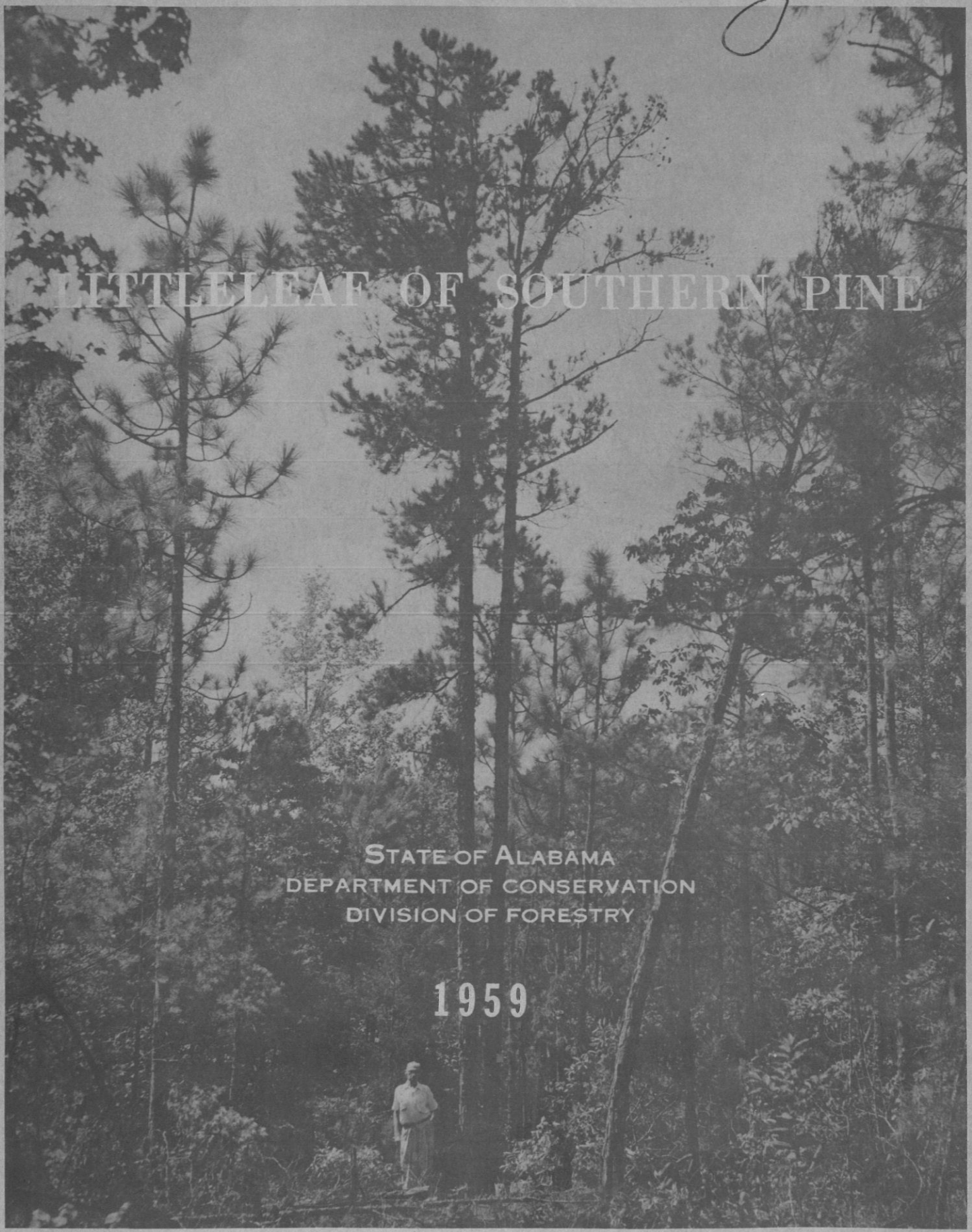
Everett W. Johnson



LITTLELEAF OF SOUTHERN PINE

STATE OF ALABAMA
DEPARTMENT OF CONSERVATION
DIVISION OF FORESTRY

1959

LITTLELEAF OF SOUTHERN PINE

State of Alabama
Department of Conservation
Division of Forestry

LITTLELEAF OF SOUTHERN PINE

by

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Issued by
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Division of Forestry

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State Forester

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Foreword

Under date of March 17, 1930, the Alabama State Commission of Forestry prepared and released to the newspapers the following news item:

> "Shortleaf Pine is practically the only pine tree that will reproduce itself by means of sprouts, states the Alabama Commission of Forestry. However, the second growth originating in this way seldom makes good timber trees but often exists as a stagnant unhealthy forest cover. Sprouting occurs only with quite young trees, seldom being found in specimens over four inches in diameter at breast height. After the Shortleaf Pine has reached this size it quickly loses its capacity for sending up sprouts from the base, whereas hardwoods retain this ability much longer.
>
> "At various places throughout extensive areas of woodland may be found patches of young Shortleaf Pine which appear to be making very slow growth, contrary to the general habit of this tree. In such cases, investigation usually discloses that a previous cover of Shortleaf seedlings and saplings had been killed by fire and that the present young growth consists of sprouts from the former, thus accounting for the latter's weak condition. The casual observer sometimes concludes that second growth Shortleaf Pine is exceedingly slow growing as a general rule. This is incorrect, however, since this tree really grows quite rapidly from the seed, is modest in its soil requirements and reaches a size and form comparable to the better species of pine."

Some years later other observers reported that shortleaf pine was suffering from a high mortality and expressed concern as to the future of this species. Attention was focused on the problem and preliminary surveys were made to appraise the degree and extent of the damage to shortleaf pine stands. It was clearly indicated from the surveys that the problem had major significance. As a result, an intensive research project was placed underway by a Federal agency with view of identifying the cause of the trouble and finding satisfactory measures of control.

In 1948, the Division of Forestry of the Alabama Department of Conservation employed a forest pathologist, Dr. Harlan H. York, to work primarily on disease problems at the Miller State Forest Nursery. Since no satisfactory conclusions as to the cause of "littleleaf" had been reached by that time, and no investiga-

tive work had been done along the line suggested by the press release of March 17, 1930, we felt that this lead deserved attention. It seemed reasonable that a study of sections cut from stumps of shortleaf pine trees to determine the origin of the tree would verify or disprove the subject matter of the press release and at the same time suggest a "tie-in" or a relationship to the occurrence of "littleleaf" disease. This is based on the belief that a tree of sprout origin has a shorter life span than a tree grown direct from the seed. This is generally accepted as being true for hardwoods and should apply to shortleaf pine and other pine, although no references or literature on the subject could be found.

The ability of shortleaf pine to sprout following fire and cutting is covered at some length in Farmer's Bulletin No. 1671, titled Shortleaf Pine, by W. R. Mattoon. The following is quoted from that publication:

> "Over large sections of the South where burning has long been the custom, practically all of the second growth shortleaf pine trees are sprouts."

Our investigative work on the significance of tree origin (sprout or seed) has been stimulated by a mounting concern over the future of shortleaf pine in forest areas and woodlands under intensive management. We have not attempted to explain morphological differences, if any, between trees of sprout origin and trees grown direct from seed. On the other hand, if it can be shown that a shortleaf pine tree of sprout origin tends to mature at an earlier age than a shortleaf pine tree grown direct from seed, then the forester who is managing a forest area under an intensive plan can, by keeping an accurate fire occurrence map on a fairly large scale, shorten the rotation for the fire burned area if the shortleaf growing thereon originated from sprouts. Thus he can retain shortleaf pine on shortleaf pine sites and not discriminate against it.

There is one positive way to determine the origin of a tree and that is by sectioning the stump in the region of the root crown. The evidence on the ground or the statements of local residents cannot always be relied upon. This was

verified in the course of our work in securing stump specimens for study.

Dr. York approached this problem with an open mind. If anything, he leaned away from the theory that sprouting contributed to the premature senility of shortleaf pine. In the course of his investigation, questions developed to which the obvious answers refuted any connection between "littleleaf" and sprouting. For instance, how to explain "littleleaf" in loblolly pine and longleaf pine; why would "littleleaf" show up on shortleaf pine growing on a soil of agricultural quality; and why would "littleleaf" appear on shortleaf pine which, superficially at least, had no fire history. Instead of being disconcerted by such questions, Dr. York concentrated his attention on the main objective of his assignment. The element of time was in his favor for he was under no compulsion for a hasty answer or a report. As it turned out, he found answers to these questions, as well as other pertinent and valuable information.

This report covers work that was done intermittently over a period of ten years. Each bit of evidence has been reviewed and discussed fully to eliminate faulty observation and biased opinion.

The specimens described in the manuscript are available for inspection.

Your attention is directed to the conclusions reached as a result of this study. I commend them to your considered attention.

J. M. Stauffer
State Forester

INTRODUCTION

According to Campbell and Copeland (2), in 1934 H. M. Spain, a lumberman of Memphis, Tennessee, wrote to E. L. Demmon, then Director of the Southern Forest Experiment Station, and called attention to considerable dead mature shortleaf pine (Pinus echinata, Mill.) in Walker and Tallapoosa Counties, Alabama. In 1934, D. J. Weddell, then on the teaching staff at the Alabama Polytechnic Institute, reported to the U. S. Division of Forest Pathology a deterioration of shortleaf pine in Tallapoosa County, Alabama. By 1940, the dying of shortleaf pine was attracting wide attention. Since the days of the chestnut blight, no forest tree disturbance here in the South has been so devastating as the "littleleaf of shortleaf pine". Unlike chestnut blight, brown spot of young longleaf pine in the grass stage, and the Cronartium fusiforme (A & K) Hedges. and Hunt, gall rust of loblolly pine, slash pine and longleaf pine which are caused by parasitic fungi, "littleleaf" is not a contagious disease. "Littleleaf" is not restricted entirely to shortleaf pine. It occurs to a limited extent on loblolly pine and longleaf pine and possibly on slash pine. Perhaps no forest tree disturbance here in America has been approached from so many different angles and more ably investigated than the so-called "littleleaf disease of shortleaf pine". The results of the investigation of the "littleleaf disease of shortleaf pine" by Dr. George Hepting, Senior Pathologist, of the Southern Forest Experiment Station, and his co-workers show:

1. The percentage of "littleleafed" trees increases as the internal drainage of the soil profile becomes poorer.

2. A general decrease in soil organic matter content from healthy to severely diseased areas.

3. As in case of soil organic matter, nitrogen, most of which is held in organic form, shows the same trend with respect to the incidence of the disease.

4. Phytophthora cinnamomi (Rands), a common soil dwelling fungus, kills the root tips and fine rootlets of shortleaf pine trees that become "littleleafed".

Phytophthora cinnamomi. This organism belongs in a large group of plants known as fungi. Some common examples of fungi are molds that sometimes get on jellies, preserves and other materials in the home. Some of the largest fungi are the bracket fungi that grow on the side of trees and logs. All fungi, since they lack chlorophyll, are dependent upon some form of plant and animal life for their food. Some fungi take their food entirely from the remains of plants and animals. Others can complete their full cycle of development either on living plants or plant remains. Phytophthora cinnamomi belongs in this class of fungi. Many fungi, of which P. cinnamomi is a good example, are capable of living on a wide variety of plants. They may attack only some special organ or part of the plant, such as leaves, roots or stems.

Phytophthora cinnamomi may become parasitic on the roots of coniferous and hardwood trees that are physiologically weak or subnormal. It was the cause of a serious root-rot of species of chestnut and chinkapin in the Southern States. On shortleaf and loblolly pine, this fungus kills the root tips and fine rootlets.

The body of P. cinnamomi, as is true of most fungi, is composed of finely branched and much tangled filaments that are visible under the high power of a microscope.

Phytophthora cinnamomi is a fairly common soil dweller and is found in some nursery soils and in forest soils.

"Littleleaf" of shortleaf pine occurs more or less throughout Alabama. It seems to be more prevalent on the heavier silty soils, especially in shortleaf and shortleaf-hardwood forest types.

According to the 1951-1955 Forest Survey, "littleleaf" was reported from Jackson County in North Alabama to Escambia County in South Alabama, and from Pickens County in the western part of the state to Barbour County in the eastern part of the state. It occurs in other counties not reported by the Survey for the reason that no trees showing the symptoms of "littleleaf" were found on the

plots at the time data were taken. For instance, several of the "littleleaf" specimens in the division's study were taken from Hale County. None of the plots in the county where they were established showed any trees with "littleleaf" symptoms.

According to Mattoon (8), "Over large sections of the South where burning has long been the custom, practically all of the second growth shortleaf trees are sprouts." Assuming that Mattoon is correct, it seems that the vast percentage of shortleaf pine and possibly loblolly and longleaf pine, that become "littleleafed", are sprout trees.

