STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION

DIVISION OF THE
NATURAL HISTORY SURVEY
STEPHEN A. FORBES, *Chief*

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Third Report on a Forest Survey of Illinois

BY

CLARENCE J. TELFORD

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ERRATA

Page 2, line 6, for *loan* read *loam.*

Page 4, line 18 from bottom, beech (after water beech) should be followed by a semicolon.

Page 138, line 10 and line 14 from bottom, for *Dane* read *Dann.*

Page 139, line 5, for *Dane* read *Dann.*

Page 180, line 5 from bottom, delete *D.*

Page 198, line 19 from bottom, for *March* read *March 16, 1918.*

Page 221, line 22, for *data* read *date.*

Page 278, lines 17 and 18 from bottom in right-hand column, for *150* read *158.*

Page 285, line 24 in left-hand column, for *Franch* read *French.*

Page 321, table III, center column, for *1.02* read *1.00+*; for *1.04* read *1.02;* for *1.06* read *1.04.*

Page 411, line 4, for *pupation* read *breaking dormancy* .

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INTRODUCTION

Until very recent years definite knowledge of the amounts and condition of our timber resources and the demands upon them has been so limited that a reliable estimate of our timber requirements and supplies at any future period has been impossible. It is now common knowledge that the present forests of the United States contain an estimated total of 481,800 million cubic feet of standing timber; that the annual drain of 25,000 million cubic feet is partially offset by a growth of 6,039 million cubic feet; and that the virgin forests will carry us another twenty-five years, after which we shall probably be wholly dependent upon growth from cut-over lands. By utilizing the entire 470 million acres of forest land, at prevailing rates of growth these cut-over lands can supply us with an estimated annual yield of 14,000 million cubic feet—a little more than half our present requirements.

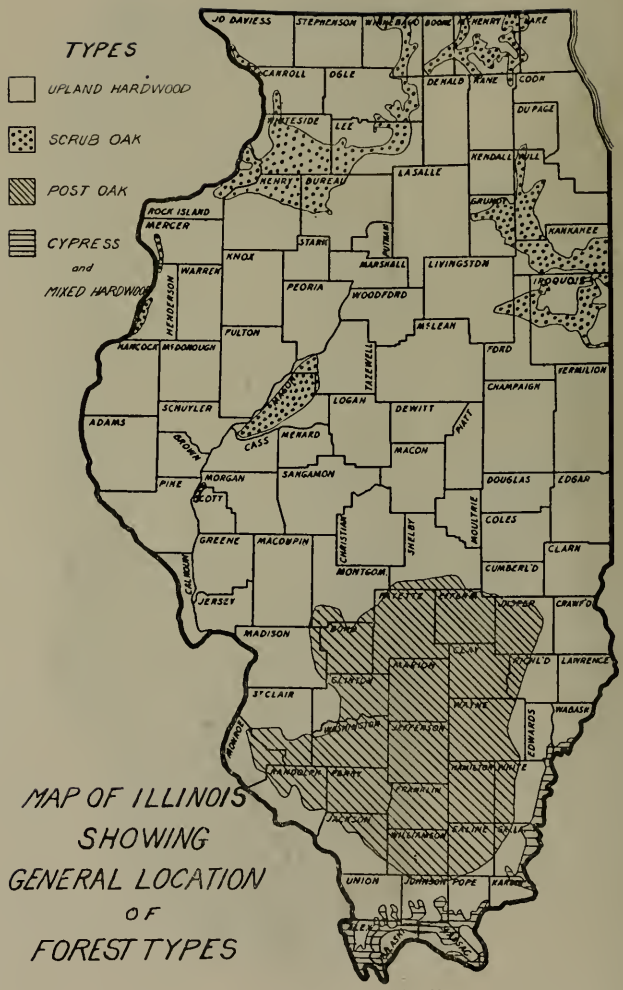
The conviction that satisfactory substitutes for wood will be found is untenable when the enormous amount of wood required is appreciated. This drain of 25,000 million cubic feet of standing timber a year means that for every hundred pounds of coal, iron, cement, petroleum, and copper consumed the forests supply 67 pounds of wood, and the crop lands supply 44 pounds of all forms of crops including cereals, seeds, clover, hay, forage, cotton, potatoes, sugar, fruit, and nuts. It is obvious that a satisfactory substitution for a commodity representing by weight two thirds of virtually all the minerals consumed, or one and a half times all crops raised in the United States, is impossible.

A timber famine will be more disastrous to Illinois than to any other state. Her manufacturing establishments employ 11.6 per cent more hands than agriculture, transportation, and mining combined, and thirty per cent of all persons employed in manufacture are in industries dependent upon wood. In the single item of lumber Illinois consumes one thirtieth the total lumber-cut of the world.

There is a striking parallel between Illinois and Great Britain in the total wood consumption and in the total area forested. Each annually consumes approximately the same quantity of wood—560,720,000 cubic feet for Illinois and 600,000,000 cubic feet for Great Britain; each has about the same area forested—3,021,650 for Illinois, and about 3,000,000 acres for Great Britain. But Great Britain, despite a population of 437.5 to the square mile as compared with 115.7 in Illinois, and the consequent pressure for land, has deliberately undertaken to replant 1,770,000 acres and this planting is being done at the rate of 20,000 acres a year. Illinois has never planted 200 acres of publicly owned forests, her farm woodlands are decreasing at the rate of 4,500 acres a year, and the unimproved and waste land on farms is increasing at the rate of 25,000 acres a year.

The State Natural History Survey has undertaken an inventory of the forests, and the purpose of this report is to present the area and condition of the forests of Illinois, and to show the productiveness of the common soil types in terms of forest crops.

Map I. Areas originally forested. Drawn from maps and data of the State Soil Survey.



MAP OF ILLINOIS
SHOWING
GENERAL LOCATION
OF
FOREST TYPES

MAP II.

ARTICLE I.—*Third Report on a Forest Survey of Illinois.* By CLARENCE J. TELFORD, Forester, Illinois State Natural History Survey.

Part I. Description of the Forests

PHYSIOGRAPHIC FEATURES

In preglacial times Illinois was not a prairie state, but was characterized by hills and valleys such as are found in the unglaciated area of Jo Daviess county today. When the ice sheets retreated, Illinois, except for a few places, was extensively covered by a deep mantle of soil, the old valleys were filled and the preglacial eminences modified and buried until the surface was a flat to rolling upland. During the period when the glaciers were melting great quantities of water were released, found outlets across this mantle of raw soil, and quickly sluiced out wide channels. The flooding was apparently intermittent, and during the periods of restricted stream-flow the exposed deposits of finely ground glacial debris, drying, were carried widely by winds and deposited extensively over Illinois.

Thus the topography of the state is that of an elevated plain having a slight slope to the south. Large streams have cut wide channels through the deep soils, and the boundary between the uplands and the large stream valleys is characterized by the abrupt bluff condition of an upland region geologically young. Lesser streams cut through the bluffs to the main rivers, forming often a hilly topography near the bluffs, but the relief becomes less pronounced as the distance from the larger streams increases. The level expanse of the glaciated area is dissected by innumerable streams and further broken by moraines and partially buried preglacial eminences rising above the general level.

Geologists recognize at least four periods of ice invasion in the state; but for a distinction of forest from prairie soils, two divisions suffice—(1) the Lower-Middle and Lower Illinoisan and (2) all others. Forests were the prevailing type of vegetation over the first of these divisions and grassy prairie the prevailing type over the second.

The Lower-Middle and Lower Illinoisan glaciation extended farther south than any of the other ice sheets, the southern limit reaching northern Johnson county, or approximately latitude 37 degrees 45 minutes N. The northern boundary conforms to the moraines of the Wisconsin glaciation from Paris to Shelbyville, and to the division between the Middle Illinoisan and the Lower-Middle Illinoisan from Shelbyville to Carlinville, or approximately latitude 39 degrees 20 minutes N. The subsoils of extensive areas of this region are but slightly pervious and the black surface soils, whose color is due to a partial decay of grass and prairie vegetation,

were wanting in this region. Forests occupied the area and open prairies were the exception.

North of this region the tight clay subsoil does not generally appear. Althought most of the other glacial deposits were made subsequent to the Lower Illinoisan deposits, yet in these other regions conditions favorable to a sod resulted in the building up of a loan rich in organic matter, the black loams of the true prairie. Tree growth here was limited to stream valleys and to eroded slopes or moraines, and grassy prairies were the rule.

Although glaciation has modified the relief throughout 93% of the state, yet the three unglaciated regions, Jo Daviess county, Calhoun county, and the entire southern 35 miles of the state, show a decidedly broken topography. The highest and lowest points in the state are within these regions, and the difference of relief may be 500 feet in a quarter section. Rock outcrops are common, clear streams follow a steep gradient over a rocky bed, and these regions present features quite at variance with the usual conception of Illinois. The soils over this unglaciated portion are not generally deep, excepting certain areas adjoining the Mississippi flood-plain where the loessial deposits occasionally attain a depth of thirty feet. These unglaciated areas were heavily forested and remain today the most picturesque and heavily wooded regions of the state.

The Original Forests of Illinois

In the solitude of the forest, surrounded by venerable trees, the impression is one of immutability as eternal as the hills. Yet change and movement is written in every chapter of forest history from that distant age when Mesozoic seas washed the roots of tree ferns, down to today. Pine followed tree fern, broad-leaved species followed pines. Long periods elapsed when soil and climatic conditions were stable, certain types of tree associations developed, and held the land until some shift of the earth's crust or change in the climate altered conditions and ushered in a new type of forest. The obliteration might be complete, as when the sea or ice came over the land, or it might be a gradual transformation. Palms and figs flourished in Illinois at certain periods; later fir and spruce followed the retreating ice sheets. Broad-leaved species eventually supplanted the conifers over most of the state. These broad-leaves were extending out onto the prairies when the white settler appeared, and along the Wabash and Ohio River they surpassed in size the hardwoods of any other region of America.

To the pioneers the prairies were a novel feature, and it naturally followed that Illinois should be called the prairie state, yet we find that her forests occupied nearly as much area as her prairies, and were unusual in both variety of species and sizes attained by individual trees. These original forests occupied something over fifteen and a quarter million acres, or 42.58 per cent of the land surface of the state. They dominated the upland and bottomland throughout the southern third of the state

and along the western and northern parts, but in central Illinois were restricted to the stream valleys in the prairie counties.

The number of tree species found in these original forests was greater than in any state of similar or higher latitude and was probably surpassed by but nine in the United States. Omitting the genus Crataegus (hawthorn) Sargent '22 lists the number of native tree species in certain states as follows: Florida, 226; Texas, 186; Georgia, 175; North Carolina, 169; South Carolina, 154; Alabama, 154; Mississippi, 139; Tennessee, 130; Louisiana, 129; Arkansas, 120; California, 116; Indiana, 114; Pennsylvania, 110; New York, 102. Excluding the Crataegi there are herbarium specimens of at least 124 native tree species, and 23 additional varieties of some of them, which have been collected in Illinois, and there are 15 naturalized species.

The range in variety of species from the cypress-gum forests of southern Illinois to the larch swamps of northern Illinois was matched by very wide extremes in the development of the trees. In the lower Ohio and Wabash valleys grew the largest hardwoods on this continent, while on the sand plains of parts of the Mississippi Valley the scrub oak scarcely attained the height of a tree.

A general description of the original forests follows: In the bottomlands of the extreme southern region a belt of cypress and mixed hardwoods extended from central Wabash county down the Wabash and Ohio rivers and up the Mississippi as far as southern Union county. In the Wabash country cypress did not extend far from the main river bottom, but in the extreme southern part it grew in the sloughs of the Cache River area and extended up some of the lesser tributaries of the Cache. In this region associated species were tupelo gum, water elm, swamp cottonwood, red gum, and soft maple. Elsewhere tupelo was probably supplanted by soft maple, red gum, and elm. The cypress of Illinois never attained the size of the same species to the south, but it has been a valuable timber tree even here.

Extending along the flood-plains of the larger streams of the state was a splendid hardwood forest. That in the Ohio-Wabash region was the finest hardwood type in the country, and the forests along the other streams were scarcely less impressive in number of species and in the size of individual trees. The principal species were pecan, bitternut, shellbark and mocker-nut hickories, willows, cottonwood and swamp cottonwood, river birch, white, bur, lyre-leaved, yellow, swamp-white, cow, Schneck's, pin, shingle, and swamp Spanish oaks; white elm, hackberry, red gum, sycamore, Kentucky coffee-tree, honey locust, red and silver maples, box-elder, and blue, red, green, black, and white ashes. Catalpa grew in the Wabash-Ohio region. In the Kaskaskia bottomland pin oak had a tendency to form nearly pure stands. Towards the northern part of the state river birch was frequent on the bottomlands, but swamp cottonwood, several oaks, and red gum, did not grow there. Bur oak was largely restricted to the bottomlands in the southern part of the state; but in the northern region it grew extensively on the uplands as well. The syca-

mores of the Wabash bottoms attained the greatest circumference of American broad-leaves. The largest circumference on record is 42 feet 3 inches at a point 5 feet from the ground for a tree standing on the Indiana side of the Wabash (Deam '21). Another, near Mt. Carmel, Illinois, in 1875 measured 160 feet in height, with a circumference at the base of 42 feet, and a spread of crown of 134 feet. (Ridgway '82.)

Probably 80 feet represents the approximate height above ground of much of the better type of forests of Illinois that we are familiar with, and 125 feet represents the height of the present tallest broad-leaved tree, outside of this Wabash region, actually recorded in field work. These splendid bottomland forests of the Wabash country, with an average tree-top level of 130 feet (Ridgway '72), were above the height of our present highest trees, while the tallest trees were probably 200 feet in height, nearly twice the height of the tallest trees from other regions of the state. Individual acres of cypress bottomlands and of the mixed hardwoods yielded more than 25,000 B. F., and the average for the bottomland forests of the state was probably 9,000 B. F. to the acre.

Along the bottomlands of the secondary streams the forests were a rich mixture of hardwoods. Black walnut here found its best development, and in the northern part of the state basswood often formed an appreciable part of the forest. The average yield for this type in the original stands was about 8,000 B. F. per acre.

The upland forests of the state showed several notable regional differences. In the broken, hilly Ozark region, and extending over the dissected bluffs bordering the Mississippi, Illinois, Ohio, and Wabash rivers, was an excellent upland forest characterized by a greater variety and better development of species than elsewhere in the upland forests of the state. The species common to this region were black walnut; butternut; shagbark, big-shellbark, mocker-nut, and pignut hickories; ironwood, water beech; beech, white, bur, red, and black oaks; white and slippery elm, hackberry, red mulberry, cucumber-tree, tulip-poplar, papaw, sassafras, red gum, shadbush, black cherry, honey locust, Kentucky coffee-tree, hard maple, black maple, Ohio buckeye, sweet buckeye, basswood, black gum, persimmon, and white ash. Individual acres of this upland type yielded more than 12,000 B. F., and the average for the type was probably 6,000 B. F. per acre.

Over the poorly drained area of south-central Illinois where the deposits of the Lower Illinois glaciation prevail, there is an extensive region, occupied by comparatively poor forests in which but few species were represented. Open inter-stream savannas broke up the continuity of the forests; post oak grew in pure stands on the poorest soils; hickory and black oak grew on the better soils; and the average yield for this post-oak flat type was probably not more than 1,500 B. F. per acre.

Throughout the remaining forested uplands of the state the forests were largely made up of the oaks, with some hickory. These oak-hickory forests extended along the small streams and carried on a continuous struggle for possession of the prairies. The pioneers describe them as

of grove-like aspect, bordering the 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 sprouts were annually killed by fires, the occasional survivors developing into gnarled, fire-scarred outposts of the forest margin. The average yield for this oak-hickory type was probably 3,000 B. F. per acre.

One other extensive and three limited types are worthy of mention. Throughout the northern part of the state are extensive areas of sandy soils. Whether on the flood-plain of a large river or as an interior sand hill, the type of vegetation reflects the lack of soil moisture. Characteristically desert forms, such as cactus (prickly pear) may be found. Under certain conditions the vegetation assumed the character of a forest. Scrub oak is one of the commoner species but, with increase in water content of the soil, black oak and hickory occur, and on the best sites white oak grows. Jack pine grows with the scrub oak in the sand area south of Lake Michigan. The pioneers found much of this sand land an unforested waste; and where forests prevailed the average yield was probably 1,500 B. F. per acre.

Now limited to less than a dozen small areas in Lake and McHenry counties, though probably in recent times in many other sections, are the tamarack swamps so common to Wisconsin and regions to the north. These stands occupy parts of swamps, and the trees are generally small.

In two localities in the southern part of the state may be found stands of shortleaf pine. These occupy very exposed slopes on bluffs, and the trees scarcely grow to sawlog size.

The original forest also held a few groves of white pine in addition to scattered specimens. The southern limit of the species for this region was represented by a grove of two acres on the west bluff of Spoon River about one mile south of Dahinda, Knox county. North of the Illinois River, an occasional tree grew on the stream bluffs; and there is still a healthy stand of nearly pure pine about eight miles west of Oregon, Ogle county.

Compared with the United States as a whole, Illinois had almost exactly the average relationship between forested and non-forested area. The estimated area originally forested for the United States was 43.2 per cent of the land area, that of Illinois 42.58 per cent. Comparison of average B. F. yields for the areas actually timbered shows that the United States had an estimated average of 6,326 B. F. per acre against 4,281 B. F. per acre for forested areas of Illinois. The lower yield per acre in Illinois forests is due to their predominantly hardwood character—hardwoods averaging less than half the yield of conifers under similar conditions.

Thus the original forests of Illinois are estimated to have contained 65,385,884,000 B. F. or 16,346,471,000 cubic feet of lumber. Based upon the present average wood requirements per capita for Illinois, this forest contained a quantity of lumber sufficient to supply all the wood needed

from settlement until 1890, but the requirements of the state now have so increased that, whereas this original forest would have supplied sufficient wood to carry the population for the first 80 years, it contained less than a twenty-year supply under present conditions.

The table on pages 58-63 shows the forested areas present and original, by counties.

Outline of Forest Use From Original to Present Forests

The importance of forests to a pioneer people is admirably shown by the trend of settlement in Illinois. In 1800 Lexington, Kentucky, with 3,000 people, was the largest town west of the Alleghanies; and the total American population of Illinois was probably not as large as that of Lexington. By 1820 Illinois had a population of 55,211, practically all within the forested area. The pioneers built near the navigable rivers; succeeding settlers pushed farther from the river up smaller streams, but always settled in the forest where clear running water and material for fuel and shelter were available. Thus the initial settlement, concentrating upon the forested areas, resulted in the rapid clearing of the secondary stream-bottoms and some of the wooded uplands, and thus far pioneering in Illinois continued the practices of the older colonies. Some of the best of the original forest was destroyed to provide crop land, but there yet remained the heavy flood-plain forests of the larger rivers and a large per cent of the upland forests.

Over half the state was prairie land, until 1830 regarded as a desert. About this time the discovery that prairie land was good crop land initiated a flood of immigration. Between 1820 and 1870 the population of the United States quadrupled, while the population of Illinois increased forty-six times. In 1830 the settlement of the prairies began, and by 1840 less than one twenty-fifth remained unsettled, and this unsettled part was the finest of the black soil belt of Champaign and Ford counties. In this decade over 300,000 people settled on the prairies, creating an enormous demand for housing material, fuel, and fence posts. Railroads did not exist, and overland wagon-haul for lumber was out of the question. Under these conditions, local supplies of timber were the controlling factors in prairie settlement. Prairie land could not be sold unless several acres of forested land were included, and the relative values of prairie and forest per acre were about 1 to 7. Prairie land commonly sold for $5.00 per acre, woodland for $35.00 per acre, and frequently such woodland was several miles from the farm.

Gaged by our standards, the prairie pioneer was obliged to be wasteful. Sawmills scarcely existed. His buildings were constructed from logs, his fences from poles or rails. Open fireplaces consumed great quantities of fuel wood. He experienced a timber shortage at the very beginning; and, under pressure of dwindling local supplies, he established forest plantations about his prairie home. If he had a wood-lot he used the timber wisely. Fires were stopped and sprouts, which formerly were destroyed, developed into thrifty trees. As a consequence the limited

remaining forests were building up under favorable conditions. About 1855 rail and water transportation were so developed that the prairie farmer could replace his log buildings with white pine lumber from the great pineries of the Lake States. His fuel problem was solved by the perfection of the coal stove. With the development of rail and water transportation, land values were reversed in this region. In Logan county $10.00 prairie land went to $50.00 while $50.00 timber-land dropped to $25.00 an acre. Woodland came to be regarded as an encumbrance. Arable parts were cleared, grazing was practiced, and these forests suffered a deterioration which has continued to the present day.

Coincident with the utilization of these original forests adjacent to the prairies, the process of nibbling in the non-prairie forested region continued. Here timber was destroyed and wasted as a thing of little value. Until 1860 agriculture was the only important industry in the forested area. Then progressive development of railroads made a market for ties. Wood-using industries sprang up along the river towns and furnished a market for the better grade of the better species. In 1860 the timber owner might find a market only for the best of his yellow poplar, white oak, and black walnut logs. By 1870 ninety-two of the 102 counties of the state had manufacturing establishments dependent upon wood. The total number of such establishments was 19.44 per cent of all manufacturing establishments of the state, employing 31.5 per cent of all persons engaged in manufacturing industry, and producing 20.51 per cent of the value of all manufactures of the state. To keep these industries supplied wood was imported from other states. By 1870 Rock Island county led all counties in value of the lumber sawed, with Pulaski second. Logs from the Minnesota, Wisconsin, and Michigan pineries were rafted down to Illinois towns along the Mississippi or Lake Michigan, and manufactured into lumber to a total of 26 per cent of all lumber manufactured within the state. During the eighties the Lake pineries reached their peak of production. Rock Island county sawed 70,000,000 feet annually, or a fifth of all produced within the state, and other points drew upon these pineries. By 1900 thirty-four per cent of all lumber produced in the state was sawed from imported white pine logs, and the total lumber production for Illinois reached its highest point with 381,584 M. B. F. By 1909 lumber from such imported logs ceased to be a factor and production had dropped to 170,181 M. This total production was further reduced to 64,628 M. in 1919 as the original forests were drained. Perhaps 22,000 acres of virgin forest, about one township, remain of the original 15,310,205 acres of Illinois forests. This remnant occurs chiefly on the undrained flood-lands of the large rivers. The remaining forest is a culled or second-growth type. The reduction in area and yield of Illinois forest is shown by the following tabulation.

Year	Area timbered on farms	Total area acres	Total B. F. contents
1800 (original forest).		15,273,245	65,285,884,000
1870	5,061,578	6,019,531	
1923	2,815,150	3,021,650	3,498,388,000

The original forests have been reduced in area 80.22 per cent and the estimated yields 94.64 per cent.

Present Forests of Illinois

The field work of the survey of the present woodlands in Illinois was begun during the summer of 1921 and finished in 1924. Approximately 66 per cent of the state was systematically surveyed to determine the location, area covered, and condition of the forested areas. The 34 per cent of unsurveyed acreage is in the prairie counties where the smallest amount of woodland exists.

The methods of making the survey were as follows:

Forested areas were drawn on a base map of the region. In the very rough sections where no roads gave access to the country, the ground was covered on foot or horseback; over much of the state such mapping was done from an automobile. Distances to the wood-lot were estimated. Usually the sections are subdivided into forties by fencing, and this serves as a useful check. The estimated yield per acre of the area under observation was entered. As a check occasional samples were tallied and yields computed. The field data were worked up in the office to show the total forested areas and yields by counties. The tabulation of this information is given on pages 58 to 63. The maps III to VI reproduce, on a scale one fourth as great, nine of a series of twenty-seven maps made in the working-up of the field data.

General comparison of bottomland and upland forests

In a description of the present forests of Illinois, several natural divisions suggest themselves. The two general divisions—bottomlands and uplands—have forests of quite dissimilar composition.

The bottomland forests of the state originally bore a higher yield per acre and a greater variety of species than did the uplands. The area of bottomland estimated to have been covered by these original forests was 2,898,945 acres, virtually all of the bottomlands of the state. They probably contained 25,725,724,000 B. F. of lumber, an average of 8,875 B. F. per acre for this large area. Small areas having more than 25,000 B. F. of hardwoods to the acre still remain. The present bottomland forests cover an area of 739,508 acres, and have an estimated yield of 1,029,937,000 B. F.; an average of 1,393 B. F. per acre. Efficient logging can not ordinarily be carried on in stands of less than 2,000 B. F. to the acre. Eliminating all stands of saplings—fully stocked immature stands yet too small to produce lumber profitably—and those stands which have been culled until only occasional trees are of sawlog size, a state-wide comparison of desirable sawlog stands between uplands and bottomlands is about as follows: 8.9 per cent of the upland stands and 22.69 per cent of the bottomland stands yield 2,000 B. F. or better to the acre. Although the bottomlands occupy but one-quarter of the total forested area of the state, yet they contain almost as many acres of merchantable sawlog

timber as the remaining three-quarters of upland. Approximately 12.27 per cent of the present timbered area of the state is in good sawlog sizes, 6.72 being upland and 5.55 bottomland. For the entire state an area equal to 19.74 per cent of the original forested area is still forested, while but 18.4 per cent of the upland area originally forested is timbered. Based upon good sawlog timber we have 5.79 per cent of the bottomland area originally forested still in such timber, and 1.64 per cent of the original upland area, or an average for the entire state of 2.42 per cent.

In actual quantity, including not only stands yielding enough to insure efficient logging, but including all merchantable timber of the state regardless of the expense of harvesting it, there is 4.00 per cent of sawlog timber left from the original forests of the bottomlands; and 6.24 per cent of the upland timber—5.36 per cent for the entire state. The acreage and estimated yield of bottomland forests by rivers is shown in the tabulation p. 17. Data taken in the best upland stand and the best bottomland stand show the following comparison.

	No. of trees per acre	Maximum diameter	Maximum height	Average diameter	Average height	Yield per acre B. F.	Yield per acre Cu. ft.
Upland	73	38	95	13.8	70.4	17,596	3,604
Bottomland ...	53	40	130	16.8	82.1	20,063	3,914

FOREST TYPES

The bottomland forests have been subdivided into three types: (1) cypress and mixed hardwood, (2) mixed hardwoods of the main streams, (3) mixed hardwoods of the secondary streams. The cypress and mixed hardwood type is the association common to the bayous of the lower Mississippi region but is limited by climatic factors to southern Illinois. The difference between (2) the mixed hardwoods of the main streams, and (3) those of the secondary streams, is largely due to flood conditions.

The upland forests have also been subdivided into three types, based largely upon soil conditions: (1) post oak (2) scrub oak (3) upland hardwoods. The so-called post oak type is found on the heavy, acidulous soils usually having a clay subsoil. Post oak, scrub oak, hickory, and black oak are the usual associates, post oak being the commonest tree. The so-called scrub oak type is found on the sands. Scrub oak may be entirely absent here, in which case a stunted form of black oak, Hill's oak, or bur oak, with hickory, forms the association. The heavy soils, largely south of the Sangamon River, support both post and scrub oak; while the sands, generally north of the Sangamon, support scrub or black oak, but post oak is uncommon. Both the post oak and the scrub oak types are on soils of high acidity, low in organic elements, and subject to excessive drying. The growth rates are very slow, and the species native to such sites are few. The area of forested upland in the post oak and the scrub oak types aggregates but 21 per cent of the total forested upland. The third upland type, the mixed hardwoods, constitutes the remaining 79 per cent of upland forests, and is found on all upland soils between the extremes of open sands and tight loams over clay.

