U. S. DEPARTMENT OF AGRICULTURE,
FOREST SERVICE—BULLETIN No. 64.
GIFFORD PINCHOT, Forester.

LOBLOLLY PINE IN EASTERN TEXAS,

WITH SPECIAL REFERENCE TO THE PRODUCTION OF CROSS-TIES.

BY

RAPHAEL ZON,
FOREST ASSISTANT, FOREST SERVICE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1905.

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GIFFORD PINCHOT, *Forester.*

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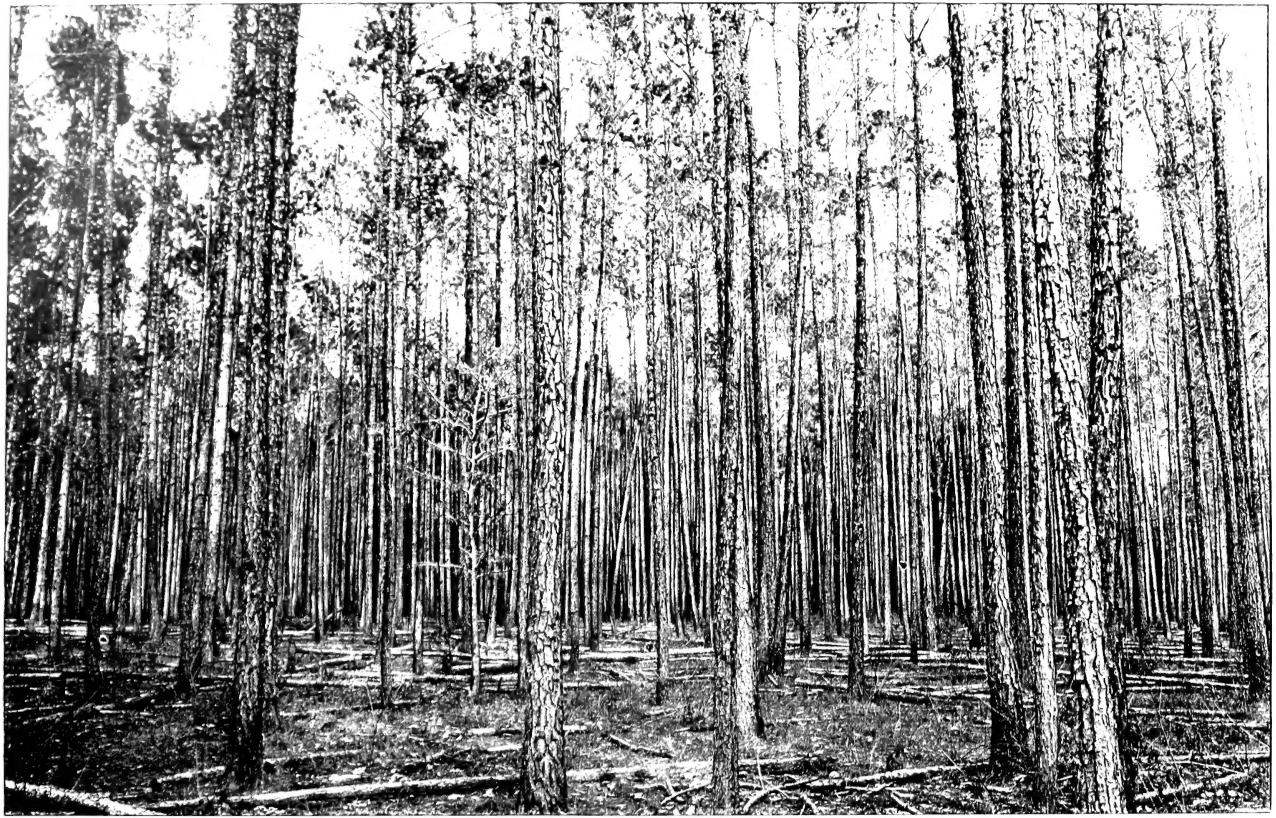

A GOOD STAND OF SECOND-GROWTH LOBLOLLY PINE ON AN OLD FIELD.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF FORESTRY,
Washington, D. C., June 30, 1905.

SIR: I have the honor to transmit herewith a report entitled "Loblolly Pine in Eastern Texas," by Raphael Zon, Forest Assistant, Bureau of Forestry, and to recommend its publication as Bulletin No. 64 of the Forest Service. This paper deals especially with the production of tie timber in the locality studied.

The four plates and two text figures accompanying the bulletin are necessary for its proper illustration.

Very respectfully,

GIFFORD PINCHOT,
Forester.

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

ILLUSTRATIONS.

PLATES.

FIGURES.

LOBLOLLY PINE IN EASTERN TEXAS.

INTRODUCTION.

The short history of loblolly pine lumbering in eastern Texas repeats, almost to the letter, the characteristic features of the development of the lumber industry in this country. In early lumbering in the United States only the most valuable and easily obtainable kinds of trees were cut. Gradually, as the supply of choice and accessible timber decreased and the stumpage prices advanced, the less valuable species came to the front. Their properties were better understood, and means were found by which they could be made serviceable for many purposes for which originally only the choicest species were used. A decade ago the cutting of loblolly pine in eastern Texas was very limited. It was used only locally in the counties where no other pine was near at hand or could easily be obtained. As the center of the lumber industry shifted from the Northeast to the South, the demand upon the Southern pineries greatly increased, and caused a corresponding advance in the stumpage price of the longleaf pine, which led to a greater recognition of the suitability of loblolly pine for many uses for which previously only longleaf pine had been employed.

A new stimulus to the use of loblolly pine was given about eight years ago, when the chemical treatment of wood to preserve it from decay was first introduced in this section. This preservative treatment made it possible to utilize loblolly pine for cross-ties, for which it is in its natural condition unsuited on account of its rapid decay on the ground. At present the bulk of all the ties produced in eastern Texas are of loblolly pine. The economic importance of this pine is bound to grow still more in the future.

Of the three pines occurring naturally in eastern Texas, loblolly has the widest distribution, and the range of its possible extension is still greater. Loblolly is the first pine to take possession of the savannas, or marshy prairies, when the latter are sufficiently drained to allow of tree growth. It encroaches upon the hardwood areas through its tolerance of shade in youth. Unless the hardwood stands are exceedingly dense and dark, loblolly germinates within them, grows rapidly, and crowds out all competitors. Loblolly successfully competes with

shortleaf pine for occupancy, and appears even amid the longleaf pine on abandoned fields on the dry, barren sands of the uplands.

Loblolly pine is adapted to a wider range of soils than any other pine in the region; this, together with its frequent and prolific seeding, rapid growth from the start, and comparative freedom from damage by hogs and fires, enables it to reproduce itself readily on cut-over land. The other pines, particularly the longleaf pine, have relatively few chances to hold their own under the methods of lumbering which now prevail. Seed years occur at long intervals; slow growth during the early years, fires, and hogs all conspire against the reproduction of longleaf pine on cut-over land. After the virgin supply of the longleaf pine has been exhausted there will not be enough young growth to take its place, unless special pains are taken to secure regeneration, while the loblolly pine, because of its capacity to renew itself under the most unfavorable conditions and its ability to occupy new ground, promises to become the principal source of the timber supply of the region. Forty years ago longleaf pine was the most important timber tree of North Carolina; now the loblolly pine occupies that place. What happened in North Carolina, and is now to some extent common throughout all the South, is taking place in eastern Texas.

Viewed in this light, the loblolly pine deserves more attention on the part of the forester and the lumberman than it has received, and it was with the purpose of securing a more intimate knowledge of its possibilities as a forest tree suitable for ties and lumber that this study was begun. This bulletin deals with one part of the loblolly pine region only, and chiefly with one industry in that region, though much of what is here said regarding the tree and its wood is applicable to other localities.

The measurements used in the preparation of the tables herein presented were obtained during the winters of 1903–4 in Orange, Newton, Montgomery, and San Jacinto counties, where loblolly was being cut for ties and lumber.

THE FOREST.

In its natural state, loblolly pine occupies many different situations, but in general it is distinguished from other pines by its dependence upon soil moisture. In eastern Texas it is the principal pine of the lowlands which border the swamps and streams, although the great diversity in the character of the soil, its fertility, physical properties, and drainage cause the loblolly forests to vary considerably. Where the soil is poor and sandy but quite moist, loblolly pine occurs in almost pure stands; where it is fresh and fertile the ground is shared with many hardwoods. On the drier, porous soils of the higher uplands loblolly gives way to longleaf and shortleaf pine, since the latter are satisfied with less moisture about their roots, or it is found

on old fields where the ground has been made more retentive of moisture by cultivation. Loblolly thus finds its home under a variety of conditions, and that fact makes it necessary to consider the tree as it occurs in different kinds or types of forest.

FOREST TYPES.

The following four natural types of loblolly pine forest have been recognized in eastern Texas:

Type 1. Loblolly pine in pure groups on the wet prairie.
Type 2. Loblolly pine in pure stands on fairly well-drained, light soil.
Type 3. Loblolly pine in mixture with hardwoods.
(*a*) On poorly drained soil (thicket).
(*b*) On well-drained, fertile soil.
Type 4. Loblolly pine in pure stands on old fields.

LOBLOLLY PINE IN PURE GROUPS ON THE WET PRAIRIE.

On the so-called prairies which occupy the greater part of the counties of Orange, Jefferson, Chambers, and Harris, in eastern Texas near the Gulf, loblolly pine is found on numerous slightly elevated mounds forming, as it were, forest islands. These areas are not prairies in any proper sense, but savannas—land which is gradually being transformed from marsh to dry ground. As soon as any portion rises above the water-level it is covered with vegetation. The islands of loblolly pine are very characteristic. At an early stage in their development they are often almost circular, with an older even-aged stand of trees in the center and younger generations around it, the youngest occupying the extreme periphery. Since the prairie is covered with water for several months each season and is wet nearly all the year round, the forests on these islands develop almost undisturbed by fires, and are, therefore, dense and thrifty. As the prairie fills in and becomes drier these islands are connected with each other by strips of young growth, and finally merge into large bodies of forest.

The direction in which these islands spread is indicative of the part which the prevailing winds play in distributing the seed. The loblolly pine seeds ripen at the end of September and the beginning of October, when northwest winds prevail. These dry winds hasten the opening of the cones and carry the seeds in a southeasterly direction. Drainage, which here is toward the Gulf, is also instrumental in scattering the seeds and promoting the extension of the forest upon the prairie, especially during high water. Other tree species—post oak, water oak, red gum, and hawthorns—are often among the vanguard of forest growth, but they do not cover large areas by themselves, and, as a rule, are soon crowded out by the loblolly pine. The presence of some of these trees is apparently due to the transportation of their

seeds by the currents, since water is undoubtedly an important agent in disseminating tree seeds, especially the larger and less perishable kinds.

The drying up of the prairie and the consequent change of vegetation is a natural process, which goes on along the whole coast. The water plants die, and their remains, together with inorganic particles which are brought by wind and water, accumulate in the course of time and gradually build up the land. The swampy areas dry out, and on the new soil thus formed appear other plants, at first grasses, and later shrubs and trees. If the prairie were not burnt over regularly during the dry season, and the dying vegetation left to accumulate on the ground, the process of foresting the prairie would proceed much faster. The change from prairie to forest, however, is not so slow a process that it is unobserved by the people. Much of the open land around Orange has grown up to loblolly pine within the memory of the inhabitants of the town, and many places in the southwestern corner of Newton County which were specified as prairie in field notes made forty or fifty years ago are now covered with fine stands of young loblolly pine already suitable for ties. Marshes within the forest which but a few years ago were impassable are now accessible to men and cattle. Furthermore, the forest in the southern portions is younger than that farther north.

When crossing one of the southernmost counties in a northward direction, the encroachment of the loblolly pine upon the prairie is very apparent. Near the Gulf nothing is seen but an immense expanse of marshy prairie, poorly drained, and covered with water during the greater part of the year. Then begin to appear, on the natural elevations, patches of loblolly pine, which, still farther north, grow larger and form extensive bodies of forest, until finally the prairie entirely disappears and gives way to a continuous forest of loblolly pine.

The grass land is burned over regularly during the dry season by fires, which may be started by accident, but which usually are intentional. These reduce to a small quantity of ashes the vegetation that otherwise would have accumulated and built up the ground, and they also destroy the young trees on the borders of the forest. Thus the annual fires are a retarding influence upon the extension of the forest.

The loblolly pine on this type is seldom above forty years of age, and the distribution of the age classes within the stands is characteristic and suggestive of the history of their development. In some instances, especially in the lower part of the prairie, where the pine has sprung up on a flat mound, the age of the stand is uniform. This doubtless is due to a favorable seed year, during which the loblolly pine succeeded in establishing itself on the elevated ground, while all around it the prairie was too wet to permit further seeding. In other instances the stand is composed of several age classes of very irregular gradations. Such occupancy of the ground occurs only when the prairie is not very wet and at the same time not dry enough to burn,

a combination of conditions occurring only once in a long while. Thus the spreading of the forest over the prairie is not steady and regular, but goes by leaps and bounds; in one place an even-aged group of trees is produced, in another the trees composing a group differ in age from 20 to 25 years.

