	.70	.....	370	7.4	41	500	140	5	49.79	1.36	Many diseased trees; some cut out.
17	Bureau.....	32	.31	.....	432	10.3	46	1,050	550	.....	131.37	2.50	Old nursery rows allowed to grow up.

Plantation 5 is on level ground, with a rich prairie loam soil. The owner started the plantation by sowing the seed thickly in shallow drills after the ground had been well prepared. When the trees came

up he thinned them to about 2 feet in the row. They were carefully tended for two or three years, and then nothing more done to them. The trees soon thinned themselves to the present condition, about 4 feet apart in the row. The stand is very dense, being heavier than that found in any other plantation except No. 8. This crowding has resulted in the production of remarkably straight, smooth trunks, and consequently the trees can be utilized very closely for posts. This is by far the most profitable plantation examined.

Plantations 6 and 7, taken together, are the largest and in some respects the most important examined. They are situated in the low bottom of the Mississippi in Marion County, Mo., about 3 miles from Quincy, Ill., where conditions are identical with those on many areas on the Illinois side of the river. The conclusions drawn from a study of these plantations, therefore, may apply also to many localities in Illinois.

The two plantations were established at the same time and are separated only by a slough. The soil is sedimentary, rather heavy, and has occasional gumbo spots. The normal water level is 8 to 15 feet below the surface. Farm crops do well on the land when not damaged by floods, but these may occur at any time. It is said that within the last twenty years the plantations have suffered 15 inundations, and that the ground has been under water for a month at a time. Washing is prevented by the surrounding natural forest. The larger plantation comprises approximately 8 acres, the smaller $1\frac{1}{4}$ acres. The latter is 3 or 4 feet nearer water level and contains much better trees.

Both plantations were established by contract. The cost is said to have been $675 for the trees and planting, and $75 per year for ten years thereafter for care. These figures are excessive, especially since the trees appear to have received no attention except cultivation. Many trees were suppressed and died when 2 to 3 inches in diameter. Most of these have fallen to the ground, though some are yet standing. No cutting had taken place up to the time the plantations were examined.

In the larger plantation nearly 60 per cent of the trees are affected at the base by rot, brought on through infection from decayed branches. This often causes a loss at the butt of from 1 to 3 feet in merchantable length. In the smaller plantation the trees are much better formed than in the other, and not more than 30 per cent are rotten at the base. Aside from rot, however, the general condition of both plantations is good.

The ownership has recently changed hands, but because of the excessive initial cost and lack of proper management they would have brought little profit to the original owner. Notwithstanding this, however, they demonstrate beyond doubt that the best use to which

28434—No. 81—07——2

low flood lands in the valley can be put is tree planting. It is interesting to note that since these plantations were examined the present owner has sold from them over 3,000 posts at from 20 to 25 cents each after being seasoned. These posts were cut from an area of a little over an acre.

To get the best returns from these plantations, the larger one should be cut clean and allowed to sprout, while in the smaller one an improvement cutting should be made, as indicated below.

Improvement cutting in plantation No. 5.—The block shown in figure 1 (page 29) represents one end of plantation No. 5. It is 128 feet north and south by 120 feet east and west, and has an area of 0.35 acre. It contains 15 rows of trees, running east and west, 8 feet apart. The position of each tree in the block is accurately indicated in the diagram. The trees were planted 4 feet apart in the row, and the present stand is purely the result of natural thinning. The figures give the diameter at breastheight, and the class is indicated by the accompanying letter. There are standing on the block 206 trees, averaging 6.9 inches in diameter, which is 43 per cent of the original stand. The trees now have an average space of 75 square feet each, against 32 square feet at first. The stand is irregular, but the average density is sufficient to produce good forest conditions.

At this stage of the plantation it will evidently be the most profitable thing to remove the poorer trees and let the better ones grow for some time. All trees which should be removed are indicated by a diagonal line. The proposed cutting includes all the suppressed trees and a portion of the intermediate ones, which are of inferior form or which are crowding better trees. It will take out a total of 51 suppressed trees of the following diameter classes: 3-inch, 14; 4-inch, 23; 5-inch, 10; 6-inch, 4. The average diameter of these trees is 4.2 inches. Twenty-three intermediate trees averaging 5.9 inches in diameter should be removed. They are of the following diameter classes: 4-inch, 1; 5-inch, 9; 6-inch, 9; 7-inch, 3; 8-inch, 1. The number of trees of both classes to be removed is 74, or 39 per cent of the present stand. The trees left after the cutting will have an average space of 116 square feet each.

After the cutting there will be left in the block 132 thriving, well-formed intermediate and dominant trees averaging 7.9 inches in diameter, which should grow rapidly for several years, after which all the trees now classed as intermediate and some of the present dominant ones will need to be cut. It is evident that the present stand is extremely irregular owing to natural thinning, and that if the block had been properly thinned about ten years ago both the quantity and quality of the stand would have been greatly improved.

CATALPA SPROUTS.

A study of the sprouting capacity of catalpa from stumps was made in a mixed grove of catalpa, larch, and ash in Kendall County. A number of the catalpa trees had been cut the year before, and the way in which the stumps had sprouted is shown in Table 4.

TABLE 4.—*Catalpa sprouts.*

Size of stump.		Number of sprouts.		Average height of dominant sprouts.
Diameter.	Height.	Dominant.	Suppressed.	
Inches.	*Feet.*			*Feet.*
8.5	1.0	6	13	5.0
8.3	.8	1	3	5.0
6.0	1.0	5	15	3.0
6.3	.8	4	1	3.5
8.5	1.2	6	10	5.0
11.9	.7	6	11	5.0
8.0	1.0	9	19	4.0
7.7	1.0	4	8	4.5
7.7	.8	7	7	4.0
6.7	1.0	5	6	4.5
7.0	.8	3	8	2.5
8.0	1.3	6	13	4.5
8.4	1.5	7	21	5.0
8.2	1.8	5	19	4.5
8.3	1.2	5	4	6.0

The investigations show that with proper care catalpa planting is profitable in many parts of Illinois. Good results can not usually be expected, however, unless more attention is given both to spacing and to thinning or pruning than is necessary with most other species. The pronounced tendency to disease renders special watchfulness imperative if catalpa plantations are to be placed on a paying basis. Catalpa will grow fairly well on ordinary farm land, but is likely to fail on heavy, poorly drained soil. On the other hand, it grows well on sandy soil, where water is within a few feet of the surface or where overflows are frequent. Without question it will pay to plant catalpa on low bottom lands, where ordinary farm crops are only partially successful. Catalpa produces excellent posts, which can be used at a small size, so that plantations should begin to give some revenue from thinnings at 10 years of age. For ordinary situations a 20-year rotation is advisable.

EUROPEAN LARCH.

In the table for European larch the plantations are arranged according to age, the youngest plantation being No. 1 and the oldest No. 16. In all cases the amount of products was determined by actual count. The prices assigned to the products were: Poles, 15-foot, 20 cents; 18-foot, 30 cents; 20-foot, 40 cents; 25-foot, 60 cents; 30-foot, 80 cents; 35-foot, $1; 40-foot, $1.25; posts, first class, 6 cents; second

class, 3 cents. Cordwood was assumed to be worth $1 per cord, being, in this case, simply what is left after the plantation has been fully utilized for posts and poles.

The cost of establishing a plantation of European larch is assumed to be $18 per acre. The plantations varied widely in original expense, and the cost of establishing some of them was undoubtedly much more than $18 per acre. This figure, however, is a fair average.