Samples of each of these six types were averaged to show species represented, and the proportion of the stand represented by each species.

BOTTOMLAND TYPES

Species	Cypress and mixed hardwood			Mixed hardwood of main streams			Mixed hardwood of secondary streams		
	Total trees on 15.46 acres	Trees per acre	Per cent of stand	Total trees on 37.7 acres	Trees per acre	Per cent of stand	Total trees on 14.9 acres	Trees per acre	Per cent of stand
White oak	65	4	5.1	206	5.5	5.7	142	9	14.8
Cow oak	2	.....	.1	16	.4	.1			
Bur oak	1	.....	.1	18	.5	.5			
Swamp white oak	19	1	1.5	21	.6	.6			
Post oak	.....	.....	.....	40	1.1	1.1			
Schneck's Oak	1	.....	.1	12	.3	.3			
Pin oak	42	3	3.3	477	12.7	13.3			
Black oak	54	4	4.2	32	.8	.9	153	10	16.0
Swamp Spanish oak	4	.....	.3	67	1.8	1.9			
Shingle oak	.....	.....	.....	9	.2	.2			
Ash	76	5	6.0	396	10.5	11.0	162	11	16.9
Elm	125	8	9.8	502	13.3	14.0	94	6	9.8
Soft maple	58	4	4.5	819	21.7	22.8			
Hickory	32	2	2.5	197	5.2	5.5	39	3	4.1
Beech	.....	.....	.....	.....	.....	.....	21	1	2.2
Tulip	.....	.....	.....	.....	.....	.....	17	1	1.8
Black gum	20	1	1.6	18	.5	.5	6	.....	.6
Hard maple	.....	.....	.....	.....	.....	.....	178	12	18.5
Red gum	134	9	10.5	154	4.1	4.3	15	1	1.6
Cherry	.....	.....	.....	2	.....	.1	10	1	1.0
Black walnut	.....	.....	.....	41	1.1	1.1	49	3	5.1
Sycamore	6	.....	.5	27	.7	.7	40	3	4.2
Honey locust	1	.....	.1	27	.7	.7	6		6.
Hackberry	8	.....	.6	52	1.4	1.4			
Basswood	.....	.....	.....	43	1.1	1.2	23	1	2.4
Willow	17	1	1.3	93	2.5	2.6	3	.....	.3
River birch	.....	.....	.....	122	3.2	3.4			
Cottonwood	51	3	4.0	173	4.6	4.8			
Kentucky coffee-tree	.....	.....	.....	.....	.....	.....	1		.1
Cypress	300	19	23.5						
Pecan	.....	.....	.....	30	.8	.8			
Catalpa	.....	.....	.....	3	.1	.1			
Tupelo gum	252	16	19.8						
Mississippi cotton-wood	7	.....	.5						
Totals	1,275	82	.....	3,597	95.	.....	959	64	
	Species = 22			Species = 27			Species = 17		

This information is given above and on the following page. As to the general regions where the cypress, post oak, scrub oak, and upland hardwood

types prevail see Map II (facing p. 1). The original woodland areas are shown by Map I (facing the Introduction). Maps III, IV, V, and VI (see folders) show forested areas for southern, south central, and northwestern Illinois respectively. The forested acreage by counties, present and original, is shown in the tabulation on pages 58-63.

UPLAND TYPES

Species	Post oak			Scrub oak			Mixed hardwoods		
	Total trees on 5.01 acres	Trees* per acre	Per cent of stand	Total trees on 7.68 acres	Trees* per acre	Per cent of stand	Total trees on 287.44 acres	Trees* per acre	Per cent of stand
White oak	1			43	6	2.6	5,196	18	33.3
Bur oak				1			49		
Acuminata							9		
Cow oak							2		
Post oak	866	173	73.8						
Red oak							298	1	1.9
Black oak	60	12	5.1	1,026	133	63.2	4,859	17	31.1
Shingle oak	11	2	.9				4		
Pin oak	6	1	.5						
Scrub oak	140	28	11.9	416	54	25.6			
Hickory	87	17	7.4	135	17	8.3	1,917	7	12.3
Elm	1						600	2	3.8
Ash	1						289	1	1.8
Hard maple							677	2	4.3
Beech							830	3	5.3
Black gum							211	1	1.3
Tulip							233	1	1.5
Black walnut				1			150		1.0
Red gum							82		
Basswood							228	1	1.4
Cherry							123		
Hackberry							45		
Honey locust							12		
Kentucky coffee-tree							18		
Mulberry							20		
Butternut				1			11		
Buckeye							4		
Big-toothed aspen							32		
Sycamore							12		
Black locust							5		
Total	1,173	233		1,623	211		15,916	55	
	* Samples from 5 counties Species = 9			* Samples from 5 counties Species = 7			* Samples from 28 counties Species = 27		

Bottomland Type

(1) cypress and mixed hardwood

The cypress and mixed hardwood type in the original forests bordered the sloughs and poorly drained areas of the Wabash bottoms from Mt. Carmel in Wabash county southward along the Ohio and Cache, and up the Mississippi to southern Union county (see Map II, facing p. 1). The finest stands were in the Cache River bottoms. Limited areas of pure cypress were found on the marginal areas of sloughs, but generally cypress was growing with broad-leaved species. Tupelo gum (*Nyssa aquatica*); water hickory; elm; soft maple; black and sweet gums; pin, swamp white, swamp Spanish, cow, overcup, and bur oaks; ash; hackberry; honey locust; water locust; Carolina poplar; Mississippi cottonwood; willow; sycamore; big shellbark, shagbark, mocker-nut, and bitternut hickories were associated species throughout the range. Beech was not an uncommon tree on the bottomlands of the Cache and the Mississippi, but generally was found on slight elevations subject, however, to inundation. Catalpa grew in the Wabash and the Cache basins but was absent from the Mississippi. Pecan grew in the Wabash and the Mississippi but was rare in the Cache basin.

The original forests containing cypress, pure or mixed with broad-leaves, could not have exceeded 250,485 acres, and probably amounted to less. The wooded areas where cypress is now found in commercial quantities total 21,088 acres in Alexander, Pulaski, Massac, Union, Johnson, and Pope counties. This acreage has an estimated total yield of 44,563,000 B. F. for cypress and broad-leaved species. Cypress does not form more than half of the total yield, and out of a possible total cypress yield of 22,000,000 B. F. not over 15,000,000 are in the yields heavy enough to justify logging.

The following quantities are given by the U. S. Census as the cypress cut for Illinois.

1899	1,435,000 B. F.
1909	2,183,000 B. F.
1919	2,228,000 B. F.

These figures indicate that the cypress of Illinois will last about seven years, or until 1931, at the present rate of cutting.

The soils in the Cache basin are largely deep silt loams. Their recognized fertility has led to drainage projects which will eventually convert much of the cypress area into crop land. This process is well advanced in the Wabash country, and throughout the cypress mixed hardwood region all but the wettest areas have been cleared. Over the entire cypress region but 8.5 per cent of the area originally forested now has timber. Clearing has been more extensive in this and the mixed hardwoods of the secondary streams than in any of the other types. The change in water-level, incident to drainage, results in the death of established trees, and prevents re-establishment of the species, so that cypress will probably disappear from the Illinois forests.

The bottomland associations in the Cache River basin are cypress and tupelo gum near the channels and sloughs, with some willow, elm, soft maple, sycamore, Carolina poplar, Mississippi cottonwood, ash, and red and black gums. Between the sloughs and the better drained parts red gum, ash, and pin oak form the bulk of the stand and water hickory may be found. On the better drained parts of the flood lands, the stands show a greater variety of species such as white, swamp white, Spanish, cow, overcup, bur and willow oaks; ash; hackberry; shagbark, big shellbark, mocker-nut, and bitternut hickories; honey and water locust; and even beech and hard maple. Approximately 43% of the Cache bottomland is still timbered.

These forests along the course of the Cache River are rather continuously wooded areas averaging two miles in width. (See Map III D.) The cutting practice has been to harvest the so-called "soft-woods" and to leave such species as oak and hickory. Consequently, these forests are composed of groups of young trees filling in between the old trees which remain. There remain but very few forties which have not been cut over from one to four times for "softwoods". In spite of this practice the growth is very fast and the yields per acre high.

The few virgin stands remaining show yields from 10 to 15M. B. F. per acre. (See Plate VI, Fig. 1.) The average for the entire 80,199 acres of Cache bottomland is 1,956 B. F. per acre as contrasted with 1,393 B. F. per acre average for all bottomlands of the state. The representation by species as given in the tabulation (page 10) shows that 22 commercial species were found on the 15.5 acres measured, and that the oaks and hickories make up but 17 per cent of the stand, while cypress and tupelo, unimportant or entirely absent from all other bottomlands, form in the Cache bottoms 43 per cent of the stand. Representation of species by per cents based on 15.46 acres (as shown on p. 10) is as follows: cypress, 23.5; tupelo gum, 19.8; red gum, 10.5; elm, 9.8; ash, 6.0; white oak, 5.1; soft maple, 4.5; black oak, 4.2; cottonwood, 4.0; pin oak, 3.3; hickory, 2.5; black gum, 1.6; swamp white oak, 1.5; willow, 1.3; hackberry, .6; Mississippi cottonwood, .5; sycamore, .5; swamp Spanish oak, .3; honey locust, .1; Schneck's oak, .1; cow oak, .1; and bur oak, .1.

Thus the Cache bottomland forests are characterized by rather continuous uneven-aged stands, by the greatest variety of species found on the bottomlands of any river system of the state, by a high representation of "softwoods" with such unusual species as cypress and tupelo gum commonly occurring, and by a relatively high yield per acre.

Measurements on a sample acre taken in a virgin tupelo-cypress slough and representing the better stands of this association are shown below. The 51 trees 12 inches and up in diameter on this acre were buttressed so that the diameter measurement was taken at 7 feet instead of 4½ feet from the ground. The tupelo gum grows very slowly and many of the larger trees were three centuries old.

Species	Tupelo	Cypress	Mississippi cottonwood	Soft maple	Total
No. of trees per acre	252	20	7	2	281
B. F. yield per acre	15,170	7,775	77	.....	22,922
Cu. ft. yield per acre	4,153	1,471	63	9	5,696
Maximum D. B. H. inches	31	32	12	8	
Maximum Ht.—Ft.	80	137	60	40	

A sample acre taken in virgin bottomland forest gave the following data on the association of trees which is common between the slough and the well-drained benches.

Species	Pin oak	Spanish swamp oak	Elm	Ash	Soft maple	Red gum	Black gum	Hickory	Total
No. of trees per acre	10	2	21	6	21	9	7	1	77
B. F. yield per acre	2,360	1,500	6,504	188	3,539	3,609	273	800	18,773
Cu. Ft. yield per acre	623	443	1,343	96	953	735	123	146	4,462
Maximum D. B. H. inches	27	34	35	14	28	30	16	26	
Maximum Ht., ft.	110	100	107	80	100	115	90	110	

A sample acre taken in a virgin bottomland forest yielded the following data on the association of trees which is common on the better drained parts of the bottomland.

Species	Pin oak	Swamp Spanish oak	Swamp white oak	Cow oak	Elm	Ash	Red gum	Hickory	Mulberry	Cotton-wood	Sycamore	Total.
No. of trees per acre ...	8	1	16	1	3	1	23	6	1	1	1	62
B. F. yield per acre	1,379	115	619	480	483	32	6,799	572	32	103	32	10,646
Cu. ft. yield per acre ...	409	43	286	85	161	21	1,620	202	21	39	21	2,908
Max. D. B. H. inches	23	15	17	.....	.....	.....	33	22				
Max. Ht., ft....	95	85	80	.....	.....	.....	105	95				

In the Wabash and Saline bottomlands the cypress is about cut out. In 1909 Gallatin, Saline, and Hamilton counties were reported to have cut 525,000 B. F. (Hall and Ingall 1911.) At present cypress is not of commercial importance north of Pope county. Formerly the associations were similar to those of the Cache bottomland except that tupelo gum and water hickory did not grow beyond Gallatin county. The incomparable hardwoods of the lower Wabash bottoms associated with the cypress were the same as those described under the mixed hardwoods of the main bottomlands (page 3). The removal of the cypress is altering this type along the main bottoms, and the limited forests of the future in this region will change to the mixed hardwood type.

(2) MIXED HARDWOOD BOTTOMS OF THE MAIN STREAMS

The division between the mixed hardwood type on the bottoms of the main streams, and the mixed hardwood type on the bottoms of the secondary streams is based upon flood conditions. Ordinarily the bottoms of the main streams are inundated for several weeks each year, and during this time the water outside of the channels has very little movement. On the secondary streams, however, the higher gradient insures that the excess waters will soon be drained off. These bottoms are flooded for a few days rather than for several weeks. Certain bottomland species which are not sensitive to excessive moisture, such as elm, soft maples, and sycamore, may be found well represented in each type; others, such as pecan, are naturally adjusted to protracted flood conditions, and are limited to the main bottoms; while others, such as black walnut, tulip, and basswood, do not grow well under conditions of protracted flooding, and are more characteristic of the bottoms of the secondary streams.

The original forest of this type, covering 2,283,679 acres, is now reduced to 718,303 acres, a reduction of 69 per cent in area. The estimated original quantity of 20,553,111,000 B. F. has been reduced to 985,374,000 B. F., a reduction of 95 per cent in quantity.

Based on samples totaling 37 acres from sixteen widely separated counties, the general bottomland representation by species in per cent is as follows: soft maple, 23; elm, 14; pin oak, 13; ash, 11; hickory, 6; white oak, 6; cottonwood, 5; red gum, 4; river birch, 3; willow, 3; swamp Spanish oak, 2; black oak, 1; bur oak, 1; basswood, 1; black walnut, 1; sycamore, 1; honey locust, 1; hackberry, 1; pecan, 1; Schneck's, shingle, cow, and swamp white oaks; black gum, cherry, and catalpa aggregating 2.

The detailed description of this type will be taken up by stream systems, but regional differences may be noted here. In general, the bottomland forests of the southern part of the state, (Wabash, Kaskaskia, Big Muddy, and Lower Mississippi rivers), show a greater variety of species, and trees attain greater sizes, than they do in the bottomland forests of the northern part (Illinois, Rock, and Upper Mississippi rivers). All the bottomland trees of northern Illinois are found in the bottoms of the southern part; while such trees as red and black gums, Mississippi cotton-

wood, catalpa, beech, and overcup, cow, swamp Spanish, and Schneck's oaks are not native to the bottomlands of the northern region at all. Elm and soft maple form about 57 per cent of the forest in the northern region, but only 21 per cent in the southern part. In the north the oaks, ashes, and hickories form 11 per cent; in the south, 66 per cent of the forest. Soft maple, the commonest tree in the northern bottomlands, makes up 43 per cent of the stand; while pin oak, the commonest tree in the southern bottomlands, makes up but 20 per cent of the total stand. Pecan is an occasional tree in the bottomlands of the Wabash, Ohio, lower Kaskaskia, lower Illinois, and entire Mississippi, rivers—extending to the Wisconsin line on the Mississippi—but does not grow on bottomlands of the Big Muddy or Rock rivers and rarely on those of the Cache.

ACREAGE AND ESTIMATED YIELDS OF BOTTOMLAND FORESTS BY RIVERS

Yields	River system							
	Cache	Wabash	Big Muddy	Kaskaskia	Illinois	Rock	Mississippi	Total
	Acreage							
C	13,105	267	1,453	.....	.....	.....	785	15,610
S	1,130	65,352	8,745	21,495	75,914	1,968	4,537	179,141
No. 1	33,895	127,206	60,611	75,112	34,624	5,525	39,984	376,957
No. 2	29,513	22,100	4,215	53,022	11,400	5,145	26,571	151,966
No. 3	2,436	598	116	11,307	713	62	133	15,365
No. 4	120	.....	.....	349	.....	.....	.....	469
Total acres	80,199	215,523	75,140	161,285	122,651	12,700	72,010	739,508
Estimated yield M. B. F.	156,869	209,057	76,267	349,827	77,025	24,130	138,979	1,032,154

* In the Yields column, C = culled forest, merchantable trees removed; S = saplings; No. 1 = stands having an estimated yield up to 2000 B. F. per acre; No. 2 = stands having an estimated yield from 2000 to 5000 B. F. per acre; No. 3 = stands having an estimated yield from 5000 to 10000 B. F. per acre; No. 4 = stands having an estimated yield over 10000 B. F. per acre.

The Wabash River System

Included in this system are the bottomlands of the Saline, Wabash, Little Wabash, and Embarras rivers. With the exception of the Wabash, these are comparatively small streams; yet, owing to the general flatness of the country, they have bottomlands out of all proportion to the size of the stream. The soils of the Saline, Little Wabash, and Embarras bottoms, grading toward clays, are generally heavy and grayish in color; those of the Wabash, grading toward sands, are generally light. Both are very fertile. The streams have a low gradient, and water stands for considerable periods in the extensive swamps. Drainage projects are reducing the area subject to flooding, yet this region still has 207,991 acres of wooded bottomland out of an original area of 736,457 acres wooded—about 28 per cent.

The early logging operations on these bottoms removed a limited number of trees, but gradually the markets absorbed an increasing variety. These bottomlands have been rather thoroughly cut over for saw-timber, until at present only about 11 per cent of the acreage has sufficient saw-timber to insure profitable logging. The average yield for the entire area of forested bottomland is the very low figure of 970 B. F. per acre as contrasted with the average of 1,393 for all bottomlands of the state. The present stands are very well stocked with saplings and young trees, and growth is rapid.

Three extensive bodies of bottomland timber remain in the Wabash region. The main Wabash bottoms, formerly growing the largest hardwoods in America, have been cleared except for the lower 10 miles. Here several thousand acres of forested land remain between New Haven and the junction of the Wabash and the Ohio. It has been heavily cut over and the present stand consists of immature timber or a few old pecan groves. The two other large areas of timbered land in the Wabash region are on the middle reaches of the Little Wabash River. Forested bottoms on Skillet Fork below Wayne City, aggregating over 30,000 acres, still contain several thousand acres of good saw-timber; while the other extensive area of forested bottom, on the Little Wabash above Fairfield, contains about 16,000 acres, mostly of saplings and immature timber. Drainage projects are developing all three of these forested bottoms, converting forest to crop land. Elsewhere in the Wabash region, the stands are belts along the streams or limited remnants of the former extensive forests.

These bottomlands are not subject to excessive deposition or erosion; rather, the water backs up over the bottoms, deposits a fine coat of soil, and eventually recedes. Under such conditions reproduction is very excellent and forests establish themselves readily.

These forests in the past supplied immense quantities of timber, mostly rough lumber. In addition special industries drew heavily upon these rich bottomland forests for material, such as sycamore in the manufacture of tobacco cases; red gum, soft maple, elm for wooden dishes, lard and sugar containers, egg crates, fruit and berry baskets; hickory for vehicle and tool stock; and white oak and black walnut for high grade veneers. The saw-timber in the present forests is rapidly being utilized, and is largely such inferior material as pin oak and defective trees left from original operations. These stands now produce large quantities of piling, railroad car stock, and cross-ties. In the Saline bottomlands even the pole-wood is worked up into mine timbers; but over the remainder of the Wabash system, trees are rarely cut commercially until they reach pile size.

In summary; some 30 per cent of the bottomland forests in the Wabash region are in three large bodies extending back from the stream two to four miles; the stands have an abundance of saplings, approach an even-aged character, have a high representation of pin oak and sweet gum, and a relatively low representation of soft maple and elm. The "hard-

woods", oak and hickory, aggregate 52 per cent of the stand; and the average sawlog yield per acre is relatively low.

The occurrence of species by per cents based on 5.53 acres of plots and line is as follows: pin oak, 30; red gum, 20; ash, 13; white oak, 9; elm, 9; hickory, 7; river birch, black gum, cow oak, black oak, swamp white oak, 2 each; soft maple, 1; with honey locust and black walnut occasional trees. Catalpa is native to these bottomlands. Pecan is common along the Wabash, but is found less frequently on the heavy soils of the lesser streams; while the big shellbark hickory is locally very abundant on these heavy soils.

The following table, derived from a sample taken in a well-drained virgin bottomland forest, shows the association and unusual sizes attained in the Wabash region.

Species	White oak	Black oak	Sweet gum	Black gum	Hickory	Elm	Honey locust	Sassafras	Ash	Black walnut	Total
No. of trees per acre..	15.5	4.3	10.2	3.3	11.2	3.6	.3	1.3	2.3	1.0	53
B. F. yield per acre....	11,081	2,133	4,556	144	1,472	92	201	31	309	44	20,063
Cu. feet yield per acre	1,891	401	993	59	379	42	36	11	88	14	3,914
Max. D. B. H., inches..	40	36	34	16	32	15	22	14	22	17	
Max. Ht., ft.....	130	120	125	70	120	95	125	80	110	70	

A fully stocked acre of 55-year-old pin oak in Hamilton county suitable for piling bore trees as follows:

Species	Pin oak	Cow oak	Schneck's oak	Swamp Spanish oak	Swamp white oak	Ash	Elm	Total	Av. Ann. growth
No. of trees per acre	58	7	1	1	1	9	4	81	
Av. D. B. H., inches.	16.9	10.0	12.0	13.0	9.0	7.7	13.0		
Average Ht., feet....	85	57	74	75	58	60	77		
Cu. ft. per acre.....	2,725.0	91.2	22.2	25.9	9.6	68.1	112.1	3,054	67.9
B. F. per acre.....	9,265	126	45	75	.....	22	375	9,908	180

The returns from this acre if harvested as piling are as follows: fifty-four piles totaling 2,450 linear feet at the average value of $ .12 per foot equals a gross return of $294.00 per acre. The cost of cutting, hauling, peeling, and loading averages $ .0575 per linear foot; the operators profit of 20 per cent of this cost of manufacturing is $.0115 per foot, making the total cost of production $ .069 per linear foot or $169.05 for the acre. Average taxes of $ .35 per acre compounded for 55 years at 4 per cent per year total $66.90. With the gross return $294.00 and the expenses $235.95 this acre gives a net return of $58.05 at the end of 55 years. Using 4 per cent over this period this return of $58.05 gives the soil a value of $7.60 per acre if devoted to the production of piling.

The returns from this acre if harvested as saw-timber are as follows: 9.9 M. B. F. having a stumpage value of $10.00 per M. gives a gross return of $99.00. Taxes at $ .35 annually, compounded for 55 years at 4 per cent total $66.90. Thus the acre yields a net revenue of $32.10 and this gives the soil a value of $4.20 when devoted to saw-timber production over a period of 55 years at an interest rate of 4 per cent.

Since waste bottomland in this region sells for $20.00 per acre, these unmanaged stands fail to return 4 per cent on this value. A yield of 80 piles or 3,200 linear feet in a 40 year period is possible in well-managed stands and represents a possible net return of $129.94. This return discounted at 4 per cent for 40 years gives the land a value of $34.18 per acre devoted to the production of piling, if the cost of management is met by returns from thinnings before the final crop is harvested. Under these conditions $20.00 land, instead of growing timber at a loss, produces a profit.

The Big Muddy River System

The Big Muddy is a relatively small river, with a low gradient, flowing through infertile, level uplands. Compared with the size of the stream the bottomlands are disproportionately large. The bottomland soils are deep gray silt loams approaching clays, and are fertile, though perhaps less so than most bottomland soils. The true bottomlands with these heavy loams are subject to flooding. On the lower course of the river

below Benton, these true bottomlands are often narrowed where the river has cut through old river terrace formations. The benches of these formations are from forty to sixty feet above the river and extend back, occasionally, two miles from it. Generally they are not subject to flooding; and the soils are very heavy, clays being common. The forests on river terrace soils elsewhere in the state generally more closely resemble upland than bottomland types; but in this region they conform more closely to the bottomland forests and are classed with the bottomland type.

The per cent of the bottomlands which are forested is high (73) and the forested area seems to be increasing in these bottoms. No important drainage projects have developed. The coal companies acquire ownership of the farms, and the forests quickly reclaim the bottomlands. These stands have been closely culled for saw-timber, and show the lowest percentage (5.8) of area in good saw-timber for any bottomlands of the state. The average yield per acre for all bottomland forested on the Big Muddy is 1,015 B. F. as compared with the 1,393 average for all bottomlands of the state. The stands are very well stocked with saplings.

Based on measurements taken on 7.8 acres in three counties, and including both bench and true bottomland sites, the representation by species is in the following per cents: pin oak, 20; hickory, 13; white oak, 12; elm, 12; ash, 10; swamp Spanish oak, 9; post oak, 5; soft maple, 4; honey locust, 3; sycamore, 2; river birch, 2; black gum, bur, Schneck's, and shingle oaks, 1 each, with red gum, hackberry, cherry, black walnut, and cow and black oaks aggregating 4. The various oaks make up 49 per cent—a decidedly higher representation for oak than is shown for forests on the other bottomlands of the state. These and the Wabash bottoms are the only bottomlands which show a higher percentage of the so-called "hardwoods," oak and hickory, than "softwoods", gum, maple, elm, sycamore, and woods used in the manufacture of baskets and hampers. In the Big Muddy bottoms these hardwoods aggregate 63 per cent of the stand.

A plot measured in an 18-year old stand on the true bottomlands indicated the relatively high volume produced on these soils. See table following.

Species	Pin oak	Ash	Honey locust	Soft maple	Elm	Total	Av. ann. growth
No. of trees per acre.	944	32	32	16	96	1,120	
Av. D. B. H., inches..	3	2	3.5	4	3.7		
Av. Ht., ft.....	30	30	30	32	30		
Cu. Ft. per acre.....	1,269	17	35	21	77	1,419	78.8

A plot measured in a 65-year old stand growing on a bench site indicates the relatively slow growth produced on these heavy soils. See table following.

Species	Post oak	White oak	Swamp Spanish oak	Shingle oak	Hickory	Black gum	Elm	Sweet gum	Total	Av. ann. growth
No. of trees per acre ..	36	12	64	8	24	8	4	4	160	
Av. D. B. H. inches	10	8	10	9.5	5.5	4	4	10		
Av. Ht., ft....	57	50	60	5.5	48	49	45	50		
Cu. Ft. per acre	513	106	828	70	68	10	25	39	1,659	25.5
B. F. per acre	772	80	820	68	.....	.....	.....	56	1,796	27.6

This is a region where many factors favor the practice of forestry, not alone in the bottomlands, but on the uplands as well. The land is largely held by coal companies. They are heavy consumers of the kind of wood produced in this region, and import large quantities from distant regions while their local holdings are not producing to full capacity. Fires which ravage the higher lands rarely damage these bottoms. Abundant natural regeneration insures heavy stocking, and permits the encouragement of the faster growing species and the removal of inferior species. Based on an average annual growth of 40 cubic feet per acre, of which 29.6 cubic feet is merchantable material, and on the average requirement of .246 cubic feet of wood for a ton of coal mined, each acre of bottomland can supply timber for 120 tons of coal annually for all time. Thus a mine with a yearly capacity of 100,000 tons requires 833 acres of such land continuously devoted to timber production.