The writer's investigation of "littleleaf", an account of which follows, was initiated on the belief that a relation exists between the occurrence of the so-called "littleleaf disease" of shortleaf pine and the origin of the tree. To his knowledge, this phase of "littleleaf" on pines had not been investigated. It seemed that such a study might throw some light on the cause of "littleleaf" and how it might becontrolled if not prevented. Since beginning this investigation, a few loblolly and longleaf pine that had "littleleaf" symptoms were included.

Importance of Shortleaf Pine as a Forest Tree

Shortleaf pine, Pinus echinata Mill., is outstanding because of the following facts: (1) some of the best pine lumber produced in the South is obtained from shortleaf pine; (2) this species will thrive on land unfavorable for loblolly, slash and longleaf pine; (3) it is rarely affected with brown spot, a serious disease of longleaf pine in the grass stage; (4) shortleaf pine is seldom, if ever, attacked by the Cronartium fusiforme which is the cause of a gall rust to which loblolly and slash pine are highly susceptible; (5) its insect enemies are equally destructive on other hard pines; (6) shortleaf pine is the only pine of commercial importance in the United States

that successfully reproduces by means of sprouting; and (7) it will sprout when the vertical part of the stem of a small tree is killed by fire or other agencies. Usually the sprouts are capable of developing into merchantable trees.

Dayton (5) stated: "Unique among American timber pines, it (shortleaf pine) can sprout from the stump after burning or cutting, as many hardwoods do." According to him, the "shoots" (sprouts) seldom attain merchantable size. Dayton is correct with reference to shortleaf pine's ability to sprout. But according to Mattoon, practically all of the merchantable second-growth shortleaf pine trees in the South are sprouts.

Sprouting of Shortleaf Pine

Shortleaf pine is unique in that usually by the time the seedlings, especially nursery seedlings, are a few months old, or by the end of the first season, two bends or crooks have developed in the basal region of the stem (Fig. 1). A curve at the base of the hypocotyl (see point A, Fig. 2) results in the seedling becoming bent more or less parallel to the surface of the ground. As the result of a second bend, which is usually above the lowest cluster of primary needles, (see point C, Fig. 2) the second growth stem assumes a vertical position. For the purpose of this discussion, the part of the stem of the little tree that is more or less parallel to the surface of the ground is termed the horizontal stem and the upright part, the vertical stem. The greater part of the horizontal stem is derived from the hypocotyl and the lesser portion from the basal part of the secondary stem. There are buds in the axils of the needles on this part of the horizontal stem and in the axils of the needles immediately above this zone. (Stone and Stone) (9).

In typical uninterrupted growth of the seedling, the buds may divide resulting in several times the original number. Some of the buds may produce needle fascicles and leafy branches which may be of short duration. The vast majority

of buds remain dormant. They may persist for several years. Each year they elongate enough to keep the apex at the surface of the bark (Fig. 3A). Traces of dormant buds show at points A and A/, Fig. 3. There are at least 30 dormant buds on the bark side of the specimen shown in Figs. 3 and 3A. The production of buds and branches in the axils of their lower primary leaves is characteristic of hard pines.

Early in the life of a young shortleaf pine, the horizontal stem becomes covered with dirt and debris which will protect this part of the tree from injury by fire or other harmful agencies. A significant characteristic of shortleaf pine is the ability of the stub or stump of the horizontal stem of young trees to sprout following the killing of the vertical stem.

The sprouts originate from dormant buds in the apical region of the horizontal stem. Following the killing of the vertical stem, one or more of the dormant buds give rise to sprout stems (Fig. 4). One of the sprout stems, occasionally two, debarring accidents, develops into a tree. As the tree enlarges, the horizontal part of the stem becomes engulfed in the tree (Figs. 3, 5 and 5A). Shortleaf pine trees that develop from sprouts are sprout trees and in a sense are coppice trees. Shortleaf pine is a prolific sprouter. Mattoon (8) stated: "Of all important commercial pines in the United States, shortleaf pine has the complete power of reproduction by sprouting. A tree can sprout after repeated burnings." The writer has observed as many as four successive generations of sprouts from a single stem. In an area in Chilton County, three successive generations of sprouts are quite common. Six sprouts, which seemed to be the second generation of sprouts, were observed on one stem. According to Mattoon (8), "After a tree reaches a certain size, 6 to 8 inches in diameter, or an age of 10 to 18 years, depending upon the quality of the soil, it loses its power to sprout successfully." Little and Somes (7) stated: "However, in southern New Jersey, shortleaf may sprout until they are 30 years old." The sprouting ability

of shortleaf pine with one exception, pitch pine (Pinus rigida, Mill.), far exceeds that of other important southern pines. This feature is possible because of the double curvature of the stem and the production of numerous dormant buds. As stated, the horizontal part of the stem of the seedling, being very near to or in contact with the surface of the ground, becomes covered with dirt and debris which will be a protection against the ravages of fire or other destructive agencies.

Other species of southern pines can sprout. As a matter of fact, sprouting of pine trees may be of wider occurrence than is generally recognized. What seems to be an unusual case of the development of secondary stems in pine occurred in a plantation of slash pine in Escambia County, Alabama. The trees were one year stock and were planted in January 1949. Soon after they were planted, their tops were browsed off by deer. Trees developed from about 80 per cent of the stubs (stumps) of the trees and are making rapid growth. There is a very slight bend in the bole of the trees just above the ground (Fig. 8). In typical growth of slash pine seedlings, as in other hard pines, buds develop in the axils of the lower primary leaves. Branches may develop from these buds and are usually of short duration. The trees in the plantation mentioned developed from such branches, if not from dormant buds. Sprouting will occur in young longleaf pine (Figs. 6 and 7).

"Littleleaf" of Shortleaf Pine

Some Characteristics: Shortleaf pine trees that have "littleleaf" symptoms tend to die before reaching the natural life expectancy of the species. Symptoms of "littleleaf" may begin to appear in the shortleaf pine by the time the trees are 20 to 30 years old, but more often between 30 to 50 years of age. In a more or less even aged stand of shortleaf, the age of the trees in which "littleleaf" symptoms first appear may vary to a wide extent. Even among trees of the same

age, some have "littleleaf" symptoms much earlier than others. This seems to be due to some inherent physiological factor, or environmental conditions, or both. There is usually a period of 3 to 12 years from the time "littleleaf" symptoms first appear in a shortleaf pine tree until the tree dies. According to Campbell and Copeland (2), "The average life span of a shortleaf pine after showing typical symptoms of 'littleleaf' is 6 years."

"Littleleaf" Symptoms: The early stages of "littleleaf" symptoms ordinarily consist of a slight yellowing of the needles. They finally become quite yellow green in color. There is a progressive annual decrease in the growth in length of the twigs. The needles become bunched in a brush-like manner at the terminal end of the twigs. With each succeeding year the needles of the current year are shorter than those of the preceding year.

Concurrent with the yellowing and the shortening of the needles, there is an abrupt decline in diameter growth to the extent that the annual rings can hardly be counted (Figs. 9 and 10). Meanwhile, the finer roots die and black resinous lesions develop on the larger roots.

Early Impressions of "Littleleaf" on Shortleaf Pine

The writer's first observations on shortleaf pine with "littleleaf" symptoms were made early in 1948. It seemed then that shortleaf pine trees with "littleleaf" symptoms were diseased because they had become intolerant of what appeared to be unfavorable soil conditions, such as hard and compact soils of low humus content which was primarily the result of repeated forest fires. In a tract of shortleaf pine, where trees with "littleleaf" were fairly common, there had been no recent fire. Yet there was scant reduction of the litter to humus. The writer found that the finer roots of the trees that had "littleleaf" symptoms were dead and diseased and there were brownish black resinous lesions on the larger roots. Judging from previous experience, he believed that the dead fine roots and resi-

nous lesions were caused by fungi that ordinarily live saprophytically in the soil and can become parasitic on the roots of physiologically weak trees, as well as the roots of other plants.

The questions arose: What is the cause of "littleleaf"? Why was "littleleaf" limited almost entirely to shortleaf pine? Why did some trees have "littleleaf" symptoms when nearby trees seemed to be healthy? The roots of the diseased and healthy appearing trees must be more or less intermingled.

The writer's active investigation of "littleleaf" was initiated in August 1949 on the theory that shortleaf pine trees that become "littleleafed" are of sprout origin. But as this investigation progressed, it became evident to the writer that the so-called "littleleaf" disease of shortleaf and loblolly pine is not a contagious disease as is for example, the chestnut blight, but is symptomatic of an interruption or a decline in the tree's normal processes which may result from the effects of one or more of a variety of factors.

Relation of "Littleleaf" to the Origin of the Tree

It was recognized at the beginning of this investigation that the only way of knowing the origin of a pine tree was to dig it up, carefully section its root crown, and polish the sections. A segment that included the root crown and that extended from the surface to usually 10 to 12 inches below the surface of the ground was cut from the stump of each tree. After the segments were either air-dried or kiln-dried, they were sectioned by means of a band saw. Each segment was cross sectioned or was cut longitudinally. In every case the sections were cut so as to expose the central region of the root crown. Simply splitting or sawing through the root crown does not properly expose the critical part to be studied. Hence, it was necessary to sand and polish the sections in order to show the details of structure of the central region of the root crown. After the sections were polished, they were given a coating of floor wax.

A total of 61 shortleaf, loblolly and longleaf pine trees were excavated. Sections from the root crown of 51 trees are described in this report. The sections from the root crown of 10 shortleaf pine trees that were "littleleafed" were accidentally destroyed. The 61 trees came from the following counties in Alabama as shown on Plate I: Bibb 2; Chilton 10; Dallas 5; Elmore 6; Hale 13; Lowndes 2; Tallapoosa 20; and Tuscaloosa 3. 10 of the 61 trees were less than 15 years old and not "littleleafed"; 12 were more than 15 years old and not "littleleafed"; 39 were more than 15 years old and were "littleleafed". The number of each species of pine is as follows: loblolly 4; longleaf 4; shortleaf 53.

List of Specimen Trees With Their Sections

No. of Tree	Species	Height	DBH	Sections
1	Shortleaf Pine	35'	3.75"	1-2, 2-2
2	" "	35'	4"	1-2, 2-2
3	" "	40'	5" Approx.	1-2, 2-2
4	" "	40'	5" Approx.	1-3, 2-3, 3-3
5	" "	40' Approx.	5.5" Approx.	1-3, 2-3, 3-3
6	" "	45' Approx.	4.5" Inside Dia.	1-8, 2-8, 3-8, 4-8, 5-8, 6-8, 7-8, 8-8
7	" "	40' Approx.	4"	1a-4, 1-4, 3-4, 4-4
8	" "	40' Approx.	4.5"	1-3, 2-3, 3-3
9	" "	35' Approx.	3.25" Inside Dia.	
10	" "	35' Approx.	3.5" Inside Dia.	1-4, 2-4, 3-4, 4-4
11	Longleaf Pine	50' Approx.	4.5" Inside Dia.	1-10, 2-10, 4-10, 5-10, 6-10, 7-10, 8-10, 9-10, 10-10
12	Shortleaf Pine	45' Approx.	6"	1-3, 2-3, 3-3
13	" "	45' Approx.	5"	1-3, 2-3, 3-3

No. of Tree	Species	Height	DBH	Sections
14	Shortleaf Pine	25'	2.5"	1-3, 2-3, 3-3
15	" "	10'-12'		1-2, 2-2
16	" "	12' Approx.	1.25"	1-2, 2-2
17	" "	40'-45'	6"	1-3, 2-3, 3-3
20	" "	32'	3" Inside Dia.	1
20A	" "	25'-30'	3.1" Approx.	1
21	" "	37'	3.5"	1
21A	" "	31' Approx.	2.5"	1
22	" "	5.5' Approx.		1
23	" "	40' Approx.	6"	1-3, 2-3, 3-3
24	" "	45'	6" Approx.	1-4, 2-4, 3-4, 4-4
25	" "	55' Approx.	5.5" Approx.	1-2, 2-2
27	" "	60' Approx.	7.5" Approx.	1-3, 2-3, 3-3
29	" "	40'	5"	1-2, 2-2
31	" "	40' Approx.	4" Inside Dia.	1-2, 2-2
32	" "	55'-60'	6.5"	1-3, 2-3, 3-3
33	" "	40' Approx.	4.5"	1-6, 2-6, 3-6, 4-6, 5-6, 6-6
34	" "	35' Approx.	4"	1-2, 2-2
35	" "	50' Approx.	5.5"	1-2, 2-2
36	" "	8' Approx.		1-2, 2-2
37	" "	6'-7'		1-2, 2-2
38	" "	7' Approx.		1
39	" "	4' Approx.		1
42	" "	5' Approx.		1
43	" "	4' Approx.		1
44	" "	2.5' Approx.		1

No. of Tree	Species	Height	DBH	Sections
45	Shortleaf Pine	35' Approx.	5" Basal Dia.	1-3, 2-3, 3-3
46	" "	35' Approx.	5" Basal Dia.	1-3, 2-3, 3-3
47	" "		10"	1
*48	" "	48'	8.6"	Serial sections cut from the trunk at 5 ft. intervals to ht. of 15'
*49	" "	46'	7.3"	Serial sections cut from the trunk at 5 ft. intervals to ht. of 15'
50	Loblolly Pine	40' Approx.	8" Basal Dia.	1-2, 2-2
51	" "	50' Approx.	10.5" Basal Dia.	1-2, 2-2
52	" "	35' Approx.	9" Approx.	1-2, 2-2
53	" "	40' Approx.	10" Approx.	1-2, 2-2
54	Longleaf Pine	55'-60'	12"	1-2, 2-2
55	" "	45' Approx.	10.5" Basal Dia.	1-4, 2-4, 3-4, 4-4
56	" "	[illegible]	8"	1

*48 and 49 were twin trees.
The sections from each specimen tree were numbered for purposes of ready identification. For example, the first number indicates the section and the second number the quantity of sections that were prepared for study.