TABLE 5.—*European larch.*

Plantation No.	County.	Age.	Area of plantation.	Original spacing.	Number of trees per acre.	Average size of dominant trees.		Products per acre.			Net value per acre.	Annual income per acre at 3 per cent.	Condition.
						Diameter breastheigh.	Height.	Poles, all kinds.	Posts, all kinds.	Firewood.			
		Yrs.	*Acres.*	*Feet.*		*In.*	*Ft.*			*Cds.*			
1	Knox	29	0.99	9 by 9	367	9.1	48	257	850	1	$187.57	$4.15	Rich soil; pastured.
2	.....do	29	.79	9 by 9	214	8.3	43	200	.....	1	117.57	2.60	Excellent; not pastured.
3	Warren	29	2.70	4 by 5	202	8.3	49	190	200	1	117.57	2.60	Good.
4	Kane	29	1.30	.....	156	5.7	40	87	125	1	None.	None.	Gravelly soil; neglected.
5	Ogle	30	.26	10 by 10	347	10.6	48	295	144	2	156.31	3.29	Good; rich soil.
6	Dekalb	30	.30	4 by 4	530	7.6	44	330	400	1	146.31	3.08	Do.
7	Bureau	30	1.00	4 by 4	880	8.0	55	660	.....	2	386.31	8.12	Excellent; dense stand
8	McHenry	30	.16	5 by 8	625	8.8	38	575	650	1	206.31	4.34	Good; light clay loam.
9	Winnebago	30	.70	.....	536	9.0	45	536	456	.....	351.31	7.38	Do.
10	Sangamon	32	.25	.....	300	9.8	37	280	280	.....	128.65	2.45	Poor; thin stand.
11	Bureau	32	2.40	.....	1,129	6.7	50	620	.....	2	313.65	5.97	Rather poor soil; dense stand.
12	Lee	32	5.50	.....	346	9.0	55	306	110	1	168.65	3.21	Good; rich soil.
13	Knox	33	.96	.....	627	7.9	48	580	365	2	252.26	4.58	Do.
14	Will	33	1.50	6 by 7	412	8.1	55	380	.....	1	232.26	4.22	Do.
15	Champaign	34	.40	2 by 4	710	8.3	55	620	.....	3	330.82	5.73	Alternate rows removed in 1877–78.
16	Bureau	45	.025	5 by 6	600	10.0	62	440	1,280	2	239.35	3.96	Good; rich soil.

The study shows that European larch is adapted to well-drained prairie soils in Illinois, and that in such situations it makes excellent growth. It is a matter of common knowledge, however, that the tree will eventually fail in situations where the drainage is poor. Bulletin 26 of the agricultural experiment station of the University of Illinois notes the effect of poor drainage on the larch plantations at that place, which may be taken as typical of similar conditions elsewhere. The plantation was established in 1871, and did very well for four or five years. Then trees occupying wet ground began to show signs of decay, and later to die. Those which survived had sparse and yellowish foliage and the branches were slender and wiry. Their roots ran near the surface, and a taproot appeared to be wanting. By 1893 not quite one-fourth as many trees were growing there as on the higher ground, where scarcely a tree, except those overtopped, had died or shown any signs of unhealthiness.

Larch will produce posts and poles in a brief time if closely spaced. It is, however, an intolerant tree, and will not endure mixing with trees which have an equal or faster rate of growth. A plantation in Kendall County was set with a mixture of larch, catalpa, and white ash. At the end of twenty-two years but 14 per cent of the larch had survived, although there were yet living 52 per cent of the catalpa and 71 per cent of the ash. Because of this intolerance, pure plantations of larch thin themselves enough to impair the crown cover, and grass is common in the older plantations. Though grass does not injure the larch as much as it does the walnut, it might be worth while to underplant larch with some shade-enduring species, such as sugar maple, at the time when the heaviest natural thinning begins, and thus maintain better forest conditions.

BLACK WALNUT.

The prices assumed for the products of the black walnut plantations are: Lumber, $20 per M board feet; first-class posts, 6 cents each; second-class posts, 3 cents each; wood, $2 per cord. The cost of establishing a walnut plantation is placed at $5 per acre. This very low cost is assumed because the planting of black walnut consists usually in dropping the nuts into a furrow and covering them by means of a plow or by hand.

It is true, of course, that most of the owners of walnut plantations have no intention of cutting them for posts, yet the trees are valueless for any other purpose until they reach lumber size, which will require at least fifty years. Though most of the walnut plantations were established without idea of financial gain, the best value possible has been given them in order to compare them with plantations of other species.

The study strongly emphasizes two facts concerning the growth of walnut in Illinois: (1) The walnut will grow well on prairie soil, notwithstanding its preference for rich bottom lands, but the situation must be well drained. Insufficient drainage was the sole apparent cause of the bad condition of many plantations. (2) The walnut is intolerant, and although plantations which are closely enough spaced preserve good forest conditions for the first twenty or thirty years, the intolerance of the tree in time becomes so marked that the natural thinning is great enough to break the crown cover. In consequence, grass gets a foothold. While in some cases the presence of a heavy sod does not appear to be detrimental to walnut, there are many other cases in which it does appear to be decidedly detrimental. For this reason all stock should be excluded from plantations, while underbrush should be encouraged. Further, to secure proper forest

conditions walnut should be underplanted with some shade-bearing species, such as sugar maple or basswood, when the heavy natural thinning begins.