The Kaskaskia River System

The Kaskaskia is a medium-sized river flowing through a flat region. In certain parts the gradient is as low as 10 feet to the mile for several miles away from the river, although definite bluffs occur where the stream has cut through glacial eminences and river terraces. The soils are generally deep gray silt loams, though sandy soils are not uncommon. North of Carlyle, drainage districts are in the process of organization; south of Carlyle, few drainage projects have been attempted.

One quarter of the area in good bottomland timber for the entire state is in the Kaskaskia bottoms. Of the 161,285 acres of bottomland forest in this region 64,678 acres, or 40 per cent, are growing timber of good saw-log size; and the average yield per acre is 2,169 B. F. as compared with the 1,393 B. F. average for all bottomlands of the state. Usually the stands near the river have been culled, and defective or low-

grade old trees and immature trees here form the forest. In the less accessible areas back from the river many stands of virgin timber remain. Finally, on accessible areas near the margin, even-aged stands of good saw-log size indicate that early cutting was heavy in such places. Near the channels and lower areas elm, soft maple, willow, honey locust, sycamore, and ash are the commonest trees. Farther back, on the better drained bottoms, pin oak often forms pure stands. The Kaskaskia forests have a higher percentage of ash, hickory, and white oak than any other bottomland forests of the state. They resemble those of the Big Muddy and Wabash bottoms in the high percentage (42) of "hardwoods", oak and hickory, which make up the stand; but differ by the absence of red and black gums, swamp Spanish and Schneck's oaks. Pecan is an occasional tree on the lower part of the river, extending up as far as Carlyle. Samples, aggregating 6.12 acres, taken in three counties, show that the stands are largely made up of relatively few species (12) in the following per cents: ash, 25; white oak, 14; soft maple, 13; hickory, 13; elm, 11; pin oak, 11; black oak, 4; sycamore, 3; black walnut, 3; hackberry, 2; river birch, honey locust, and cottonwood occasional. Thus 91 per cent of the forest consists of hickory, ash, oak, elm, and soft maple.

These forests are being worked up chiefly as lumber. They contain large amounts of low-grade species, such as pin oak, and lesser quantities of merchantable ash, hickory, and walnut.

A sample acre taken in virgin timber shows the following composition, yields, and sizes of individual trees which were characteristic of forests growing on the moderately well-drained flood lands.

Species	White oak	Pin oak	Hickory	Hackberry	Ash	Elm	Total
No. of trees per acre 6" D. B. H. and up.....	3	14	10	2	5	11	45
B. F. yield per acre....	427	7,588	2,540	.....	420	2,170	13,145
Cu. ft. yield per acre..	101	1,546	673	23	155	529	3.027
Max. D. B. H., inches...	22	39	25	9	20	32	
Max. Ht., ft.....	90	105	100	40	90	80	

The Mississippi River System

Approximately one third the entire length of the Mississippi borders Illinois. The difference in latitude between the extremes of the state is more than five degrees. The mean annual temperature of the Cairo station (58° F.) averages 10° F. warmer than that at the Dubuque, Iowa, station (48° F.). The mean annual rainfall at Cairo (41.6 inches) averages 6.6 inches greater than that at Dubuque (35.0 inches). The effect of these factors on the forest is to lessen the number of species in the association, and to cut down the growth-rates of the northern as compared with the southern forests.

From southern Union county to the Wisconsin border, there is approximately 533,350 acres of bottomland on the Illinois side. This is less than the area in bottomland on either the Wabash River or the Illinois River. The soils are very variable, but usually approach clays in the southern part and sands in the northern. The forested area, totaling 12,010 acres, or 16 per cent of the total bottomland, is about the same as the forested area on the bottomlands of the Big Muddy River. Thirty-seven per cent of this area is in timber of good saw-log size; the average yield per acre for this bottomland is 1,930 B. F.; and more than half of the forested area is in five counties. Jo Daviess, Carroll, and Whiteside counties in the north have 21,538 acres of woods on the Mississippi bottomland; while at the southern extreme Union and Jackson counties have 21,351 acres of this bottomland forested. The forests of each of these regions will be described as representing the conditions at the northern and the southern extremes where the larger bodies of timber are found.

In the southern part of the state, the bottomlands on the Illinois side are from three to four miles wide. (See Map III.) Depressions and sloughs of old river channels are frequent throughout, but usually the elevation near the bluffs is slightly less than nearer the river. Also the deposition near the bluffs is very fine, and clays are common; while much of the recent deposit along the present channel is of a sandy nature. The soils on this river plain are usually very fertile; and, despite the unfavorable factors, much of this land now forested will be developed, as virtually all is within organized drainage districts.

At present, forests are found as rather continuous bodies averaging less than a mile in width on the heavier soils near the bluffs; as strips bordering the sloughs throughout the bottomlands; and as a belt along the present river channel outside the levees.

Based on 4.6 acres measured in Union county, the representation of species in per cent is as follows: soft maple, 33; ash, 18; cottonwood, 14; elm, 12; hackberry, 10; pin oak, 3; red gum, 3; pecan, 2; river birch, 2; willow, 1; with occasional swamp white, bur, and lyre-leaved oaks.

The stands inside the levees, usually restricted to poorly drained depressions or heavy clay soils, are the remnants of the original bottomland forests. In their virgin state these forests were heavy stands of ash, elm, hackberry, soft maple, honey locust, various oaks, hickories, and gums, but logging operations have left very little of the original forests. At present these stands contain defective, or low-grade material, with valuable trees present in varying amounts. The best stands average as high as 12,000 B. F. per acre. Logging is still conducted on a limited scale. "Softwoods" suitable for fruit-containers' veneering grow very rapidly on these bottoms, and this region is the logical source of supply of this material for the adjacent fruit and truck gardening region. Pecan, being native to this region, is also encouraged and in places on these flood-plains the regular bottomland association is enriched by beech.

A sample plot taken in a 30-year-old stand shows the nature of the second growth now developing.

Species	Soft maple	Ash	Elm	Pecan	Pin oak	Willow	Box-elder	Total	Av. annual growth
No. of trees per acre	204	88	40	16	12	12	8	380	
Av. D. B. H., inches	7.0	6.0	4.6	7.0	9.0	12.0	3.5		
Av. Ht., ft.	70	60	55	76	77	90	50		
Cu. Ft. per acre	1,995	512	156	137	152	475	14	3,441	114.7
B. F. per acre	2,024	172	.....	.....	176	464	.....	2,836	945

The belt of forested land along the river is usually outside the levees. The width is rarely more than half a mile. Such forests are subjected to frequent flooding. New channels are constantly developing and old channels filling up. The recent deposit in this region is usually of a sandy nature, rich in organic substance. Under such conditions willow, cottonwood, and sycamore show abnormally rapid growth-rates. Although of limited area and relatively unstable, such land promises to pay higher returns per acre for managed timber-production than any other forested area in the state. Usually in unmanaged stands non-commercial willows control the site, with maple, sycamore, and cottonwoods as occasional trees. Cottonwood 18 years old is now being harvested from such stands, and sold to egg-crate manufacturers for veneers. Trees attain a height of a hundred feet, and an average D. B. H. of 12 inches at this age. The best trees attain a D. B. H. of 18 inches. Under management with cottonwood given precedence, pulp-wood can be produced in 10 years, veneer and sawlogs in 18.

Data from sample taken in an 18-year old unmanaged stand where cottonwood was almost wholly in control of the site follow.

Species	Cotton-wood	Willow	Total	Av. annual growth
No. of trees per acre	88	2	90	
Av. D. B. H. inches	11.5	9		
Av. Ht., feet	92.	90		
Cu. Ft. per acre	2,198.0	25	2,223	123.5
B. F. per acre	5,174	.....	5,174	287.

The value of the stand as pulp-wood at the 18-year period is as follows: 24.7 cords, valued on the stump at $1.25 per cord, totals $30,875; annual taxes at $ .40 per acre compounded at 5 per cent for 18 years total $11.25; returns as pulp-wood are $19.62 or $1.09 per acre per year.

The timber on this plot which was merchantable for veneer logs was harvested. Thirty-eight trees per acre were cut with a total scale of 5,174 B. F., Doyle rule: the stumpage value was $12.00 per M. This gives a gross return of $62.09 per acre. After the $11.25 cost of taxes and interest on taxes for 18 years has been deducted, this acre has returned $50.84 or $2.83 per year when devoted to the production of veneer logs. In addition to the 38 trees harvested for veneer, there remain 52 trees suitable for pulp, which contain 7.3 cords having a stumpage value of $1.25 per cord. Thus the acre has actually returned $50.84 over taxes, and has in addition a pulp-wood stand worth $9.12 giving the total returns, if cut clear, of $3.33 per acre annually from true waste land.

In the northern three counties, Whiteside, Carroll, and Jo Daviess, the bottomlands on the Illinois side are narrower than in the south. They average about a mile from the bluffs to the river in Jo Daviess county and widen out in Whiteside county to three miles. The bottomland soils are usually sands and gravels, and much of the land is scarcely worth development. Here also, the Mississippi flows through many channels, and the wooded islands are usually less than six feet above the general river-level. The bottomlands in Jo Daviess county are about 40 per cent wooded, and the forests frequently extend from the river to the bluffs. In Carroll and Whiteside counties the forests are on the islands, and along the river as a rather continuous belt with a maximum width of two miles, while the area near the bluffs is cleared. (See Map VI A.)

Between 1830 and 1850 these forests were heavily culled to supply fuel and building material for settlers on the neighboring prairies, and fuel for steamboats, river towns, and the Galena mines of Jo Daviess county. By 1870 the Wisconsin white pine was supplying the building material for this region. In recent years cutting has been light, reproduction by both sprouting and seedling abundant, and the stands are generally overstocked with immature trees crowding in among the occasional old and defective trees. Much of this second growth is passing from pole-wood to sawlog size.

The association is largely "softwoods", and a half dozen of the less valuable species make up 95 per cent of the stand. Based upon measurements totaling 6.36 acres, the representation of species by per cents is as follows: soft maple, 39; elm, 22; willow, 14; river birch, 12; pin oak, 7; ash, 5.

A sample taken in a 25-year old sprout-seedling stand furnished the following data:

Species	Soft maple	Elm	Pin oak	Ash	River birch	Total	Av. annual growth
No. of trees per acre..	224	240	152	24	8	648	
Av. D. B. H., inches..	4.4	3.7	4.2	5.0	12		
Av. Ht., feet.....	38	36	38	45	60		
Cu. Ft. per acre.....	494	355	377	50	142	1,418	56.7

The Mississippi bottomland between the northern and southern extremes has been developed. Forests are found rather generally on the low islands, outside the levees, and hold a very restricted area elsewhere. Also, river development, notably at Keokuk, has raised water levels over considerable areas, thus drowning out the forests outside the levees. In certain regions (Carroll and Henderson counties) sands are found on the flood-plain. Here the forest growth is altogether different from the usual bottomland association. It is described under the scrub oak type. In many instances the stands on the islands are cut regularly for cordwood from which charcoal for gunpowder is derived. A pulp manufacturing company has purchased several islands and is developing plantations of cottonwood and maple.

The association is similar to that in the extreme northern area, the soils are usually fertile, and growth rates are excellent.

The Illinois River System

The bottomlands of the Illinois River are very definitely bounded on each side by bluffs from four to ten miles apart. The soils are light, pure sands being common. Formerly this river valley contained many large areas of shallow lakes and sloughs where reeds and willows prevailed. Drainage projects have reclaimed most of this valley with the exceptions of the lower twelve miles, of the region near the junction of the Sangamon, and of the region of the Big Bend at Hennepin. These areas have some 3,000, 4,000, and 16,000 acres respectively of bottomland forested, but 77.4 per cent of the entire valley is cleared. The development of levees, in most places, has confined the river within a narrow channel, while the Chicago Sanitary Canal has increased the volume of water. Consequently, those forests outside the levees or in undrained areas have been killed by excess flooding, and throughout the lower part of the valley forest conditions have been changed by changing water-levels.

These forests have been culled heavily for saw-timber until there remains but 12,113 acres, or 9.8 per cent, in good saw-timber on a total of 122,651 acres forested. Even saplings and immature timbers are harvested for pulpwood and cordwood. Based upon samples aggregating 4.78 acres taken in two counties, the representation in per cents by species is as follows: soft maple, 55; cottonwood, 18; elm, 11; pin oak, 4.5; pecan, 3.5; ash, 3; willow, 2; river birch, 2; with infrequent bur oak, hickory, sycamore, black walnut, and honey locust. Thus soft maple, cottonwood, and elm make up 84 per cent of the stands; and oak-hickory comprise less than 5 per cent of the stands.

With the adjustment of the average water-mark to new and higher levels, there has followed a readjustment of forest associations. The cottonwood, maple, and elm have at first controlled many of the new sites. Cottonwood, on light soils such as prevail over much of these bottomlands, outstrips all competitors in growth, and is the most profitable forest tree for such land.

Measurements taken on a 20-year old stand seeded on an abandoned field show the following:

Species	Cotton-wood	Soft maple	Willow	Elm	Total	Av. annual growth
No. of trees per acre..	260	428	48	88	824	
Av. D. B. H., inches....	7.61	2.87	7.25	1.95		
Av. Ht., Ft.....	65	35	65	30		
Cu. Ft. per acre.....	1,866.0	476.0	286	50	2,678	133.9
Cords	20.7	5.3	3.2	.5	29.7	1.5

A sample acre taken in a 45-year old stand shows the relatively high yield for saw-timber, veneering, and pulpwood obtained in this period.

Species	Cotton-wood	Soft maple	Elm	Ash	Total	Av. annual growth
No. of trees per acre..	58	105	32	1	196	
Av. D. B. H., inches....	18	9	7	8		
Av. Ht., ft.....	95	60	52	60		
Cu. contents per acre..	3,379	1,623	227	6	5,235	116.3
B. F. yield per acre....	13,059	3,498	104	.....	16,661	370

The acre taken in the 20-year old stand has produced 23.9 cords of cottonwood and willow of a size suitable for pulpwood purposes. The elm and soft maple form an unmerchantable under-story. This pulpwood has a stumpage value of $1.25 per cord, or $29.88 per acre. The land was originally purchased for the shooting privileges. Taxes at forty cents per acre per year compounded for 20 years at 5 per cent total $13.23 per acre. This acre, if harvested at twenty years as pulpwood, will pay the carrying charges of taxes with interest on taxes; and will show a net return of $16.65 or $ .83 per acre per year from land unsuitable for agriculture.

The sample taken in the 45-year old stand shows a production of 58.1 cords of cottonwood, soft maple, and elm suitable for pulpwood, or 16,600 B. F. of material suitable for veneer logs. Devoted to pulpwood, the stumpage value for 58.1 cords at $1.25 per cord is $72.62. Taxes, at $ .40 per acre, compounded over 45 years at 5 per cent total $55.88. Thus, this acre, if harvested for pulpwood at 45 years, returns $16.74 over the carrying charge of taxes with interest on taxes; or $ .37 per acre per year.

Devoted to veneer or sawlogs, the 45-year old plot shows a yield of 16,600 B. F. per acre of this material. A stumpage value of $10.00 per M. gives the value of this acre for veneer material as $166.00, annual taxes at $ .40 per acre compounded at 5 per cent total $55.88. Thus, this acre, if harvested for veneer logs, returns $110.12 over carrying charges of taxes and interest on taxes, or $2.67 per year.

These figures serve to show that returns are dependent upon the form of product, and the period required to produce a wood crop, as well as on the amount of wood which can be grown annually. The annual increment of the twenty-year plot, 1.195 cords per acre, gives a net return of 0.83 per acre annually as pulpwood. The higher annual increment of the 45-year old plot, 1.291 cords per acre, gives a net return of but $0.37 per acre annually as pulpwood; but harvested as veneering it gives a net return of $2.67 per acre annually.

The Rock River System

The upper stretches of the Rock River flow through a region of numerous lakes. The soils over the entire drainage basin are light, gravels and sands predominating. Consequently, this river is not subject to extreme flood conditions, nor does it have extensive bottoms where water stands for several weeks. The forests in many respects resemble those described under the mixed hardwoods of bottoms of secondary streams. Approximately 92 per cent of the bottomland is cleared. The remaining bottomland forests, totaling 12,700 acres, are on the islands or as strips along the river margin. About 41 per cent of this area is in timber of good sawlog size, chiefly elm, ash, cottonwood, soft maple, bur oak, and basswood. Samples totaling 2.5 acres show the following representation of species by per cents: elm, 35; basswood, 20; ash, 16; soft maple, 11; black walnut, 11; hackberry, 5; and bur oak, 2.

Very little of the Rock River region is in organized drainage districts, and probably the present forested area will be retained. The Rockford furniture factories offer a market for high-grade logs for furniture, or low grade for crating; but in general the bottomland forests have supplied very little material.

A sample acre of virgin bottomland shows the association, sizes, and yield of such stands.

Species	Elm	Ash	Black walnut	Soft maple	Bass-wood	Hack-berry	Bur oak	Total
No. of trees per acre	28	14	9	9	17	4	2	83
Max. D. B. H. inches	30	21	23	13	19	17	16	
Max. Ht., feet..	90	85	90	60	70	77	75	
Cu. ft. per acre.	1,281	365	363	120	435	142	33	2,739
B. F. per acre...	5,320	885	1,119	325	1,011	399	80	9,139

(3) MIXED HARDWOODS OF BOTTOMS OF SECONDARY STREAMS

The bottoms of the minor streams of the state have accumulated the wash from adjacent slopes and the deposits from occasional floods. These soils are generally mixed loams, rich, deep, well drained, and highly valued for crop land. Originally forested, they are now cleared wherever in

units large enough to crop. It is a type intermediate between the association of the flood-plains of the large rivers and the upland types; and in general more nearly conforms to the sandy loam associations of the upland hardwood type than to any other. Such characteristically bottomland species as river birch, cottonwood, sycamore, and silver maple are associated with such typically upland species as basswood, hard maple, tulip-poplar, and red oak; or certain species common to both bottomland and upland, such as elm, hackberry, and honey locust, grow best on these well-drained bottoms. Black walnut makes its best growth throughout the state in this type. In the Ozark region, the species commonly found on these bottoms are beech, hard maple, red gum, tulip, shagbark and shellbark hickories, black and white walnuts, red and white oaks, white elm, hackberry, sycamore, honey locust, Kentucky coffee-tree, black gum, and white and green ash. About the same association occurs where such bottoms are wooded in the counties bordering the Wabash River, although pin oak becomes a common tree here. Along streams tributary to the Big Muddy, Kaskaskia, Saline, and Little Wabash rivers, this type has a higher percentage of the oaks. Pin and shingle oaks are the commonest trees, with white, cow, bur, and red oaks, and shagbark, bitternut, and mocker-nut hickories of frequent occurrence, and black walnut, honey locust, hard maple, black cherry, river birch, and cottonwood occasional. Red gum does not occur in the Kaskaskia region; hard maple and basswood are not common in either the Big Muddy or Kaskaskia basins; and tulip does not occur north of a line extending from southern Randolph county on the Mississippi side to southern Williamson and Saline counties, thence up the Wabash to Vermilion county, and inland to eastern Hamilton and Wayne counties.

Throughout the central and northern parts of the state, the bottoms along the secondary streams have appreciable quantities of elm. Near the heads of streams just off the prairies, soft maple and elm often form the entire stand; but honey locust, box-elder, hard maple, river birch, black and white walnuts; bur, white, swamp white, and red oaks; ash, black cherry, Kentucky coffee-tree, and shagbark and bitternut hickories may enter into the composition. Basswood, in some of these stands in La Salle county, makes up a high proportion of the forest and is a commoner tree in the northern than in the southern part of the state. Hickory forms nearly pure stands on the bottoms along Bear Creek, Hancock county. It is doubtful if beech occurs native anywhere in the central or northern part of the state north of Vermilion county, with the exception of a very few trees in Lake and Ogle counties.

A representation of species by per cents based on 14.4 acres of samples from the northern, central, and southern regions shows hard maple, 19; ash, 18; black oak, 17; white oak, 15; elm, 10; black walnut, 5; hickory, 4; basswood, 3; beech, 2; tulip, 2; cherry, 1; and black gum, honey locust, and Kentucky coffee-tree aggregating 2. Ash, black walnut, and hard maple occur more frequently in this type than in any other.

In certain parts of Boone, McHenry, and Lake counties, where stream erosion has not developed sufficiently to properly drain the recently glaciated region, a marsh or meadow type of vegetation prevails on the bottomlands, and forests are on the elevations. In Lake and McHenry counties some of these poorly drained bottoms have the tamarack bog association common to Wisconsin. This is of ecological interest as representing one phase of the initial period of forest development, just as the few beeches in the ravines of Lake county are of interest as representing the climax type or final state of forest development for the region. However, neither is important as a producer of wood, since there are only a few beeches, and since the tamarack, covering but 157 acres, is rarely more than 12″ D. B. H. (Waterman, '21.)

Upland Type

(1) *Post Oak*

The area included in this type lies largely between southern Shelby and southern Williamson counties in those regions drained by the Kaskaskia, Big Muddy, Saline, and Little Wabash rivers. Thus it extends from within ten miles of the Mississippi on the west across the interior of the state to within twenty miles of the Wabash on the east. It is somewhat less than, but almost entirely within, the area covered by the Lower and Lower Middle Illinoisan glacial invasion. (See Map II, facing p. 1.) Isolated areas of small extent are found in Knox, Massac, Hardin, Pike, Union, and other counties.

During the ice invasion, preglacial eminences were ground down and valleys were filled. The retreating ice left a deep deposit of unstratified boulders, gravel, sand, silt, and clay similar to the glacial till of northern Illinois. Following a later ice invasion (the Iowan), which was limited to the northern part of the state, a very fine soil was carried by the wind and deposited extensively over the entire state. Later ice invasions buried and modified this loessal deposit in the central and northern parts of the state, but throughout the south-central region it averages from four to ten feet in depth and forms the very fine, poorly drained soils of this post oak region. These fine-textured, gray, surface soils are generally underlaid by a stratum of silty clay. The resultant poor drainage renders these soils of low agricultural value.

The general flatness of the region is broken by occasional glacial moraines or preglacial eminences, rarely more than one hundred and fifty feet above the plain level, and by the valleys of the intersecting streams. The larger stream valleys have a wide level floor but a few feet below the general plain-level. Gradients are low and extensive bottomlands are common. About 12% of this region is bottomland, whereas the average for the entire state is 8%. Where the layer of loess has been eroded, as along the stream courses, the soil is a yellow-gray silt loam, changing to yellow silt loam as erosion progresses deeper.

Originally the forests completely covered the bottomlands and about 58 per cent of the uplands. About 63 per cent of the entire region was forested. At present 6.9 per cent of the uplands have forests, representing in area 13.4 per cent of the area originally forested.

This type extends over 8,600 square miles, and variation in the forest is consequently to be expected. Throughout this region the upland forests are of two rather distinct types, the post oak associations on the level lands (type 1), and the upland hardwood association on the slopes (type 3).

The post oak flats have a light gray soil and a very tight subsoil. On the poorest soils post oak (*Q. stellata*) may grow pure or associated with black-jack oak (*Q. marilandica*). Improved drainage conditions bring black oak, shingle oak, and hickory associated with the post oak. In the basins within these upland flats, where moisture collects but where the subsoil is somewhat more pervious, pin oak often grows. The representation of species by per cents, as given in the tabulation, page 11, based on measurements of stands totaling 5.01 acres in five counties, is as follows: post oak, 73.8; scrub oak, 11.9; hickory, 7.4; black oak, 5.1; shingle oak, .9; and pin oak, .5. On these soils all of these trees have a low growth-rate, and the stands usually have a great number of stunted, bushy trees to the acre. At 100 years, post oak averages 56 feet in height and 14 inches in diameter at the stump on these poor soils. Occasional trees may attain a height of 65 feet and a diameter up to 30 inches, but such trees represent defective and gnarled veterans upwards of 300 years old. (Plate VI, Figure 1.) Ordinarily the stands appear decadent at 100 years and do not produce trees of sawlog size. Sawlogs have been harvested from virgin stands; but such forests contain comparatively few trees to the acre, such trees are over a century in age, and the product is of low quality. This combination of the very long period required to grow sawlogs, the low yield per acre secured, and the inferior quality of logs, makes sawlog production on post oak sites a very unprofitable undertaking.

Throughout this region the coal mines use large quantities of small timber in the round for props, legs, bars, and mine ties. Seventeen counties of this region produce 73 per cent of the coal mined in Illinois. Based upon an average wood consumption for mine timbers of .246 cubic foot per ton, the mine timber consumption for this region was 14,438,753 cubic feet in 1921. A cubic foot of standing timber in the trees of the class from which mine timbers are produced will yield .74 cubic foot of mine timbers. Hence the consumption of 14,438,753 cubic feet at the mine is equivalent to 19,511,830 cubic feet of standing timber.

The annual growth per acre, for 14 plots in post oak stands taken in this region, varied between 9 and 24 cubic feet with an average of 15.8 cubic feet. The product of the entire 386,418 acres of forested upland in the post oak region, if fully stocked, would supply about 31 per cent of the mine requirements. The mines draw upon the Ozark bottomlands and uplands as well as on the post oak region for material.

The returns from post oak land devoted to raising timber crops do not pay the taxes when the crop is harvested as fuel wood, and barely pay taxes when devoted to production of fence posts or mine timber. Over 30 years are required to grow trees large enough for fence posts and from 30 to 60 for mine material. The average annual production of 15.8 cubic feet per acre of standing timber is equivalent to 11.7 cubic feet of mine timber. The net stumpage value, based on the sale value from which is deducted the cost of logging plus 20 per cent, is $ .0418 per cubic foot. Thus the annual returns on an acre devoted to the production of mine timber are $ .489. The taxes on such land average $ .50 per acre per year.

If cordwood is harvested, the annual increment of 15.8 cubic feet per acre at a net stumpage value of $ .0115 per cubic foot gives a return of $ .18 per year. Since the taxes average $ .50 this land is costing the owner $ .32 per acre yearly.

The possibilities of finding a more profitable use for this type of land seem remote. It is in timber because experience has proven that it can not be farmed at a profit, but these areas are among the least productive for forest crops of any in the state.

With improved drainage conditions post oak improves in both form and growth rate, and black, white, and shingle oaks and hickory are associated. Much of this type of land has been cleared. The remaining stands show yields intermediate between the post-oak flat stands and the upland hardwood stands of the slopes.

Samples from fully stocked stands are tabulated below.