Trees that did not have "Littleleaf" Symptoms

Trees less than 15 years old. Twelve young shortleaf pine that were less than 15 years old and were of sprout origin were collected in Chilton County. The vertical stems were 5 to 10 years old. These trees were collected with the hope that sections of their root crowns might be of service in interpreting some of the structural features in the root crowns of older shortleaf that might be of sprout origin. The trees had two to three generations of sprouts. The fine

roots of these trees seemed to be in excellent condition. There were no resinous lesions on the larger roots. Descriptions of 10 of these trees are as follows:

Specimen Tree No. 36. This tree was about 7 years old and approximately 8 feet tall. As a result of the killing of the primary stem, at least three sprouts developed. Two of them were dead. What seems to be the remnant of the primary stem is partially engulfed in the live stem. Apparently the primary stem was 3 years old when killed. Two sections, 1-2 and 2-2, were cut from the root crown of Specimen Tree No. 36. There is an abundance of dormant buds on section 1-2. No photograph of this specimen is included in the manuscript. However, the specimen has been marked as follows: A, indicates traces of dormant buds in sections 1-2 and 2-2; X, in sections 1-2 and 2-2, indicates what seems to be part of the primary stem; and O, indicates the base of a stem that was killed when about 3 years old.

Specimen Tree No. 37. This tree came from a large area that had been burned over at least three times in the past 15 years. Specimen Tree No. 37 was a sprout that was at least 7 years old and 6 to 7 feet high. Longitudinal sections 1-2 and 2-2 were cut from the root crown of Specimen Tree No. 37. The red line on section 2-2 represents the ground level. At least four sprouts developed from the horizontal stem. Apparently they were not the same age. Since the stub at X, which is the largest of the three stubs, is so decayed, it may be the remains of the primary stem (Fig. 11) which was being engulfed in the sprout stem of the tree.

Specimen Tree No. 38. This tree was in the same area as Nos. 36, 37, 39 and 22. Specimen Tree No. 38 was about 7 feet tall and apparently developed directly from the seed. If so, the stem at Z is a branch that was being suppressed (marked on specimen but not photographed). Apparently the tree had not been hit by fire.

Specimen Tree No. 39. The primary stem of this tree was killed by fire when about 5 years old. The sprout, the only one, was 4 years old when the tree was removed from the ground. It was about 4 feet tall. There is a period of about 9 years from seedling to the time when tree was taken up (specimen not photographed).

Specimen Tree No. 42. This tree was taken down early in 1954. The stem labeled 5 was living. It is a sprout that apparently originated in 1950. The stub labeled 7 is from a sprout that was killed in 1950. Since it was 6 years old when killed, this sprout seems to have originated in 1944. The central stub seems to be the remains of the primary stem that was killed by fire in 1944. It was at least 6 years old at the time of the fire and originated from a seed in 1939. There is a period of about 15 years from the origin of the seedling and when the tree was taken down (specimen not photographed).

Specimen Tree No. 43. This tree was taken down early in 1954. It stood 12 to 15 feet from Specimen Tree No. 42. There were two living sprouts on Specimen Tree No. 43 when it was excavated. Both of them were 4 years old and originated in 1950. They were about 4 feet high. The large stem was 4 years old when it was killed by fire. It originated in 1946. The base of a stem that is labeled X seems to be a part of the original primary stem (Fig. 4). Apparently it was 4 years old when it was killed by fire. There seems to be a period of about 12 years from the seedling until the tree was removed from the ground.

Specimen Tree No. 44. This tree was excavated early in 1954. There were 7 living stems on this tree. The tallest stem was about $2\frac{1}{2}$ feet high. It, like the others, was about 4 years old. Judging by the number of annual rings in the tap root, the tree originated as a seedling in 1946 (specimen not photographed).

Specimen Tree No. 22. This tree was excavated early in 1954. It was growing in a red, coarse, sandy soil where there was a very thin layer of top soil. Apparently it had never been injured by fire. The tree was about ten years old

and 5½ feet high. It developed directly from the seed (specimen not photographed).

Specimen Tree No. 15: This tree was collected early in 1954. It was about 12 years old and 10 to 12 feet high. Sections 1-2 and 2-2 were cut from the root crown of this tree. Section 1-2 was cut about 1½ inches below the surface of the ground and section 2-2 was cut just above section 1-2. Traces of dormant buds were very pronounced in both sections. Specimen Tree No. 15 was of sprout origin (specimen not photographed).

Specimen Tree No. 16. This tree was about 12 feet high, 1½ inches dbh and at least 14 years old. Sections 1-2 and 2-2 were cut from the stump of Specimen Tree No. 16. Section 1-2 was cut at ground level and section 2-2 immediately below section 1-2. What seems to be the remnant of the primary stem is seen at X on section 2-2. In both sections there are what appears to be the remains of sprouts that developed after the primary stem was killed. Specimen Tree No. 16 was of sprout origin (specimen not photographed).

Trees More Than 15 Years Old

Specimen Tree No. 1. This tree came from Dallas County, Alabama, and was taken down in March 1954. It did not have "littleleaf" symptoms, although it was in a tract of shortleaf pine where many of the trees were "littleleafed". This tree was about 35 feet tall,, 3.75 inches dbh (dib), and about 20 years old. Where this tree was growing, the topsoil was a fine, sandy, loam 7 to 8 inches in depth and gradually merged into a yellowish-red, compact, subsoil. The land was fairly level.

Sections 1-2 and 2-2 were cut from the root crown of Specimen Tree No. 1. Section 1-2 is the part of the stump that was cut just beneath the surface of the ground. There was a small resinous lesion in the axil of the lateral root. Section 2-2 was cut just below section 1-2. This tree developed from the primary stem (specimen not photographed).

Specimen Tree No. 2. This tree came from Dallas County. It stood about 50 feet from Specimen Tree No. 1. Specimen Tree No. 2 was at least 18 years old, 4 inches dbh and approximately 35 feet high. The tree appeared to be in a vigorous condition and did not have "littleleaf" symptoms. The soil conditions where Specimen Tree No. 2 was growing were quite similar to those where Specimen Tree No. 1 was located.

Sections 1-2 and 2-2 were cut from the root crown of Specimen Tree No. 2. The lower surface of section 1-2 was cut about 2 inches below the surface of the ground. The resemblance of a pitch pocket is at one edge of the lower surface and extends into section 2-2. It seems to be the result of insect injury. Section 2-2 was cut just below section 1-2. Therewere three small resinous lesions on Section 2-2. They seem to be the work of insects (specimen not photographed).

Specimen Tree No. 3. This tree came from Dallas County and was in the same stand of pine as Specimen Trees Nos. 1 and 2. The soil conditions where the tree was growing were essentially the same as where Specimen Tree No. 1 was located. Two sections, 1-2 and 2-2, were cut from the root crown of Specimen Tree No. 3. The lower surface of section 1-2 was cut about $2\frac{1}{2}$ inches below the surface of the ground. The black spot on the lower surface of this section apparently was not caused by fire. It was a small part of a larger spot seen on section 2-2.

Section 2-2 was cut directly below section 1-2 of Specimen Tree No. 3. Traces of three roots that are on the lower surface of section 2-2 are the centers of the three prongs of the tap root. Judging from the sections of the root crown of this tree, it developed from the primary stem of the seedling. The tree was about 40 feet tall, nearly 5 inches dbh (inside bark), and was at least 20 years old (specimen not photographed).

Specimen Tree No. 4. This tree came from the same stand of pine as Specimen Trees No. 1, 2 and 3. The tree was about 40 feet tall, nearly 5 inches dbh (inside bark), and at least 20 years old. The soil conditions were essentially

the same as where Specimen Trees Nos. 1, 2 and 3 were located. Serial cross sections 1-3, 2-3 and 3-3 were cut from the root crown of Specimen Tree No. 4. Section 1-3 was from that part of the root crown that extended from the surface to about 3-3/4 inches below the surface of the ground. Section 2-3 was cut immediately below section 1-2. Section 3-3 was from that part of the stump that was from 6 to 8½ inches below the surface of the ground. Evidently dirt had filled in around the base of the tree. In sections 2-3 and 3-3 there were remnants of branches that seemed to have been killed by fire early in the life of the tree. The horizontal part of the main stem was dissected out of section 3-3 (Figs. 5 and 5A). There was no evidence of injury by fire to this part of the tree. There were traces of dormant buds on the bark side of section 3-3. Specimen Tree No. 4 was of primary origin. Section 3-3 was sent to the Forest Products Laboratory for examination.

Specimen Tree No. 5. This tree came from Dallas County. It seemed to be a hybrid between loblolly and shortleaf pine. The tree stood in an old field that had been reforested. The soil was a medium, sandy, clay loam. The tree was about 40 feet tall, 5½ inches dbh (inside bark), and at least 22 years old. It was excavated in March 1954. It seems that it was hit by fire in 1943, 1946, 1948 and 1950. The tree seemed to be in a vigorous condition and had no "littleleaf" symptoms. It developed directly from the primary stem of the seedling.

Three serial cross sections, 1-3, 2-3 and 3-3, were cut from the root crown of this tree. Section 1-3 was cut at the surface of the ground. Section 2-3 was cut immediately below section 1-3 and section 3-3 below 2-3 (specimen not photographed).

Specimen Tree No. 7. This tree came from Tallapoosa County and was excavated in March 1954. It was about 40 feet tall, 5 inches dbh (inside bark), and about 30 years old. The topsoil where this tree grew was heavy, reddish clay with small, rounded stones and was underlaid by a red, compact subsoil. Serial

sections 1a-4, 1-4, 2-4 and 3-4 were cut from the root crown of this tree. Section 1a-4 was about 4 inches long and was cut 2 inches above the surface of the ground. Section 1-4 was just below section 1a-4. The lower end of section 1-4 was about $2\frac{1}{2}$ inches below the surface of the ground. Section 2-4 was from $2\frac{1}{2}$ to $4\frac{1}{2}$ inches below the surface of the ground and section 3-4 was immediately below section 2-4. About two-thirds of the circumference of all four of the sections were girdled by a resinous canker that extended up the bole of the tree to a height of about 20 inches. At the rate the canker seemed to be progressing, the tree would very likely have died within two years.

Specimen Tree No. 7 was selected because it did not have "littleleaf" symptoms and because it stood about 8 feet from a severely "littleleafed" shortleaf pine tree. Specimen Tree No. 7 was in a weak condition yet it did not have "littleleaf" symptoms. Some of its roots must have been intermingled with the roots of the tree that had "littleleaf" symptoms. Since it has been shown that Phytophthora cinnamomi kills the fine roots of shortleaf and loblolly pine, it might seem that the fine roots of Specimen Tree No. 7 were being attacked by P. cinnamomi. If so, Specimen Tree No. 7 did not have "littleleaf" symptoms. It was quite evident from sections 1a-4, 1-4, 2-4, and 3-4 that Specimen Tree No. 7 developed directly from the seed (specimen not photographed).

Specimen Tree No. 8. This tree came from Tallapoosa County. It stood 8-10 feet from Specimen Tree No. 7 and near a shortleaf pine that had "littleleaf" symptoms. Specimen Tree No. 8 was about 40 feet tall, $4\frac{1}{2}$ inches dbh (inside bark), and at least 30 years old. This tree was selected because it had no "littleleaf" symptoms and seemed to be in a healthy condition.

Sections 1-3, 2-3 and 3-3 were cut from the root crown of this tree. Section 1-3 was cut $1\frac{1}{2}$ to $3\frac{1}{4}$ inches below the surface of the ground. Section 2-3 was cut just below section 1-3 and was 2-3/4 inches long. A resinous canker covered about one-third of the circumference of the section. Section 3-3 was

cut directly below section 2-3 and was 5-3/4 to 8 inches below the surface of the ground. There were black resinous lesions on this section. This tree developed directly from the seed. (specimen not photographed).