This type contains ideal trees for the tie maker, but its occurrence in comparatively small patches separated by large stretches of wet prairie is frequently a drawback to its profitable utilization. The islands of loblolly pine, however, are now cut more and more for pole ties. Table I shows the composition of the forest on them, and the average number of trees of different diameters per acre.

TABLE I.—*Composition of loblolly pine forest, 35 to 40 years old, on the wet prairie.*

[Average of 10 acres.]

Diameter breasthigh.	Number of trees per acre.			
	Loblolly pine.	Dead loblolly pine.	Red gum.	Other species.[a]
Inches.				
1				
2				
3	0.10	0.10	0.30	0.10
4	.20	.90	.20	.10
5	2.40	1.20	.60	
6	4.70	1.70	1.10	.30
7	9.40	3.50	.60	.20
8	11.20	3.30	1.10	.10
9	20.70	3.40	.40	
10	24.30	1.10	1.00	
11	23.70	.80	.40	
12	20.10	.40	.30	.10
13	20.50	.30	.10	.20
14	14.50	.20		
15	7.50			
16	5.60			
17	1.60		.10	
18	1.50	.10		
19	1.20			
20	.40			
21	.60			
22	.30			
23	.20			
24	.10			
25	.20			
26	.10			
27				
28	.10			
Total	171.20	17.00	6.20	1.10
Per cent	87.57	8.70	3.17	.56
TREES 10 INCHES AND OVER IN DIAMETER BREASTHIGH.				
Total	122.50	2.90	1.90	0.30
Per cent	96.00	2.27	1.49	.24

[a] Tupelo gum, Spanish oak, water oak.

LOBLOLLY PINE IN PURE STANDS ON FAIRLY WELL-DRAINED, LIGHT SOILS.

This type is rather limited in area, occupying the poor sandy soils adjoining the marshy prairie. As the soil is gradually improved by the pine forest standing upon it, hardwoods begin to creep in, and the pure loblolly pine is changed into a mixed growth. This type, therefore, may be considered, at least in the southernmost counties, as a transition between the pure groups of loblolly pine on the wet prairie, Type 1, and the mixed growth of loblolly pine with hardwoods, Type 3. Table II shows the composition of a forest of this type 24 years old, and Table III the composition of a forest 60 years old. It will be observed that shortleaf pine and several hardwoods represented in the older forests do not appear in the younger.

TABLE II.—*Composition of loblolly pine forest 24 years old on fairly well-drained, light soils.*

[One-half acre.]

Diameter breasthigh.	Number of trees per acre.			
	Loblolly pine.	Dead loblolly pine.	Red gum.	Other species.[a]
Inches.				
1				
2		2.00		
3	8.00	8.00	4.00	
4	12.00	16.00		4.00
5	38.00	10.00	6.00	
6	36.00		6.00	2.00
7	28.00			
8	18.00		2.00	
9	44.00	2.00		
10	22.00			2.00
11	16.00			
12	16.00			
13	4.00			
14				
15	4.00			
16	2.00			
17	2.00			
18	2.00			
19	2.00			
20	2.00			
21	2.00			
Total	258.00	38.00	18.00	8.00
Per cent	80.13	11.80	5.59	2.48
TREES 10 INCHES AND OVER IN DIAMETER BREASTHIGH.				
Total	74.00			2.00
Per cent	97.37			2.63

[a] Water oak, summer haw.

TABLE III.—*Composition of loblolly pine forest over 60 years old on fairly well-drained, light soils.*

[Average of 4 acres.]

Diameter breasthigh.	Number of trees per acre.				
	Loblolly pine.	Shortleaf pine.	Red gum.	Black gum.	Other species.[a]
Inches.					
1			2.25		2.00
2			.75		1.00
3			1.25		1.50
4	0.75	0.75	1.50		.25
5	1.50	.25	1.00		
6	2.00		.50	1.00	.25
7	3.25	.50	.75	1.75	.25
8	1.50	.25	.50	.75	.25
9	3.50		.75	.25	.25
10	3.25	.50	.50	.50	.25
11	5.50	.25		.25	
12	5.50	.25	1.00	.25	
13	9.00		.50	.25	.25
14	8.25			.50	
15	8.25				
16	9.25	.25			
17	8.00		.25		
18	8.00				
19	5.25				
20	5.50				
21	4.00			.25	
22	2.50		.25		
23	1.00				
24	.75				
25	.50				
27	.25				
33	.25				
Total	97.50	3.00	11.75	5.75	6.25
Per cent	78.47	2.41	9.46	4.63	5.03
TREES 10 INCHES AND OVER IN DIAMETER BREASTHIGH.					
Total	85.00	1.25	2.75	2.00	0.50
Per cent	92.90	1.37	3.00	2.18	.55

[a] Red maple, red mulberry, water oak, red oak, white oak.

The trees of this type are, as a rule, older than those in groups on the prairie, and large enough for lumber. They form a more open stand than those in mixture with hardwoods, and therefore grow faster in diameter, but are more tapering and shorter than those of the latter type.

LOBLOLLY PINE IN MIXTURE WITH HARDWOODS.

This type is found along all the larger rivers and creeks, and on land adjacent to them known locally as river swamps, bottom lands, and hummocks. It is found, also, on the higher uplands along the narrow, partially inundated depressions, locally known as "bay galls," which serve as the natural drainage channels of the flat longleaf pine land. It is not uniform throughout, but presents many variations in the associated hardwood species and in the character of loblolly pine growth, due to the drainage conditions. On light, sandy soils, overflowed for several months during the year, the associated hardwood species are mostly sweet bay (sweet magnolia), water oak, red maple, red gum, and black gum; on stiffer and better drained soils the typical associated hardwoods are white oak, cow oak, hickories, beech, and (evergreen) magnolia. The bay galls, which receive their name from the sweet bay (*Magnolia glauca*), the characteristic tree of such situations, are of scarcely any economic importance at present. They occur, as a rule, in the form of narrow strips, seldom over 200 feet in width, varying from several rods to several miles in length. Single loblolly pines, usually unsound, occupy the drier spots. The soil is poor, differing but little from that of the longleaf pine land, except that it is moist. The undergrowth is dense and is composed of shrubs, vines, and briers.

Loblolly pine on poorly drained soil (*thicket*).—These conditions are found frequently on extensive areas adjacent to large creeks and rivers. The tracts are commonly called "thickets," and may stand as the representative of the subtype. The soil, like that in the bay galls, is very poor. Dwarf palmetto and hawthorn compose the undergrowth of such situations. Though the loblolly pine attains good dimensions under these conditions, its growth is slow, as a result of the poor soil and the frequent overflows. Large trees, as a rule, are very old, often more than 250 years of age, and usually show signs of decay. In the thickets loblolly pine occurs singly or in groups of a few trees, and forms less than 28 per cent of the forest. On account of the dense undergrowth, young pines are not found evenly distributed, but occur only in openings, which are generally made by storms.

The thickets present many difficulties to lumbering on account of the scattered occurrence of the pine, the dense undergrowth, and the soft ground; but since the largest trees and the best timber, that resembling most closely the shortleaf pine in density, grain, amount of heartwood, and other desirable properties, are found principally in these situations, loblolly pine is now cut on a large scale from the thickets. Table IV shows the composition of this type of forest.

TABLE IV.—*Composition of mixed loblolly pine and hardwood forest 150 years old on poorly drained soil (thicket).*

[Average of 5 acres.]

Diameter breasthigh.	Number of trees per acre.							
	Loblolly pine.	Shortleaf pine.	White oak.	Red gum.	Water oak.	Red oak.	Black gum.	Other species.[a]
Inches.								
1	4.20		0.20	7.20	4.40	1.40		5.20
2	3.60		1.60	6.20	2.60	1.40		8.40
3	3.00	0.40	1.20	1.80	1.40	.80		14.00
4	2.60	.20	1.00	1.00	1.00		0.20	12.20
5	2.00		1.60	.40	1.00		.20	10.20
6	3.00	.20	2.00	.80	.80		.20	8.80
7	2.40		1.40	.40	.60		.20	7.80
8	4.80		3.60	.40	.60	.20	.20	4.40
9	3.20		4.40	.40	.20		.20	2.40
10	1.00		3.00	.20	.80			1.60
11	2.60		1.60		.20			1.00
12	3.00		1.80	.60	.40		.40	.20
13	3.20		1.60		.20			.20
14	3.00		1.60	.20	.20		.20	
15	1.60		1.60		.40			.20
16	2.00		1.00	.40		.20		
17	2.20		.80	.20	.40			
18	.80		.60		.40			
19	1.00	.20			.40		.20	
20	1.40		.60				.20	
21	.40				.20			
22	2.20	.20	.20					
23								
24	.60							
25	.80		.20					
26	1.40		.20					
27	.80							
28	.20							
29	.20							
30	.40							
31	.20							
32								
33	.20							
Total	58.00	1.20	31.80	20.20	16.20	4.00	2.20	76.60
Per cent	27.59	.57	15.13	9.61	7.71	1.90	1.05	36.44
TREES 10 INCHES AND OVER IN DIAMETER BREASTHIGH.								
Total	29.20	0.40	14.80	1.60	3.60	0.20	1.00	3.20
Per cent	54.07	.74	27.41	2.96	6.67	.37	1.85	5.93

[a] Red maple, ashes, holly, dogwood, ironwood, elms, magnolias, hickories, blue beech.

Loblolly pine on well-drained, fertile soil.—On the better drained and more fertile soils the loblolly grows faster in diameter, but is usually smaller and younger than that in the thickets. This probably is due in part to the more recent invasion of these areas by the loblolly, and in part to the more rapid but less persistent growth on such stronger soils. The latter fact is true of tree growth in

general, and is clearly shown in the old-field stands of loblolly pine. As a rule, the loblolly grown with hardwoods attains a greater height and is less tapering than that found by itself in pure stands. Sometimes the pine is of the same age as the associated hardwoods, but more often, especially on good soils, the hardwoods are considerably older than the loblolly pine, showing that the latter must have come in after the former had possession of the ground (Pl. II).

Table V gives the composition and the average number of trees of different diameters per acre in forests of this type from 30 to 40 years old, and Table VI gives similar figures for stands over 40 years of age.

TABLE V.—*Composition of mixed loblolly pine and hardwood forest 30 to 40 years old on well-drained, fertile soil.*

[Average of 10 acres.]

Diameter breasthigh.	Number of trees per acre.							
	Loblolly pine.	Red gum.	Water oak.	White oak.	Red oak.	Cow oak.	Black gum.	Other species.[a]
Inches.								
1	.....	3.80	0.80	1.10	0.10	0.30	1.10	8.80
2	.....	7.30	1.90	3.30	.60	3.00	2.20	16.70
3	0.10	8.20	4.90	5.10	1.90	2.70	1.80	17.90
4	1.70	5.80	4.50	2.90	2.80	1.80	1.30	14.00
5	.10	4.00	4.70	1.40	4.20	.30	.30	2.80
6	2.20	3.00	3.90	.70	1.60	.40	.30	2.10
7	9.60	3.00	2.90	.60	.60	.10	.70	1.60
8	13.20	1.30	1.80	.20	.70	.10	.30	.60
9	15.00	1.20	1.30	.....	1.10	.20	.....	.30
10	17.00	.60	.60	.....	.30	.10	.....	.30
11	18.80	.80	.30	.....	.20	.10	.....	.20
12	15.80	.50	.40	.....	.20	.....	.50	.10
13	14.50	.80	.40	.....	.10	.10	.30	.30
14	12.50	.50	.30	.....	.10	.20	.10	.20
15	7.70	.40	.50	.....	.....	.20	.....	.70
16	4.80	.10	.20	.....	.10	.20	.....	.10
17	3.20	.10	.20	.....	.10	.20	.10	.....
18	1.70	.20	.10	.....	.....	.10	.....	.....
19	.90	.10	.20	.....	.30	.....	.....	.10
20	1.60	.10	.10	.....	.....	.....	.....	.....
21	.60	.....	.10	.....	.....	.....	.10	.....
22	.....	.....	.....	.....	.....	.10	.....	.10
23	.....	.....	.....	.....	.....	.10	.....	.....
24	.10	.....	.20	.....	.....	.10	.....	.....
25	.....	.....	.....	.....	.....	.10	.....	.....
29	.....	.....	.....	.....	.....	.10	.....	.....
Total	141.10	41.80	30.30	15.30	15.00	10.60	9.19	66.90
Per cent	42.74	12.66	9.18	4.64	4.54	3.21	2.76	20.27
TREES 10 INCHES AND OVER IN DIAMETER BREASTHIGH.								
Total	99.20	4.20	3.60	.....	1.40	1.70	1.10	2.10
Per cent	87.55	3.71	3.18	.....	1.24	1.50	.97	1.85

[a] Red maple, magnolias, chinquapin, ashes, hickories, downy basswood, ironwood, holly, prickly ash, dogwood, black cherry, beech, red mulberry, sassafras, witch hazel.