A 40-year old Stand, Perry County

Species	Post oak	Scrub oak	Pin oak	Hickory	Total	Av. annual growth
No. of trees per acre.....	232	236	4	4	476	
Av. D. B. H., inches.....	4.6	5.3	7.0	2.0		
Cu. ft. per acre.....	33	30	35	30		
B. F. per acre.....	414	402	2	13	831	20.8

A 65-year old Stand, Franklin County

Species	Post oak	Scrub oak	Black oak	White oak	Hickory	Total	Av. ann. growth
No. of trees per acre.....	84	40	40	4	20	188	
Av. D. B. H., inches.....	5.0	7.4	9.6	88.0	7.4		
Av. Height, feet.....	32	32	54	45	48		
Cu. ft. per acre.....	175	179	416	19	128	917	14.1
B. F. per acre.....	.....	96	540	.....	148	784	12

A 75-YEAR OLD STAND, RANDOLPH COUNTY

Species	Post oak	Black oak	Hickory	Total	Av. annual growth
No. of trees per acre.....	184	20	16	220	
Av. D. B. H., inches.....	7.5	8.1	5.0		
Av. height, feet.....	35	40	32		
Cu. feet per acre.....	739	153	28	920	12.3

The flatness of this section is varied by occasional preglacial eminences and glacial moraines rising above the general level, and by stream courses cut nuder this level surface. In such places drainage is good, and the stands belong to the upland hardwood type found throughout the interior in the central and northern parts of the state.

On the moraines and like areas of the preglacial eminences where the soils are deep, forest growth is the best for the uplands of the region. Black oak is the commonest tree; associated species are white and red oak, hickory, ash, and cherry. These are the only upland areas within this region where black walnut grows well. On those preglacial eminences where the soils are thin, frequently a very inferior growth of scrub oak (*Q. marilandica*) occurs.

On the slopes where the flat upland breaks to the stream, the soil type changes to yellow-gray silt loam and lacks the tight subsoil. These slopes are among the best agricultural soils of the region. They were originally entirely forested, but have been cleared in those areas where the slopes permit tillage. Gully erosion was noted in Perry, Washington, Williamson, Franklin, Jefferson, Clay, Hamilton, and Wayne counties. In general the steeper slopes are forested. White oak is often the commonest tree. Shingle and black oaks together with white oak often comprise 90 per cent of the stand on the southern and the western exposures. Other species are hickory, ash, basswood, cherry, hard maple, elm, and black walnut.

The virgin forest has long since been cut from the uplands, the succeeding growth is harvested as soon as the trees grow to small sawlog size, and even the saplings are frequently worked into mine timbers; yet fire and grazing injury has not been common, the result being that the remaining stands throughout this region are better stocked than those of either the Ozark bluff region or the upland hardwood region to the north. Regeneration is by both sprouts and seedlings. The stands are uneven-aged, with full representation from saplings to small sawlog size.

(2) *Scrub Oak*

Sands and sandy loams are found throughout central and northern Illinois. Waters from the melting ice-sheets carried great quantities of soils. The coarser materials, such as gravels and sands, were quickly deposited. Receding floods exposed these deposits to wind action, and the finer sands drifted. Whenever conditions became stabilized to the

extent that grasses and trees could gain control the sands were anchored. With the destruction of the vegetative cover they resumed their drifting. Forests have a very important place in the land economics of these sandy regions. Solely as protective cover they are justified. As will be shown later, they may also be developed to produce a profit.

The sandy loams, being fertile are universally cleared. The dune sands are the least fertile of any of the soils of the state. The presence of very moderate quantities of loam or loess greatly improves the quality of the sandy soils, while a very little organic matter in the surface soil binds dune sand. Thus the sandy soils are very sensitive and unstable, reacting disproportionately to very slight changes in physical composition. It follows that improper handling of these soils may not only quickly destroy their productivity but also convert them into drifting wastes which menace adjacent areas.

In Illinois the wind is a more important agent than water in eroding, transporting, and depositing sands. Bare sand washes readily, but such soils are so open that in ordinary rains there is no appreciable surface run-off nor consequent erosion. The ground surface in the sandy areas is ordinarily a series of swells and depressions, the gradient of slope is low, and gullying does not occur. Very different conditions arise when the sands are modified by strata of clay or by loess. On these modified soils the run-off increases, yet the high sand content insures good drainage under ordinary conditions. In certain parts of Whiteside and Carroll counties, however, where the slopes are considerable, the modified sands have gullied seriously. Such ravines ordinarily develop during an exceptionally heavy storm, the process of formation being very rapid. A gully several feet deep often develops in an unbroken field during a single storm. Once started it eats back into the fields. An example of such erosion in 15 years has cut back into a field 125 feet, gouging a ravine 100 feet wide and 70 feet deep. Areas as large as twenty acres are so thoroughly gullied that they can not be crossed. (See Pl. II for examples.) Ultimately such land reverts to forest. The areas where such erosion occurs aggregate several thousand acres and merit detailed study before attempting to classify the land into agricultural and absolute forest land.

The effect of wind upon sand is evident in all these sandy regions. Drifting sand forms low hills having a gentle slope on the windward side, and a steep slope to the leeward. The ridges are often in parallel alignment and move before the wind burying everything in their progression. Covered by vegetation these dunes become fixed. Destruction of the cover results, under certain conditions, in the development of crater-like depressions from which the sand is blown. In extending agriculture into these areas, man has destroyed the cover and initiated a new advance of some dunes previously fixed; he has also attempted through cover crops and forest plantations to fix sands which are in motion. The desirability of a forest cover on blow sand is apparent, but the site is so unfavorable that forests do not readily establish themselves. Bunch grass and prickly

pear gain a foothold and stabilize the sands. A scrubby forest may then develop. Of the trees native to the sand areas, black oak (*Q. velutina*) is the commonest. In the southern areas black-jack oak (*Q. marilandica*) is common, and in the northern areas bur oak (*Q. macrocarpa*) occurs frequently. Hickory (*Carya cordiformis* Wang.) and white oak (*Q. alba*) are found throughout the sand regions, but their presence generally indicates better soil conditions.

The tabulation on page 11 shows that the representation of species by per cents based on measurements covering 7.68 acres in five counties, is as follows: black oak, 63.2; scrub oak, 25.6; white oak, 2.6; and hickory, 8.3.

Extensive areas of sand, in the form of dunes or river and lake deposits, are known to exist in twenty-eight counties of the central and northern parts of the state. The State Soil Survey has covered twenty-six of these counties, computing the sandy areas in twenty. In the remaining six, these areas have been estimated from maps completed but not yet measured. In two counties where sand deposits exist, no information as to their area is available. The twenty-six counties show approximately 221,000 acres of dune sand and 71,000 acres of river and lake deposit sand. The greater part of the sand deposits of the state are included in these twenty-six counties, and the total area of the state covered by sand is at least 310,000 acres. (See Map II, facing p. 1.)

The delineation of those areas in the sandy region which were originally forested is less reliable than for non-sandy soils. The organic carbon contents in the upland prairie loams are decidedly greater than in the upland timber soils, and in the field the transition from prairie to timber soil is readily apparent in the lighter color of the latter. The organic carbon content of sands is not markedly greater for prairie sand than for timbered sand, and in neither case is sufficient to give a decided color to the soil. About 75 per cent of the sand soils are classified by the Soil Survey as terrace soils. Such soils in this study are considered upland soils, and are generally regarded as originally non-forested. At present considerable areas of such land are forested with even-aged stands of an age roughly corresponding to the period which has elapsed since the region was settled.

The total area included in the scrub oak type is 2,145,120 acres, of which 20.94 per cent is estimated to have been forested originally, and of which 4.26 per cent is at present forested. Within the general areas covered by this 2,145,120 acres are 310,000 acres of pure sand and the balance of the area has soil of a generally sandy nature. The sandy loams have been cleared and the 91,611 acres of the scrub oak type now wooded are largely on poor sand land.

While forests are justified here solely on their ability to check the drift of sands upon neighboring fertile soils, yet the stands native to the site are stunted and scrubby. Black oak commonly attains a height of 50 feet with a clear bole of 10 feet and with a bushy crown. The products from such forests have little value other than for fuel and post ma-

terial, the yields being very low. The annual growth on 24 plots of this type, varied between 11 and 47 cubic feet, with an average of 28.6 cubic feet per acre.

The tabulation below shows data on fully stocked stands.

A 25-year old Stand, Mason County

Species	Scrub oak	Black oak	Hickory	Total	Av. ann. growth
No. of trees per acre	656	240	32	928	
Av. D. B. H., inches	2.8	3.5	2.0		
Av. height, feet	20	26	20		
Cu. ft. per acre	434	248	16	698	27.9

A 40-year old Stand, Kankakee County

Species	Black oak	White oak	Sassafras	Total	Av. ann. growth
No. of trees per acre	240	48	176	464	
Av. D. B. H., inches	6.8	5.6	3.6		
Av. height, feet	47	40	30		
Cu. ft. per acre	1,097	154	184	1,435	35.9

A 55-year old Stand, Henderson County

Species	Scrub oak	Hickory	Total	Av. ann. growth
No. of trees per acre	260	4	264	
Av. D. B. H., inches	6.7	4.0		
Av. height, feet	27	25		
Cu. feet per acre	720	4	724	13.2

A 75-year old Stand, Mason County

Species	Black oak	Hickory	Total	Av. ann. growth
No. of trees per acre	112	24	136	
Av. D. B. H., inches	12.3	5.9		
Av. height, feet	62	55		
Cu. feet per acre	2,159	83	2,242.0	29.9
B. F. per acre	4,104		4,104	55

Taxes on the less productive soils vary from 14 to 65 cents per acre. Probably 50 cents is a fair average. The unmanaged stands of this region have an indicated yield per acre of less than one third of a cord per year. One dollar per cord is a fair price for cordwood stumpage. Thus it is evident that fuel wood returns do not pay the taxes. Such sand is ordinarily a liability, and forests are retained at a loss as insurance against

sand drift, the additional cost being met from returns from the more productive parts of the farm. It is very doubtful if ideal treatment and protection would greatly improve the quality of the product or raise the yields of the stands native to this region. Fire and grazing protection would make conditions favorable for a gradual increase in the organic matter in the soils with a consequent improvement in physical and chemical composition, yet this improvement measured in increased forest returns would probably be very slow.

In attempts to anchor the sands and turn them to profitable productiveness, experiments have been made by land owners in introducing and planting species not native to these sites. Studies of these plantations and data collected in other states of growth upon similar sites, indicate that pine plantations may afford the best economic use to which the sands can be put.

Black locust has been planted more extensively than any other species. It is easily established, binds the soil with its excellent root system, and produces relatively good yields of high-grade post material. In addition to these excellent qualities, it has the ability to build up the nitrogen content of the soil. It is an ideal tree for the sand regions, but since the appearance of the locust borer in destructive numbers in 1856, only occasional plantations have been successful. The greatest insect injury occurs when the trees are from 3 to 8 inches in diameter. When locust is planted in pure stands, the borers generally destroy the plantation, whereas insect damage seems to be less severe when locust is in mixture with other species. On dune sand in Mason county, a thrifty plantation of 50-year-old trees had an average diameter of 13¼ inches inside the bark on the stump, and a height of 66 feet. From single trees were cut 40 split and 6 round posts. Such a plantation yields in 50 years 1,575 posts with a market value of 40 cents each, a gross return of $630.00 per acre.

The following costs are charged against the operation:

Taxes annually $ .50 per acre 4% for 50 years	$ 76.33
Cost of establishing plantation $15.00 compounded 50 years	106.60
Cost of cutting and marketing $ .10 per post	157.50
Total	$340.43

Net income at end of 50 years, $630.00 minus $340.43, equals $289.57. Discounted as a recurring crop or rental with interest at 4%, this gives the above land a value of $47.42 when devoted to locust, or an annual return at 4%, on this value, of $1.90 per acre above taxes, planting, and harvesting costs. This indicates that under favorable conditions locust plantations can be profitable.

This is one of the two types of the state where black walnut and catalpa plantations are failures. Neither should be planted on any other than fertile well-drained soils. Cottonwood (*Populus deltoides*) on these

soils shows a very variable growth-rate. On a 20-year old plantation in the crater of a blowout the effect of shading was very pronounced. In the three outside rows, the trees averaged 10 inches D. B. H. and 70 feet in height. On a plot taken at least 5 rows (35') inside the margin and representing average interior conditions, the tree average 5 inches D. B. H. and 50 feet in height, with the largest tree 9 inches D. B. H. and 52 feet in height. The plot showed an average growth per acre per year of 69.1 cubic feet as compared with 28.6 cubic feet for oak grown on similar sites. The product of the cottonwood plantation was suitable for fuel, posts, and pulp-wood. Cottonwood planted as a shelter-belt on these sands is a success; as a forest crop in plantations its value is in doubt. Thus far, experiments with the other broad-leaved species have shown that they will not produce a profitable crop on sands.

The prospect of growing certain pines on these soils at a profit is better. In general, conifers require about 1/10 the amount of water needed by broad-leaved species, are less exacting as to soil requirements, produce more trees to the acre, and have a faster rate of growth and a higher quality of product. Red, white, jack, and western yellow pines within their respective regions of growth produce valuable wood crops on sand. Plantations of white pine, already established on such soils in Illinois, are generally too immature to show the possibilities of wood production. However, they do demonstrate that white pine plantations can be established, and that the growth rates during the juvenile period is rapid. The occasional open-grown white pines planted in this region indicate that the excellent growth-rate is carried through to maturity. At 40 years such individual pine trees on sand near Amboy, Lee county, produced 38 cubic feet as compared with 4.8 cubic feet produced by black oak at the same age on sand.

Studies were made in two plantations growing on dune sand and representing 20- and 50-year age classes. The twenty year stand has an average D. B. H. of 4.1 inches and an average height of 27 feet. The largest trees are 7 inches D. B. H. and have a height of 30 feet. The mean annual growth for the twenty-year period is 95 cubic feet per acre. The trees were vigorous; the plantation well managed. (Plate I, Figures 1 and 2.)

The fifty-year plantation has an average D. B. H. of 10 inches and an average height of 55 feet. The largest trees have a D. B. H. of 15 inches and a height of 60 feet. The mean annual growth for the fifty-year period is 91 cubic feet per acre. This stand averages 27,264 B. F. per acre for the 50-year period, which is almost exactly the yield given for similar soils in Massachusetts (Hawley and Hawes '12). An increase of 318 per cent in the yields for white pine over the native hardwood stands, and an increase in the quality of product—from cordwood to excellent lumber—is indicated as possible for those in position to make the initial investment of establishing the plantation and carrying the costs

from 30 to 50 years. Approximate costs and returns per acre are as follows:

*3-year old transplants, 1210 per acre	$5.50
Planting cost	7.50
	$13.00
Compounded 50 yrs. at 4% this equals	$92.387
Taxes 50 cents per acre per annum compounded 50 years equals. .	76.333
Total cost at 50 years	$168.72

* Can not be bought in Illinois at a reasonable price.

The yield of 27,264 B. F. per acre at $20.00 per M. on the stump equals $545.

Net income at 50 years equals $545.00 minus $168.72, or $376.28.

Discounted as a recurring crop or rental at 4 per cent this gives the land a value of $61.62 per acre. The annual return at 4 per cent on this value is $2.46 per acre. Thus after paying all expenses such as taxes and planting costs, such a plantation returns annually $2.46 per acre per year from a timber crop on land which, devoted to natural growth of hardwoods does not return the taxes.

In conclusion:—These sandy soils require a vegetative cover; native forests are uneconomical; introduced species such as certain pines can probably be grown at a profit; and forestry in these regions is of an intensive nature, involving planting.

(3) *Upland Hardwoods*

In the third upland type, the upland hardwoods, are included 60 per cent of all the forests of the state, and 79 per cent of all upland forests. It is that upland forest which grows on soils between the extremes of open sand and tight loams over clays. The representation by species in this type is very variable. The relative stability of soil moisture appears to exert a controlling influence over the composition of the forest. In general, the fewest of species are found on those soils approaching the heavy post oak soils, and the greatest variety, on deep well-drained sandy loams. The gradation from forests made up almost entirely of oak and hickory to those showing considerable variety is not usually distinct. The following generalization for the upland hardwood type may be advanced: Forests in the southern part of the state show a greater variety than those in the northern; those on non-glaciated regions a greater variety than those on the glaciated; those on moraines a greater variety than those on the inter-morainal areas; those in the broken eroded regions a greater variety than those in the more level; those on sandy loams a greater variety than those on clayey loams; and even those in virgin all-aged forests a greater variety than those in even-aged stands.

The annual growth on 35 fully stocked plots of this type varied between 22 and 58 cubic feet per acre, with an average of 36.4 cubic feet as compared with the average of 15.8 cubic feet for the post oak type, and 28.6 cubic feet for the scrub oak type.

Certain extensive regions of the state manifest a tendency toward either the oak-hickory extreme or the rich mixture, and the general upland hardwood type will be described under two subtypes, (a) upland mixed hardwoods, less than 90 per cent oak-hickory, and (b) the oak-hickory, 90 per cent or more oak-hickory. From seventy samples taken in this type in twenty-eight counties, the oaks and hickories make up 90 per cent of the stand in thirty-six.

Subtype (a) *Upland Mixed Hardwoods*

The regions where this subtype commonly prevails are the entire non-glaciated part of southern Illinois, the deeply eroded section along the bluffs of the Mississippi River as far north as the Wisconsin line, the eroded bluffs of the Illinois River, and the modified uplands of the Wabash as far north as Vermilion county. This mixed hardwood association occurs locally in many counties of the state on moraines, well-drained slopes, and similar sites favorable to variety.

In the Ozark upland region this subtype extends completely across the state; but elsewhere the general areas where it is found are restricted to a strip, bounded on the river side by a very definite line where the uplands break to the river plain by precipitous slopes or rock ledges, often with a relief of several hundred feet. The interior boundary of this strip is not clearly demarked, as mixed hardwoods here merge with the oak-hickory extreme; but, in general, the mixed hardwood subtype is associated with deposits of deep and medium loess, and varies in width from 2 to 12 miles. The depth of the soil varies greatly in this bluff area, as it is a region where wind-carried soils built up deep deposits and where erosion has been very active. Rock outcrops are frequent along the outer rim of the bluffs and where the lesser streams have cut through the heavy soil mantle; but generally soils are deep. In texture these loessal soils are very fine-grained and may approach sands or clays, but they are characteristically porous, friable, and fertile. They readily absorb moisture, and slopes which on heavier soils will gully disastrously, are safely cleared in this bluff region.

The Ozark uplands extend from the Mississippi to the Ohio, and from the Big Muddy and Saline rivers to the Cache as an upthrust with an axis running east and west. The highest points, which are among the highest of the state, are near each end and close to the rivers. This results in a pronounced relief along the eastern and western parts, which together with the series of cliffs marking old faults along the southern part, make this a region of rugged topography, characterized by more or less gentle northern and more or less abrupt southern slopes. The older residual soils were buried under a loessal deposit of varying depth. Subsequent erosion and weathering have altered these deposits, but they form the main soils of the region. The soils of the interior section are shallower and less porous than the loessal deposits of the bluffs, hence unprotected slopes erode seriously. (Plate II.)

Originally about 95 per cent of the bluff and Ozark upland region was forested. The fertile soils have put a premium on arable land, and customarily the flat hill-tops and the narrow creek-bottoms are cleared; yet the region is so dissected that 22.6 per cent of its area is yet forested, as contrasted with an average of 6.8 per cent forested for the total of the uplands of the state. The actual reduction in area from the original forests is estimated at 76.2 per cent and the reduction in quantity of timber at 95.5 per cent.

In the Ozark region the bluffs rise abruptly several hundred feet above the Mississippi flood-plain to the general level of the uplands. These uplands are so dissected for the first three to nine miles from the bluffs that the continuity of the forests is broken only by clearings on the narrow bottoms, or infrequently on the yet narrower ridge tops. (See Map III N.) This region is the only place in Illinois where relatively continuous upland forests in a single region aggregate 100,000 acres; and this forest is a belt averaging three and one-half miles in width by fifty in length, rather than a compact area.

Rock outcrops are frequent where the uplands break to the Mississippi flood-plain, but in general loessal deposits are heavy and soils are deep. This is a limestone region, and caverns and subterranean streams usual to such formations exist. Springs of considerable volume are numerous at the base of the bluffs, but within the region itself springs are rare.

The dry slopes rising abruptly from the Mississippi flood-plain are forested save where sheer cliffs break their continuity. These forests consist of short, sturdy trees, mostly oak. The upper part of this western slope has black oaks and hickory on the more favorable sites, with post oak or red cedar on the thin soils. It is on this dry upper part of the westernmost slope in Union county that the bulk of the shortleaf pine grows, a few stragglers reaching the second western slope.

These poor forests mark only the exposed margin, and within this region of innumerable ravines and spurs a rich variety of trees may be found. In general the ridge tops and upper parts of the south and west slopes have few species other than black oak, white oak, and hickories. The north and east slopes, the lower south and lower west slopes, and the bottoms of the innumerable narrow draws, in addition to black and white oak and hickories, have red oak, tulip, beech, hard maple, black walnut, ash, cucumber-tree- butternut, basswood, elm, Kentucky coffee-tree, black and red gum, and mulberry. Customarily the oaks predominate, yet it is not unusual to find nearly pure stands of beech in the draws and on lower slopes.

The difficulty of logging in this extremely broken region delayed the harvesting of the virgin stands until the more accessible areas to the east were cut out. Early operations were light and the large trees of the few more valuable species were harvested and marketed in the log. This was followed by sawmills operating chiefly in the larger oak. In recent years this region has been drawn upon heavily for sawlogs, ties, and

mine timbers, and virtually every species is utilized down to very low diameters. As a consequence the forests in this region are over-cut, growth does not equal the cut, and the amount of growing timber per acre steadily diminishes. An average acre based upon a tally of all trees 6 inches D. B. H. and up, on a strip 66 feet wide totaling nearly 23 miles in length and equivalent to 181.66 acres, gives the average number of trees per acre as 37 and the average contents as 886.73 cubic feet. The same acre fully stocked with trees of the sizes present should have 108 trees and total 2,586.95 cubic feet of timber. Alexander, Union, and Jackson counties contain over 100,000 acres of such forest, averaging about one-third fully stocked (34.275 per cent). This means a loss in yields of at least 2,400,000 cubic feet of wood annually, and is equivalent to more than 200,000 first-class ties—a total annual revenue of $200,000.00.

The average acre has 21 trees with a D. B. H. 10 inches or better; i. e. trees suitable for ties or even sawlogs, and it has 16 trees in the 6-7-8-9 inch classes. Since cutting has been comparatively light in this latter group it represents more nearly the actual association of species in the forests of the future. A comparison of the data in table p. 45 showing per cents of species represented in the smaller and larger diameter classes respectively, indicates that the future stand will have a slightly lower per cent of black oak, tulip, black gum, maple, and red gum, and a very much lower per cent of beech; also it will have a higher per cent of white oak, elm, and ash, and a very much higher per cent of hickory.

STAND TABLE BASED ON 181.66 ACRES, UNION COUNTY

	Black oak	White oak	Hickory	Beech	Tulip	Red oak	Elm	Maple	Ash	Red gum	Misc.	Total
No. trees per acre.....	13.4	8.4	5.9	4.3	1.2	1.0	.7	.7	.4	.4	.4	37.1
Per cent of present forest	36.1	22.8	16.0	11.7	3.1	2.6	1.9	1.9	1.8	1.0	1.0	100.0
Per cent of merchantable sizes (10" and up)	21.6	11.5	6.4	9.8	2.0	.8	.8	1.2	.7	.6	.5	57.2
Per cent in future stand	33.9	26.3	22.4	4.5	2.6	2.7	2.7	1.6	2.6	1.0	1.2	100.0

A few areas yet show virgin stands. The tabulation from the sample plot on page 47 shows the association, sizes, and yields. In general, the forests are more or less culled. Down to the present, cuttings have been in the larger diameter classes alone, and the same area could be profitably logged at intervals of about twenty years. The recent cuttings have been heavy in the smaller diameter classes with a consequent increase in the interval before another cutting will be profitable.

Forest fires do more damage in this region than anywhere else in the state. An examination in 33 sections in this region in 1921 disclosed that 12 had been partially or completely burned over in the past three years. An average interval of eight years between fires is insufficient to carry the immature trees to a fire resistant stage. The reproduction is naturally excellent in this region but fires must be controlled before well-stocked stands can be realized. Growth rates vary, but generally average slightly lower than for the same species on comparable soils elsewhere in the state. (See page 47.)

East of this belt of heavily wooded hills, the Ozark upthrust continues as a divide between Saline River on the north and the Cache on the south. (See Map III C.) The average width is scarcely twenty miles, the average elevation of the divide less than 400 feet above the rivers; yet this region presents a very broken surface. Generally the divides and spurs show broad tops, breaking abruptly to the narrow valleys. Cliffs are common along lines of faulting and along the gullies cut through the the limestone by streams.

The ridge tops and rolling uplands are cultivated; the steep slopes and narrow gulches, wooded. It is a region of relatively shallow soils. Splendid forests originally grew in the protected coves and pockets where soil collected, and this region yet produces some high-grade veneer logs. The arable lands have been cleared, the forests remaining are on thin soils and precipitous slopes. Occasional patches of sawlog timber may be found in ravines and on lower slopes; but generally the stands are of a pole-wood or sapling nature and are cut closely for mine timbers. At the eastern end (Hardin county) cutting has been less severe than in the counties to the west. Cedar grows in nearly pure stands on some of the bluffs, and a rich mixture of beech, cucumber, hard maple, tulip, ash, and basswood may be found in the draws, but generally the rather poor stands of this interior region are black and white oaks and hickory.

The soil common to these uplands—yellow silt loam—is more susceptible to erosion than any other common soil type. Much of the upland in this region has been unwisely cleared as the numerous gullied and abandoned fields testify. (See Plate II.)

STAND TABLE BASED ON 181.66 ACRES, UNION COUNTY

Species	Black oak	White oak	Hickory	Beech	Tulip	Black gum	Elm	Hard maple	Ash	Red gum	Misc.	Total
No. of trees per acre..	13.37	8.43	5.92	4.34	1.16	.96	.71	.70	.66	.38	.37	37
Av. D. B. H., inches....	11.0	10.7	9.7	15.8	11.8	13.7	9.4	12.7	9.7	12.2	10.3	
Av. Ht., ft.....	60	58	58	77	70	70	50	68	60	70		
Cu. Ft. per acre.....	275	172	92	225	26	35	10	25	9	11	7	887
B. F. per acre.....	679	496	229	885	73	169	16	87	17	30	18	2,699

SAMPLE ACRE OF VIRGIN TIMBER, UNION COUNTY

Species	White oak	Black oak	Red oak	Hickory	Ash	Tulip	Elm	Hard maple	Sweet gum	Black gum	Beech	Mulberry	Carpinus	Ostrya	Dogwood	Sassafras	Total
No. of trees per acre	20	14	1	41	2	6	4	21	19	17	19	3	12	12	103	6	300
Max. DBH, inches..	14	20	19	19	20	14	13	8	14	15	22	7	9	5	8	8	
Max. ht., feet.....	65	80	80	88	82	80	63	45	85	70	85	30	30	25	25	30	
Av. cu. ft. per acre.	119	78	63	517	37	78	27	31	324	214	425	5	20	13	109	16	2,076
B. F. per acre....	157	419	237	1,149	94	117	47	.....	598	477	1,229	.....	.....	.....	.....	.....	4,524

Sample of Virgin Stand on Fertile Agricultural Soil

Species	White oak	Black oak	Hickory	Tulip	Black gum	Black walnut	Sassafras	Total
No. of trees per acre	10	12	6	8	2	2	4	44
Max. D. B. H. inches	25	31	13	27	13	15	12	
Max. Ht., feet..	90	92	65	90	60	70	50	
Cu. contents per acre	359	1,000	81	808	42	55	65	2,410
B. F. contents per acre	1,376	4,380	144	3,100	94	150	124	9,368

Between the Cache and the Ohio rivers the uplands are from 3 to 12 miles wide and about 40 miles long. Gentle slopes lead up from the Cache bottoms to the rolling uplands—about 150 feet above the bottoms—and break abruptly to the Ohio. The deep fertile soils of this region early invited settlers. The remnants of the splendid forests which covered it are along the abrupt slopes. The present forests are similar to those in the heavily wooded area near the western part of the Ozark uplands; but growth rates are better here, and one additional species, chestnut, has established itself in one locality near Olmsted, Pulaski county.

