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DEPARTMENT OF REGISTRATION AND EDUCATION
DIVISION OF THE
NATURAL HISTORY SURVEY
STEPHEN A. FORBES, Chief

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Second Report on a Forest Survey of Illinois. The Economics of Forestry in the State

BY
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and
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INTRODUCTION

A forest survey of Illinois was begun by the State Natural History Survey in July, 1919, when Mr. R. B. Miller was engaged for a preliminary general study of the Illinois situation and conditions and for educational and publicity work intended to open the way to active, practical studies on a larger scale. In 1921 three additional foresters, with Mr. C. J. Telford in charge, entered upon a systematic survey of Illinois woodlands with a view to their location and area, their composition and condition, their present management and utilization, and their productivity as shown by the rates of growth of important kinds of trees on various soils, in various situations, under various conditions, and in all parts of the state.

As these data were accumulated, it first became possible to make an intelligent study of the values of our woodlands, of the economics of forest management and production in Illinois, and of the relation of the local supply of forest products, present and prospective, actual and possible, to the demands of our Illinois industries—matters fundamental to any adequate forestry policy, either for the state or for the owner of forest property or of lands especially adapted to forest culture.

This difficult, intricate, and supremely important part of the survey program was taken up by Herman H. Chapman, Professor of Forest Management in the Yale University School of Forestry, and the present report, filed by him for publication in June, 1924, is the product of his work during the summers of 1922 and 1923, supplemented by much additional inquiry carried on under his direction by foresters Miller and Telford, the former especially having been employed during the greater part of two years in the accumulation and tabulation of additional data. All these materials were passed, however, under the scrutiny of Professor Chapman, who is the final authority for the statements, inferences, and recommendations of the report.

Special mention should be made of the cordial co-operation, in all stages of the survey, of the Agricultural Experiment Station of the University of Illinois, which has given us free access to its accumulated data and much valuable information of a more personal character contributed by the members of the Station staff.

STEPHEN A. FORBES.

ARTICLE III.—*Second Report on a Forestry Survey of Illinois. The Economics of Forestry in the State.* By HERMAN H. CHAPMAN, Professor of Forest Management, Yale University School of Forestry, and ROBERT B. MILLER, Forester, Illinois State Natural History Survey.

FOREWORD

Although Illinois is known as a prairie state, yet originally over 40 per cent of its area was covered by virgin forests containing magnificent stands of hardwoods. Now ranked as third in the importance of its agricultural products with its forest area reduced to but 8 per cent of the state's surface, and these remaining forests depleted by axe and fire, the state is yet dependent to an enormous extent on the continuation of abundant supplies of wood to support existing industries, furnish labor and livelihood to her increasing urban population, keep down the cost of living, and maintain the prosperity of the farmer, as well as those engaged in mining, manufacturing, and transportation. To depict these conditions, to determine the relative importance of wood in all its forms in the present economic life of Illinois, and to indicate the lines on which it may be possible to develop a sound and comprehensive policy of dealing with this problem of future wood supply, is the purpose of this report.

WOOD AND THE INDUSTRIES OF ILLINOIS

The state has an area of 56,665 square miles, of which 56,043 square miles, or 35,867,520 acres, is land area. Of this, 89.1 per cent is included in farms and 76.1 per cent is actually devoted to crop production. The state ranks third in value of agricultural products, being exceeded only by Texas and Iowa.

The population numbers 6,485,280, giving the state third rank, following New York and Pennsylvania. There are 237,181 farms, averaging 134.8 acres, and 16.9 per cent of the total population, or 1,090,736 persons, live upon these farms, while 68 per cent reside in towns of 2500 or more inhabitants, and 3,095,137 persons, or nearly 48 per cent of the total population, live in Cook and DuPage counties alone. The density of population on the farms alone does not exceed 20 per square mile, while the average density for the state as a whole, includ-

ing the remaining village and urban population, is 115.7 per square mile, which is exceeded only by eight states, namely,

Rhode Island	566.4	New York	217.9
Massachusetts	479.2	Pennsylvania	194.5
New Jersey	420.0	Maryland	145.8
Connecticut	286.4	Ohio	141.4

In all densely populated states, it is evident that industries other than farming must support a very large proportion of the population and wage-earners. These immense urban populations do not live as parasites on the labor of the farmer. It is not surprising therefore to note that Illinois ranks third in manufacturing, being outranked only by New York and Pennsylvania, and exceeding Massachusetts and other states in which manufacturing is paramount and agriculture of little importance. Transportation ranks next to agriculture and manufacturing in importance as an employer of labor and capital. The fourth great industry in Illinois is mining in which the state outranks all but three other states, Pennsylvania and West Virginia where coal is of first importance, and Oklahoma whose value is found in oil. Bituminous coal is what gives Illinois fourth rank in mining.

The relative importance to the state of these four main branches of industry may be gaged first as giving employment to labor, second as representing invested capital, and third as to the value of their products. Their statistical rank is set forth in tables on p. 48.

The differences between these four groups are brought out by the totals. Manufacturing takes materials valued by the U. S. Census of 1919 at $3,448,270,446 and by employing approximately twice the number of persons shown by its nearest competitor, agriculture, adds about 1¾ times the total valuation of farm products. This requires an investment of relatively one half the capital required in agriculture.

Agriculture, because of the permanent productiveness of the soil and its limited area, has thus already been capitalized at a value nearly four times as great in proportion to gross income as in manufacturing, and with correspondingly lower margin for profits. By working longer hours, and by the part time employment of minors, farmers produce a greater value per person employed than is produced in factories with the aid of the power obtained from fuel and machinery. The great factory for food products represented by the fertile soil and equable climate of Illinois is effectively utilized. The high investment of capital per person

Class of industry	Persons employed	Capitalization	Value added to products
Manufacturing	804,805[1]	3,366,452,969[1]	1,936,974,248[1]
Agriculture	378,129[2]	6,666,767,235[1]	1,118,000,000[5]
Transportation	220,361		
(Steam railroads)	107,116[3]	1,126,087,160[4]	281,423,557[6]
Mining	90,644[1]	116,669,312[1]	178,673,065[1]

Per person employed	Capitalization	Value added to products
Manufacturing	4,182.94	2,406.76
Agriculture	17,630.93	2,956.63
Steam railroads	10,512.78	2,627.27
Mining	1,287.11	1,971.15

employed and the large production per man indicates the degree to which the art of agriculture has developed and, by inference, reveals the handicap under which the owners of farms on the poorer soils compete with their more fortunately situated neighbors, and offers an explanation of the tendency to abandon certain of the less fertile soils.

In steam transportation, as is to be expected, the capital invested,

[1] U. S. Census 1920.

[2] 380,705 less 2,576 employed in fisheries, and lumbering or forest industries.

[3] The total of 220,361 persons covers all forms of transportation including motor, street railway, and water transport. From this, only those engaged in steam railroad transportation have been taken, totaling 107,116 persons.

[4] Capitalization of steam railroads, only. State Commerce Commission, Springfield.

[5] Through the cooperation of Assistant Professor Roscoe R. Snapp of the Department of Animal Husbandry, University of Illinois, a tentative estimate was made of the value of crops fed to live stock resulting in the following figures for which no claim to mathematical accuracy is made.

Value of all feed sold, U. S. Census	$231,733,123
Value of feed bought	64,528,040
Net value of feed sold	167,205,083
Value of animals and animal products produced	570,000,000
Grand total value of animals, animal products, corn, oats, hay, etc., not fed, approximately	737,205,083
Values of wheat, fruits and nuts, vegetables, seeds, miscellaneous crops, eggs, poultry, honey, wool, dairy products, nursery and greenhouse products including forest products, U. S. Census, 1919	380,594,856
	$1,117,799,939

The figure of $1,118,000,000 was therefore adopted as the approximate value of products of Illinois farms. The value of $1,298,906,947 as given by the U. S. Census is stated by that authority to contain duplications from the fact that the products fed to live stock were not separable.

[6] Value added to products is here assumed as equal to the gross freight revenue.

representing permanent improvements or construction, is proportionately large and the earning power per person employed correspondingly high while the percentage of earnings to capital invested is relatively low.

In the mining industry, the capital investment is valued proportionately small. Potentially it is much higher, but as the full value can not be realized except as the product is mined, this prospective income is severely discounted in fixing capital values. The mines fall below the other groups in value produced per person employed, indicating that labor represents a relatively larger portion of the energy expended in comparison to values produced than in other groups.

The extent to which wood is used as raw materials on farms and in the great industries of manufacturing, mining and transportation as well as in construction and public works, and in merchandising and crating goods for shipment, and the relative dependence of these activities upon the continuance of wood supplies are subjects of vital importance to the entire population of the state.

Total Consumption of Wood in Illinois

Wood is used in many forms. The total consumption includes not merely sawed lumber but cordwood, cross-ties, fence posts, poles, piling, cooperage, shingles, lath, logs for veneer, charcoal, pulp, excelsior and other wood products.

Illinois consumed 2,353,662,000 board feet of sawed lumber in 1920, or an average of 363 board feet per capita.* Since the per capita consumption for the entire United States was but 295 board feet in 1919, and was estimated at 316 board feet in 1920, Illinois though known as a prairie state consumes nearly 15 per cent more lumber per capita than the average for the country as a whole. In the Chicago district alone, comprising Cook and DuPage counties, with 3,095,137 population an average of 1,166,820,000 board feet of lumber was consumed during the decade 1910-1920.† For this urban population, the per capita use of lumber based on the 1919 census was 473.9 board feet, which lowers the average consumption for the remainder of the state to 258 board feet per capita. The consumption of lumber on farms as computed in this study is approximately 272 board feet per capita. It is evident, therefore, that the lumber required to support the great manufacturing industries, especially in Chicago, raises the per capita consumption in

* Data furnished by the U. S. Forest Service.
† Based on records of lumber received and shipped from Chicago for decade 1910-19 inclusive.

this state above the average for the districts outside of Chicago and for the nation at large.

Converted into cubic feet of wood required to yield this quantity of sawed lumber, a volume of 392,277,000 cubic feet is consumed, which constitutes 69.96 per cent of the total quantity of wood used for all purposes in the state. An additional quantity is used amounting to 168,442,988 cubic feet, or 30.04 per cent, consisting of cordwood, ties, mine timbers, posts, cooperage, veneers, shingles, piles, and poles. The total consumption of wood for the state is 560,719,988 cubic feet, which is 86.46 cubic feet per capita. To supply this quantity of wood, perpetually, would require an average of about one acre of land for each person in the state or 6,445,057 acres to be devoted to the intensive practice of forestry. Twice this area would hardly suffice to produce this quantity under the present neglectful, wasteful, and injurious practices of handling our woodlands.

The total consumption of wood in the state for an average year is shown in the following table.

Although the per capita consumption of lumber on farms as shown on page 51 appears to be less than for the urban population, yet farmers, as ultimate consumers of wood, require a larger proportion than these figures show, since they are based more upon consumption of lumber by the industries than by the consumer who ultimately receives the

Consumption of Wood in Illinois

Product	Unit	Quantity	Converting factor	Cubic feet	Per cent of total	Per cent exclusive of lumber
Lumber	Bd. Ft.	2,353,662,000	.16⅔	392,277,000	69.960	.....
Fuel wood	Cord	950,770	80.	76,061,600	13.565	45.156
Cross-ties						
Steam roads	Piece	6,327,854	4.25	28,630,745	5.106	16.997
Electric "	Piece	292,509	3.5			
Mine timbers	Cu. Ft.	19,710,000	.....	19,710,000	3.515	11.701
Posts	Piece	20,680,000	.8	16,544,000	2.950	9.822
Cooperage*	Cu. Ft.	11,483,600	.....	11,483,600	2.048	6.817
Veneers*	Cu. Ft.	6,537,600	.....	6,537,600	1.166	3.881
Shingles*	Cu. Ft.	5,516,100	.....	5,516,110	.984	3.275
Piles	Piece	110,284	22.3	2,459,333	.439	1.460
Poles	Piece	150,000	10.0	1,500,000	.267	.891
Total				560,719,988	100.00	100.00
Total exclusive of lumber.....				168,442,988		
Total exclusive of cordwood and lumber..				92,381,388		

* For basis of contents, see Appendix Note 1.

THE ANNUAL CONSUMPTION PER CAPITA OF LUMBER FOR ALL PURPOSES *

Class	Population	Wood-using industries M. ft. B. M.	Building M. ft. B. M.	Total M. ft. B. M.
State	6,485,280	1,373,900	979,762	2,353,662
Per capita consumption		217.9	145.73	362.92
Cook and DuPage counties	3,095,137	989,205	465,507	1,454,712
Per capita consumption		319.6	150.4	470.0
Towns outside Chicago district	2,031,443	384,695	217,779	602,474
Per capita consumption		189.3	107.2	296.6
Farms	1,090,736		296,476	296,476
Per capita consumption			271.81	271.81

manufactured articles. The table indicates that the per capita consumption of lumber on the farm for construction purposes exceeds by 86.5 per cent that required for the state as a whole. The rapidly growing Chicago district exceeds this average by only 3.2 per cent, while the remainder of the state's population consumes but 73.56 per cent of the average for building purposes and only 39.44 per cent as much as is required per capita by the farm population. These data also show that the rate of consumption of wood in the wood-using industries in the Chicago district exceeds by 68.83 per cent the rate for towns outside of Chicago and by 46.67 per cent the rate for the entire state. Undoubtedly the greatest economic burden resulting from the depletion of the supply of virgin timber as a source of lumber will fall on the farmer, by increasing his cost of building; and on the Chicago district, by diminishing its wood-using industries.

PRODUCTION OF WOOD IN ILLINOIS †

Of the total of wood products required to meet the needs of Illinois, the woodlands of the state, 2,863,764 acres in extent, or 44.16 per cent of the minimum required area, yielded but 56,900,000 board feet of lumber, or 2.379 per cent of that consumed. In other products 106,318,627 cubic feet was harvested within the state, amounting to 63.118 per cent of the total consumed. But of these remaining wood

* See Appendix, Note 12.
† For foot-note, see next page.

products, 76,061,600 cubic feet is in the form of cordwood or fuel wood which is but a very small fraction of the total fuel consumption for the state, though it furnishes 25.59 per cent of fuel burned on farms. Of the remainder, totaling 92,381,388 feet, a quantity equal to 30,257,027 cubic feet or 32.75 per cent is grown in the state. Illinois therefore has to import over 97.6 per cent of its lumber and 65 per cent of wood used in industry in forms other than cordwood.

TOTAL PRODUCTION OF WOOD IN ILLINOIS FOR AN AVERAGE YEAR

Product	Unit	Quantity	Quantity in cu. ft.	Per cent of total
1. Cordwood	Cord 80 cu. ft.	950,770	76,061,600	65.768
2. Mine timbers	Cu. ft.	11,960,076	11,960,076	10.342
3. Posts	Post .8 cu. ft.	10,767,752	8,614,202	7.448
4. Lumber	Bd. Ft.	56,900,000	9,333,333	8.070
5. Cross-ties	Tie	1,021,888	4,343,024	3.756
6. Veneer logs	Bd. Ft. log scale 1/6 cu. ft.	24,367,000	4,061,166	3.511
7. Piling	Pile 22.3 cu. ft.	40,474	902,570	.780
8. Cooperage stock	Cu. ft.	375,989	375,989	.325
Total			115,651,960	100.00
Exclusive of lumber			106,318,627	
Exclusive of cordwood and lumber			30,257,027	

BASIS OF THE TOTAL-PRODUCTION FIGURES

1. Total woodland × .332 cord—average derived from 100 per cent of 440 wood-lot owners' replies to questionnaire.

2. 62.3 per cent of total consumption, as indicated by statements in reply to mining questionnaire.

3. Total woodland × 3.76 posts—average derived from 100 per cent of 440 wood-lot owners' replies to questionnaire.

4. Bulletin 1119, U. S. Department of Agriculture, making full allowance for unrecorded customs-mills.

5. Average total production estimated from replies to railroad questionnaire —1921 and 1922.

6. U. S. Census data, 1919—statistics for Illinois.

7. Since the average length of piling from a large number of pieces was found to be 36.27 feet, the average contents was placed at 22.3 cubic feet. The number of cubic feet produced in Illinois was derived from figures in the books of piling contractors showing the number of lineal feet of piling which was secured in the state, this amounting to between 37 and 38 per cent of the total consumption of piling.

8. U. S. Census data, 1919, converted into cubic feet by using the U. S. Forest Service equivalent.

PER CENT OF TOTAL WOOD USED WHICH IS GROWN IN THE STATE

	Per cent		Per cent
Lumber	2.379	Veneers	62.120
Other products ...	65.099	Piling	36.700
Fuel wood	100.000	Cooperage	3.274
Mine timber	60.683	Poles*	
Posts	52.068	Shingles	.000
Cross-ties	15.169		
Average exclusive of fuel wood and lumber...			32.75
Average exclusive of fuel wood only.....			8.169
Wood of all kinds.....			20.626

* Rural telephone companies use mostly white oak poles, obtained locally for renewals, but it has been impossible to secure any data from these companies on the total number used in the state.

FUTURE SUPPLIES OF WOOD

What can the state do to insure to her major industries the continuance of wood supplies? Shall land now devoted to agriculture be planted to trees to fill this gap between production and consumption so that Illinois shall become self-supporting as to its timber needs? As shown later, the average annual crop of wood per acre which can be grown on Illinois land varies from 16 to 160 cubic feet. At an average production of 87 cubic feet per acre annually which could only be attained by intensive forestry practice it would require 6,445,057 acres or 17.967 per cent of the state's surface, to grow this amount. All but 23.9 per cent of the state is under actual cultivation for crops and this percentage includes cities, mines, and all waste and forest land and unimproved pastures. The maximum area which could ultimately be used for forest production is probably not over 5 million acres. It is evident, therefore, that not even by the devotion of every acre of this land to the most intensive forest cultivation could the industries now dependent on wood continue to exist without relying as at present on importations from outside the state in order to maintain their present scale of operations, irrespective of future increase in population or industry. Failure to obtain these enormous quantities of wood by importation supplemented by growth of local timber will ultimately mean a basic change in industry and perhaps very serious consequences in standards of living and even in the growth and distribution of population. It is out of the question for this state or its citizens to deliberately seek to curtail the production of farm crops, live stock and horticultural products for the sake of growing forests on soils better adapted for these higher uses. The policy indicated is to develop forest production on soils unprofitable for food crops wherever such soils are found so that the state may produce as

large a percentage as possible of home-grown timber, and to take a lively interest in national forestry problems and policies which tend to encourage forest production in other states and in the nation at large. With the utmost effort, it would probably take the state 100 years or more to reach a condition of self-support in wood production even on the present basis of consumption.

Illinois must therefore continue to depend in large measure upon regions which possess a greater percentage of true forest soils, from which states it is hoped that timber may continue to be exported provided a surplus is produced within them. Favorably situated to draw with equal readiness from the pine and hardwood forests of the Lake states, the hardwoods of the Mississippi Valley and the uplands of Kentucky, Tennessee, and Arkansas, the largest remaining reserve of southern yellow pine in Louisiana and Texas, and the last great store of virgin soft-wood timber on the west coast and in the Inland Empire, the industries of the state are assured of the continuance of their supply of raw materials until such time as these supplies *fail at the source* for lack of proper conservation and renewal by forestry measures. That such failure may occur and that the available supplies of virgin timber, especially of the hardwoods which make up approximately 50 per cent of the demands of Illinois manufacturers, will in all probability suffer great depletion within comparatively few decades are facts not open to question.

Illinois industry all along the line faces the prospect of higher costs for wood with growing scarcity of supplies. With the inability to secure the raw materials in proper quantities except at prohibitive price, there arises the problem of substitution of other materials whose cost, as measured by price and utility, shows a favorable margin as against wood.

SUBSTITUTES FOR WOOD

If for all the uses to which wood is put, the human race could find substitutes which would render just as satisfactory service at lower cost, the question of growing timber might cease to be an issue. But as long as wood in any form for any purpose gives greater and better service at less cost, it will continue to be used.

When wood was abundant and cheaply obtained the quantities used per capita were excessive and the waste ran to high percentages. Now that the original forests are melting away, a new factor enters the economic situation, that is, the cost of producing wood as *a crop to replace those supplies.* Will the value of wood as compared with wood sub-

stitutes bear this additional charge, when added to the cost of logging, milling, and transportation? Or will substitutes be found more economical and practical than the enterprise of timber production to which the term forestry is given?

In general, it may be said that the use of substitutes for wood is certain to increase very rapidly in the next two or three decades, due to the steady advance to be expected in the cost of wood of all kinds, but that ultimately wood can be grown and placed on the market at costs which for many purposes should easily restore its economic supremacy and use. Such future use of wood and its extent will be limited only by the quantities capable of being produced. Wood production, or forestry, will be one of the safest forms of industry and of investment.

Meanwhile, the prospects in the near future for reduction in the cost of living are not bright, so far as they are affected by the supply and cost of wood. The extent to which industry will be disrupted and costs increased by the withdrawal of wood as a raw material and the substitution of other products, mineral, vegetable, or animal, may be roughly approximated by an analysis of the economic position which wood now occupies in Illinois industry.

The Use of Wood in Manufacturing Industries

Of the four major groups of industry, namely, manufacturing, agriculture, transportation, and mining, the first, or manufacturing, uses most of its required wood-supply in the form of lumber, while the consumption by the other three groups requires a large proportion of wood in the form of round products, such as cordwood, posts, ties, and timbers.

Thus 58.37 per cent of the total lumber requirements of the state are absorbed by the wood-using manufacturing industries, or a total of 1,373,900,000 board feet in 1920, as against 41.63 per cent for lumber required in construction.

A complete study of the consumption of wood in the wood-using industries, which would mean a revision of the bulletin on "Wood-using Industries of Illinois"* (giving data for 1909 and published in 1910) was not attempted. Instead, the total consumption of wood in all forms was studied for certain important wood-using industries and for agriculture, mining, and rail transportation.

* By Roger E. Simmons, Statistician in Forest Products, U. S. Forest Service, under direction of J. C. Blair, Chief, Dept. Hort., Univ. Ill., and H. S. Sackett, Chief, Office of Wood Utilization, U. S. Forest Service.

The manufacturing industries for which this study was conducted were: *railway-car construction* and *repair, farm machinery and implements, wagons and vehicles,* and *automobiles.*

The consumption of wood in these industries, compared with the quantities used in 1909 are as follows in board feet:

	1909	1920	Per cent of consumption in 1920 as compared with that of 1909
Railway cars*	407,333,000	425,000,000*	104.33
Farm machinery and implements	137,157,000	85,867,313	62.60
Wagons and farm vehicles	35,686,000	28,327,875	79.38
Automobiles	652,602	14,177,391	2,172.44

The indicated shrinkage of wood in all manufacturing industries for the state was 22.9 per cent, but hardwood supplies had diminished by 46.49 per cent. Comparing these per cents with the above data, it is seen that the consumption of wood for agricultural machinery and implements, for which purposes hardwoods are largely required, corresponds with the shrinkage in hardwood consumption. One implement manufacturer sums up the situation by stating, "There are numerous places where wood, if of suitable grade, and at equal cost, would be superior to iron and steel, but on account of the growing scarcity we are substituting iron and steel in places where we really prefer to use wood."

The distribution of the remainder of the total quantity of wood used in manufacturing among the groups of industries having the largest consumption is approximately indicated below. The statements concerning the packing-box industry, planing-mill products, and furniture are based upon the 1909 consumption reduced by the average shrinkage of 22.9 per cent applicable to the total for the state. The showing for the rest of the list is for 1920.

	Board feet	Per cent
Car manufacture and repairs	425,000,000	30.934
Packing boxes	286,831,275	20.877
Planing-mill products	171,987,618	12.518
Furniture	63,683,636	4.635
Farm implements and machinery	85,867,313	6.250
Wagons and vehicles	28,327,875	2.062
Automobiles	14,177,391	1.032
All other manufactures	298,024,892	21.692
Total	1,373,900,000	100.00

* Covers repairs also.

FARM IMPLEMENTS AND MACHINERY

The amount of wood consumed in the manufacture of farm implements and machinery in 1920 as obtained from the questionnaires sent out to the several firms was 84,214,272 board feet, and it was assumed that this was related to the capitalization of the companies which, with the exception of firms rated at less than $10,000, was obtained from the Illinois Manufacturers' Association and the Secretary of State, Springfield. Firms consuming 82,652,082 board feet had a capitalization of $290,133,100, while those representing a capitalization of $5,855,000, or 2.018 per cent, made no report. Assumption that the same rate of consumption applies to those who did not report would add 1,653,041 board feet to the former estimate of those reporting, or a total of 85,867,313 board feet, which it is believed is very nearly correct. A comparison of 1909 and 1920 consumption is as follows:

Class of product	Year 1920	Year 1909	Ratio of 1909 to 1920 consumption
Farm implements and farm machinery	137,157,000	85,867,313	62.6%
Wagons and heavy vehicles.....	35,686,000	28,327,875	79.38%

Relative Importance of Wood in the Manufacturing Industries of Illinois

The manufacturing industries utilizing wood as a raw material entering into their products may be divided into, first, those dependent entirely upon wood, and which would cease to exist with the discontinuance of its use; second, industries largely dependent on wood or making large use of it which would be seriously incommoded by failure of supply; third, industries dependent on wood pulp which would be severely crippled by scarcity of wood; and fourth, industries dependent on wood for minor uses and which it seems probable could survive without serious loss if compelled to make complete substitution of other material for wood. For convenience in tabulation these industries have been designated as A, B, C, and D.

GROUP A. INDUSTRIES DEPENDENT ENTIRELY ON WOOD

In this group come the manufacture of wooden packing-boxes, lumber and planing-mill products, wood furniture, wood and paper pulp, cooperage, wood preservation, and charcoal.

The use of wood for packing and crating illustrates the entire problem of wood in industry. With increasing costs for lumber, many forms

of substitutes appeared, such as cartons, most of them made of wood refuse or by-products. Although adopted for a large percentage of the lighter forms of merchandise, damage of goods in transit when shipped in such containers caused the shipper to adhere to wood for so many lines and in such a large proportion of freight shipments that wood for packing boxes was largely retained, and the quantity consumed in this industry alone, in Illinois in 1909 required 21.05 per cent of the entire consumption of lumber in manufacturing, or about 375,000,000 board feet, and this proportion probably holds today. In this form, cheap supplies of wood can render an invaluable service to nearly every form of manufactured products, including many which do not use wood as raw materials.

GROUP A.—INDUSTRIES DEPENDENT ENTIRELY UPON WOOD*

	Persons employed	Capital invested	Cost of principal materials	Value of products	Value added by manufacture
Wooden packing-boxes	4,920	$9,002,089	$10,297,194	$18,856,685	$8,491,880
Lumber and planing-mill products	6,320	24,059,331	20,393,106	34,588,576	13,909,099
Wood furniture	15,160	35,330,352	22,164,038	49,686,849	26,979,464
Wood pulp and paper	2,002	13,928,741	8,162,201	14,356,529	5,144,076
Cooperage	1,601	4,849,702	7,623,833	11,576,824	3,903,720
Wood preservation	564	2,252,853	1,618,683	3,142,545	1,417,240
Charcoal	27	37,676	17,113	40,565	23,250
	30,594	$89,460,744	$70,276,168	$132,248,573	$59,868,729

All industries in this group are obviously dependent on wood as a raw material and would be discontinued with its disappearance. Together these industries constitute 3.18 per cent of the total of Illinois manufacturing enterprises.

GROUP B. INDUSTRIES WHICH MAKE EXTENSIVE USE OF WOOD

In this second group are found those industries which are greatly benefited by access to abundant and cheap supplies of wood, especially of hardwoods. Their products will show a decided increase in cost with the lessening of this supply or the necessity for using substitutes, and in

* From "Manufactures", 1919, Ill., Fourteenth Census of the U. S. Dept. of Commerce, Bureau of the Census, Washington, D. C.

many instances there will be a loss also in efficiency or satisfactory service.

Lumber and planing-mill products constitute that portion of the industry of lumber manufacture exclusive of logging, which takes place within the state. Logging as an industry in Illinois is relatively insignificant, constituting an enterprise equivalent to less than 1/5 of 1 per cent of the total manufacturing industries. But the planing-mill industry is of greater importance, handling in 1909 12.52 per cent of all lumber consumed within the state, and having closest contact with the building industries and the use of finished lumber for the construction of buildings in cities and on farms, which, with other uses of lumber outside of manufactures, absorb nearly 40 per cent of all lumber consumed in the state.

The manufacture of wooden furniture as an industry must cease to exist with the substitution of metal for wood. This industry will be one of the last to abandon the use of wood altogether, since the preference for wood remains strong enough to permit high prices to be paid for woods of high quality, such as walnut.

Holding chief place among these in point of demand for wood and its place in industry, is the *construction and repair of steam and electric railway cars*, which, while listed under manufactures, is one of the chief uses of wood in the transportation industry. Car-making uses for new cars alone 28.42 per cent of all lumber used in manufacturing, and employs 7.7 per cent of all the factory employes.

Although the use of steel in car construction is increasing, yet out of 158,022 cars of all types made in 1919 in the United States, 66.15 per cent were built with a wooden superstructure on a steel frame, 2.68 per cent were all of wood, and 2.61 per cent had wooden interior finish or linings, making a total of 71.44 per cent of new car construction all or in part of wood.

Agricultural implements and machinery rank next as large consumers of wood, taking 5.74 per cent of all lumber used in manufacture. In this industry, more and more of the parts formerly made of wood are being replaced by metal, and it is difficult to predict how far the substitution will go. The same is true of wagons and vehicles, requiring 2.00 per cent, and to a certain extent of others of the industries shown in tabulation B; but substitution becomes an urgent question first in the great industries which require large and dependable supplies and can not exist on the precarious output of second growth or cut-over areas.

The automobile industry furnishes one of the best illustrations of the importance of wood. The consumption for automobiles in the United States in 1923 is given by the National Automobile Chamber of Commerce as 780,000,000 board feet of high-grade hardwood lumber, in addition to which 200,000,000 feet were used for crating and shipping cars. Michigan of course ranks first among the states, but Illinois occupies sixth place in the value of motor vehicles produced, including bodies and parts, her factories approximating 3 per cent of the total output, which indicates a consumption of 14,177,391 board feet for 1922 and 16,610,292 for 1923. The statement for consumption of wood in Illinois by this industry is by no means complete, since there are several factories making accessory parts, such as bows for tops and running boards of cars, merely as a side-line to some other industry.