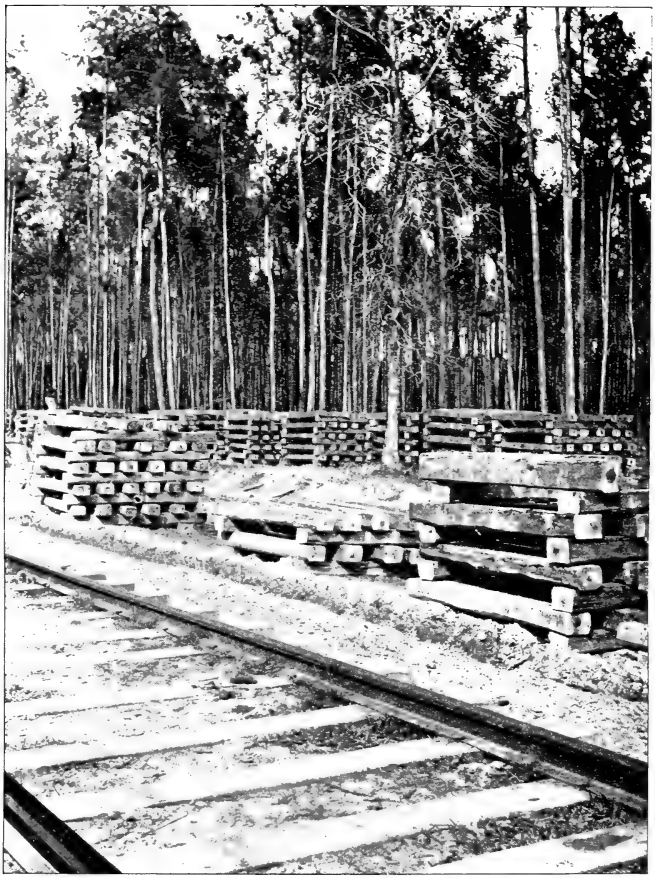

FIG. 1.—LOBLOLLY PINE FOREST, WITH HEWED TIES READY TO SHIP.

FIG. 2.—FOREST OF LOBLOLLY PINE AND HARDWOODS ON FAIRLY WELL DRAINED FERTILE SOIL.

FIG. 1.—NATURAL REPRODUCTION OF LOBLOLLY PINE ON CUT-OVER LAND.

FIG. 2.—INTERIOR OF A RAPIDLY GROWING LOBLOLLY PINE FOREST, 10 YEARS OLD, ON AN OLD FIELD.

TABLE VI.—*Composition of mixed loblolly pine and hardwood forest, over 40 years old, on well-drained fertile soil.*

[Average of 12 acres.]

Diameter breasthigh.	Number of trees per acre.								
	Loblolly pine.	Red gum.	Water oak.	Spanish oak.	Shortleaf pine.	White oak.	Red oak.	Post oak.	Other species.[a]
Inches.									
1	0.08	1.58	0.50	0.67	0.08	0.50	.....	0.33	1.00
2	.08	2.08	1.75	.67	.25	1.25	0.33	.25	1.33
3	.42	3.17	3.75	1.67	.83	1.25	2.08	.83	1.92
4	.17	2.75	3.67	1.00	.83	1.25	1.33	.50	1.67
5	.17	3.33	2.67	1.08	1.08	1.00	1.42	.67	.83
6	1.08	1.92	2.08	1.42	.67	.42	.58	.08	.75
7	2.58	1.33	1.33	1.00	.92	.33	.50	.25	.67
8	3.50	.42	1.08	1.25	.33	.17	.33	.25	.25
9	4.75	.75	.75	.58	1.17	.08	.17	.17	.25
10	5.50	.67	.67	.33	.92	.17	.33	.08	.50
11	4.50	1.17	.83	.08	.08	.17	.08	.08	.25
12	5.92	.50	.17	.42	.58	.42	.....	.17	.17
13	7.33	.33	.50	.25	.50	.42	.....	.17	.67
14	6.58	.50	.42	.25	.58	.08	.....	.25	.42
15	5.58	.83	.....	.17	.25	.42	.....	.17	.08
16	4.58	.25	.08	.25	.42	.17	.....	.....	.17
17	3.58	.25	.....	.08	.17	.33	.....	.....	.42
18	3.83	.17	.17	.17	.17	.08	.....	.....	.25
19	2.58	.17	.08	.....	.17	.42	.....	.17	.25
20	1.50	.....	.....	.08	.....	.33	.....	.....	.08
21	1.42	.....	.....	.....	.08	.....	.....	.....	.....
22	.58	.....	.....	.....	.08	.08	.....	.....	.08
23	.67	.....	.08	.....	.....	.....	.....	.....	.....
24	.42	.....	.....	.....	.....	.17	.....	.....	.....
25	.08	.....	.....	.....	.....	.....	.....	.....	.17
26	.50	.....	.....	.....	.....	.....	.....	.....	.....
27	.08	.....	.....	.....	.....	.....	.....	.....	.08
28	.25	.....	.....	.....	.....	.....	.....	.....	.08
33	.08	.....	.....	.....	.....	.....	.....	.....	.....
35	.08	.....	.....	.....	.....	.....	.....	.....	.....
Total	68.47	22.17	20.58	11.42	10.16	9.51	7.15	4.42	12.34
Per cent	41.19	13.34	12.38	6.87	6.11	5.72	4.30	2.66	7.43
TREES 10 INCHES AND OVER IN DIAMETER BREASTHIGH.									
Total	55.64	4.84	3.00	2.08	4.00	3.26	.41	1.09	3.67
Per cent	71.34	6.21	3.85	2.67	5.13	4.18	.52	1.40	4.70

[a] Basswood, hickories, dogwood, ironwood, red mulberry, holly, red maple, longleaf pine, cow oak, black gum.

LOBLOLLY PINE ON OLD FIELDS.

This type is very common throughout the South. In eastern Texas it is found on the lowlands on all kinds of soil and under all conditions, and on the uplands, on old fields which have proved too poor or too wet for cultivation, and which have been abandoned after several years of tilling. In this section the country is still thinly settled. The

clearing of land for agricultural purposes dates back but a few years, and has never been attempted on a large scale; consequently, the extent of this type is very limited. The trees are comparatively young, seldom over 40 years old, and usually are found in scattering groups a few acres in extent. The characteristic forest is a pure, dense stand of loblolly pine, usually of exceedingly rapid growth, and subject to deterioration, especially on good soils, after reaching the age of from 25 to 30 years. The trees in these stands are commonly covered with branches long after they reach a size at which the same species in the virgin forest is clear, because there has not been time to accomplish natural pruning. Growths of this kind produce a great volume of timber at the expense of quality (Pl. III). Old fields on higher uplands, amid the longleaf pine, are readily stocked by self-sown seeds from mature loblolly pines in the neighborhood (Pl. III, fig. 1).

Table VII gives the composition of the type in stands of normal density 10 years old, and Table VIII shows the same in stands 25 to 29 years old.

TABLE VII.—*Composition of loblolly pine forest, 10 years old, on old fields.*

[Average of 1½ acres.]

Diameter breasthigh.	Number of trees per acre.		
	Loblolly pine.	Dead loblolly pine.	Other species.[a]
Inches.			
1	60.00	120.00	.....
2	195.33	30.00	.....
3	285.33	3.33	1.33
4	209.33	.....	.....
5	184.00	.....	.....
6	73.33	.....	.....
7	22.67	.....	.....
8	8.00	.....	.....
9	5.33	.....	.....
10	.67	.....	.....
Total	1,043.99	153.33	1.33
Per cent	87.10	12.79	.11

[a] Red gum, post oak.

TABLE VIII.—*Composition of loblolly pine forest, 25 to 29 years old, on old fields.*

[Average of 3½ acres.]

Diameter breasthigh.	Number of trees per acre.			
	Loblolly pine.	Dead loblolly pine.	Red gum.	Other species.[a]
Inches.				
1			0.29	
2			.86	0.58
3	0.57		1.71	
4	.86	0.29	.86	.29
5	1.43	.57	.86	
6	6.29	4.57	.29	
7	17.14	2.86		
8	20.57	1.71	.29	
9	18.00	.29		
10	15.71			
11	14.57			
12	16.29			
13	9.43			.29
14	10.00			
15	3.71			
16	2.00			
17	.86			
18	1.43			
19	.29			
20	.29			
21	.57			
22	.57			
Total	140.58	10.29	5.16	1.16
Per cent	89.43	6.55	3.28	.74

[a] Post oak, water oak, red mulberry.

THE FOREST CHARACTERISTICS OF LOBLOLLY PINE.

In order fully to understand the aggressive character of loblolly pine in spreading over unoccupied land, and its rapid renewal after lumbering, one must become acquainted with the life history of the tree, its demands upon soil, moisture, light—in other words, with the silvical qualities of the species.

FORM.

Mature loblolly pine, though it frequently reaches a diameter of 4 feet and a height of 130 feet, is usually from 90 to 110 feet in height and from 2 to 2½ feet in diameter. It seldom attains an age of over 300 years. A tree 100 years of age is already old and subject to red heart, an early stage of decay. In a stand of mature loblolly from 70 to 80 years old the timber affected by red heart may not exceed 1 per cent, but in those considerably over 100 years the cull timber often amounts to fully 10 per cent.

Loblolly pine grown in the forest forms a long, fairly cylindrical stem, often free of branches for 65 feet or more, though it often is

not perfectly straight, a fact that may be accounted for in various ways, such as the character of the soil or the effort of the tree to keep its crown in the light.

Table IX shows the progress in the development of the clear length of loblolly pine. At first, when the tree is very young, the crown covers the whole stem. Gradually, as the canopy of the stand closes, the lower branches die off, on account of lack of light, and the clear length increases steadily at the expense of the crown. The greatest clear length in proportion to the total height is attained in trees having a diameter between 14 and 18 inches. These are developed in comparatively dense stands, where the crowding to which they are subjected helps to clear the bole of the lower branches. After loblolly pine has attained a full development it requires a great amount of light for its further growth; old stands, therefore, of pure loblolly become greatly thinned out by the suppression of the weaker trees. In mixed stands with hardwoods the old loblolly pine overtops the hardwood species, as a rule, and has its crown in full enjoyment of light. For this reason the lower branches, no longer shaded to a great extent, remain on the tree, and the length of the crown increases with the increase of the height of the tree, while the clear length remains stationary. Since the larger trees are usually found in mixed forests, this explains why the sizes from 19 to 24 inches in diameter in Table IX have a smaller proportion of clear length than those from 14 to 18 inches.

TABLE IX.—*Relation between the total height and the clear length of loblolly pine trees grown under various conditions.*[a]

Diameter breasthigh.	Total height.	Clear length.	Ratio of clear length to total height.
Inches.	*Feet.*	*Feet.*	*Per cent.*
10	85	53	63
11	88	57	61
12	90	60	67
13	92	63	68
14	93	65	70
15	93	65	70
16	94	66	70
17	95	66	70
18	96	67	70
19	98	67	68
20	99	67	68
21	101	67	66
22	102	67	65
23	104	67	64
24	105	67	67

[a] See Table XVI for total heights in each type.

TAPER.

The taper of loblolly pine is comparatively slight. For the merchantable portion of the tree a taper of from 1.2 to 1.5 inches in diameter for every 10 feet of height in trees between 10 and 20 inches in diameter breasthigh, and a little over 1.5 inches for every 10 feet in trees above 20 inches in diameter, may be accepted as the average. The taper is greater and more variable at the butt and in the top than in the portion between 4.5 feet from the ground (breasthigh) and the base of the crown.

Since the clear length includes most of the merchantable portion of the tree, a knowledge of the ratio of the diameter at the point where the crown begins (or clear length ends) to the diameter breasthigh is very serviceable in forest practice, especially in estimating the number of ties or kind of pole or log which can be obtained from a given tree. This relationship between the two diameters is fairly constant, and characterizes the species almost in the same degree as the form factor does.