Specimen Tree No. 17. This tree came from Tallapoosa County in August 1949. It was 40-45 feet tall, 6 inches dbh (inside bark), and at least 22 years old. Specimen Tree No. 17 was growing on a reddish-silty, fine, gravelly soil. This tree was selected because it seemed to be healthy and did not have "littleleaf" symptoms. This tree stood in a large tract, composed mainly of shortleaf pine, a large percentage of which had "littleleaf" symptoms. It was about 50 feet from Specimen Tree No. 23 which had "littleleaf" symptoms. Sections 1-3, 2-3 and 3-3 were cut from the root crown of Specimen Tree No. 17. Section 1-3 was cut just above the surface of the ground (Fig. 12). Section 2-3 was cut longitudinally from that part of the root crown that extended 11 inches below the surface of the ground. The section became discolored with blue stain. On section 2-3, X indicates pith, Y what seems to be part of the horizontal stem, Z root centers, and D traces of dormant buds. Section 3-3 was a portion of one of the roots of Specimen Tree No. 17. Black resinous lesions were not observed on the roots of Specimen Tree No. 17. The tree was never hit by fire and developed from the primary stem of the seedling (section 1-3 photographed; other sections not photographed).

Specimen Tree No. 20. This tree was in Hale County and was taken down about the middle of July 1954. It was 32 feet tall, 3 inches dbh (inside bark), and at least 20 years old. This tree and Specimen Trees Nos. 20A, 21, 21A were naturally seeded in an old field of an area of about one acre. The topsoil was a very light, sandy loam, 7 to 8 inches deep and merged gradually into a yellowish red, compact subsoil. There has been no fire in the area since it seeded into pine. Specimen Tree No. 20 (Fig. 3) developed directly from the seed. In section 1-1, X designates the vertical stem of the seedling, Z the horizontal

part of the primary stem and A,A/ traces of dormant buds. There were traces of at least 30 dormant buds on the bark side of section 1-2, Specimen Tree No. 20.

The one acre tract of shortleaf pine mentioned above is owned by Miller and Company, Inc., Selma, Alabama, and was set aside in July 1954 for experimental purposes. There were 3,054 trees on the tract. It was surrounded by mature shortleaf pine, the majority of which had "littleleaf". All of the shortleaf pine of sawlog size were logged early in 1953. The tract, for the purpose of the experiment, was divided into three plots, each 1/3 acre. Plot #1 is on the west side of the tract. It was bordered on three sides by mature shortleaf pine about 95 percent of which were "littleleafed". Originally there were 1,275 trees on Plot #1; 875 trees were removed, which left 400, or at the rate of 1,200 per acre. Plot #2 was not thinned. There were 892 trees on Plot #2, which is at the rate of 2,676 per acre. Originally there were 887 trees on Plot #3, which is at the rate of 2,661 trees per acre; 587 trees were removed, leaving 300 which is at the rate of 900 per acre. Since there has been no fire on the tract after it was seeded into shortleaf pine, and being surrounded by mature shortleaf pine that were heavily "littleleafed", the tract affords an excellent opportunity to note whether any of the trees become "littleleafed".

If any of the trees become "littleleafed", is there any relation between the frequency of occurrence and the density of the stand of trees? Will there be any difference in the rate of growth between the two thinned plots? How will the rate of growth on the thinned plots compare to the unthinned plot? Will any of the trees become "littleleafed" from being attacked by Phytophthora cinnamomi? Dan Royal, Chief Forester, Miller and Company, Selma, Alabama, installed the experimental plots and is taking care of them.

Specimen Tree 20A. This tree was in the same stand of pine as Specimen Tree No. 20. Specimen Tree No. 20A was 25-30 feet tall, about 3 inches dbh (inside bark), and about 20 years old. It was growing under the same conditions as

Specimen Tree No. 20. In Specimen Tree No. 20A, X designates the region of the horizontal part of the primary stem; L-L represents the ground level; D traces of dormant buds, N needles traces. This tree developed directly from the seed (specimen not photographed).

Specimen Tree No. 21. This tree came from Hale County and was in the experimental plot mentioned in a preceding paragraph. This tree was 37 feet tall, $3\frac{1}{2}$ inches dbh (inside bark), and about 20 years old. This tree was growing under much the same conditions as Specimen Tree No. 20. The horizontal line on the specimen represents the ground level and the longitudinal line the center of the vertical stem. X indicates what seems to be part of the horizontal stem. The cut for this section was made in a plane that is at right angle to the plane of the cut in Specimen Tree No. 20 (specimen not photographed).

Specimen Tree No. 21A. This tree came from Hale County and stood about 35 feet from Specimen Tree No. 20A. This tree was about 31 feet tall, $2\frac{1}{2}$ inches dbh (inside bark), and about 20 years old. The red line H on Specimen 21A represents the ground level of the tree and the red line in the center of the vertical part is the primary stem.

Specimen Trees Nos. 20, 20A, 21 and 21A developed directly from the seed. Since they were selected at random from the experimental plot described above, it seems fair to assume that the vast percentage, if not all of the trees in the plot, developed directly from the seed. Also, the plot had not been burned over after it seeded into pine.

Trees That Had "Littleleaf" Symptoms

Shortleaf Pine

Specimen Tree No. 6. This tree, shortleaf pine, came from Tallapoosa County. It was about 45 feet tall, $4\frac{1}{2}$ inches dbh (inside bark), and about 40 years old. The topsoil where this tree grew was a heavy, reddish, clay loam with small,

rounded stones and was underlaid with a compact subsoil. This tree was in a large tract of shortleaf pine with an occasional loblolly and longleaf pine. A large percentage of the shortleaf pine had "littleleaf" symptoms. This tract of pine was in the Piedmont zone where the mortality from "littleleaf" seems to exceed that of any other section of Alabama.

Serial cross sections 1-8, 2-8, 3-8, 4-8, 5-8, 6-8, 7-8 and 8-8 were cut from the root crown of this tree. Section 1-8 was cut one inch above the surface of the ground. Section 2-8 was cut directly below section 1-8. Sections 3-8 and 4-8 (Fig. 13) were from a section that was immediately beneath section 2-8. There were traces of dormant buds on the lower surface of section 3-8. Sections 5-8 (Fig. 14) and 6-8 were from a block of the uppermost part of the taproot that was cut directly below sections 3-8 and 4-8. Section 7-8 was cut immediately below sections 5-8 and 6-8. The reddish-brown color in the central region of all of the sections indicates a pathological condition which was the result of a wound through which fungi and bacteria entered the tree. This condition was found only in trees that had "littleleaf" symptoms. Specimen Tree No. 6 was of sprout origin and was selected because it had "littleleaf" symptoms.

Specimen Tree No. 9. This tree was taken down late in July 1954 and came from Tallapoosa County. It was about 35 feet tall, $3\frac{1}{4}$ inches dbh (inside bark), and about 30 years old. This tree was selected because it seemed to have the early stages of "littleleaf" symptoms. The needles were slightly pale yellow and the 1954 needles were somewhat bunched at the tips of the twigs. Apparently they had ceased to elongate. Sections 1-5, 2-5, 3-5, 4-5 and 5-5 were cut from the root crown of this tree. Sections 1-5 and 2-5 were from a block, the lower surface of which was cut about 2 inches below the surface of the ground. Sections 3-5 and 4-5 (Fig. 15) were cut directly below sections 1-5 and 2-5. It is seen from these sections that a disturbance of some sort, apparently fire, happened to the tree when quite young and killed what appears to be the primary vertical stem.

The discolored wood indicated that the tree was severely wounded when quite young. The reddish to black color of the wood is characteristic of that found in the stumps of pine trees of secondary origin and were "littleleafed". The writer believes that Specimen Tree No. 9 was of sprout origin. There were traces of several dormant buds on section 3-5.

Specimen Tree No. 10. This tree came from Tallapoosa County and was taken down in July 1954. It was about 35 feet tall, $3\frac{1}{2}$ inches dbh (inside bark), and about 30 years old. This specimen stood about 40 feet from Specimen Tree No. 9 and the soil conditions were much the same as where No. 9 was located. This tree was selected for study because it seemed to have the early stages of "littleleaf" symptoms. Its needles were somewhat yellow and those of 1954 were slightly shorter than those of 1953 and somewhat bunched at the tips of the twigs. Serial sections 1-4, 2-4, 3-4 and 4-4 were cut from the stump of Specimen Tree No. 10. Section 1-4 was cut just above the ground. Section 2-4 was cut directly below section 1-4 (Figs. 16 and 17). Sections 3-4 and 4-4 were cut just below section 2-4 (Fig. 17) and were from the part of the stump that was 2-4 inches below the surface of the ground. As stated above, the reddish-brown color of the central part of the sections was characteristic of that found in the stumps of shortleaf pine trees of sprout origin and "littleleafed". The vertical part of the stem was severely injured, if not killed, when the tree was quite small. Apparently, this tree was of sprout origin.

Specimen Tree No. 12. This tree came from Hale County and was taken down in May 1954. This tree was about 45 feet tall, 6 inches dbh (inside bark), and about 30 years old and had "littleleaf" symptoms. It grew on what seemed to be a good site for shortleaf pine. The topsoil was a fine sandy loam 7 to 8 inches deep and gradually merged into a yellowish to reddish compact subsoil.

The rate of increase in diameter for the first 20 years averaged about 0.35 inches per year. Following the 22nd year, a rather abrupt slowing down in the

rate of growth occurred. Sections 1-3, 2-3 and 3-3 were cut from the stumps of Specimen Tree No. 12. Section 1-3 was cut from that part of the base of the bole that was from one to two inches below the surface of the ground. Section 2-3 was cut immediately below section 1-3 and section 3-3 directly below section 2-3. The dark center in sections 2-3 and 3-3 (Fig. 18)was mainly the charred remains of a number of stems. Evidently, the primary vertical stem of the young tree was killed by fire. Specimen Tree No. 12 was of sprout origin. Note traces of dormant buds in Fig. 11 and at X on the lateral surface of section 3-3.

Specimen Tree No. 13. This tree came from Hale County and was taken down in May 1954. It was about 45 feet tall, 5 inches dbh (inside bark), and about 25 years old. It stood about 25 feet from Specimen Tree No. 12. The soil and other environmental factors were the same as for Specimen Tree No. 12. There was considerable irregularity and slowing down in the rate of growth after the 15th year of Specimen Tree No. 13. Sections 1-3, 2-3 and 3-3 were cut from the root crown of Specimen Tree No. 13. Section 1-3 was cut at ground level. Section 2-3 was cut from that part of the root crown that was 3 to 5 inches below the surface of the ground and section 3-3 was cut immediately below section 2-3. Judging from the brown and black areas in the center of section 2-3, the vertical stem of the tree was killed by fire when the tree was quite young. Note traces of dormant buds in section 2-3. Specimen Tree No. 13 was of sprout origin and had "littleleaf" symptoms (specimen not photographed).

Specimen Tree No. 14. This tree came from Hale County. It was 25 feet tall, 2½ inches dbh (inside bark), and about 25 years old. Sections 1-3, 2-3 and 3-3 were cut from the base of the bole and the root crown of this tree. Section 3-3 was cut 3 to 4 inches below the surface of the ground. Section 2-3 was cut from ground level to 1 inch below the surface of the ground and section 1-3 from ground level to 1 inch above the ground. Specimen Tree No. 14 had the advanced stages of "littleleaf" symptoms. It was of sprout origin (specimen not photographed).

Specimen Tree No. 23. This tree came from Tallapoosa County and was taken down in August 1949. It stood about 60 feet from Tree No. 17 and was selected because it had "littleleaf" symptoms. Specimen Tree No. 23 was about 28 years old, 6 inches dbh (inside bark), and about 40 feet tall. The topsoil was 3 to 4 inches thick and was a heavy reddish silt-like clay that merged into a hard compact subsoil.

The vertical stem of Specimen Tree No. 23 was killed by fire when the tree was only a few years old. Specimen Tree No. 23 was of sprout origin. When the tree was about 9 years old (Fig. 10), it was hit by fire and a slowing down in its rate of growth followed. Up to that time, the increment in diameter averaged almost one-half inch per year. When Specimen Tree No. 23 was 11 years old, it was burned again and about 3 years later it was again hit by fire. At least four fires hit Specimen Tree No. 23. The first resulted in the tree being of sprout origin. The other three fires apparently slowed down the rate of increase in diameter. Specimen Tree No. 23 had "littleleaf" symptoms at least five years prior to being taken down. The width of the last five annual rings is characteristic of pine trees that have "littleleaf" symptoms (Fig. 10). Fires may have hastened the occurrence of "littleleaf" symptoms in Specimen Tree No. 23. Section 1-3 of this tree was cut just above the surface of the ground.