There are comprised in this industry three main classes of motor vehicles—passenger or pleasure cars, trucks, and commercial bodies for delivery purposes. Data upon the number of each of these classes are obtainable from the National Automobile Chamber of Commerce, but are not given out by states. By taking their estimate for the amount of wood in each class of car* and using the figures furnished by the United States Bureau of Census on the number of each class produced in Illinois, it is possible to arrive at a fairly accurate figure for the total amount of wood consumed in the state by this industry.

Through the co-operation of the Forest Products Laboratory, Madison, Wisconsin, we were able to obtain the figure of 12,000,000 board feet as the consumption for passenger cars, which varies from 150 board feet for open cars to 325 or even 350 board feet for large closed cars. Truck bodies require each from 200 to 250 board feet and their number is known, but the number of commercial bodies had to be approximated, since the Forest Products Laboratory survey did not extend to commercial bodies. The total stands at over 14,000,000 board feet. This amount is likely to increase rather than decrease from the fact presented by the National Automobile Chamber of Commerce that there is a marked trend towards closed cars, there having been an increase in the use of this type from 9 per cent in 1919 to 35 per cent in 1923, and closed cars require more wood.

Of this 12,000,000 feet for passenger bodies alone used in Illinois, which does not include the lumber used for shipping and crating cars,

* Appendix, Note 3.

the Forest Products Laboratory reports that it was all No. 1 common or better, and was divided on the basis of species as follows: ash, 71 per cent; oak, 10 per cent; maple, 8 per cent; yellow poplar, 5 per cent; birch, 3 per cent; basswood, 2 per cent; walnut, 1 per cent. Ash, because of its moderate weight in proportion to its strength, its high degree of toughness, its comparative freedom from warping, and its ease of working, leads all other woods for this purpose; and it is especially preferred for the bodies of high-class cabs because of its ability to withstand the shocks and jars incident to city traffic, with its occasional accidents. A very large proportion of the ash for cab manufacture is imported from Arkansas.

The great increase in the use of wood with the expansion of this industry can be seen by comparing the consumption in Illinois for 1909 with that of 1920 or 1923. With the decline in the demand for buggies, coming with the introduction of motor-driven vehicles, many small factories began to make automobile bodies; but the amount of wood used by them is inconsiderable when compared with that used by the larger and better equipped shops, which are in some instances connected with railway-car building.*

Steel is substituted for wood wherever possible, and instead of using solid pieces of wood there is a tendency with the perfecting of waterproof glues to use ply-wood made up of thin pieces of veneer; and some firms are producing a veneered top for sedans as one of their specialties.

The importance of this industry for the state as indicated particularly by the number of men employed and value of products manufactured, may be thus shown here in tabular form.

	Number of establishments	Av. number of wage-earners	Wages paid out	Cost of materials	Value of products
Motor vehicles including bodies and parts (passenger vehicles, trucks, etc.)	156	3,885	$5,992,655	$32,200,781	$56,796,893
Motor vehicles (All 4-wheeled motor-propelled steerable vehicles)	22	1,324	$2,126,618	$26,019,704	$41,043,496
Total	178	5,209	$8,119,273	$58,220,485	$97,840,389

* For further details as to consumption of wood in the automobile industry see Appendix, p. 168, Notes 2, 3, and 4.

GROUP B.—ILLINOIS INDUSTRIES LARGELY DEPENDENT UPON WOOD
CENSUS OF 1920

	Persons employed	Capital invested	Cost of principal materials	Value of products	Value added by manufacture
Car construction and repair	61,957	$158,455,923	$121,086,018	$235,915,008	$110,889,474
Agricultural implements and machinery	26,555	150,484,328	62,893,409	128,284,716	63,124,896
Automobiles	10,959	43,584,252	73,476,977	104,883,442	30,929,634
Pianos and organs and materials	9,500	45,409,050	15,156,407	36,255,055	20,716,681
Wagons and vehicles	3,374	16,151,535	8,112,159	15,364,522	7,040,539
Picture frames	2,282	3,257,085	2,658,425	7,160,155	4,417,179
Dairyman's supplies	787	3,175,310	1,293,061	3,505,720	2,183,190
Sewing-machines	2,501	8,115,991	2,287,574	7,166,783	4,789,751
Handles	1,900	4,074,736	3,983,803	7,339,470	3,296,862
Laundry appliances	2,446	9,176,002	8,515,647	14,435,533	5,861,444
Cooperage	1,260	4,067,672	2,563,643	5,786,820	3,173,741
Refrigerators	349	898,984	375,815	1,198,255	811,762
Miscellaneous*	8,416	19,289,218	16,848,422	35,178,544	18,061,332
	132,286	458,140,086	$319,251,360	$602,474,023	$275,296,485

This group of industries in which wood is almost indispensable but which may be either forced out of business or be obliged to use substitutes eventually, now totals 14.58 per cent of all Illinois manufactures. That these industries would be tremendously benefited by the continuance of cheap and plentiful supplies of lumber suited to their needs, goes without saying.

GROUP C. INDUSTRIES DEPENDENT ON WOOD PULP AND PAPER

This third group of industries includes printing and publishing, and the manufacture of paper for stationery and other paper goods.

Wood pulp and paper are well-nigh indispensable in this industry and in spite of the relatively small quantities required to supply this demand, which is approximately 4,550,000 cords per year as against 110,000,000 cords used for fuel alone in the United States, yet the limitations of species, cost of transportation, and the relatively large quantities of material which must be assembled at one plant to reduce the cost of manufacture have not only prevented the extensive use of substitutes but have caused the price of pulp wood and of paper to increase constantly, until American operators, dependent on the exploitation of virgin

* For itemization of "miscellaneous", see Appendix, Note 5.

forests with increasing costs of raw material and of transportation, are already facing serious competition from European plants whose supplies are drawn from well-managed forests. This condition is clearly shown by the average prices paid for wood consumed in the manufacture of pulp as given by the U. S. Census for 1919, covering the two previous decades.*

These industries dependent on wood pulp and paper represent a total of 4.73 per cent of the state's manufacturing enterprises.

GROUP C. INDUSTRIES DEPENDING UPON WOOD PULP

Name	Persons employed	Capital invested	Cost of materials	Value of products	Value added by manufacture
Job printing.....	25,059	$53,872,011	$39,332,048	$92,232,447	$52,125,173
Printing and publishing newspapers and periodicals	19,604	54,099,750	10,058,026	26,641,359	16,278,247
Book-binding and blank-book making	2,872	4,703,224	2,581,130	7,477,722	4,839,431
Book publishing and printing...	591	1,415,609	817,281	2,521,467	1,692,249
Printing and publishing music..	241	677,430	375,920	1,211,810	832,603
Stationery goods not specified elsewhere	2,180	7,623,135	3,176,611	8,950,598	5,720,178
Envelopes	1,650	3,994,921	3,281,992	6,431,059	3,104,760
Labels and tags..	914	2,473,797	1,295,883	3,428,419	2,107,909
Paper goods not elsewhere specified	786	2,501,059	2,972,047	5,588,956	2,587,928
	53,897	$131,260,936	$63,890,938	$154,484,837	$89,288,478

GROUP D. INDUSTRIES DEPENDENT UPON WOOD FOR MINOR USES

Frequently these minor uses are very important in the economy of the industry. For example, pattern material essential for foundries is getting so scarce that fabulous prices are paid for rather small quanti-

*Year	Average price per cord	Year	Average price per cord
1899	4.95	1917	11.10
1905	5.56	1918	13.93
1914	8.81	1919	15.95

ties of clear white pine lumber required for this use. In electrical machinery about seven million board feet is used for minor purposes. These two industries alone total 5.07 per cent of Illinois manufacture.

GROUP D. INDUSTRIES USING WOOD IN A MINOR CAPACITY

	Persons employed	Capital invested	Cost of principal materials	Value of product	Value added by manufacture
Foundries	13,297	$34,557,499	$18,580,191	$ 52,109,714	$31,026,971
Electrical machinery	36,515	96,811,473	50,258,394	119,528,022	67,901,723
Total	49,812	$131,368,972	$68,838,395	$171,637,736	$98,928,694

If the fourth group (D) is omitted, and the situation summed up on the basis of those industries which would be seriously crippled by failure of wood supplies, we find that they employ 26.93 per cent of the total labor employed in Illinois manufacturing industries and 20.40 per cent of the capital invested, and that 20.91 per cent of the value added by manufacturing is represented by these industries. The cost of materials, dealing as they do with basic raw products, is 13 per cent of the total costs for all industries and the value of the products is 16.38 per cent of the total value of manufactured products.

Weighting the three groups on the basis of persons employed, capital invested, and value added by manufacture the results are:

	Per cent
A. Industries dependent entirely on wood	3.18
B. Industries making extensive use of wood	14.83
C. Industries dependent on wood pulp	4.73
Total largely dependent on wood	22.74

ECONOMIC VALUE OF WOOD INDUSTRIES

Allowing for materials other than wood used in these industries, it is probable that wood and its uses in manufacture represents between 8 and 10 per cent of the value of all raw products so used, and that its economic value is not less than this proportion to the total manufacturing industry of the state. With failure of the supply, notably of hardwoods, a very large percentage of these industries will be forced either to discontinue operations and seek other forms of investment or to produce a more expensive product of less relative value, or else to

THE RELATION OF WOOD-USING INDUSTRIES TO TOTAL MANUFACTURING INDUSTRIES OF ILLINOIS

Class of wood-using industry	Persons employed, number	Per cent of total	Invested capital, dollars	Per cent of total	Cost of materials, dollars	Per cent of total	Value of products, dollars	Per cent of total	Value added, dollars	Per cent of total
A	30,594	3.80	$9,460,744	2.66	70,276,168	2.02	132,248,573	2.43	59,868,729	3.09
B	132,286	16.44	466,140,086	13.85	319,251,360	9.15	602,474,023	11.11	275,296,485	14.21
C	53,897	6.69	131,260,936	3.89	63,890,938	1.83	154,484,837	2.84	89,288,478	4.61
D*	49,812	6.19	131,368,972	3.90	68,838,395	1.97	171,637,736	3.16	98,928,694	5.11
Total.....	266,589	33.12	$18,230,738	24.30	522,256,861	14.97	1,060,845,169	19.54	523,382,386	27.02
Total of all manufacturing industries of state.....	804,805	.....	3,366,452,969	.....	3,488,270,446	.....	5,425,244,694	.....	1,936,974,240	.....

* Class D, including industries which use wood in a minor capacity, has been omitted in showing the relation of wood-using industries to the industries of the state.

relocate elsewhere, if such location can be found. It is evident that the manufacturers of Illinois and the wage-earners dependent on these investments as well as the state as a whole must take a deep and lasting economic interest in the movement for the establishment of timber production as an enterprise, not only in Illinois but in other states as well. What happens in the southern yellow pine cut-over lands and in the forest areas of northern Minnesota and the upper Peninsula of Michigan, concerns the future welfare of Illinois, which can not afford to remain indifferent to methods or neglect which may result in serious loss through permanent failure of the indispensable flow of raw materials to her wood-demanding industries.

The Consumption of Wood by Steam Railroads in Illinois

Steam railroads in Illinois had a trackage in 1922 of 25,736.24 miles, classified as large roads 23,157.68 miles, small roads 805.13 miles, switching and terminal companies, 1,773.43 miles. Railroads are not only one of the largest consumers of wood in the state but, owing to the preference for wooden ties, will probably remain so. Wood is required by railroads for two major purposes, cross-ties, and cars. In addition, lumber is consumed for buildings and minor uses, while round products are used in the form of fence posts, piling, and poles.

CROSS-TIES AND BRIDGE AND SWITCH TIES

The consumption of cross-ties in Illinois was obtained from figures on total consumption of cross-ties by roads with trackage in Illinois, multiplied by the percentage of trackage within the state. These figures give the total consumption as follows:

Consumption in 1920

Cross-ties, Pieces

Class	Ties laid in replacement and betterment	Ties laid in new track	Total ties
Large roads	5,187,645	220,799	5,408.444
Medium and small roads	218,806	770	219,576
Switching and terminal companies	342,540	40,230	382,770
Totals	5,748,991	261,799	6,010,790
Per cent	95.64	4.36	100

Switch and Bridge Ties, Board Feet

			Total bd. ft.
Large roads	15,562,682	1,194,672	16,757,354
Medium and small roads	694,231	19,377	713,608
Switching and terminal companies	3,270,772	300,470	3,571,242
Totals	19,527,685	1,514,519	21,042,204
Per cent	92.80	7.20	100

The average contents of bridge ties is 58.6 board feet, and of switch ties, 44 board feet. About one third of these classes are bridge ties, and the remainder switch ties, giving an average content for both classes, of 48.867 board feet. Converting the board-foot contents by this factor into ties, indicates the number so used in 1920 as 430,601, and that used in 1921 as 428,737.

The total number of board feet for bridge and switch ties, as taken from the tables for 1920 and 1921, are respectively 21,042,204 and 20,951,122 board feet. Converting the cross-ties into their equivalent in board feet by using 35 board feet, gives for 1920 a total of 210,377,650 board feet, and for 1921, 202,502,300, or an equivalent in number of ties of 6,010,790 (1920) and 5,785,780 (1921).

The total number of all ties consumed becomes 6,441,391 for 1920 and 6,214,317 for 1921, and the total number of board feet for this number of ties is 231,419,854 for 1920 and 223,453,422 for 1921.

CONSUMPTION IN 1921

Class	Ties laid in replacement and betterment	Ties laid in new track	Total ties
Cross-ties, Pieces			
Large roads	4,812,200	232,535	5,044,735
Medium and small roads	236,380	7,916	244,296
Switching and terminal companies	491,978	4,771	496,749
Totals	5,540,558	245,222	5,785,780
Per cent	95.7	4.3	100
Switch and Bridge Ties, Board Feet			
Large roads	15,343,954	1,182,347	16,526,301
Medium and small roads	448,564	37,625	486,189
Switching and terminal companies	3,728,336	210,296	3,938,632
Totals	19,520,854	1,430,268	20,951,122
Per cent	93.2	6.8	100

The following table conveniently summarizes the foregoing details.

RECAPITULATION FOR THE YEARS 1920 AND 1921

Year.	Switch & bridge ties		Cross-ties		Total No. of all ties consumed	Total contents of all ties, board feet
	Number	Contents in board ft.	Number of ties	Contents in board ft.		
1920	430,601	21,042,204	6,010,790	210,377,650	6,441,391	231,419,854
1921	428,737	20,951,122	5,785,780	202,502,300	6,214,317	223,453,422
Average for the two years					6,327,854	227,436,638

CAR MANUFACTURE AND REPAIR

Car manufacture and repair constitutes the second major use of wood by railroads. The total quantity of lumber used in these operations of which actual record was obtained, was 420,087,887 board feet, divided as follows:

Construction of new cars	338,941,801
Repairs	77,146,086
Not specified	4,000,000
Total	420,087,887

It is roughly estimated that the addition of firms not reporting would bring this total to 425,000,000 board feet.

FUTURE REQUIREMENTS FOR WOOD IN THE CAR-MANUFACTURING INDUSTRY

The substitution of steel for wood in car manufacture has made rapid strides in the last decade, but has so far not reduced appreciably the demand for wood in this industry. Cars made entirely of wood now constitute but 2.68 per cent of all cars manufactured, while all-steel cars have increased to 27.95 per cent. But there remains 66.75 per cent of all new construction, which consists of a steel frame with wooden body, and 2.61 per cent with steel body and wooden interior. The type of cars with steel frame manufactured in Illinois requires, for box cars, between 5,000 and 5,500 board feet of wood for construction, while the older type of wooden box-car required between 6,000 and 6,500 board feet, a saving of but 1,000 board feet per car. For flat cars the reduction in wood used is about 1,500 board feet per car, all-wood flats requiring 3,100 board feet as against 1,600 board feet for cars with steel frames. Wooden coaches requiring 25,000 board feet, still utilize 18,000 board feet when steel frames are substituted, while for wood finish in steel coaches, over 6,000 board feet is required. Thus while steel construction is effecting an undoubted saving of wood and adds to the strength of construction, the extensive use of wood is continued by preference to all-steel cars in 72 per cent of new construction at the present time, in spite of the relatively greater increase in cost of wood materials as compared to steel. As in so many other instances, the complete substitution of other materials for wood will not be brought about by relative superiority of the substitute, but solely by the increasing scarcity and rising prices of wood itself.

Taking the total used for car manufacture and repair at 425,000,000 feet in 1923, there has been an increase of 17,667,000 board feet, or almost 5 per cent, despite substitution during the last decade. Partial returns were obtained on consumption of lumber, fence posts, and piling by railroads. The figures were given for the entire systems and prorated to Illinois on the basis of relative mileage, as for cross-ties. The indicated consumption of wood exclusive of car repair for the year 1922 was:

Class	Lumber Bd. feet	Posts Number	Piling Linear feet
Large roads	65,512,789	66,886	219,388
Small roads	1,947,177	952	84,751
Switching and terminal Co's	12,545,696	676	13,862
Total	80,005,662	68,514	318,001

The total consumption per annum of wood by steam railroads in Illinois is thus estimated to be:

Lumber	Board feet
Car manufacture and repair	425,000,000
Miscellaneous uses	80,000,000
Total	505,000,000

	Pieces	Cubic feet	Multiple cu. ft.
Cross-ties	6,327,854	26,893,379	4.25
Fence posts	68,514	54,811	.80
Piling 318,001 (lin. feet)	8,767	195,504	22.30

Cubic equivalent of all except lumber, 27,143,694.
Cubic equivalent of lumber at 6 board feet per cubic foot, 84,166,166.
Total consumption of wood, cubic feet, 111,309,860.
Total board-foot equivalent, 733,936,507.*

Consumption of Wood by Electric Lines and Light and Power Companies in Illinois

During the years 1921 and 1922 there were in operation 3,513.8 miles of electric railways and light and power companies in the state, and for the electric railways 2,450 miles were main track. From the books of the State Commerce Commission at Springfield it appears that the number of new ties laid in all tracks was 292,509 for 1921 and 326,455 for 1922, an average for the two years of 309,482.

Further, from the books of the State Commerce Commission, it was learned that 58 of the roads had made statements as to the average num-

* The converting factor of 6 board feet per cubic foot can be used for piles, poles, posts, and lumber, but for cross, switch, and bridge ties averaging 35.9421 board feet each and 4.25 cubic feet the converting factor is 8.4569.

ber of ties per mile, and weighting these numbers by the mileage of the respective roads it was ascertained that for 2035.82 miles of track 5,-638,321 ties were in service, or an average of 2,770 ties per mile. Since from the new ties laid in 1921 and 1922 we obtain an average for replacements and new construction of 88 ties per mile, we conclude that the average length of service rendered is 31.5 years. Trolley traffic is not so hard on ties as steam traffic because the cars are very much lighter. Some treated ties are used, and in the one case where steel ties were used the cost appeared to be almost prohibitive. The permanent requirement per annum for cross-ties by electric lines and trolley lines may be roughly placed at 312,000 for renewals and new construction*, assuming that there are 9,730,000 ties now in service on the entire 3,514 miles of these roads. In addition to cross-ties, these electric and light and power lines in 1921 required 46,327 poles and 8,042,399 board feet of lumber.

The total wood consumed by electric lines exclusive of lumber used for electric cars, in 1921 was:

	Number	Cubic feet	Multiple
Cross-ties	292,509	1,023,781	3.5
Poles	46,327	463,270	10.0
Total cubic products.....		1,487,051	
	Board feet		
Lumber	8,042,399	1,340,400	1/6
		2,827,451	
Equivalent in board feet.....			18,912,267

The total, for both steam and electric transportation is:

	Cubic feet
Lumber.....	85,506,566
Round products.....	28,630,745

114,137,311 cu. ft. or 752,848,774 board feet

Tie Renewals and Replacements and the Future Tie Supplies for Illinois Railroads

Transportation is literally the life-blood of the industries of the state. Whatever affects the security or cost of railroad operation brings immediate readjustments in both the cost of living and the standard of living.

The security of the road-bed is a necessity in making possible the steady increase in weight and driving power of locomotives, speed of passenger service, and reduction of cost of haul per ton mile. . The

*This was determined by returns from questionnaires sent out to members of the Illinois Electric Railways Association through the courtesy of their Secretary-Treasurer, Mr. R. V. Prather.

weight of the standard rail has been increased; but the foundation of the entire structure of rail transportation is still the wooden tie.

Faced with the possibility of ultimate exhaustion of the supply of wooden ties through depletion of the forest resources, railroad engineers have for three decades experimented with substitutes in order to be ready for the transition when wood was no longer available; but even in the face of threatened serious shortage of supply and in spite of rapidly increasing costs, cross-ties continue to be made almost exclusively from wood.

Not only is the number of ties other than wood now in use infinitesimal, but this substitution is not yet increasing at a rate indicating a tendency to abandon wood. For the year 1920, Census figures show that out of a total of 86,829,307 ties laid in Class I track for replacements in the U. S., but 154,378 were of material other than wood, or 18/100 of 1 per cent.

The two factors which will determine the rate of possible substitution for wood in this field are service and cost. Service means the durability or preservation of the tie in a serviceable condition capable of supporting the rail and preserving the gage of the track. Ties cease to render service when they break, decay, get out of shape, crumble, or in any way lose their form and structure.

Ties in modern road-beds must withstand terrific shock from traffic. Resiliency rather than rigidity is required, and wood presents this quality, while more rigid metal or cement lacks it. Cement ties crumble rapidly and are no longer considered of value. The rigid steel tie, in spite of its less desirable qualities might ultimately supplant wood, but this substitution depends also on relative costs and demonstrated period of service. These factors still favor the wooden tie.

Wooden ties fail from two sets of causes, namely, decay, and mechanical stress which causes the tie to wear out. For these reasons cross-ties were originally made only from woods which possessed the maximum resistance to shock, combined with the greatest resistance to decay when exposed to the surface conditions in the track. White oak and chestnut were the favorite hardwoods, and heart pine the most widely used material in coniferous regions.

TIMBER PRESERVATION

During the past decade the supply of the so-called class "U", or untreated ties, those naturally resistant to decay and therefore not requir-

ing treatment, became insufficient to meet the needs of the roads. No sap ties possessed this quality, and small timber, even of the desired species, would show too large a proportion of sap to class as "U" ties. The roads met this situation, not by substitution but by timber preservation, which enabled them to draw upon a large reservoir of timber of species not sufficiently resistant to decay to have been formerly acceptable. Instead of being confined to white oaks, black locust, walnut, pine, cedar, cypress, catalpa, chestnut, mulberry, and sassafras, and mainly heartwood, the sap ties of all these species, and in addition many new species could now be used. Of these the most important is the red or black oak group, which grows nearly twice as rapidly as the white oak group. Others are the ashes and hickories, honey locust, beech, formerly a wood in little demand in most regions, birches, including the paper birch which formerly was permitted to burn after pine lands were logged, cherries, gums, which constitute an enormous quantity of timber in the South, hard maple, one of the most numerous species in the northern woods, elms, hackberry, soft maple, sycamore, and butternut. Practically the only trees remaining which are unsuitable for ties are such species as cottonwood, tulip-poplar, and basswood, which are too weak to withstand mechanical stress, and are more valuable for other purposes. The expansion of the field of utilization and market for cross-ties to cover practically every species not otherwise valuable found in the wood-lots and forests of Illinois, is one of the most significant and encouraging phenomena of recent years, and is a striking proof of the fact that timber crops, when grown to merchantable sizes, regardless of the species which compose the stand, will in the future find a ready market unless the national neglect of forest production reaches such colossal proportions that entire industries are dislocated and forced to resort to substitutes. Even should such shifts occur through necessity, wood will regain its place at any future time when it is produced in sufficient quantities to furnish a dependable source of supply.

The effect of preservatives upon the life of ties of different species is to establish an average service of from 15 to 16 years per tie including those species formerly rejected, as against about 10 years for the formerly accepted durable species, and 2 to 5 years for the unserviceable kinds. The relative durability is affected by several factors. Very durable woods, such as white oak, do not show a corresponding increase in longevity when treated. The greatest relative gain comes in treating such woods as birch and maple which otherwise decay rapidly.

The period of service is diminished by heavy traffic because of increased wear, and some species, like soft maple and elm, show less relative resistance to heavy than to light traffic when compared with ash, hickory, and red oak. To meet this condition in lines where the traffic exceeds ten million tons annually, tie plates are used which distribute the load and prevent the cutting of the tie by the rail.

The preservation of wood has been standardized by experience until practically all commercial plants use either creosote or zinc chloride or a combination of the two. The wood is impregnated with these materials in closed cylinders under air pressure. The use of creosote is more expensive, and gives greater length of service. The choice of the method is determined by the effort to secure the lowest annual charge for replacements, which is derived from first cost of the treated tie and years of service secured. As ties increase in price the tendency will be to substitute creosote for the cheaper processes.

The following table, prepared for the use of one of the larger eastern roads, shows both the effect of preservation upon the period of service and the shortening of this period resulting from excessive traffic. In final analysis, it is the total work which the tie is called on to perform, in terms of tons of traffic, which will limit the service which can be expected of cross-ties, no matter of what species or how well preserved and protected. Demand for tie timber will therefore increase in the same proportion as the increase in tonnage, and regardless of efforts to conserve the supply by preservative treatment.

The extent to which this economic revolution in the practices of railroads with respect to the utilization of cross-ties has progressed, is shown by statistics of wood preservation for 1921. In that year, 55,383,515 cross-ties were treated in the United States, of which 54,227,471 were for use on steam railroads and 1,156,044 on electric lines. As the annual consumption of ties is approximately 100,000,000 over one half of all ties are now treated. This includes practically all the woods classed as "T", or needing the treatment.

Within another decade, practically all ties except a certain per cent of the more durable "U" ties and ties used by small roads, will receive preservative treatment. The larger roads which have not already adopted the practice *in toto*, are rapidly enlarging their percentage of treated to untreated ties. Partial figures indicate that the roads with trackage in Illinois used, during 1921, 41 per cent of treated ties, and several of the larger systems increased this per cent substantially in 1922.

SERVICEABILITY OF TIES

I. Species native to Illinois

Species	Untreated ties		Treated ties	
	Heavy traffic Years	Light traffic* Years	Heavy traffic Years	Light traffic* Years
Ash	3	3	10	16
Beech	4	4	8	14
Birches	2	2	8	14
Cherry	4	6	7	14
Elm	2	3	6	12
Gums	2	2	10	14
Hackberry	2	3	6	12
Hard maples	4	4	10	14
Hickory	3	3	10	16
Honey locust	3	3	10	16
Red oak	5	5	10	16
Soft maples	2	2	6	12
Sycamore	2	2	6	12
White oak				
Heart	8	10	10	16
Sap	7	8	10	16
Walnut, black				
Heart	6	15	8	16
Sap	5	12	8	16
Butternut	1	2	1	10

II. Species not constituting a source of native supplies of cross-ties

Chestnut				
Heart	3	14	3	16
Sap	2	10	3	16
Cypress				
Heart	4	12	4	14
Sap	3	5	4	16
Douglas fir				
Heart	5	8	7	16
Sap	3	3	7	16
Hemlock	3	4	7	14
Larch	3	6	7	14
Pine				
Heart	6	12	8	16
Sap	3	3	8	16

Southern Illinois is the center of the industry of commercial wood-preservation, containing nine large plants, while three others are located elsewhere in the state. This is due to the strategic location of this region with respect to available supplies of hardwood and pine ties requiring treatment, on the one hand, and to railroad mileage in need of ties on the other. This fact offers a distinct advantage to producers of local tie timbers, which is only partly nullified by the practice of offering uniform prices for ties delivered on the right-of-way.

* Light-traffic tracks are those carrying not more than ten million tons annually.

The effect of wood preservation upon the requirements of Illinois railroads for tie timber is twofold. It greatly increases the potential supply from all, and especially from local, sources, and it cuts the requirements for renewals nearly in half, thus improving the position of the roads from 300 to 400 per cent and postponing the day when the roads will be forced to introduce other materials in place of wood for ties.

The rate of annual renewals is the gage of the length of service of the average cross-tie. For main tracks the number of ties per rail of 33 feet averages 20, giving 3200 per mile, while on side-tracks it runs 18, or 2880 per mile. An average for all track and roads is sometimes taken as 3,000 ties per mile. The annual replacements per mile, divided into this figure, represent the life of the average tie with approximate accuracy after the initial period following construction has elapsed. As new construction has been practically at a standstill since 1915, this figure should gage the future requirements of Illinois roads for tie timber.

Figures for the years 1917-21 inclusive give for all Class 1 railroads of the United States an average annual renewal of 235 ties per mile. This is equivalent to a life of 12¾ years, which indicates, first, the extent to which the more durable woods have in the past been preferred and, second, the transition which is rapidly taking effect. The roads simply could not afford to use ties whose service fell much below 10 years, and made the shift as soon as economic necessity compelled action.

The annual requirements of Illinois roads for replacements are slightly more than this average, being 241.0 ties per mile for replacements alone, and 245.9 per mile when new construction is included. It will require probably ten years to reduce this figure to 174 ties per mile for all tracks, which is the goal set for 100 per cent use of treated cross-ties. Should the mileage of track remain fairly stable at 25,000 miles, this would require 4,350,000 ties annually. Allowing an increase in trackage of 10 per cent and a further increase in renewals due to heavier traffic of 20 per cent upon the ultimate mileage, the number required would be 5,742,000 ties annually.

Unless unforeseen factors arise it appears safe to estimate that a permanent supply of 6,000,000 ties for steam roads alone should guarantee the continuous use of wood for cross-ties in Illinois.

The Uses of Wood in Mining

Mining finds its great importance as a basic industry upon which the entire structure of manufacturing depends for fuel to furnish power, heat, and light, which are equally essential for domestic consumption. Hence the relation of wood-supplies to this industry has an importance much greater than if measured solely by the quantity of wood required in the mining processes.

In Illinois this importance is increased by the fact that 95.2 per cent of the entire mining output of the state is in the form of fuel, of which bituminous coal comprises 77.7 per cent, and petroleum 17.5 per cent. The residual output of 4.8 per cent is made up of limestone 2 per cent, sandstone 7/10 per cent, and other materials 2 per cent.

The production of bituminous coal, according to the reports of the Department of Mines and Minerals, in short tons of 2000 lbs. for the last seven years is as follows:

	Tons
1916	63,673,530
1917	78,983,527
1918	89,979,469
1919	75,099,784
1920	73,920,653
1921	80,121,948
1922	63,276,827
Average	75,007,962

Illinois ranks fourth in the value of all mining products and third in the production of coal, the value of the latter alone in 1919 being $138,767,835. For the year ending June 30, 1921, the number of employes in coal mines was 95,763 and the sum of $80,309,689 was paid out in wages. Illinois coal-mine operators control 799,060 acres of land, of which 754,235 acres is classed as coal land, and 44,825 acres as timber and other lands.