TABLE X.—*Relation between the diameters of loblolly pine breasthigh and at base of crown.*

Diameter breasthigh.	Diameter at base of crown.	Ratio of diameter at base of crown to diameter breasthigh.	Diameter breasthigh.	Diameter at base of crown.	Ratio of diameter at base of crown to diameter breasthigh.	Diameter breasthigh.	Diameter at base of crown.	Ratio of diameter at base of crown to diameter breasthigh.	Diameter breasthigh.	Diameter at base of crown.	Ratio of diameter at base of crown to diameter breasthigh.
Inches.	*Inches.*	*Per ct.*	*Inches.*	*Inches.*	*Per ct.*	*Inches.*	*Inches.*	*Per ct.*	*Inches.*	*Inches.*	*Per ct.*
11.....	6.2	56	16.....	7.7	48	21.....	10.4	50	26.....	15.2	58
12.....	6.4	53	17.....	8.2	48	22.....	10.9	50	27.....	16.1	60
13.....	6.6	51	18.....	8.5	47	23.....	12.5	54	28.....	17.2	61
14.....	6.9	49	19.....	9.1	48	24.....	13.0	54	29.....	17.9	62
15.....	7.0	47	20.....	9.7	49	25.....	14.5	58	30.....	18.5	62

SOIL AND MOISTURE REQUIREMENTS.

Though loblolly pine is naturally found on soils widely differing in fertility, structure, and drainage, for its best growth it requires better physical and chemical qualities than do either the shortleaf or the longleaf pines. A deep, fairly loose sandy or light loamy soil, with a uniform supply of moisture and a moderate amount of humus, suits the species best. There the trees produce long clear stems and foliage that is dense and more persistent than in other situations.

In the thickets, where the soil is subject to frequent flooding, the growth of pine is retarded. On stiff, heavy soils, which prevent the formation of a deep root system, and on poor sand, the height growth is below normal, the trees developing short or crooked boles and large, branchy crowns.

ROOT SYSTEM.

The occurrence of loblolly pine on a wide range of soils is due primarily to the capacity of its root system to adapt itself to most varied conditions. Like the two other pines of Texas, the loblolly forms, on deep sandy or light loamy soils with a moist subsoil, a taproot penetrating several feet into the ground; on poor, sandy, and marshy soils it produces only superficial lateral roots, which spread a long distance in all directions in order to obtain the necessary nourishment. On stiff clayey or loamy soils it develops a short, stout taproot. The taproot rarely attains the same development as that of the longleaf or shortleaf pines, because the tree is not often found on the dry, loose sands on which the latter flourish. As a rule the taproot penetrates to a depth of from 4 to 5 feet, and strong laterals reinforce it. On soils in which the tree is capable of establishing such a root system as this, loblolly is most resistant to winds, but in other situations it is often overthrown.

TOLERANCE.

Loblolly pine is decidedly intolerant of shade, though it requires, especially in its youth, less light than the longleaf and shortleaf pines. The tree forms a loose, open crown, to all parts of which sunlight has access. During the first stages of its development it can endure overshading for a time, especially if the soil is good or moist, but after one or two decades it becomes very sensitive to any shade, either from above or from the side. The shade which loblolly pine can endure during its early life enables it to secure ground inaccessible to longleaf and shortleaf pines, and accounts for its being found more frequently than any other pine in Texas in stands of varied age and in mixture with hardwoods. It also explains why the dense young stands of pure loblolly can maintain themselves until they are 30 or 40 years old.

SEED PRODUCTION.

At about 30 years of age loblolly pine enters upon a regular and vigorous seed production. As a rule the tree produces seeds every year. Specimens 10 years old often bear a few scattering cones, but seeds from trees less than 30 years of age are of inferior quality. The best seeds are produced when the tree is between 35 and 60 years old; after 60 years is reached the seeding may be particularly plentiful, but as the trees grow older the cones gradually become smaller and the seeds of lower vitality.

In eastern Texas the flowers open late in March, when all danger from spring frosts is over, and the cones mature in eighteen months, though they remain on the branches for two years and more. The seeds begin to fly at the end of October, and continue through the

winter and early spring. Under favorable conditions they may be scattered by the wind to a distance of from one-eighth to one-fourth of a mile; within that distance an open area can receive in two or three seasons a sufficient number of seeds to stock it fully. Some of the seeds germinate in the fall, others early in the spring. The young seedlings need a fairly fresh mineral soil, and consequently are not found on the dry, porous sands of the uplands nor on the deep leaf mold of the forest. Though the seeds readily take root on ground covered with grass, they germinate much better on the exposed soil of fresh burns, abandoned fields, windfalls, rootings of swine, etc.

RATE OF GROWTH.

Though adaptable to a wide range of soils, it does not by any means follow that loblolly pine grows at the same rate upon all. A comparison of figures derived from trees grown in different situations brings out clearly the effect of varying influences.

HEIGHT GROWTH.

The rate of height growth does not remain uniform throughout the tree's whole life, but varies at different periods. (See Table XII.) On old fields and on knolls on the wet prairie, where the soil conditions are exceedingly favorable for the development of the root system, the seedlings enter at once upon their most rapid growth in height. During the first decade the trees on old fields grow at the rate of 3.4 feet a year, but during the second decade growth drops to 2.8 feet, and steadily decreases as the tree becomes older.

Under all other conditions loblolly pine grows slowly for several years, while the development of the root system takes place, and its period of most rapid growth does not commence until the second decade. A comparison of the rate of growth in height in the different types shows that the most favorable conditions for the development of the loblolly pine are found in a mixed hardwood forest on well-drained, fertile soil, in spite of the fact that the trees on old fields and knolls in the wet prairie grow much faster at first.

How height growth progresses in the five types or subtypes that have been recognized is clearly shown in Table XI.

TABLE XI.—*Height of loblolly pine in different situations.*

Age.	On old fields.	In pure groups on the wet prairie.	In pure stands on fairly well-drained, light soil.	Mixed with hardwoods.	
				On well-drained, fertile soil.	On poorly drained soil (thicket).
Years.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
5	18	11	6	7	5
10	34	29	21	23	13
15	50	45	35	34	21
20	62	57	45	45	28
25	69	67	53	55	34
30	74	73	60	65	39
35	78	79	67	75	44
40	82	84	73	85	49
45	.....	89	78	95	53
50	.....	95	83	105	57
60	.....	.....	88	.....	64
70	.....	.....	91	.....	72

The variability in the rates of height growth at different periods and the differences between the types are well shown in Table XII.

TABLE XII.—*Average annual height growth of loblolly pine in different types at different periods.*

Decade.	On old fields.	In pure groups on the wet prairie.	In pure stands on fairly well-drained, light soil.	Mixed with hardwoods.	
				On well-drained, fertile soil.	On poorly drained soil (thicket).
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
First	3.4	2.9	2.1	2.3	1.3
Second	2.8	2.8	2.4	2.2	1.5
Third	1.2	1.6	1.5	2.0	1.1
Fourth	.8	1.1	1.3	2.0	1.0
Fifth	.....	1.1	1.0	2.0	.8
Sixth	.....	.....	.5	.....	.7
Seventh	.....	.....	.3	.....	.8

DIAMETER GROWTH.

The rate of growth in diameter on the different types is similar to the rate of growth in height. On old fields and on prairie knolls the most rapid growth occurs in the first decade; on all other situations it occurs in the second, third, and even fourth decade. In all cases the most rapid diameter growth sets in later than the most rapid height growth. Even on old fields and prairie knolls it does not begin until the second half of the first decade. In pure stands rapid diameter growth commences earlier and exhausts itself sooner than in mixed forests, because the more open character of the pure forests when young favors early growth in diameter, while the close stand and the

undergrowth in the hardwood forest stimulate growth in height at the expense of the diameter growth. In the latter case the period of most rapid diameter growth sets in only after the pine trees have succeeded in outgrowing the associated hardwoods and carried their crowns above the shade, but it continues for a longer time than it does in pure stands. Thus, while the average annual diameter growth on old fields and prairie knolls has dropped to 0.17 and 0.21 inch, respectively, in the third decade, the trees in mixture with hardwoods still grow at the rate of 0.21 inch a year up to the seventh decade. (See Table XIV.) The rapid falling off of diameter growth on old fields is due principally to the very close stand.

A comparison of the rate of growth in diameter in the different types again points to the mixed forest as offering the most favorable conditions for the development of loblolly pine. The greater growth in height of the trees grown in mixture, together with their more persistent, though slower, diameter growth, tends to produce fine, fairly cylindrical stems clear of branches for a long distance.

Table XIII shows the average rate of growth in diameter on each type. Table XIV gives the average annual growth at different periods, and Table XV makes the influence of locality more apparent by giving the time required to increase the diameter of the average tree 1 inch.

TABLE XIII.—*Diameter of loblolly pine in different types.*

Age.	On old fields.	In pure groups on the wet prairie.	In pure stands on fairly well-drained, light soil.	Mixed with hardwoods.	
				On well-drained, fertile soil.	On poorly drained soil (thicket).
Years.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
5	1.9	1.5	0.2	0.2	0.2
10	4.3	3.7	2.2	2.1	.9
15	6.1	5.5	4.8	4.0	1.6
20	7.6	6.7	7.6	6.1	2.2
25	8.5	7.7	10.4	7.9	3.0
30	9.3	8.8	12.8	9.5	3.8
35	9.9	9.9	15.0	10.9	4.7
40			16.9	12.4	5.6
50			20.0	15.0	7.8
60			22.3	17.2	9.8
70			24.0	19.3	11.9

31051—No. 64—05——4

TABLE XIV.—*Average annual diameter growth of loblolly pine in different types at different periods.*

Decade.	On old fields.	In pure groups on the wet prairie.	In pure stands on fairly well-drained, light soil.	Mixed with hardwoods.	
				On well-drained, fertile soil.	On poorly drained soil (thicket).
	Inch.	*Inch.*	*Inch.*	*Inch.*	*Inch.*
First	0.43	0.37	0.22	0.21	0.09
Second	.33	.30	.54	.40	.13
Third	.17	.21	.52	.34	.16
Fourth			.41	.29	.18
Fifth			.31	.26	.22
Sixth			.23	.22	.20
Seventh			.17	.21	.21

TABLE XV.—*Time required to increase diameter of loblolly pine one inch in different types.*

Diameter breast-high.	On old fields.		In pure groups on the wet prairie.		In pure stands on fairly well-drained, light soil.		Mixed with hardwoods.			
							On well-drained, fertile soil.		On poorly drained soil (thicket).	
	Age.	Time required to grow 1 inch.	Age.	Time required to grow 1 inch.	Age.	Time required to grow 1 inch.	Age.	Time required to grow 1 inch.	Age.	Time required to grow 1 inch.
Inches.	*Years.*	*Years.*	*Years.*	*Years.*	*Years.*	*Years.*	*Years.*	*Years.*	*Years.*	*Years.*
1	4	4	4	4	7	7	7	7	11	11
2	5	1	6	2	9	2	10	3	18	7
3	7	2	9	3	11	2	12	2	25	7
4	9	2	11	2	13	2	15	3	31	6
5	12	3	13	2	15	2	17	2	37	6
6	15	3	17	4	17	2	20	3	42	5
7	18	3	21	4	19	2	22	2	46	4
8	22	4	26	5	21	2	25	3	51	5
9	28	6	31	5	22	2	28	3	56	5
10	35	7	36	5	24	2	32	4	61	5
11					26	2	35	3	66	5
12					28	2	39	4	70	4
13					30	2	42	3	75	5
14					33	3	46	3	81	6
15					35	2	50	4	86	5
16					38	3	54	4	91	5
17					40	2	59	5	98	7
18					43	3	64	5	104	6
19					47	4	69	5	112	8
20					50	3	74	5	120	8
21					54	4			131	11
22					59	5			142	11
23					64	5			156	14
24					70	6			169	13
25									185	16
26									203	18

Table XVI gives the relation between the diameter and height of trees in different types, and serves to show further how the growth is influenced by the situation.

TABLE XVI.—*Total height of loblolly pine grown in different types.*[a]

Diameter breasthigh.	On old fields.	In pure groups on the wet prairie.	In pure stands on fairly well-drained, light soil.	Mixed with hardwoods.	
				On well-drained, fertile soil.	On poorly drained soil (thicket)
Inches.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1	10	9	13	14	15
2	16	15	20	22	25
3	23	22	27	29	34
4	31	31	32	34	40
5	40	42	36	39	45
6	50	52	39	44	50
7	59	61	42	50	54
8	66	68	45	56	58
9	73	75	48	62	62
10	79	80	51	69	65
11	.....	.....	54	77	69
12	.....	.....	57	84	72
13	.....	.....	60	91	75
14	.....	.....	67	97	79
15	.....	.....	70	103	82
16	.....	.....	74	.....	86
17	.....	.....	77	.....	89
18	.....	.....	80	.....	93
19	.....	.....	84	.....	97
20	.....	.....	87	.....	101
21	.....	.....	.....	.....	105
22	.....	.....	.....	.....	109
23	.....	.....	.....	.....	114
24	.....	.....	.....	.....	119
25	.....	.....	.....	.....	124

[a] See Table IX for average height in all types.

LOBLOLLY PINE LUMBER.