Specimen Tree No. 24. This tree came from Tallapoosa County and was dug up in August 1949. It was 45 feet tall, about 6 inches dbh (inside bark), and apparently 30 years old. Specimen Tree No. 24 stood about 25 feet from Specimen Tree No. 23 and had advanced symptoms of "littleleaf". Section 1-1 is a mid-longitudinal section that includes a portion of the root crown and tap root. It extends from 2 inches above to 10 inches below the surface of the ground. The blue line on section 1-1 represents the ground level. Specimen Tree No. 24 was a sprout tree. When the vertical stem of the little tree was killed, a wound resulted which became an avenue for the entrance of fungi and bacteria. The reddish brown in the

central region of section 1-1 was not normal heartwood. Similarly, colored wood was not found in pine trees that developed directly from the seed (specimen not photographed).

Specimen Tree No. 25. This tree came from Hale County and was taken down in July 1954. It was at least 50 years old, about 55 feet tall, and $5\frac{1}{2}$ inches dbh (inside bark). It had the advanced stages of "littleleaf" symptoms. Specimen Tree No. 25 was in a tract of shortleaf pine where a large percentage of the trees had "littleleaf" symptoms. The average age of the trees was about 50 years. It seems that the land was cleared about 85 years ago and was used as a pasture prior to becoming seeded into shortleaf pine. The topsoil is a fine, sandy loam and is 6 to 7 inches deep. It merges gradually into a compact, reddish-yellow subsoil. There was a fairly heavy ground cover of litter and duff. There were no indications that the area was ever burned over after it seeded into pine. The area seemed to be an ideal site for shortleaf pine. Yet it seemed so unusual that a large percentage of the trees had "littleleaf" symptoms. Judging from the remains of dead pine trees, pine trees had been dying over a period of five years, if not longer. The writer had examined stands of shortleaf pine in at least six different counties in Alabama where "littleleaf" was fairly common to being abundant and in every stand there was evidence that fire at one time or another had swept over them. But the stand of shortleaf pine in Hale County, Alabama, seemed to be an exception for as stated, there was no appearance that it had ever been burned over. Therefore, it seemed that shortleaf pine in the Hale County tract was becoming "littleleafed" without ever being injured by fire. As is shown in the following paragraphs and in Fig. 19, the Hale County stand of shortleaf pine was burned over because the "littleleaf" trees whose root crowns were sectioned were sprout trees. The vertical stems of the trees, when small, had been killed by fire. Thus, it was only by sectioning the root crowns of "littleleafed" trees that it became known that the Hale County stand of shortleaf pine had been burned over.

Sections 1-2 and 2-2 were cut from Specimen Tree No. 25. Section 1-2 was cut about 2 inches above the surface of the ground. As seen from the section 1-2, the tree had made a rather slow rate of growth (Fig. 9). Section 2-2 was cut from 2 to 8-3/4 inches below the surface of the ground. It extended through the root crown and a portion of the tap root. Specimen Tree No. 25 was of sprout origin. The color of the heartwood indicates that the tree in early life was severely injured, apparently by fire which killed the vertical stem of the tree and made possible the entrance of bacteria and fungi.

Specimen Tree No. 27. This tree came from Hale County. It stood about 50 feet from Specimen Tree No. 25. This specimen was at least 50 years old, about 60 feet tall, and $7\frac{1}{2}$ inches dbh (inside bark). It had the advanced stages of "littleleaf" symptoms. Sections 1-3, 2-3 and 3-3 were cut from the root crown of Specimen Tree No. 27. Section 1-3 was cut at the ground level. Sections 2-3 and 3-3 were cut from that part of the root crown that was from 1 to 10 inches below the surface of the ground. It is very evident from these sections that Specimen Tree No. 27 was severely burned when quite young (Fig. 19). Prior to sectioning its root crown, there was no indication that the tree was ever hit by fire. There is no way of knowing whether a pine tree that shows no external signs of being hit by fire was ever burned except by sectioning its root crown. Sectioning the root crowns of Specimen Trees Nos. 25, 27, 29 and 31 was the only means of determining whether they had ever been hit by fire.

Specimen Tree No. 29. This tree had advanced stages of "littleleaf" symptoms. It came from Hale County and was in the same tract of pine as Specimen Trees Nos. 12 and 13. Specimen Tree No. 29 was about 25 years old, 40 feet tall, and 5 inches dbh (inside bark).

Sections 1-2 and 2-2 were from the same block which was from that part of the root crown that was 2 to 14 inches below the surface of the ground. What seems to be a remnant of the primary vertical stem is seen at X in Sections 2-2 and 1-2.

The horizontal part of the stem was cut across at XX in section 2-2. Specimen Tree No. 29 was of sprout origin (specimen not photographed).

Specimen Tree No. 31. This tree came from Hale County and was in the same tract as Specimen Trees Nos. 25 and 35. It was a codominate tree and had the advanced stages of "littleleaf" symptoms. It was about 40 feet tall, 4 inches dbh (inside bark), and about 40 years old.

Sections 1-2, 2-2 and 2A were cut from the root crown of Specimen Tree No. 31. Section 1-2 was cut nearly 2 inches above the surface of the ground. About two-thirds of the section was girdled by a resinous canker which extended a short distance below the surface of the ground. Sections 2-2 and 2A were cut just below section 1-2. As will be seen from these sections, there had been some interference with the growth of the tree, especially with the tap root, which resulted in the enlargement of three lateral roots. The dark resinous centers of the roots indicate a pathological condition which seems to be the result of an injury. Judging from the sections, the tree was of sprout origin (specimen not photographed).

Specimen Tree No. 32. This tree came from Tallapoosa County and was taken down in August 1949. It was 55 to 60 feet tall, $6\frac{1}{2}$ inches dbh (inside bark), and at least 65 years old. It was in a tract of shortleaf pine where a large percentage of the trees had "littleleaf" symptoms. The topsoil where Specimen Tree No. 32 stood is a reddish, fine, gravelly loam 5 to 6 inches deep and merged into a hard, compact subsoil. This tree had the advanced stages of "littleleaf" symptoms. It was in the immediate vicinity of Specimen Trees Nos. 9, 17 and 23. Specimen Tree No. 32 had been hit by at least five different fires, the first of which killed its vertical stem when the tree was quite young. Sections 1-3, 2-3 and 3-3 were cut from a section of the stump of Specimen Tree No. 32 that extended from $1\frac{1}{2}$ inches above to 13 inches below the surface of the ground. Section 3-3 was cut midway of the root crown (Fig. 20). The remnants of two vertical stems are labeled Z and X. The one at Z may be from the vertical stem of the seedling.

The stub labeled X apparently was the remains of a sprout. It seems that the tree was hit by two fires when quite young. At XY is a view of a cross section of the horizontal part of the primary stem of the seedling. Specimen Tree No. 32 was of sprout origin.

Specimen Tree No. 33. Specimen Tree No. 33 came from Tallapoosa County and was taken down in August 1949. This tree was at least 30 years old, 4½ inches dbh, and about 40 feet tall. It had the advanced stages of "littleleaf" symptoms. Specimen Tree No. 33 was in the general vicinity of Specimen Trees Nos. 17 and 32. Sections 1-6, 2-6, 3-6, 4-6, 5-6 and 6-6 were cut from the root crown of Specimen Tree No. 33. Judging from sections 1-6, 2-6 and 3-6, Specimen Tree No. 33 was of sprout origin. The reddish-brown colored wood in these sections is typical of the color of wood in the root crowns of stumps of shortleaf pine trees of sprout origin.

Sections 4-6 and 5-6 were cut from the roots of Specimen Tree No. 33. The black resinous lesions on these sections are typical of the lesions on the roots of shortleaf pine trees that have "littleleaf" symptoms. The writer has observed many times similar lesions on the roots of pine trees that did not have "littleleaf" symptoms. Such lesions, as well as those that occur on the roots of pine trees that have "littleleaf" symptoms, appear to be a sign of low vitality (specimen not photographed).

Specimen Tree No. 34. This tree came from Hale County and was taken down in July 1954. It was in the immediate vicinity of Specimen Trees Nos. 12 and 13. Specimen Tree No. 34 had the early stages of "littleleaf" symptoms. It was about 35 feet tall, dbh 4 inches, and about 25 years old. Section 1-2 was cut from that part of the root crown that extended nearly 13 inches below the surface of the ground. At X there is a view of a transverse cut of the horizontal part of the stem of the young tree. XX and XXX indicate the remains of stems. Specimen Tree No. 34 was of sprout origin (specimen not photographed).

Specimen Tree No. 35. This tree came from Hale County and was in the vicinity of Specimen Trees Nos. 12 and 13. It was about 50 feet tall, $5\frac{1}{2}$ inches dbh (inside bark), and 40 to 45 years old. It had the advanced stages of "littleleaf" symptoms. Sections 1-2 and 2-2 were cut from that part of the stump that was $1\frac{1}{2}$ to $9\frac{1}{2}$ inches below the surface of the ground. At X and XX on section 2-2 there were the remains of stems. Apparently these stems were killed by fire. Specimen Tree No. 35 was of sprout origin (specimen not photographed).

Specimen Tree No. 45. This tree came from Elmore County and was dug up September 20, 1956. It stood about 35 feet from twin shortleaf pines, Specimen Trees Nos. 48 and 49. Specimen Tree No. 45 was about 35 feet tall, 5 inches dbh, (inside bark) and about 35 years old. It had the advanced stages of "littleleaf" symptoms. Sections 1-3, 2-3 and 3-3 were cut from the root crown of Specimen Tree No. 45. Section 1-3 was from the base of the bole. Sections 2-3 and 3-3 were from that part of the stump that extended from 2 inches to 10 inches below the surface of the ground. At X, section 2-3, there is the remnant of a stem. Specimen Tree No. 45 was of sprout origin. Following the 15th or 16th year there was a marked slowing down in diameter growth. The last 10 to 12 annual rings were so narrow a lens was needed to count them (specimen not photographed).

Specimen Tree No. 46. This shortleaf pine tree came from Elmore County. It was about 35 feet tall, 5 inches dbh (inside bark), about 50 years old, and stood about 60 feet from twin Specimen Trees Nos. 48 and 49. Specimen Tree No. 46 was excavated September 20, 1956. It was in the advanced stages of "littleleaf" symptoms. There was considerable die-back of the branches in the lower part of the crown. Sections 1-3, 2-3 and 3-3 were cut from Specimen Tree No. 46. Section 1-3 was cut at ground level. Sections 2-3 and 3-3 are from that part of the stump that was from 2 inches above to 10 inches below the surface of the ground. Apparently there was a disturbance of some sort, likely fire, early in the life of the tree. At XX in section 2-3 there appears to be the end of a charred stem. There

seems to be the end of a stem at X in section 3-3 and at Z in section 2-3. Specimen Tree No. 46 was a sprout. In its early life the tree was hit by fire which not only killed the primary vertical tree but left a wound that made possible the entrance of fungi and bacteria (specimen not photographed).

Specimen Tree No. 47. The stump of this tree was excavated by David E. Hampe, Forester, Tennessee Coal & Iron Division, U. S. Steel Corporation, in October 1955 and later sent to the Alabama State Department of Conservation. The tree came from near West Blockton, in Bibb County. Mr. Hampe stated that the tree was 10 inches dbh, and had been sick a long while. The tree stood about 30 feet from a diseased longleaf pine tree, the stump of which was sent to the Alabama State Department of Conservation. The stump of Specimen Tree No. 47 was so badly decayed only one section of it was saved. As seen from section 1-1, the tree was severely injured when quite young, apparently by fire. At X on specimen 1-1 there seems to be the remnant of a stem. The writer believes Specimen Tree No. 47 was of sprout origin and had "littleleaf" symptoms (specimen not photographed).

Specimen Trees Nos. 48 and 49. These trees were twin shortleaf pine and were discovered by Charles Walsh, Project Forester, Alabama Department of Conservation, while cruising timber February 1, 1956. The trees were located near Weoka, in Elmore County, on the property of Roland Teil, 132 Ann Street, Montgomery, Alabama. The twin trees were joined together from about 10 inches above to below the surface of the ground. One of the trees had symptoms of "littleleaf" while the other one appeared to be healthy (Figs. 21, 22, 23 and 24). It seemed unusual that two shortleaf pine trees, one apparently healthy and the other one with "littleleaf" symptoms, should be structurally joined together (Fig. 24). Since the symptoms of the diseased tree were so suggestive of "littleleaf", it was hoped that a detailed study of the stumps of these two trees would establish their true relation to each other and add to our knowledge of the factors that predispose shortleaf pine to become "littleleafed". The trees were dug up September 5, 1956.

Comparative Measurements of Specimen Trees Nos. 48 and 49

	Tree No. 48	Tree No. 49
Height	48'	46'
DBH	8.6"	7.3"
Live Crown	31'	22.8'
Age	44 (approx.)	44 (approx.)