The use of wood is essential to the production of coal at reasonable costs. Coal-mining requires large quantities of small timbers in the round, leading to very close and economical utilization of timber crops and of the contents of trees as contrasted with the waste incidental to cutting for saw-timber only. Supplies of local timber on which freight charges are moderate permit the utilization and later abandonment of timbering in mines, without the excessive costs which would

be incurred in the use of substitutes such as steel or cement. In most instances the recovery of such supports is dangerous and impracticable.

The forms in which this wood is needed are props, legs and bars, lagging, caps, mine ties, and lumber.

Props are small timbers, either split or round, used in temporary openings, such as in rooms for supporting the roof. Props run from 3 to 5 inches in diameter at the tip and from 2¼ to 10 feet in length, depending upon the thickness of the coal seam.

The vertical pieces used in the entries and other more permanent positions are called *legs* or *posts* and the horizontal piece is called a *cross-bar* or, more briefly, a *bar*. These may be 6 or 8 inches in diameter at the top end and up to 16 feet long.

Lagging, or *riprap*, consists of small poles or boards which extend from one set of legs and bars to another to keep small pieces of roof or wall from falling into the entries. In most cases the lagging is used only where the ground is loose, as the rooms are usually cut in the coal so that the walls stand well without support. The quantity of this material used in Illinois coal mines is comparatively small.

Caps are pieces of board about one foot square used to place on top of props or legs for the purpose of tightening up the pieces which support the roof. Old props might be cut up and used for this same purpose. The ordinary size for cap pieces is 12x12 inches and 1 inch in thickness. Mine ties may be as small as 3½ feet long by 2x4 inches, and up to 5½ feet long by 5x6 inches. Lumber is used for general construction, and for mine cars.

The production of bituminous coal for Illinois in 1921, of 80,121,948 tons is taken as the basis for determining the quantity of wood required in mining this coal. Of this total, 78,399,082 tons were the output of shipping mines.

The total consumption of wood in coal-mining was obtained for mines producing a total of 22,146,784 tons, or 27.64 per cent of the total output, well distributed over the entire state. The remainder was calculated by proportion, assuming the same rate of consumption. On this basis the coal industry consumed in 1921, 21,552,250 cubic feet of wood in all forms, of which 19,710,000 cubic feet went into the mines in the form of timbers* and the remainder, 1,842,260 cubic feet, was

* All forms of wood were converted into cubic feet by proper equivalent. For props, the truncated cone formula was used:

$$V = 0.2618\ L\ (D^2 + dD + d^2)$$

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where V = volume, L = length, D = top diameter, and d = butt diameter.

For lumber 6 board feet was taken as equaling 1 cubic foot.

An average taken on 3,300,000 pieces indicated that the dimensions of the average mine prop were 5.2 feet long by 5.4 inches at the middle, or a little over 5 inches at the small end, and contained .83 cubic feet. Mine ties averaged .7 cubic feet. Mine caps are of various sizes, but averaged 1 board foot or ⅛ cubic foot. Legs and bars averaged 1.91 cubic feet.

used as lumber, amounting to 11,053,560 board feet, for mine cars and construction purposes.

The consumption of wood per ton of coal mined, was:

For all purposes, including lumber .269 cubic feet.

For mine-timbering, excluding lumber and mine cars, .246 cubic feet.

The forms in which this wood is used, and the quantity of each are shown in the following table.

WOOD CONSUMED IN COAL-MINING IN ILLINOIS *

Class of material	Pieces, number	Average contents, cu. ft.	Total contents, cu. ft.	Per cent of total used	Per cent exclusive of lumber
Props	16,115,640	.83	13,375,989	61.922	67.864
Mine ties	3,844,850	.70	2,691,399	12.459	13.655
Caps	11,413,266	.16⅔	1,902,220	8.806	9.651
Legs and bars	805,220	1.91	1,537,970	7.120	7.803
Riprap, or lagging	.....	.....	202,422	.937	1.027
		Total	19,710,000	91.244	100.00%
		Total bd. ft.			
Mine cars	36,600	7,978,800	1,329,800	6.320	
Construction	.....	3,074,760	512,460	2.436	
Total lumber.	.....	11,053,560	1,842,260	8.756	
Total both classes	.....	.....	21,552,260	100.00	

The total consumption for the state was obtained by multiplying the average consumption per ton, .246 cubic feet, by 80,121,948 tons and adding to this total the lumber used in mine cars, which gave an average total per ton of .269 cubic feet.

By applying the distribution per cents already obtained to the total of wood consumed, the total of each class was found, and this was in turn converted into the number of pieces in the class by applying the

* The data were from two sources, those collected by R. B. Miller on 16,642,160 tons of coal, and those by H. E. Tufft, of the U. S. Bureau of Mines, on 5,504,624 tons. The lumber required for mine-car construction was not included in their figures and has been added.

Amount of wood (cu. ft.) required per ton of coal.

Tufft	5,504,624 tons	847,644	.154	cu. ft. per ton
Miller	16,642,160 tons	4,611,243	.277	cu. ft. per ton
Combined and averaged	22,146,784 tons	5,458,887	.246	cu. ft. per ton

Miller's data gave itemized consumption by classes. In tabulation this was used (1) as the basis of cubic contents of average pieces, and (2) was, on this cubic basis, expressed in per cent of the total consumption for each class of products.

average contents per piece already determined. It will be noted that 91.24 per cent of all wood used in mines is in the form of round or hewn products of which but 7.12 per cent are legs and bars of sizes capable of yielding lumber. Thus 84.12 per cent of all the wood used in coal mines consists of relatively small props, mine ties, and lagging, which utilizes trees down to from 3 to 4 inches in diameter breast high.

The only use of wood comparable to this in closeness of utilization is as cordwood for fuel. But the economic value of mine timbers is much higher than that for cordwood, since for the consumption of .246 cubic feet, or, at 80 cubic feet per cord, of 00.3 per cent of a cord, one ton of coal is obtained, having a fuel value, at .8 tons per cord, of 406.5 times that of the wood consumed. It requires a total of 246,375 cords of wood to mine all the coal produced in Illinois, while if wood were substituted for coal as fuel, the requirements would be 100,152,438 cords as against an actual output of 1,024,614 cords, or not much over 1 per cent of these requirements. It is therefore evident that if wood must be grown to supply fuel, its most economical use is by converting this wood into coal through the mining industry, and that the land required to produce mine props is performing a service of very high value to the community.

Cost of Mining-timbers

These relative values are reflected in the prices paid for mining timbers as compared with those for cordwood. The average price paid at the mines for all classes of timber reduced to cubic feet was in 1921, 18.3 cents per cubic foot, which at .246 cubic feet per ton of coal mined gives a cost of 4.5 cents per ton of coal for wood delivered at the mine.*

The price for the larger sizes in the form of legs and bars, was 26.7 cents, or 46 per cent greater than this average, while for mine props it was 16.2 cents per cubic foot, or 11.5 per cent lower. The larger dimensions thus command a price per cubic foot 64.3 per cent greater than the smaller props.

* Costs of Timber Delivered at Mine, 1921

Summary of Results from Combining Figures of Harry E. Tufft and R. B. Miller

Tufft	8,845,650 tons	$302,298	3.5 cents per ton
Miller	14,049,475 tons	717,601	5.1 cents per ton
Combined	22,895,125	$1,019,899	4.5

The discrepancy in tonnage between this showing for Miller and the number of tons reported on by him in the foot-note on page 78 is explained by the fact that for 2,592,685 tons he had cubic feet of wood requirement but no data on costs.

Reduced to cords by the equivalent of 80 cubic feet per cord, the price paid per cord for wood at the mines was:

Props	$12.96
Legs and bars	21.36
Average, weighted	$14.64

Using 6 board feet per cubic foot, the lumber represented by the larger-sized timbers costs $44.50 per thousand board feet at the mine, while the same equivalent applied, for sake of comparison, to props gives a value of $27.00 per thousand board feet.

It is evident that at these prices, mine timbers will bear the cost of transportation over considerable distances. As the cost of substitutes is still much higher than for wood, and, as the timbers are indispensable to operation, it follows that as long as the freight charges from the nearest available supply do not exceed this margin, the freight will be paid and added to the cost of the timber laid down at the mine. The marketing of small sizes in this form gives a commercial outlet to material otherwise unmerchantable. Yet under present conditions and practices, the immediate supply of timber obtainable for Illinois mines is insufficient for the demand, and is constantly decreasing.

Based on returns from companies mining one fifth of the total output of coal, it was found that for 1921, 62.3 per cent of all wood used was obtained from Illinois sources, and 37.7 per cent was shipped in from outside the state. The centers of largest coal production, in Franklin and Williamson counties, which in 1921 produced 29.3 per cent of all coal mined in the state, are contiguous to the largest timbered area in the state containing the greatest percentage of non-agricultural land. Rather than be forced to pay excessive freight on these low-grade materials, these mines will always offer an active market for locally grown timber. The higher the freight charges the greater the margin in favor of local supplies. As the cost of cutting and transportation to the railroad is apt to be similar for similar conditions, what would otherwise be paid in freight becomes available either as reduced cost to the mines, increased profit to the contractor or jobber who purchases the timbers, or increase in the stumpage value of the timber itself. The closer the competition and the greater the scarcity of timber, the greater the proportion of this margin which will be secured by the owner of the timber in the form of stumpage value.

There are but two factors working against this prospective increase in value to the owner. One is the possibility of substituting other material for wood in the mines, the other, which is a corollary of the first, is the disruption of the business of furnishing mine timbers from a given region because of the extreme scarcity of wood. In either case the tendency of mine operators is to seek a dependable supply, whether of wood or substitutes, that can readily be secured in the needed quantities. For such guarantee of supply, and because of the cheapened cost of business and of handling, larger prices can be paid than for odd lots, insufficient in quantity, irregular in delivery, and perhaps of variable quality. It follows that local mine-timbers have a great economic advantage over shipments from greater distances, but that to fully secure these advantages, these timbers must show equally good quality and, still more important, be produced in quantity sufficient to supply a large percentage of the requirements of the mines. The kinds of wood used in the mines include nearly all classes of local timber. For legs and bars, where strength is required, white oak is sought. For props, mixed species are used, the only requirements being soundness or unimpaired strength. This undiscriminating market is a great advantage in the utilization of mixed stands.

Most of the mine timbers imported, come at present from the Ozark region of Missouri where large tracts of small white and post oaks are being exploited for this purpose. It is significant that in spite of these rather extensive timber tracts in a contiguous state, the mines of Illinois still draw more than 60 per cent of their timber supply from the second growth and cut-over areas near at hand, and they will continue to do so as long as these timbers can be obtained at prices comparable with those of importations.

In no other industry does the intimate relation between forestry and close utilization of wood appear so strikingly as in coal-mining. No enterprise is more dependent on wood for its operations, and none except the paper industry uses sizes which can be so rapidly, abundantly, and cheaply produced. Yet in spite of these favorable circumstances, it is generally admitted that wherever extensive mining is conducted, the wood required for these operations is becoming increasingly scarce and difficult to obtain. The cure for this situation lies in fire protection and the growing of crops of timber on an extensive scale. Coal-mining will be the first industry to feel the beneficial effect of such practice.

It should be emphasized that nothing but the production of large quantities of cheap timber of small sizes will solve the problem of supply for coal-mining. It is only to a very small degree a question of treating or preserving timbers to prolong their life. Legs and bars which remain in place more than two or three years may be treated profitably, but the entire consumption of these sizes constitutes but 7.8 per cent of total requirements, exclusive of lumber. Ties, constituting 13.65 per cent, might be treated to advantage. But the props, caps, and riprap, or 78.54 per cent of consumption, would seldom warrant the expense of preservation. If about two years of use is secured, they can then be abandoned. The substitution of metal, concrete, or other mineral supports for such temporary entries presents a problem of expense which will seriously handicap all mines which can not continue to secure cheap timber.

If the growth of timber is placed at the low average of 40 cubic feet per acre annually, it would still require less than 500,000 acres of woodland to furnish a perpetual supply of mining timbers for this industry. The mining companies own 799,060 acres, or 60 per cent more land than they need to produce their own supplies. Owing to the small sizes of the average prop or tie, these supplies can be grown in a shorter period than for any other use except fence posts or fuel. Depending on the soil and species, props may be grown in from 15 to 30 years. In actual practice, lands devoted to the growing of timber should produce nearly twice this yield, or one cord per acre. But instead of being cut clear for small mine-timbers, these should be obtained as thinnings made to release the better trees in order to permit the latter to grow into sizes suitable for legs, bars, or saw-timber. Props can also be cut from the tops of trees used for these higher purposes. Under such intensive forest management it will be possible to furnish Illinois coal mines with a perpetual supply of timber for all purposes from the equivalent of 400,000 acres, by utilizing only the thinnings and by-products or cordwood and tops grown in raising higher-priced timber. It is probable that most companies will fail to improve this opportunity as long as they can continue to obtain their supplies by purchase through middlemen or contractors, preferring this method to the assumption of the enterprise of forestry as a side-issue to their main undertaking. Woodland owners in Illinois are probably assured of a continuous market for mining timber at constantly increasing prices, due to this lack of foresight of the operators in providing for their future needs.

The Consumption of Wood on Farms

The three outstanding uses of wood on farms in Illinois are for lumber, fence posts, and fuel. The consumption of lumber is estimated to average 1,250 board feet per farm, or a total of 296,476,250 board feet per year on the 237,181 farms. These, and other data on use and production of wood on farms are based partly on the results of a questionnaire sent to 1,600 farmers through cooperation with the Office of Farm Organization and Management and the State Leader of Farm Advisers. Each county agent was asked to supply the names of representative farmers in his county who owned woodland. Another list of names of farmers having over 40 acres of woodland was secured through the assistance of Mr. A. J. Surratt, Agricultural Statistician at Springfield. The Natural History Survey takes this occasion to thank the 440 farmers who aided the investigation by furnishing data.

The consumption of fence posts in Illinois

The average farm in Illinois contained 134.8 acres in 1920. The amount of fencing which is required for all farms in the state was derived in two ways. In Bulletin 321 of the U. S. Department of Agriculture on the subject "Cost of Fencing Farms in the North Central States", Humphrey ('16) gives the number of rods of fence per acre for farms of different sizes. Those between 100 and 140 acres require 6.3 rods per acre. The second method was the questionnaire, answers to which covered 121,434 acres. On this area of 189.74 sections there was required 10 miles and 140 rods of fence per section, or 5.2185 rods per acre.

The area of the average farm for which these data were taken was 354 acres. It was assumed that the average of all fences would require 1 post per rod of fence. The ratio of rods of fence per acre increases as the farm-unit diminishes in area, hence a factor of increase of 20 per cent was applied to these figures, which gave a requirement of 6.26 posts per acre for average Illinois farms of 134.8 acres as against 6.3 posts based on Bulletin 321 (in 1916) for farms of 100 to 140 acres.

The average farm, then, requires 843.8 fence posts in good repair. With 31,974,775 acres of farm land in 237,181 farms, the total number of fence posts in place is 200,163,000 in 625,506 miles of fence, equivalent to 25 times the earth's circumference.

As the area of land in farms is not increasing but, rather, diminishing, any tendency to increase the amount of fencing on the average farm

is offset for the state as a whole. The quantity of fence posts required annually for farm-fencing will depend upon the need for replacing defective posts. These annual replacements and the ratio they bear to the total number of posts in use is in turn determined by the average length of life of fence posts in the ground. If this is 10 years, one tenth of the number will represent the annual consumption required to keep up the farm-fencing throughout the state.

To determine the average period of renewals two methods can be applied. One is to compute it from the average duration of service of each class of posts, weighted by the proportion of posts of this class used. The second is to compile data on the actual number of posts required to maintain fences which have been in place long enough to need annual replacements.

It was impracticable to determine the percentage of posts of each species on the basis of the data gathered; but by the second method, based on 1800 miles of fence, the average period of service of a post was found to be 9¾ years. This would indicate an annual requirement by farmers in the state for renewals, of 20,530,000 posts, taking no account of the quantity used by other consumers.

In the construction of the original fences on the farms of the state, at least two thirds of the individual owners probably had a source of supply of fence-post material in their own wood-lots, while a large proportion of the remainder could purchase posts from their neighbors at no great distance. These native wood-lots yielded sufficient supplies of the more durable species to satisfy the demand. In the southern portion, white oak was the principal source of supply, with mulberry preferred whenever it was present and walnut used extensively when available. The wood-lots of the northwestern counties yielded burr and post oak, superior even to the white oak in durability. Sassafras was made use of as posts when it had come in on old fields and had attained proper sizes.

But there remained in many of the prairie counties large areas with no timber or post material except at considerable distances. On these farms, hedges of Osage orange were extensively planted in the early days, and small plantations of black locust were set out by many farmers as a source of future post material. Later, about 15 to 20 years ago, hardy catalpa was extensively advertised and planted for the same purpose.

The Osage orange hedges served a double purpose. During their initial period of growth they were substituted for fences. Later, when land became more valuable and many rods of hedges were grubbed out, these old hedges yielded large quantities of posts, averaging from 16 to 20 per rod of hedge, thus furnishing posts for a fence 16 to 20 times as long as the original hedge.

Of late, the supply of post timbers of these more durable species, such as mulberry and white oak, in the wood-lots, has been nearing the point of exhaustion. White oak grows more slowly than trees of the red or black oak group, and on wood-lots which have been extensively cut and grazed is less numerous than red and black oaks in the reproduction which springs up. The close selection of mulberry for posts tends to exterminate this species in mixture. The white or burr oak land in the northwest counties is of a better grade than black oak soils and tends to pass under cultivation. This has increased the use of several less durable species for posts, principally red or black oak, elm, and even such trees as cottonwood, willow, ash, and maple. All these species are short-lived in the ground, and it does not pay to set them unless first treated with preservatives. When so treated, their average life compares favorably with that of untreated posts of the better species.

To determine the average length of service of the more common post-timbers for Illinois conditions, replies to inquiry on this point were tabulated, and the results compared with the standards of durability published by the U. S. Forest Products Laboratory at Madison, Wisconsin. On the basis of the actual experience of over 400 farmers, corrected when the data which they furnished were insufficient and not in agreement with those of the Laboratory, the following (p. 87) standards of durability for posts of these species untreated, were arrived at.

The most striking fact brought out is the remarkable durability or indestructible character of the hedge or Osage orange posts. Hedge has been used for so long in Illinois, and so many replies were received, that this fact, of which abundant corroborative evidence is available, can be accepted as proved. The only question is the length of this period. As with any species of post, this depends somewhat on the size or diameter. But in Osage orange posts this has less effect than for any other species. The sapwood is narrow, and changes to heartwood in 3 to 4 years, and small posts 2 inches in diameter have frequently given service for 50 years. In fact, these small posts wear out by splitting through the driving of staples, before they decay.

AVERAGE DURABILITY OF SPECIES OF WOOD USED FOR FENCE POSTS ON ILLINOIS FARMS, UNTREATED

Species	No. of replies received	Average durability years	Durability based on white oak—10 years (U. S. Forest Service) years	Standard recommended for Illinois years
I. *Durable*				
Osage orange	128	40	25	40
Mulberry	38	20	20	20
Black locust	22	19	20	20
Catalpa	8	16½	15	15
Northern white cedar	40	14½	15	15
Burr oak	45	13	....	12½
Post oak	8	11½	....	11
Walnut	24	9½	11	11
White oak	241	10½	10	10
Sassafras	10	9	....	9
II. *Not durable*				
Elm	8	6	6	6
Black and red oak	39	6½	4¾	5
Ash	3	4	4¾	5
Maple	5	2½	4½	4½
Cottonwood	1	5	3½	3½
Willow	4	4½	3½	3½

REQUIRED RENEWALS OF UNTREATED POSTS

Number of untreated posts required for renewals annually on farm of 134.8 acres (based on 843.8 posts per farm)	Species	Number of untreated posts required annually *per mile of fence*	Number of untreated posts *in each 100 posts* in fence that must be renewed annually
21	Osage orange	8	2.5
42	Mulberry	16	5
42	Black locust	16	5
56	Catalpa	21	6⅔
56	Cedar	21	6⅔
67	Burr oak	26	8
76	Post oak	29	9
76	Walnut	29	9
84	White oak	32	10
94	Sassafras	35	11
141	Elm	54	16⅔
168	Black or red oak	64	20
168	Ash	64	20
187	Maple	71	22⅙
241	Cottonwood	91	28½
241	Willow	91	28½

NUMBER OF POSTS OF DIFFERENT SPECIES REQUIRED ANNUALLY PER 100 ACRES
(Based on 6.26 posts per acre, or 626 per 100 acres)

Osage orange	15 to 16
Mulberry	31
Black locust	31
Catalpa	42
Cedar, untreated	42
Burr oak untreated	50
White oak, old growth untreated	63
Walnut	56
Treated posts of inferior woods—20 years basis	31
On basis of 30 years	21

The figure of 25 years given by the Forest Service is much too low for this species, as evidenced by testimony on the actual life of posts. It probably represents, not the full life of the posts but the life since they were set out. This is the case with many of the Illinois replies.

It is evident, then, that in hedge posts we have material which, size for size, will give twice the length of service of any known wood, and does this without the additional expense of preservative treatment.

In other respects the results obtained from Illinois sources agree closely with the accepted standards, except in the case of some of the less durable species where insufficient evidence was collected. Here the standard adopted agrees closely with that of the Forest Service. The indicated durability of the red oak group is shortened to 5 years. None of these species should ever be used as permanent posts without treatment.

These standards of durability apply to the average post-material as taken from the wood-lot during the past 20 to 30 years. But with the exhaustion of the virgin stand, posts are being taken to much greater degree from saplings, and round posts substituted for split posts of such species as white oak. With the increased rate of growth of saplings on cut-over lands comes a greater percentage of sapwood, which decays more rapidly than heartwood and shortens the average life of these posts.

FUTURE SUPPLY AND PRICE OF WOODEN FENCE POSTS

Data obtained from questionnaires sent out to farmers indicate that in spite of depletion the woodlands of the state are still supplying nearly 50 per cent of the fence posts needed annually on farms for replacements, or a total of 10,031,860 posts. Under existing conditions a shortage of post timber has already developed and will increase in severity. This shortage is being made up in part by importations of white cedar posts from the Lake states, creosoted yellow-pine posts from the south, and locust and red cedar posts from Kentucky and Tennessee.

The species and number of these posts shipped into certain regions of the state is governed, as in the case of lumber, largely by freight rates. During a nine-months period ending June 30, 1923, one southern pine lumber company alone shipped 138 cars containing over 148,000 creosoted yellow-pine posts into the central prairie region of the state. The number of imported posts will probably increase. In the southern part of the state white oak posts sell at the lumber yards for 16 cents and red cedar and sassafras at 30 to 40 cents. Mulberry posts sold in Union county for 7 cents each in the woods, but this species is generally reserved by farmers when selling timber for mine props. In northern Illinois white cedar posts from Wisconsin sell at 25 to 45 cents, red cedar at 45 cents, and creosoted longleaf pine at 50 cents each. Native white or burr oak posts could be bought in the summer of 1922 in northern Illinois for 15 cents and Osage orange and black locust for 40 cents each.

It is probable that sapling or second growth white oak will not last in the ground much over 8 years, hence it will pay to treat such posts as well as those of the less durable species. The open-tank treatment with creosote, in which heavy absorption or practically complete penetration of the butt of the post is secured, is recommended for all species listed on page 86 except red cedar, Osage orange, black locust, mulberry, and catalpa. When so treated, all of the remaining species except willow and cottonwood will last 20 years and probably considerably longer, thus reducing the annual renewal to less than 5 per cent and making red oak, elm, soft maple, and other inferior species last as long as the more durable species. The wood of willow and cottonwood does not take treatment uniformly, and due to this fact posts may develop decay in a shorter time than would be the case with some of the other species. Yet when these two species are available in quantity they will pay for the cost of securing and treating them in spite of this drawback.

According to MacDonald ('15) the total initial cost for treated cottonwood posts 7 feet long and 4½ inches at the top-end is 40 cents with creosote figured at 30 cents a gallon. This makes the annual charge for the post in place 1.6 cents, if it gives a service of 25 years, and 2 cents a year if it lasts 20 years.

In comparison with this the annual charge for an untreated white cedar post costing 35 cents with 10 cents for setting, a total of 45 cents, would be 3.2 cents per year if it lasted 14 years and 4.5 cents if it lasted only 10 years. The results, then, seem to stand 2 to 1 in favor of the treated cottonwood post over white cedar untreated.

Information on the treating of fence posts by the open-tank method is easily procurable from the U. S. Department of Agriculture (Hunt '16)* and several agricultural stations, such as Iowa (MacDonald '15)†, Minnesota, and Louisiana (Mattoon '20)‡, and it is not necessary to go into the details of the process here since so many excellent bulletins have been written on the subject. There is not only a direct saving in the cost of fencing to the farmer by creosoting the non-durable species, but, more important still, if the practice of treating the wood of all inferior species is universally adopted, extending the life of posts to an average of 20 years instead of 10, there will be required in Illinois annually but 10,000,000 posts instead of the present 20,000,000 or more. By adopting preservative treatment of fence posts the farmers of Illinois can produce enough fence posts, at the present rate, to supply from the farm woodlands all of the needs of the farms for fencing.

THE USE OF SUBSTITUTES—CAST IRON, STEEL, AND CEMENT POSTS

Unless home-treating of fence posts is practiced to a greater extent by Illinois farmers, the unsatisfactory service and frequent renewals resulting from the use of the more numerous inferior species and the increasing prices of durable or treated posts will result in the substitution of steel, iron, and concrete posts. Good authorities say that approximately 1,800,000 steel posts alone were sold in Illinois in 1922, to say nothing of concrete and cast-iron posts, and such sales will undoubtedly be increased by advertising.

Undoubtedly great advances have been made by manufacturers in the production of substitutes for the wooden post, and the steel or iron post may have certain advantages which are strongly pressed. Among these it is mentioned that time is saved in building fence since the posts are driven into the ground, the bearing-surface being increased by anchor plates; that the steel posts act as conductors during lightning storms; that fence-rows can be burned out without damaging the fence; that frost heave is eliminated; that there is no expense for staples, and that the farm can be given a neater appearance by the use of uniformly shaped posts,—all of which are good selling points for the agent.

Among the types of metal posts on the market may be mentioned those made of steel, and of galvanized and cast iron, the last two being un-

* 1916 Hunt, George M. The Preservative Treatment of Farm Timbers. U. S. Dept. of Agr. Farmers' Bulletin 744, Washington, D. C., Sept. 21, 1916.
† 1915 MacDonald, G. B. Preservative Treatment of Fence Posts. Bulletin 158, Iowa Agricultural Experiment Station, Ames, Iowa, August, 1915.
‡ 1920 Mattoon, W. R. Treating Fence Posts on Farms. Circular No. 37, Extension Division Louisiana State University in Cooperation with the U. S. Dept. Agr. Baton Rouge, Louisiana. March, 1920.

doubtedly the most durable, and of course more expensive. The weak points in steel posts mentioned by the Ohio Agricultural Experiment Station, poor quality of metal and too thin material, are being overcome by some manufacturers. Greater care is being taken in the selection of steel and the posts are being made heavier in cross-section, some being of the same shape as a railroad iron. Such steel posts sell for about 45 cents each and are rated by the manufacturers with a durability of 15-25 years, although according to the Ohio Agricultural Experiment Station, which made exhaustive observations on over 10,000 steel and concrete posts, "this type of post has not been in use long enough to judge of its merits". Galvanized iron posts, round in form, are made which spread when driven into the soil, giving them a firmer anchorage. These, which require no staples, cost 55 cents each and are rated with a durability of 22 years. The manufacturers of galvanized steel windmill towers are making posts of the "angle iron" variety, lighter than those of the "T" form, which sell for 45 cents each, and they claim that some of their windmill towers of the same material have been in service for 30 years. Makers of cast-iron posts claim that the purchase of steel posts is a waste of money, and no one doubts the durability of cast iron who has seen it used for underground water-pipes. As with untreated and treated wooden posts, the relative value of steel or other substitutes must be determined by comparing the average annual charges for the various kinds, including the setting and renewal of the posts over a period of years sufficiently long to afford a fair comparison.

We were not able to get a reliable estimate as to the number of concrete posts used in Illinois yearly. Although of higher price when purchased than steel, they have the advantage that with proper molds they can be made on the farm with farm labor. It has been demonstrated that they need to be reinforced and even then, due to difference in composition of materials and faulty workmanship, they have not given as good an account of themselves as expected. The Ohio Agricultural Experiment Station places the concrete post in about the same class as catalpa or white cedar, the later type used by the Big Four railroad showing from 10-30 per cent disintegration in from 8 to 15 years.

The existing information on the relative efficiency of steel and concrete posts does not permit of the conclusion that they have as yet established their superiority over either the durable species of post timber or the inferior species when properly treated. Substitution is yet accompanied by considerable risk and, as in other instances, is being brought

about, not by the proved superiority of the substitute but by the progressive exhaustion and failure to replace the needed supplies of wood for this purpose.

Consumption of Wood for Fuel on Farms

The largest consumers of wood for fuel are those who own wood-lots and cut their own wood. A certain amount of wood is sold to city and town dwellers and to farmers who do not own woodland, but this quantity is limited by the comparatively high cost of transportation of wood and the greater labor required in cutting and splitting, storing and piling the wood for use as compared with coal, as well as by the necessity of seasoning green wood. To dwellers in Chicago, wood is a luxury and not a staple. The abundance and wide distribution of coal throughout the state and its greater convenience in handling and storing, smaller requirement in labor, and greater facility for heating and holding fire over night in cold weather have led to a wide substitution of coal for wood, even for domestic purposes, on farms which have wood-lots. Coal and oil almost completely replace wood as a source of power in industry.