This mixed hardwood subtype, with the species listed for the Ozark uplands, is not found in the interior of the state north of the Ozarks, but it extends almost to the headwaters of the Wabash to the east and to the Kaskaskia along the uplands bordering the Mississippi in the west, the variety of species decreasing in the northern advance.

In the Wabash region, the upland soils are deep; and near the main river they show a tendency toward the sandy textures. Loessal deposits occur in the form of low hills, usually within six miles of the main Wabash bottomlands. The slopes are relatively gentle, the soils deep, fertile and well drained, and conditions ideal for tree growth. It was probably on these uplands that the large tulips measured by Dr. J. Schneck were found (Ridgway, '82), and where even black walnut and red oak attained a height of 150 feet. These splendid forests have disappeared. The uplands are cultivated save for the few wood-lots covering the steeper slopes, and these contain second-growth timber. Beech and tulip extend to Vermilion county, black gum to Lawrence; cucumber-tree in Illinois does not get beyond the Ozark uplands; while red gum, which in the Ozark region extends to the upland association, in this region is restricted to the bottomlands. Basswood, ash, or hard maple may form high percentages of the stand. Beech is not a common tree.

Along the Mississippi, the transition from the upland forests of the Ozarks, with a great variety of species, to the mixed hardwoods of the central and northern part of the state, is made in the thirty miles of bluffs between the Big Muddy and the Kaskaskia rivers. This region is a con-

tinuation of the extremely dissected belt described as the western part of the Ozark uplands. Deep loess deposits extend inland to an average of nine miles from the bluffs. Sink-holes pit this region to a greater degree than elsewhere in the state. For the first mile or two from the bluffs, the forests are continuous; farther inland the ridge tops and stream bottoms are cleared, and the forests are on the slopes.

These stands consist of an uneven-aged mixture from which the larger trees have been removed. The transition of species is in about the following order: cucumber-tree and sweet gum do not grow in these uplands north of the Big Muddy; Mary's River is the upper limit for beech and tulip while black gum goes to the Kaskaskia. Two variations from the mixed hardwood association usual to this region merit mention. Piney Creek, a tributary of Mary's River, has cut a ravine about seventy feet in depth; and here, on the shallow soils of the slopes, some thirty mature shortleaf pines represent the most northern outpost of this species. (See Plate VIII.) On Rock Castle Creek, some five miles north of Piney Creek, there were formerly specimens of this tree. The shortleaf pine (*Pinus echinata*) is the yellow pine common to the clay soils of the Gulf States but it extends up into southern Missouri and southern Illinois. Its occurrence in Union and Randolph counties marks the extreme northern limit of the species. The Piney Creek ravine is also probably the northern limit in the western part of the state for tulip and beech. The second variation is found in the many sink-holes which occur in the uplands near the bluffs. These are generally circular depressions, having a diameter from thirty up to several hundred feet, and a depth often of forty feet. Water may collect and remain in these basins, but ordinarily it is drained off through underground streams. Such formations are especially numerous in Monroe county but occur in Randolph, Union, and Hardin counties. The soils, washed in from near-by fields, are fertile. The slopes are often steep and wooded. Tree growth is exceptionally rapid. Black and white oaks commonly predominate, but sycamore, elm, river birch, cherry, and cottonwood are frequent trees in this association.

North of these Ozark uplands, of the upland belt extending along the Wabash system to Vermilion county, and of the belt extending up the Mississippi to the Kaskaskia, the mixed hardwood forests, in which oak and hickory make up less than 90 per cent of the stand, are in the belt of bluffs bordering the Mississippi and Illinois rivers; on the unglaciated areas of Calhoun and Jo Daviess counties; on many of the moraines throughout the glaciated area; and occasionally on the inter-morainal areas where well-drained fertile slopes are forested.

Such southern species as red and black gums, tulip, cucumber-tree, and beech* drop out, while big-toothed aspen is added in the northern part. White and bur oaks, basswood, black walnut, ash, elm, cherry, and hackberry have a higher percentage in these mixed stands in the north than in the south, while hickory and black oak have a lower percentage

* Small colonies of beech are reported in Lake and Ogle counties.

in the north. A comparison as to the number of trees per acre shows that the northern forests have about twice as many as the southern, and that they are often even-aged, whereas in the southern region they are rarely so. In the even-aged stands the oldest have been growing about 90 years, the majority, between 60 and 90 years; the diameters are mostly under 18 inches; 65 per cent of the trees have a D. B. H. of 10 inches or better; and the average acre has about 80 trees. The number of trees per acre and the representation of species in the stands by per cents for both the northern and the southern part of the state is shown in tabulation on page 54.

The belt of heavily wooded bluffs extending from Alexander county north, terminates at about the northern boundary of Monroe county. In this distance of more than one hundred miles, there is scarcely a break in the forests as viewed from the Mississippi bottoms. North of Monroe county, even this westernmost slope is freely cleared, and the forests are disconnected strips along the slopes, rather than a continuous belt. Only in the rougher sections of Jersey and Calhoun, and to a lesser degree in Jo Daviess counties, are there comparatively continuous upland forests.

In Jersey and Calhoun counties, the uplands bordering the Mississippi and Illinois rivers are heavily wooded. (See Map V, C.) Calhoun is a narrow unglaciated headland between the Illinois and the Mississippi rivers and is but five miles wide in its narrower parts. The divide, often 300 feet above the rivers, is buried under a shallow loessal deposit and the slopes break more abruptly on the eastern than on the western side. Air drainage and soil conditions combine to make this upland especially adapted to apple production, and the less precipitous uplands along the crest are cleared, together with much of the western slope, but the abrupt eastern slopes are wooded. Black oak is the dominant tree, and much white oak, hard maple, elm, hackberry, black walnut, and basswood occur. The stands approach the even-aged type, and are of seedling rather than sprout origin. The same rugged topography and forest conditions exist in the western six miles of the uplands of Jersey county, although the stands here have been more heavily culled for sawlog and tie material. The area forested in these rough uplands, where forests are comparatively continuous, totals approximately 50,000 acres.

The topography of Jo Daviess county, with the exception of a small strip along the eastern border which has been modified by glaciation, is that of an old eroded upland through which the southwestward flowing streams have cut deep valleys. In the north, the slopes lead back to the broad uplands and culminate in occasional conical mounds. The highest of these, Charles Mound, with an altitude of 1,241 feet above sea-level, is the highest point in the state. In the central and the southern sections the slopes rise rather moderately from the narrow stream-valleys until the upper slopes are reached. Here the slope is steep or precipitous up to the narrow flat-topped ridge. In the north-central part streams have cut through the rock, forming canyons or gorges. The most notable,

Apple River Canyon, is a gorge 160 feet deep with frequent cliffs, miniature park-like bottoms, and forested slopes.

Despite the fact that there may be a difference in elevation of 400 feet between the valley floor and the neighboring ridge-top, and that cleared slopes up to twenty and even twenty-five degrees are common, gully erosion is not noticeable. These steep slopes when not wooded are pastured and protected by a sod. The soils are well drained, and in periods of drought vegetation on the thin soil suffers. Pepoon cites an instance of extreme drought in 1898 when even old trees died (Pepoon, H. S., 1919).

The present upland forests totaling about 50,000 acres, occur usually as belts along the steep upper slopes. (See Map VI N.) The lower slopes and often the ridge tops are cleared. The uplands bordering the Mississippi River are usually wooded in the southern half of the county but cleared in the northern half; and the forested region extends into the unglaciated interior region twenty-five miles from the Mississippi plain. The stands are well stocked with young as well as with merchantable timber and growth rates are excellent. They are dominantly white and black oak, containing some basswood, hickory, black walnut, elm, ash, cherry, maple, and occasionally a big-toothed aspen or Kentucky coffee-tree. Hard maple is found in almost pure stands in the northern part of the county, and white pine occurs occasionally on the rocky slopes of the gorges.

Between Calhoun and Jo Daviess counties the topography of the uplands along the bluffs becomes modified, the slopes are less precipitous, and relief less pronounced. These uplands are customarily cleared, but Mercer and Rock Island counties show somewhat more forested area on them. In parts of Henderson, Carroll, and Whiteside counties sand has blown inland; and such areas, when wooded, have the oak forests described under the scrub oak type.

Based on measurements of all trees 6 inches D. B. H. and up, on 17.4 acres, an average acre in Jo Daviess county furnishes the following data.

Species	White oak	Black oak	Bass-wood	Hick-ory	Black walnut	Elm	Ash	Cherry	Maple	Big-toothed aspen	Ky. coffee-tree	Total
No. of trees per acre..	34.4	27.7	5.6	4.2	2.6	2.7	2.1	.9	.8	.2	.06	81.3
Av. D. B. H.	10.3	12.3	11.8	7.6	10.5	9.2	9.6	8.4	10.8	9.2	8.0	
Av. Ht.	50	60	55	45	50	48	55	50	55	55	45	
Cu. Ft. per acre.....	314	483	93	8	27	26	15	4	10	2		982
B. F. per acre.....	507	1,141	207	15	66	64	31	7	26	4		2,068

Sixteen reproduction plots of a square rod each, taken at 600-foot intervals under forest conditions usual to this region, indicate that seedling reproduction is predominant.

Species	White oak	Black oak	Hick-ory	Elm	Black walnut	Cherry	Bass-wood	Hard maple	Ash	Big-toothed aspen	Total
Seedlings	80	650	130	1,130	30	100	560	60	90	10	2,840
Sprouts	.....	210	40	20	.....	.....	.....	.....	30	.....	300
Total per acre.....	80	860	170	1,150	30	100	560	60	120	10	3,140

Comparison of these results with the representation of species by per cent of trees per acre 6 inches D. B. H. and upwards follows.

Species	White oak	Black oak	Hick-ory	Elm	Black walnut	Cherry	Bass-wood	Maple	Ash	Poplar	Misc.
Per cent by species of trees 6" D. B. H. on av. acre.....	42.4	34.2	5.0	3.2	3.2	1.1	6.9	1.0	2.6	.2	.2
Per cent by species of reproduction on av. acre.....	2.6	27.3	5.4	36.6	1.0	3.1	16.4	1.9	3.8	.3	1.6

This comparison justifies the conclusion that there is a tendency toward increase in white oak and decrease in elm and basswood.

The status of a sample from a 75-year old stand of mixed hardwood in Hancock county is here shown.

Species	White oak	Black oak	Hickory	Ash	Elm	Black walnut	Cherry	Total	Av. ann. growth
No. of trees per acre	88	88	24	24	4	4	4	236	
Av. D. B. H.	5.2	10.1	5.3	8.8	10.0	5.0	12.0		
Av. Ht.	52	65	50	65	65	55	70		
Cu. Ft. per acre....	363	1,591	60	271	61	7	101	2,454	32.7
B. F. per acre.....	472	2,132	.....	428	88	.....	228	3,348	45

Along the Illinois River from the Hennepin bend down to Peoria, the narrow draws, running back into the western bluffs some two or three miles, as well as the face of the bluff, are wooded as a continuous belt with this mixed hardwood subtype. Elsewhere cleared bluffs and draws are as frequent as wooded ones. In the northeastern part of Calhoun and extending into the southeastern corner of Pike county is an area of upland where the soils are heavy. Here this mixed hardwood phase changes to scrub and post oak. In many places near the Illinois valley, notably in Mason county, sands have buried the old soils; and in such places the stands are of the type described under "scrub oak".

Throughout the interior of the state this mixed hardwood subtype occurs on the moraines and well-drained uplands, more frequently near the Indiana line in Vermilion county and the Wisconsin line in Winnebago and Stephenson counties; but it is usually less frequent than the oak-hickory extreme, even in these regions.

A sample plot from a virgin stand in McLean county shows the splendid sizes attained by trees under conditions favorable to this type. See table following.

Species	White oak	Black oak	Red oak	Hickory	Ash	Elm	Hard maple	Black cherry	Total
No. of trees per acre	17	5	1	8	14	10	25	1	81
Max. D. B. H. inches	38	23	8	21	25	20	9	11	
Max. Ht., feet.....	92	80	.....	95	95	80	.....	82	
Cu. Ft. per acre...	2,695	269	8	238	278	165	141	21	3,815
B. F. per acre.....	14,688	990	.....	673	743	382	77	43	17,596

REPRESENTATION OF SPECIES BY PER CENTS AND NUMBER OF TREES PER ACRE IN SUBTYPE (*a*) UPLAND MIXED HARDWOODS (NORTH AND SOUTH) AND SUBTYPE (*b*) OAK-HICKORY

Species	Oak-hickory 90 per cent and over		Oak-hickory Less than 90 per cent			
			North		*South*	
	Trees per acre	Per cent	Trees per acre	Per cent	Trees per acre	Per cent
*White oak	52.8	47.93	25.1	34.55	8.5	22.41
*Bur oak	.8	.76	.4	.50		
*Chinquapin oak			.1	.15		
*Cow oak				.04		
*Red oak	2.4	2.21	2.1	2.86		.02
*Black oak	41.0	37.23	14.6	20.22	13.3	35.30
*Shingle oak	.1	.11				
*Swamp Spanish oak		.05				
Hickory	10.1	9.18	5.2	7.24	6.1	16.12
Elm	1.1	1.03	6.7	9.18	.7	1.98
Ash	.4	.34	2.4	3.31	.6	1.73
Hard maple	.1	.11	7.2	9.99	1.0	2.54
Beech					4.4	11.56
Black gum					1.1	22.89
Tulip					1.2	3.27
Black walnut	.1	.14	1.5	2.14	.2	.65
Red gum					.4	1.15
Basswood			3.6	4.91		.02
Cherry	.8	.70	1.5	2.09		.01
Hackberry			.7	.96		.06
Honey locust			.2	.26		.01
Kentucky coffee-tree			.3	.39		
Mulberry		.08	.1	.16		.08
Butternut			.1	.17		.04
Buckeye				.08		
Big-toothed aspen		.06	.5	.65		
Sycamore	.1	.11		.08		0.4
Black locust						.06
Totals	110.2		72.54		37.75	
	Per cent of oak-hickory equals 97.42.		Per cent of oak-hickory equals 65.56.		Per cent of oak-hickory equals 73.85.	
	Based on 32.4 acres measured in 20 counties.		Based on 63.2 acres measured in 15 counties.		Based on 188.4 acres measured in 3 counties.	

* In part of the field-notes all white, bur, chinquapin, and cow oaks were tabulated as white, and all red, black, shingle, and swamp Spanish as black, consequently the figures listed for white and for black oak in the above table contain also these other oaks.

Subtype (b) *Oak-Hickory*

The total area of upland forests of the mixed hardwood type where oak-hickory makes up less than 90 per cent of the stand is estimated at

594,379 acres. Throughout the northern and the central parts of the state are broad regions where oak-hickory makes up 90 per cent or more of the stand, and such an association occurs locally even in the Ozark uplands, loessal bluffs, and post oak region. The total forested area of this oak-hickory extreme is estimated as 1,209,734 acres.

Throughout the post oak region the oak-hickory subtype is found on the slopes where the flat upland breaks to the stream bottom. The soils are usually yellow-gray silt loams. White oak is the commonest tree, shingle and black oaks, hickory with occasional ash, basswood, cherry, hard maple, elm, and black walnut form the stand.

North of this post oak region, the oak-hickory extreme prevails throughout the interior of the state. It is a region of undulating upland prairies and very deep glacial deposits. These prairies are naturally poorly drained so that, over the centuries when the prairie sod held the site, decay of grass roots has been but partial, and the rich black soils of the prairies have been built up. Below the dark prairie soils, yellow-gray and yellow silt loams are generally found. Where these soils are exposed on the slopes along the streams forests occupied the site; and on the steeper slopes of the numerous moraines, forests were found. Prairies, however, prevailed over 70 per cent of this region. About 82 per cent of the area originally forested is now cleared, and the forests remaining are small wood-lots retained on the rougher slopes. However, this is a region of relatively gentle slopes; and much land now timbered can be converted to arable land or to permanent pasture.

Soil classification, made by the University of Illinois Agricultural Experiment Station in twenty-two counties of this region, shows that 51 per cent of all timbered soils not bottomland are yellow-gray silt loams, and 33 per cent are yellow silt loams. These are comparatively heavy soils, and the yellow silt loams are those common to the less gentle slopes; consequently, erosion is a possibility where this soil type is cleared. Gully erosion was noted in Bureau, Fulton, Knox, Warren, Brown, McDonough, and Madison counties and was especially severe in Pike county.

These oak-hickory stands are usually even-aged, and occur as narrow strips along the slopes and as isolated wood-lots. Shingle oak may occur, but the commonest tree in the central region is black oak; in the northern, white oak. Oak and hickory often make up the entire stand. In the northern quarter of the state bur oak is a common tree in the association, and often forms the entire stand in wood-lots of counties along the northern border of the state. These bur oak stands are usually poorly stocked with short-boled, wide-crowned, and "limby" trees. Elsewhere the oak-hickory wood-lots usually show good stocking with trees up to small sawlog size and under 80 years of age. The usual drain on these wood-lots has been for posts and fuel. For these purposes inferior and smaller trees are customarily cut, leaving the better trees. These latter are, in most wood-lots, from 60 to 80 years old and entering into the sawlog class. The practice of grazing these wood-lots is almost universal. Statements from 430 woodland owners show that 92 per cent graze wood-

lands. Under this practice a sod is formed which effectively keeps out the reproduction necessary to replace the trees harvested. The presence of a sod, the lack of young trees to continue the forest, and the presence of timber of sawlog size tempt the owner to clear his land immediately rather than by the equally certain and slower process of grazing the woodlands.

The number of trees per acre and the representation of species in the stands by per cents for this oak-hickory subtype is shown in the tabulation on page 54.

Samples from fully stocked stands are shown (I, II, III, IV, V) as follows.

I. A 62-year old Stand, Whiteside County

Species	White oak	Black oak	Hickory	Black cherry	Total	Av. ann. growth
No. of trees per acre	132	49	6	6	193	
Av. D. B. H., inches	8.0	11.8	6.7	13.0		
Av. height, feet	70	70	65	70		
Cu. ft. per acre	1,440	1,029	46	152	2,668	43
B. F. per acre	2,134	1,957	41	346	4,478	72

II. An 85-year old Stand, Mercer County

Species	White oak	Black oak	Hickory	Elm	Total	Av. ann. growth
No. of trees per acre	102	16	3	6	127	
Av. D. B. H., inches	11.9	11.9	6.7	5.8		
Av. height, feet	80	80	60	55		
Cu. ft. per acre	2,402	396	17	30	2,845	33.5
B. F. per acre	6,229	887	.....	.....	7,116	84

III. An 85-year old Stand in Vermilion County

Species	White oak	Black oak	Red oak	Shingle oak	Hickory	Total	Av. ann. growth
No. of trees per acre	48	55	6	1	19	129	
Av. D. B. H., inches.	11.1	14.2	14.0	13.0	9.6		
Av. height, feet	70	70	70	70	67		
Cu. feet per acre	900	1,751	184	26	256	3,117	36.7
B. F. per acre	1,797	4,588	461	60	571	7,477	86

IV. An 80-year old Stand, Piatt County

Species	White oak	Black cherry	Elm	Total	Av. ann. growth
No. of trees per acre	71	3	6	80	
Av. D. B. H., inches	13.8	6.3	6.7		
Av. height, feet	70	35	35		
Cu. ft. per acre	2,062	15	16	2,093	26.2
B. F. per acre	5,309	.....	.....	5,109	66

V. A 90-year old Stand, St. Clair County

Species	White oak	Black oak	Hickory	Total	Av. ann. growth
No. of trees per acre	74	62	2	138	
Av. D. B. H., inches	12.1	14.8	8.0		
Av. height, feet	70	75	60		
Cu. ft. per acre	1,558	2,183	16	3,757	41.7
B. F. per acre	3,352	6,232	.....	9,584	106

FOREST ACREAGE BY COUNTIES

Counties	Type	Present (1924) acreage							Original
		Cull	Sapling	No. 1	No. 2	No. 3	No. 4	Total	County total	County total
Adams	U	.....	2,187	28,202	5,208	119	.....	35,716		
	B	.....	225	1,343	587	.....	.....	2,155	37,871	369,523*
Alexander	U	8,044	286	21,470	1,936	.....	.....	31,736		
	B	5,644	141	3,101	178	.....	.....	9,064		
	Cyp.	.....	.....	3,047	.....	.....	.....	3,047	43,847	122,655
Bond	U	.....	3,625	12,985	341	.....	.....	16,951		
	B	.....	146	1,716	.....	.....	.....	1,862	18,813	107,539*
Boone	U	.....	211	4,680	252	.....	.....	5,143		
	B	.....	.....	168	.....	.....	.....	168	5,311	62,451
Brown	U	.....	2,594	10,512	957	.....	.....	14,063		
	B	.....	336	599	17	.....	.....	952	15,015	148,495
Bureau	U	.....	239	22,084	3,957	11	.....	26,291		
	B	.....	7,682	.....	.....	.....	.....	7,682	33,973	124,581*
Calhoun	U	.....	734	22,376	4,568	46	.....	27,724		
	B	.....	718	5,671	5,254	.....	.....	11,643	39,367	138,936
Carroll	U	10	3,187	11,167	1,214	.....	.....	15,578		
	B	.....	262	5,798	3,273	.....	.....	9,333	24,911	167,162
Cass	U	.....	824	9,237	2,827	.....	.....	12,888		
	B	.....	9,137	10,496	172	.....	.....	19,805	32,693	91,904
°Champaign	U	.....	309	4,599	1,449	43	.....	6,400	6,400	47,659*

Explanation of terms, symbols, and abbreviations used.
† Counties partially covered by forest survey.
° Counties estimated but not surveyed.
* Counties having soil survey completed and area originally timbered tabulated.

Types
U=Upland
B=Bottomland
Cyp=Cypress
P=Pine
T=Tamarack

Yields
Culled=Merchantable trees removed.
No. 1=Stands having an estimated yield up to 2000 B. F. per acre.
No. 2=Stands having an estimated yield from 2000 to 5000 B. F. per acre.
No. 3=Stands having an estimated yield from 5,000 to 10,000 B. F. per acre.
No. 4=Stands having an estimated yield over 10,000 B. F. per acre.

°Christian	U	.....	207	3,087	973	29	.....	4,296	4,296	73,170
°Clark	U	.....	5,180	16,510	958	55	.....	22,703		
	B	.....	2,229	5,079	597	9	.....	7,914	30,617	190,865
Clay	U	.....	4,581	19,869	725	.....	.....	25,175		
	B	.....	1,619	6,406	278	.....	.....	8,303	33,478	170,669*
Clinton	U	.....	488	2,655	177	.....	.....	3,320		
	B	.....	6,110	28,457	14,438	3,689	.....	52,712	56,032	129,702
°Coles	U	.....	5,517	17,580	1,020	59	.....	24,176		
	B	.....	2,374	5,409	636	10	.....	8,429	32,605	100,099
†Cook	U	.....	1,172	15,194	6,155	397	.....	22,918		
	B	.....	131	113	456	267	.....	967	23,885	84,593
†Crawford	U	.....	2,705	10,640	1,971	413	.....	15,729		
	B	.....	2,749	4,717	3,831	82	.....	11,379	27,108	162,234*
°Cumberland	U	.....	3,710	11,821	686	39	.....	16,257		
	B	.....	1,596	3,637	427	7	.....	5,667	21,923	99,079*
DeKalb	U	.....	133	3,505	1,784	118	.....	5,540		
	B	.....	123	.....	18	.....	.....	18	5,558	42,284*
°DeWitt	U	.....	.....	1,830	577	17	.....	2,547	2,547	50,832
°Douglas	U	.....	124	1,839	579	17	.....	2,559	2,559	26,216*
DuPage	U	.....	424	6,270	3,101	21	.....	9,816	9,816	51,419*
°Edgar	U	.....	6,526	20,795	1,207	69	.....	28,597		
	B	.....	2,808	6,398	752	12	.....	9,970	38,567	137,804*
Edwards	U	.....	328	6,320	1,203	.....	.....	7,851		
	B	.....	1,810	3,744	462	.....	.....	6,016	13,867	119,205*
†Effingham	U	.....	12,721	16,701	232	.....	.....	29,654	29,654	140,591
†Fayette	U	.....	6,161	17,817	436	.....	.....	24,414		
	B	.....	9,021	14,691	197	.....	.....	23,909	48,323	278,958
°Ford	U	.....	148	2,205	695	20	.....	3,068	3,068	2,974
Franklin	U	.....	954	8,319	409	49	.....	9,731		
	B	170	4,841	25,307	772	.....	.....	31,090	40,821	243,276*
Fulton	U	192	5,415	52,883	2,685	.....	.....	61,175		
	B	.....	7,669	966	622	17	.....	9,274	70,449	369,236
Gallatin	U	329	8,218	9,629	665	.....	.....	18,841		
	B	192	9,633	23,396	771	.....	.....	33,992	52,833	183,439
Greene	U	.....	3,200	26,458	1,717	.....	.....	31,375		
	B	.....	.....	2,534	.....	.....	.....	2,534	33,909	229,387
Grundy	U	.....	290	4,230	151	.....	.....	4,671		
	B	.....	53	1,757	2,187	164	.....	4,161		
	P	.....	.....	.....	.....	.....	5	5	8,837	11,366*