Loblolly pine is at present extensively cut and sawed for lumber. The mills of Texas turn out annually not less than 300,000,000 board feet, of which a considerable amount is in the form of sawed ties. Most of the lumber is shipped to the north-central States and the States of the Plains. The markets of Louisiana and Texas are somewhat prejudiced against it, although a great deal is sold there also.

The lumber is rarely handled under its own name, but, either alone or mixed with true shortleaf, is sold as shortleaf pine. The latter is heavier, harder, and stronger than typical loblolly, yet often it is impossible to distinguish the two. In general loblolly is less valuable than shortleaf, though for many purposes it answers quite as well; many mills are reluctant to admit that they use it. Yet it should

be frankly offered for what it is. The objections to it are based chiefly upon a prejudice in favor of longleaf and shortleaf pine, formed at the time when there was an abundance of the more valuable material.

Loblolly pine usually contains a large proportion of sapwood, and must therefore be kiln dried immediately after it is sawed to avoid a fungus that attacks the green lumber and stains it blue. Clear boards are usually planed also after they are dried and before they are put in stock.

For purposes requiring chemically preserved timber, like piling and railroad ties, the quickly grown, sappy loblolly is better than shortleaf or even longleaf, because it absorbs the preservative more readily. Its relative softness is a disadvantage in ties, though that can be overcome by using plates of metal or hardwood to take the wear of the rails. Loblolly pine lumber is especially suitable for interior finish and for sash and doors, because it receives and holds paint remarkably well, and after being kiln dried does not swell and shrink with the changes in the moisture of the air, as the harder pines do. In this respect it resembles the white pine of the North.

The cost of logging loblolly pine is usually slightly higher than the cost of logging longleaf pine. The softer ground and the denser undergrowth in many of the loblolly pine stands increase the cost of tram construction and necessitate the building of bridges and clearing out the undergrowth. Little of that work has to be done in the open and comparatively dry longleaf pine land. The hauling also is more difficult because of the soft ground and because green loblolly pine is heavier than green longleaf pine. Though dry loblolly is lighter than dry longleaf, the sappy, green loblolly pine is so heavy that driving by water is almost impossible. The large amount of sapwood in the trees also raises the cost of felling, since it causes the saw to bind so that two sawyers, who usually saw from 15,000 to 16,000 board feet of longleaf pine a day, can saw scarcely 12,000 board feet of loblolly. But the higher cost of lumbering loblolly pine is more than offset by its low stumpage price, which ranges between 50 cents and $1 per thousand feet.

YIELD OF LOBLOLLY PINE LUMBER.

In order to learn the actual yield of loblolly pine lumber from trees of different diameters, 944 trees were measured and the logs produced by each scaled. From the figures thus obtained a table was made showing the contents of trees grown on each of the three types which now produce large timber. The number of trees over 10 inches in diameter on old fields and on prairie knolls is too few to make it wise to consider those types here. Table XVII therefore gives the quantity of lumber that may be produced from trees of different diameters grown under various conditions, according to the Herring

log rule, the rule commonly used in eastern Texas, and also according to the more widely used Doyle-Scribner log rule.

TABLE XVII.—*Volume of loblolly pine grown under various conditions.*

Diameter breasthigh.	In pure stands on fairly well-drained, light soil.		In mixture with hardwoods.				Average of all.	
			On well-drained, fertile soil.		On poorly drained soil (thicket).			
	Herring rule.	Doyle-Scribner rule.	Herring rule.	Doyle-Scribner rule.	Herring rule.	Doyle-Scribner rule.	Herring rule.	Doyle-Scribner rule.
Inches.	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*
11	62	23	74	45	30	20	69	43
12	89	50	95	63	55	44	93	64
13	116	76	119	87	82	69	118	86
14	144	106	145	114	111	98	143	110
15	174	139	174	144	145	130	172	138
16	199	172	207	175	182	165	202	171
17	229	205	241	210	224	207	236	207
18	259	240	278	250	267	254	269	249
19	288	277	317	295	316	309	317	294
20	317	312	357	340	374	374	347	342
21	348	348	395	390	433	445	389	395
22	382	389	437	445	500	530	435	450
23	413	432	483	500	578	628	480	510
24	449	478	537	560	660	730	528	578
25	487	527	595	630	751	839	582	650

Table XVII may be used to find the quantity of lumber on a forest tract. Naturally the results will be most accurate if the diameter of each tree is calipered, and the total calculated from the yield per tree on the corresponding type; but in practice on tracts of large size very satisfactory results will be obtained by counting and calipering the trees on a few acres representing the average conditions of the whole tract, calculating the yield on that area, reducing it to the average for one acre, and then multiplying that yield by the total area of the forest, exclusive of openings.

THE VALUE INCREASE IN TREES OF DIFFERENT SIZES.

The rate of increase in value of trees, apart from the quantity of wood produced, is discussed at length on page 41, but what is there said regarding tie trees is even more applicable to those used for lumber. Even if it be assumed that the grades of lumber which are obtained at the mill from trees of different diameters are the same, the contents of the average tree, and consequently its value, increase annually 10.7 per cent between the ages of 32 and 35 years, and only 2.8 per cent between 64 and 69 years. As a matter of fact, however, the percentage of the different grades of lumber obtained at the mill from small and from large trees is not the same; large logs, and consequently larger and older trees, yield almost invariably a greater percentage of superior grades than small trees.

Table XVIII shows in a conclusive way how the volume yield from small trees is out of all proportion to the rate of growth of such trees, and indicates the wastefulness in cutting them while rapid growth keeps up.

TABLE XVIII.—*Rate of growth, in volume, of loblolly pine grown in mixture with hardwoods on well-drained, fertile soil.*

Diameter breasthigh.	Age.	Volume.	Increase in volume per inch of diameter.	Annual rate of increase in volume.
Inches.	*Years.*	*Bd. ft.*[a]	*Per cent.*	*Per cent.*
11	35	74	28	7
12	39	95	25	8
13	42	119	22	6
14	46	145	20	5
15	50	174	19	5
16	54	207	16	3
17	59	241	15	3
18	64	278	14	3
19	69	317	13	3
20	74	357	.....	.....

[a] Herring log rule.

Table XIX, based on data obtained at various mills in North Carolina, brings out in another way the economy that may be effected by refraining from cutting immature trees.

TABLE XIX.—*Grades of lumber sawed from loblolly pine.*[a]

Diameter breasthigh.	Percentage of graded lumber.					
	Firsts.	Seconds.	Thirds.	Box.	Culls.	Total.
Inches.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
9	0	25	25	32	18	100
10	8	21	23	31	17	100
11	12	20	24	29	15	100
12	14	20	24	27	15	100
13	14	22	25	25	14	100
14	15	23	25	22	15	100
15	16	20	29	21	15	100
16	22	20	26	19	13	100
17	24	21	25	18	12	100
18	25	21	27	16	11	100
19	27	21	26	16	10	100
20	29	21	24	17	9	100
21	30	21	23	17	9	100
22	31	20	22	17	10	100
23	33	21	22	16	8	100
24	35	19	23	15	8	100
25	36	25	21	10	8	100
26	36	22	21	13	8	100
27	38	22	20	13	7	100
28	38	20	19	15	8	100
29	39	21	18	15	7	100
30	41	20	17	15	7	100

[a] From The Loblolly Pine of North Carolina, by W. W. Ashe.

This table was made up from records of nearly 2,000 logs carefully marked and followed through the sawmill, where the lumber was tallied by a skilled grader and scaler. It contains some irregularities, but they are not important, and conditions in the two regions are near enough alike to justify applying it to the product of the Texas forests.

It is seen that while a tree 10 inches in diameter furnishes only 8 per cent of first-grade lumber, a tree 20 inches in diameter furnishes 29 per cent, or nearly four times as much, and a 30-inch tree 41 per cent, or over five times as much as a 10-inch tree. The grades "box" and "culls" are manufactured at present at only a few Texas mills, and must be regarded practically as waste.

The current prices at the mills for seasoned loblolly pine boards 1 inch thick, 8 inches and over wide, and 10, 12, 18, and 20 feet long are $12.75 per thousand board feet for grade No. 1, $10.75 for grade No. 2, and $8.75 for grade No. 3. With these figures, the percentage given in Table XIX, and the volumes for trees of different sizes from Table XVII, it is possible to compute the value of the average tree of each diameter. Table XX presents the results of such a computation, with an allowance of $4.50 per thousand for the cost of logging and milling.

TABLE XX.—*Net value of loblolly pine grown in mixture with hardwoods on well-drained, fertile soil, at present prices for lumber at the mills in eastern Texas.*

Diameter breasthigh.	Net value.	Diameter breasthigh.	Net value.	Diameter breasthigh.	Net value.
Inches.		*Inches.*		*Inches.*	
11	$0.10	16	$0.54	21	$1.35
12	.16	17	.72	22	1.46
13	.23	18	.90	23	1.77
14	.30	19	1.06	24	1.99
15	.40	20	1.19	25	2.75

These figures are low, since they do not include all that the trees may yield under the best conditions, but they show pretty nearly the relative values of the different sizes.

From Table XX and Table XVIII it is possible to show the annual rate of increase in value. This is given for one subtype in Table XXI.

TABLE XXI.—*Annual rate of increase in value of loblolly pine grown on well-drained, fertile soil in mixture with hardwoods.*

Between the breasthigh diameters of—	Between the ages of—	Annual rate of increase in value.	Between the breasthigh diameters of—	Between the ages of—	Annual rate of increase in value.
Inches.	*Years.*	*Per cent.*	*Inches.*	*Years.*	*Per cent.*
11–12	35–39	15	16–17	54–59	7
12–13	39–42	15	17–18	59–64	5
13–14	42–46	8	18–19	64–69	4
14–15	46–50	8	19–20	69–74	2
15–16	50–54	9			

This table points directly to the most profitable time for cutting trees for lumber. It stands to reason that as long as trees grow in value at a higher rate of interest than the money realized for them could bring, they should be left to grow. Trees below 18 inches in diameter increase at a rate of over 5 per cent, but beyond that point the increase in value falls to a low rate.

LOBLOLLY PINE AS TIE TIMBER.

As tie timber, loblolly pine is not merely a substitute for longleaf pine and other valuable woods, but, from the manner of its occurrence and its intrinsic qualities, has a value of its own. In the moist climate of the Gulf region few natural woods last long on the ground, and when it was discovered that loblolly pine could be made even more durable than more costly woods by means of preservatives, its place as a tie timber was assured.

In no other State is loblolly cut to such an extent for hewed ties as it is in Texas. The reason for this is the great quantity of trees of sizes just suitable for pole ties, and the presence in large quantities of a superior lumber tree—longleaf pine. It is estimated that nearly 80 per cent of all merchantable loblolly pine now standing in Texas is of tie size, and only 20 or 25 per cent of lumber size. This preponderance of small and comparatively young timber is due primarily to the heavy storms of 1865 and 1873, which overthrew the old loblolly pine on many thousands of acres, and caused the areas to be reseeded.

The effects of these earlier storms upon the loblolly pine forest can be understood from the damage wrought upon it by the storm of September 9, 1900, which destroyed Galveston, threw down every tree on many thousands of acres, and affected the whole forest region west of the Trinity River. After the September storm of 1873, in which four days of rain were followed by four days of strong wind, fallen timber so impeded travel that it had to be burned. The fires, though they destroyed many standing trees, prepared for the loblolly pine seeds excellent beds, which were soon occupied, and gave rise to the polewood stands which now mark the path of the storm.

The storm of 1865 is recorded in many trees which, up to that date, grew slowly and formed narrow rings because they were overshadowed by larger ones. The overthrow of the latter by the storm, however, gave more light to the remaining previously suppressed trees, and their subsequent more rapid growth is read in their wider rings.

The more northern counties of the loblolly region, like San Jacinto, Walker, and Montgomery, have been settled for a comparatively long time and contain nearly 25 per cent of cleared land. The loblolly pine, which is the principal tree, has been cut for local use for more than a quarter of a century, and there is now a large amount of

second-growth loblolly pine forest which, in part, occupies abandoned fields.