TABLE 6.—*Black walnut.*

Plantation No.	County.	Age.	Area of plantation.	Original spacing.	Number of trees per acre.	Average size of dominant trees.		Products per acre.			Net value per acre.	Annual income per acre at 3 per cent.	Condition.
						Diameter breasthigh.	Height.	Lumber.	Posts.	Firewood.			
		Yrs	*Acres*	*Feet.*		*In.*		*Bd.ft.*		*Cords*			
1	Adams	16	0.05	6 by 12	600	6.4	28	.....	.....	.....	.....	.....	Healthy.
2	Ogle	20	.70	2 by 15	630	6.4	35	.....	860	12	$54.97	$2.05	Good.
3	Marshall	24	.44	4 by 5	430	6.7	35	.....	470	10	31.83	.92	Poor.
4	Livingston	24	.70	4 by 12	495	6.6	44	.....	1,250	10	65.83	1.91	Good.
5	McLean	25	.84	10 by 10	320	7.4	44	.....	730	12	52.53	1.44	Good; well cared for.
6	Ford	25	.....	.....	.....	8.7	52	.....	.....	.....	.....	.....	Good.
7	Marshall	27	1.40	.....	220	7.7	40	.....	600	10	35.89	.88	Poor; pastured.
8	McLean	27	.50	.....	230	7.4	50	.....	570	10	35.89	.88	Fair; not pastured.
9	do	29	4.00	4 by 10	305	7.4	45	.....	680	12	47.21	1.04	Fair.
10	Warren	29	.40	5 by 8	588	6.5	43	.....	.....	.....	.....	.....	Good; bottom land.
11	McLean	30	.25	.....	380	8.3	45	.....	890	20	73.86	1.55	Poor; pastured.
12	Sangamon	30	.60	10 by 15	230	9.4	60	800	1,035	18	91.86	1.93	Fair; pruned.
13	Livingston	32	.....	6 by 12	....	8.8	53	.....	.....	.....	.....	.....	Good; grassed.
14	Sangamon	32	2.00	.....	320	9.3	62	.....	1,560	25	120.12	2.29	Good; pruned and thinned.
15	Christian	34	13.00	.....	304	7.5	43	.....	950	4	47.34	.82	Fair; heavily grassed.
16	McLean	35	1.00	10 by 15	280	8.2	51	.....	1,020	15	68.93	1.14	Do.
17	Warren	35	3.78	9 by 13	165	9.4	60	.....	955	6	52.93	.88	Good; grassed.
18	McLean	36	.90	.....	300	8.1	46	.....	970	12	60.51	.96	Fair; pastured.
19	Woodford	37	.83	.....	260	9.4	52	.....	610	20	61.07	.92	Good; heavy sod.
20	Douglas	37	4.03	10 by 10	236	9.0	45	.....	1,165	10	73.07	1.10	Good; thinned.
21	Marshall	38	1.84	8 by 10	215	9.9	67	2,000	1,590	18	136.62	1.98	Fair; pastured.
22	Henry	39	1.45	.....	264	9.1	55	.....	.....	.....	.....	.....	Fair.
23	McLean	40	2.50	8 by 10	174	9.3	54	290	765	15	59.69	.79	Fair; some thinning; pastured.
24	do	40	1.50	10 by 15	200	9.2	63	600	995	18	81.69	1.08	Many dead trees; pastured.
25	do	40	.25	.....	260	9.0	59	.....	1,180	24	96.69	1.28	Fair; some damage by caterpillars.
26	do	40	1.80	12 by 15	235	9.3	62	800	1,535	16	110.69	1.47	Excellent; thinned; grassed.
27	Greene	40	.52	7 by 8	337	9.2	65	.....	2,460	8	141.69	1.88	Fair; fungi; hog lot.
28	Mason	42	2.50	.....	166	12.2	68	2,300	900	15	102.69	1.25	Fair.
29	Logan	47	.....	.....	71	13.0	63	5,000	255	11	114.94	1.15	Good.
30	Whiteside	49	.23	.....	148	14.7	75	16,000	910	25	396.72	3.66	Do.
31	Ogle	52	1.58	10 by 10	193	9.6	55	1,400	705	18	76.74	.63	Poor; many dead tops; grassed.
32	Adams	52	8.00	4 by 4	56	11.5	47	.....	.....	.....	.....	.....	Poor; hog and cattle lot.
33	Montgomery	52	5.00	1½ by 7	238	11.3	57	6,000	1,195	24	211.74	1.74	Good.
34	Knox	64	4.50	8 by 10	83	11.9	74	.....	.....	.....	.....	.....	Fair: thinned; pastured.
35	Morgan	64	.60	4 by 4	199	19.0	85	16,600	1,460	40	631.84	3.32	Good; wind-break.

None of the plantations except 30 and 35 shows a sufficient profit at its present age to encourage the planting of walnut as a commercial investment. The tree has a long life, and requires a longer time for the heartwood to develop than many other species. A properly cared-for and well-grown walnut plantation would undoubtedly show considerable profit when 50 years old, and the profit would probably be greater at 100 years. Such a long-time investment, however, is seldom considered desirable.

SILVER MAPLE.

Silver maple has been more extensively planted in Illinois than any other species. It is liked because of its rapid growth, but this is almost the only thing in its favor. The wood is considered to be worth $2 per cord on the stump, and no other product is given. The cost of establishing a plantation is placed at $10 per acre.

Plantation 10 is typical of many others in the State. It is 40 years old, and the original spacing was 4 by 8 feet. Only dead trees have been removed, and the struggle for existence has gone on until the surviving trees now number only about 17 per cent of the original stand. These are practically all dominant trees, with an average diameter of nearly 10 inches and an average height of 70 feet. The clear length is 40 feet, but the stems are crooked—often a characteristic of this species. When the plantation was started, a number of sugar maples were mixed with the silver maples. At present only an occasional sugar maple is found. The survivors are from 3 to 4 inches in diameter and from 20 to 30 feet high and are in good condition—an excellent illustration of the tolerance of sugar maple.

TABLE 7.—*Silver maple.*

Plantation No.	County.	Age.	Area of plantation.	Original spacing.	Number of trees per acre.	Average size of trees.		Yield per acre.		
						Diameter breast-high.	Height.	Wood.	Net value.	Annual income at 3 per cent.
		Yrs.	*Acres.*	*Feet.*		*Inches.*	*Feet.*	*Cords.*		
1	Hancock	18	0.81	10 by 10	250	7.8	47	24.7	$32.38	$1.38
2	do	18	.60	6 by 10	508	5.6	42	29.5	41.98	1.79
3	Rock Island	31	1.70	5 by 5	788	4.4	38	34.5	44.00	.88
4	do	31	1.81	5 by 5	608	4.5	38	27.5	30.00	.60
5	Ford	32	5.00	10 by 12	200	10.1	70	41.9	58.10	1.11
6	Winnebago	33	.....	7 by 8	.....	9.3	49	.....	.....	.....
7	Lee	35	1.80	5 by 10	308	10.9	70	51.1	74.10	1.23
8	Sangamon	35	.90	.....	173	13.4	80	47.1	65.98	1.09
9	do	35	5.60	6 by 6	264	10.6	71	62.4	96.74	1.60
10	Kane	40	7.00	4 by 8	222	9.8	70	35.2	37.78	.50
11	Lee	41	1.60	.....	269	9.8	68	52.0	70.40	.89
12	Whiteside	40	1.49	8 by 8	206	11.15	80	40.6	48.58	.64

Silver maple is valuable chiefly as a quick-growing shelter-belt tree and for fuel. The wood is too inferior to make the planting of the species profitable for any other purpose.

ASH.

Seventy per cent of the volume of white ash is figured as handle wood at $4 per cord and 30 per cent as cordwood at $2 per cord. This seems to be the best way to utilize ash of small size. Another way, however, is to cut the trees into posts. Ash will not make a very durable post, but it is assumed that a first-class ash post is worth 6 cents and

a second-class post 3 cents. Figuring all the plantations except No. 1 on this basis, and assuming the waste material to be worth $2 per cord for firewood, the net value of the plantations by each method can be compared. The comparison shows only a small difference in favor of cutting the ash for posts. Both methods indicate, in fact, that under present conditions ash plantations have but a small money value.

The condition of the plantations in general was good. Ash ordinarily does well on upland prairie soil, though it grows more rapidly in moister situations. Its principal use is as a shelter-belt tree. Here it can be rather closely planted, and the necessary thinnings from time to time will furnish good poles for use about the farm.

TABLE 8.—*White, green, and black ash.*

WHITE ASH.

Plantation No.	County.	Age.	Area of plantation.	Area of sample plot.	Original spacing.	Number of trees per acre.	Per cent of dominant trees.	Average size dominant trees.		Average annual growth dominant trees.		Total yield per acre.	Average annual increment per acre.	Money yield per acre.	
								Diameter breastheigh.	Height.	Diameter.	Height.			Net value.	Annual income at 3 per cent.
		Yrs	*Acres.*	*Acres.*	*Feet.*			*In.*	*Ft.*	*In.*	*Ft.*	*Cords*	*Cords*		
1	Livingston	25	0.50	0.10	9 by 4	440	70	5.7	36	0.23	1.4	14.4	0.58	$3.63	$0.10
2	McLean	27	4.50	.10	8 by 8	400	67	7.0	54	.26	2.0	27.0	1.00	65.25	1.60
3	Christian	32	2.50	.25	10 by 10	308	71	8.2	53	.26	1.7	27.6	.86	62.92	1.20
4	Ford	32	.....	.50	10 by 12	230	75	8.3	62	.26	1.9	23.2	.73	48.11	.92
5	.....do	33	1.72	.25	.....	372	75	8.6	50	.26	1.5	37.7	1.14	96.19	1.75
6	.....do	34	.....	.....	.....	.....	.....	8.0	50	.24	1.5	.....	.....	.....	.....
7	Woodford	37	.20	.20	6 by 10	290	78	7.5	35	.0	.9	23.2	.63	43.19	.65

GREEN ASH.