FOREST ACREAGE BY COUNTIES—Continued

Counties	Type	Present (1924) acreage							Original
		Cull	Sapling	No. 1	No. 2	No. 3	No. 4	Total	County total	County total
Hamilton	U	51	3,586	11,148	617	24	.....	15,426		
	B	.....	1,055	11,691	6,658	.....	.....	19,404	34,830	245,242
Hancock	U	.....	2,485	28,875	2,420	.....	.....	33,780		
	B	.....	.....	220	.....	.....	.....	220	34,000	229,864*
Hardin	U	1,729	4,692	24,093	4,426	133	.....	35,073		
	B	.....	.....	.....	.....	.....	.....	.....	35,073	108,169*
Henderson	U	17	6,474	11,728	1,780	8	.....	20,007		
	B	.....	170	1,428	1,666	.....	.....	3,264	23,271	148,272
Henry	U	.....	231	11,290	2,123	10	.....	13,654		
	B	.....	.....	.....	586	.....	.....	586	14,240	253,667
°Iroquois	U	.....	332	4,943	1,558	46	.....	6,879	6,879	42,272*
Jackson	U	3,562	7,442	51,131	2,387	11	.....	64,533		
	B	1,189	573	23,939	1,866	.....	.....	27,567	92,100	315,418
†Jasper	U	.....	3,304	14,957	2,352	.....	.....	20,613		
	B	.....	2,769	5,889	576	.....	.....	9,234	29,847	165,747
Jefferson	U	.....	5,977	26,347	948	.....	.....	33,272		
	B	.....	1,583	2,612	.....	.....	.....	4,195	37,467	218,770
Jersey	U	.....	7,573	34,330	643	16	.....	42,562		
	B	.....	332	3,952	224	.....	.....	4,508	47,070	170,601
Jo Daviess	U	.....	1,827	47,296	1,385	.....	.....	50,508		
	B	.....	7	168	9,355	.....	.....	9,530	60,038	292,153
Johnson	U	341	20,438	24,986	3,695	38	.....	49,498		
	B	282	27	3,345	6,276	93	.....	10,023		
	Cyp.	.....	.....	1,910	3,347	.....	.....	5,257	64,778	215,040*
Kane	U	.....	924	6,611	1,151	.....	.....	8,686	8,686	103,934*
°Kankakee	U	.....	198	2,946	928	28	.....	4,100	4,100	32,448*
Kendall	U	.....	96	3,184	4,743	.....	.....	8,023		
	B	.....	.....	340	479	.....	.....	819	8,842	49,245
Knox	U	26	1,641	32,631	1,103	.....	.....	35,401		
	B	.....	90	774	.....	.....	.....	864	36,265	152,422*

†La Salle	U	.....	1,096	20,268	7,267	274	.....	28,905	28,905	103,788*
Lake	U	.....	1,392	15,713	1,582	34	.....	18,721		
	B	.....	59	244	160	.....	.....	463		
	T	.....	145	.....	.....	.....	.....	145		
	P	.....	.....	20	.....	.....	.....	20	19,349	159,342*
Lawrence	U	35	2,291	7,498	2,339	.....	.....	12,169		
	B	.....	4,261	5,059	2,915	59	.....	12,294	24,457	184,495
Lee	U	.....	238	9,341	1,351	60	.....	10,990	10,990	45,696*
°Livingston	U	.....	309	4,599	1,449	43	.....	6,400	6,400	28,806*
°Logan	U	.....	183	2,721	857	25	.....	3,786	3,786	30,874
McDonough	U	218	5,126	15,685	1,211	220	.....	22,460	22,460	119,001*
McHenry	U	.....	1,589	4,829	211	.....	.....	6,629		
	B	.....	31	61	.....	.....	.....	92		
	T	.....	12	.....	.....	.....	.....	12	6,733	133,044*
°McLean	U	.....	353	5,252	1,655	49	.....	7,309	7,309	76,723*
°Macon	U	.....	173	2,580	813	24	.....	3,590	3,590	55,636*
Macoupin	U	.....	18,096	41,416	1,424	.....	.....	60,936	60,936	273,938
Madison	U	.....	4,147	13,071	5,985	243	.....	23,446		
	B	.....	159	1,497	3,870	513	.....	6,039	29,485	278,553
Marion	U	.....	12,451	28,446	537	.....	.....	41,434		
	B	.....	55	824	.....	.....	.....	879		198,208*
†Marshall	U	98	.....	17,018	1,054	.....	.....	18,170		
	B	.....	8,382	.....	.....	.....	.....	8,382	26,552	119,103
°Mason	U	93	2,025	28,671	1,277	31	.....	32,097		
	B	.....	4,987	714	729	46	.....	6,476	38,573	118,977*
Massac	U	17	255	6,957	1,182	13	.....	8,424		
	B	1,036	757	4,200	11,579	1,344	.....	18,916		
	Cyp.	.....	.....	117	3,982	115	50	4,264	31,604	130,253
°Menard	U	53	1,157	16,376	729	18	.....	18,333		
	B	.....	2,849	408	416	26	.....	3,699	22,032	79,655
Mercer	U	117	394	17,419	1,694	.....	.....	19,624		
	B	.....	791	6,662	46	.....	.....	7,499	27,123	131,239*
Monroe	U	.....	3,164	43,078	6,524	.....	.....	52,766		
	B	.....	5	1,452	3,417	278	.....	5,152	57,918	231,968*
†Montgomery	U	.....	12,676	31,335	2,083	79	.....	46,173		
	B	.....	129	196	.....	.....	.....	325	46,498	143,572
Morgan	U	.....	862	10,855	985	18	.....	12,720		
	B	.....	170	1,776	.....	.....	.....	1,946	14,666	179,708
°Moultrie	U	.....	100	1,490	470	14	.....	2,074	2,074	39,181*

Counties	Type	Present (1924) acreage							Original
		Cull	Sapling	No. 1	No. 2	No. 3	No. 4	Total	County total	County total
Ogle	U	.....	1,925	22,192	3,447	.....	.....	27,564		
	P	.....	.....	.....	.....	.....	193	.....	27,757	110,970*
Peoria	U	131	2,108	44,587	1,089	125	.....	48,040		
	B	.....	1,977	33	.....	.....	.....	2,010	50,050	223,907*
Perry	U	.....	9,597	34,871	3,071	101	.....	47,640		
	B	75	1,758	8,528	2,687	116	.....	13,164	60,804	184,716
°Piatt	U	.....	134	1,989	627	18	.....	2,768	2,768	27,780
Pike	U	14	4,249	24,394	2,752	237	.....	31,691		
	B	.....	114	1,683	.....	22	.....	1,819	33,510	360,275*
Pope	U	141	23,715	33,626	2,855	60	.....	60,397		
	B	131	.....	1,442	1,059	.....	30	2,662		
	Cyp.	.....	.....	2,200	.....	.....	.....	2,200	65,259	208,608
Pulaski	U	14	.....	1,340	64	41	.....	1,459		
	B	5,936	215	7,820	2,514	400	40	16,925		
	Cyp.	.....	.....	4,568	96	484	.....	5,148	23,532	103,117
†Putnam	U	.....	.....	5,408	1,209	.....	.....	6,617		
	B	.....	12,630	.....	.....	.....	.....	12,630	19,247	58,402
Randolph	U	265	5,789	53,002	7,735	201	.....	66,992		
	B	.....	276	3,810	5,757	3,394	.....	13,237	80,229	294,753*
Richland	U	.....	2,322	13,425	1,418	44	.....	17,209		
	B	.....	841	3,599	691	116	.....	5,247	22,456	152,922*
Rock Island	U	.....	3,065	22,461	1,999	.....	.....	27,525		
	B	.....	3,123	2,239	2,592	.....	.....	7,954	35,479	162,604*
St. Clair	U	.....	850	9,432	6,828	902	.....	18,012		
	B	.....	1,115	7,905	19,110	1,454	349	29,933	47,945	291,030
Saline	U	139	3,842	20,199	315	32	.....	24,527		
	B	13	167	9,816	.....	.....	.....	9,996	34,523	207,059*
°Sangamon	U	146	3,196	45,254	2,015	49	.....	50,660		
	B	.....	7,872	1,127	1,151	73	.....	10,223	60,883	110,558*
Schuyler	U	.....	7,095	26,550	1,106	.....	.....	34,751		
	B	.....	.....	1,875	940	.....	.....	2,815	37,566	220,857

Scott	U	.....	806	8,827	675	.....	.....	10,308		
	B	.....	.....	464	.....	.....	.....	464	10,772	85,056*
°Shelby	U	.....	8,112	25,852	1,501	86	.....	35,551		
	B	.....	3,490	7,954	935	14	.....	12,393	47,944	192,920*
Stark	U	.....	36	5,905	808	.....	.....	6,749	6,749	29,622
Stephenson	U	.....	750	9,662	534	.....	.....	10,946		
	B	.....	.....	927	147	.....	.....	1,074	12,020	132,430
°Tazewell	U	108	2,361	33,424	1,488	36	.....	37,417		
	B	.....	5,814	832	850	54	.....	7,550	44,967	166,054*
Union	U	2,165	4,436	41,122	11,313	511	16	59,563		
	B	861	997	8,018	1,690	33	.....	11,599		
	Cyp.	.....	.....	1,158	131	.....	.....	1,289		
	P	.....	.....	200	.....	.....	.....	200	72,651	218,802
°Vermilion	U	.....	273	4,061	1,280	38	.....	5,652	5,652	138,311*
Wabash	U	11	686	2,202	2,228	35	.....	5,162		
	B	.....	347	2,156	2,233	224	.....	4,960	10,122	117,321
Warren	U	.....	350	14,603	2,346	.....	.....	17,299	17,299	132,603
Washington	U	.....	5,469	25,732	3,650	40	.....	34,891		
	B	.....	275	5,827	8,157	2,062	.....	16,321	51,212	209,037
Wayne	U	.....	2,449	16,351	1,109	24	.....	19,933		
	B	.....	28,236	20,503	1,202	.....	.....	49,941	69,874	347,470
White	U	.....	1,094	7,540	1,090	114	.....	9,838		
	B	.....	2,596	6,525	109	82	.....	9,312	19,150	252,054*
Whiteside	U	72	699	5,819	2,932	23	.....	9,545		
	B	.....	680	2,399	3,967	62	.....	7,108	16,653	125,984*
†Will	U	.....	1,386	15,493	797	.....	.....	17,676		
	B	.....	.....	2,202	.....	.....	.....	2,202	19,878	53,056*
Williamson	U	117	8,296	15,114	249	28	.....	23,804		
	B	81	1,077	14,411	560	.....	.....	16,129	39,933	243,681
Winnebago	U	.....	2,278	11,137	1,521	.....	.....	14,936		
	B	.....	108	2,211	622	.....	.....	2,941	17,877	129,338*
°Woodford	U	88	1,927	27,276	1,215	29	.....	30,535		
	B	.....	4,745	679	694	44	.....	6,162	36,697	98,621*
Total	U	18,343	327,158	1,733,433	197,019	5,755	16	2,281,724		
	B	15,610	178,984	363,957	144,410	14,766	419	718,146		
	Cyp.	.....	.....	13,000	7,556	599	50	21,205		
	P	.....	.....	220	.....	.....	198	418		
	T	.....	157	.....	.....	.....	.....	157	3,021,650	15,273,245

PLATE I

WASTE LAND.

Dune sand, Mason county. Illinois has 300,000 acres of sand.

THE CROP.

Twenty-year old white pine on dune sand.

PLATE II

WASTE LAND.

Eroded upland, Carroll county.

Eroded upland, Union county. Illinois has nearly 5,000,000 acres of broken upland where cover crops are essential.

PLATE III

THE CROP

A 70-year old stand of white oak on broken upland, Randolph county.

A wood-lot on broken upland in Union county yielding high-grade veneer oak.

PLATE IV

GRAZING DESTROYS WOOD-LOTS.

Wood-lot in Lee county showing contrast between grazed and ungrazed areas.

PLATE V

GRAZING DESTROYS WOOD-LOTS.

Wasteful transition of wood-lot to pasture, Grundy county.

PLATE VI

Virgin upland post-oak forest. Perry county. The scrubby small trees usually live about a century, the occasional large veterans growing to three centuries. Yields are very low.

Virgin bottomland stand. Wabash county. Large trees are red gum. Yields are very high.

PLATE VII

OUTPOSTS.

Virgin bottomland cypress-tupelo gum stand. Massac county.

Tamarack bog. Lake county. (Photo by Waterman)

PLATE VIII

OUTPOSTS.

Northernmost group of short-leaf pine. Randolph county.

PLATE IX

OUTPOSTS.

Southernmost stand of white pine. Ogle county.

Part II. Growth and Yield Studies

The objects of the survey were twofold. The one included locating, mapping, and classifying the forests; the other was a study of the productiveness of different soils in terms of forest crops.

Growth studies were made upon individual trees, and upon plots. The studies on individual trees were made with the object of determining the average rate of growth in height, diameter, and cubic contents for a given species upon a given soil type. When a comparison is made of all species growing upon a given soil type these average growth rates show which are the fastest growing trees for that soil type. See Tables 1 and 2, pp. 78-80. When a comparison is made of the rates of growth of a single species on different types of soil, there is shown the soil type best fitted for that species. See Table 3, pp. 81-89. The studies on plots were made to determine the number of trees and volumes per acre produced on a fully stocked stand for virgin plots and for even-aged plots at ten year intervals.

(1) Studies of Growth Rates of Individual Trees

The chief factors which influence the rate of growth of a tree are (1) atmospheric, including temperature, light, humidity, and precipitation as the most important; (2) soil, including water contents, gas contents, soil composition, soil temperature, exposure, slope, character of the surface and altitude; (3) biotic, or plants and animals which react upon forest vegetation. It is impossible to secure exact duplication of these dozen or more factors even in trees growing upon the same acre, hence there results a variation in the rate of growth of individual trees quite independent of the variation due to qualities inherent in different species. In the effort to standardize as far as possible those factors which influence the rate of growth of a given species, all measurements were made on plantation or forest-grown trees; the soil type as identified by the State Soil Survey was used as a basis for soil standardization; the measurements were worked up for trees growing in even-aged stands and all-aged stands separately; and as many felled trees as possible were measured. Average, rather than abnormally rapid or slow growing trees, were measured. No division is made between data collected in different parts of the state, other than those derived from even or uneven aged stands and from the soil type.

Under the soil survey made by the University of Illinois Agricultural Experiment Station, the soils have been classified as unglaciated or as belonging to a definite period of glaciation; and as bottomland and swamp, or upland timber and prairie; and some 150 different types have been identified in the 93 counties surveyed. A list of those counties for which information is available is given on page 83. This information gives, for any definite area, the soil types represented and a description of the physical and chemical characters for each type.

The studies of growth rates are based upon this system of soil classification and are carried on separately for bottomland and upland soils

as classified by the Soil Survey, but, with a single exception, separate studies were not made for growth rates when the same soil type was found on unglaciated and glaciated areas, or on areas of different periods of glaciation. The growth rates for certain acidulous upland soils of the lower Illinoisan area of glaciation were found to be so markedly lower than for similar soil types elsewhere that a special grouping of studies on these soils is made under the title Illinoisan.

The studies are incomplete in that the investigation of the growth rates for a given species was not made on each soil type upon which the species grows, nor were sufficient data collected to determine with finality the varying degrees to which growth is influenced by soil and site conditions, but the studies do show the general growth relations for the various commoner species of the state on the common soil types.

A diameter of 10 inches inside the bark on the stump is adopted as the minimum diameter at which trees will be harvested for sawlogs or for railroad ties. Such a tree will produce but one first-class tie, and in sawlog operations a 12″ stump D. I. B. more nearly represents the average cutting limit. Comparison of the periods required to attain this merchantable size (Table 1, pp. 78-79) brings out the facts that (1) on the same soil type, trees grown in even-aged stands require a shorter period than those grown in all-aged stands, that (2) there may be a very great difference in this period for different species on the same soil type, and that (3) the difference in this period for the same species growing on different soil types is not so marked.

(1) That trees grown in even-aged stands require a shorter period than those grown in all-aged stands to attain such a relatively low diameter as 10 inches is shown by the following tabulation.

Species	Soil type	Period required to attain a stump D.i.b. of 10 inches, years	
		Even-aged	All-aged
Ash	Yellow-gray silt loam	50	78
Hickory	Yellow silt loam	69	72
Swamp Spanish oak	Yellow-gray silt loam	54	58
Pin oak	Deep gray silt loam	40	50
White oak	Yellow fine sandy loam	41	62
	Yellow-gray silt loam	57	97
	Yellow silt loam	64	96
Black oak	Yellow silt loam	60	57

These six species are the only ones on which studies have been made for trees grown in both even and uneven aged stands on the same soil type. With the exception of black oak, the trees grown in all-aged stands had not yet made up for the period of initial suppression and overcome the lead of the trees grown in even-aged stands. The fact that ash on yellow-gray silt loam attained a merchantable size in 50 years grown in even-aged stands while it required 78 years to attain the same size in

all-aged stands does not necessarily mean that the yields per acre are greater for the even-aged than for the all-aged, because during this initial period of suppression the area in all-aged forest is producing two crops, whereas the even-aged stand has full possession of the soil from the beginning. The importance of this study is rather in the fact that there is established a standard period required to produce merchantable sawlog or tie material when trees are grown under the more uniform conditions, such as prevail in fully stocked, even-aged stands.

(2) That there may be a very great difference in the interval required to attain merchantable size for different species on the same soil type is shown by the following tabulation.

Soil type	Interval required to produce 10" trees			
	Species	Min. years	Species	Max. years
Yellow fine sandy silt loam	Black walnut	36	Hickory	86
Yellow-gray silt loam	White pine	21	White oak	57
Yellow silt loam	Tulip	37	Hickory	69
Sand	Black locust	35	Black oak	53
Bottomland gray fine sandy loam	Cottonwood	8	Elm	101
Bottomland deep gray silt loam	Pin oak	40	Hickory	85
Bottomland drab clay	Water locust	26	Tupelo gum	75

It so happens that, of all the species studied, the fastest and the slowest diameter growth up to a 10-inch diameter was made on the same soil type. The cottonwood on bottomland gray fine sandy loam attained this average diameter in the remarkably short period of 8 years, and elm required 101 years. This contrast is modified somewhat by the fact that the cottonwood was in an even-aged group while the elm had grown in an all-aged group—yet both grew in the same stand. In the case of bottomland deep gray silt loam, pin oak and hickory grew in the same all-aged stand, yet the hickory required twice the period of pin oak to attain a merchantable size. It is apparent that in general two to three crops of the fastest growing trees come into merchantable size in the period required to grow one crop of the slowest growing trees; and the waste of permitting these slow growing trees to monopolize the site becomes more apparent when it is seen that these fast growing trees produce also the more valuable crops, rated on a board foot basis.

Although a minimum stump D. I. B. of 10 inches is used as a standard to measure the period required for a species to attain a merchantable size, the relative rating of trees for a given soil should include both diameter and height growth. The two are expressed in cubic contents, and the cubic contents grown for each 20-year period for all different species studied on a given soil type are shown in the tabulation, on pp. 72-80.

(3) That the difference in the period required to attain a merchantable size for the same species growing on different soil types is not so marked is shown by the following tabulation.

Species	Soil type	Intervals required to produce 10-inch trees	
		Even-aged	All-aged
Ash	Bottomland deep gray silt loam		42
"	Bottomland drab clay		53
"	Upland yellow fine sandy silt loam		66
"	Upland yellow-gray silt loam	50	78
Cottonwood	Bottomland gray fine sandy loam	8	
"	Bottomland river wash	12	
"	Upland brown prairie loam	26	
Elm	Upland yellow fine sandy silt loam		62
"	Bottomland drab clay		61
"	Bottomland gray fine sandy loam		101
Hickory	Bottomland deep gray silt loam		85
"	Upland yellow silt loam	69	72
"	Upland yellow fine sandy silt loam		86
"	Upland yellow-gray silt loam		93
Hard maple	Upland yellow fine sandy silt loam		76
" "	Bottomland yellow-gray silt loam		93
Soft maple	Bottomland gray fine sandy loam	26	
" "	Bottomland drab clay		32
Pin oak	Bottomland drab clay		29
" "	Bottomland deep gray silt loam	30	40
Red oak	Upland yellow fine sandy silt loam		52
" "	Upland yellow silt loam		56
" "	Upland yellow-gray silt loam	52	
" "	Upland red-brown fine sandy silt loam		66
Black oak	Upland yellow-gray sandy loam	44	
" "	Upland yellow-gray silt loam	52	
" "	Upland red-brown fine sandy silt loam		72
" "	Upland sand	53	
" "	Upland yellow silt loam	60	57
" "	Upland Illinoisan yellow-gray silt loam	63	
Post oak	Upland light gray silt loam on tight clay		66
" "	Upland yellow-gray silt loam	66	
" "	Bottomland yellow-gray silt loam on clay		74
White oak	Upland yellow-gray sandy loam	41	62
" "	Upland yellow silt loam	64	96
" "	Upland yellow-gray silt loam	57	97
Tulip poplar	Upland yellow fine sandy silt loam		42
" "	Upland yellow silt loam		37
Black walnut	Upland yellow fine sandy silt loam		36
" "	Prairie brown silt loam	40	
" "	Prairie black clay loam	49	

For the species studied, the difference in time required to attain a merchantable size is greatest for the elm and this difference is but 40 years. In the case of the white and the black oaks, where the studies have been the more complete, there is surprisingly little difference due to

soil in the interval required to attain a merchantable diameter. Black oak in even-aged stands on upland yellow-gray sandy loam attained such a diameter in 44 years, on upland yellow-gray silt loam in 52 years, on dune sand in 53 years, on upland yellow silt loam in 60 years and on the heavy yellow-gray silt loams of the Illinoisan in 63 years. The influence of soil is more accurately reflected in the height growth than in diameter growth. Thus 55-year old black oak on upland yellow-gray sandy loam has a height of 61 feet, on upland yellow-gray silt loam of 55 feet, on upland yellow silt loam of 55 feet, on dune sand of 50 feet, and on the Illinoisan yellow-gray silt loam of but 40 feet. Since height and diameter determine the cubic contents, the ratings of the productiveness of soils for any given species is best expressed by cubic contents. Such a rating is shown in Table 3, pp. 72-80, in which E signifies even-aged stand, and A equals all-aged stand.

TABLE 1.—Average Growth in Cubic Feet showing Species Best Suited to the Specific Soil Type

UPLAND SOILS

Species	20 Yrs.		40 Yrs.		60 Yrs.		80 Yrs.		100 Yrs.		150 Yrs.		Years required to attain a minimum sawlog or tie size of 10-in. stump D. i. b.	
	E*	A†	E	A	E	A	E	A	E	A	E	A	E	A
Yellow fine sandy silt loam														
Black walnut	.....	1.6	.....	19.8	.....	51.5	.....	81.5	.....	.....	.....	.....	.....	36
Tulip	.....	.5	.....	6.4	.....	26.0	.....	68.2	.....	124.1	.....	.....	.....	42
Red oak	.....	.5	.....	2.3	.....	12.6	.....	55.6	.....	.....	.....	.....	.....	52
Basswood	.....	.6	.....	2.4	.....	11.2	.....	33.9	.....	70.6	.....	.....	.....	60
Elm	.....	.6	.....	2.3	.....	10.3	.....	27.3	.....	58.3	.....	135.5	.....	62
Ash	.....	.4	.....	2.0	.....	8.8	.....	27.2	.....	47.3	.....	122.0	.....	66
Hard maple	.....	.4	.....	2.0	.....	6.4	.....	17.2	.....	40.5	.....	121.3	.....	76
Hickory	.....	.4	.....	2.0	.....	6.1	.....	14.3	.....	28.7	.....	82.6	.....	86
Yellow fine sandy loam														
Beech	.....	.3	.....	1.0	.....	2.5	.....	7.7	.....	20.3	.....	84.6	.....	91
Yellow-gray sandy loam														
Black oak	1.3	.....	8.4	.....	27.1	.....	52.7	.....	.....	.....	.....	.....	44	
White oak	1.2	.5	7.9	3.0	21.1	13.1	40.1	32.1	.....	51.7	.....	118.6	41	62
Red-brown fine sandy silt loam														
Red oak	.....	.8	.....	2.8	.....	8.7	.....	23.8	.....	48.5	.....	.....	.....	66
Black oak	.....	.7	.....	2.3	.....	7.8	.....	22.0	.....	43.7	.....	.....	.....	72
Yellow-gray silt loam														
White pine	3.6	.....	31.1	.....	63.6	.....	.....	.....	.....	.....	.....	.....	21	
Red oak	.7	.....	4.1	.....	17.8	.....	39.4	.....	.....	.....	.....	.....	52	
Black oak	1.0	.....	5.2	.....	18.6	.....	37.3	.....	.....	.....	.....	.....	52	
Ash	1.1	.2	5.2	1.4	15.9	5.5	32.2	15.4	50.1	25.4	.....	59.2	50	78
Shingle oak	.....	.7	.....	3.1	.....	11.5	.....	27.3	.....	35.7	.....	.....	.....	60

*E—Trees grown in even-aged stands. †A—Trees grown in all-aged stands.