Serial cross sections were cut from the trunks of Tree No. 48 and Tree No. 49 at five foot intervals to a height of 15 feet. The measurements are of air dried sections and only of the wood.

	Tree No. 48	Tree No. 49
Size of Trunk @ 5'	7"	6"
" " " @ 10'	6.6"	5.5"
" " " @ 15'	6.3"	5.22"

Number of Annual Rings in Each Section

	Tree No. 48	Tree No. 49
No. of Rings @ 5'	40 (approx.)	40 (approx.)
" " " @ 10'	35 "	35 "
" " " @ 15'	30 "	30 "

Apparently at its beginning, Tree No. 49 was not as advantageously located on the horizontal stem as Tree No. 48 and was smaller than Tree No. 48. There were comparatively few lateral roots in the region of the base of the bole of Tree No. 48 (Fig. 25), as compared with Tree No. 48 (Fig. 26). Both trees grew rapidly for their first five years and then abruptly slowed down (Figs. 27, 28, 29 and 30). Their early rapid growth is characteristic of pine trees of sprout origin as in the case of hardwood sprouts (Figs. 8, 9 and 12). About 1941, Tree No. 49 was struck by lightning which did not seem to seriously affect the tree's growth (Figs. 30 and 31). The scar was 6 feet long.

The Tap Root. It can be seen from Figs. 25 and 26 that the tap root of Trees 48 and 49 may have been formed as the result of the fusion of the tap roots of two seedling trees. A cross section of the tap root was cut at X (Fig. 25) which was

about 18 inches below the surface of the ground. As can be seen from Fig. 34, there was only one single root center. Therefore, Trees 48 and 49 had one tap root in common.

Origin of Specimen Trees Nos. 48 and 49. There was the possibility that Specimen Trees Nos. 48 and 49 were from a tree that forked when quite young. In order to determine their place of origin, longitudinal sections were cut from that part of the stump that extended from just above to 14 inches below the surface of the ground (Fig. 32). As can be seen in Fig. 32, points O, X, Y and Z show the remains of the stumps of trees that were sprouts. Point X shows a transverse cut of a stem that may be from the primary tree. The number of sprouts that preceded those from which Trees 48 and 49 developed is obscure. It does seem that there were at least three generations of sprouts of which Trees 48 and 49 were the third generation.

"Littleleaf" Symptoms on Tree No. 49. A comparison of what appeared to be "littleleafed" symptoms on Tree 49 with published descriptions of "littleleaf" on shortleaf pine follows:

"Littleleaf" Symptoms in Tree No. 49

"Littleleaf" Symptoms as Described in Various Publications	"Littleleaf" Symptoms in Tree No. 49
1. Diseased trees produce one internode per season.	One internode per season.
2. As disease progresses, twigs and branches die throughout the crown.	Dead and diseased branches throughout the crown.
3. Sprouts (adventive branches) commonly develop on the branches	Sprouts abundant on the branches and main stem.
4. Dieback of branch terminals common.	Dieback of branch terminals common.
5. Needles yellow-green. In final stages much shortened and confined to ends of branches	Needles yellow-green. Shortened and confined to ends of branches.
6. Pronounced reduction in rate of increase in diameter.	Marked reduction in rate of increase in diameter.

"Littleleaf" Symptoms as Described in Various Publications	"Littleleaf" Symptoms in Tree No. 49
7. Fine roots dead.	Fine roots dead.
8. Resinous lesions on larger roots.	Resinous lesions on larger roots.

As seen from the above data, the symptoms of the disease on Tree No. 49 were strikingly similar to the described symptoms of "littleleaf". Evidently Tree 49 had "littleleaf" symptoms. It seems quite unusual that of two shortleaf pine trees the same age, having the same tap root being structurally united at the base (Figs. 24 and 25), one would apparently be healthy and the other one have "littleleaf" symptoms. So far as known to the writer, a case similar to the one at hand has not been reported. Trees Nos. 48 and 49 were really branches which developed from dormant buds that originated in the axils of primary needles of a small seedling shortleaf pine. Tree 49 was not as advantageously located on the axis of the tree as was Tree 48 (Figs. 26 and 27). Tree 49 was smaller than Tree 48 and as seen in Figs. 27 and 28, the early rate of growth of Tree 49 was somewhat less than in Tree No. 48. There was quite a paucity of roots on the side of the tap root on which Tree No. 48 was located (Fig. 26). Tree 49 was receiving most of its supply of water and soil nutrients through the tap root which also served Tree 48. Tree No. 49 did not have enough roots through which its various needs could be supplied and had become an impoverished tree whereupon Phytophthora cinnamomi and other fungi were apparently hastening its demise. The writer believes that if Trees 48 and 49 had not been taken down, Tree 48 would have become "littleleafed" the same as Tree 49 because it was a sprout tree. There were the decayed remains of three twin pine trees within a radius of about 60 feet of Trees 48 and 49. In all three instances, one of the trees had apparently died before the other since it was much more highly decayed than its companion.

SUMMARY

Specimen Trees 48 and 49 were twin trees, were the same age, and were sprout trees. They were structurely united at the base of the bole and originated independently from each other on the same parent stem. Specimen Tree 49 was "littleleafed", whereas, Specimen Tree 48 appeared to be healthy.

Loblolly Pine

Specimen Tree No. 50. This tree came from Tallapoosa County and was taken down October 29, 1956. It was about 40 feet tall, with a dbh of 8" inside bark, and was 18 years old. Specimen Tree No. 50 was selected because it showed symptoms of "littleleaf". The needles were greenish-yellow in color and more or less thickly massed in a broom-like manner at the ends of the twigs. There were no 1955 needles. The 1956 needles were 3 to 5 inches long. The length of the needles of normal loblolly pine trees is 5 to 9 inches. There was one cone, $1\frac{1}{2}$ inches long, which had not opened and was on 1953 wood.

Sections 1-2 and 2-2 were cut from the stump of Specimen Tree No. 50. Section 1-2 is a cross section of the bole that was cut at the surface of the ground. As can be seen, the tree made rather rapid growth for the first 12 years. At the end of the 10th year, the inside diameter was about 5 inches. Beginning with the 14th year, there was a marked retarding in diameter growth. The 17th and 18th rings were so narrow a lens was needed to distinguish them (Fig. 33).

There was an area about 3 inches long and 2 inches wide in the widest part, the color of which was a mixture of pale yellow and yellowish-brown. The cells in the darker part were more or less broken down which indicates incipient decay (Fig. 33). There were a number of black resinous lesions between the bark and the wood.

Section 2-2 was from that part of the stump of Specimen Tree No. 50 that was from 4 to 12 inches below the surface of the ground. It was quite evident from

this section that Specimen Tree No. 50, loblolly pine, developed directly from the seed (Fig. 35).

Specimen Tree No. 50 seemed to be physiologically weak, even though it had made rapid growth its first 12 years. It was infected at the base of the bole with wood destroying and bark killing fungi. The condition of its needles and their location on the branches indicated that the tree was diseased. Specimen Tree No. 50 had "littleleaf" symptoms. There was no reddish brown or other discoloration in the root crown of Specimen Tree No. 50, as in the root crown of pine trees that were of sprout origin.

Specimen Tree No. 51. This tree came from Tallapoosa County and was dug up October 29, 1956. It was about 50 feet tall, 10.5 inches dbh inside bark, and at least 35 years old. The tree was somewhat isolated. The nearest tree was a healthy loblolly pine that was about 40 feet high and 35 feet distant.

Specimen Tree No. 51 had advanced "littleleaf" symptoms. The vast percentage of the needles were quite yellow and were crowded in a broom-like manner at the tips of the branches. The needles were 2 to 5 inches long. Their average length was about $3\frac{1}{2}$ to 4 inches. No 1955 needles were observed. Ordinarily the needles of loblolly pine are deciduous their third year. There was an abundance of cones on this tree. Some branches had cones on the 1950, 1951, 1952, 1953 and 1954 wood. The largest crops of cones were on the 1953 and 1954 wood. Cones were developing on the 1956 wood. Measurements on 16 cones taken at random averaged 2-3/8 inches. There was an abundance of resinous lesions on the roots.

Sections 1-2 and 2-2 were cut from Specimen Tree No. 51. Section 1-2 is a cross section of the bole that was cut just above the surface of the ground. It is 12 inches in diameter and about $4\frac{1}{2}$ inches thick. On the upper surface there seems to be 34 annual rings. For the first 25 years the growth in diameter averaged about one-half inch per year. A marked reduction in diameter growth followed the 25th year (Fig. 36). In the following nine years, the increase in diameter

was about one inch. The last annual rings were so indistinct it was necessary to use a lens to determine their outline (Fig. 36).

Section 2-2. This section was cut midway of that part of the stump that was from 4 to 12 inches below the surface of the ground. Judging from the black color of the wood in the center of the upper part of the section, the tree was severely injured by fire when quite small. Apparently the upper part of the main stem was killed. A remnant of the stem is seen at X (Fig. 37). The entire central region of the section is pale yellowish brown in color and seems to be in the early stages of decay. There were narrow cracks that had been filled with resin that extended full length of the section. The bordering wood was yellowish brown.

Loblolly pine No. 51 was of sprout origin and had "littleleaf" symptoms. The needles were yellow, about half as long as normal loblolly pine needles, and were bunched at the ends of the branches. The tree was retaining its cones from 1950 to 1954. There were black resinous lesions on the larger roots.

Diseased Loblolly Pine on the Rice Place

April 10, 1957, the writer examined a group of 10 diseased loblolly pine in Lowndes County, Alabama, on the property of Julian Rice, 407 Fairview Avenue, Montgomery, Alabama. The trees were in a large pasture and were about 25 to 30 years old. With the first signs of the disease, which were in the lower part of the crown, the needles on one or more of the branches became chlorotic. In the early stages of the disease, the needles were normal in length, being 5 to 7 inches long. Where the disease was more advanced, there were no 1955 needles. The 1956 needles were 3 to 5 inches long andmany of them were partially dead. They were more or less bunched at the ends of the branches. The 1957 needles were 1 to 2 inches in length. They were closely crowded at the ends of the branches and were very yellow. On a normal loblolly pine about 200 yards away, the 1957 needle buds were slightly more than one-fourth of an inch in length and the needles had not

broken through the needle sheath. The early elongation of the needles on the unhealthy trees, as contrasted to the normal development of the needles on the healthy trees, suggested a condition that might be attributed to the mode of origin of the tree. Permission was obtained from Mr. Rice to dig up the stumps of two of the diseased trees and they were excavated May 8, 1957. One of the stumps was from a severely diseased tree (Specimen Tree No. 52). The second stump was from a tree (Specimen Tree No. 53) on which the needles on the lower branches were somewhat chlorotic. After drying, the root crowns were sectioned, polished and examined.

Specimen Tree No. 52. This tree was about 35 feet tall, almost 9 inches dbh (inside bark), about 25 years old, and severely diseased. Some of the lower branches were dead. There were comparatively few 1956 needles. The 1957 needles were 1 to 2 inches in length and were closely bunched at the end of the twigs. The finer roots were dead. The larger roots were black and their inner bark was pink to red in color. There were a few resinous lesions on the large roots and on their underside there was an abundance of abnormally large lenticels.

Section 1-2, Specimen Tree No. 52, was cut from the bole of the tree at the surface of the ground (Fig. 38). As will be seen, the tree made a rapid growth up to about 1952 when there followed an abrupt slowing down in its growth. Section 2-2, Specimen Tree No. 52, was cut from that part of the stump that was from 2 to 11 inches below the surface of the ground (Fig. 39). The greater portion of the section is light yellowish-brown in color. There were traces of pith at X. At Y there seemed to be the remnant of a stem and at Z what may be traces of a secondary stem. The discoloration in the central region of the section indicates that the tree was severelyinjured when quite young. The writer believes that Specimen Tree No. 52 was of sprout origin. There was some uncertainty as to whether the stem, the remnant of which at Y (Fig. 39), was the remains of the primary stem. There was a progressive shortening of the branches and leaves. Specimen Tree No. 52 had "littleleaf" symptoms.