1	Champaign	34	3.0	0.25	2 by 4	332	53	8.0	61	0.24	1.8	28.4	0.62	.....	.....

BLACK ASH.

1	Warren	24	0.83	0.073	5 by 10	576	47	8.1	58	0.30	2.4	.....	.....	.....	.....
2	.....do	25	.50	.50	5 by 12	300	....	8.4	47	.34	1.9	.....	.....	.....	.....
3	Hancock	28	.17	.17	5½ by 5½	350	65	7.1	35	.25	1.3	.....	.....	.....	.....
4	Warren	29	.092	.092	.....	695	....	6.6	....	.23	....	.....	.....	.....	.....
5	.....do	29	1.23	.10	4 by 8	383	47	7.3	49	.25	1.7	.....	.....	.....	.....
6	Bureau	46	2.10	.50	.....	304	....	7.8	55	.17	1.2	.....	.....	.....	.....

The only green ash plantation examined was that at the University of Illinois. The trees have grown thriftily and the plantation is in good condition. Green ash is a hardy tree. It will succeed in many places where white ash would fail. Since, however, various

other species can be grown in Illinois which produce wood of greater value, green ash plantations serve their best use as shelter belts.

No products were estimated for black ash. The plantations are uniformly in good condition and the rate of growth closely approximates that of white ash. The plantations are useful as shelter belts.

OSAGE ORANGE.

Only two plantations of Osage orange were examined in the State. The species has been extensively planted for hedges, from which posts are frequently cut. Osage orange, because of its durability, has high value as a post timber. In computing the products of the plantations first-class posts are assumed to be worth 15 cents each, second-class posts 10 cents each, and third-class posts 5 cents each. Since first-class Osage orange posts often bring 25 cents each and sometimes sell as high as 50 cents, this valuation is very conservative. The refuse material left after making posts is figured as firewood at $2 per cord. The cost of establishing a plantation is placed at $12 per acre.

Osage orange grows well on almost every variety of soil throughout Illinois, except in the extreme northern part, where, owing to the severe winters, it winterkills to some extent. The great adaptability of the tree to varying soil conditions and its extreme tenacity under severe treatment, together with its general immunity from insects, render it especially suited for planting on land where neither catalpa nor larch will succeed.

TABLE 9.—*Osage orange, bur oak, and mulberry.*

Plantation No.	County.	Age.	Area of plantation.	Original spacing.	Number of trees per acre.	Average size dominant trees.		Products per acre.					Annual income per acre at 3 per cent.
						Diameter 17 breasthigh.	Height.	Posts.			Firewood.	Net value.	
								First class.	Second class.	Third class.			
		Yrs.	*Acres.*	*Feet.*		*In.*	*Feet.*				*Cords.*		
OSAGE ORANGE.													
1	Christian	27	4.00	4 by 8	1,200	3.7	26	.....	536	1,200	4.0	$94.95	$2.33
2	.....do.....	28	1.34	4 by 12	513	6.0	35	528	762	513	.8	154.77	3.91
BUR OAK.													
1	Christian	34	0.50	3 by 17	282	7.7	40	462	.....	.....	6.7	$36.70	$0.64
2	Montgomery	50	1.25	3 by 6	392	10.7	58	2,568	.....	.....	18.3	220.12	1.95
RUSSIAN MULBERRY.													
1	Morgan	19	.....	5 by 10	704	6.4	48	1,200	550	.....	15.0	$106.69	$4.25

Neither of the plantations examined was properly spaced, yet the better one has paid a fair profit. To get the best returns a plantation should be set with from 2,000 to 3,000 trees per acre and afterwards pruned and thinned when necessary. Since a large percentage of the trees will not grow straight enough for poles, it will be more profitable to cut the plantation clean when the straighter trees reach post size and thus secure from the sprouts a second crop of posts in less time than was required for the first one.

BUR OAK.

The prices assumed for the products of the bur oak plantations are: First-class posts, 8 cents each; wood, $2 per cord. The cost of establishing a plantation is placed at $5 per acre.

Since the rate of growth shown in Table 9 approximates that of natural bur oak in Illinois, it is safe to assume that this species will succeed on prairie soils throughout the State. But the rate of growth is slow, and in order to produce durable posts the trees must reach a larger size than is necessary for many other species. On the whole, therefore, there is no inducement to plant bur oak on agricultural land unless for wind-breaks or for ornament.

RUSSIAN MULBERRY.

Only one small plantation of Russian mulberry was examined. For the value of the products, first-class posts are priced at 8 cents each and second-class posts at 4 cents each. The refuse material is valued at $1 per cord for firewood. The cost of establishing a plantation is placed at $12 per acre.

No general conclusions can be drawn from the examination of a single plantation, yet the indications are that Russian mulberry will do well throughout the central part of the State at least. It is certain that a plantation will produce a large number of posts in a comparatively short time.

BLACK LOCUST.

Black locust was extensively planted in the early days, and for a time it thrived. Then its greatest enemy, the borer, appeared and most of the plantations were cut. In the plantations examined the damage done by borers was extremely variable. In some places the trees were very slightly, if at all, affected, while in others they had suffered greatly.

The durability of black locust posts is well known in Illinois, where they sell for a high price. It is not uncommon to find posts sound after twenty years' use. In one instance the posts were still fairly sound after thirty-nine years of use.

Black locust is adapted to planting on sandy soil, such as occurs along the Mississippi and Illinois rivers. The likelihood of injury by borers does, it is true, render doubtful the production of large material, yet the fact remains that in many situations plantations for posts will pay. The growth is rapid, and if proper treatment is given post size will be reached before the damage from borers is serious. Black locust is as hardy as Osage orange, and is not likely to winterkill anywhere in the State. When forest planting on poor land is contemplated this species should be considered. Further, the tree is an excellent one for hillside planting to prevent washing.

COTTONWOOD.

Cottonwood grows well throughout the State and makes a good shelter belt. It is planted at present only in the towns. Here the tree is a favorite because of its rapid growth, but it is far from being the most desirable street tree.

HONEY LOCUST.

Honey locust should do well throughout Illinois, though it has little value as a commercial tree. The plantations examined in Rock Island County are on wind-blown, sandy soil, and are in poor condition. Black locust has grown excellently on the same tracts.

SUGAR MAPLE.

Sugar maple is preeminently a shade and ornamental tree. Its rate of growth is rather slow, but it grows to a large size, develops a splendid crown, and lives to a great age.

Many sugar maples in the northern part of the State have, within the last few years, become stag-headed and have slowly died. This stag-headed condition is not peculiar to the sugar maple, however, since many other trees, such as white and black oak and hickory, are affected in the same manner. Its cause has not been fully determined, but it seems to have been increased, if not produced, by the very severe winter of 1898–99, followed by some exceptionally dry summers.