In the southernmost counties, where the center of the tie industry now is—for the last two years Orange and Newton and the southern

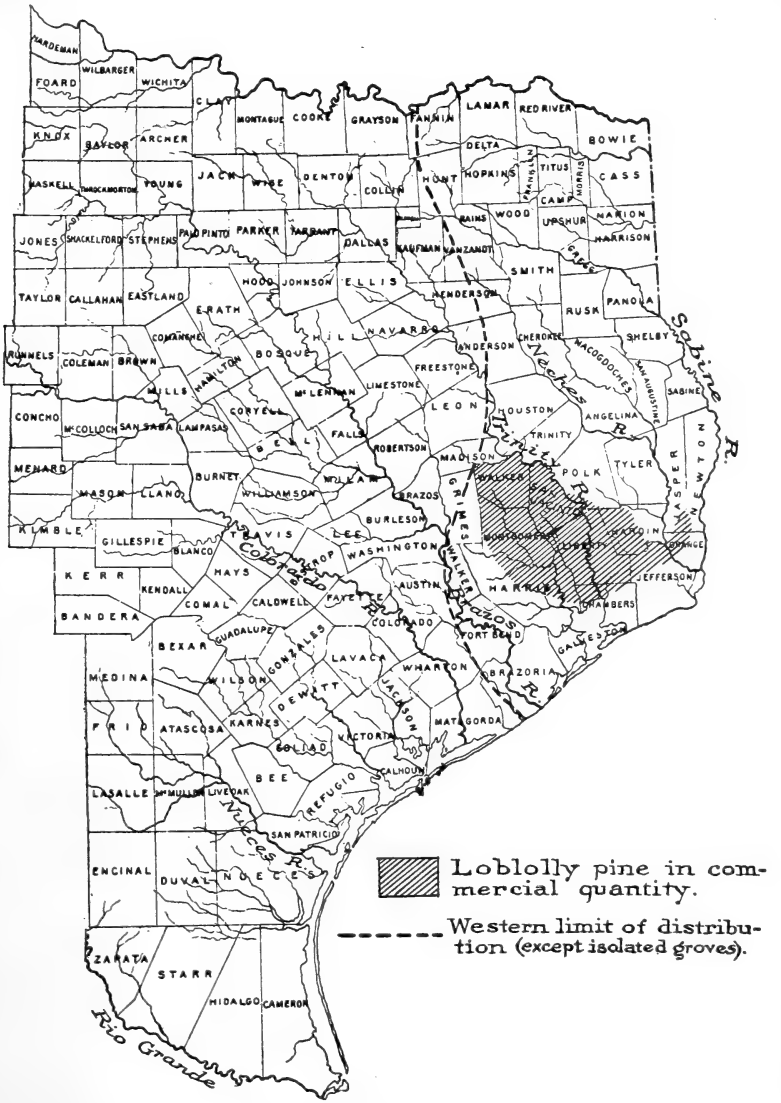

FIG. 1.—Eastern Texas, showing limits of loblolly pine.

part of Jasper County alone have furnished from 1,000,000 to 1,500,000 hewed ties each year—the loblolly pine is of very recent origin; the forest is but of yesterday, and is still in process of formation and extension. (See page 10.)

In this section loblolly pine is found in commercial quantities over an area of nearly 5,000 square miles, and its botanical range includes over 6,800 square miles. (See fig. 1.)

HEWING TIES.

As has just been said, the loblolly pine in Texas is largely hewed into ties because so many of the trees are of just the right size. There is, however, a considerable quantity sawed into ties at the mills of Montgomery and San Jacinto counties. In those mills about one-third of the output is in the form of sawed ties.

The hewing of ties is, as a rule, done by contractors, who do not own the land or the timber, but who buy stumpage—that is, the right to cut the trees. Stumpage is usually bought either by the tie or by the area. On tracts which contain both large and small timber, the tie contractor tries to work ahead of the lumberman, because the tops left on the ground after lumbering make the removal of ties very difficult, and because the lumberman breaks many trees which the tie cutter could use. In many instances, however, lumber concerns hew the remaining tops and the smaller timber into ties after they have cut all the sawlogs on the tract.

The railway specifications call for ties 8 feet long and not less than 6 inches thick and 8 inches face. The trees are felled with the saw, sawed up into 8-foot lengths, and hewed into the required dimensions with the broadax. The Slavonians and Croatians, who make up, to a large extent, the army of tie cutters, first hew the whole stick to the proper shape and then cut it into tie lengths. The tie cutter is paid by the piece for ties which conform to the specifications and are accepted by the inspector, the price averaging between 11 and 13 cents, according to the character of the timber. In first-cut timber, or virgin forest, the price is lower than in cull timber (forest once cut over for ties). The average tie cutter makes from 20 to 25 ties a day; 600 ties a month is considered very good cutting.

SIZES OF TREES USED FOR HEWED TIES.

Hewed ties are seldom exactly of the specified dimensions. As a rule they are of the proper length, but the other dimensions are nearly always greater than are called for. In order to make ties 6 inches by 8 inches with the least hewing, only logs from 8½ to 9 inches in diameter at the upper end, or trees 10 inches in diameter breasthigh, should be cut. As a matter of fact, however, the hewers use trees from 11 inches to 17 inches in diameter breasthigh, and give preference to those 12, 13, 14, and 15 inches in diameter. This is made clear in Table XXII, which gives the percentage of trees of different diameters in a lot of 603 which were tallied for this purpose.

TABLE XXII.—*Loblolly pine of different diameters used by tie cutters.*

Diameter breasthigh.	Trees cut.	
	Number.	Per cent.
Inches.		
11	31	5.14
12	137	22.72
13	177	29.35
14	161	26.70
15	79	13.10
16	17	2.82
17	1	.17
Total	603	100.00

The preference for trees of only certain diameters becomes still more evident if the percentages of trees of each diameter selected by the hewers for ties are compared with the total number of trees of each diameter standing on a given area, as is done in Table XXIII.

TABLE XXIII.—*Stand of loblolly pine on 5 acres of typical forest, and proportion selected for ties.*

Diameter breasthigh.	Total stand.	Trees cut.	Ratio of trees cut to total stand.
Inches.	*Number.*	*Number.*	*Per cent.*
11	78	12	15
12	76	49	65
13	68	59	86
14	57	56	98
15	40	27	68
16	28	4	15
17	15	1	7
Total	362	208	.....

The percentages in this table are not directly comparable with those in Table XXII, though it is evident at once that the trees from 12 to 15 inches in diameter have the preference in both. In each case the greatest number of trees cut were 13 inches, though in Table XXIII the highest percentage falls on the 14-inch size, of which only 2 per cent were left standing. This contrasts strongly with the small number of 11-inch and 16-inch trees that were cut—only 15 per cent of each.

YIELD OF TIES PER TREE.

The average number of ties cut from trees 16 inches in diameter, breasthigh, is the practical limit of the number of pole ties which can be obtained from loblolly pine. Larger trees, unless they are split or sawed, will yield, on an average, no more, and, at the same time, will give a great deal of additional work in hewing them. This fact fixes

a natural limit to the size of trees that may be used for pole ties, and explains why the tie cutters pass by the larger trees.

Table XXIV gives a record of 996 trees cut from ordinary stands in two common types of forest, and shows the average number of ties actually yielded by trees of different diameters on each type, and the two combined.

TABLE XXIV.—*Average number of ties in loblolly pine grown in various situations.*

Diameter breasthigh.	From mixed loblolly and hardwood stands cut for the first time.		From pure loblolly stands cut once before.		From the two stands combined.	
	Number of trees.	Ties cut from each.	Number of trees.	Ties cut from each.	Number of trees.	Ties cut from each.
Inches.						
11	34	2.5	43	2.3	77	2.4
12	155	3.3	81	2.7	236	3.1
13	196	4.1	61	3.5	257	3.9
14	181	5.0	50	4.0	231	4.8
15	92	5.5	48	4.6	140	5.2
16	18	6.0	35	5.5	53	5.7
17	2	6.0	.....	.....	2	6.0

Table XXIV will be found useful for finding out the number of ties that may be cut from a given area. The best procedure on a tract not too large is to measure each tie tree at breastheight, and multiply the totals of each diameter by the figure in the table representing the number of ties that one tree will yield. The sum of these will be the total yield. If measuring all the trees would entail too much labor, typical sample areas may be measured off and their yield of ties calculated as above. Then, knowing the number of ties on the small area, those on the larger can be determined by a simple proportion. This latter method will give sufficiently accurate results if the whole area is similar in character to the portion which was measured. If the forest which is to be cut presents differences in density or character, it will be necessary to measure sample areas in several representative parts, and from these to calculate, first, the number of ties on each part or type, and then the total number.

It will be observed that a mixed growth of loblolly pine with hardwoods, cut for the first time for ties, yields a higher average number of ties to the tree than a pure stand of loblolly pine on land once cut for ties. This is because the trees in the mixed forest have a greater height and less taper than those in pure stands. (See Table XVI.) Further, in the first cut the hewers took out the straightest and tallest trees, leaving for the second cut only those that were small, crooked, or otherwise less perfect.

The use of this table for determining the number of ties on a given tract will give results far more accurate than the most careful ocular

FIG. 1.—A TREE WITH STANDING SLAB. ONE OF THE MANY WAYS IN WHICH TIE HEWERS SAVE WORK.

FIG. 2.—MIXED FOREST CULLED FOR HEWED TIES. ALL LOBLOLLY PINE TREES BETWEEN 11 AND 17 INCHES DIAMETER HAVE BEEN CUT.

estimates, and, since it does not require expert judgment regarding each individual tree, simplifies the operation. At the present low stumpage price of loblolly pine in Texas, however, any estimate beyond a mere approximation is superfluous, and ocular estimation will for a long time remain the principal way of determining the yield. Where the timber is sold at a price for each tie cut, such an estimate is entirely sufficient, since the buyer only wants to form an approximate idea of the number of ties which he can secure from a certain tract.

WASTE IN HEWED TIES.

Since the tie inspectors do not object to, but even favor, ties of greater dimensions than 6 inches by 8 inches, the tie maker never hews a large log to the minimum size. A hewn tie, therefore, contains, as a rule, more than the 32 board feet which are contained in a sawed tie of the specified dimensions. This waste of timber, though considerable, is less than that which goes into slabs and chips in hewing.

Table XXV is compiled from records made of the actual yield of 603 trees, and conveys an idea of the sum of these wastes. It shows that from 54 to 71 per cent of the timber cut for pole ties goes into slabs and excessive dimensions. If to this waste is added the timber lost in unreasonably high stumps, and the large tops left entirely unused, the proportion of the tree actually used in the shape of ties is exceedingly small. Thus, only from 26 to 30 per cent of the total volume of the tree is made remunerative, while the rest, 70 to 74 per cent, is either thrown away entirely or practically wasted in making needlessly large ties. These figures of course include some material that could not be used in any case, e. g., the tops above 9 inches. The statement is made in this way solely to show how small a proportion of the forest is utilized, and to emphasize the importance of the economies that are recommended farther on.

TABLE XXV.—*Amount of timber wasted by making hewed pole ties.*

Diameter breasthigh.	Total volume of tree.[a]	Volume of round logs in used portion.	Volume of ties cut (6 by 8 inches by 8 feet.)	Volume wasted.	
				In portion of tree used for ties.	In the whole tree.[a]
Inches.	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Per cent.*	*Per cent.*
11	24.5	12.9	6.4	50	74
12	31.0	18.0	8.3	54	73
13	36.5	24.2	10.4	57	72
14	42.5	31.6	12.8	60	70
15	48.0	39.3	13.9	65	71
16	55.0	46.8	15.2	68	72
17	62.0	54.3	16.0	71	74

[a] Exclusive of branches.

The figures of the average number of ties actually yielded by trees of different diameters, Table XXIV, do not represent all that could be obtained from the same trees under a more careful and economical system of cutting. Since the tie makers are paid by the tie, their aim is to make as many as possible in the shortest time and in the easiest way. They commonly avoid all crooked and knotty trees, and fell only the tallest and straightest ones, those which will yield the greatest number of ties. Because the butt of the tree is tough and requires most ax work, the stumps are cut as a rule excessively high, seldom less than 2.5 feet in trees of small diameters, and often 3 feet to 4 feet in the larger trees. Many trees, after being felled, are also butted off 3 or 4 feet, because they are too large to be hewed easily. Another means of saving work is to saw the trees through about three-fourths of their thickness, and throw them by means of wedges driven into the kerf. In falling the tree splits up for a considerable length, and leaves a long slab attached to the stump which would otherwise have to be taken off the log by the axe. (Pl. IV, fig. 1.) Old, suppressed trees, which after being felled prove hard to hew, are frequently left to rot, or only a small part of what could be made into ties is used. Most of the trees felled for ties could be safely used to a diameter of 9 inches in the top, but the tie cutter, guessing at the size and unwilling to risk making a cull tie (one below the specified dimensions), for which he is not paid, remains on the safe side and seldom cuts beyond 10 inches. Often a large part of a tree with a knot or crook, or slightly buried in the sand so that it is difficult to saw into the proper lengths, is left unused.

POSSIBLE SAVINGS IN TIE MAKING.

Many of the wastes that have been just described are easy to reduce or to eliminate entirely. By merely cutting the stumps about 2 feet high or less and utilizing all the tie timber in each tree, the average number of ties to the tree could be perceptibly raised.

Table XXVI shows clearly how great a saving may be effected by cutting all stumps at 2 feet above the ground and utilizing the stem to 9 inches in diameter outside the bark at the top. The figures are based upon taper measurements of 603 trees.