Specimen Tree No. 53. This tree was about 75 feet from Specimen Tree No. 52. Specimen Tree No. 53 was about 40 feet tall, 10 inches dbh (inside bark), and 25 years old. The tree was slightly diseased. The needles on the lower branches were chlorotic and the tips of some of the needles were dead. The needles were 5 to 7 inches in length. Sections 1-2 and 2-2 were cut from Specimen Tree No. 53. Section 1-2 was cut from the bole at the surface of the ground (Fig. 40). As seen, Specimen Tree No. 53 was making a good rate of growth. Section 2-2, Specimen Tree No. 53, was cut from that part of the stump that was from 2 to 11 inches below the surface of the ground. The light reddish-brown color of the central region of the section indicates that the tree was injured, possibly by fire, when quite young (Fig. 41). The area marked X indicates what seems to be a remnant of the primary stem. Apparently Specimen Tree No. 53 was a sprout. The chlorotic condition of the needles in the lower part of the crown seemed to be the beginning stage of "littleleaf" in Specimen Tree No. 53. According to Mr. Rice, the pasture in which Specimen Trees Nos. 52 and 53 were located had been fertilized for a period of 10 years. For the past five years the fertilizer, 0-14-14, was applied at the rate of 400 pounds per acre per year. He did not remember the formula of the fertilizer used preceding the last five years other than it was a complete fertilizer, apparently rich in phosphate and potash.

The writer believes that the long continued use of mineral fertilizer explains in part the diseased and dying condition of the loblolly pine trees on the Rice property. In another pasture not far away there were 12 or more loblolly pine trees that were similarly diseased to those described above. The pasture in which these 12 trees were located had been fertilized in the same way and for the same number of years as the one mentioned in the preceding paragraph.

Longleaf Pine

Specimen Tree No. 11. This tree came from Tallapoosa County. It was about

50 feet tall, 4½ inches dbh (inside bark), and at least 40 years old. It was in a rather open area. The nearest tree, a shortleaf pine that had "littleleaf" symptoms, was 35 to 40 feet distant. The soil is similar to that described for Specimen Tree No. 9. Specimen Tree No. 11 was selected for the following reasons: (1) It was a longleaf pine tree with needles quite yellow and more or less massed at the tips of the branches which was suggestive of "littleleaf" symptoms; and (2) Since the tree had "littleleaf" symptoms, it might be of sprout origin. Ten serial sections, 1-10, 2-10, 3-10, 4A-10, 5-10, 6-10, 7-10, 8-10, 9-10, and 10-10, were cut from the base of the bole and the root collar of Specimen Tree No. 11. Sections 1-10 and 2-10 were cut respectively 3 inches and 1½ inches above the surface of the ground. The lower surface of 3-10 was cut 1½ inches below the surface of the ground. Sections 4A-10 and 5-10 were from a block that was from that part of the stump that was 1½ to 3½ inches below the surface of the ground. From these two sections, including sections 6-10 and 7-10 that were 3½ to 5½ inches below the surface of the ground, it is evident that in early life the vertical stem was apparently killed by fire. The reddish and dark colored wood indicates that the tree was wounded when quite young and is similar to that found in stumps of shortleaf pine trees in which there were remains of stems that were killed by fire.(specimen not photographed).

The writer believes that Specimen Tree No. 11 was of sprout origin.

Specimen Tree No. 54. A longleaf pine that had "littleleaf" symptoms was observed on the Folmar place a few miles south of Weoka, Elmore County, September 5, 1956. The tree stood on the border between an old field and a wooded area. Since the tree had "littleleaf" symptoms, it was dug up September 5, 1956, in order to determine its source of origin. The tree was at least 50 years old, 55 to 60 feet tall, and 12 inches dbh (inside bark). It died late in the summer of 1956. There were comparatively few needles on the tree. They were about 4 inches long and were at the ends of the branches. There had been considerable dieback of the branches, especially in the lower part of the crown. The larger roots and the

root crown were found to be infected with the shoestring fungus, Armillaria mellea (Fr.). Grayish-black stringlike bodies, rhizomorphs, were abundant in the soil surrounding the roots and root crown. There was an abundance of white mycelial strands and mats between the bark and wood of the longer roots, root crown and base of the bole of the tree.

Sections 1-2 and 2-2 were cut from Specimen Tree No. 54. Section 1-2 is a cross section of the bole which was cut just above the surface of the ground. Up to and including the 45th year, the annual increment averaged slightly more than one-fourth inch. Beginning with the 48th year, there was a sharp decline in the annual rate of growth in diameter (Fig. 42). Section 2-2 is a longitudinal section which includes a portion of the stem, root crown and tap root (Fig. 43). As can be seen, there is a direct connection of the stem with the tap root. Specimen Tree No. 54 developed directly from the seed. The tree had "littleleaf" symptoms.

Specimen Tree No. 55. This tree appeared to have "littleleaf" symptoms. It was on the Martin place south of Weoka in Elmore County. Specimen Tree No. 55 was dug up September 20, 1956, for the purpose of making a special study of the stump in order to determine the mode of origin of the tree. The tree was about 45 feet tall, 10½ inches dbh (inside bark), and about 35 years old. For the first 26 years of its life, its diameter growth averaged nearly one-half inch per year. The tree was severely injured by fire February 18, 1953. Since that time, the annual rings were so narrow it was necessary to use a lens to count them. There was considerable dieback of the branches in the lower part of the crown. There was the tendency for the needles in the lower part of the crown to be bunched at the tips of the branches. They were more yellow and shorter than on the topmost part of the crown (Fig. 44). The average length of the needles on the lower branches was 4 inches and on the topmost branches 5 to 6 inches. The vast percentage of the 1955 needles had been shed. Sections 1-4, 2-4, 3-4 and 4-4 were cut from Specimen Tree No. 55. Section 1-4 is a cross section of the bole cut at the surface of the ground. About one-

third of the polished surface of the section was light to dark brown in color. The discolored portion spreads out irregularly from the center in a fan-like manner to the bark. The discolored wood was dead and seemed to be in an early stage of decay (Fig. 45).

Sections 2-4, 3-4, and 4-4 were longitudinal sections that were cut from that part of the stump that extended from the surface to 10½ inches below the surface of the ground. The greater portion of sections 2-4, 3-4 and 4-4 were yellowish-brown in color which seems to indicate incipient decay.

As contrasted with section 2-2 of Longleaf Pine No. 54 (Fig. 43), which developed directly from the seed, there was considerable distortion and irregularity of growth in sections 2-4, 3-4 and 4-4 (Fig. 46). Evidently in its early life, there was a disturbance that so injured the tree as to interrupt its normal development and which made possible the entrance of fungi and bacteria. A portion of the main stem was killed or destroyed. It appears that Specimen Tree No. 55 was of sprout origin. Increase in diameter growth slowed down abruptly two years prior to the fire which indicates that the tree was in the early stages of "littleleaf". The writer believes the tree had "littleleaf" symptoms because of the injury in its early life. It seems that the progress of the occurrence of "littleleaf" symptoms was accelerated as the result of the fire.

Specimen Tree No. 56. In October 1955, David E. Hampe, Chief Forester, Tennessee Coal and Iron Division of U. S. Steel Corporation, had a longleaf pine near West Blockton, Bibb County, Alabama, pulled up for the Division of Forestry, Alabama State Department of Conservation. He stated that the dbh of the tree was 8 inches and that it had just died. Mr. Hampe also stated, "I have watched the tree for quite some time and it had all the symptoms of 'littleleaf'. I feel that if Dr. York determines that it is of sprout origin, we should have pretty good reason to believe that any pine species of sprout origin is more susceptible to "littleleaf" than other species."

The stump was not received until about a year after it was pulled up. It was so badly decayed that most of the essential details were lost. However, it is evident that the tree was injured by fire when quite young. The writer believes that Specimen Tree No. 56 was of sprout origin.

DISCUSSION

For this study of "littleleaf" of Southern Pine, 61 trees (53 shortleaf pine, 4 loblolly pine, and 4 longleaf pine) were excavated. Portions of the stumps, including the root crown of 37 of the shortleaf, the 4 loblolly, and the 4 longleaf pine trees, were sectioned. The sections were polished and examined. The sections from 10 shortleaf pine trees that had "littleleaf" and were of sprout origin were accidentally destroyed. The stumps from 6 small shortleaf pine trees of sprout origin were not sectioned but were described in this report. Thirty-nine of the 61 trees had "littleleaf" symptoms.

In the central region of the root crown of 37 of the trees that had "littleleaf" symptoms, there were reddish to yellow-brown discolorations in the wood and often the blackened remnants of stems. Such discolorations were found only in the stumps of pine trees that were "littleleafed" and were of sprout origin, or injured when quite young. The writer believes that the discoloration of the wood in the central region of the root crown of the trees that had "littleleaf" symptoms was caused by fungi and bacteria that entered the trees through wounds that were made by fire or other agencies when the trees were quite young. With the exception of Specimen Trees Nos. 50 and 54, which were not of sprout origin, the trees that had "littleleaf" symptoms were very largely, if not entirely, of sprout origin. In a few of the specimens, indications of sprout growth were not sharply defined. Owing to the possibility that the writer might have misinterpreted what seemed to be evidence of the interruption of growth found in the central region of the root crown

of a few of the trees, the sections from the stumps of 16 representative trees, 15 shortleaf and 1 longleaf pine, were sent March 18, 1955, to the United States Forest Products Laboratory, Madison, Wisconsin, for their examination and interpretation. A copy of the description of the specimens sent to the Forest Products Laboratory and a copy of the report of their examination of the sections follows and it is followed by a copy of the comparison between the writer's interpretation and that of the U. S. Forest Products Laboratory.

SECTIONS SENT TO THE U. S. FOREST PRODUCTS LABORATORY

Specimen Tree No. 1. This tree came from Dallas County, Alabama, and was taken down in March 1954. It had no symptoms of "littleleaf", although it was in a tract of shortleaf pine where there was a considerable amount of the disease. Specimen Tree No. 1 was about 35 feet tall, 3.75 inches dbh (inside bark), and at least 16 years old. The topsoil where this tree was growing was a fine sandy loam from 7 to 8 inches in depth, and gradually merged into yellowish-red, compact subsoil. The land was fairly level.

Two sections, Nos. 1-2 and 2-2, were cut from the stump of Specimen Tree No. 1. Section 1-2 was the part of the stump that was cut just beneath the surface of the ground. There was a small resinous lesion in the axil of the lateral root. Section 2-2 was cut just below section 1-2. There were two small resinous lesions on section 2-2, the cause of which was not determined. Specimen Tree No. 1 developed from the primary stem.

Specimen Tree No. 4. This tree came from Dallas County, Alabama, and from the same stand as Specimen Trees Nos. 1, 2 and 3. The tree was about 40 feet high, nearly 5 inches dbh (inside bark), and at least 20 years old. The soil conditions where Specimen Tree No. 4 was growing were essentially the same as those for Specimen Trees Nos. 1, 2 and 3. Serial sections 1-3, 2-3 and 3-3 were cut from the stump of Specimen Tree No. 4. Section 1-3 was from that part of the root collar that

extended from the surface of the ground to about 3-3/4 inches below the surface. Section 2-3 was cut immediately below section 1-3. Section 3-3 was directly below section 2-3. Section 3-3 was from that part of the root collar that was from about 6 inches to $8\frac{1}{4}$ inches below the surface of the ground. Of all the 49 shortleaf pine stumps, the horizontal part of the primary stem of Specimen Tree No. 4 was farther below the surface of the ground than in any of the other 48 trees. As seen in sections 2-3 and 3-3, there were remnants of branches that seem to have been killed by fire early in the life of the tree. In dissecting out the horizontal part of the main stem which was in section 3-3, there seemed to be no evidence of injury by fire to this part of the tree. There were traces of dormant buds in section 3-3. The vertical part of the primary stem was not killed and the tree developed from that part of the tree. Specimen Tree No. 4 showed no signs of "littleleaf". Externally, it seemed to be normal.

Specimen Tree No. 6. Specimen Tree No. 6 was selected because it had "littleleaf". This tree came from Tallapoosa County, Alabama. It was about 50 feet tall, 4.5 inches dbh (inside diameter), and about 40 years old. The topsoil, where this tree grew, was a heavy, reddish clay loam with small rounded stones that was underlaid by a red, compact subsoil. Specimen Tree No. 6 stood in a large tract of shortleaf pine with an occasional loblolly and longleaf pine. Many shortleaf pine in this stand that were "littleleafed" had died and a large percentage of the remaining shortleaf pine had symptoms of "littleleaf". This tract of pine was in the Piedmont zone where the mortality from "littleleaf" seems to exceed that of any other section of Alabama.

Serial sections 1-8, 2-8, 3-8, 4-8, 5-8, 6-8, 7-8 and 8-8 were cut from the stump of Specimen Tree No. 6. Section 1-8 was cut about one inch above the surface of the ground. Section 2-8 was cut immediately below section 1-8. Sections 3-8 and 4-8 were from the same block that was directly beneath section 2-8. Apparently, the vertical part of the primary stem, when quite small, was killed by fire.

Thus Specimen Tree No. 6 seemed to be of sprout origin. Traces of dormant buds can be seen on the lower surface of section 3-8. Sections 5-8 and 6-8 were from a block of the taproot that was cut immediately adjoining sections 3-8 and 4-8. The reddish colored center of all four of these sections seems to be pathological conditions that resulted from injury to the primary stem when the tree was quite young.