TABLE 10.—*Other hardwoods.*

BLACK LOCUST.

Plantation No.	County.	Age.	Area of plantation.	Original spacing.	Number of trees per acre.	Average size of trees.	
						Diameter breast-high.	Height.
		Years.	*Acres.*	*Feet.*		*Inches.*	*Feet.*
1	Adams	4	0.61	.....	1,434	1.7	.....
2	do	18	1.20	.....	960	4.6	.....
3	do	21	.10	.....	668	6.7	45
4	Marshall	40	.....	.....	.....	14.6	.....
5	Adams	47	.....	.....	.....	15.2	65

COTTONWOOD.

1	Ford	32	0.50	10 by 10	130	12.9	60
2	Sangamon	41	12.00	.....	29	20.5	93
3	Hancock	46	5.50	12 by 12	52	17.5	82
4	Tazewell	53	Open row.		.....	21.7	60

HONEY LOCUST.

1	Rock Island	31	0.90	5 by 5	624	3.2	23
2	do	31	.25	5 by 5	584	4.1	23
3	Champaign	24	.25	4 by 8	300	6.3	35

SUGAR MAPLE.

1	Lee	63	0.60	.....	175	10.5	54
2	Champaign	36	.40	.....	435	6.0	35

BOXELDER.

1	Warren	29	0.22	4 by 5	509	7.1	38
2	Champaign	27	.25	4 by 4	850	6.8	50

CHESTNUT.

1	Sangamon	30	0.40	8 by 8	182	8.8	41
2	Mason	32	.88	20 by 20	49	13.8	40

BUTTERNUT.

1	Lee	32	1.50	.....	165	9.2	45
2	Champaign	35	.25	2 by 4	.....	6.0	40

WHITE ELM.

1	Kendall	8	3.00	2 by 5	.....	2.8	23
2	Warren	29	.22	4 by 5	509	7.1	38
3	do	29	.14	5 by 7	400	7.9	51
4	Rock Island	26	Open rows.		.....	11.2	35
5	do	30	do.		.....	13.3	38
6	Champaign	35	.125	4 by 4	.....	10.6	50

BOXELDER.

Boxelder has but scrubby growth, and there is little reason why it should be chosen where so many superior species grow well. It has, however, been planted extensively as a street tree, and is still being grown for this purpose.

CHESTNUT.

Of the two chestnut plantations examined, only that in Sangamon County was originally spaced close enough to produce good form. Even then the trees have been gradually dying, and the general condition of those still standing is poor. A few good chestnut trees are found in the towns, but the species is likely to winterkill in the northern part of the State. Attempts were made to establish a block of chestnut in the experimental forest at Urbana, but without success.

BUTTERNUT.

Of the two butternut plantations measured, that in Lee County is in good condition, while that in Champaign County has done very poorly. Nowhere is there any indication that the general planting of this species will be successful.

WHITE ELM.

White elm has been planted only for ornament or for protection. It does well throughout the State, and is one of the best trees for the purposes for which it is planted.

WHITE PINE.

The white pine plantation at the University of Illinois was the only one found in the course of the study which had been properly spaced in the beginning, and which, accordingly, had developed as it should. Its excellent growth demonstrates that plantations of this species can be established successfully on prairie soil, though there is little inducement to undertake them as an investment.

White pine has been largely used for ornamental planting in parks and yards, nearly always with success. It grows better in Illinois than any other planted pine, and makes an excellent shelter belt.

SCOTCH PINE.

Scotch pine has been widely planted as an ornamental tree, but has little to recommend it. It is generally short-lived and scrubby. When open grown it is likely to become flat-topped. Because of the ease with which it is propagated and transplanted it is a favorite with the nurserymen, and with others who desire a quick-growing evergreen without regard to its later development.

TABLE 11.—*Conifers.*

WHITE PINE.

Plantation No.	County.	Age.	Area of plantation.	Original spacing.	Number of trees per acre.	Average size of trees.	
						Diameter breast-high.	Height.
		Years.	*Acres.*	*Feet.*		*Inches.*	*Feet.*
1	Champaign	30	1.00	4 by 4	404	7.5	40
2	Lee	32	1.70	12 by 24	69	13.1	50

SCOTCH PINE.

1	Winnebago	33	2 rows.			9.0	36
2	Champaign	35	0.42	4 by 4	266	8.6	40

AUSTRIAN PINE.

1	Winnebago	33	1 row.			8.3	31
2	Champaign	35	0.33	4 by 4	240	5.9	35

NORWAY SPRUCE.

1	Champaign	34	0.50	2 by 4	320	7.3	50

TAMARACK.

1	Bureau	45	0.075	5 by 6	506	7.6	57

AUSTRIAN PINE.

The plantation of Austrian pine at the State University has been a decided failure. The single row of trees measured in Winnebago County has done well. Individual trees found throughout the State, however, often are poorly developed. Apparently there is little to recommend this tree for planting in Illinois.

NORWAY SPRUCE.

Norway spruce has been widely planted as an ornamental tree, usually with success. The only plantation studied was that at the University of Illinois, which has done excellently. Norway spruce is a good tree for shelter belts, but it is short-lived, and it may be that even for this purpose white pine is more desirable.

TAMARACK.

But one tamarack plantation, a small one in Bureau County, was found. It is on a west slope, with a clay loam soil. Some European larch planted near by has far outstripped the tamarack, both in height and in diameter growth. A few years ago an unusually dry season occurred. The larch suffered little from it, but many tamarack trees died and others were badly injured.

OTHER SPECIES.

Brief reference should be made to other species which were noted in the State only as individuals or in single rows.

White willow is planted in some of the northern counties for hedges and wind-breaks. The ability of this species to sprout after repeated cutting and its rapid growth result in the production of a large amount of wood from comparatively few trees.

Balsam fir is planted occasionally for ornament. As a rule it does well, though a small plantation in Lee County has been a failure.

White and Lombardy poplars are common and manifest their usual characteristics.

Hemlock, arbor vitæ, and bald cypress occur as ornamental trees and are usually thrifty. The same is true of slippery elm, sycamore, and white birch.

Two species to which little attention has so far been given are coffee-tree and black cherry. The first is a hardy tree and well adapted to shelter-belt and ornamental planting; the second is worthy of trial in plantations, since its rate of growth and quality of wood make it valuable.

COMMERCIAL RETURNS.

Table 12 brings together for the principal species the most important facts relative to commercial returns. These figures are averages obtained from the large tables for individual species, based on all plantations which have had such treatment as to justify consideration. Plantations which show a net annual income, at 3 per cent, of $4 an acre or more are regarded as commercially successful. Judged by this standard, the only species which would have paid throughout are catalpa, with an average return of $5.18 per acre, and larch, with a return of $4.38 per acre.

TABLE 12.—*Average rate of growth and value of principal species.*

Species.	Age.	Number of trees per acre.	Annual growth.		Annual increment per acre.	Annual income per acre at 3 per cent.
			Diameter.	Height.		
	Years.		*Inches.*	*Feet.*	*Cords.*	
Hardy catalpa	21	694	0.32	1.8	1.35	$5.18
European larch	32	496	.28	1.6	1.39	4.38
Osage orange	27	856	.18	1.0	.54	3.12
Black walnut	37	271	.26	1.5	.90	1.41
Silver maple	32	345	.30	1.9	1.27	1.06
White ash	31	340	.23	1.6	.89	1.03

With catalpa, 10 plantations, out of 15 whose products were computed, have paid more than $4 per acre, while two of these have paid $9.35 and $16.70, respectively. Though the average indicated return

from catalpa is but little more than that from larch, it is often preferable to plant catalpa. It grows a trifle faster, can be utilized for posts and poles at a smaller size, and its wood is more durable. Besides, catalpa will grow well on ground that is too wet for larch, or which is flooded so often that success with farm crops is uncertain.