From the returns of a questionnaire* it was calculated that farmers consume 93.166 per cent of all the wood burned for fuel; and that wood supplies 25.59 per cent of the combined or total consumption by farmers of wood and coal. The consumption of fuel oil was not obtained, and would reduce the percentage of wood to the total of all fuels used by farmers. The basis of this calculation is the questionnaire to farmers, which indicated that as a class they purchased as much wood as they sold, and hence consumed the equivalent of the production of cordwood from farm wood-lots, leaving the cities to be supplied by the equivalent of cordwood from remaining timber lands. The average yield per acre annually was .332 cords, or a total consumed on farms alone, of 885,792 cords from 2,668,050 acres of farm wood-lots. By using standard weights of wood of different species, and computing the true average based on an approximate per cent of different species used as cordwood, a fuel equivalent of .8 ton of bituminous coal was obtained to one cord of air-dry wood. A cord of black locust or hickory is the equivalent of a ton of coal. A cord of oak is approximately equivalent to .9 ton of coal; beech, walnut, and ash to .8 ton; red maple, gum,

* See Appendix, Note 6, for tabulated data.

sycamore, and elm to .7 ton; yellow poplar and cottonwood to .6 ton; willow and basswood to .5 ton.

It was found that the average farm of 140 acres which burned wood exclusively used 21.4 cords per year, while on farms which burned both coal and wood 13.4 cords were used and 7.66 tons of coal. Farms burning coal only consumed 9.8 tons per year. The wood burning or wood and coal burning farms were those which had fairly large wood-lots, and the average of wood on all farms using it wholly or partly for fuel was 16.1 cords per year. From this figure, divided into the assumed total wood-production for farms of 885,792 cords, it is indicated that about 55,018 farms, or 23.3 per cent of all farms, use wood for fuel at this average rate of consumption per farm, while 76.7 per cent burn coal or oil exclusively. When the acreage of woodland per farm is more than 5 acres, 98.1 per cent of the owners make considerable use of wood for fuel, but when the wood-lot drops below 5 acres per farm, only 44 per cent of such owners burned wood for fuel. These small wood-lots are often grazed and park-like, or are prized for shelter or appearance, and are not adequate as a source of wood fuel.

The indicated consumption of coal by farmers is 2,061,046 tons. The assumed 885,792 cords of wood produced on farms at .8 ton per cord gives the equivalent of 708,634 tons, or a total equivalent of 2,769,680 tons for the farmers of the state as a whole, of which wood forms 25.59 per cent in fuel value. While 23.3 per cent of all farmers burn some wood, 7.9 per cent still burn it exclusive of coal and 15.4 per cent burn both coal and wood.

A significant fact brought out by this inquiry is that those farmers who have a plentiful supply of wood-fuel use considerably larger quantities of fuel than when forced to buy coal. Based on fuel equivalents, farmers burning only wood consume 176.5 per cent of the heat units consumed by farmers burning only coal, while those who supplement the use of wood by purchasing some coal consume 177.3 per cent of the heat units consumed by those burning only coal. This discrepancy is too large to be completely offset by the supplementary use of kerosene or other fuel oils by those who do not have wood to burn. Farmers who have wood-lots apparently live in greater comfort than those who do not. Yet the coal-burning farmer pays as much for his smaller quantity of fuel as his wood-burning neighbor, even when the cost of labor and a fair price for stumpage is charged against the wood. The average cost of coal to farmers was $6.60 per ton. For wood the cost

of stumpage plus labor cost was $2.94 per cord, or the equivalent of $3.67½ per ton of coal, a saving of 45 per cent over coal-prices, which indicates that wood obtained from the wood-lot or neighbors at $2.94 a cord gives 79.6 per cent greater fuel-value for species with .8 tons fuel value per cord than coal at $6.60 per ton. The relative amounts spent on fuel at these values, and assuming all wood as purchased, are as follows:

Coal-burners		
Coal 9.8 tons at $6.60		$64.68
Coal-and-wood burners		
Coal 7.66 tons at $6.60	$50.56	
Wood 13.4 cord at $2.94	$39.40	$89.96
Wood-burners		
Wood 21.4 cords at $2.94		$62.92

Considering the fact that labor by the farmer, his family, or hired help is in 90 per cent of all cases expended in place of money, the cash outlay of those who burn both coal and wood is probably less than for coal-burners, while those burning wood exclusively expend considerably less cash. Where labor is used in winter months which would otherwise be laid off, it helps to solve the problem of steady employment, and still further increases the advantage of the use of wood for fuel.

The drawbacks to the use of wood for fuel lie in the labor required for its handling, and, in regions where labor is scarce, coal may be used for this reason. Wood, being more bulky than coal, will not stand transportation by either wagon or railroad over long distances in competition with coal, hence for any but local consumption on short hauls, wood loses the economic advantage which it bids fair always to retain for home use on farms.

The sale of cordwood at luxury prices in large cities is of less importance in the general economy of the state, though it is frequently a source of profit to land-owners who happen to be favorably situated. Otherwise, most of the profit from such sales is absorbed by transportation, and by local wood dealers*.

Sources of Supply of Woods for Illinois Consumers

Sawed lumber is not only the most important and valuable of the forms of wood consumed in Illinois, but it is the class of which the greatest per cent is imported, and from the farthest points. But 2.4 per

* For figures indicating total consumption of cordwood in Illinois for the years 1917, 1919-1921 inclusive, see Appendix, Note 7.

cent of the lumber required in the state is home-grown and a part of that is shipped to Indiana and Missouri.

Of the 2,353,662,000 board feet of lumber consumed in the state, 2,310,453,000 is imported, and 43,209,000 is home-grown and consumed within the state. The sources of this imported lumber are given in Table on page 97.

The cost of lumber to the consumer in Illinois has risen rapidly in recent years and this rise has exceeded that of other commodities.* Since the cost of raw materials is the automatic regulatory factor which reflects growing scarcity as contrasted with demand, the behavior of lumber prices and the causes of these fluctuations are worth examining. If other materials will serve as satisfactory substitutes for lumber for all purposes, the prices of the latter can not rise much higher than those of the substitutes without driving lumber from the market. It is because lumber is still in demand and substitutes are not yet accepted in so many lines, that these lumber prices can and will continue to rise until the economic advantage of cheap lumber is completely lost to the consumer.

Lumber prices have risen because of several factors. First is the general rise in the price of all commodities as the result of the lessened purchasing power of money. In this, lumber has obviously shared. Second is the increased distance of haul from mill to consumer, which takes the form of freight charges. Third is the increase in freight rates of late years. Fourth is the increased cost of logging and transportation to the mill, due to rising prices of wages, but, in addition to these, a fifth factor is the increasing inaccessibility of the remaining timber. Lastly comes actual exhaustion or serious diminution of the supply, until it fails to meet demand. This is followed by breakdown and exodus of the manufactures which depend upon wood for raw materials.

The first of these six factors needs no demonstration and would work no great hardship were prices and wages adjusted rapidly and equitably to the new standards. It is the fact that wood prices rise faster than those of average commodities, which indicates the existence of more serious conditions.

The increased distance of haul is the most influential factor affecting prices. When the Chicago market was supplied largely from the Lake states by water transportation, prices were abnormally low. With

*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 during this period but 40 per cent.

the cessation of this barge traffic, an increasing proportion of the supply came from the South, which still furnishes over 50 per cent of the total. Freight charges rose sharply. But already 25.85 per cent of shipments come from the Rocky Mountain and Pacific Coast region, 18.58 per cent coming from two states, Washington and Oregon, with an average freight rate nearly twice that from the South. Within the next decade, these percentages will be reversed and the proportion shipped from the far west will inevitably rise to more than one half of the total, while that from the South will be correspondingly reduced by depletion and exhaustion of her virgin timber lands.

Even the western timber is not unlimited. The area upon which it grows is scarcely a tenth of that which bore the forests of southern yellow pine, and while the stand is heavier per acre, the demand of the entire country will be concentrated upon it. Imports into far eastern states are increasing rapidly and are successfully competing with southern yellow pine.

Freight rates advanced sharply during the war and will probably never recede to their former levels.

There is no question about the greater costs of logging nor the relative inaccessibility of much of the timber which is now being logged. Operators are forced to cut the more accessible timber first, when prices are low and margin for profit and stumpage is small. By the time these easy chances are cut over, prices have usually risen sufficiently to permit the logging of more remote stands. Finally, in a region of high prices near to markets, the most difficult chances can be logged at a profit, and the margin will bear the cost of long freight hauls to bring timber from remote regions, and of expensive operations in those regions to tap the reservoirs of timber in rough mountainous districts, by means of logging railroads, flumes, or other costly improvements.

With the exhaustion of the supply in any locality and the change from an exporting to an importing region, the average local prices are fixed by imports and based on cost of obtaining this imported lumber. The residual local timber-supplies then advance rapidly in value, especially in stumpage value. It follows that those who hold such residual stumpage profit largely by such holdings. This factor operates powerfully to make the local production of timber profitable, since such products get the advantage of the freight differential and can easily undersell the imported product if of equal quality, and still return large profits to the owner or producer. But if through complete breakdown of sup-

ply, the more important wood-using industries are driven out of Illinois or forced to close, the tendency will be to ruin the markets for the more valuable products and take the cream off of the profits of forestry.

STATES AND REGIONS EXPORTING LUMBER TO ILLINOIS

The question as to where this enormous quantity of lumber, amounting to 98.16 per cent of the quantity used annually in the state, is obtained and whether such importation can be continued is one of vital interest to its citizens. For convenience, the states exporting lumber to Illinois have been assembled in ten groups, to conform to the grouping used in Bulletin 1119 of the U. S. Department of Agriculture on the Lumber Cut of the United States, 1870-1920. Only those states within each group which shipped lumber *to Illinois* in 1920 were included. The groups, ranked in their relative importance as sources of lumber shipped to Illinois, and the states from which lumber was imported in that year are as follows:

1. Southern Group: Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Oklahoma, Texas.
2. North Pacific Group: Washington, Oregon.
3. Lake states Group: Michigan, Wisconsin, Minnesota.
4. North Rockies: Idaho.
5. Central: Indiana; Kentucky, Missouri, Tennessee, West Virginia.
6. South Pacific: California.
7. South Rockies: Arizona, Colorado.
8. North Carolina Pine: Virginia, North Carolina, South Carolina.
9. Northeastern: Maine, New Hampshire, Pennsylvania.
10. Prairie: Kansas.

These groups of states shipped to Illinois in 1920, the following quantities of lumber.

Group	M. Ft. B. M.	Per cent of total
Southern	1,196,797	50.85
North Pacific	437,206	18.58
Lake states	383,811	16.31
North Rockies	115,968	4.93
Central	112,487	4.78
South Pacific	42,924	1.82
South Rockies	12,299	.52
North Carolina Pine	4,564	.19
Northeastern	3,365	.14
Prairie	1,032	.04
		98.16
Illinois	43,209*	1.84
Total	2,353,662	100.

Separated into softwoods, or conifers, and hardwoods, the shipments were approximately as follows.

Group	Conifers M. Ft. B. M.	Per cent	Hardwoods M. Ft. B. M.	Per cent
Southern	1,004,684	54.206	192,183	38.420
North Pacific	436,637	23.559	569	.114
Lake states	211,906	11.433	171,905	34.366
North Rockies	115,806	6.248	162	.032
Central	21,271	1.148	91,216	18.235
South Pacific	42,910	2.315	14	.003
South Rockies	12,299	.660		
North Carolina Pine	3,353	.181	1,211	.242
Northeast	2,441	.132	924	.185
Prairie	310	.017	722	.144
Total	1,851,547		458,906	
Illinois	1,902	.103	41,307	8.259
Total	1,853,449	100.	500,213	100.

Total consumption 2,353,662,000 feet B. M.

* The total production of lumber in 1920 in Illinois was 56,900,000 board feet. The residue was exported into adjoining states.

PER CENTS OF TOTAL SHIPMENTS FROM DIFFERENT REGIONS, REPRESENTED BY CONIFERS AND HARDWOODS

Region	Per cent Conifers	Per cent Hardwoods	Per cent Total
Southern	42.686	8.165	50.851
North Pacific	18.551	.024	18.575
Lake states	9.003	7.303	16.306
North Rockies	4.920	.007	4.927
Central	.904	3.875	4.779
South Pacific	1.823	.001	1.824
South Rockies	.522		.522
North Carolina Pine	.142	.051	.193
Northeast	.104	.039	.143
Prairie	.013	.031	.044
	78.668	19.496	98.164
Illinois, local	.081	1.755	1.836
Total	78.749	21.251	100.

Several important points are emphasized by these figures. Hardwoods, which in 1910 supplied more than half of the raw material for the wood-using industries of Illinois and in 1920 about one fifth, must evidently continue to be secured, if at all, from eastern sources. The central hardwood region, or states contiguous to Illinois on the east, south, and west, supply but one fifth of the hardwood lumber used. One third continues to come from the Lake states notwithstanding the fact that two of these states, Minnesota and Michigan, are now importing a large per cent of their total consumption of lumber (Michigan imports 70 per cent of her lumber for all purposes). Nearly 40 per cent is obtained from the South. In each of these general regions the supplies of virgin timber from which these shipments are being drawn are dwindling rapidly.

Hardwoods usually grow on the better types of soil in these states, which, when cleared, are of potential value for agriculture. There exists in the Lake states a certain residue of poor soils which might grow hardwoods, but, on the whole, the poorer grades of soil in these states are suited to the production of conifers and will not grow commercial hardwoods. This is also true of the hardwood lands of the Southern states. Here the hardwoods occupy river bottoms almost exclusively, areas of alluvial land subject to occasional floods, most of which, like the Mississippi bottoms in Illinois or those of the Cache River, are capable of drainage and agricultural development. The poorer uplands are occupied largely by pine. With the completion of cutting by present opera-

tors, this 40 per cent of hardwoods will cease to be a factor in Illinois industry.

When these facts are realized, the significance of the local supply of hardwoods is emphasized. Illinois will never produce conifers, or softwoods, on a large scale, for the reason that both soil and climate favor hardwoods instead, and wherever such conditions exist, hardwoods are capable of crowding out conifers in natural competition. In spite of the great drafts upon local supplies for round products, which absorbed 91.27 per cent of all hardwoods produced, the remainder, or 8.73 per cent, which was sawed into lumber and used in the state, supplied 8.26 per cent, or one twelfth of the present consumption of hardwood lumber, from forests which, on the whole, have not only received no care or protection, but which have been exposed to the ravages of uncontrolled fires since the advent of the white settler a century ago. If capable of conversion entirely into lumber, the Illinois production of hardwoods would have supplied almost the entire quantity of hardwood lumber consumed. As will be shown, the area of land in the state unsuited to agriculture is for the most part well adapted to the production of hardwood timber of fair or even of superior quality. The state thus possesses unique natural advantages within its own borders for producing the raw materials most needed by its wood-working industries. It is obvious that Illinois must depend on importations for its softwood lumber. But it is *equally certain* that an adequate permanent future supply of hardwood lumber from outside sources may not be forthcoming.

Softwoods, or lumber from cone-bearing trees, forming approximately 79 per cent of the total consumption, furnishes all but about 10 per cent of wood used for structural material or building, and in 1920 supplied two thirds of that consumed in the wood-using industries. How large a factor these supplies of softwood timber are in the prosperity and progress of the state can be realized by a rough appraisal of its value, which at an estimated price of $50.00 per thousand board feet would amount annually, for conifers, or softwoods, alone, to about $93,000,000.

In the decades from 1850 down to 1900, by far the greater proportion of this lumber came from the pineries of Michigan, Wisconsin, and Minnesota. Only when these supplies began to wane could southern pine compete in the Chicago market with the lake shipments of white pine or even rail rates from Minnesota. Meanwhile the magnificent forests of the Pacific coast, unexcelled in quality and stand per acre but restricted in area as compared with southern yellow pine, struggled

against the handicap of heavy freight rates over distances more than twice as great, and entered the market only by virtue of better grades and light weights.

During the present decade these conditions are again changing rapidly, and for the first time western lumber is entering the market on a large scale in direct competition with southern shipments. The proportion now stands, Southern states, 54.38 per cent of all conifers; Western states, 32.78 per cent, or nearly one third of the total; Lake states, 11.43 per cent, and all other sources 1.41 per cent.

The cut of southern pine is already past its maximum. Another decade will see the position of southern and western supplies reversed, with the Lake states still nearer complete exhaustion. The effect of this process is best brought out by an analysis of the comparative cost of freight on this lumber from the different regions to Chicago. Whenever it becomes necessary to secure the major portion of the lumber for Illinois from Washington and Oregon, not only will the freight charges on this lumber for these distances, which are over 2,000 miles, be added to the price of the western lumber, but the same differential or margin may be added to all other lumber of similar grade shipped from near-by points or from the South.

The regions producing softwoods and hardwoods may be combined and grouped into four general ones: Southern, Western, Lake states, and Central (including Illinois and the Northeast). The supply furnished by these respectively is shown in the following table.

Region	M. Ft. B. M.	Per cent of total	Per cent of lumber shipped into state
Southern, including North Carolina group	1,201,361	51.04	51.99
Western	608,397	25.85	26.33
Lake states	383,811	16.31	16.61
Central, including Illinois and Northeastern group	160,093	6.80	5.07
	2,353,662	100.	100.

FREIGHT CHARGES

An exact determination of the freight charges incurred on lumber from outside the state is impossible, but by computing the approximate average weight of lumber per thousand feet, board measure, and, from freight rates, the rate per thousand feet board measure by regions, these

charges may be ascertained with accuracy sufficient for the purpose of this study.

The table following gives these average weights and freight charges and the total for each region by states.

FREIGHT CHARGES ON LUMBER SHIPPED INTO ILLINOIS IN 1920

Group	Quantity shipped M. Ft. B. M.	Average weight per M. Ft. B. M. lbs.	Average cost per M. Ft. B. M.	Total freight charges
Southern	1,196,797	2,980	$12.414	$14,857,452
North Pacific ...	437,206	2,716	19.028	8,319,179
Lake states.....	383,811	3,123	5.407	2,075,398
North Rockies....	115,968	2,461	16.572	1,921,786
Central	112,487	3,666	11.26	1,266,442
California	42,924	2,440	17.32	743,443
South Rockies ...	12,299	2,398	10.85	133,489
North Carolina Pine	4,564	3,610	16.838	76,850
Northeast	3,365	2,852	13.99	47,076
Kansas	1,032	3,033	9.40	9,700
Total	2,310,453	Av. 2,949.1	Av. 12.746	$29,450,815

The rates used and resultant charges per M. Ft. B. M. are shown in the table following.

FREIGHT BY RATES AND WEIGHTS OF LUMBER FROM SELECTED POINTS IN EACH STATE. 1920 RATES

States	Mileage basis used	Rate per 100 lbs.*	Freight per M. Ft. B. M.	Total cost of freight
Louisiana	1,149	.44	$13.11	$5,755,080
Mississippi	828	.40	11.92	2,796,551
Arkansas	670	.385	11.47	2,331,770
Texas	1,056	.44	13.11	2,099,173
Alabama	784	.41	12.22	1,035,522
Florida	1,028	(.39)	11.62	476,733
Oklahoma	740	(.335)	9.98	199,130
Georgia	881	.39	11.62	163,493
Average weight per M. ft. B. M.	2,980 lbs.	Av. rate 12.41	.....	14,857,452
Washington	2,325	.73	19.82	6,133,120
Oregon	2,291	.72	17.11	2,186,059
Average weight per M. ft. B. M.	2,716 lbs.	Av. rate 19.03	.....	8,319,179
Wisconsin	263	.14	4.37	847,937
Minnesota	608	.205	6.40	698,457
Michigan	310	(.21)	6.56	529,004
Average weight per M. ft. B. M.	3,123 lbs.	Av. rate 5.41	.....	2,075,398
Idaho	1,737	(.685)	16.85	1,314,266
Montana	1,578	(.65)	16.00	607,520
Average weight per M. ft. B. M.	2,461 lbs.	Av. rate 16.67	.....	1,921,786
Missouri	527	.29	10.63	471,929
Tennessee	527	.36	13.20	515,182
Kentucky	388	.31(?)	11.36	168,048
Indiana	193	(.175)	6.41	65,798
West Virginia	534	.31	11.36	45,485
Average weight per M. ft. B. M.	3,666 lbs.	.....	Av. 11.26	1,266,442
California	1,981	.71	17.32	743,443
Average weight per M. ft. B. M.	2,440 lbs.	.....	.....	.....
Arizona	1,717	(.45)	10.79	128,451
Colorado	1,174	.535	12.82	4,948
Average weight per M. ft. B. M.	2,398 lbs.	.....	Av. 10.85	133,489
North Carolina	1,059	.49	17.69	40,138
South Carolina	1,036	.47	16.97	24,962
Virginia	809	.395	14.26	11,750
Average weight, per M. ft. B. M.	3,610 lbs.	.....	Av. 16.83	76,850
New Hampshire	1,258	(.475)	13.54	41,026
Pennsylvania	620	(.365)	10.41	2,061
Maine	1,355	(.475)	13.54	650
Average weight, per M. ft. B. M.	2,850 lbs.	.....	Av. 13.99	43,737
Kansas	.....	(.31?)	9.40	9,700
Average weight per M. ft. B. M.	3,033 lbs.			
			Total	$29,447,476

Rates in parentheses are for 1923; the rest for 1920.

The total freight bill may now be compared by regions with the shipments of lumber from the same regions.

Region	Total freight bill (dollars)	Per cent by regions	Per cent of shipments by regions
Southern	14,934,302	50.71	51.99
Western	11,117,897	37.75	26.33
Lake states	2,075,398	7.05	16.61
Central and East.	1,319,879	4.48	5.07
	29,447,476		

	Average freight rate per M. ft. B. M.	Average weight per M. ft. B. M. lbs.	Freight rates per 100 lbs. cents
Southern	12.43	2,980	41.70
Western	18.27	2,641	69.18
Lake states	5.40	3,123	17.29
Central and East.	11.29	3,637	31.04
Average, weighted	12.80	2,950	43.38

	Rate in per cent of average rate	Rate in per cent of Lake states rate
Southern	96.12	241.17
Western	159.47	400.12
Lake states	39.85	100.00
Central and East.	71.55	179.52

These figures reveal the influence of freight charges in increasing the price of lumber to Illinois consumers. A shift of the center of production to the South added $7.03 per thousand board feet in freight alone, to the cost of all lumber from that section. The further shift to the far west increased the freight bill by $12.87 over the Lake states and by $5.84 over the southern shipments. These discrepancies become greater when weight and not volume is compared, for the average western shipments are 339 lbs. lighter per thousand feet board measure than those from the South, 482 lbs. lighter than Lake states shipments, which include hardwoods, and 996 lbs. lighter than shipments from the central hardwood region, in which hardwoods predominate. Comparing the average rates per 100 lbs., it is seen that the shipments from the Lake states can be brought to Chicago for 40 per cent of the average cost of freight by all-rail shipments, a fact which in itself indicates that the great and now largely devastated pineries of these states form the natural economic unit for supplying Illinois with softwood lumber in

the future. Again, it is seen that already the average freight rate on all lumber, by weight, has risen above that from the Southern states, due to the 60 per cent greater cost and the increasing quantity of western lumber. Finally, the southern freight rates are seen to average nearly two and a half times those from the Lake states, while the western freights reach four times the Lake states rates. At present, these western freight rates are fixed partly to meet southern competition. The rate per mile on 100 lbs. of lumber for the different regions is shown below.

Region	Aver. haul, miles	Aver. freight rate per 100 lbs. (cents)	Aver. rate per mile of haul on 100 lbs. (cents)
Southern	952	41.70	.0438
Western	2,158	69.18	.0321
Lake states	371	17.29	.0466
Central and East.	496	31.04	.0625

Thus the present rate on western lumber per 100 lbs. for one mile is but 73 per cent of that from the South. If raised to an equal rate, the cost of freight from the West would be increased 26 per cent over present rates. This will probably not occur, since long hauls are given a proportional reduction in rates over shorter hauls on account of equality of terminal charges. But with southern pine eliminated, the tendency will be for the railroads to secure an upward readjustment of freight rates on western lumber, the only other restraining influence being water transportation.

That the freight bill on lumber, now close to $30,000,000, will steadily increase by the substitution of western for southern and Lake states lumber is inevitable. With this increase, the consumer will have to pay proportionately more for his lumber than this increase indicates, since basic costs delivered become the basis for computing retail expense and profit. But the greatest danger lies in the fact that by the law of marginal costs, the prices of southern and Lake states softwood lumber will ultimately be determined by that of the Pacific coast shipments, and this freight charge will be added, not merely to these western shipments but to the entire remaining supply. The deduction can be drawn—since southern pine lumber can be produced in reasonable quantities to replace the vanishing present supply and can be laid down at 60 per cent of the cost of western lumber—that, next to the Lake states, the South should eventually furnish the larger part of the needed

lumber to Illinois in the more or less distant future. Pacific coast timber can be shipped by water to the Atlantic seaboard at less cost than to Chicago by rail.

The percentage of shipments from the far west will rapidly increase as the eastern region declines, and in the decades of 1930-1960 this region must supply by far the larger portion of the quantity used, at steadily increasing prices. This condition will make it more and more profitable to grow timber as a crop in regions located nearer the consumer and with lower freight charges. Because permanently prevented by her climate and soils from ever producing an appreciably large per cent of softwood lumber, Illinois has a direct economic interest in the proper management of these great pine regions to the north and south, and her citizens should emphasize this fact on every possible occasion. Meanwhile the state, by a vigorous forest policy, may succeed in producing within her borders a substantial proportion of the hardwoods needed in many lines of industry.

Retail Prices for Lumber in Illinois

No exhaustive study was made of the retail prices of lumber in Illinois, but the effect of the exhaustion of the Lake states pineries, and later of the increasing scarcity of eastern timber and shifting of the center of production towards the far west, can be seen by exhibiting the average prices by years of a few standard grades of lumber for the past few decades. These are given for the decades up to 1900, and for each year since that date, to exhibit the course of lumber prices during the war and their subsequent stabilization at a level considerably higher than before.

Retail Prices, Chicago Market, 1850 to 1919, Inclusive

Northern White Pine, Common Boards

Year	Price per M. ft.	Year	Price per M. ft.
1850	$ 9.75	1908	$31.50
1860	9.57	1909	31.00
1870	10.92*	1910	30.75
1880	12.00	1911	31.00
1890	13.17	1912	31.25
1900	18.81	1913	33.80
1901	19.25	1914	33.00
1902	21.25	1915	33.67
1903	21.86	1916	35.50
1904	23 17	1917	45 75
1905	25.67	1918	55.75
1906	30 00	1919	61.60
1907	33.50		

* Gold.

*Southern Yellow Pine—Finish, S2S**

Year	Price per M. ft.	Year	Price per M. ft.
1900	$33.80	1912	$ 40.00
1901	30.62½	1913	45.60
1902	34.50	1914	40.33
1903	35.00	1915	39.00
1904	33.86	1916	40.50
1905	38.83	1917	51.54
1906	41.50	1918	64.17
1907	39.50	1919	89.91
1908	38.18	1920	143.94
1909	37.73	1921	80.00
1910	37.33	1922	94.17
1911	37.33		

* Surfaced on 2 sides.

Northern White Pine—Clear Boards (Rough)

Year	Price per M. ft.	Year	Price per M. ft.
1850	$17.00	1909	$90.00
1860	26.45	1910	91.25
1870†	39.57‡	1911	92.00
1880†	43.50	1912	92.00
1890	43.17	1913	97.00
1900	57.53	1914	97.33⅓
1901	60.53	1916	99.50
1902	77.00	1917	116.87½
1903	85.00	1918	129.00
1904	84.33⅓	1919	151.83⅓
1905	84.00	1920	225.00
1906	90.00	1921	225.00
1907	94.37½	1922	230.00
1908	90.62½		

† Data from "Industrial Chicago," Vol. V, p. 194, by George W. Hotchkiss.
‡ Converted from currency to gold basis.

Southern Yellow Pine

No. 2 Common Boards S1S or S2S 4" and 6"*

Year	Price per M. ft.	Year	Price per M. ft.
1902	$19.33	1913	$25 44
1903	20.00	1914	23.47
1904	20.00	1915	24.73
1905	21.66	1916	26.40
1906	25.00	1917	33.98
1907	23.44	1918	44.35
1908	20.51	1919	53.57
1909	20.88	1920	67.73
1910	19.95	1921	38.20
1911	21.20	1922	42.10
1912	23.45		

* Surfaced on 2 sides.

Douglas Fir No. 1 Common 2 × 4; 16'

Year	Price per M. ft.	Year	Price per M. ft.
1905	$22.00	1919	$53.57
1910	23.00	1920	67.73
1915	24.73	1921	38.20
1918	44.35	1922	42.10

Oak, Clear, Quarter-sawed White 2¼"

Year	Price per M. ft.	Year	Price per M. ft.
1900	$ 66.00	1919	$190.00
1910	83.00	1920	360.00
1915	92.00	1921	182.00
1918	113.00	1922	165.00

Oak, Plain-sawed White 2¼"

Year	Price per M. ft.	Year	Price per M. ft.
1910	$ 57.00	1920	$260.00
1915	63.00	1921	137.00
1918	80.00	1922	125.00
1919	138.00		

Chicago prices for mixed lumber up to 1910 were:

Year	Price per M. ft.	Year	Price per M. ft.
1860	$ 8.26	1890	$15.16
1870	10.95*	1900	14.04
1880	12.70	1910	24.49

* Gold.

SUMMARY CONCERNING PROPORTION OF WOOD PRODUCTION TO WOOD CONSUMPTION IN ILLINOIS AND CONCLUSIONS THEREFROM

Referring to the table on page 52 we see that the wood-lots of the state have depreciated until at the present time two thirds of their entire yield is fire-wood only, which supplies farmers with one fourth of their fuel, so that for this inferior purpose alone the output would supply but half the quantity burned; and a ready substitute exists in the form of coal. The veneer industry, especially for low-grade materials used for fruit packages, can not afford to import logs from long distances hence it imports less than 40 per cent of its logs, and the local supply is rapidly disappearing. About sixty per cent of the post and mine material, which can be filled by products of small sizes, is still obtained from local timber but with increasing difficulty, while the supply of cross-ties has dropped to about 15 per cent of consumption. In the case of lumber, but 2.4 per cent is produced locally, although of hardwoods the state supplies 8 per cent of the consumption. This means that trees of

larger sizes are becoming increasingly scarce. The total consumption of wood of all kinds including fire-wood is five times the rate of production, and when fire-wood is excluded, only one twelfth of the wood products consumed annually are grown within the state.