TABLE 1.—Average Growth in Cubic Feet showing Species Best Suited to the Specific Soil Type

UPLAND SOILS—Concluded

Species	20 Yrs.		40 Yrs.		60 Yrs.		80 Yrs.		100 Yrs.		150 Yrs.		Years required to attain a minimum saw-log or tie size of 10-in. stump D. i. b.	
	E*	A†	E	A	E	A	E	A	E	A	E	A	E	A
Yellow-gray silt loam—Concluded														
Hard maple	.....	.4	.....	1.5	.....	3.8	.....	10.0	.....	18.9	.....	46.3	.....	93
Hickory	.....	.4	.....	1.6	.....	3.5	.....	9.2	.....	17.8	.....	48.5	.....	93
White oak	.5	.1	3.0	.9	11.6	2.3	.....	4.6	.....	9.6	.....	28.8	57	97
Yellow silt loam														
Tulip	.....	2.1	.....	12.1	.....	30.3	.....	53.2	.....	.....	.....	.....	.....	37
Red oak	.....	.7	.....	3.4	.....	15.5	.....	42.7	.....	.....	.....	.....	.....	56
Black oak	.8	.8	3.7	3.7	13.4	13.6	26.7	32.1	.....	49.0	.....	.....	60	57
Hickory	.....	.5	.....	2.1	.....	6.5	.....	18.5	.....	31.2	.....	.....	.....	72
White oak	.6	.3	2.9	1.5	9.9	3.2	.....	7.1	.....	12.5	.....	35.7	64	96
Prairie brown silt loam														
Cottonwood	3.5	.....	33.2	.....	71.9	.....	.....	.....	.....	.....	.....	.....	26	
Black walnut	1.5	.....	11.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	40	
Prairie black clay loam														
Black walnut	1.4	.....	8.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	49	
Sand														
Black locust	2.4	.....	16.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	35	
Black oak	1.0	.....	5.2	.....	13.6	.....	.....	.....	.....	.....	.....	.....	53	
Illinoisan light gray silt loam on tight clay														
Post oak	.....	.7	.....	2.8	.....	7.8	.....	.....	.....	.....	.....	.....	.....	66
Illinoisan yellow-gray silt loam														
Black oak	.8	.....	3.1	.....	8.1	.....	.....	.....	.....	.....	.....	.....	63	
Post oak	.2	.....	1.5	.....	5.1	.....	.....	.....	.....	.....	.....	.....	66	
Illinoisan yellow-gray silt loam on clay														
Post oak	.....	.3	.....	1.3	.....	4.1	.....	.....	.....	.....	.....	.....	.....	74

TABLE 2.—Average Growth in Cubic Feet showing Species Best Suited to the Specific Soil Type

BOTTOMLAND SOILS

Species	20 Yrs.		40 Yrs.		60 Yrs.		80 Yrs.		100 Yrs.		150 Yrs.		Years required to attain a minimum saw-log or tie size of 10-in. stump D. i. b.	
	E	A	E	A	E	A	E	A	E	A	E	A	E	A
Gray fine sandy loam														
Cottonwood	70.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8	
Sycamore	.....	10.8	.....	62.9	.....	101.8	.....	138.9	.....	.....	.....	.....	.....	22
Soft maple	4.5	.....	53.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	26	
Elm	.....	.7	.....	2.0	.....	3.9	.....	6.5	.....	13.4	.....	37.6	.....	101
River wash														
Cottonwood	37.7	.....	96.7	.....	161.0	.....	.....	.....	.....	.....	.....	.....	12	
Deep-gray silt loam														
Pin oak	3.1	1.9	23.6	10.4	.....	38.7	.....	74.3	.....	.....	.....	.....	30	40
Ash	.....	1.3	.....	10.0	.....	30.4	.....	55.4	.....	.....	.....	.....	.....	42
Schneck's oak	.8	.....	6.2	.....	33.4	.....	.....	.....	.....	.....	.....	.....	46	
Hickory	.....	.4	.....	1.5	.....	4.7	.....	13.7	.....	22.9	.....	42.3	.....	85
Drab clay														
Honey locust	.....	2.3	.....	25.8	.....	72.0	.....	138.2	.....	191.3	.....	.....	.....	31
Water locust	.....	5.2	.....	28.5	.....	57.6	.....	.....	.....	.....	.....	.....	.....	26
Pin oak	.....	2.5	.....	25.7	.....	66.9	.....	129.9	.....	.....	.....	.....	.....	29
Soft maple	.....	2.1	.....	23.4	.....	72.0	.....	123.9	.....	.....	.....	.....	.....	32
Ash	.....	.9	.....	4.7	.....	17.0	.....	37.1	.....	50.3	.....	71.5	.....	53
Hackberry	.....	.7	.....	3.3	.....	12.1	.....	28.4	.....	45.3	.....	108.7	.....	61
Elm	.....	.7	.....	3.3	.....	11.3	.....	25.7	.....	41.0	.....	97.2	.....	61
Tupelo gum	.....	.7	.....	2.6	.....	6.4	.....	13.4	.....	23.4	.....	63.9	.....	75
Yellow-gray silt loam														
Swamp Spanish oak	1.0	.8	4.9	4.3	14.9	13.6	29.9	29.8	.....	.....	.....	.....	54	58

TABLE 3.—Average Growth-Rates on Specific Soil-Types by 20-Year Periods for 25 Tree Species to show Soil Type Best Suited to Species

Soil type	20		40		60		80		100		150		Basic trees	
	E*	A†	E	A	E	A	E	A	E	A	E	A	E	A
						Ash								
						Stump D. i. b. Inches								
Deep gray silt loam—B‡	.....	3.9	.....	9.6	.....	13.7	.....	17.3	.....	.....	.....	.....	...	9
Drab clay	.....	3.7	.....	7.6	.....	11.2	.....	14.6	.....	16.4	.....	19.0	...	10
Yellow fine sandy silt loam—U§	.....	1.8	.....	4.7	.....	8.2	.....	12.2	.....	15.4	.....	24.0	...	14
Yellow-gray silt loam—U	3.9	1.5	7.9	3.7	11.6	7.3	13.9	10.2	16.6	12.0	.....	17.3	10	6
						Height. Feet								
D. G. S. L.	.....	30	.....	54	.....	74	.....	86						
D. C.	.....	21	.....	43	.....	64	.....	79	.....	87	.....	93		
Y. F. S. S. L.	.....	19	.....	39	.....	62	.....	83	.....	94	.....	105		
Y. G. S. L.	26	14	44	34	58	52	78	68	84	80	.....	93		
						Contents. Cubic Feet								
D. G. S. L.	.....	1.3	.....	10.0	.....	30.4	.....	55.4						
D. C.	.....	.9	.....	4.7	.....	17.0	.....	37.1	.....	50.3	.....	71.5		
Y. F. S. S. L.	.....	.4	.....	2.0	.....	8.8	.....	27.2	.....	47.3	.....	122.0		
Y. G. S. L.	1.1	.2	5.2	1.4	15.9	5.5	32.2	15.4	50.1	25.4	.....	59.2		
						Basswood								
						Stump D. i. b. Inches								
Yellow fine sandy silt loam	.....	2.4	.....	5.7	.....	10.0	.....	15.2	.....	20.0	.....	.....	...	10
						Height. Feet								
	.....	19	.....	37	.....	55	.....	68	.....	80				
						Contents. Cubic Feet								
	.....	.6	.....	2.4	.....	11.2	.....	33.9	.....	70.6				

*E=Trees grown in even-aged stands.
†A=Trees grown in all-aged stands.
‡B=Bottomland soil type.
§U=Upland soil type.

AVERAGE GROWTH-RATES ON SPECIFIC SOIL-TYPES BY 20-YEAR PERIODS FOR 25 TREE SPECIES TO SHOW SOIL TYPE BEST SUITED TO SPECIES—Continued

Soil type	20		40		60		80		100		150		Basic trees	
	E*	A†	E	A	E	A	E	A	E	A	E	A	E	A
Beech														
Stump D. i. b. Inches														
Yellow fine sandy loam—U	.....	1.6	.....	3.2	.....	5.3	.....	8.2	.....	11.6	.....	20.8	...	10
Height. Feet	.....	15	.....	29	.....	42	.....	56	.....	69	.....	91		
Contents. Cubic Feet	.....	.3	.....	1.0	.....	2.5	.....	7.7	.....	20.3	.....	84.6		
Cottonwood														
Stump D. i. b. Inches														
Gray fine sandy loam—B	18.6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	10
River wash—B	14.5	.....	21.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	26
Brown prairie loam—U	7.4	.....	15.6	.....	21.0	.....	.....	.....	.....	.....	.....	.....	...	8
Height. Feet														
G. F. S. L.	104	.....												
R. W.	93	.....	108	.....										
B. P. L.	33	.....	69	.....	82									
Contents. Cubic Feet														
G. F. S. L.	70.3	.....												
R. W.	37.7	.....	96.7	.....										
B. P. L.	3.5	.....	33.2	.....	71.9									
Elm														
Stump D. i. b. Inches														
Yellow fine sandy silt loam—U	.....	2.6	.....	5.6	.....	9.6	.....	13.6	.....	18.4	.....	26.2	...	13
Drab clay—B	.....	2.8	.....	6.6	.....	9.8	.....	13.2	.....	16.0	.....	24 0	...	10
Gray fine sandy loam—B	.....	2.2	.....	3.9	.....	5.2	.....	6.4	.....	9 1	.....	15.0	...	3
Height. Feet														
Y. F. S. S. L.	.....	19	.....	37	.....	55	.....	68	.....	79	.....	91		
D. C.	.....	28	.....	41	.....	57	.....	68	.....	73	.....	77		
G. F. S. L.	.....	24	.....	45	.....	60	.....	70	.....	74	.....	77		

						Contents. Cubic Feet										
Y. F. S. S. L.		.6		2.3		10.3		27.3		58.3		135.5				
D. C.		.7		3.3		11.3		25.7		41.0		97.2				
G. F. S. L.		.7		2.0		3.9		6.5		13.4		37.6				
						Gum, Tupelo										
						Stump D. i. b. Inches										
Drab clay		3.0		6.2		8.3		10.6		13.0		19.0				18
						Height. Feet										
		20		36		48		58		65		81				
						Contents. Cubic Feet										
		.7		2.6		6.4		13.4		23.4		63.9				
						Hackberry										
						Stump D. i. b. Inches										
Drab clay		2.3		6.0		9.7		13.6		16.5		25.4				10
						Height. Feet										
		26		48		61		70		76		77				
						Contents. Cubic Feet										
		.7		3.3		12.1		28.4		45.3		108.7				
						Hickory										
						Stump D. i. b. Inches										
Yellow silt loam—U.	2.4	2.2	4.8	5.4	8.5	8.2		11.8		13.8				10		10
Deep gray silt loam—B.		1.7		3.8		6.8		9.2		11.7		15.4				24
Yellow fine sandy silt loam—U		1.4		3.5		6.4		9.1		12.3		20.0				9
Yellow-gray silt loam—U		1.4		3.0		5.4		8.4		10.8		15.9				10
						Height. Feet										
Y. S. L.		18		35		50		63		75						
D. G. S. L.		18		35		52		66		76		82				
Y. F. S. S. L.		25		48		67		78		87		97				
Y. G. S. L.		26		45		54		62		70		90				
						Contents. Cubic Feet										
Y. S. L.		.5		2.1		6.5		18.5		31.2						
D. G. S. L.		.4		1.5		4.7		13.7		22.9		42.3				
Y. F. S. S. L.		.4		2.0		6.1		14.3		28.7		82.6				
Y. G. S. L.		.4		1.6		3.5		9.2		17.8		48.5				

AVERAGE GROWTH-RATES ON SPECIFIC SOIL-TYPES BY 20-YEAR PERIODS FOR 25 TREE SPECIES TO SHOW SOIL TYPE BEST SUITED TO SPECIES—Continued

Soil type	20		40		60		80		100		150		Basic trees	
	E*	A†	E	A	E	A	E	A	E	A	E	A	E	A
						Locust, Black								
						Stump D. i. b. Inches								
Sand—U	5.6	.....	11.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	
						Height. Feet								
	38	.....	60											
						Contents. Cubic Feet								
	2.4	.....	16.1											
						Locust, Honey								
						Stump D. i. b. Inches								
Drab clay—B	.....	5.7	.....	13.5	.....	20.0	.....	27.0	.....	31.5	.....	.....	...	4
						Height. Feet								
	.....	33	.....	66	.....	82	.....	87	.....	89				
						Contents. Cubic Feet								
	.....	2.3	.....	25.8	.....	72.0	.....	138.2	.....	191.3				
						Locust, Water								
						Stump D. i. b. Inches								
Drab clay—B	.....	7.6	.....	14.4	.....	18.2	.....	.....	.....	.....	.....	.....	...	10
						Height. Feet								
	.....	47	.....	65	.....	80								
						Contents. Cubic Feet								
	.....	5.2	.....	28.5	.....	57.6								
						Maple, Hard								
						Stump D. i. b. Inches								
Yellow fine sandy silt loam—U	.....	2.1	.....	5.1	.....	7.6	.....	10.6	.....	15.1	.....	24.8	...	10
Yellow-gray silt loam—B	.....	1.8	.....	3.6	.....	6.1	.....	8.7	.....	11.0	.....	15.4	...	10

Height. Feet

Y. F. S. S. L.	.....	17	.....	35	.....	55	.....	70	.....	82	.....	90				
Y. G. S. L.	.....	18	.....	38	.....	52	.....	63	.....	72	.....	91				

Contents. Cubic Feet

Y. F. S. S. L.	.....	.4	.....	2.0	.....	6.4	.....	17.2	.....	40.5	.....	121.3				
Y. G. S. L.	.....	.4	.....	1.5	.....	3.8	.....	10.0	.....	18.9	.....	46.3				

Maple, Soft

Stump D. i. b. Inches

Gray fine sandy loam—B	7.1	....	17.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	4			
Dray clay	.....	5.8	.....	13.0	.....	19.8	.....	24.8	.....	.....	.....	.....	...	7		

Height. Feet

G. F. S. L.	47	.....	84	.....												
D. C.	.....	32	.....	65	.....	84	.....	93								

Contents. Cubic Feet

G. F. S. L.	4.5	.....	53.0	.....												
D. C.	.....	2.1	.....	23.4	.....	72.0	.....	123.9								

Oak, Pin

Stump D. i. b. Inches

Drab clay—B	.....	5.8	.....	15.4	.....	21.2	.....	27.6	.....	.....	.....	.....	...	10		
Deep gray silt loam—B.	6.3	4.3	14.3	10.1	.....	16.6	.....	21.2	.....	.....	.....	.....	20	20		

Height. Feet

D. C.	.....	29	.....	59	.....	80	.....	90								
D. G. S. L.	32	29	63	58	.....	76	.....	88								

Contents. Cubic Feet

D. C.	.....	2.5	.....	25.7	.....	66.9	.....	129.9								
D. G. S. L.	3.1	1.9	23.6	10.4	.....	38.7	.....	74.3								

Oak, Red

Stump D. i. b. Inches

Yellow fine sandy silt loam—U	.....	1.6	.....	3.7	.....	9.4	.....	17.7	.....	.....	.....	.....	...	3		
Yellow silt loam—U	.....	2.5	.....	6.1	.....	11.0	.....	16.2	.....	.....	.....	.....	...	24		
Yellow-gray silt loam—U	2.7	.....	7.0	.....	11.8	.....	16.1	.....	.....	.....	.....	.....	31			
Red-brown fine sandy silt loam—U	.....	2.4	.....	4.8	.....	8.4	.....	12.8	.....	17.3	.....	.....	...	9		

AVERAGE GROWTH-RATES ON SPECIFIC SOIL-TYPES BY 20-YEAR PERIODS FOR 25 TREE SPECIES TO SHOW SOIL TYPE BEST SUITED TO SPECIES—Continued

Soil type	20		40		60		80		100		150		Basic trees	
	E*	A†	E	A	E	A	E	A	E	A	E	A	E	A
Height. Feet														
Y. F. S. S. L.	.....	25	.....	45	.....	65	.....	81						
Y. S. L.	.....	22	.....	42	.....	60	.....	73						
Y. G. S. L.	.....	.....	41	.....	59	.....	68	.....						
R. B. F. S. S. L.	.....	25	.....	44	.....	57	.....	67	.....	73				
Contents. Cubic Feet														
Y. F. S. S. L.	.....	.5	.....	2.3	.....	12.6	.....	55.6						
Y. S. L.	.....	.7	.....	3.4	.....	15.5	.....	42.7						
Y. G. S. L.	.7	.....	4.1	.....	17.8	.....	39.4	.....						
R. B. F. S. S. L.	.....	.8	.....	2.8	.....	8.7	.....	23.8	.....	48.5				
Oak, Shingle														
Stump D. i. b. Inches														
Yellow-gray silt loam—U	.....	3.0	.....	6.4	.....	9.9	.....	13.6	.....	.....	.....	.....	...	6
Height. Feet														
	.....	20	.....	40	.....	57	.....	68						
Contents. Cubic Feet														
	.....	.7	.....	3.1	.....	11.5	.....	27.3						
Oak, Black														
Stump D. i. b. Inches														
Yellow-gray sandy loam—U	4.4	.....	9.2	.....	13.2	.....	17.4	.....	.....	.....	.....	.....	36	
Yellow-gray silt loam—U	3.5	.....	7.6	.....	11.6	.....	15.4	.....	.....	.....	.....	.....	61	
Red-brown fine sandy silt loam—U	.....	2.2	.....	4.6	.....	7.8	.....	11.7	.....	15.8	.....	.....	...	10
Sand—U	3.6	.....	7.8	.....	11.1	.....	.....	.....	.....	.....	.....	.....	59	
Yellow silt loam—U	3.0	2.9	6.4	6.6	10.0	10.5	12.9	14.3	.....	17.2	.....	.....	32	58
Illinoisan yellow-gray silt loam—U	3.3	.....	6.9	.....	9.7	.....	.....	.....	.....	.....	.....	.....	22	

					Height. Feet									
Y. G. sandy L.	27	.....	51	.....	71	.....	80	.....						
Y. G. silt L.	25	.....	47	.....	64	.....	72	.....						
R. B. F. S. S. L.	.....	25	.....	44	.....	61	.....	73	.....	80				
S.	25	.....	45	.....	55	.....								
Y. S. L.	24	24	47	45	63	62	72	72	.....	76				
I. Y. G. S. L.	21	.....	35	.....	45	.....								
					Contents. Cubic Feet									
Y. G. sandy L.	1.3	.....	8.4	.....	27.1	.....	52.7	.....						
Y. G. silt L.	1.0	.....	5.2	.....	18.6	.....	37.3	.....						
R. B. F. S. S. L.	.....	.7	.....	2.3	.....	7.8	.....	22.0	.....	43.7				
S.	1.0	.....	5.2	.....	13.6	.....								
Y. S. L.	.8	.8	3.7	3.7	13.4	13.6	26.7	32.1	.....	49.0				
I. Y. G. S. L.	.8	.....	3.1	.....	8.1	.....								
					Oak, Swamp Spanish									
					Stump D. i. b. Inches									
Yellow-gray silt loam—B	3.7	3.0	7.5	7.0	11.0	10.3	14.4	14.1	.....	.....	.....	....	10	19
					Height. Feet									
	23	23	46	46	60	61	66	69						
					Contents. Cubic Feet									
	1.0	.8	4.9	4 3	14.9	13.6	29.9	29.8						
					Oak, Schneck's									
					Stump D. i. b. Inches									
Deep gray silt loam—B.	3.1	.....	8.3	.....	15.1	.....	.....	.....	.....	.....	.....	.....	10	
					Height. Feet									
	24	.....	47	.....	68	.....								
					Contents. Cubic Feet									
	.8	.....	6.2	.....	33.4	.....								
					Oak, Post									
					Stump D. i. b. Inches									
Light gray silt loam on tight clay—U	.....	3.5	.....	6.7	.....	9.6	.....	.....	.....	.....	.....	.....	...	10
Yellow-gray silt loam on clay—B	.....	1.6	.....	3.9	.....	6.9	.....	.....	.....	.....	.....	.....	...	10
Yellow-gray silt loam—U	1.7	.....	4.9	....	8.4	.....	.....	.....	.....	.....	.....	.....	29	

AVERAGE GROWTH-RATES ON SPECIFIC SOIL-TYPES BY 20-YEAR PERIODS FOR 25 TREE SPECIES TO SHOW SOIL TYPE BEST SUITED TO SPECIES—Concluded

Soil type	20		40		60		80		100		150		Basic trees	
	E*	A†	E	A	E	A	E	A	E	A	E	A	E	A
					Height. Feet									
L. G. S. L. on T. C.	.....	18	.....	34	.....	46								
Y. G. S. L. on C.	.....	16	.....	31	.....	46								
Y. G. S. L.	14	.....	27	.....	40	.....								
					Contents. Cubic Feet									
L. G. S. L. on T. C.	.....	.7	.....	2.8	.....	7.8								
L. G. S. L. on C.	.....	.3	.....	1.3	.....	4.1								
Y. G. S. L.	.2	.....	1.5	.....	5.1	.....								
					Oak, White									
					Stump D. i. b. Inches									
Yellow-gray sandy loam—U	4.8	1.9	9.8	5.6	13.3	9.5	16.5	13.1	.....	16.2	.....	24.3	20	10
Yellow silt loam—U.	2.7	1.7	6.1	3.9	9.4	6.1	.....	8.4	.....	10.4	.....	15.4	37	69
Yellow-gray silt loam—U	2.5	.9	6.4	2.7	10.6	4.7	.....	6.7	.....	9.2	.....	15.5	58	10
					Height. Feet									
Y. G. sandy L.	22	24	45	48	60	69	70	86	.....	91	.....	92		
Y. S. L.	22	20	41	34	57	46	.....	53	.....	59	.....	71		
Y. G. silt L.	20	15	39	30	54	43	.....	54	.....	58	.....	60		
					Contents. Cubic Feet									
Y. G. sandy L.	1.2	.5	7.9	3.0	21.1	13.1	40.1	32.1	.....	51.7	.....	118.6		
Y. S. L.	.6	.3	2.9	1.5	9.9	3.2	.....	7.1	.....	12.5	.....	35.7		
Y. G. silt L.	.5	.1	3.0	.9	11.6	2.3	.....	4.6	.....	9.6	.....	28.8		
					Pine, White									
					Stump D. i. b. Inches									
Yellow-gray silt loam—U	8.6	.....	18.0	.....	22.6	.....	.....	.....	.....	.....	.....	.....	10	
					Height. Feet									
	29	.....	64	.....	85	.....								
					Contents. Cubic Feet									
	4.6	.....	43.2	.....	81.4	.....								

Sycamore

Stump D. i. b. Inches

Gray fine sandy loam—B	.....	8.8	.....	17.6	.....	22.1	.....	25.8	.....	.....	.....	.....	...	11

Height. Feet

	.....	67	.....	96	.....	100	.....	101				

Contents. Cubic Feet

	.....	10.8	.....	62.9	.....	101.8	.....	138.9				

Tulip-Poplar

Stump D. i. b. Inches

Yellow fine sandy silt loam—B	.....	2.9	.....	9.4	.....	14.9	.....	20.3	.....	25.8	.....	.....	...	10
Yellow silt loam—U	.....	5.6	.....	10.6	.....	14.2	.....	17.6	.....	.....	.....	.....	...	16

Height. Feet

Y. F. S. S. L.	.....	19	.....	39	.....	62	.....	83	.....	94		
Y. S. L.	.....	33	.....	57	.....	75	.....	86				

Contents. Cubic Feet

Y. F. S. S. L.	.....	.5	.....	6.4	.....	26.0	.....	68.2	.....	124.1		
Y. S. L.	.....	2.1	.....	12.1	.....	30.3	.....	53.2				

Walnut, Black

Stump D. i. b. Inches

Yellow fine sandy silt loam—U	.....	4.8	.....	11.3	.....	16.6	.....	20.4	.....	.....	.....	.....	...	11
Prairie brown silt loam —U	5.2	.....	10.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	
Prairie black clay loam —U	4.0	.....	8.2	.....										

Height. Feet

Y. F. S. S. L.	.....	30	.....	71	.....	87	.....	91				
P. B. S. L.	25	.....	54	.....								
P. B. C. L.	31	.....	60	.....								

Contents. Cubic Feet

Y. F. S. S. L.	.....	1.6	.....	19.8	.....	51.5	.....	81.5				
P. B. S. L.	1.5	.....	11.1	.....								
P. B. C. L.	1.4	.....	8.4	.....								

Summarizing the studies of average growth, and grouping somewhat similar soil types together, the following lists show the rates on different soils for the trees studied.

Upland Sandy Loams

Species	*Cubic contents at 60 years*	
	Even-aged	All-aged
Black walnut	.....	51.5
Tulip-poplar	.....	26.0
Black oak	27.1	
White oak	21.1	13.1
Red oak	.....	10.6
Basswood	.....	11.2
Elm	.....	10.3
Ash	.....	8.8
Hard maple	.....	6.4
Hickory	.....	6.1
Beech	.....	2.5

Upland Yellow and Yellow-Gray Silt Loams

Species	*Cubic contents at 60 years*	
	Even-aged	All-aged
White pine	63.6	
Tulip-poplar	.....	30.3
Red oak	17.8	15.5
Black oak	16.0	13.6
Shingle oak	.....	11.5
Ash	15.9	5.5
Hickory	.....	5.0
Hard maple	11.6	2.3
White oak	10.7	2.7

Upland Sand

Species	*Cubic contents at 60 years*	
	Even-aged	All-aged
White pine	18.0	
Black oak	13.6	

Heavy Loams—Illinoisan

Species	*Cubic contents at 60 years*	
	Even-aged	All-aged
Black oak	8.1	
Post oak	5.1	5.9

Bottomland Light Soils

Species	*Cubic contents at 40 years*	
	Even-aged	All-aged
Cottonwood	96.7	
Sycamore	.....	62.9
Soft maple	53.0	
Elm	.....	2.0

Bottomland Heavy Soils

Species	*Cubic contents at 40 years*	
	Even-aged	All-aged
Water locust	.....	28.5
Honey locust	.....	25.8
Soft maple	.....	23.4
Pin oak	23.6	18.0
Ash	.....	7.3
Schneck's oak	6.2	
Swamp Spanish oak	4.9	4.3
Hackberry	.....	3.3
Elm	.....	3.3
Tupelo gum	.....	2.6
Hickory	.....	1.5

The minimum-sized tree suitable for ties or sawlogs averages about 10 inches stump D. I. B. and 60 feet in height. Such a tree contains approximately 13 cubic feet of wood in the peeled stem. Using this figure as a standard, it is seen that, in the upland sandy loams, black walnut, tulip-poplar, and black and white oaks are the only species which average a sawlog tree at 60 years age. However, it is probable that red oak, basswood, elm, and ash will make such trees if grown in even-aged stands.

On the upland yellow and yellow-gray silt loams the species which average a tree of minimum sawlog size or more at 60 years are white pine, tulip-poplar, red oak, black oak, shingle oak, and ash; while hickory, hard maple, and white oak grow very slowly.

White pine and black oak were the only two species studied on the sand and each produces a merchantable tree in 60 years. On the heavy loams of the post oak region neither post oak nor black oak made sawlogs at 60 years.

The bottomland soils produce several species of very rapid growth-rates and 40 years is taken as the period of comparison. On the light soils of the bottomland, sycamore, cottonwood, and soft maple have a very high growth-rate, while elm fails to make trees of average sawlog size in the 40-year period.

On the heavy bottomland soils water locust, honey locust, soft maple, and pin oak produce merchantable trees at 40 years, while ash, Schneck's

oak, swamp Spanish oak, hackberry, elm, tupelo gum, and hickory require longer periods.

Soil Reports

Reports or maps available		Information available but maps or reports not yet published		No information available
Adams	Logan	Alexander	Jo Daviess	Calhoun
Bond	McDonough	Boone	Kendall	Fayette
Bureau	McHenry	Brown	Lawrence	Jasper
Champaign	McLean	Carroll	Macoupin	Marshall
Clay	Macon	Cass	Madison	Piatt
Crawford	Marion	Christian	Massac	Putnam
Cumberland	Mason	Clark	Menard	Schuyler
DeKalb	Mercer	Clinton	Montgomery	Washington
Douglas	Monroe	Coles	Morgan	Wayne
DuPage	Moultrie	Cook	Perry	
Edgar	Ogle	DeWitt	Pope	
Edwards	Peoria	Effingham	Pulaski	
Franklin	Pike	Ford	Richland	
Grundy	Randolph	Fulton	St. Clair	
Hancock	Rock Island	Gallatin	Scott	
Hardin	Saline	Green	Shelby	
Iroquois	Sangamon	Hamilton	Stark	
Johnson	Tazewell	Henderson	Stephenson	
Kane	Vermilion	Henry	Union	
Kankakee	White	Jackson	Wabash	
Knox	Whiteside	Jefferson	Warren	
La Salle	Will	Jersey	Williamson	
Lake	Winnebago			
Lee	Woodford			
Livingston				

(2) Studies of Yields

Data were collected from 104 plots selected as representing average fully stocked stands. The 72 even-aged upland plots were divided between the upland types as follows: (1) post oak, 14 plots; (2) scrub oak, 23 plots; and (3) upland mixed hardwoods, 34 plots. There were 19 even-aged bottomland plots. The 13 all-aged virgin plots were divided as follows: upland mixed hardwoods, 7 plots; bottomland mixed hardwoods, 6 plots. The plots ranged from one-sixteenth to one acre and averaged .36 acres each. The ages ranged from 20 years to 110 years for the even-aged plots, and three quarters of the even-aged plots were fifty or more years old.

All trees on the plots were calipered at a point 4½ feet from the ground (D. B. H.) and the tally was made by species. Record was made of the soil type, density of crown-stocking, ground cover, and location. The age of each even-aged plot was secured by ring counts. The heights of trees in the dominant and other crown classes were measured and registered by diameter and species.

The even-aged plots were divided between the three upland types—post oak, scrub oak, and upland mixed hardwoods—and the one bottomland type; and the data were worked up to show, for each decade between the second and tenth, the total number of trees for a fully stocked acre, the average height of the dominant trees, the D. B. H. of the average tree, the basal area per acre, the total cubic feet contents exclusive of branchwood, and the average annual growth per acre. (Tables 4-8, pp. 95-97.)