Reference to Table 5 for larch shows that of the 16 plantations examined, 10 have paid more than $4 per acre, and of these two have paid more than $7 per acre. This indicates that if a market develops for larch posts and poles, as seems likely, planting larch will at least be as profitable as raising ordinary farm crops.

Because Osage orange has been planted mainly for hedges its value as a plantation tree has been passed over. That it is unsurpassed in soil adaptability and in hardiness has been amply demonstrated. The only danger lies in the northern part of the State, where it is likely to winterkill. The two Osage orange plantations examined show an average annual income of $3.12 per acre, a sum which undoubtedly could have been increased had the original spacing been closer. There is good reason to believe that Osage orange will pay on ground which is unsuited to catalpa or larch and which, at the same time, will not bring a proper return from farm crops.

The average return from black walnut is low, since this tree requires many years to reach a size profitable to cut. It is true that one 20-year-old grove shows an annual income of $2.05 per acre, but this is computed for posts, and no owner of a walnut grove is likely to cut it for these. The groves in Whiteside and Morgan counties show annual incomes of $3.66 and $3.32 per acre, respectively, at the end of forty-nine and sixty-four years. These, however, are by far the best groves measured. Even under the best conditions walnut requires at least fifty years to reach a profitable cutting size, while in one hundred years the profit should be much larger. Few persons, however, are likely to undertake such a long-time investment.

Silver maple and white ash are given, simply to show that there is little in the money returns to justify their planting. They grow well and will serve many useful purposes about the farm, but they are unsuitable as a purely commercial investment.

THE MARKET FOR FOREST PRODUCTS.

In order that commercial forest planting shall succeed, a market for the products is essential. At present the owners of forest plantations commonly use the posts and poles cut about their farms or sell them to their neighbors at the best price that can be obtained. It was found necessary in computing the values of the plantations studied to arbitrarily assign a uniform value to each of the various

classes of products. The attempt was made, in all cases, to make this arbitrary price a conservative one and one which the user of the products would be justified in paying. There is reason to think, however, that in the future there will come to be a recognized market for the products of forest plantations with something like a uniform scale of prices. The supply of native white oak fence posts has become seriously depleted, and now the white cedar posts from Michigan and Wisconsin are being generally used. It is safe to assume, however, that this supply will be greatly diminished in a few years, and then will come a corresponding increase in prices. The pronounced upward tendency in the prices of all kinds of forest products is certain to continue, and, so far as one can judge, the person who establishes forest plantations on the basis of present prices will receive considerably higher prices than he anticipates when the crop is harvested twenty or thirty years hence.

THE URBANA PLANTATION.

The University of Illinois in 1871 established at Urbana an experimental forest plantation covering about 13 acres and containing 20 species of forest trees. Its situation is typical of the central Illinois prairie, and conclusions drawn from a study of it will apply to a large portion of the State. In Table 13 are shown the size, rate of growth, and condition of the different species. All of the white, Austrian, and Scotch pine, European larch, Norway spruce, white elm, and black walnut were measured. Of the other species, typical sample rows and areas were taken. The age is counted from seed, and the rate of growth is figured on this basis. The diameters and heights are averages.

TABLE 13.—*Measurements in the Urbana plantation.*

Species.	Age from seed.	Number of trees measured.	Diameter breast-high.	Height.	Annual diameter increase.	Condition.
	Years.		*Inches.*	*Feet.*	*Inch.*	
White pine	35	405	7.5	40	0.21	Good.
Scotch pine	35	112	8.6	40	.25	Poor.
Austrian pine	35	81	5.9	35	.17	Very poor.
European larch	34	267	7.3	50	.21	Excellent.
Norway spruce	35	146	7.3	45	.21	Fair.
Common catalpa	35	61	8.6	45	.25	Poor.
Hardy catalpa	38	22	8.8	35	.31	Fair.
Osage orange	35	39	8.1	30	.32	Do.
White elm	35	42	10.6	50	.30	Excellent.
Black walnut	35	112	8.3	55	.24	Good.
Butternut	35	37	6.0	40	.17	Poor.
Basswood	28	70	7.0	35	.25	Good.
Honey locust	24	45	6.3	35	.26	Do.
Bur oak	24	190	4.9	35	.20	Excellent.
Ailanthus	25	37	6.0	40	.24	Poor.
Boxelder	27	67	6.8	50	.25	Good.
Silver maple	36	40	12.5	75	.35	Do.
Sugar maple	36	48	6.0	35	.17	Do.
Green ash	35	635	7.4	50	.21	Do.
Hickory	24	137	2.6	22	.11	Do.
Hickory, transplanted	24	153	2.9	18	.12	Do.

The best developed species in the plantation are European larch, white pine, green ash, and black walnut. These have formed straight, clear stems, due largely to close spacing and to pruning. Though the stand of larch, except that portion previously mentioned, which has failed because of insufficient drainage, is excellent, the crowns are neither large enough nor heavy enough to exclude the light, and in consequence the ground beneath bears a thick growth of weeds, grass, and underbrush. This, however, is held in check by cutting, and the trees are healthy.

White pine is the only species which has established and maintained a good forest floor. The ground is covered with needles and only a small amount of underbrush has come up. Sugar maple has partially succeeded in establishing forest conditions, but only in small isolated areas is this the case with the other species.

Scotch pine has made a good diameter growth, but apparently has reached its limit in this respect. The stems are clear but crooked. Austrian pine is practically a failure. Some of the Norway spruce have died, and others are in poor condition. There are, however, a number of good trees, and the species shows its superiority to Scotch pine. Common catalpa has failed. The trees are badly formed and affected with rot. Hardy catalpa has made good diameter growth, but the stand is not dense enough to give straight stems. Several cases of frost crack occur. Osage orange is in open stand and the trees are very crooked. Black walnut has made good growth, but butternut is in bad shape. White elm, basswood, honey locust, silver and sugar maple, and boxelder have all done well. Bur oak has made slow growth, but the trees are in excellent condition and at present would give from 2 to 3 posts each. Ailanthus has failed. Most of the trees have frozen back, and it is doubtful if any of those measured were original members of the plantation. Hickory includes both shellbark and big shellbark. When 3 years old some of the trees were transplanted to rows 4 by 8 feet apart, while the remainder were thinned to 4 by 4 feet. At present the transplanted trees are slightly larger in diameter, but shorter in height than the others. All are in good condition, but the rate of growth, which has been slow, would undoubtedly have been greater had sufficient cultivation been given.

THINNING A FOREST PLANTATION.

By the choice of species and by correctly spacing and thinning a forest plantation the owner can, within certain limits, produce any class of material he desires. With a knowledge of local requirements the selection of proper species and the determination of spacing should not be difficult. Thinning, however, is much more complicated, and

should not be undertaken without a clear idea of its objects and of the methods by which it can best be done.