Two conclusions may be drawn form this summary. First, it is evident that as a state Illinois can continue to obtain twelve times as much wood as is produced from her own woodlands only so long as other states consume less than they produce, for when the surplus in the exporting states is used up, the remaining wood will tend to stay at home and be manufactured near the source of production. The state will continue to secure a portion of this wood, by paying sufficiently high prices to draw it away from competitors in spite of the advantage of freight differentials, but as it costs less to ship manufactured products than logs or lumber, these wood importations will be largely of high-grade lumber as long as such may be obtained. It is equally evident that this great excess of consumption of lumber over actual rate of home production is a purely temporary condition made possible by a store of original growth which by this process is being depleted and destroyed. When there is no wood remaining, wood must cease to be used. The consumption of wood in the country at large will probably within 50 years drop perforce to a point which no longer exceeds growth, and will then be 100 per cent of production. Unless imported from foreign countries, America will be producing as much wood as it consumes. How much that will be will depend upon the success of the efforts put forth to grow wood on forest lands. Already many Illinois industries are feeling the pinch of scarcity and must either migrate, substitute other materials for wood, or discontinue. The state and its population can not afford to neglect its 5 million acres of potential woodland. Not only can this area be made to produce from 250,000,000 to 400,000,000 cubic feet of wood, or from one half to two thirds the total present consumption, but by better management the percentage of the more valuable products can be greatly increased, reducing the percentage of cordwood proportionately, and relegating it largely to the salvage of waste in tops and slabs. With this conservation of her potential forest resources, the state will receive tremendous benefits in all lines of industry through the increased or maintained prosperity flowing from the forest industries and production.

The Forests of Illinois, Original and Present

THE ORIGINAL FORESTS

The pioneers who were to settle in this region, viewing for the first time extensive natural prairies, were so impressed that they named Illinois the prairie state. Yet it appears that over 40 per cent of the state was originally wooded.

Estimates made by early explorers, and later tentatively confirmed by the State Soil Survey, indicated that this forest area was about one third of the state. A map prepared from the reports of the Soil Survey reveals the original distribution of this timber. The southern counties were all heavily timbered. These timber areas extended northward along all the streams, diminishing in quantity and area as the land became more level and true prairie more abundant. An extensive belt of woods followed the Mississippi and the Illinois rivers, and in the northwestern counties woodland again increased in area.

By carefully checking existing records it has been concluded that the original area of woodland in the state was larger than these previous estimates have indicated, being approximately 15,588,965 acres, or 43.46 per cent of the total of 35,867,520 acres of land in Illinois.

The manner in which these forest areas have thus been reconstructed brings out points of considerable interest. In conducting the intensive work of soil-mapping, the Illinois Soil Survey found that a very sharp distinction existed between prairie soils and forest soils in the amount of humus content. The soils which had been continuously in prairie, under a heavy sod of grasses, contained about twice the per cent of humus that was found in soils of similar origin and structure, but which had continuously borne forest-cover. This difference was caused by the effects of the grass roots, which filled the upper layers of the soil with vegetable matter and excluded air, favoring the accumulation of humus, while, by contrast, tree roots in decaying admitted air and were oxidized, while most of the tree litter was burned, or oxidized, on the surface.

The balance between forest and prairie seems to have remained fairly constant over a considerable period and to have been determined by two factors, topography and soil being one, and fire the other. Wherever the surface was broken or hilly, as along streams, tree vegetation became established, aided by soils which contained coarser materials, while on the flat, poorly drained prairie the soil was a black loam, of a fine texture which is less favorable for tree growth even in planted groves than for farm crops. Trees might and probably would have invaded the prairies

in spite of these handicaps of soil and drainage had it not been for fires in the grass, which must have burned at frequent, perhaps annual, intervals. The prevailing winds are southwest. Almost without exception, the map of forest soils shows that the strips of timber along streams were considerably wider on the north or east banks than on the south or west. The fires on the exposed banks confined the timbers closely to the stream, while this stream-barrier permitted the forest to creep out in the lee of the protection thus afforded. While clearing has over wide areas removed all traces of the original forests, the record of its previous existence is thus imbedded in the character of the soil itself, and the reliability of the classification thus indicated has been abundantly proved in areas where the evidence still remained in the form of stumps, or remnants of the forest itself.

Based upon these soil classifications, the Soil Survey states that in 44 counties for which records are completed, a total of 6,105,032 acres was originally forested. A map showing the gross areas of these forested soils for all counties indicates that approximately 50 per cent of the state might have originally had timber cover. But there exist many smaller areas of prairie soils within these districts. For the 44 counties above mentioned, it was found that the area of forest soils as shown by the map was apparently 7,016,223 acres, thus indicating that but 85.73 per cent of the apparent forest area was actually forested, or 6,105,032 acres.

For the entire state, a gross area of 17,838,971 acres of original forest soils was indicated by this soil map. Applying the same reduction per cent to this figure, the resulting net area originally forested was indicated as 15,293,349 acres, or 42.64 per cent of the state. This rough check was then confirmed in another manner.

The forty-four counties on which the Soil Survey figures were based are distributed as follows:

In the sixty-one counties lying in the north half of the state thirty-two were covered and twenty-nine omitted. In the forty-one counties making up the more heavily wooded southern half, twelve were covered and twenty-nine omitted. It is these southern counties, whose weight is thus considerably lessened, which raise the total of wooded area above the one third, which applied more correctly to the remainder of the state than to the whole. A separate computation of these two groups of counties gave areas originally wooded as follows:

Northern group, 61 counties

From map, 32 counties.....	4,665,049	acres
Actually compiled	3,928,101	
Difference ..... or 15.797 per cent	736,948	
From map, 61 counties.....	8,656,683.	
15.797 per cent.....	1,367,496	
Net area forested.....	7,289,187	

Southern group, 41 counties

From map, 12 counties.....	2,308,838	
Actually compiled	2,086,931	
Difference ..... or 9.611 per cent	221,907	
From map, 41 counties.....	9,182,288	
9.611 per cent.....	882,510	
Net area forested.....	8,299,778	
Total for state, area forested...	15,588,965	acres

These original forests showed an unusual variety of species. The gums, cypress, and similar subtropical trees grew in southern Illinois, while tamarack, arbor vitae, and associated sub-arctic species could be found occasionally in the northern part of the state. Between these extreme zones grew the wealth of hardwoods dominantly oak in character which reached their culmination for this continent in the lower Ohio and Wabash valleys. This hardwood forest varied, for different sections of the state, in species composing the stand and in the forms of trees. Thus in the southern uplands the forests were continuous and show a greater variety of species as well as a generally better growth for similar species than in the northern upland stands. These southern forests were noted for the high quality of the timber which they contained. In the northern uplands the trees grew in open park-like formations, thinning in the advance toward the prairie to the fire-scarred and gnarled outposts. There is evidence that the forests were constantly endeavoring to encroach upon the prairie, but that annual fires generating an intense heat in the abundant grass-cover burned back the tree seedlings and served as a check upon the advance of the forest. The pioneers describe the old forests of the prairie counties as being stands of grove-like aspect bordering streams and thinning rapidly as the prairie was approached. Toward the margin, the forest floor was carpeted with a dense growth of seedling sprouts growing between the scattered old trees. These seedling sprouts were killed annually by the fires. The forests in the lower Ohio

and Wabash basins were the finest hardwood stands in America. Those of the southern uplands were excellent in character. The forests in the valley of the larger streams of the central and northern parts of the state were but slightly inferior to those of the Wabash-Ohio basin. Those of the smaller streams near the prairies were open and park-like.

Several local variations are worthy of mention. While dominantly hardwood in character, yet conifers were found in the original forests. Cypress extended up the Ohio and Wabash rivers and along the lower Mississippi for several miles. Probably the best stands of cypress were found in the Cache River basin, where it grew pure or mixed with tupelo gum. One small grove of shortleaf pine occurs on the dry slopes of the westernmost bluff of Union county and another group occurs in a sandstone ravine in southeastern Randolph county. White pine grew along the river bluffs in several regions north of the Illinois River, the southernmost outpost being on a bluff of the Spoon River in Knox county. The red cedar was found generally throughout the state on the drier bluffs.

Throughout the state may still be found small remnants of these original forests. Studies made in the best of these are tabulated below. The average yields for the original virgin stands for the respective regions of the state were lower than those shown for the limited areas measured.

DATA OBTAINED FROM STUDIES MADE IN THE BEST ORIGINAL FORESTS OF ILLINOIS

I. Cypress bottom, Cache River. Based on strip line of 3.94 acres

Species	Cypress	Soft maple	Carolina poplar	Elm	Ash	Hickory	Hackberry	Total
No. of trees per acre D. B. H. 6″ and up	70	3.3	12.7	2	2	.5	1	91.5
B. F. yield per acre	13121	291	141	50	12	9	7	13931
Max. D. B. H., inches	30	29	20	17	15	10	12	
Max. height, ft.	100	80	70	60	80	60	50	

II. Ozark uplands, agricultural soil, Union county. Based on ½ acre plot

Species	Wh. oak	B. oak	Tulip	Hickory	B. gum	B. walnut	Sassafras	Total
No. of trees per acre D. B. H. 6″ and up	10	12	8	6	2	2	4	44
B. F. yield per acre	1836	4460	5480	286	270	210		12542
Max. D. B. H., inches	25	31	27	13	13	15	14	
Max. height, ft.	90	100	100	65	60	65	40	

III. Little Wabash basin*, White county. Based on 3.03 acres

Species	Wh. oak	B. oak	Sw. gum	Bl. gum	Hick-ory	Elm	Sassa-fras	H. lo-cust	Ash	Bl. Wal.	Total
No. of trees per acre D. B. H. 6″ and up	15.5	4.3	10.2	3.3	11.2	3.6	1.3	.3	2.3	1.0	53.0
B. F. yield per acre	15503	2529	5643	188	2334	100		230	493	63	27083
Max. D. B. H., inches	40	36	34	16	32	15	14	22	22	17	
Max. height, ft.	130	120	125	70	120	90	80	125	110	70	

IV. Kaskaskia bottoms, Randolph county. Based on 1 acre

Species	Wh. oak	Pin oak	Hickory	Hack-berry	Ash	Elm	Total
No. of trees per acre D. B. H. 6″ and up	3	14	10	2	5	11	45
B. F. yield per acre	423	9680	3880	10	545	1736	16274
Max. D. B. H., inches	22	39	25	9	20	32	147
Max. height, ft.	90	105	100	40	90	80	505

V. Upland, McDonough county. Based on 4 acres

Species	Wh. oak	Bl. oak	Hick-ory	Cherry	Elm	Bl. Wal-nut	Bass-wood	Total
No. of trees per acre D. B. H. 6″ and up	26.25	12.5	8.75	1	5.75	2	.75	57
B. F. yield per acre	3977	947	271	59	346	110	50	5760
Max. D. B. H., inches	30	22	17	15	18	16	18	
Max. height, ft.	80	80	70	60	70	60	70	

For a thousand tree-generations these forests held the land. The Mound-builders followed the dim trails and vanished. The later Indians altered them less than the beetles. In the hundred years that the French held the settlements the forests were as when the Mound-builders found them. Then entered the white settler, and in one tree-generation the forest areas were reduced from 15,588,965 acres to 2,863,764 acres of woodland, or but 18 per cent of the former area, largely cut over. Of the stands of virgin forest there survives a mere remnant.

The pioneers coming from the east and from Kentucky, where the very habits of living were moulded by association with the forest, knew the value of the woodland. Experience had taught them that the finest hardwoods grew on the most fertile soils and led them to think that areas naturally devoid of trees were barrens. So coming upon the great expanse of Illinois prairie they sought out the forested bottoms for home sites. Even had the pioneer appreciated the superior agricultural value of the prairies he could not have settled there at that time. He had not yet emerged from the period of incessant frontier warfare and the forests often concealed his home. Nor was he familiar with the walled-in well,

* For figures on individual trees of original forest see "Additional Notes on the Native Trees of the Lower Wabash Valley", Robert Ridgway. (Proc. U. S. Nat'l Mus., Vol. 17, 1894, pp. 409-421.)

and so sought out a site near a running spring. The forests were the only source of fuel and building material and he was ill-equipped to haul heavy loads over great distances. The prairies were swept by intensely hot fires, the winter winds found nothing to break their bleak force, and innumerable malarial mosquitoes bred in stagnant pools. For several years prairie land could be bought for five dollars, while forested land sold for thirty-five dollars an acre.

Thus we find the flow of settlers in the early decades of the past century at first a mere seepage creeping over the heavily forested areas of the southern part of the state, skirting the prairie, extending back up the rivers, ever following river and forest, held from the prairie until about 1830. The tide of immigration became ever greater, crept out from the margin of the woods in the early thirties, and suddenly flooded the prairies in the late thirties. In 1830 the prairies had scarcely been touched by settlement. By 1840 less than one twenty-fifth remained unsettled. This last frontier was not the rough forest land, but parts of Ford, Iroquois, and Champaign counties.

Settlement in Illinois in its effect upon the forests but repeated the conditions of the older-settled states. The loamy bottomlands and best soils were cleared. Generally the logs were heaped and burned. The rougher slopes and poorer soils remained in forest. Although for the most part destructive in his attitude toward forests, yet throughout the uplands in the central and northern parts of the state, it happened that probably for the first time in the nation's history the pioneer unwittingly improved these forests. When in the thirties the prairie sod was broken, forest fires were checked. The seedling sprouts which sprang up yearly after the fires, now developed into a thick stand of saplings. The demands of the region for fuel and building material resulted in cutting the older inferior overwood. Free from shade the saplings quickly developed into a dense even-aged stand and even encroached upon the prairie where not checked by the plow.

The settlement of the prairie increased the value of the limited wooded parts of the prairie counties. Settlers would not buy prairie land unless several acres of woodland were included. This frequently resulted in the wood-lot, which supplied the fuel and building material, being several miles from the farm.

Two events ocurring about 1860 reversed the relative values of prairie land and forest land for the prairie regions. The railroads came to the farms, bringing building material and coal. The base-burner coal

stove was patented and added comfort to the life of the prairie farmer. From this date forward the forests did not greatly increase in value, but prairie land began its climb towards $250 per acre. Thus the timber-land owner was under a pressure to clear wherever tillage was possible, and this has been the trend to the present day.

Present Forested Areas and their Relation to Land Economics in the State

The figures given for the present wooded area in Illinois are as yet tentative, pending the completion of the forest survey now being conducted. They are based upon data gathered in 33 counties north and west of the Illinois River and 13 counties in the southern part of the state.

Those areas of woodland more than 5 acres in extent were mapped and their totals found by counties. Two other sources of information were available as checks. The 1920 census reported farm woodland by counties, and in 1922 crop reports were made showing farm woodland. The forest survey included all woodlands, the census and crop surveys included only woodland on farms. It was shown by comparison that the census returns were about 36 per cent higher for timber on farms than actually shown by survey for total timber. The crop reports were less than two per cent higher than the survey. In computing the total timber on farms the nature of the ownership of the timber-lands was taken into consideration. If the county had large areas of timbered bottomland, was evidently a county where mine-company holdings were important, or for any reason contained considerable bodies of timber-land not on farms, the crop report figures were ordinarily used to compute the area of woodland on farms. If the timber-land was entirely on farms the survey figures were used. To get the total timber for the state the survey figures were used where complete, and crop-report figures where the survey has not yet been completed.

The preliminary result gives:

Areas of woodland on farms	2,668,050
Area of woodland not on farms	195,714
Total area of woodland in state	2,863,764

This total is 92.3 per cent of the area shown by the census of 1920 as contained in farm woodlands alone, and when the 195,714 acres above indicated as not included in farms is added to the census figures, this

total, based on actual mapped areas supplemented by crop report data, falls to 86.8 per cent of the census figures. If the original forested area of the state was 15,588,965 acres, this indicates that 82 per cent of the forest lands has been actually cleared and is either under crops, or pasture, or is classed as waste or eroded land, and has ceased to be forest or woodland.

The changes wrought in this remaining one sixth of the state's woodlands by lumbering, fire, and grazing have steadily reduced the stand of timber in both volume per acre and number of trees, and if continued unchecked must finally result in an almost complete ruin of this residual area for forest production by natural processes.

Classification of Timber by Regions

The wooded regions of Illinois can be divided, first, into bottomland and upland, with a further classification of each of these based on the prevailing soils and species. The regional classes might be arranged for the state as follows:

I. BOTTOMLAND

a. Southern cypress.—This extends from Wabash county south along the Wabash, Ohio, and Mississippi bottoms to McClure, in Alexander county, and is found also in the Cache River bottoms. Mixed with the cypress are such species as sweet gum, silver maple, elm, willow, ash, cottonwood, and Carolina poplar. In the Mississippi bottoms and in the Cache River bottoms, in addition to these species is found tupelo gum.

b. Mixed hardwood.—This extends from the northern range of cypress along the flood-plains of the principal rivers, Mississippi, Illinois, Kaskaskia, Wabash, and the lower reaches of the Little Wabash and the Embarras. It is characterized by a great diversity of species and shows the best growth rates and yields of any type in the state. It is composed of such trees as the gums, sycamore, ash, hickory, pecan, elm, cottonwood, silver maple, and pin, swamp-white, burr, white, Schneck's and overcup oaks, in the south; with white, swamp-white, burr, pin, and shingle oaks, elm, hickory, ash, soft maple, river birch, hackberry, sycamore, and cottonwood in the central and northern sections of the state.

c. Gray clay bottoms of the Big Muddy, Saline, upper Little Wabash and upper Embarras. Pin, shingle, swamp-white, white, and post oaks and ash, elm, hickory, and sweet gum are typical trees.

d. Alluvial strips along the secondary streams throughout the state. Soils are mixed loams and fertile. Basswood is a common tree in the northern region and black walnut grows freely.

e. Sand-plains and dunes.—These are found along the middle Illinois River in Mason county, southern Whiteside, and western Lee, Henderson, Kankakee, Grundy, and Iroquois counties. While found on and near bottoms they yet may have a desert vegetation. Black-jack oak *(Quercus marilandica)* is found on the poorer sites, with black oak, hickory, and white oak on the better ones. The types *d* and *e* are really intermediate between bottomland and upland types.

UPLAND

a. Ozark upland.—This is upland south of the limit of ice invasion, extending from southern Jackson county through southern Williamson, Saline, Pope, and Gallatin counties. Characterized by beech, hard maple, red, black, white, and shingle oaks, hickories, tulip-poplar, ash, red gum and black, elm, wild black cherry, black walnut, and cucumber-tree.

b. Loessial uplands bordering the Mississippi, Illinois, and Wabash river flood-plains. In the south, along the Mississippi and Wabash rivers, are found all species common to the Ozark upland and, in localities, considerable basswood in addition.

c. Gray silt loam uplands of the Illinois glaciation, in the interior of the state extending from the Ozark uplands north to the Wisconsin moraine and black soil belt. Characterized by post, black, shingle, white, and pin oaks and hickory.

d. Yellow silt loam uplands of central and northern Illinois. Characterized by a good growth of black, white, and burr oak, and hickory, with black walnut and black cherry on the better and scrub oak on the poorest soils.

The tamarack swamps of Lake county, the white pine of Ogle county, and the shortleaf pine in Union, Jackson, and Randolph counties are of ecological interest but are not important timber types.

Included in these forest areas at present are stands of every size and all ages from saplings to over-mature virgin stands. In general the bottomland stands throughout the state show a greater diversity of species than the upland stands and are not usually even-aged. Again, in uplands of the southern part of the state, removal by species or by occasional larger trees has resulted in stands of uneven age. In the

northern part of the state the upland stands are usually even-aged and from sixty to eighty years old.

The original forests probably averaged 8,000 B. F. per acre. The present forests for the entire state average approximately 1,435 B. F. to the acre. The better stands of upland even-aged immature timber of the northern part of the state run from 3,000 to 6,000 B. F. per acre. Trees below 16 inches are numerous; above that size, very few.

The all-aged upland forests of the southern part of the state have been overcut and not enough trees remain to insure maximum yields. The bottomland stands throughout the state vary within greater limits as to yield and representation of species, but probably show a higher average than the uplands. The final class of forested lands which are worthy of consideration are the sands supporting black-jack oak and the gray clays supporting post oak. Yields of such stands are very low and seldom produce any materials other than fuel, posts, and mine props.

SAMPLE STANDS AND YIELDS—UPLAND

I. Even-aged immature fully stocked stand, age 85 years. McHenry county
Based on strip line of 7.6 acres

Species	White oak	Black oak	Hickory	Cherry	Total
No. of trees per acre D. B. H. 6" and up	19.5	50.4	6.8	1.3	78.0
B. F. yield per acre	522	1836	83	26	2467
Maximum D. B. H. inches	21	20	13	13	
Max. height, ft.	70	70	60	60	

II. Even-aged immature fully stocked stand, age 71 years. Whiteside county
Based on 1 acre

Species	White oak	Black oak	Cherry	Elm	Hickory	Total
No. of trees per acre D B. H. 6" and up	69.0	18.0	2	13	9	111
B. F. yield per acre	5667	900	132	633	150	7482
Maximum D. B. H. inches	21	17	17	21	15	
Max. height, ft.	70	70	60	60	60	

III. Even-aged immature fully stocked stand, age 90 years. St. Clair county
Based on 1 acre

Species	White oak	Black oak	Totals
No. of trees per acre D. B. H. 6" and up	70	60	130
B. F. yield per acre	4482	6770	11252
Max. D. B. H., inches	17	23	
Max. height, ft.	71	80	

IV. Even-aged immature fully stocked stand, age 62 years. Knox county
Based on 1.06 acres

Species	White oak	Black oak	Hickory	Ash	Totals
No. of trees per acre D. B. H. 6" and up	62.3	91.5	5.66	1	160.46
B. F. yield per acre	1052	4770	170	8	6000
Max. D. B. H., inches	19	21	13	7	
Max. height, ft.	70	71	50	50	

V. All-aged stand. Ozark uplands. (Average based on 182.3 acres)

Species	White oak.	Black oak	Beech	Hickory	Tulip	B. Gum	Maple	Ash	Misc.	Total
Trees per acre D. B. H. 6" and up	17.4	28.8	8.8	11.92	2.53	2.14	1.39	1.25	2.51	76.74
Bd. ft. yield	465	603	404	316	114	100	103	37	86	2228
Max. D. B. H.	34"	30"	32"	26"	26"	27"	31"	21"		
Max. ht. ft.	100'	90'	100'	100'	60'	60'	60'	60'		

The original stands have been altered by cutting, fires, and grazing. In the southern part of the state the stands were first cut over for choice yellow poplar, black walnut, and white oak. Later, other species were harvested, but the tendency has been to remove the valuable species from the stand, leaving the less valuable, defective, and diseased trees. This in itself increased the proportion of undesirable trees. These latter species then became the seed-producers of the forest, and the succeeding stands contain a higher per cent of undesirables. Along with this, periodic burning in this region has kept out all but the most fire-resistant reproduction. This combination of causes was unfavorable to restocking by the more valuable species. Recently the markets have

absorbed practically all species down to comparatively small diameter limits. Consequently in cutting-practices very few trees of any kind are left. The opening up of the stand to light, results in a stimulation of weed-growth and the periodic burnings prevent the establishment of a second crop. This fire damage is an especially serious factor in the strip of forested bluffs bordering the Mississippi plain from southern Randolph county south to central Alexander county and in parts of the uplands of Gallatin, Saline, Pope, and Hardin counties. These areas should produce much more timber than is now being grown.

The forests of the south-central part of the state from Carbondale to Pana, roughly representing the extent of the Illinoisian glacial deposit, are a reflection of the extremely poor soils which characterize this region. Post oak is the prevailing species on the poorest soils, a very limby black oak and hickory come in on the better soils, with white and black oak on the better-drained slopes. Along the stream bottoms very good timber is produced, but the general type of growth for the uplands is poor. Fires are not common, grazing is not practiced, and the stands are well stocked, even frequently overstocked, but tree growth is very slow. As one approaches the Wabash on the east or the Mississippi and Illinois rivers on the west the tight gray clay soils are modified by sands and loess, tree growth is better, and a wider range of species is found. In these latter regions fires are not common nor is grazing of the woodland the rule.

The stands of the uplands from about Pana north, or roughly corresponding to the Wisconsin glacial area, show a tendency toward an even-aged type of from 60 to 80 years of age. Where not grazed they are generally well stocked and thrifty; but grazing wood-lots is the common practice throughout this area, resulting first in the formation of a sod, and ultimately in the conversion from a wood-lot to a treeless pasture.

The bottomlands of the central and northern parts of the state are largely cleared. Where forests persist they are uneven-aged, heavily stocked with saplings and large defective trees, and have evidently produced excellent timber.

The history of Illinois forests thus parallels that of other states to the east, south, and north, where in the pioneer era, enormous energy was expended in hewing farms out of the forests. The great advantage which Illinois possessed in having nearly 60 per cent of her area already bare of trees and this on the most fertile soils, released that much

more energy for forest clearing, and by subdividing the forests into wood-lots and distributing it among numerous owners, insured the rapid diminution of area which has occurred.

The interplay of the three tendencies to decrease our cultivated land, increase other unimproved land than forest on farms, and reduce decidedly our farm woodland area during the decade of 1910 to 1920 is forcibly shown in the following tables easily deduced from the agricultural statistics for Illinois from the U. S. Bureau of Census.

a. Decrease in area of land under cultivation:

Year	Acres of improved land	Per cent of total land area of the state	In other classes
1910.....	28,048,323	78.20	21.8
1920.....	27,294,533	76.098	23.092
Decrease	753,790 acres or 2.7%		

b. Increase in area of other unimproved or waste land on farms:

Year	Unimproved land, acres	Per cent of total land area of state	Per cent of forest area
1910.....	1,326,735	3.69	42.1
1920.....	1,577,663	4.4	56.2
Increase	250,928 acres 18.9%		

c. Decrease in area of woodland on farms:

Year	
1910.....	3,147,879 acres
1920.....	3,102,579
Decrease	45,300 acres or 1.4%; rate of clearing, 4530 acres per year.

Out of a total land area in Illinois of 35,867,520 acres, about 31,974,775 acres, or 89.1 per cent, is in farms. The ownership of the 8,572,987 acres of untilled land in the state may be shown as follows:

Classification of land not tilled

	Acres	Per cent of total area of state
Included in farms.....	4,680,242	13.04%
Not so included.....	3,892,745	10.05%
Total	8,572,987	23.09%

A study of these figures shows that the area of improved land in farms in the state reached its highest point of 28,048,323 acres in 1910

and that in the last decade it has decreased 2.7 per cent. The waste land on farms has increased 250,928 acres or 18.9 per cent, while our forest area has shrunk 45,300 acres in the last ten years, or at the rate of 4,530 acres per year.

These figures have added significance when taken with those from adjoining states, which indicate that the tide of pioneer effort in land-clearing is on the ebb, and that at least for the present in all states of the eastern wooded area, more land is being abandoned than is being brought under cultivation annually. Even in a state as fertile, and with so large a proportion of its surface arable, as Illinois, a large residue of land is found which has never been cleared because it was unfit for agriculture, and another large acreage has been cleared which after trial has evidently proved to be of such low agricultural value that its use for crop production has been abandoned as unprofitable.

The amount of land unsuited to ordinary farming because of its hilly character, which makes the soil subject to erosion when cleared and renders its cultivation unprofitable in comparison with more level and fertile areas, has been the subject of careful investigation by the State Soil Survey. January 4, 1917, Professor J. G. Mosier summed up the conclusions reached by that department in the following letter:

UNIVERSITY OF ILLINOIS

AGRICULTURAL EXPERIMENT STATION

URBANA, ILLINOIS, *January 4, 1917.*

DR. S. A. FORBES,
University of Illinois.

DEAR DOCTOR FORBES: In reply to your inquiry concerning the amount of hilly land in the state not suited for ordinary farming, will say that the area of such land covers approximately 17 per cent of the state, or 6,000,000 acres. This large area is very irregularly distributed, but is principally along the larger streams, as the Rock River, Mississippi, Illinois, Sangamon, and some minor ones.

The Ozark Ridge in southern Illinois gives rise to a large area of very hilly land. All of this was originally forested, but since it has been cleared, much of it has eroded so badly that profitable crops can not be grown any longer, and much of it is being abandoned or used for pasture.

In the seven southern counties, approximately 55 per cent of the area is of this kind. In the counties bordering the Mississippi, approximately one-third is too hilly to be farmed successfully, while along the Illinois to La Salle, probably 25 per cent of the counties are made up of this land.

As to the distribution of this soil; in Johnson county it constitutes 67 per cent of the area and is made up of the two types, yellow silt loam and stony loam. Edwards county contains about 24 per cent and is composed of the types, yellow silt loam, yellow fine sandy silt loam, and yellow sandy loam. Cumberland county is considered a level county, and yet 10 per cent of its area is too hilly to farm successfully. This land comprises the yellow silt loam and yellow sandy loam.

The only use that can be made of this land is for pasture or forest. In many places it is left in permanent pasture. There is little doubt, however, but that if this could be re-forested it would become a source of permanent income to the owner. The abandoned land is growing up to persimmon, sassafras, and some other forms that are of little value from the forestry standpoint.

Very truly yours,

(Signed) J. G. Mosier.

In July, 1923, the areas of land of hilly and broken character, or so-called eroded lands, were given for 44 counties by Professor R. S. Smith, Assistant Professor of Soil Physics in the College of Agriculture, as 2,004,860 acres, or 11.8 per cent of the total area of these counties. These are the same counties on which the per cent of forest lands was based. The area of these 44 counties was 16,934,240 acres, or 47.21 per cent of the land area of the state. If this proportion held good, the area of eroded lands for the state would be 4,232,367 acres. But the southern half of the state containing 41 counties included but 12 of the 44 counties measured, and so is not weighted properly. Correcting this average by weighting these two sections, gives a total of hilly or so-called eroded land of 4,810,149 acres.

Eroded land as described by the Soil Survey is land the original surface of which has been washed away, leaving as a rule what is known as yellow silt loam as the present surface, although the erosion sometimes reaches deeper to other subsoils. Such land is commonly subject to still further erosion which may in time injure it severely, but it is not now necessarily unfit for general agriculture. It is impossible to state with any certainty the absolute area within the state which is better fitted for the growing of forest crops than for tillage, improved pasturage, or orchards, since this will vary with economic conditions as well as with soil quality and physical drawbacks. Not all of the so-called eroded land is unsuited to agriculture; on the other hand there are some areas of sandy land, or of tight clay soils, and some bottomlands subject to overflow which it will not pay to drain. To these could be added a considerable acreage in the aggregate representing wood-lots, plantations, windbreaks, and hedgerows, on better soils. The total area in Illinois which is or could be forested is probably equivalent to 4,810,149 acres, or 13.41 per cent of the state.