TABLE XXVI.—*Average number of hewed ties now obtained from loblolly pine and number that can be cut.*

Diameter breasthigh.	Number obtained.	Number which can be obtained.	Per cent of increase.
Inches.			
11	2.4	2.5	4
12	3.1	3.5	13
13	3.9	4.5	15
14	4.8	5.5	15
15	5.2	6.0	15
16	5.7	6.5	14
17	6.0	7.0	17

The increased number of ties that it is possible to obtain is somewhat variable, because lengths of 8 feet must always be cut, yet the gain is very real, and amounts to considerable when applied to even 1 acre of forest. Taking the figures of Table I as an example, it requires but a simple calculation to show that the 93 trees between 11 and 17 inches in diameter produced by 1 acre of forest from 35 to 40 years old may yield 45 more ties than they do ordinarily. If this be applied to a piece of land yielding 40,000 ties, the increase will amount to at least 5,000 ties, worth, at the present price of 24 cents a tie, $1,200.

HEWED VERSUS SAWED TIES.

The hewing of ties, however, no matter how complete the utilization of the tree may be, is a most wasteful process, whose extent will be best understood by comparing the volume of average hewed ties with the product of logs of the same dimensions sawed into ties and lumber. By means of a series of diagrams, like figure 2, the amount of lumber and ties which can be obtained from logs of various sizes by sawing has been ascertained. A large part of the log, which in hewing is entirely wasted in the form of chips and excessive dimensions, is thus shown to be available for useful material—boards and planks.

It is impracticable to make a direct comparison between the tie and the lumber yield of trees of various sizes, because the hewers might be more saving, and because the lengths obtainable are not always multiples of the tie length, 8 feet, but such a comparison can be made on the basis of logs 16 feet long, which will produce two ties, or lumber of standard length. This is done in Table XXVII, and the possibility of saving from 23 per cent of the hewed tie volume, in 10-inch logs, to 191 per cent in 15-inch logs is clearly shown. The saving here indicated may rarely be reached in practice, since the logs are not apt to be perfectly cylindrical nor straight, as the diagrams from which the table was made assume them to be, yet after making every reasonable allowance for such irregularities, the waste in hewed ties is striking.

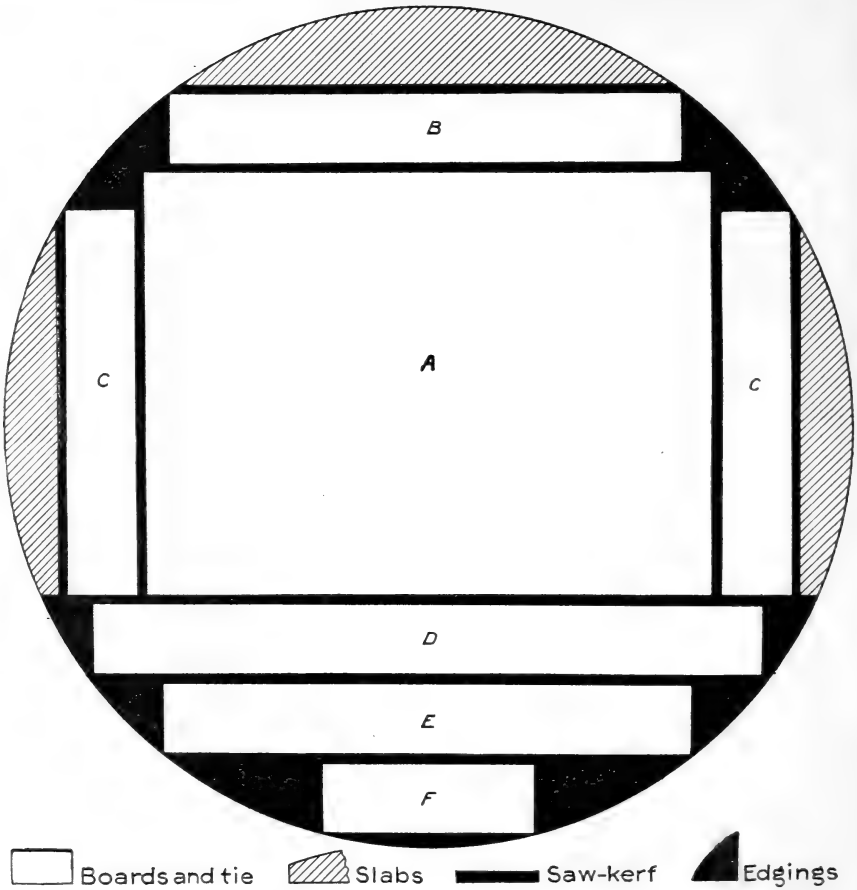

FIG. 2.—Diagram to show how a 12-inch log may be made to yield ties and lumber. *A*, railroad tie 6 by 8 inches; *B*, board 7 inches wide; *C C*, boards 5½ inches wide; *D*, board 9½ inches wide; *E*, board 7½ inches wide; *F*, board 3 inches wide.

TABLE XXVII.—*Gain in lumber effected by sawing instead of hewing ties.*

Diameter of log at small end inside bark.	Yield of a 16-foot log.				Percentage of the volume of hewed ties gained by sawing.
	In hewed ties.	In sawed ties and lumber.			
		Ties.	Lumber.	Total.	
Inches.	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Per cent.*
10	64	64	14.8	78.8	23
11	64	64	27.0	91.0	42
12	64	64	52.4	116.4	82
13	64	64	70.8	134.8	112
14	64	64	97.2	161.2	152
15	64	128	57.6	185.6	191

TREE SIZES MOST PROFITABLE FOR TIES.

There is a still more important reason why ties should be sawed instead of hewed than the saving of lumber, namely, that the latter method demands those trees which are in their best period of growth. As was shown on page 34 and in Tables XXII and XXIII, the tie cutters prefer trees 12, 13, 14, and 15 inches in diameter, or between 30 and 50 years of age, when they are still growing rapidly in diameter.

Table XXVIII shows that the rate of diameter increase in trees of the sizes used for hewed ties, though steadily falling, is maintained at more than one-quarter of an inch a year until the age of 50 years is passed.

TABLE XXVIII.—*Increase in diameter of loblolly pine grown in mixture with hardwoods on well-drained, fertile soil.*

Age.	Diameter breast-high.	Annual increase in diameter.	Age.	Diameter breast-high.	Annual increase in diameter.
Years.	*Inches.*	*Inch.*	*Years.*	*Inches.*	*Inch.*
10	2.1	0.40	50	15.0	0.22
20	6.1	.34	60	17.2	.21
30	9.5	.29	70	19.3	.....
40	12.4	.26			

But the loss that is entailed by cutting immature trees is made much more apparent when the increasing money value of the trees is considered. This is shown in Table XXIX.

TABLE XXIX.—*Rate of increase in stumpage value of loblolly pine trees suitable for ties, grown in mixture with hardwoods on well-drained, fertile soil.*

Diameter breasthigh.	Value of tree at 3 cents a tie.	Annual rate of increase.	Diameter breasthigh.	Value of tree at 3 cents a tie.	Annual rate of increase.
Inches.	*Cents.*	*Per cent.*	*Inches.*	*Cents.*	*Per cent.*
11	7.5	8	15	16.5	2
12	9.9	8	16	18.0	.....
13	12.3	5	17	18.0	.....
14	15.0	3			

These two tables show that the rate of increase in diameter and in value for hewed ties is greater in the smaller trees than in those from 14 to 16 inches in diameter. In other words, the money capital represented by the trees of 11 and 12 inches in diameter increases at a rate equal to an interest of 8 per cent per annum, while the capital represented by trees of from 13 to 16 inches in diameter bears interest at the annual rate of only 2.5 per cent. If the owner of the land were to cut down all the loblolly pine trees between 11 and 13 inches in diameter and place the money received for them in some safe enterprise, he would

scarcely receive such a high rate of interest as he does from the growing trees. If it is necessary that the trees should be cut for hewed pole ties, only those 15, 16, and 17 inches in diameter should be used, as their rate of increase in value is smaller than that of trees 11, 12, and 13 inches in diameter. In this way the capital is allowed to work at a higher rate of interest.

Further, the forest is not threatened with entire destruction. In a forest from which regular and sustained yields are expected, trees of all ages must be present and the young ones must preponderate over the old ones, just as in a self-perpetuating community the number of children must be greater than the number of adults. By cutting out the young trees and leaving the old ones, as is now the common rule, the very existence of the forest is attacked. Since hewing the trees into ties instead of sawing them entails more labor and greater waste, it is clear that to get the greatest income from the forest the practice of hewing must give place to sawing.

There is still another consideration. Trees cut for the mill are usually more fully utilized than those cut for hewed ties. Table XXX, based on actual scaling in the woods of trees cut for hewed pole ties, and of trees of the same diameters cut for the mill, reveals a greater utilization of the tree in the latter case than in the former one, the increase amounting to from 20 to 45 per cent.

TABLE XXX.—*Comparison of the product of loblolly pine grown in mixture with hardwoods on well-drained, fertile soil, when hewed into ties and when cut into sawlogs.*

Diameter breasthigh.	Trees cut for pole ties.		Trees cut for sawlogs.		
	Number.	Yield per tree.	Number.	Yield per tree.	Excess in sawlogs.
Inches.		*Bd. ft.*[a]		*Bd. ft.*[a]	*Per cent.*
11	31	35	9	45	29
12	135	53	32	63	20
13	178	70	50	87	24
14	161	90	64	114	27
15	79	108	78	144	22
16	17	125	79	175	40
17	1	145	79	210	45

[a] Doyle-Scribner log rule.

From the point of view of the forest owner, however, this difference is not apparent. At the present stumpage price for lumber and ties he is willing, in the majority of cases, to have his young loblolly pines cut for ties instead of lumber, because the tie timber brings him a slightly higher price per tree, as can be seen from Table XXXI.

TABLE XXXI.—*Comparative values of loblolly pine from all situations, if sold for pole ties or for lumber.*

Diameter breast-high.	Volume of tree.		Value of tree.		Diameter breast-high.	Volume of tree.		Value of tree.	
	Lumber.[a]	Hewed ties.	At 75 cents per M board feet.	At 3 cents per tie.		Lumber.[a]	Hewed ties.	At 75 cents per M board feet.	At 3 cents per tie.
Inches.	*Bd. ft.*	*Number.*	*Cents.*	*Cents.*	*Inches.*	*Bd. ft.*	*Number.*	*Cents.*	*Cents.*
11	43	2.4	3.2	7.2	15	138	5.2	10.4	15.6
12	64	3.1	4.8	9.3	16	171	5.7	12.8	17.1
13	86	3.9	6.5	11.7	17	207	6.0	15.5	18.0
14	110	4.8	8.3	14.4					

[a] Doyle-Scribner log rule.

The smaller value of the trees when cut for lumber is due mainly to the log scales now in vogue, which give an exceedingly low scale to small logs as compared with their actual contents. The extent of this difference is shown in Table XXXII, though the argument for sawing must rest upon other considerations, since it will be hard to alter the established practice in scaling.

TABLE XXXII.—*Comparative log and tie scales of loblolly pine, grown in mixture with hardwoods, actually cut for ties.*

Diameter breast-high.	Scale of the unhewed logs.	Ties cut from tree.	Scale of the hewed ties at 32 feet each.	Excess of tie over log scale.	Diameter breast-high.	Scale of the unhewed logs.	Ties cut from tree.	Scale of the hewed ties at 32 feet each.	Excess of tie over log scale.
Inches.	*Bd. ft.*[a]	*Number.*	*Bd. ft.*	*Per cent.*	*Inches.*	*Bd. ft.*[a]	*Number.*	*Bd. ft.*	*Per cent.*
11	35	2.5	80.0	129	15	108	5.5	176.0	63
12	53	3.3	105.6	99	16	125	6.0	192.0	54
13	70	4.1	131.2	87	17	145	6.0	192.0	32
14	90	5.0	160.0	77					

[a] Doyle-Scribner log rule.

In this connection it is proper to consider why trees are hewed at all. One would naturally expect that the persistent demand for hewed pole ties, whose production is coupled with such a waste of timber and the most extravagant use of the forest, must be based on very good reasons, and that the railroads are paying a higher price than for sawed ties, as is the case with those made of longleaf pine and other woods. As a matter of fact, however, hewed and sawed ties of loblolly pine command exactly the same price in eastern Texas. The apparent reason for the preference is that hewed ties are thought to last longer than sawed ones, because the smooth surface made by the ax is less retentive of the water that promotes decay than is the sawed wood. There may be some truth in this when untreated ties are considered, but, since all the loblolly pine ties now used are treated before they are laid in the track, the objection does not hold. According to

Doctor von Schrenk,[a] sawed ties, when properly treated, last as long as hewed ones, and there is no good reason why they should not be used. The farmers of Texas probably will continue to furnish hewed ties so long as they are demanded, in spite of the drain on their forests, but the railroads can easily curtail the waste by encouraging the production of sawed ties. The railroads are heavy consumers of timber in many forms. Besides ties, they require every year enormous quantities of bridge timber, telegraph poles, and lumber for cars and houses. The present wasteful use of young timber for ties, which could be readily avoided, will lead to a rapid exhaustion of the timber supply in general, which can not remain without influence upon the lumber market.