The quantity of wood formed by a tree depends upon the area of leaf surface which is exposed to sunlight. A small leaf surface produces a small amount of wood and a large leaf surface produces a large amount of wood. A healthy tree is constantly endeavoring to increase its leaf surface, and it is by taking advantage of this inherent tendency that the forester is enabled to control the amount and quality of the wood produced.

Trees increase their size in two ways—growth in height and growth in diameter. The rate of increase, however, is never greatest in both ways at the same time. Trees which are crowded while young grow rapidly in height, through the effort to get the crowns into the sunlight, but the diameter growth is correspondingly slow. Crowding produces long, slim stems, which serve as a basis upon which to form the valuable timber of later years. When the stem is of a sufficient height, thinning gives room for an increased crown development and, in consequence, a larger leaf surface in the trees remaining. Height growth then becomes less rapid and diameter growth more rapid. In other words, the desired height and straightness of stem having been obtained, the new wood tissue which is added now goes to increase the tree's diameter, and this begins the period of most profitable development. Thus the natural tendency of trees toward rapid height growth when young is strengthened by crowding, and the later tendency to slower height growth and more rapid diameter growth is encouraged by thinning.

With regard to their ability to bear shade, trees are divided into two classes—tolerant and intolerant. Tolerant trees are those which will bear more or less heavy shade in youth and which will, in consequence, develop fairly well even when overtopped by other trees. Intolerant trees are those which make poor growth or even die if sunlight is cut off. Examples of tolerant trees are spruce, sugar maple, and hemlock; of intolerant trees, larch, black walnut, and yellow poplar. Tolerant trees will grow in very dense stand, and since their branches persist even when shaded it is necessary to crowd such trees at first in order to form good stems. When the desired form of stem has been produced the stand should be heavily thinned. Intolerant trees will grow in dense stands only when comparatively young, and thinning is less necessary with them than with tolerant trees.

A plantation composed of rapid-growing species will, when from 10 to 20 years old, contain three distinct classes of trees: (1) Suppressed trees, those which have been outgrown by competitors and whose tops are completely overshadowed; (2) intermediate trees, those whose tops are more or less exposed to the sunlight but the

sides of whose crowns are shaded by neighboring trees; and (3) dominant trees, those which have been the most successful in the struggle for existence and whose crowns are fully exposed to sunlight.

Left to themselves the dominant trees are the only ones capable of good future development. The intermediate trees will gradually become suppressed, and the suppressed trees will eventually die. This method of nature, however, is wasteful. It produces good timber with part of the trees, but allows the others to decay and die. Thinning at the proper time produces better trees with a larger per cent of the stand, and, in addition, utilizes the timber which is removed.

The frequency and extent of thinnings should depend upon the kind of soil, the age of the plantation, and the class of material desired. Theoretically, frequent but light thinnings will give the best results. In practice, however, it is best to thin only at stated periods, when enough material may be taken out to compensate for the cost.

With regard to the manner of removal, thinnings may be designated as regular and irregular. In regular thinnings a certain definite proportion of the stand is removed, as one-half, one-third, etc., without regard to the condition of the individual trees. In irregular thinnings the number of trees to be removed is determined by inspection and consideration of the needs of the plantation. To make an irregular thinning requires a much better knowledge of the laws of tree growth than is necessary for a regular thinning, but if well executed it will result in the production of better material.

Regular thinnings are best adapted to regularly spaced plantations, in which conditions are uniform throughout. For example, if a plantation is spaced 5 by 5 feet by the square system, one-half of the trees can be removed and the remaining stand will be spaced practically 7 by 7 feet, with the new rows running diagonally to the original ones. A thinning of this kind is shown in the accompanying diagram, in which the trees to be removed are underscored:

T T T T T T

T T T T T T

T T T T T T

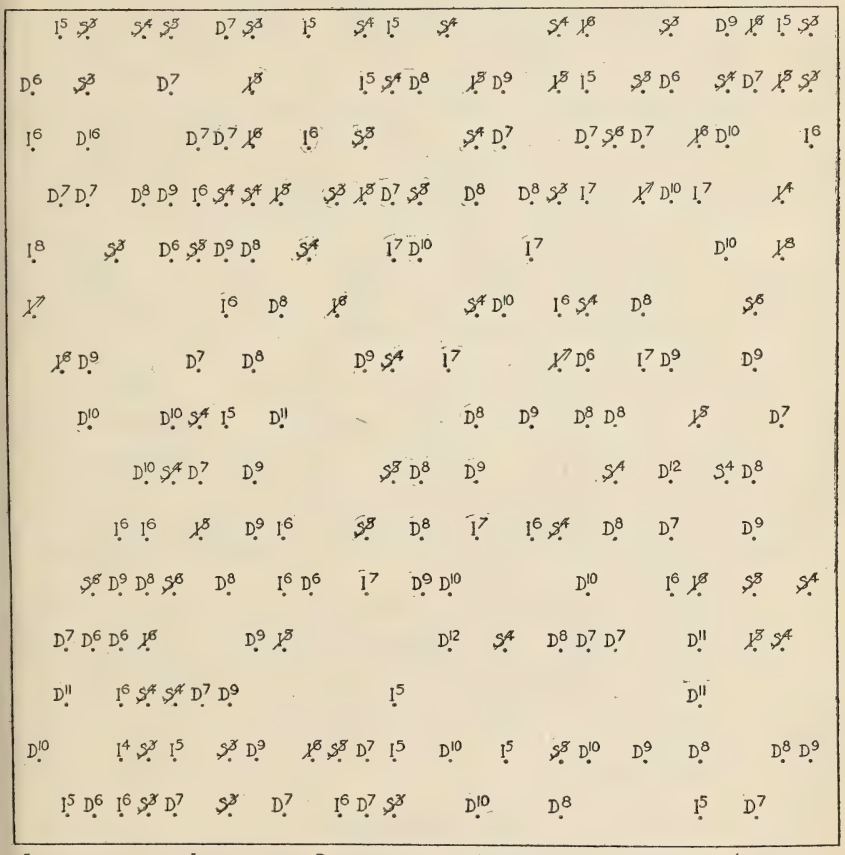
Irregular thinnings are especially adapted to plantations which have grown unevenly or which are irregularly spaced. The manner of executing an irregular thinning is shown in the following diagram, in which the dominant trees are indicated by D, the intermediate trees by I, and the suppressed trees by S. The trees to be removed are underscored.

I D I S D D S

S D I D S S D

I S I D S D I

All the suppressed trees should be cut. In the first row, the first intermediate tree should be cut, because it is being overtopped by the adjacent dominant tree and will have passed its prime before another thinning takes place. The second intermediate tree in the first row has room in which to grow for several years and should stand. In the second row the intermediate tree should be removed, because it will be suppressed by the two adjacent dominant trees. In the third row



S=suppressed tree, I=intermediate, D=dominant; numerals show diameter breast high; /=to be cut

FIG. 1.—Method of thinning catalpa plantation No. 5 (see page 10).

the first two intermediate trees have space in which to grow for some time longer, while the third one has a poorer chance and should be cut.

Thinnings are designated as moderate when all the suppressed trees and a portion of the intermediate trees are removed, and as heavy when all the suppressed and intermediate trees and some of the dominant trees also are taken out. The thinning just illustrated, therefore, is a moderate thinning. The suppressed trees might even be left,

so far as their physical effect upon the other trees is concerned. There are good reasons, however, why suppressed trees should be cut. They will make little, if any, future growth, and their wood will deteriorate in quality. Eventually they will die and may become a breeding place for injurious fungi and insects.