What condition is this area in at present? It is probable that all but a very small fraction of the remaining woodlands of 2,863,764 acres, amounting to 7.98 per cent of the state's surface, are included in this acreage. This leaves 1,946,385 acres as the approximate area which has been cleared for either agriculture or pasturage, or has been used

for hillside orchards. Subtracting the area of 1,577,663 acres listed by the Census as waste lands, leaves a possible net acreage in productive use other than either woodland or agricultural crops, of 368,722 acres.

Since no attempt has been made to segregate the timber-covered areas of land which will ultimately be cleared for agriculture, though the total has been deducted from or charged against the area of hilly, non-agricultural land, it is probable that in the form of groves and plantations, or wood-lots fully as large an area of the more level lands in the state will be retained in timber voluntarily as will be needed for pasturage or orcharding on the non-agricultural soils or steep hillsides. Of the 368,722 acres of soil not accounted for by woodland or by waste land in farms, a certain per cent must fall in the area not included in farms.

The existence of a very considerable area of land actually abandoned or waste, equal to 55.1 per cent of the total existing woodlands in the entire state, and not classified by the owners as pasture lands, indicates that whatever may be the ultimate division of use of non-agricultural lands between pasture and forests, the present forest area may be increased one half without taking an acre from any existing use. The soils of many of these hilly areas are easily eroded. This is especially true of the yellow fine sandy silt loam, yellow silt loam, and yellow sandy loam types in the southern counties, though examples of advanced erosion are not lacking elsewhere as set forth by Bulletin 207* of the State Agricultural Experiment Station. These hilly areas constitute the larger percentages of the non-agricultural or absolute forest soils of the state.

Two other classes of soil are found, which under certain conditions should be in forest. The first is wet lands which are infertile when drained, or which can not be drained successfully. In this class come many islands in the Mississippi River, and areas not protected by levees. Other tracts may be found, of which certain lands along the Big Muddy River in Jackson and Union counties are examples, where the soil is a tight clay which does not repay the expense of drainage. The total area of undrained bottomland is steadily diminishing and in time will become a negligible quantity, while the fertility of such soils and the drainage taxes which they must pay in organized districts force their improvement and cultivation at the earliest possible moment. Many stands of young timber of rapid growth may yet develop on some of the least desirable

* University of Illinois, Agricultural Experiment Station, Bulletin 207. "Washing of Soils and Methods of Prevention", by J. G. Mosier and A. F. Gustafson, Urbana, Illinois, April, 1918.

of these areas before the time when they are finally cleared for cultivation.

The second type of soil on which forests may be grown is sand. In several areas, of which examples may be found in Whiteside, Lee, Mason, and Kankakee counties, soils of a very sandy character occur, sometimes taking the form of dunes. In Mason county, success has been attained with alfalfa on much of this soil. A great many plantations of black locust have been made, few of which have done well. Cottonwood makes good development on these sands. There is great possibility that various conifers may make profitable crops on such sands. The state should vigorously undertake experimental work in reforesting typical areas of all soil types whose agricultural value is questionable.

The Production of Wood on Illinois Farms; the Actual Number and Total Acreage of Farm Wood-lots; the Average Area of Wood-lots for the Farms having them and for the State

The economic importance of the wood-lot on Illinois farms depends upon the total area in farm wood-lots and the number of owners, from which can easily be ascertained the average area of wood-lot per farm and for the farms of the state. It is to be expected that in a state where 43.46 per cent of the original area was forested, including practically all of the more hilly and eroded sections and poorer soils, the farms which were carved out of these woodlands would still retain forested areas perhaps more or less denuded of merchantable timber, but not yet converted into cleared pasture or tilled fields.

As to the first item, the preliminary figures of the State Natural History Survey indicate that the total farm-woodland area of the state is 2,668,050 acres. But the number of farms actually having woodlands is not easily ascertained. The United States Bureau of Census does not give this information, although it does collect figures on the total acreage of farm woodlands in the various states. The number of Illinois farms reporting merchantable timber through the Census for 1919 was but 20,051, which indicated a reluctance to report timber of taxable value, and a condition of depletion or over-cutting which has reduced the majority of woodlands to brush areas or young saplings.

Again, forest products of some sort were reported to the Bureau of Census as being sold from 37,874 farms in the year 1919; but it is improbable that this represents the entire number owning wood-lots. Even

if every wood-lot had merchantable timber that could be sold every year, not all of the owners would have the time to cut and market it. The most common product of the wood-lot is fire wood for home consumption, but only 13.63 per cent of farmers who cut wood sell it to others, while only 7.34 per cent of wood-lot owners cut cross-ties for sale. Lumber is largely cut on the farms for home use, though in most instances when this occurs some surplus is sold. The number of wood-lot owners cutting lumber, according to data based on farm woodland questionnaires, was only 60.66 per cent. Fence posts were produced on 86 per cent of the wood-lots, but largely for home consumption. All of this goes to show that the number of farmers reporting wood-lot products for sale is not a reliable index of the total number of owners, but that the number is very much greater than 37,874.

The number of farms having wood-lots may be based on the amount of wood fuel burned on the average farm, which was found to be 16.1 cords. The farmer who produced cordwood, according to the farm woodland questionnaries, cut an average of .332 cords per acre annually, which for 2,863,764 acres of woodland in the state would make a total production of 950,770 cords. Farmers own 93.166 per cent of this woodland, and on this basis would produce 885,792 cords of fuel wood per year, which at 16.1 cords per year would supply 55,018 farms with fuel. Since the number of wood-lot owners producing their own fuel annually was 87.36 per cent, this gives the number of wood-lot owners as 62,978, which is about twice the number of those selling forest products from the farm. This gives an average area per wood-lot of 42.36 acres, and an average area of woodland for all farms of 11.25 acres.

A calculation based upon forest survey figures for certain counties where they have been completed, supplemented by crop-report returns from county assessors, shows a total of 2,668,050 acres of woodland on farms owned by 98,307 farmers. This would give an average wood-lot area of 27.14 acres per farm, or for all the farms of the state one of 11.239 acres, and for each person living on farms one of 2.44 acres.

It has been shown that to supply the wood consumption of the state requires the product of from one to two acres per person, depending upon the fertility of the soil and the skill of the owner in forest production. This area of 2.44 acres per person on farms indicates that the woodland owner can, if he desires, supply the entire needs of the farming population of the state for wood in the future but that little or no surplus would be left for the remaining industries or population. By

simply supplying their own needs, farmers owning woodland could sell two thirds of the products, either to other farmers or to other industries. Since the marketing of products will follow the natural economic trend, farmers who do not own wood-lots will suffer from lack of adequate timber supplies as keenly as any other class of the population.

WOOD AS A CROP

The enterprise of producing wood as a crop for Illinois land is subject to the same physical and economic conditions as govern the growing of agricultural crops, fruits, or live stock.

The profits to be derived from wood production depend upon the price of the products on the market, the continued demand for these products, the cost of harvesting and marketing the crop, and, finally, upon the productiveness of the crops themselves compared with the cost incident to growing them.

Wood as a crop requires the practically exclusive use of land for a long period of years. In theory, land devoted to wood crops should remain in woodlands. The devotion of land to this crop, therefore, means its withdrawal from agricultural production, just as the clearing of woodlands means the withdrawal of land from wood production. When woodland is cleared for farming, the expense of the operation is often heavy enough to absorb all the revenue derived from the crop of timber which is cut at the time, thus reducing the value of the woodland as such to zero, but putting it in condition to realize presumably higher values for farm crop production.

Since both agricultural and horticultural crops require a very high proportion of labor annually to grow, harvest, and market them, and the amount of this labor is for the most part determined not by the abundance of the crop but by the area which it occupies—especially for field crops, it follows that with successively poorer grades of soil, or with lessened productiveness or increased costs per acre, a point is soon reached where the costs absorb all the income and the use of such lands for food crops leads to progressive impoverishment of the soil and of the owner, resulting in ultimate abandonment.

By contrast, in forest crop production the cost of labor and annual cultivation is reduced to a remarkably low point. Natural processes need only to be successfully initiated by the establishment of the crop and its later protection from destructive agencies and the stand develops with a minimum of attention. This great reduction of cash outlay and labor costs permits the use for wood crops of practically every acre of

land which is too poor to yield profits in food production, and this use for forest crops promises to yield a profit or large return over and above the actual outlay in cash or labor, a return running into hundreds, even thousands per cent.

Against this certainty of large economic returns in yields of wood there are two obstacles which diminish the financial profits to owners of forest lands, namely, the cost of marketing the crop and the time required to produce it. Since the value of wood is determined, for any owner of woodlands in any given region, by the market prices which wood products command at the nearest point of delivery, his profits are limited by this price less the cost of getting the wood to the market. But often the initial form of the product, such as logs, must undergo further manufacture, or the product is bought by jobbers or middlemen who endeavor to keep down the price to the producer. Still more frequently it happens that the purchaser buys the standing timber at a lump sum and the owner fails to realize the value of his stumpage.

Again, wood in any form is both a bulky and heavy product. A cubic foot of green hickory weighs 42 pounds; one of oak, 35 pounds or more. A cord weighs between 3100 and 3750 pounds. Transportation costs are based largely on weight, and to stand a long train-haul from the forest to the market the price per cubic foot or per pound must show a margin over this cost, plus costs of labor in cutting, shaping and loading, freight, remanufacture, and wholesale and retail delivery. As all of the above processes constitute well-organized businesses which will operate only on the basis of securing a living profit, the owner of timber stumpage, even if he receives a fair price, gets what is left after these demands are satisfied, and this margin may be too small to defray any costs incidental to crop production. This partly explains the phenomena of cheap stumpage values and low returns which even now are manifest in regions which have an excess of woodland over farm land, or are located far from markets.

But the same economic processes which have operated to keep down values of timber as a crop in the past, bid fair greatly to increase these values in the future, provided sufficient wood is produced to maintain the customs of its use in major industries, and to prevent the too complete substitution of other materials for wood.

Prices for wood have increased more rapidly than for other products, and more rapidly than costs of labor and transportation. This leads directly to an increase in the margin left for stumpage values, and

this margin has increased, on the average, at a more rapid rate than the prices for finished products. As products become scarcer, the factor of competition becomes more active, and the producer stands a better chance of receiving his fair share of the final market value. This process raises the value of wood crops on all areas regardless of their location. It makes possible a profit or stumpage value on hitherto inaccessible tracts, but the chief advantage is to the owner of woodland located near markets, and whose costs of marketing are comparatively low.

If this is the situation with timber as a crop grown for sale, the value of such crops grown for home consumption is still further enhanced. Every farmer is a large consumer of wood crops, as will be shown later. With no home product he is forced to buy wood at the highest retail price, paying all the costs and profits exacted in the course of transportation for long distances, and rehandling by dealers. To the extent that he can supply his own needs, the only costs to him are those of labor and contract-sawing, and those incident to growing the crop. It is the purpose of this investigation to determine the value of such wood crops to the farmer as a consumer, as well as a producer for the market.

In the selection of the species of trees to grow, the woodland owner is largely influenced by the condition already established by natural processes on his woodland. Trees show fully as great an adaptation to environment as any other plant association, and from the first settlement of this country the character of the forest growth has been relied upon to indicate that of the soil itself. In practically all the eastern states, the dearth of tree-vegetation indicated impoverished soil. Until the nature of prairie soil became known, early settlers avoided it for this reason. It is a safe maxim that unless proved otherwise by experience, the best trees to grow on a given site are the species which naturally grew there in the virgin forests, and that trees, such as catalpa, found in nature only on rich well-drained soils, will not produce satisfactory forest crops if introduced on a poorer or drier site.

Again, trees inured to unfavorable conditions, like the pines, may grow very rapidly on better soils, but will fail to reproduce naturally in competition with the species found on such habitats.

Wood crops, as to species of trees grown and quality produced, are, therefore, less adjustable or less easily modified than food crops. Once the choice is made it must be followed through to maturity. Often this choice is already determined, as in well-established forests. Aside from

these features the producer has several advantages. He can often choose between different kinds of product into which he can convert his timber. He can postpone harvesting his crop in times of depression and put it on the market when prices are high. He can produce different quantities of products of different classes by postponing or withholding harvesting of a portion of his stand, or selected trees. In addition, he can greatly modify or increase the value of his crop by selection of species for harvesting, taking out the more worthless for fire wood and reserving the more valuable for higher uses. When creating a new forest by planting he can exercise choice of species, just as a farmer can decide as to what he shall plant, and, like the farmer, his success will depend on his ability to select the crop which is adapted to the soil and site, and not merely on his skill in planting trees or potatoes.

The relative productiveness of different forest soils can be judged by the volume measured in cubic feet of wood produced annually. To obtain this figure is not an easy process unless the wood crop on the area is all of the same age, otherwise it can not be known whether the amount cut from the lot represents the growth of a definite period or is merely the accumulation of an indefinite number of years. Again, wood crops must be measured for volume production when they have attained a reasonable maturity, else the average annual production is not fairly realized. Potato crops, measured when half grown, do not show full production. But all field crops reach definite ripeness while with woods crops this period is comparative only, and the measurement of many different stands is necessary to determine the approximate period of highest average annual crop-yields, and those of greatest production of money income.

This study will be undertaken in Illinois during the years 1924 and 1925. Meanwhile preliminary figures show that an acre of soil grown to hardwoods will produce annually from 16 to 160 cubic feet of wood. The production of wood, as may be expected, is in direct ratio to the fertility of the site. This is illustrated by the following samples.

Extremely dry sandy hills may yield less hardwoods per acre than the lowest yields which are recorded. If planted to suitable conifers, the apparent yields may be doubled, yet when weight is considered may not exceed greatly that of hardwoods. The maximum yields on any site can only be secured by the growing of species best adapted to this site and to the condition of the land at the time. When land is bare

PLOT YIELDS (ONE ACRE EACH)

Plot location	Species	Age years	Cubic feet contents	Mean annual growth cu. ft.	Weight produced per year in pounds
1. Prairie, agricultural	Catalpa	15	2430	162	4350
2. Alluvial bottom ...	Maple, ash, elm, sycamore	37	5361	144	4595
3. Prairie, agricultural	European larch..	52	5792	111	3414
4. Alluvial bottom....	Sycamore, burr oak	30	3087	103	2994
5. Prairie	Black walnut....	50	4965	99.3	3777
6. Upper Miss. bottoms	Maple, elm, pin oak, others ...	25	2119	85	2185
7. Hilly upland.....	White pine	75	6383	85	1929
8. Alluvial bottom....	Pin oak, black oak, red gum, ash, others	25	1800	72	2451
9. Hardwood bottom..	White oak, cherry, hickory, others.	25	1456	58.0	2049
10. Prairie	Black walnut.....	63	3427	54.4	2069
11. Upland, hilly.....	White oak, black oak, others.....	71	2991	42	1561
12. Sands	Black oak, others	70	2660	38	1365
13. Upland, thin rocky..	White oak, black oak, hickory...	85	1376	16.2	604

or cleared it is often possible to start with a rapidly growing species that would not succeed in competition with well-established natural vegetation.

The indicated yields in pounds per acre on different classes of soils compare favorably with the yields of agricultural crops.

Prices per pound for wood crops may be based on an average weight of 35 lbs. per cubic foot for comparison. Taking average prices received, as given by replies to the questionnaire, these were:

	Decimals of 1 cent per lb.	Ratio of value of fuel wood
Veneer logs	.92	5.1
Posts	.85	4.7
Piling	.657	3.65
Lumber	.62	3.4
Cross-ties	.54	3.0
Mine timbers	.43	2.4
Fuel wood	.18	1.0
Cooperage	.62	3.4

Owing to the fact that a large percentage of the forest crop may be composed of the cheaper grades of wood, such as cordwood, the average price per cubic foot may fall considerably below that for the highest

products. On the average farm wood-lot it was found that the proportion of the various classes of product obtained were as follows:

	Per cent	Proportion of average price
Fuel wood	65.68	.118
Mine timbers	10.33	.044
Posts	7.44	.063
Lumber	8.19	.051
Cross-ties	3.75	.020
Veneer logs	3.51	.032
Piling	.78	.005
Cooperage stock*	.32	.002
Weighted average price per lb.	.....	.335

It is thus seen that the crop from the farm wood-lot averages 0.335 cents per pound. This price is due to the large proportion of low-priced fuel wood. This price is equivalent to $6.70 per ton while the more valuable products bring prices of over $18.00 per ton. The average crop per acre now being harvested is 1415 pounds or about ¾ of a ton, worth $4.74, or a crop value of nearly $5.00 per acre annually.

These comparatively low prices per pound as compared with concentrated food crops are offset by a much lower cost of actual outlay per pound in the production of the timber crop so that the net profit over cash expenses greatly increases the favorable position of this crop in land economy.

The chief objections urged against actually undertaking to grow timber as a crop are based, not so much on the yields per acre or prices which are possible as on the crop-period or time required, which for private enterprise is often regarded as prohibitive, and which results in the accumulation of interest deemed necessary to return a given per cent on the investment, and of taxes at compound interest.

For farmers who own wood-lots there are several strong arguments offsetting these factors. In the first place, the wood-lot, unless already badly cut over or nearly ruined by grazing, is often if not usually in position to sustain an annual production approaching the full possible yield of the land in wood crops. It is a going business and, if managed as such, incurs no compound interest charges since each year's expense is met by income from cuttings. This is the ideal condition to maintain, and is exemplified by many wood-lots carefully preserved and cared for, in the southern portion of the state, which continue to yield quantities of high-grade lumber, posts, and other products.

*Cooperage stock taken as of same value as lumber.

In the second place, it is not necessary to wait 30 to 80 years for yields from a wood-lot. The intensive use to which a farmer can put the small material enables him by thinnings to obtain fuel, stakes, fence posts, and other small-sized material in not over 15 years; even within 8 to 10 years when plantations are made on bare soil, and these returns carry the investment until the more valuable material is ready for cutting, and pay the taxes.

The question of taxes is one which requires legislation or change in practice. But in small wood-lots taxes are not the factor which will either encourage or prevent the practice of forestry to any great extent, for the reason that ordinarily the taxes on this land would be about the same whether or not forest crops were grown, and the crop offers a means to pay these taxes, while non-productive land does not. As between pasturing and forest crops, the question is one of relative net annual income to the farm as a whole as well as to the land so used. This will be discussed later. Forest land is usually classed as unimproved and as such bears a lesser valuation than improved land. Such a practice, of valuing forest lands lower than lands producing agricultural crops or orchards, is sound in theory and practice, since, as shown, forests are crops which can and should normally be grown on poorer soils unsuited to higher uses of food production, hence worth considerably less per acre than a good quality of agricultural land. When small quantities of high-grade agricultural lands are devoted to the production of special forest crops, such as hedge or catalpa posts, the values of the crops are or should be sufficiently high to bear the usual taxes on lands of this value.

One principle can be clearly laid down which will remove any injustice in taxation of forest property. Growing timber itself should not be taxed, but only the land upon which it grows. It is as sensible to tax growing crops of grain as to tax repeatedly the same crop of timber during its growth.

To determine whether the woodland property belonging to the farmers of the state is now producing crops which measure up to the possible yields of such lands, the returns from 440 wood-lots were tabulated. The table on page 134 gives the results obtained. In column 2 is indicated the area out of the total of 19,986 acres which yielded products of the designated kind within a period of 5 years for lumber, and 3 years for other products. Fuel is cut annually on most wood-lots, and a very high proportion amounting to 86 per cent still continue to yield fence posts for the annual upkeep of the farm. A significant figure is the

proportion of wood-lots yielding saw-timber, 60.66 per cent of those reported falling in this class.

This, however, is probably higher than would apply to all farm wood-lots, for a large proportion of them have been already stripped of the more valuable trees which produce sawlogs. Based on indications from total yields of saw-timber for the state, there are probably 30 per cent of the wood-lots which still contain crops of this class of timber.

PRODUCTION OF WOOD ON FARM WOOD-LOTS, TOTAL FROM 19,986 ACRES OF WOODLAND COVERED BY FARM QUESTIONNAIRE—440 ANSWERS

Class of material	Area cut over to obtain yield	Per cent of area of all wood-lots	Unit of measurements	Quantity	Yield per acre cut-over, units	Yield per acre of total area, units
Fuel wood ...	18,158	90.85	Cord	6.631	.365	.332
Lumber	12,124	60.66	Bd. Ft.	862,306	71.12	43.145
Fence posts ..	17,197	86.04	Post	75,210	4.37	3.763
Hedge posts ..	767	3.84	.....	.....	.....	.....
Cross-ties	1,467	7.34	Tie	9,591	6.54	.480
Mine timbers .	1,721	8.67	Cu. Ft.	61,144	35.5	3.059
Piling	335	1.68	Piece	1,069	3.19	.053

Included in fuel wood are sales of cordwood from 2134 acres, or 10.68 per cent of the area.

The production of wood on farms is not confined to wood-lots. Hedges yield considerable quantities of posts and fuel. Willows and other trees springing up along streams and on small corners or patches of rough ground are periodically cleaned out and used for fuel or even for posts, and the aggregate production of wood from these sources is sometimes sufficient to supply a considerable proportion of the fuel for the farm at least, and for the state must reach a considerable total.

In order to measure the actual yields of the wood crop and value the different products on a comparative basis, each product must be converted into cubic feet, to serve as a common standard. (For converting-factors, see Appendix, Note 8.)

On this basis, the yield in cubic feet from an acre of woodland as returned by owners, was as shown by the following table.

YIELD PER ACRE OF WOOD ON FARM WOOD-LOTS
BASED ON ANSWERS TO QUESTIONNAIRE

Character of products	Unit of measure	Quantity per acre	Converting factor per cubic foot	Yield per acre cubic feet
Fuel	Cord	.332	80	26.560
Lumber	Bd. Ft.	43.145	.16⅔	7.191
Posts	Post	3.763	.8	3.010
Cross-ties	Tie	.48	4.25	2.040
Mine timbers	Cu. Ft.	3.059	1.	3.059
Piling	Pile	.053	22.3	1.185
				43.045

If as shown on page 115, the total area in farm wood-lots is 2,668,050 acres, this area divided among the 237,181 farms of the state gives 11.239 acres of woodland per farm.

The yield per farm, or per average wood-lot, on this basis of wood material is given in the table on page 138.

In thus endeavoring to measure production of wood crops by merely recording the yields obtained on an average acre of a large total area of woodland from questionnaires sent to selected individual owners, two factors of error may be present. First, those responding may possess the better grades of woodland, or may have more recently sold or cut timber crops. This would tend to raise the indicated yields above the true average. Second, the amounts cut on given areas in given years, even when distributed over the total area of woodland involved, does not necessarily indicate what the *growth* was on these areas for the same period, or even their average annual production, since it may mean, rather, a mere removal or cutting into the accumulated capital of the wood-lot. The rate of cutting may exceed the annual average rate of growth, or be less than this growth. The owner may cut his crop clean and entirely replant or permit sprouts and seedlings to restock the area. The capital of a wood-lot is like a sum invested permanently whose interest only is to be expended. If in any period, less than the interest is used, the capital increases. Continual expenditure of more than the interest diminishes not only the capital but the annual income as well, and ultimately will dissipate the resource. But unlike money, this forest capital can only increase by means of the interest earned, or growth,

hence if "cut clean" or completely dissipated it takes many years to build it up again to its full productiveness.

The annual yield of these wood-lots as indicated by the farm questoinnaire was 43.045 cubic feet per acre. When we compare this yield with the data shown in Table on page 135, indicating the productiveness of different classes of soil, it is evident that average grades of forest soils will grow this much wood annually, hence it is possible to grow timber fast enough to maintain the present rate of cutting forever, and it may be possible to double it. But the probability is that, instead, this yield will continue to decrease. There are two reasons for this. First, the maintenance of an annual cut requires the reservation of a certain quantity of wood capital in the form of young trees partly grown. Depending on the products desired and the period required to produce them, the growing stock required may be roughly calculated by taking one half of the total growth or final yield of the crop. For example, if the yield is 40 cubic feet per year and can be harvested at 50 years, the crop yields 2000 cubic feet. Then 1000 cubic feet per acre is a normal forest capital; actually somewhat less than this quantity will suffice. But if the stock or capital is exhausted by clear-cutting for cordwood or mine timbers, it drops way below this required minimum, and when this happens it becomes impossible to maintain the same rate of yield until the gradual processes of growth have again built up the stock. This scarcity occurs first for the larger and more valuable products, such as saw-timber or veneer logs. The smaller the material harvested the sooner it can be replaced and the greater the probability of sustaining the yield. The second factor is far more serious, and consists of destroying the reproduction which would naturally take the place of the timber removed. When this happens for any cause, such as fire or excessive grazing, there is no hope of ever restoring the yield to its former volume until such cause is removed and the reproduction re-established, perhaps by expensive measures followed by the long wait for the new crop to mature.

The average acre of woodland in Illinois now contains but 635 cubic feet, which, for a low average yield of 43 cubic feet per year, would indicate that this yield can be maintained only on the basis of cutting the material at an age of 30 years. This period is insufficient to produce saw-timber or even cross-ties and will yield only posts, mine timbers, and cordwood. Either the future yields of Illinois wood-lots will be confined to these products after the residue of the larger trees

remaining has been cut, or else the cut must actually be reduced considerably below 43 cubic feet per acre in order to grow new crops of these more valuable products.

It is fair to assume, therefore, that the process of denudation or exhaustion of the average or normal forest capital has proceeded to the danger point, and that this annual cut of 43 cubic feet is not at present being replaced, but that the cut actually constitutes a further depletion of the remnant of forest capital, and may further reduce the yields and growth in the future. The steady diminution of the cut of saw-timber per decade in Illinois gives evidence of this tendency. Census figures give the following production for the state in timber.

Year	Board feet	Year	Board feet
1879	334,244,000	1909	170,181,000
1889*	218,938,000	1919	64,628,000
1899	381,584,000	1920	56,900,000

The percentage of sawed lumber to total output of wood has undoubtedly fallen off faster than the total production, since this material came from the older or virgin growth of timber of which there now remains but a fragment of the original stands. Some of the above output undoubtedly represents clearing of land for agriculture.

But as these figures of actual cut in cubic feet per acre are shown to agree closely, though accidentally, with the yields of wood crops possible on the poorer grades of land which can be termed forest soils, they will serve as an indication, not merely of the present money-yields from farm woodlands, but of the minimum net income which the continuous use of such lands for wood crops may be expected to produce without undue or unusual expense in crop production and by the same natural processes as have served to grow these crops in the past. Great improvement over these figures is possible in the way of increased yields and better money-returns through thinnings and improved prices.

These actual yields as reported on wood-lots were then compared with the total production of different classes of material for the state, in order to correct any error occasioned by departure of the replies from this average due to selection of better wood-lots. The figures on total production used for this basis are given in the table on page 138.

In applying these totals to the wood-lot areas it was assumed that these would produce fully as much per acre as the total woodlands of the state, given as 2,863,764 acres.

*See Appendix, Note 9.

In determining the average yield per acre of farm wood-lots it was considered more accurate to assume that when the total production of the given class of product for the state was known, that for the farm woodlands would bear the same proportion to this total as the woodlands themselves bore to the total forested area. This proportion is 93.166 per cent. The alternative of multiplying the results obtained from questionnaires representing 440 units of 19,986 acres, or 86/100 of 1 per cent of the farm woodlands was considered less reliable and in some instances was manifestly in error for the state as a whole. Production of cordwood and of fence posts was based upon this question-

PRODUCTION OF WOOD FROM ILLINOIS FARM-WOODLANDS OF 2,668,050 ACRES

Product and unit	Total for farm woodlands	Average per acre	Average per wood-lot of 27 acres
Fuel wood cords	885,792	.332	8.96
Mine timbers cubic feet	11,142,700	4.176	112.75
Posts piece	10,031,860	3.76	101.52
Lumber board feet	53,011,340	19.869	536.46
Cross-ties piece	952,050	.357	9.64
Veneer logs board feet	22,701,710	8.508	229.72
Piling piece	37,708	.0141	.38
Cooperage stock cubic feet	350,293	.131	3.54

QUANTITIES OF WOOD CUT ANNUALLY FROM FARM WOOD-LOTS

Product	Per acre cubic feet	On 11.239 acres cubic feet	On 27 acres cubic feet	Per cent of total
Cordwood	26.56	298.50	717.12	65.68
Mine timbers	4.176	46.93	112.75	10.33
Posts	3.008	33.81	81.22	7.44
Lumber	3.311	37.21	89.40	8.19
Cross-ties	1.517	17.05	40.96	3.75
Veneer logs	1.418	15.94	38.29	3.51
Piling	.314	3.53	8.48	.78
Cooperage stock	.131	1.47	3.54	.32
Total	40.435	454.44	1,091.76	100.00

naire, since state-wide figures on production were not available and for cordwood were open to question. It will be noted that while the yield from the questionnaire was 43.045 cubic feet per acre, that obtained from the check in total state production was 40.435 cubic feet, or nearly identical. But the average wood-lot yields a greater proportion of its output in the form of cordwood and mine timbers and less high-grade products, such as lumber, than did the selected lots, hence its net revenue will be lower.

The percentages shown in this table indicate that at present nearly two thirds of the wood produced by farmers goes into wood fuel, which is the cheapest product of the wood-lot. Eleven per cent is utilized as lumber or veneer logs and a little under 5 per cent as cross-ties, piling, or cooperage stock, while mining timbers absorb over 10 per cent and posts nearly 8 per cent, or a total of nearly 85 per cent in small sizes. Although these proportions clearly indicate that the wood-lot is not being worked to its capacity for crops of highest value, yet it must be pointed out that logs measuring less than 9 inches at the small end will yield less than 50 per cent of their contents as lumber. Even with full and close utilization the proportion utilized will be

Diameter at small end (inches)	Per cent utilized as lumber
9	50.7
8	47.7
7	44.8
6	39.5
5	34.4
4	23.8
3	10.5

A tree which will cut one log 9 inches at the small end inside the bark and 16 feet long will measure from 12 to 13 inches outside the bark at 4½ feet, or 13 to 15 inches on the stump. Hence it is not possible to convert a large percentage of a stand into sawlogs unless the timber has been allowed to reach an age of 70 to 80 years. Even where this age is attained it will follow that unless logs are cut to 5- and 4-inch tops a very large percentage of the stand will not make log timber and will probably be better utilized in the form of posts or mine timbers provided the resultant return per cubic foot is better.