A comparison of growth on these even-aged upland stands in Illinois and the even-aged second growth hardwoods in Connecticut and Massachusetts indicates that the Illinois post oak type has about the same number of trees per acre at a given decade as the poorest upland type in Connecticut—Quality III Oak (Frothingham '12), but that the diameter growth averages less on the post oak, and that the height growth averages decidedly lower. This Quality III Oak type in Connecticut represents thin-soiled upper slopes. It is very poor land, yet it produces better trees than the post oak type in Illinois.

A study of the scrub oak stands on the sands in Illinois shows that these sands produce trees of an average diameter and height-growth comparable to that of the better sites in Connecticut—between Quality I and Quality II Oak sites—but that the fully stocked Illinois stands do not have nearly as many trees per acre as the eastern forests.

A study of the upland mixed hardwoods type of Illinois shows that the diameter growth for such fully stocked even-aged stands averages about the same as the better sites in Connecticut (Quality I Oak), that the height growth of dominant trees averages about the same as that of the medium sites in Connecticut (Quality II Oak), and that the number of trees per acre for a given decade is again very low in Illinois. At 70 years these fully stocked stands in Illinois have but 70 per cent as many trees as such stands on the Quality I Oak site in Connecticut, and but 45 per cent as many trees as fully stocked even-aged stands of 70 years on Quality I sites in Massachusetts. (Spaeth '20.)

The annual rainfall of Connecticut is about 47 inches, and of Illinois about 37 inches. The annual evaporation for Connecticut amounts to about 39 inches, for Illinois to approximately 41 inches. The lesser amount of rain and the greater evaporation in Illinois is thus reflected in the decrease in the number of trees supported on an acre. This indicates that, in the management of the hardwood forests on the uplands of Illinois, the conservation of moisture is one of the important factors.

Post Oak Type

The post oak plots selected were on the heavy acidulous soils common to the level uplands of south-central Illinois described in Part I under the post oak type, p. 32. Post oak constitutes 74 per cent of the trees on the plots measured, scrub oak 12, with various black oaks and hickories totaling 14 per cent. An examination of the tables 4-6, pp. 95, 96, shows that these post-oak stands have a greater number of trees per acre, a smaller total basal area per acre and consequently a smaller average

D. B. H., that the height of the dominant trees is decidedly less than for the other two upland types, and that the yields for corresponding decades are the lowest. Reference to the tabulation of the D. B. H. of the average tree brings out the point that these stands do not enter the sawlog class—minimum D. B. H. 10 inches—within the first hundred years. The product is suitable for posts, mine timbers, and cordwood at about 60 years.

Scrub Oak Type

The scrub oak plots selected were on the sands in central and northern Illinois. The representation of species on the plots measured, shows black oak 62 per cent, scrub oak 29, hickory 8, and white oak 1 per cent. A marked variation in the individual plots as to growth indicates that probably in Illinois the sandy sites within this type should be classified; but insufficient data compelled a general grouping of all plots on sand. The tabulation, on page 96, brings out the fact that the diameter growth on sand in these plots averages even greater than for corresponding decades on the more fertile soils of the upland hardwoods type. This fact was also borne out in the individual tree study (see table on pp. 81-89). The height growth is less at similar periods for trees of the scrub oak type than for those of the upland hardwood type and the number of trees per acre beyond the 60-year period on sand is the least for the upland types. These stands enter the sawlog class at about 65 years. The yields given are for a fully stocked acre on which all trees are sound and free from crooks. The stands of the scrub oak type are very defective and the trees both limby and crooked, hence the use of the factor 4.4 into the cubic yield, giving a result only for sound straight trees, gives too high yields for characteristic scrub oak stands.

Upland Hardwood Type

The plots on the upland hardwood type were taken on those upland soils between sands and loams over clay. The commonest soil types are the yellow and yellow-gray silt loams, and in general the upland soils are heavier than upland soils in Connecticut and Massachusetts. The point brought out in the individual tree study that growth on the upland sandy loams is better than on the heavier loams is also apparent in the plots, as those selected on sandy loams have an average yield above the average for the general upland type. The representation of species by per cents on these plots is as follows: white oaks, 52, black oaks, 26, hickory, 11, elm, 5, hard maple and cherry totaling 4, the remaining 2 per cent being made up of nine other species. Since white oak is one of our slowest growing hardwoods and constitutes more than half of the stands on these plots, it is very evident that in managed forests of this kind yields can be increased by the substitution of such trees as tulip, red oak, and ash. Reference to the tabulation of the D. B. H. of the average tree (Table 6, p. 96) shows that these stands enter the sawlog class at about 63 years.

Bottomland Type

The bottomland forests of Illinois are not usually even-aged. On the 19 even-aged plots studied there was such a marked variation in yields for a given decade, due to the composition of the stands, that the data were worked up separately to show yields for stands composed dominantly of fast-growing species, and yields for stands composed dominantly of slow-growing species. (Tables 7, 8, pp. 96, 97.) On the 8 plots where such rapidly growing trees as cottonwood, sycamore, soft maple and sweet gum dominated, the average tree entered the sawlog class at 40 years and the acre produced 4,180 cubic feet of wood, exclusive of branch wood.

On the 11 plots where such slow-growing species as oak, elm, ash, and hickory dominated, the average tree entered the sawlog class at 63 years and the acre produced 2,757 cubic feet of wood. Thus the fast-growing species produce approximately 18,000 B. F. per acre in 40 years as compared to 12,000 B. F. per acre in 63 years for the slow growing species. The influence of soils is somewhat apparent in the per cents of occurrence of the fast- as compared to the slow-growing species. Thus the cottonwood and soft maple were abundant on the sandy loams, while the oaks, hickories, and ash were abundant on the heavier soils. Honey locust, sycamore, and red gum, trees of rapid growth, seemed to occur with equal frequency on the heavier and lighter soils.

Yield Tables for Even-aged Stands in Illinois

(1) *Upland Types*

Table 4.—Post Oak Type. Based on 14 Plots

Age Years	No. of trees per acre	Height of dominant trees Feet	D. B. H. of average trees Inches	Basal area per acre Sq. Ft.	Yields per acre in peeled stems Cu. Ft.	Average annual increment Cu. Ft.
20	1,025	22	2.8	45	250	12.5
30	775	29	3.6	56	420	14.0
40	605	35	4.4	63	610	15.2
50	470	40	5.1	67	775	15.5
60	360	43	5.9	69	950	15.8
70	285	46	6.8	71	1,150	16.4
80	235	49	7.5	73	1,360	17.0
90	195	51	8.4	75	1,550	17.2
100	170	52	9.1	77	1,780	17.4

TABLE 5.—SCRUB OAK TYPE. BASED ON 23 PLOTS

Age Years	No. of trees per acre	Height of dominant trees Feet	D. B. H. of average trees Inches	Basal area per acre Sq. Ft.	Yields per acre in peeled stems Cu. Ft.	Average annual increment Cu. Ft.
20	1,035	25	2.9	47	450	22.5
30	670	36	4.0	59	775	25.8
40	400	46	5.6	68	1,075	26.9
50	260	54	7.3	75	1,400	28.0
60	180	61	9.1	81	1,750	29.2
70	120	67	11.6	88	2,075	29.7
80	90	72	13.8	93	2,375	29.7
90	75	74	.....	.....	2,650	29.4
100	65	77	.....	.....	2,920	29.2

TABLE 6.—UPLAND HARDWOOD TYPE. BASED ON 34 PLOTS

Age Years	No. of trees per acre	Height of dominant trees Feet	D. B. H. of average trees Inches	Basal area per acre Sq. Ft.	Yields per acre in peeled stems Cu. Ft.	Average annual increment Cu. Ft.
20	1,010	36	3.6	72	810	40.5
30	630	47	4.8	79	1,175	39.2
40	400	55	6.5	84	1,520	38.0
50	250	61	8.1	89	1,870	37.4
60	185	66	9.5	94	2,175	36.2
70	155	70	11.0	99	2,500	35.7
80	130	73	12.5	103	2,825	35.3
90	110	75	13.9	106	3,125	34.7
100	100	78	15.6	109	3,425	34.2

To convert cubic feet to cords divide by 86.

To convert cubic feet to board feet multiply by 4.4. Since 10″ D. B. H. is taken as the minimum cutting diameter limit, this converting factor can only be applied to those stands where the average D. B. H. is greater than 10 inches. Thus post oak has no merchantable B. F. contents. Scrub oak and upland mixed hardwoods show merchantable board-foot contents between 60 and 70 years.

Yield Table for Even-aged Stands in Illinois

(2) *Bottomland Type*

TABLE 7.—RAPIDLY GROWING SPECIES, COTTONWOOD, SYCAMORE, SOFT MAPLE, HONEY LOCUST, SWEET GUM. BASED ON 8 PLOTS

Age Years	No. of trees per acre	Height of dominant trees Feet	D. B. H. of average tree Inches	Basal area per acre Sq. Ft.	Yields per acre in peeled stems Cu. Ft.	Average annual increment Cu. Ft.
20	450	75	6.0	87	2,450	122
30	290	82	8.6	118	3,400	113
40	230	87	10.2	130	4,180	104
50	205	90	10.9	137	4,930	99
60	190	92	11.7	143	5,600	93
70	165	94	12.7	146	6,150	88

Table 8.—Slow-growing Species. Oak, Elm, Ash, Hickory
Based on 11 Plots

Age Years	No. of trees per acre	Height of dominant trees Feet	D. B. H. of average tree Inches	Basal area per acre Sq. Ft.	Yields per acre in peeled stems Cu. Ft.	Average annual increment Cu. Ft.
20	1,100	42	3.5	74	1,075	54
30	530	53	5.4	84	1,560	52
40	330	62	7.1	92	2,000	50
50	250	69	8.5	98	2,375	47.5
60	200	76	9.7	104	2,675	45
70	170	81	10.8	109	2,950	42
80	145	85	12.0	113	3,225	40
90	125	88	13.0	116	3,500	39
100	110	91	14.0	118	3,750	37.5

To convert cubic feet to cords divide by 86.

To convert cubic feet to board feet multiply by 4.4. Since 10″ D. B. H. is taken as the minimum cutting diameter limit, this converting factor can only be applied to those stands where the average D. B. H. is greater than 10 inches.

Table 9.—Yields for fully Stocked Virgin Stands in Illinois

Type	Av. No. of trees per acre	Height of dominant trees Feet	D. B. H. of average tree Inches	Basal area per acre Sq. Ft.	Yield per acre in peeled stems Cu. Ft.	Basis
Upland hardwoods	146.2	97.2	10.9	94.5	3,053	6 plots
Bottomland stands	69.5	98.4	16.4	101.6	3,297	5 plots

The all-aged virgin plots were separated into upland and bottomland types and the data were averaged to show the average number of trees supported on an acre, the D. B. H. of the average tree, height of dominant trees, basal area, and cubic feet yields. (Table 9, above.) Such information is based upon well-stocked virgin stands containing trees of many different-aged classes. In such stands the growth and decay balance, and the total yields per acre represent about the maximum for the type. The even-aged stands (Table 6, p. 96) show a total growth equal to the average for these all-aged virgin stands for upland hardwoods at 90 years; and for slow-growing bottomland stands (Table 8, above) the total content of the even-aged stands equals that of the virgin stands at about 80 years.

Part III. Proposed State Forest Policy

A proposed forest policy for Illinois has been outlined in two previous bulletins (Hall and Ingall '11, and Chapman and Miller '24). Three measures were recommended by Hall and Ingall:

(1) The adoption of an adequate state fire protection system, providing for forest fire wardens in those counties where this seems desirable.

(2) The inauguration of an educational campaign with the object of spreading scientific and practical forest management.

(3) Further investigation of the problems involved in developing and extending Illinois woodlands.

The measures recommended by Chapman and Miller are:

(1) Formulation and dissemination of information on wood-lot management.

(2) The teaching of farm-wood-lot management at the State University and the establishment of experimental areas.

(3) Establishment of an adequate system of fire prevention.

(4) Purchase of a considerable area in southwestern Illinois for State forests.

The information contained in this bulletin on forested areas and average rates of growth, and in the bulletin by Chapman and Miller '24, on the total amount of wood cut from the forests of Illinois, enables us to measure the forces of production and of destruction, to measure also, to a limited extent, the benefits possible from reasonable wood-lot management, and to distinguish the areas where state aid is necessary to fire protection.

The total timbered area of Illinois is 3,021,650 acres, as shown in table, pp. 58-63. The average annual volume produced per acre for each of the general forest types is shown in Tables 4-8, pp. 95-97. By multiplying the average annual growth per acre for a given type by the forested acreage of this type we may find the total yield for that type if all the timbered area were fully stocked, and a summation of these total yields for all types gives the total yields for the state which will be secured if the forests are kept fully stocked. This total is 124,333,235 cubic feet.

The total production of wood from the forests of Illinois, as given by Chapman and Miller ('24), is 115,651,960 cubic feet. This total is for the cubic contents of that part of the tree which goes into the product. In order that a proper comparison might be made between the amounts which the fully stocked forests can produce continuously, and the amounts which are now being harvested, this drain of 115,651,960 cubic feet was converted to the corresponding amount in the total peeled stems, and after slightly raising the forested acreage and consequently the production as shown in the above bulletin, the total cut from the forests of Illinois becomes 135,014,335 cubic feet. About 59 per cent of this cut is utilized as cordwood. In the computations it is assumed that but one product—either cordwood, sawlogs, ties, mine props, piling, or veneer logs—is made

from a given tree, that is, for example, that approximately 65 per cent of the cubic contents of the tree is made into sawlogs, and that no use is made of the remaining 35 per cent. It is thus apparent that the total cut of 135,014,335 cubic feet will be too high by the amount utilized in making smaller products, such as mine timbers, posts, and cordwood, from this otherwise unutilized portion. But since no allowance is made for drain on the forests through decay, insects, and damage by fire and storm this figure is probably not greatly in error.

It is evident that the drain is in excess of the growth by at least 10,681,100 cubic feet per annum, but the actual excess of drain over growth is very much greater, since the forests are not fully stocked. The degree of stocking ordinarily runs from 34 per cent, as shown from extensive studies on the Ozark region (p. 45), to 80 per cent. The average product per annum for the state is probably more nearly 80,800,000 cubic feet than the 124,333,235 cubic feet possible for fully stocked forests. We are probably cutting fully 54,200,000 cubic feet annually in excess of the growth of 80,800,000 cubic feet, and continued overcutting at this rate would strip the state of forests in 31 years.

Until 1910 a larger acreage of improved land was being added annually to the farms of Illinois than there was of improved land reverting to waste; but since 1910 more improved land by 250,928 acres has reverted to waste than has been improved—most convincing evidence that development of unimproved lands to crops lands in Illinois has been carried too far. The 1920 census shows that Illinois now has 1,577,663 acres of waste land on farms. The labor and materials which are consumed in clearing, developing, and cropping such land are of greater value than the crops produced; and when ultimately the land is abandoned, it often lies idle for decades before it is restocked by a forest inferior to that originally cleared. It is probable that fully 2,700,000 acres of the present forested area of Illinois, if the drain continues unchecked, will revert to waste land unproductive of even the taxes.

The stumpage value of the timber cut to make the total of 135,014,335 cubic feet above arrived at, amounts to $4,958,331. Thus by cutting 65 per cent more than grows, an average return of $1.64 per acre is secured, from which must be paid taxes and land rental. This low return must further decline as the growing stock is reduced through excess cutting, until the wood-lots become waste land and the returns are zero. The alternatives are waste land or wood land.

By keeping the wood-lots fully stocked with the species normally represented the average growth of 41.1 cubic feet per acre annually will very nearly meet the drain of 44.7 cubic feet. By removing the slow growing and inferior trees as thinnings are required, the annual yield may be increased. The extremes in growth rates of different species of trees are greatest for the bottomland types, and consequently managed bottomland forests offer an encouraging field for increase in production, yet a greater growth per acre can be secured by encouraging the faster growing species on the uplands also. The yield tables 7, 8, pp. 96, 97, show

that the faster growing species in unmanaged bottomland stands average twice the volume growth of the slower growing trees. The protection of forests from fire and grazing, and the regulation, through thinnings, of the kinds of trees which will be left, are simple forms of good management which will nearly double the annual production of cubic feet of wood. A better utilization of this product, which will enlarge the proportion of high grade material to the total production, will increase the returns. Much of the 59 per cent of the wood production of Illinois which is now used as cordwood is suitable for uses having general stumpage values from four to sixteen times that of cordwood.

That part of the 1,577,663 acres of waste land which is not reverting to productive forest land should be replanted. To the end that the land owners may have access to a supply of suitable planting stock at a reasonable price, the state should establish a forest tree nursery.

Any plan which contemplates the establishment of state-owned forests should give weight not only to the forested area of southwestern Illinois, but also to the practicability of establishing pine forests on the unforested sands of central and northern Illinois. As computed on page 37, there are at least 310,000 acres of sand, of which more than 200,000 acres is unforested. These sandy areas are often in large units, a single county containing 75,000 acres.

In outlining state aid in fire control the principle should be that such aid should be given to those regions where the forests are continuous and cover relatively large areas, but that in those regions where the wood-lots are relatively small and isolated the owners can cope with fires. The maps III to VI cover those areas in Illinois where upland forests are the most continuous. Continuous bodies of forest cover relatively large areas in the following regions:

(*a*) As shown on Map III such a forest extends along the bluffs in the western part from central Alexander county to central Monroe county and contains approximately 202,000 acres of forest.

(*b*) As shown by Map III a heavily forested area occurs at the eastern extreme of the Ozark uplands in southwestern Gallatin, southeastern Saline, eastern Pope and Hardin counties. This upland area contains approximately 86,000 acres forested.

(*c*) Possibly the region embraced in Calhoun and western Jersey counties has woodlands of such a nature as to require organized fire protection (see Map V). There are approximately 50,000 acres of such upland forest in this region. Elsewhere in the state the forests are less continuous and protection can be given by the land-owner.

CONCLUSION

Until 75 years ago poor transportation facilities resulted in low woodland values in the heavily wooded areas, while in the prairie region these values were as much as seven times those of prairie land. During the past 75 years the development in transportation has enabled Illinois and the nation at large to enjoy the products from the virgin forests of the Lake States, of the South, and of the West.

With the exhausting of the virgin forests the nation will be confronted with much the same problem as confronted the pioneer prairie farmer. The cut-over timber-lands will be called upon to meet the wood requirements of the nation. Those annual requirements are now nearly four times the average annual growth of all timber-land for the nation at large, and ten times the average annual growth for Illinois.

For the public this condition predicates a decided increase in the cost of wood products, for the wood-using manufacturers a dislocation of industry and the use of substitutes where substitutes are economically possible, but for the wood-lot owner correspondingly greater returns from the productive wood-lot.

The process of forest destruction is far advanced in Illinois. First growth or virgin timber has virtually disappeared, and the present drain on the cut-over forests and second-growth stands, unchecked, will result in an early disappearance of all forests in Illinois.

There was an increase in unforested waste land of a quarter of a million acres in the ten years from 1910 to 1920, and Illinois now has a total of 1,577,663 acres in this class. The 3,021,650 acres now forested are on lands unsuited to ordinary farming and if cleared will generally revert to waste land.

There is an urgent need for the educating of both the wood-lot owner and the public on the measures required to protect the present forests, to balance growth and cut and bring them to their fullest possible production, and to reforest as much of the 1,577,663 acres now in waste land as is economically justifiable, so that when the supplies of virgin timber fail elsewhere, the farm wood-lots of the state shall provide for the needs of the farm, and unproductive waste land be turned to profitable use.

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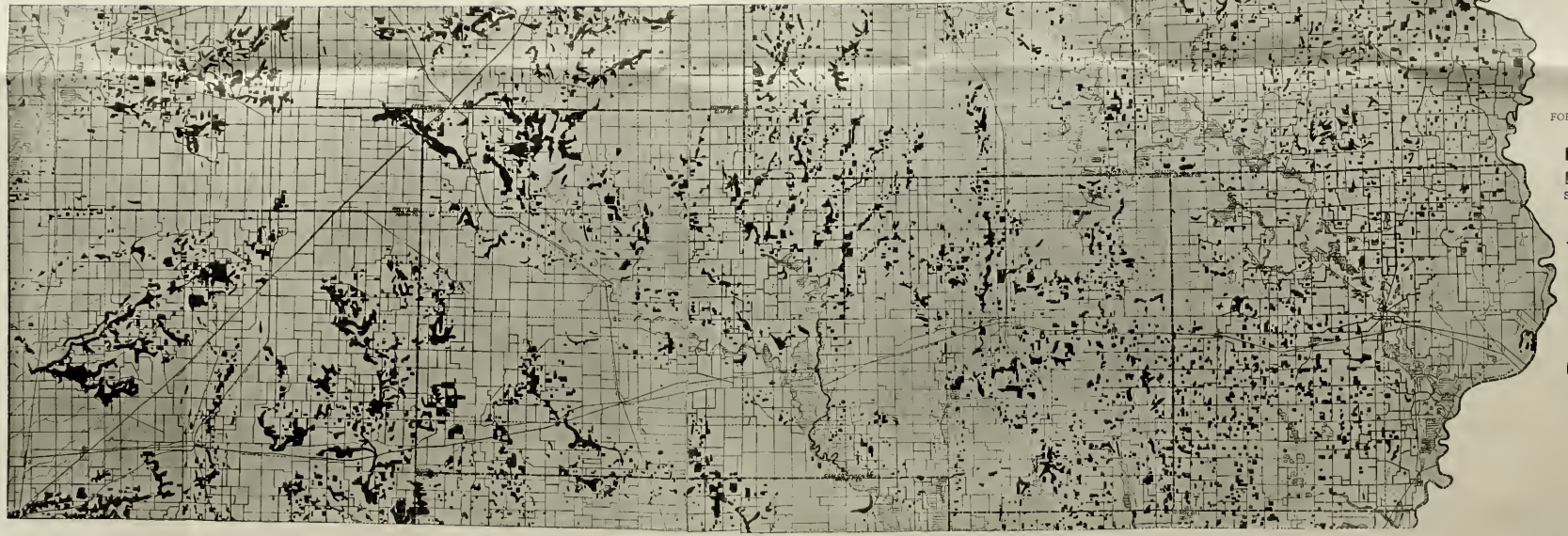
Map No. III
FOREST MAP OF EXTREME SOUTHERN ILLINOIS
A Mississippi bottomland
B Heavily wooded bluffs
C Ozark uplands
D Cache bottomland
E Big Muddy bottomland
F Bottomlands at junction of Wabash and Ohio rivers
Upland forest
Bottomland forest
Scale. 1/250,000



Map No. IV

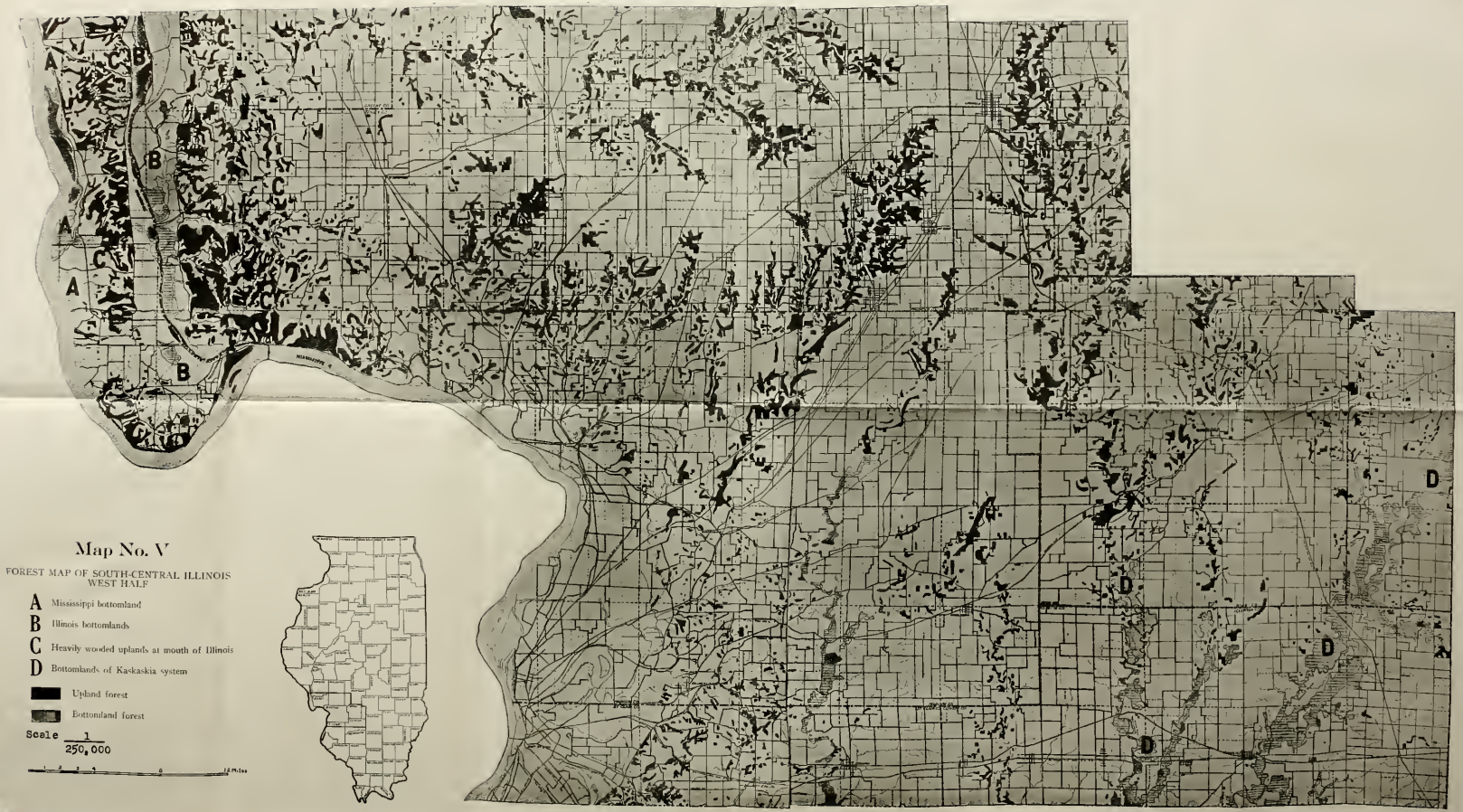
FOREST MAP OF SOUTH-CENTRAL ILLINOIS. EAST

Upland forest in small wood-lots

Upland forest

Bottomland forest

Scale $\frac{1}{250,000}$


A
B
C
D
Map No. V
FOREST MAP OF SOUTH-CENTRAL ILLINOIS
WEST HALF
A Mississippi bottomland
B Illinois bottomlands
C Heavily wooded uplands at mouth of Illinois
D Bottomlands of Kaskaskia system
Upland forest
Bottomland forest
Scale 1/250,000


Map No. VI
FOREST MAP OF NORTHWESTERN ILLINOIS
A Mississippi bottomland
B Eroded uplands
C Prairie
D Forested region along Rock River
Upland forest
Bottomland forest
Scale 1/250,000