PLANTING PLAN.

The Forest Service has made a number of plans for forest plantations in Illinois. One which should have a permanently instructive value is that which is being carried out by the Northern Illinois State Normal School at De Kalb. A rectangular area, 198 feet by 281 feet, was set aside for the plantation. The soil is a black prairie loam, from 8 to 12 inches deep, underlaid by a gravelly subsoil which tree roots can easily penetrate. There are 54 rows of trees, 198 feet long and 5.2 feet apart, running east and west. Each row contains approximately 33 trees, spaced 6 feet apart in the row. Beginning on the north side of the plantation, the first nine rows are European larch, the next 36 rows an equal mixture of black walnut, white ash, and wild cherry, and the last 9 rows, on the south side, white pine. This required 297 seedlings each of larch and pine, and 396 each of walnut, white ash, and wild cherry, a total of 1,780 trees. On the accompanying diagram (fig. 2), which shows the arrangement of the plantation, larch is designated by L, white pine by P, white ash by A, black cherry by C, and black walnut by W. It will be seen that the first trees in alternate rows are, respectively, at the edge of the plantation and 3 feet from the edge.

The equilateral-triangle method of spacing was used, since it places each tree equally distant from all surrounding trees. In this way the ground is fully utilized and the trees will develop symmetrically. In the mixed plantation of walnut, ash, and cherry each tree is completely surrounded by trees of the two other species, and an ideal mixture is thus secured.

SHELTER BELTS.

Forest planting in Illinois has been mainly for shelter belts, and the species used have been the rapid-growing ones. When it is considered, however, that the shelter belt around the farm buildings should be as permanent as the buildings themselves, it might in the end be better to plant slower-growing, longer-lived species, such as white pine, elm, oak, sugar maple, or even ash. Since the chief function of a shelter belt is protection against winter storms, white pine, wherever it will thrive, will serve this purpose well, and will, in addition, last for many years.

A proper mixture of species and subsequent thinning will give a shelter belt which is both rapid growing and long-lived. The mixture should consist of a fast-growing, light-demanding species for

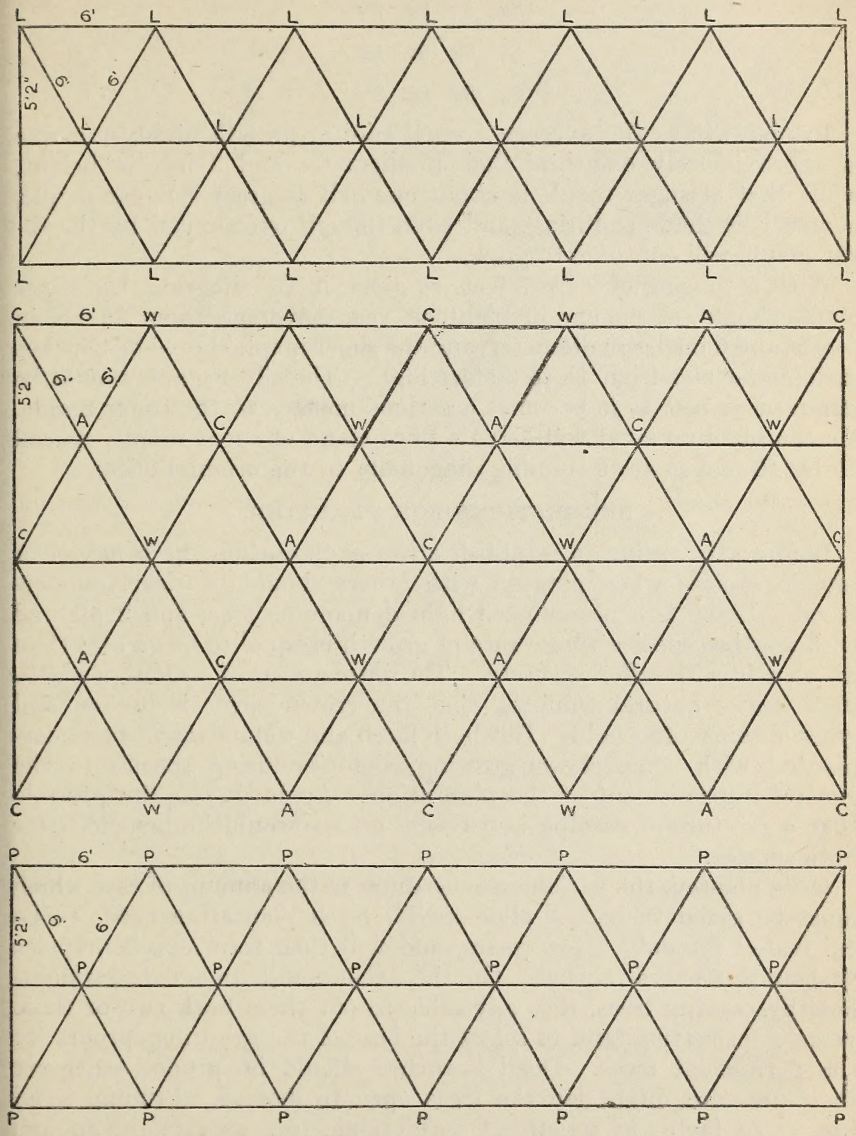


Fig. 2.—Diagram of pure and mixed plantations.

the temporary tree, and a slower-growing, shade-enduring species for the permanent tree. These requirements are met by a mixture of silver maple and sugar maple. The trees should be planted 7 feet apart and in squares. In the following diagram, which shows the

method of planting, silver maple is referred to by Sv and sugar maple by Sg:

Sv Sg Sv Sg

Sg Sv Sg Sv

Sv Sg Sv Sg

Sg Sv Sg Sv

In plantations the average annual rate of growth of silver maple is approximately one-third inch in diameter and 2 feet in height, while that of sugar maple is about one-half as great. Sugar maple, however, is shade enduring, and even though overtopped by the silver maple will continue to grow.

With a spacing of 7 by 7 feet, as given in the diagram, the silver maple should, at the end of eighteen years, average about 35 feet in height and 6 inches in diameter, and the suger maple should be 3 inches in diameter and from 15 to 20 feet high. The silver maple should be removed as fast as it becomes a serious menace to the sugar maple. Its complete removal will leave a pure stand of sugar maple, spaced 10 by 10 feet in rows running diagonally to the original ones.

SUGGESTIONS FOR PLANTING.

Before attempting to establish a forest plantation the behavior of certain species when planted with others should be clearly understood. Larch is a pronounced light-demanding tree, and if planted with another species whose rate of growth is equal to or greater than its own it will suffer severely. The intolerance of walnut leads to such heavy natural thinning that the crown cover is broken and grass obtains a foothold. But both larch and walnut might be underplanted with some slower-growing, shade-enduring species to the general improvement of the plantation. Again, it is quite possible that a mixture of catalpa and Osage orange would be beneficial for both species.

Once planted, the various species differ in the amount of care which must be given them. A close-spaced larch plantation needs to be cultivated for only a few years, and will then form excellent poles without further attention. On the other hand, to secure straight, healthy catalpa trees, it is advisable to cut them back two or three years after setting, and to select the best of the resulting sprouts for the permanent trees. Dead branches should be pruned wherever their presence might lay the trees open to disease. Pruning is an important factor in assisting Osage orange to grow straight enough for fence posts.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *February 26, 1907.*

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