Were all stands to be grown on a rotation capable of producing lumber it is probable that the yield of saw-timber might be raised to about 50 per cent of the total cubic contents, but not to much more than this. This would increase the output of sawlogs fourfold on the basis

of present production. But if the yield per acre were also increased by at least 50 per cent, which is easily possible, the capacity of the present farm woodland area would be at least six times the yield of lumber and logs now being cut within the state, and would then equal the total annual output of the virgin forests of the state during the decades of their highest production. It is improbable that this result will be attained from the existing woodlands because of the pressure for cutting at earlier ages and for bulky products, such as mine timbers or fuel. But the yield of saw-timber can at least be increased threefold by proper management and its percentage of the total crop doubled, so that one quarter of the cubic yield will be in this form, which bids fair to be the product most needed in future farm maintenance, and the most expensive to purchase.

Consumption of Wood on Illinois Farms

As stated on page 83, the three major forms in which wood is consumed on farms are fuel, posts, and lumber, amounting to 576 cubic feet per farm. An additional 7.33 cubic feet of wood is used annually on farms for shingles. (Appendix, page 171, Note 10.) But the farmer is also the ultimate consumer of much of the wood which enters into the construction of manufactured products, such as farm machinery, boxes and crating, furniture, paper and utensils of various kinds. The total consumption for such purposes in the state has been considered under manufacturing industries but it was not possible to compute the amounts consumed on farms. This consumption, however, must be charged to the farmer's account and added to the more obvious major forms of wood which he uses and which to a considerable extent he can produce in the wood-lot. A deduction should of course be made to the extent to which steel and cement are used as substitutes for wooden posts. But in spite of this reduction the actual consumption per farm will be somewhat greater than that shown in the table which follows.

Consumption of Wood on Farms Annually

Class of product and unit	Total consumed on farms	Average per farm	Average per farm, cubic feet
Fuel wood, cords	885,792	3.734	298.72
Lumber, bd. ft.	296,476,250	1,250.	208.33
Posts, pieces	20,534,690	86.578	69.26
			576.31

The balance between farm consumption and farm production of wood may be shown best by assuming that the existing woodlands averaging 27.14 acres each, on 98,307 farms, is equally distributed among the 237,181 farms of the state, giving each a wood-lot of 11.239 acres.

PRODUCTION PER AVERAGE FARM ON 11.239 ACRES OF WOODLAND

a. Products useful on farms

Product and unit	Quantity	Cubic feet
Fuel wood, cords	3.728	298.50
Lumber, bd. ft. (including veneer logs)	318.9	53.15
Posts, pieces	42.26	33.81
Total produced of these classes		385.46

b. Products not useful on farms

Product and unit	Quantity	Cut, cu. ft.
Mine timbers, cubic feet	46.93	46.93
Cross-ties, pieces	4.012	17.05
Piling, pieces	.158	3.53
Cooperage stock, cu. ft	1.47	1.47
Total not useful on farm		68.98
Total grown on farm		454.44

These values are derived from table on page 138 by multiplying the product of one acre of woodland by 11.239.

Thus the average farm wood-lot of 11.239 acres produces 25 per cent of the lumber, 49 per cent of the posts, and 26 per cent of the fuel used on the farm, which is a total of 385 cubic feet of wood or 67 per cent of the total wood requirements of the farm. In addition it produces for sale in the form of mine timbers, cross-ties, piling, and cooperage 69 cubic feet, bringing the total production to 454 cubic feet or 79 per cent of total consumption.

Offsetting this, the farmers secured from sources other than the farm wood-lots of the state 51 per cent of the wooden posts, 75 per cent of the lumber, and 74 per cent of the fuel used on farms.

The farmer who is actually harvesting products from his wood-lot consumes his own output in the following quantities: fuel wood, 85 per cent; lumber and veneer logs, 53 per cent; posts, 92 per cent. The amount which he sells forms a relatively small part of the total farm

consumption in the following percentages: fuel wood, 14 per cent; lumber and veneer logs, 12 per cent; posts, 4 per cent. The enforced purchase of a material capable of being produced on the farm wood-lot is a serious economic handicap to the farmers, which is becoming increasingly evident in the steadily advancing prices he must pay for wood or its substitutes. The value of this wood crop can be measured in two ways, first as a saleable product, second as taking the place of material which must otherwise be purchased. High prices lead inevitably to the curtailment of the use of both wood and its substitutes. Less fuel is burned; buildings in need of renewal are not renewed; and money which would appear as a profit is sunk in the cash outlays for upkeep.

The farmer who possesses an average wood-lot of 27 acres is cutting annually less fuel than the average farmer consumes in a year; if expressed in wood, 8.964 cords as against 14.6 cords consumed in the form of wood or coal.* In lumber and logs he produces 766.14 board feet as against 1250 board feet used. This will supply him with all his heavy timbers and fencing and all of his rough lumber, requiring the purchase of only the finishing grades. He produces 101 but requires only 86 fence posts annually. His total requirements including the exclusive use of wood fuel are 1990 cubic feet. He produces 926.03 cubic feet of these same classes of material representing, however, a surplus of posts, and a deficit of lumber and cordwood. To balance this required expenditure he produces for sale 165.73 cubic feet of mine timbers, crossties, piling, and cooperage stock. A 27-acre wood-lot in the average neglected condition of woodlands today supplies the farmer with 55 per cent of his wood consumption and if adequately managed the increased production and sale of merchantable products will make him permanently independent of outside markets for wood or wood substitutes, and relieve him of the cost of purchasing fuel, building material, and fencing for all time. If coal is substituted in the ratio of 7.66 tons to 13.4 cords of wood, shown as the average for those farms using wood and coal together, and the wood-lot managed for the production of larger percentages of higher grade material, the area may be further reduced to about 16.7 acres for the average farm. Under these circumstances there is in the present area of woodland enough productive capacity to supply two thirds of the farms of the state with wood forever.

*See Appendix, Note 11.

STUMPAGE PRICES IN ILLINOIS FOR SAW-TIMBER

From data gathered by the U. S. Forest Service in Illinois, Indiana, and Ohio, based on 14,102,000 board feet of logs, the average price received at the mill for hardwood logs was $24.92 per thousand board feet. Based on 26,537,000 board feet of logs, the average price received for hardwood stumpage was $12.86 per thousand board feet. This leaves a margin for cost plus profit in logging, of $12.06, agreeing closely with the results of the questionnaire, which indicated that average costs of logging plus 20 per cent profit was $12.32.

The returns from the Illinois questionnaire were not sufficiently numerous to indicate a safe average price of stumpage for saw-timber. This varied from an average of $19.86 for the higher grades of logs, to $5.22 for low-grade timber. This would indicate that the average of this much larger quantity, or $12.86, may be safely adopted as the average stumpage value of saw-timber for the years 1919 to 1922, in Illinois.

By species the yearly average figures show a wide variation, from a maximum of $85.00 per thousand for walnut in 1920 to a minimum of $3.29 for sycamore in 1922. Little reliance can be placed on these specific averages. Walnut commands the highest stumpage prices, followed by ash and hickory. Veneer logs of white oak command prices up to $25.00 per thousand board feet, while the poorer grades of oak lumber are sometimes sold at less than one half this price. The value of stumpage is residual or marginal and is thus dependent on the total of costs incurred to bring the logs to the market, as well as on the price received for these logs, or for the lumber, or products.

The receipts and stumpage values for saw-timber were slightly influenced by the demand for walnut during the war. This species constituted 13.07 per cent of the total reported sold, while census figures for 1919 show that 3,690,000 board feet was produced in the state, or 6.48 per cent of the total. The relative amount of walnut in the returns from farm questionnaires is, therefore, twice as great as the average per cent for this species in the total state output, and with its high stumpage value of $49.29 per thousand board feet tends to raise the average price of stumpage above the actual.

The average price of oak stumpage at $32.44 is undoubtedly higher than cash prices paid for such stumpage by purchasers, who have not often gone much above $25.00. But the greater portion of the lumber reported was cut by the owner and sawed in a customs sawmill. The owner thus realized both stumpage and 20 per cent profit, which, at the

average price of $53.07 for the lumber, netted him $32.44 stumpage and $3.42 profit on costs of logging.

This stumpage contained a considerable percentage of veneer logs of white oak, and to this extent represents a type of timber found only in the remnants of the virgin forest and not likely to be reproduced in the future. But other species, especially red and black oak, will furnish materials for timbers and other domestic use, which, while not bringing as high a price on the market, will serve as fully acceptable substitutes in framing buildings for which purchased lumber would cost approximately the same price as that received for the saw-timber sold. The sale of lumber at low prices is not justified where it can thus be used for local purposes. Returns of 6.46 per cent of the total quantity reported were for inferior species which brought a net price of $29.23 per thousand board feet, leaving but $8.70 stumpage value. 1920 Census figures give an average of all species for Illinois as $8.59.

The tendency for stumpage values to absorb an increasing per cent of final value of the product is well illustrated by the prices paid for walnut timber, which averaged $49.29 on the stump. So great is the demand for this lumber in certain lines of manufacture, especially furniture and gun-stocks, that buyers usually purchase it on the stump, and even buy and grub up large stumps if still sound in order to get the wood they contain in the crown and upper roots. Yet buyers are not averse to purchasing walnut groves at much less than these figures whenever the purchaser is in ignorance of the value of his stumpage and there is absence of local competition.

Wood-lots containing virgin white oak are now quite scarce in southern Illinois, and the entire region has been gone over thoroughly. A few owners are found who sell each year a small number of choice trees as logs, at satisfactory prices to net them an annual income from the wood-lot. But except for such species as walnut, which can continue to be grown in plantations, on good soil, the day of the large high-grade sawlog is about over for Illinois woodlands, and the saw-timber of the future will be obtained more largely from 12 to 14-inch trees than from those 20 to 25 inches in diameter. Such trees can be produced in shorter periods and will suffice to supply the needs of the farm in this direction. The sale values, costs of cutting and hauling, and stumpage values of the remaining products were derived from the averages of the replies

to the questionnaire to farmers. The resultant income derived from the average wood-lot is shown in the following tables.

SALE PRICE AND STUMPAGE VALUE OF PRODUCTS GROWN ON WOOD-LOTS

Product	Unit	Contents cubic feet	Sale value	Stumpage value
Fuel wood	Cord	80	$ 5.06	$ .92
Lumber	M. ft. B. M.	166⅔	35.97	12.86
Veneer logs	M. ft. B. M.	166⅔	53.61	33.10
Posts	Post	.8	.24	.136
Mine timbers	Cubic feet	1.	.15	.052
Cross-ties	Tie	4.25	.81	.323
Piling	Pile	22.3	5.12	3.15
Cooperage	Cubic feet	1.	.216	.216

VALUE, COSTS, AND NET STUMPAGE VALUE PER CUBIC FOOT FOR WOOD PRODUCTS ON ILLINOIS FARMS

Product	Sale value	Cost of logging	Profit of 20% on logging	Stumpage value plus profit on logging	Net stumpage value
Fuel wood	$.0633	$.0432	$.0086	$.0201	$.0115
Lumber	.2158	.1027	.0205	.1131	.0926
Veneer logs	.3217	.1027	.0205	.2190	.1985
Posts	.2962	.1050	.0210	.1912	.1702
Mine timbers	.1510	.0910	.0182	.0600	.0418
Cross-ties	.1899	.0948	.0189	.0951	.0762
Piling	.2296	.0778	.0156	.1518	.1362
Cooperage	.2158	.1027	.0205	.1131	.0926

VALUE OF PRODUCTS GROWN ANNUALLY ON 1 ACRE OF WOODLAND

Product	Sale value	Cost of logging	Profit of 20% on logging	Stumpage value plus profit on logging	Net stumpage value
Fuel wood	$1.681	$1.147	$.228	$.534	$.305
Lumber	.714	.340	.068	.374	.307
Veneer logs	.456	.146	.029	.311	.281
Posts	.891	.316	.063	.575	.512
Mine timbers	.631	.380	.076	.251	.175
Cross-ties	.288	.144	.029	.144	.116
Piling	.072	.024	.005	.048	.043
Cooperage	.028	.013	.003	.015	.012
Total	$4.761	2.510	.501	2.252	1.751

VALUE OF PRODUCTS GROWN ANNUALLY ON WOOD-LOTS

Average wood-lot per farm, 11.239 acres			Average actual wood-lot, 27 acres	
Product	Sale value	Stumpage value	Sale value	Stumpage value
Fuel wood	$18.89	$3.43	$45.39	$ 8.23
Lumber	8.02	3.45	19.28	8.29
Veneer logs	5.12	3.16	12.31	7.59
Posts	10.01	5.75	24.06	13.82
Mine timbers	7.09	1.97	17.04	4.73
Cross-ties	3.24	1.30	7.78	3.13
Piling	.81	.48	1.94	1.61
Cooperage	.31	.13	.76	.32
Total	53.49	19.67	128.56	47.72

RATIO OF STUMPAGE VALUE TO SALE VALUE OF PRODUCT

Product	Per cent
Fuel wood	18.16
Lumber	43.02
Veneer logs	61.72
Posts	57.44
Mine timbers	27.78
Cross-ties	40.12
Piling	59.26
Cooperage	41.93

RATIO OF STUMPAGE VALUE OF PRODUCTS IN TERMS OF STUMPAGE VALUE OF CORDWOOD (BASED ON CUBIC FOOT VALUE FOR EACH PRODUCT)

Lumber	8.0
Veneer logs	17.3
Posts	14.8
Mine timbers	3.6
Cross-ties	6.6
Piling	11.8
Cooperage	8.0

The second table on this page indicates that four fifths of the value of a cord of fuel wood is represented by labor costs, while this proportion drops to two thirds for mine timbers, nearly 60 per cent for lumber cross-ties and cooperage, and to about 40 per cent for piling, posts, and logs of high quality.

At present prices and costs, fence posts are by far the most profitable wood crop that can be grown. This product commands a fair price nearly equal to that of the highest quality of lumber, when comparison is based on cubic contents of the tree required to yield each product respectively. But it requires 100 years or more to grow logs suitable for high-priced veneers, and 50 to 70 years for good piling, while posts can be grown in from 15 to 25 years depending on the soil. By comparing the second table on page 145 with these values, it becomes evident that, in spite of the advantage to the farmer of cutting his own fuel, the practice of utilizing growing timber for this purpose exclusively or to too great an extent does not pay. As shown, the ratio of sale-value per cubic foot of these products to cordwood varies from 2.4 for mine timbers up to around 5 for posts and veneer logs, 3.0 for cross-ties and about 3.5 for lumber, piling, and cooperage. But the true comparison is found in the relative stumpage values, for these measure the value of the timber crop itself and not merely the return of cost of labor in harvesting. These ratios are shown in the last table on page 146.

On the basis of these relative crop values, the wood-lot should evidently be managed so as to produce as great a volume as possible of the higher priced products, utilizing only the non-saleable tops, limbs, and slabs as cordwood.

The loss through converting a stand into cordwood when it will make other products is shown in the following table, assuming a stumpage value of $1.00 per cord for cordwood.

Product	Unit	Value if converted into cordwood	Actual value	Loss by converting to cordwood
Lumber	M. B. F.	$2.08	$12.86	$10.78
Veneer logs	M. B. F.	2.08	33.10	31.02
Posts	Post	.010	.136	.126
Mine timbers	Cubic Ft.	.0125	.052	.0395
Cross-ties	Tie	.053	.323	.270
Piling	Pile	.279	3.15	2.871

A cord of wood has an actual stumpage value of 92 cents but if it can be converted into other products the value is as follows:

Lumber	6.18
Veneer logs	15.91
Posts	13.60
Mine timbers	4.16
Cross-ties	6.09
Piling	11.29

The time element in growing timber must be considered in this comparison. Posts and mine timbers may be grown in practically the same period as cordwood, with the exception of bars and legs which require about twice as long. Setting this period at 25 years, lumber, cross-ties, and piling will require approximately 100 years, or 75 years longer. With cordwood at $1.00, the value of the other products in order to earn 3 per cent compound interest on price alone, regardless of growth or volume, would be:

Lumber, cross-ties, and piling 75 years	$ 9.18
Veneer logs, 105 years	$22.28

The actual prices and per cents earned are:

	Price per cord	Per cent
Lumber	$ 6.18	2½
Cross-ties	6.09	2½
Piling	11.29	3¼
Veneer logs	15.91	3

The average annual income from farm woodlands is indicated as standing around $1.688 per acre for stumpage alone, clear of all expenses of harvesting. It is obvious that such income per acre will not indicate a value equal to corn land. But corn land would grow from 2 to 3 times as much wood as this per acre annually. True forest soils, too rough and hilly or with soil too poor in quality to permit of profitable agriculture, will not command corn-land values nor a tenth part of them. The capitalized value of an income of $1.688 at 5 per cent is $33.76 per acre. But this allows nothing for cost of crop production. In a wood-lot which is normally stocked with many-aged trees, has abundant reproduction, and every prospect for continuing to produce the normal yield of the soil every year, the only deduction from the above value per acre would be such annual expenses including taxes, as are required to protect and maintain the stand in its healthy and productive condition. Even if these expenses reached 50 cents per acre, which, capitalized, is $10.00, the value of the property would still be $23.76. Reproduction in such wood-lots is by natural processes largely, and the chief expense is vigilance to keep fire out of the lot.

The above value of course represents that of the land with its stock of standing trees, and not the bare denuded soil, which is worth very much less than this amount. True forest land of this quality is assessed in the southern counties at around $5.00 per acre.

Forests as a Crop on Soils of Different Qualities

INTRODUCTORY

The practice of forestry, or forest culture, will produce crops of timber yielding from 50 to 100 per cent more per acre in annual growth than the average now being harvested, of less than 45 cubic feet per acre. A considerable proportion of these increased yields will be obtained in the form of thinnings in even-aged stands. When no cutting is done in a stand or crop until it is finally ready to harvest, the surviving trees which make up the crop at that time constitute a very small per cent of those originally composing the stand. When it happens, as in plantations for post timber, that all the planted trees, thanks to an even start, survive for a time, the rate of growth in diameter soon shows a marked falling off and the growth on the whole stand tends to stagnate until the numbers are reduced by competition and the survivors obtain the increased crown-space required for thrifty development.

In cultivated stands of timber this reduction of numbers, instead of being left to nature, with consequent injury to the stand and loss by decay of the dead trees, is forestalled by removing a sufficient number of trees at from 5 to 10-year intervals to release those selected for the final crop. The ultimate number per acre will depend on the age and size of the crop which is desired. Plantations seldom have over 2000 trees per acre, and unless very early thinning is possible they will not be set closer than about 6×6 feet apart, or 1210 trees per acre. At 15 years, post timbers may be cut from such plantations. At 40 years, under natural conditions, this number would not be over 800 trees. At 60 years it would have diminished to 450, while at 80 years, about 270 trees would survive on an acre. Normally, but one half to two thirds of this number should be permitted to survive.

Without including the income possible from such thinnings or advance yields, the value of the final crops produced on typical acres of Illinois woodland can be calculated.

PLANTATIONS IN STARK, OGLE, AND CHAMPAIGN COUNTIES

The possibility of supplying home-grown posts on prairie farms is illustrated by yields of catalpa plantations at 15 years from time of planting. Many such plantations in the state have been absolute failures, but this is due to ignorance as to the soil requirements of the tree. Catalpa will not develop even into post timber unless planted on land of high fertility and supplied with abundant moisture.

PLOT 1*. *Catalpa Plantations in Stark county.*

Yields from plantations in Stark county, at 15 years, planted 3 feet apart in rows 6 feet apart, produced 2,430 cubic feet of wood, equivalent to 162 cubic feet or 1.8 cords per year of growth. From these trees 2,000 posts averaging 4 inches could be cut, leaving 830 cubic feet or 34 per cent in the form of stakes and small fuel wood which equals .612 cords per year. The annual average production is, then, 133 posts and .612 cords of stake or fuel wood per acre. According to table on page 86, the requirements of an average farm of 134.8 acres if catalpa is used, are 56 posts yer year, or for 100 acres, 42 posts. In order to maintain perpetually the fences on the average farm all posts needed will be furnished by a plantation of .42 of an acre or .315 acres respectively. In other words, the posts may be grown on the farm by devoting a little over 3/10 of 1 per cent of the fertile or crop area to this crop.

The value of these posts, per year, at 30 cents each, is $40.00, and the cost of cutting and hauling should not exceed 6 cents each, or $8.00 per acre, leaving a net stumpage value or income per acre annually, of $32.00 on an average annual expenditure, for planting, of $2.00 (if cost of establishment is $30.00 per acre). If this sum of $30.00 per acre is expended to establish a plantation the outlay per post is 1½ cents, which in 15 years will return 30 cents minus 6 cents for cutting at present prices, with the owner in position to profit by every increase in value of post material from now on. This first cost and taxes are the sum total of actual expense in growing this post timber. It is frequently argued that compound interest on these expenses should be included as a cost, since the money so expended might be earning interest for 15 years at 6, 7, or 8 per cent. Quite true; but the investor who puts his money out at these rates does not consider this interest *a cost* to him, it is, rather, his *income*. In the same manner, the compound interest on the cash costs of a plantation may be computed if desired, but these do not represent a dollar expended nor do they increase the actual cost a cent. They do enable the farmer to judge how good his investment is; but here again, the returns if gaged by compound interest are better than those ordinarily secured by investors who receive annual interest payments, since compound interest, especially at rates of 6 to 8 per cent, increases much faster than simple interest at the same rates. In

* These numbers refer to the plots listed on page 131.

compound interest the money is already reinvested at the end of the year, with no temptation to spend it or expense and delay in placing it.

Gaged by direct comparison, then, an outlay of $2.00 per acre annually, or a total of $30.00 for one acre, will return a net income of $32.00 per acre annually after an initial period of 15 years has elapsed, or $480.00 on one acre. Spread over the period of waiting, this means a return of the original cost, plus $30.00, or an income of $1.00 per year for each dollar invested, which is $30.00 per acre annually over and above cost of the crop. After the fourth or fifth year, at most, no further expense is required nor is any labor of crop production involved.

Money can be borrowed on farm property at 6 per cent. Land at $250.00 per acre must produce a net income of $15.00 clear of expenses to justify this value.

If compound interest at 6 per cent for 15 years is required, the land, bare of trees, at the year of planting is worth for a crop of catalpa posts $261.55 per acre as follows:

Taxes per acre at $1.84 for 15 years, compounded	$ 42.83
Initial costs, $30.00 for 15 years	71.89
Total costs	114.72
Net income every 15 years	$365.28

Discounted as a recurring crop or rental this gives the above land a value of $261.55. The rental at 6 per cent on this value is, per acre, $15.69 annually.

Catalpa when grown in this manner as a crop on rich agricultural soils yields over twice the cubic volume per year that can be expected on true forest soils of average quality. Early maturity into post sizes and a high per cent of utilization in spite of the small sizes of the trees, due to using the material in the round, give 66 per cent merchantable. No account has been taken of the other 33 per cent of wood or stakes, which will serve to defray any protection costs. The wood, even as fuel, should be worth $3.00 per cord, and serve to reduce the coal consumption or to supply kindling. The yield of this material, 830 cubic feet, is equivalent to 10.6 cords per acre, which at $1.00 per cord stumpage gives $10.60 or 70 cents per acre annually.

After such a plantation or system of post-production becomes established, the property, or land with growing timber, increases rapidly in value and becomes worth much more than $261.55. If a plantation of 15 acres is established by planting 1 acre per year, or one of an acre in

extent by putting in 1/15 acre each year for 15 years, the plantation will be worth per acre, $469.33.

The annual costs distributed over each acre are:

Taxes on $250.00-land	$1.84
Planting and other expenses	2.00
Total cost	$3.84
Stumpage value of crop cut annually per acre	32.00
Net income per acre annually	28.16
Capitalized at 6 per cent	469.33

If 5 per cent were used, values of land and property would be proportionately higher.

Catalpa posts constitute a crop which may be profitably grown on $250.00 land. They can not ordinarily be grown with profit, except on land of good quality. Catalpa, to succeed as a crop and to produce in 15 years the indicated yields of 2 good posts per tree, requires in the selection of the site and soil as great care as for any variety of farm crop. A failure with an annual crop may be remedied in one season, but with trees the loss extends over the entire period of growth and is cumulative. Just as corn and other field crops become unprofitable when grown on marginal land, since the rate of income to expense diminishes, so in the planting of this species the same principle holds good. Plantations require a considerable initial investment, which must be returned with interest to justify the venture. On poor soil, either sandy or dry, or stiff clay, compact silts, or other soils of medium or low agricultural value, catalpa is a failure and should not be planted.

This species, therefore, is a tree with special adaptation as a post timber—though not so durable as hedge, black locust, or mulberry—but with very exacting requirements as a crop, which makes it profitable to grow in competition with field crops on good soil rather than on the poorer natural forest-soils of the state. The utilization of an area of a little over 3/10 acre for every 100 acres of crop lands, on farms without other timber, for the purpose of furnishing a perpetual supply of fence posts of good quality, seems justified by the demonstration that the value of such land for this crop equals that for its use for other purposes.

Plot 7. *White Pine in Ogle county.*

The planting of white pine may be possible in limited areas which are free from the competition of hardwood sprouts, and in the northwestern portion of the state. The growth of this species in the limited

area in Ogle county approaches the maximum yields obtainable in northern Minnesota and Wisconsin. This stand at 75 years of age has produced lumber of the finest quality though deficient as yet in the quantity of lumber of clear grades suitable for pattern stock or other special uses. The stumpage value of such pine timber in Minnesota has reached an average of $20.00 per thousand on sites approaching this in accessibility. At 39,690 board feet the value of the crop is now $793.80 per acre, giving an average yield per year for the total period, of $10.58 per acre, exclusive of the possibility of thinnings. It is not permissible to use over 4 per cent compound interest to apply over a period as long as 75 years, and any investment which yields this total, which returns 18 times the initial investment, must be considered a very profitable one.

This seeding was natural, hence the only expense was taxes. The value of the crop, $793.80, properly discounted, would indicate a land-value of $44.23, which at 4 per cent would yield an annual rental of $1.77 per acre. Annual taxes would have to be met in theory from this rental.

These data indicate that crops of white pine should not be grown upon agricultural soils in place of farm crops, but that they possess possibilities for sandy or poor soils whose value falls below $40.00 per acre. Once the forest on such soils is brought to a condition of annual yields, the value per acre based on gross income would be $\frac{10.58}{.04}$ or $264.50 per acre, approximately that of good agricultural land. But this value includes the average stand of half-grown timber. It is just these timber values which restore the balance of value to the poorer classes of soil and cause these soils to bear their proportionate burden of production and of taxes. On poorer sands, experiments should be made with other pines.

These pines on account of their straight form and comparative lightness of wood produce a far greater ratio of lumber per cubic foot of wood than do hardwoods, and the proportion is still greater when weight is considered, or fuel value.

Plot 3. *European larch in Champaign county.*

This species weighs 30.65 lbs. per cubic foot as against 22 lbs. for white pine. The yield of a plantation of larch at Champaign on rich black loam exceeded that of the pine in Ogle county in weight per year, giving 3,414 lbs. annually as against 1,929 lbs. for pine. In cubic feet, the relative yields were, for larch 111 cu. ft. annually and for pine 85

cu. ft., but reduced to board feet, larch yielded but 491 ft. per year as against 529 for pine. The larch plantation was but 52 years old, had never been thinned, and had stagnated badly for over a decade, else this latter comparison might have been more favorable. Used as lumber, this species is not as valuable as the white pine. At $15.00 per thousand stumpage, the crop is worth at present, based on a yield of 25,552 board feet, $383.28 per acre, which at 5 per cent discounts to $32.92 per acre, giving a rental of $1.65 per acre. This allows nothing for the expense of planting, or for taxes. At $15.00 for planting, the soil value shrinks to $16.63, yielding $.83 with which to meet taxes.

Larch can not be raised on agricultural soils for saw-timber at a profit. It grows well on black loam soils and would pay better returns if cut at an earlier age for fence posts.

PLANTATIONS IN EDGAR, FULTON, AND WHITESIDE COUNTIES

PLOT 5. *Black walnut in Edgar county.*

Plantations of this species if on soil of good agricultural quality will yield up to 100 cubic feet and 3,000 lbs. of wood per year, giving, as in this case, over 300 (328) board feet per year on an acre. Average prices for walnut logs of good quality, on the stump, are about $50.00 per thousand feet B. M. This crop yielded 16,432 board feet, valued at $821.60 per acre, at 50 years of age, or an average per year of $16.43. Without considering expense, the indicated soil-value at 4 per cent is $134.54. From this, planting must be deducted, which at $15.00 per acre, discounted, still leaves a value of $117.08 per acre for the land if put to this use, equivalent to an annual rental of $4.68 from which to meet taxes. This indicates that walnut plantations, while they may serve as a grove and shelter or windbreak in part, give the soil a reasonably high value though not as high as under farm crops. Plantations made for the purpose of producing large trees should if possible be of walnut, at least in part, due to the relatively high stumpage value which should be maintained or even increased in the future if sufficient quantities of the species are produced to maintain its use. Its qualities for certain purposes, such as gun-stocks and furniture, are so superior that its future use seems assured.

PLOT 2. *Plantation of Hardwoods in Fulton county on alluvial bottom.*

Alluvial bottoms subject to flooding and capable of being drained, produce rapidly growing crops of hardwood timber of good quality with-

in reasonably short periods. This plot in Fulton county yielded 4,595 pounds per year, or 144 cubic feet of wood, and at 37 years of age had produced a possible cut of 13,412 board feet of lumber or 362 feet per year. Due to the small sizes produced at this age, the maple, elm, and sycamore lumber would not command a high price as such. Ash, composing 9 per cent of the stand, has a higher value. Adopting the average value of $12.86 per thousand board feet, the crop of timber is worth $172.48 per acre. In addition to the sawlogs, 29.8 cords of wood are yielded from tops, limbs, and smaller trees, worth 92 cents per cord on the stump, or $27.42, a total of $199.90 per acre.

Using 5 per cent for this period of 37 years gives a soil value of $39.34 per acre, equivalent to a rental of $1.96 per year out of which to pay taxes. There is no expense for planting. Such soils, unless stumpage prices received are considerably higher than $12.86, can not be retained as forest land if they are capable of being drained and farmed; but if not, the forest crop gives them a definite productive value and should not be neglected.