In some instances the cutting of young timber for hewed ties may be justified. Where the stand is very dense the removal of the trees which lagged behind in the competition for light and room would prove beneficial to the growth of those remaining. Since from the several thousand young seedlings which usually start on an acre only from 140 to 160 trees reach maturity, timely thinning would perceptibly increase the yield per acre by furnishing useful material which would otherwise decay in the woods and add to the danger from insects and fires. If, however, the cutting of pole ties were limited to trees removed in thinnings, a qualified person would be required to mark every tree which should be cut, and that could be profitably done only by owners of large forest tracts.

A LOBLOLLY PINE FOREST AS AN INVESTMENT.

Since the use of hewed ties is likely to continue for many years to come, it remains to be considered how the demand can be supplied with the least damage to the forests, and how much profit there may be in raising loblolly pine for that purpose.

It has been shown already that this species possesses all the qualities necessary to qualify a timber tree for the production of railroad ties. These qualities may be summed up as follows:

(1) It must furnish a tie which, at least when treated, will give continuous service for from five to eight years, otherwise the expense of frequent renewal will make it too costly.

(2) It must not be so valuable for lumber that it can not be cut for ties.

(3) It must be of rapid growth, in order to attain a suitable size in a short time.

(4) It must renew itself easily after cutting, so as to maintain the forest without much expense.

[a] "The Decay of Timber and Methods of Preventing it." By Hermann von Schrenk. Bulletin No. 14, Bureau of Plant Industry, U. S. Department of Agriculture, p. 22.

YIELD OF TIES.

The actual number of ties that may be cut from a given area of considerable size is rarely the product of the number of ties in trees of different diameters (Table XXIV) multiplied by the stand on sample areas (Tables I to VIII) multiplied by the number of acres, because the forest is seldom solid or continuous. In eastern Texas almost one-third of each 640-acre section is prairie, or is occupied by other growth than tie timber. The forest proper yields from 200 to 400, or occasionally even 500 ties to the acre, but the average per acre for a section of land is 70 to 80. The forest which is now being cut over for ties in Orange and Newton counties, and which yields from 200 to 400 ties to the acre, is from 35 to 40 years old; consequently ties were produced at the rate of from 5 to 12 per acre and year, not counting the remaining timber below and above tie size.

This is a pretty wide range, though it is no greater than will be found in other localities. In order to determine what rate of production could be counted on in this locality, careful measurements of twelve tracts aggregating 38.5 acres were made. These figures, and others derived from them, are given in Table XXXIII. It will be observed that there is a lack of uniformity in the figures relating to any two areas, even though they are in the same type, but this is natural and indicates only the ordinary variability. If these points be ignored, one may learn much of value from the larger facts.

TABLE XXXIII.—*Stand and yield per acre of loblolly pine on several sample areas.*

Sample area.	Age.	Density of stand.	Stand per acre.				Yield per acre.						
			Total.	1 to 10 inch trees.	11 to 16 inch trees.	17-inch and over trees.	Total.		1 to 10 inch trees.	11 to 16 inch trees.	17-inch and over trees.	Average annual production.	
Acres.	*Years.*		*No.*	*%*	*%*	*%*	*Cu. ft.*	*Bd. ft.*[a]	*%*	*%*	*%*	*Cu. ft.*	*Bd. ft.*[a]
PURE STANDS ON OLD FIELDS.													
1.5	10	0.9	1,044	100	.....	.....	2,125	.....	100	.....	.....	213	.....
1.5	25	.5	104	43	56	1	2,717	681	21	76	3	109	27
2.0	29	.6	168	63	33	4	3,720	7,315	38	49	13	128	252
PURE STANDS ON FAIRLY WELL-DRAINED, LIGHT SOIL.													
4.0	38	0.7	140	42	54	4	4,030	10,191	21	68	11	106	271
5.0	40	.7	164	41	54	5	4,844	12,386	20	65	15	121	310
1.0	41	.8	329	48	52	.....	8,221	17,664	30	69	1	201	431
IN MIXTURE WITH HARDWOODS.													
1.5	24	0.8	258	79	16	5	4,142	6,856	48	32	20	173	286
5.0	40	.8	162	47	48	5	4,362	11,203	24	63	13	109	280
5.0	44	.9	119	34	58	8	3,803	11,030	17	66	17	86	251
5.0	45	.6	92	26	54	12	3,443	10,778	12	60	28	77	250
2.0	58	.6	66	27	49	24	3,046	10,459	7	43	50	53	180
5.0	58	.8	45	23	35	42	2,593	9,389	5	26	69	45	162

[a] Herring log rule.

Thus in the samples from type 4, from 33 to 56 per cent of all the trees between 25 and 30 years old are of tie size. In type 2 about 54 per cent of the trees are of tie size when 38 to 41 years of age. In type 3 the trees that have reached tie size at 24 years form only 16 per cent of the whole number, and though one stand has 58 per cent of tie timber at 44 years of age, the average of the type is lower than in type 2.

The important fact revealed in this table is that when the forest is about 40 years old approximately 55 per cent of the trees are of tie sizes; about 5 per cent are above and 40 per cent below the diameter suitable for ties.

When the amount of wood produced is considered, one must bear in mind that though the young stands have a relatively large volume, it is not in available form. The older stands, on the other hand, show a comparatively low annual yield, and are also unavailable for ties, because the trees are mostly too large. Again, the stands approximately 40 years old yield most ties, because the average annual production of 109 to 201 cubic feet, though a trifle less than that in younger stands, is found to correspond with the highest percentages of 11-inch to 16-inch trees. That is, the 40-year old stands have between 63 and 69 per cent of their timber of tie sizes.

Since it takes about 9.5 cubic feet of wood (including the waste in the form of top, stump, and slabs (Table XXV) to make one tie, the annual growth amounts to from 11 to 20 ties per acre per annum (Table XXXIII).

These figures are suggestive, but they are indefinite. In order, therefore, to estimate what may reasonably be expected from loblolly pine forests in eastern Texas, the data furnished by the sample areas have been plotted on cross-section paper and a curve drawn which removed the variability noted in connection with Table XXXIII. The results of this averaging are given in Table XXXIV to suggest the quantity of wood that may be grown on an average tract of any type. In several ways this is less exact than Table XXXIII, but for practical purposes it is better, and it has the great advantage that it gives full weight to the poorer growths, which are always sure to be found, and thereby cuts down the figures derived from the favored areas.

TABLE XXXIV.—*Estimated stand and yield per acre of loblolly pine.*

Age.	Stand of trees.		Yield from all types combined.					
	Pure loblolly pine.	Mixed with hardwoods.	Total.		Within each decade.		Annual average within each decade.	
Years.	*Number.*	*Number.*	*Cu. ft.*	*Bd. ft.*[a]	*Cu. ft.*	*Bd. ft.*[a]	*Cu. ft.*	*Bd. ft.*[a]
10	1,040	.....	1,650	.....	1,650	.....	165	.....
20	405	295	2,600	6,500	950	.....	95	.....
30	185	205	3,200	7,450	600	950	60	95
40	150	140	3,700	9,300	500	1,850	50	185
50	.....	105	4,150	11,900	450	2,600	45	260
60	.....	85	4,600	14,500	450	2,600	45	260
70	.....	80	5,000	17,100	400	2,600	40	260

[a] Herring log rule.

From these figures it is clear that the average stand is ready to be cut when it is about 40 years old. At earlier ages the growth is more rapid, but the trees are not large enough to be available for ties, while after that time the annual rate of growth falls off. (See Tables XII and XIV.)

THE PROFIT IN GROWING LOBLOLLY PINE FOR TIES.

The problem then is: Since it takes forty years to produce a crop of loblolly pine ties, will it pay to devote land to that purpose, and how large an area will be required to furnish indefinitely the number of ties that are now cut each year? The latter question is quickly answered. Since it takes 9.5 cubic feet of wood to make 1 tie, or 8.5 cubic feet if greater economy is practiced (see p. 46), an acre will produce, on the basis of the yield indicated in Table XXXIV, 11 ties every year. But since either the pine forests are interrupted by prairie or the pine trees are found among hardwoods, to such an extent that about 3 acres of land must be counted to 1 of effective forest, the average yield per acre, taking the land as it is found, is 4 ties. This divided into 2,000,000, the number of ties now produced each year by the loblolly forests of eastern Texas, makes 500,000 acres necessary to maintain the output. That this area is available is beyond question.

There is another consideration, however. The forest as it stands contains old and young trees, and only a part is of the right age for tie making. If it were intended to work a forest systematically and continuously, just so much should be cut every year as is replaced by the annual growth. In other words, if it takes forty years on the average to produce tie timber, one-fortieth of the whole area may be cut every year without depleting the stock. Where this is done, one-fortieth of the area necessarily has trees 40 years old, another fortieth trees 39 years old, and so on. But in Texas this condition can not be reached for a long time, and the following calculation is made to show

how loblolly pine land as it stands may be worked as a permanent investment.

Such land can now be bought in Texas for about $3.25 an acre, and will yield by the section, including prairie and swamp, 80 ties to the acre and 2,500 board feet of lumber. The ties may be assumed to be worth 3 cents each, and the lumber 75 cents per thousand feet, on the stump.

Taxes in eastern Texas are at present from 75 to 80 cents on $100 of assessed value, but for the sake of simplicity it may be assumed that the tax is equal to 1 per cent of the assessed value.

It is difficult to estimate the cost of looking after the forest and protecting it from injury, but since loblolly pine reproduces itself naturally with great ease and the forests suffer but little from fire, on account of the wet ground that surrounds many of them, it may be assumed that the annual cost is 5 cents per acre. It is also assumed that a piece of forest is cut over within three years, that during that time there is no expense for management, and that the cut-over land is worth 50 cents per acre.

These figures then furnish the basis of the calculation:

Estimate of the outlay and returns per acre on loblolly pine land cut for hewed ties and lumber.

OUTLAY.

Cost of land	$3.25
Compound interest on same until present crop is cut, 3 years at 6 per cent	.62
Taxes, $0.03 for 3 years with interest at 6 per cent	.10
Total	3.97

RETURNS.

80 ties, at 3 cents each	2.40
2,500 board feet of lumber, at 75 cents per M	1.87
Land	.50
Total	4.77
Less outlay	3.97
Net profit	.80

The above calculation shows that simply buying the land and selling the stumpage at current prices gives a 6 per cent investment and a net profit of 80 cents. The owner can now take the land at its sale value of 50 cents and hold it for a second crop. It contains a good many small trees, which will keep on growing, and reproduction is almost sure.

In the following computation, estimate must enter to a considerable extent, but from the tendency of lumber prices to advance it is apparently safe to assume that after 40 years tie stumpage will be worth 8 cents and lumber $2 per thousand. The yield of the forest may easily

be more than the first crop, because it will be cared for, and because the area of prairie is steadily lessening, but it will be safest to count on the same yield after 40 years as is obtained now.

Estimate of outlay and returns per acre in holding cut-over loblolly pine land for a second crop.

OUTLAY.

Cost of land		$0.50
Interest on same, at 5 per cent	$0.025	
Taxes, at 1 per cent of value	.005	
Cost of management	.05	
Annual charge	.08	
This 8 cents paid annually for 40 years, and with compound interest at 5 per cent, amounts to		9.66
Total		10.16

RETURNS AT END OF FORTY YEARS.

80 ties, at 8 cents each	$6.40
2,500 board feet of lumber, at $2 per M	5.00
Land will sell for	1.00
Total	12.40
Less outlay	10.16
Net profit	2.24

This shows a 5 per cent investment with a margin of $2.24, or a net return of a little less than 6 per cent on the outlay. There is little doubt that this rate can be considerably increased in many cases, because all the figures used are conservative. If ties are cut more carefully, for instance, it will be possible to get at least 10 more from each acre, which means 80 cents, and increases the return on the investment to 6 per cent.

Other elements of this question are too problematical to be set forth in figures with safety, yet they deserve to be considered. First, the forests of eastern Texas are nowhere as dense as they might be, and it will require only a little care to increase the average stand from about 140 trees to the acre to at least twice that number. In addition, the actual forest-bearing area can be increased by reclaiming the marshes, which now form so large a part of the region that the actual forest yield in these calculations is one-third of what it might be. Second, the tie supply must be kept up, and a plan which promises to do it while paying upward of 5 per cent compound interest is worthy to form part of the maintenance systems of the railways which are interested in that section.

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