Plot 11. *Oaks in Whiteside county on hilly land.*

This typical plot, on land of poor agricultural value, yielded at the rate of but 1,561 lbs. or 42 cubic feet per year, or about the average which the woodlands of the state are now yielding under the existing lack of management. The species were 89 per cent oaks, and at 71 years would give 7,427 board feet of lumber, or 105 feet per year, worth at $12.68 on the stump, $94.17 per acre. In addition, 1,124 cubic feet of mine timbers can be secured, at 5.2 cents stumpage per foot, or $58.45, leaving a residue of 3.32 cords at .92 or 3.05, a total yield per acre of $155.67 or $2.19 per year. Such investments if capitalized at 4 per cent indicate a soil value of $10.24 per acre, equivalent to a rental of 41 cents per year to meet taxes. Such lands if valued at more than $10.00 do not pay 4 per cent compound interest on timber crops, though it must never be lost sight of that over 70 years this rate gives a return of 155.7 per cent on the dollar, or $15.57 for every dollar invested and that when established as a business yielding annual returns, such crops give the soil with its average stand of half-grown timber a value of $54.75 per acre, which is higher than they would have for any other purpose if essentially unprofitable for agricultural use.

The Grazing of Farm Woodlands

Grazing or pasturage forms an alternative use for practically all farm woodlands in Illinois. Being under fence for the most part, it is an accepted practice in the farm economy to give certain classes of stock the run of woodlands to get what grazing they can.

The attitude of farm wood-lot owners toward this portion of their holdings is shown by the results of the questionnaire as follows:

Land which should be cleared for agriculture	16.45 per cent
Land which should be cleared for pasture	15.00 per cent
Total which owners desire to devote to other use than woodland	31.45 per cent
Land which should be permanently retained as woodland	68.55 per cent

This large percentage, over two thirds, of the present woodland area which the owners desire to retain as woodland indicates the increasing value placed upon forest property by farmers, without any systematic effort by the state to demonstrate this value, or to educate such owners in the possibilities of timber as a crop, or the methods of production. Nevertheless the tendency in the past to regard all forest land as non-productive and to clear it as rapidly as possible still sways the thought of many who own woodland which occupies fairly level and fertile soil. A certain percentage of this remaining woodland probably should be cleared and will be in time. If the owners' estimates are carried out the ultimate area of farm woodland will shrink from its present acreage of 2,668,050 acres to 1,828,948 acres. An area of 442,894 acres will be added to the cultivated lands, and 400,207 acres to cleared pastures.

It may be seriously doubted whether such results will actually be secured as a whole, for parallel to the possible clearing and conversion of these woodlands there has appeared a marked tendency towards abandonment of the poorer grades of farm land as unprofitable for cultivation. In the one decade from 1910 to 1920 an area of 753,790 acres went out of cultivation, or more than the total combined area of proposed clearing of woodland for grazing and cultivation. Again, on the estimates of farm owners, some 221,477 acres, or an area 55% as great as that to be cleared for pasture, should be restored to forest by planting. Without doubt the area which could be profitably planted or restored to forest is many times as large as this, but the individual farm-owners do not yet see the value of such a policy, or else they are so impoverished by endeavoring to cultivate inhospitable soils that they

have no desire to undertake forest improvement for the sake of the future.

The questionnaire returns indicate an average of two acres of forest plantations for every hundred acres of woodland, but it is not thought that a complete census would quite bear out this total, which would indicate 53,361 acres of forest plantations in the state. Considerable planting has been done, however, especially in prairie sections, and when these are added Illinois may well have over 40,000 acres all told.

In spite of the intention of Illinois farmers to retain over two thirds of their present wood-lots as forest land, grazing of stock is practiced on 84.57 per cent of all farm woodlands, and stock is excluded from only 15.43 per cent of the total. The practice is thus well-nigh universal of considering the woodland as available for pasture, due partly to convenience and the arrangement of fences, partly to the desire for shade for the stock in hot weather, but primarily to the desire to extract from the woodland a greater annual return. This pasturage yields an annual income and increases the carrying capacity of the farm in live stock. It utilizes land which has generally been regarded as non-productive of income. So logical does its use as pasturage appear that exclusion of stock even from the residual 15 per cent is not usually intentional so much as it is due to inaccessibility, lack of fencing, or inconvenience. This practice will continue unless woodland owners become convinced that it does not pay. To demonstrate this two questions must be correctly answered. First, do forest crops pay better than grazing or pasturage? Second, are the two uses incompatible or mutually exclusive? It is generally conceded that the quality of grasses growing under the shade of timber is poorer than when grown in sunlight, and that the grazing on a woodland or shaded pasture is poorer, in contrast with open lands, in direct proportion to the amount of shade.

The carrying capacity of more or less open woodland pastures, was found by E. R. Hodson, of the U. S. Forest Service, to be 2.4 acres per head of cattle. Its value in Illinois is estimated at one fifth of that of good bottomland pasture. In Ohio, the value of the grazing is placed at an average of 35 cents per acre as against $2.00 to $1.00 for good grazing. The most liberal estimate of the value of grazing on woodland pastures for Illinois is from $1.00 to $1.50 per acre annually, or not half the value of improved pastures, which are placed at $3.00 per acre.

Stock does not need the amount of shade furnished by such woodlands. A few scattered trees in an open pasture are sufficient for this

purpose. The value of woodland for pasture is unquestionably increased from 100 to 200 per cent when totally cleared of forest growth, or improved. When the forest is completely destroyed this land should bring in a revenue from pasturage of about $3.00 per acre.

By comparison, it is seen that the stumpage value of the products now being taken from the average wood-lot per acre, without care or management, are valued at $1.688 per year, and that these products bring $4.76 per acre when sold. But when it is realized that the greater portion of these products are used on the farm and take the place of an equal quantity of wood or wood substitutes which would otherwise have to be purchased, the economic value of the farm woodland begins to be evident.

A rough comparison of the values of these home-grown products and their substitutes is shown below:

Product	Produced on farm	Purchased
Fuel, per cord.....	$ 5.068	$ 5.28
Fence posts, per post.....	.237	.40
Lumber, per M. ft. B. M...	25.00*	50.00

When it is considered that the labor expended in the harvesting of the wood crops can be distributed over the slack seasons and that this tends to give steady all-year round employment, the actual value to the farmer of the crops from his wood-lot must be placed considerably higher than the net stumpage value which he would obtain if he sold the wood in place and did not receive any of the benefits of using it for farm needs. At a conservative estimate, the average acre of farm woodland is worth as much in annual income to the farmer as this same acre would produce if totally cleared for grazing. But can this income be obtained and at the same time the land be used for grazing and thus a larger total revenue be obtained? Universal observation and experience in the hardwood forests of Ohio, Indiana, and Illinois answer this question in the negative. To be sure, the timber which the land has already produced will continue to live in most instances until felled and removed, hence will yield its value to the owner. But this value does not necessarily represent net annual income, and will not, unless a quantity equal to that removed is being added to the forest by growth.

The rate of growth of the standing trees diminishes noticeably on areas heavily grazed, and some trees die from trampling. But even in this way the effect of grazing upon income is not brought out in its

* Stumpage $12.86 plus cost of logging and profit, $12.14.

true aspects. In order to perpetuate this annual yield of the wood-lot it is not sufficient that the existing stand continue to lay on wood, for every time a tree dies or is cut the stand becomes thinner and more open. Under normal or natural forest conditions, young saplings are constantly springing up to replace the veterans and fill in these gaps. The forest is densely stocked with trees of all ages and sizes. Very little grass is on the forest floor, and but little underbrush. A carpet of leaves, slowly decaying into humus, keeps the soil moist and permeable to water. The forest thrives, and the trees are healthy, sound, and vigorous. Many wood-lots in southern Illinois well cared for by their owners, show such conditions.

But on woodland areas which are grazed by cattle, horses, or sheep, a change sets in almost immediately, and continues progressively as long as the practice is maintained. The stock devour readily all the leafy foliage within reach, and this includes all seedlings and young saplings not too tall for them to get at the crowns. Their trampling hardens the soil and decreases its moisture content. Under these conditions, the removal or death of an old tree is not followed by a thicket of vigorous young reproduction, but instead a permanent opening is formed. These openings extend, and grasses, resistant to grazing, form a sod which makes it difficult or well-nigh impossible for tree-seedlings to start, or else favors the less valuable species, such as ironwood or elm, instead of oaks, tulip-poplar, and basswood.

The process of degeneration may be prolonged over a period of half a century, but the forest is doomed as certainly as if it were allowed to burn over every year or two. With the final cutting of the last decrepit veterans, the revenue for the woodland ceases, the forest capital is bankrupt, and the only possibility of annual income lies in continuing the practice of grazing which has brought about this destruction, meanwhile possibly permitting the barns to deteriorate because the high price of lumber makes the cost of their replacement prohibitive.

It is certain that such a policy is self-determinative. The forest land is not being used as such, and the future forest revenue is being sacrificed for the sake of an immediate return for grazing, which in itself does not constitute a complete or efficient use of the land. The general policy indicated by these facts is the separation of forest from pasture. The two uses are actually incompatible. The forest will not reproduce in the presence of grazing, yet its presence depresses grazing values. The continuance of this policy is a deliberate rejection, whether

conscious or otherwise, of the policy of growing wood crops for the farm. Instead of retaining two thirds of the farm woodland as forest, the owners are actually engaged in clearing for pasturage 85 per cent of their present woodlands by a most inefficient and time-consuming method.

It seems probable that a more enlightened and profitable policy would be to recognize this conflict, and to definitely decide upon the areas desired for permanent forest and for permanent grazing. Then these areas should be separated by fence, excluding the stock from the true forest area, and the pasture areas should be cleared as rapidly as possible of all forest growth. The relative percentage of forest and pasture desired must be worked out by each owner, with the advice of the state department of forestry as to true forest values as a guide in this determination.

Fire in Forest Lands

Forestry Circular No. 2 of the Natural History Survey has set forth the damage done by fires in Illinois woodlands. It is sufficient here to summarize.

In the hardwood forest areas, which comprise practically all of the Illinois woodlands, fire is an unmitigated evil. There is no class of fire which does any benefit whatever to the forest. It neither benefits reproduction nor reduces the danger of subsequent fires. Instead it makes the recurrence of fires more certain and their character more disastrous. There is but one thing which fires accomplish; they progressively destroy the forests. The process is much the same as that of grazing. The reproduction of seedlings is killed as fast as it occurs, and this eventually—by opening up the forest and bringing in heavy sod and a tangle of briers and brush—prevents tree reproduction from surviving or even starting. Fire acts far more rapidly and disastrously than grazing upon the mature stand. Occasionally the entire stand is killed. With hardwoods this usually occurs when the stand is fairly small and young. The butts of the older trees, even though protected by heavy bark, are sooner or later fire-scarred by killing the cambium or live tissue on the most exposed side and this would eventually, perhaps many years later, cause the destruction of the tree by rot and blow-down. It is safe to say that every fire permitted to burn through a woodland area destroys the equivalent of a year's increase at the very least. This when harvested would be worth from $3 to $12 per acre.

Most fires destroy far greater values than this. *Periodic fires* burning at *three* or *four-year intervals*, or even at ten-year intervals, may destroy all the reproduction for the period; hence effect a loss equaling from three to ten times the annual income, when harvested. This loss is seldom visualized or reckoned, but constitutes a damage far greater in its eventual total than the complete destruction of the existing stand of old timber. It would be as sensible for a farmer to try to continue a live-stock industry and pay no attention to losses of young stock because at the time of birth they had no market value as for an owner of forest land to expect to continue to derive revenue from it while permitting fires to consume the progeny of the forest.

The questionnaire here gave interesting results. Out of 217 replies 44 or 20.28 per cent were not opposed to fire in wood-lots, in fact favored it, while the remaining 173 or 79.72 per cent desired its complete exclusion. As was to be expected the chief cause of fire in these woodlands is the hunter or camper. Fox hunters, bee hunters, coon hunters, nut and berry pickers, and ginseng hunters are all charged by the woodland owner with a share in the guilt. The following causes were listed by the given number and per cent of owners, and the list serves to indicate the relative prevalence of these agencies in the starting of fires:

	No.	Per cent
Campers and hunters	103	35.7
Carelessness	54	18.7
Burning to kill insects	37	12.8
Brush and grass burning	32	11.1
Railroads	26	9.0
Smoking	25	8.7
Lightning	8	2.7
Incendiary	3	1.0
	288	99.7

Of these causes the burning to kill insects and the burning of brush and grass are due to practices of the land owners. Comparatively few railroad fires occur since most railroads do not run through forest lands, yet such fires do occur frequently along timber stretches, especially in southern Illinois. The Chief Entomologist of the Natural History Survey, in an effort to correct the practice of broadcast burning of woodlands against the chinch-bug, has called attention to the fact that these insects do not hibernate in damp or shady spots, but seek the sunny borders of woods or fence-rows, where it is comparatively dry. The burning-over of a wood-lot to kill bugs when a 50-foot strip along the

south border would get them all is as bad as burning down a house to roast the pig instead of using the oven.

In most regions the individual wood-lot is fairly well protected against fires occurring on the land of others. Cultivated fields and roads form effective fire-lines, hence the predominance of the fire directly set by persons making use of the woodland, and abusing the privileges thus accorded them by burning over the property. A certain measure of protection may be had by posting such lands against all trespassers, but in the greater areas of forests in southern Illinois the ability of the owner to keep fire off his land is largely determined by its location, and where it is surrounded or joined on one or more sides by unprotected forest-lands constant vigilance is necessary in the dry seasons to prevent the inevitable annual fires from burning him out. As a result, some owners secure protection by back-firing at the first intimation of the approach of the blaze and thus secure immunity at the sacrifice of other lands; while others, less favorably situated, make no attempt to check the fire but breathe a sigh of relief when the conflagration is over for the season and their buildings are still standing.

The owners who by reason of fortunate location or diligence have succeeded in excluding fires and who have in addition kept out grazing, have had the reward of seeing their forest areas restocked densely with all manner of vigorous young trees. The reproduction of these hard-woods in southern Illinois is especially prolific and when lacking, the cause is not far to seek. Many of these owners take great pride in their wood-lots as well they may, but for one wood-lot so nurtured there are twenty which show the frightful ravages of either fire or grazing, or of the two combined. These, and not timber-cutting, are the factors which threaten to destroy 90 per cent of the remaining forests of Illinois and put an end to their productiveness and future yields. If the present practices of firing the woods and grazing are continued, then inside of two more decades the production of Illinois woodland will drop permanently to not over a fifth of its present low capacity. More may be accomplished and at less cost by correcting these conditions in existing woodlands than by replanting an area equally great at enormous outlay.

A Forest Policy for Illinois

The woodland area of Illinois is comparatively small, yet together with the waste lands which might be forested it comprises some five

million acres capable of producing at least 250,000,000 cubic feet of wood annually. The present annual production is but 115,000,000 cubic feet, and is rapidly diminishing. The stock of timber or forest capital is being exhausted with no thought of the future and no wide-spread application of sound principles of crop renewal and production. Grazing is progressively ruining the best forest areas and fires are destroying the poorer and less well-protected tracts. Yet these forests are still supplying one half of the farmer's total needs for wood, one sixth of the railroad ties used in the state's transportation system, sixty per cent of the timber used in its mines, thirty per cent of the piling and twenty-five per cent of the farmer's fuel, and one half of his fence posts. The exhaustion of these supplies will be felt in several industries, but its influence will fall most heavily upon the farmer who, deprived of local sources of wood for fencing and buildings, will be forced to pay increasingly higher prices for these necessities or cease to operate.

On the other hand, the ownership of ninety-three per cent of the woodlands of the state is in the hands of these farmers, who would be the largest beneficiaries of their intensive use. There is enough woodland on farms to supply all the present needs of these farmers for wood products if the wood-lots are properly managed. Farmers can get along without extending their areas of pasturage, but they can not avoid the use of wood or high-priced substitutes. Those who still have an overabundance of wood and perhaps have had wood for sale and failed to realize a profit, are too apt to underestimate the value now and in the future of the home supplies which they are drawing upon. They see only the labor of getting out the wood crops. The farmer, because of his ownership of comparatively small areas of woodland, can give it more intensive care than any other class of owner and can make it produce more per acre. His utilization can be practically 100 per cent. The tops not suitable for lumber, ties, or even posts or props, can still find service as home fuel or even sale as cordwood. It is to the farm-owners of woodland, then, that the state must look first for the turn of the tide and the establishment of proper practices in the care of forest lands. With farm wood-lots in thrifty condition there will be a constant production for sale of railroad cross-ties, mine timbers, and even saw-timber, as well as of cordwood for consumption in cities.

The farm owner knows many things about his woods, but as a rule he does not know enough about either the possible future value of this woodland or the methods necessary for its protection, reproduction, and

management. Farmers were slow to recognize the need of agricultural experiment stations and county farm bureaus. They will more readily admit their need for information regarding their wood-lots. Information must be formulated regarding production on farm wood-lots, and disseminated throughout the state by means of direct contact with the farmers and by co-operation with the county farm advisers.

Next in importance in this program of farm extension in forestry comes the teaching of farm forestry at the state university, in order to supply its agricultural students with basic information on the management of such woodlands for use either in the rôle of owners or as teachers and demonstrators connected with farm-extension work as county agents.

The first duty of the state is to provide for this instruction. This should require a definite organized department of forestry as one of the main branches of the state experiment station at Urbana. The purpose of this department should be, first, to establish experimental areas in forestry, located at several points within the state on different classes of soils, on which experiments may be conducted in the management of existing tracts of natural forests, the reclamation of eroded lands by forest planting, and the testing of methods of treatment of woodlands for greater profit.

Second, from the results of these experiments supplemented by extensive observations and study throughout the state, definite practical recommendations should be formulated for the management of farm woodlands and this information should be carried directly to the farmer by personal contact as well as by bulletins and other methods of promoting publicity.

Third, Illinois must make a definite effort to put an end for all time to forest fires. This will ultimately mean, at least in certain portions of the state, a system of fire-wardens similar to that in successful operation in other states. A system of unpaid local or township fire-wardens might be inaugurated to begin with, until experience indicates the needed measures for improvement. The laws now on the statute books prescribing penalties for the setting of fires in woodlands are probably sufficient with a slight overhauling. The essential thing is to have fire protection of forested lands placed under the jurisdiction of some branch of state government sufficiently interested and with machinery at its command for the successful enforcement of the fire laws.

Fourth, the state should acquire by purchase a tract of about 75,000 acres in certain counties in the southwestern portion containing the largest unbroken areas of forest land, and consequently most exposed to damage by fire. Upon this area fire-protection should be undertaken by the use of modern methods and equipment already successful in many other states, such as look-out-towers, paid fire-wardens, and a telephone and trail system. The cost should be kept within reasonable proportions, based on the area acquired, but the protection should extend over the entire region tributary to the state-holding of land. As is now the case in Ohio, it would be desirable for this organization for fire-protection in the comparatively small and relatively inaccessible state forest area to be placed under the direct jurisdiction of the state forestry division at the agricultural experiment station rather than have it attached to some other administrative department where it would not receive proper attention or guidance and might completely fail of effectiveness. All such projects on the part of the state, for the present at least, must be purely educational in intention, the purpose being to reach and influence the farm-woodland owner as rapidly and effectively as possible.

The establishment of forest parks for recreation, as exemplified by the creation of the Cook County Forest Preserves, is not forestry in the economic sense, nor is it intended to provide supplies of wood for Illinois industry or consumption. There are several areas of woodland of great scenic beauty in the state where the timber is still preserved by the owners. These tracts should be acquired by the state or by counties as parks and managed as such for the absolute preservation of the forests and the beauty of the site. The management of these park areas requires but a limited knowledge of forest economics or silviculture, though this knowledge is helpful in protecting and improving the forest. The urban populations of the state will be directly and intensely interested in these park projects, which should be encouraged in every possible manner. But for the present at least, they should be kept sharply distinct from forestry, and their acquisition and management should not be confused with that of state forests acquired for forest production or with the project for farm wood-lot extension.

Opportunities for the State of Illinois to constitute large public holdings of forest land, outside of a few tracts in the south, are circumscribed by the divided and scattered character of the remaining timber lands which will continue to be owned by farmers as part of the farm economy. The great wood-using industries of the state, now drifting with the tide

and for the most part adopting a fatalistic attitude regarding the future of their wood supplies, should be the first to encourage the forestry movement in the nation at large, and in this movement the general public of the state, through the State Forestry Association and other organizations, should heartily join.

APPENDIX

NOTE 1.—Cooperage, Veneers, and Shingles.

For cooperage, U. S. 1921:

	M pieces	Multiple for cubic feet	Cubic feet
Tight staves	532,000	83	44,156,000
Heading	178,000	333	59,274,000
Slack staves	362,000	25	9,050,000
Heading	333,000	167	55,611,000
Hoops	21,500	25	537,500
			168,628,500

For veneers, U. S. 1921:

576,000 M ft. B. M. log scale.

Based on log scale, a divisor of 6 is used for cubic feet = 96,000,000 cu. ft.

For Illinois, no statistics on consumption of cooperage stock or veneers are available, hence the quantity consumed must be obtained by proportion from the total produced in the U. S. The result can only be an approximation, but it is more accurate to include such an approximated total than to omit the item altogether. For total cooperage and total veneers, then, the per cent consumed has been based, not on relative population nor on the relative per cent of manufactures in the state to total for U. S., namely, 8.12 per cent, but on the state's relative consumption of lumber, which is 6.81 per cent, falling below the other two figures.

Total cooperage, 1921:

168,628,500 × .0681 = 11,483,600 cubic feet.

Total veneers, 1921:

96,000,000 × .0681 = 6,537,600 cubic feet.

These quantities may be considerably in error on the basis that Illinois consumes larger or smaller proportions of the total production than those adopted.

Shingles.

The consumption of wooden shingles in Illinois was based on the same percentage, namely, 6.81 per cent of the total for the United States

Total consumption in U. S., 1921:

9,192,704 M shingles.

Conversion factor 9 cubic feet per M shingles.

9,192,704 M × .0681 = 626,023 M, or

× 9 = 5,634,207 cubic feet.

The years on which our data are based are given below:

Fuel	1922	Veneers	1921
Cross-ties	1921-1922	Shingles	1921
Mine timbers	1922	Piles	1922
Posts	1922	Poles	1922
Cooperage	1921	Lumber	1920

NOTES 2, 3, AND 4.—Automobiles.

NOTE 2.—Although cars are made largely of other materials, yet the average quantity of wood used in their construction was:

Year	Passenger cars, board feet	Trucks, board feet	All cars, board feet
1921	184.8	231	189
1922	173.6	217	176

NOTE 3.—Consumption of lumber in the United States for Automobiles (from National Automobile Chamber of Commerce):

1920	Passenger cars	1,883,158	board feet.
	Trucks	322,039	" "
	Total used, approximately	400,000,000	" "
1921	Passenger cars	1,514,000	" "
	Trucks	147,550	" "
	Total lumber used	313,800,000	" "
1922	Passenger cars	2,406,396	" "
	Trucks	252,668	" "
	Total lumber used	468,074,640	" "

NOTE 4.—According to the Forest Products Laboratory, the proportion of lumber used in passenger cars and trucks bears the relation of 160 to 200. U. S. figures show that in 1922 trucks made up 9.5 per cent and passenger cars 89.5 per cent. Multiplying 160 by 89.5 and 200 by 9.5, a weighted average of 162.2 is obtained. But the total average is actually 176 feet, or 108.5 per cent of the trial average. The average for each class is obtained by increasing the 160 to 200 feet by 108.5 per cent, which gives the values shown in table ...

The figure on consumption for both classes has been obtained by taking 3 per cent of the output of the U. S. for each class, autos and trucks, and multiplying by these figures. The Forest Products Laboratory gives 12,000,000 board feet for passenger car bodies alone, not counting blocking and other incidental uses. It is not certain whether the figures for actual output for Illinois are 3 per cent for each of the

two classes, which would indicate for passenger cars 12,532,531 board feet and for trucks 1,644,860 board feet, but the agreement with the above figure is significantly close.

NOTE 5.

GROUP B—CONTINUED

MISCELLANIES ITEMIZED. CENSUS OF 1920

	Persons employed	Capital invested	Cost of materials	Value of products	Value added by manufacture
Ship and boat building	139	479,365	209,189	461,226	246,080
Wooden goods not specified	215	581,630	402,071	820,475	413,033
Baskets	63	67,217	79,312	167,299	86,366
Hand-stamps	337	569,960	346,255	1,013,769	656,658
Models and patterns	649	689,598	347,536	1,636,787	1,269,133
Miscel. Instr.	766	1,416,943	773,058	2,170,915	1,371,601
Phonographs	2,225	6,570,855	7,007,723	12,841,682	5,745,424
Pipes—tobacco	129	438,869	150,570	456,011	299,831
Show-cases	250	611,000	463,765	1,026,844	556,203
Athletic goods	602	1,533,149	1,134,868	2,309,768	1,140,101
Toys and games	753	1,094,674	1,010,181	2,130,968	1,101,540
Trunks	1,495	3,639,108	3,824,742	7,292,902	3,439,462
Cigar boxes	254	404,946	292,086	694,664	396,235
Wood engraving	259	227,963	165,066	826,342	659,383
Total	8,136	18,325,277	16,206,422	33,849,652	17,381,050

NOTE 6.

DATA ON FUEL USED ON FARMS*

Classes of farms†	Total number of answers	Coal-burners		Coal-and-Wood burners			Wood-burners	
		Tons	Average acreage of farms	Coal Tons	Wood Cords	Average acreage of farms	Cords	Average acreage of farms
Up to 200 acres in size	171	9.8	141	7.66	13.4	141	21.4	136.5
From 200 to 400 acres in size	182	13.3	281	7.70	14.3	279	26.1	277
From 400 to 600 acres in size	43	15.8	517	8.20	17.9	478	24.3	498
Total	396							

* Obtained from replies to farm-woodland questionnaire.
† Large acreages, where there might be several tenants, are omitted

NOTE 7.—The U. S. Department of Agriculture has figures which indicate a consumption of cordwood for Illinois as follows:

1917	2,400,000 cords
1919	1,896,000 cords
1920	1,422,000 cords
1921	1,659,000 cords

These figures are considerably in excess of the deductions made by this study and, if correct, indicate a production of cordwood for 1921 of .591 cords per acre of woodland for the state, in addition to the yield of all other products. It is not thought that such yields are probable. If correct, it indicates a still more rapid exhaustion of the forests of the state by over-cutting.

NOTE 8.—For cordwood, 80 cubic feet is taken as the converting factor. For saw-timber, the lumber output is reckoned as requiring 1 cubic foot from the tree to produce 6 board feet, giving a factor of .16⅔. For fence posts, an average size of 4 inches at the top end of a 7-foot post was fixed, giving about .8 cubic feet per post. For cross-ties, 35 board feet per tie, and 8⅓ board feet per cubic foot gave 4.25 cubic feet per average tie, allowing for waste in hewing.

Mine timbers were estimated directly in cubic feet by converting factors as follows:

Mine props	.83 cubic feet
Bars and legs	1.91 cubic feet
Mine ties	.70 cubic feet

which was found to be the average for material consumed in the mines. (See p. 77 on consumption of timber in mines.)

Piling was taken as averaging 22.3 cubic feet per piece.

NOTE 9.—Tabulation of census figures for lumber production by decades in Illinois shows 334,244,000 B. F. in 1879 and 56,900,000 in 1920. During the eighties and nineties the relatively high production was largely accounted for by logs imported from other states. During the eighties Rock Island county produced annually 70,000,000 B. F., leading all other counties. The second in amount at that time was Massac county with 14,000,000 B. F. The Rock Island production was from Wisconsin and Minnesota white pine logs, the Massac from both local and imported hardwoods. The importation of logs into southern Illinois is probably still considerable, but it is negligible elsewhere.

NOTE 10.—Consumption of shingles on farms.

It is assumed that the same proportion of shingles is consumed on farms as of lumber. This is 31.522 per cent of the total for the state. This proportion of 5,516,110 cubic feet of shingles gives 1,738,788 cubic feet consumed on farms, or 7.331 cubic feet per year. This is a total of 193,198 M shingles, or 814 shingles per year on each farm, taking no account of the substitutes for shingles, which considerably increase the total of roofing used.

NOTE 11.—Total coal and wood, 2,769,680 tons, converted to cords by .8 equivalent and divided by 237,181 farms.

NOTE 12.—Origin of data concerning consumption of lumber.

In distributing the total quantity of lumber, 2,353,662,000 board feet, consumed in the state in 1920, accurate statistical data are not available. The results are approximate only, and are based on percentages derived from previous studies and partial data. The total consumption of lumber in the Chicago district in 1920 was 1,454,712,000 board feet*. This agrees closely with the average for the decade 1911-21 of 1,466,820,300 board feet. In 1909 the total consumption of lumber in the Chicago district was 1,622,690,000 board feet of which the building trades used 31.172 per cent, or 505,835,000 board feet, and the wood-using industries, 1,116,855,120 board feet or 68.83 per cent.

Assuming that the same ratio of consumption applies between the building trades and the total consumption in Chicago for 1920 as for 1909 and applying this 32 per cent to the total consumption in the Chicago district for 1920 the building trades would have consumed in that year 465,507,000 board feet, which would leave 989,205,000 board feet for the wood-using industries of Chicago alone. The best information available in Chicago for 1923 places the consumption by the building trades at 600,000,000 feet, so that it seems safe to place the annual consumption for that purpose at between 500 and 600 million feet, exclusive of planing-mill products.

That there has been a decrease in the total consumption of wood in these wood-using industries in the last decade is indicated by the apparently large decrease in the amount of hardwood timber shipped into the state (page 98). The decrease in Chicago alone, on this basis, is indicated as approximately 11.5 per cent since 1,116,855,120 board feet was used in 1909 in these Chicago industries. Outside of Chicago the

* Chicago Board of Trade.

apparent decrease had been greater. Chicago manufactures constitute 72 per cent of the manufacturing industry in Illinois. Applying this per cent to wood-using industries, the indicated consumption of wood in these industries outside of the Chicago district is 384,695,000 board feet and the total for the state is 1,373,900,000 board feet. The indicated decrease in wood consumed outside of Chicago by these industries, based on 664,681,000 feet in 1909, is 42.12 per cent and for the state as a whole is 22.9 per cent. The consumption of lumber for building purposes in the state as a whole including Chicago is thus indicated as 979,762,000 board feet and in the state outside of the Chicago district as 514,255,000 board feet. Of this amount, approximately 296,476,250 board feet is used on farms or an average of 1250 board feet per farm annually, leaving 217,778,850 board feet for building construction in towns other than the Chicago district (Cook and DuPage counties).

ERRATA

P. 85, line 13 from bottom, for 87 read 86.
P. 115, in table, for areas and area, read acres.
P. 136, line 5, for 135 read 131.