Specimen Tree No. 7. This tree came from Tallapoosa County, Alabama, and was taken down in July 1954. It was about 40 feet tall, 4 inches dbh (inside bark), and about 30 years old. The soil where it grew was similar to that described for Specimen Tree No. 6.

Specimen Tree No. 7 was selected for the following reasons: (1) It stood within 8 feet of a shortleaf pine tree that was severely "littleleafed"; (2) It had no apparent symptoms of "littleleaf"; (3) There was a large resinous canker at the base of the bole of the tree.

Sections 1A-4, 1-4, 2-4 and 3-4 were cut from the stump of Specimen Tree No. 7. The lower surface of section 1-4 was from a cut of that part of the stump that was 2 inches below the surface of the ground. More than two-thirds of this section was girdled by a resinous canker. The traces of bark beetle galleries were made while the stump was being seasoned. Section 2-4 came immediately below section 1-4 and section 3-4 was directly below section 2-4. About one-third of section 3-4 was girdled by a canker. The writer believes Specimen Tree No. 7 developed directly from the primary stem of the seedling.

Specimen Tree No. 9. This tree was taken down in July 1954, and came from Tallapoosa County. It was about 35 feet tall, $3\frac{1}{4}$ inches dbh (inside bark), and about 30 years old. Specimen Tree No. 9 was selected because it seemed to be in the early stages of "littleleaf". The needles were slightly pale green and those of the current season were slightly shorter than those of the previous years. The 1954 needles had apparently ceased to elongate.

Sections 1-5, 2-5, 3-5, 4-5 and 5-5 were cut from Specimen Tree No. 9. Sec-

tions 1-5 and 2-5 were from the same block. The lower surface of these sections was from a cut that was made from the taproot about 2 inches below the surface of the ground. Sections 3-5 and 4-5 were contiguous with sections 1-5 and 2-5. They were cut from the same block which was from the part of the taproot that was $2\frac{1}{2}$ to 6 inches below the surface of the ground. It is seen from these sections that a disturbance of some sort occurred when the tree was quite young and the primary vertical stem was killed. The writer believes that the tree was of sprout origin. There were several traces of dormant buds on section 3-5. Section 5-5 was contiguous with sections 3-5 and 4-5.

Specimen Tree No. 10. This tree came from Tallapoosa County, Alabama, and was taken down in July 1954. It stood about 35 feet from Specimen Tree No. 9. Specimen Tree No. 10 was about 30 years old, $3\frac{1}{4}$ inches dbh (inside bark), and approximately 35 feet tall. The soil in which Specimen Tree No. 10 was growing was very similar to that described for Specimen Tree No. 11 below.

Specimen Tree No. 10 was selected for study because it seemed to be in the early stages of "littleleaf". Its needles were somewhat yellow and those of 1954 were slightly shorter than those of 1953. Serial sections 1-4, 2-4, 3-4 and 4-4 were cut from Specimen Tree No. 10. Section 1-4 was cut just above the surface of the ground. Section 2-4 was cut immediately beneath section 1-4. Sections 3-4 and 4-4 were cut just below section 2-4 and were from the part of the root 2 to 4 inches below the surface of the ground. The brown color of the central part of the sections indicates that the vertical part of the tree was severely injured, if not killed, when quite young. It is the writer's opinion that the tree was of sprout origin.

Specimen Tree No. 11. Longleaf Pine. This tree came from Tallapoosa County, Alabama, and was taken down in July 1954. It was about 50 feet tall, $4\frac{1}{2}$ inches dbh (inside bark), and at least 40 years old. This tree was in a rather open area. The nearest tree, a shortleaf pine infected with "littleleaf", was 35 to 40

feet away. The soil where Specimen Tree No. 11 was growing was a reddish clay with a mixture of small rounded stones underlaid with a hard compact red material. Specimen Tree No. 11 was selected for study for the following reasons: (1) It appeared to be a longleaf pine tree whose needles were quite yellow and apparently of uniform length; (2) Possibly the tree might have "littleleaf"; and (3) It might be of sprout origin. The writer had observed a number of examples of young longleaf sprouting after the greater part of the primary stem had been killed by fire.

Serial sections 1-10, 2-10, 3-10, 4A-10, 5-10, 6-10 and 7-10 were cut from Specimen Tree No. 11. Section 1-10 was cut about 3 inches above the surface of the ground. Section 2-10 was contiguous with section 1-10. Section 3-10 was cut immediately below 2-10 and its lower surface is a cut of the taproot $1\frac{1}{2}$ inches below the surface of the ground. Sections 4A-10 and 5-10 were from the same block that was cut immediately below section 3-10. In these two sections there was evidence of an injury to the tree when quite young which was also seen in sections 6-10 and 7-10. The writer believes that Specimen Tree No. 11 was of sprout origin.

Specimen Tree No. 12. This tree came from Hale County, Alabama. It was taken down in May 1954. Specimen Tree No. 12 was about 50 feet tall, about 6 inches dbh (inside bark), and at least 25 years old. This tree had "littleleaf". It grew on what seemed to be a good site for shortleaf pine. The topsoil was a fine sandy loam and 7 to 8 inches in depth. It was underlaid by a yellowish to a reddish compact subsoil.

The rate of diameter growth of Specimen Tree No. 12 for about the first 15 years averaged approximately one-half inch per year. A marked slowing down of the growth then followed.

Sections 1-3, 2-3 and 3-3 were cut from the stump of Specimen Tree No. 12. Section 1-3 was from that part of the taproot which was from 1 to 2 inches below the surface of the ground. Section 2-3 was cut immediately below section 1-3 and 3-3 was directly below 2-3. The brown and black areas in these two sections indi-

cate that the primary vertical stem of the tree was killed, apparently by fire, when quite young. Specimen Tree No. 12 was of sprout origin.

Specimen Tree No. 13. This tree came from Hale County, Alabama, and was taken down in May 1954. It was about 50 feet tall, 5 inches dbh (inside bark), and about 25 years old. It stood about 25 feet from Specimen Tree No. 12. The soil structure and other environmental factors were essentially the same as for Specimen Tree No. 12. There was considerable irregularity in the rate of increase in diameter following the 15th year.

Sections 1-3, 2-3 and 3-3 were cut from the stump of Specimen Tree No. 13. Section 1-3 was cut at ground level of the tree. Section 2-3 was cut from that part of the root collar that was 3 to 5 inches below the surface of the ground. Section 3-3 was cut immediately below section 2-3. Judging from the black and brown areas in section 2-3, the primary vertical stem of the tree was killed by fire when quite young.

Specimen Tree No. 25. This tree came from Hale County and was taken down in 1953. It was at least 50 years old, $5\frac{1}{2}$ inches dbh (inside bark), and 55 feet high. This tree was in a stand of shortleaf pine where the average age of the tree was about 50 years and where "littleleaf" was quite severe. The topsoil was a light sandy loam, 7 to 8 inches thick and merged gradually into a yellow to reddish subsoil. Sections 1-2 and 2-2 were cut from the stump of Specimen Tree No. 25. Section 1-2 was cut about 2 inches above the surface of the ground. Section 2-2 was from that part of the root crown that was 2 to 9 inches below the surface of the ground. Specimen Tree No. 25 was severely "littleleafed" and was of sprout origin.

Specimen Tree No. 27. This tree came from Hale County and stood about 50 feet distant from Specimen Tree No. 25. It grew under conditions somewhat similar to those of Specimen Tree No. 25.

Specimen Tree No. 27 was about 60 feet tall, $7\frac{1}{2}$ inches dbh (inside bark), and about 50 years old. It was in the advanced stages of "littleleaf". Sections 1-3,

2-3 and 3-3 were cut from the stump of Specimen Tree No. 27. Section 1-3 was cut at the ground level. Sections 2-3 and 3-3 were from a section of the root crown that was from one to almost ten inches below the surface of the ground. The vertical stem of the tree was killed by fire when quite young. Judging by what seems to be the cut ends of stems, the young tree was hit by more than one fire. At least one stem, and sometimes as many as 5 to 6 stems, developed from dormant buds at the base of the primary stem following the destruction of the upright part of the stem.

Specimen Tree No. 29. This tree came from Hale County, Alabama, and stood about 40 feet from Specimen Tree No. 12. Specimen Tree No. 29 was about 40 feet tall, 5 inches dbh (inside bark), and approximately 25 years old. It was in the advanced stages of "littleleaf". Sections 1 and 2 were taken from the same block which was cut from that part of the root crown that was from 2 to about 14 inches below the surface of the ground. The remnant of a vertical stem X and a surface view of a transverse cut through the horizontal part of the primary stem XX were seen in section 1. Specimen Tree No. 29 was of sprout origin.

Specimen Tree No. 32. This tree came from Tallapoosa County and was taken down in August, 1949. It was about 60 feet tall, $6\frac{1}{2}$ inches dbh (inside bark), and at least 65 years old. It was in a large tract of shortleaf pine where a large percentage of the trees had "littleleaf". The topsoil where Specimen Tree No. 32 stood was a reddish fine gravelly loam, 5 to 6 inches thick, and merged into a hard compact reddish subsoil. Specimen Tree No. 32 was in the advanced stages of "littleleaf". Sections 1-3 and 2-3 were cut from the stump of this tree. The upper surfaces of these sections were cut $1\frac{1}{2}$ inches above the surface of the ground. The remnants of two stems were designated X and Z. At XY was a surface view of a transverse cut through the horizontal part of the primary stem. Specimen Tree No. 32 was of sprout origin.

Specimen Tree No. 35. This tree came from Hale County and was in the same

tract of shortleaf pine as Specimen Trees Nos. 12, 13 and 35. Specimen Tree No. 35 was about 55 feet tall, $5\frac{1}{2}$ inches dbh (inside bark), and 40 to 45 years old. It was in the advanced stages of "littleleaf". The slow rate of growth of this tree seems to be at least partly due to competition with other trees. Sections 1-2 and 2-2 were cut from that part of the root crown that was from $1\frac{1}{2}$ to $9\frac{1}{2}$ inches below the surface of the ground. At X and XX in section 2-2 there seem to be remnants of stems. The writer believes that Specimen Tree No. 35 was of sprout origin.

Specimen Tree No. 37. This tree came from Chilton County, Alabama. It was in a stand of young shortleaf pine that had been burned over at least three times in the past fifteen years. Specimen Tree No. 37 was one of a number of young shortleaf pine that were of sprout origin. These trees were collected and sectioned with the hope they might be of service in interpreting structural features in older shortleaf pine trees that were of sprout origin.

Sections 1-2 and 2-2 were cut from Specimen Tree No. 37. The red line on section 1-2 represents the ground level of the tree. The areas labeled X were dead when the tree was taken down. Apparently Specimen Tree No. 37 was hit by more than one fire and was of sprout origin.

Specimen Tree No. 43. This tree was collected in Chilton County, February 1954. This specimen was a good example to show the tendency of young shortleaf pine trees to produce epicormic buds, and to sprout when the vertical or the primary stem was killed. The buds may remain dormant for an indefinite period of time and progressively elongate with the addition of each annual ring. There were two living sprouts on Specimen Tree No. 43 when it was removed from the ground, both of which were about four years old. Apparently they originated as the result of a late burn in 1948 or early in 1949. The large central stub was at least five years old when it was burned. From the time of its origin until the tree was removed from the ground, there seems to be a period of ten years. There is a badly decayed sprout that may have been the original or primary stem. Apparently it

was about five years old when it was killed. If so, Specimen Tree No. 43 was at least fifteen years old.

REPORT ON EXAMINATION OF TREE SPECIMENS

by

Ralph O. Marts, U. S. Forest Products Laboratory

Specimen Tree No. 1	Section 2-2 shows a single main stem.
Specimen Tree No. 4	Section 3-3 shows crook of the main stem and lateral adventitious buds.
Specimen Tree No. 6	Section 3-8 shows three stem structures at one level with only one surviving at a slightly higher level. There are lateral adventitious buds.
Specimen Tree No. 7	Section 1-4 shows a single stem. Pith diameter would indicate that this specimen is longleaf.
Specimen Tree No. 9	Section 4-5 indicates crook in early years and a number of adventitious buds. The main stem structure shows on section 3-5.
Specimen Tree No. 10	Section 3-4 shows single stem structure with a crook and a few adventitious buds.
Specimen Tree No. 11	Two cross sections of stem structure appear in section 5-10. Crook and adventitious buds are also apparent. Diameter of the pith indicates species other than longleaf.
Specimen Tree No. 12	Section 3-3 marked top shows seven stem structures indicating developed sprouts. Adventitious buds are present.
Specimen Tree No. 13	Section 1-3 shows single stem structure but the connection between 1-3 and 2-3 is not distinct. Adventitious buds are present. Decided crook is present in early years.
Specimen Tree No. 25	Section 2-2 shows crook present in early years. Presence of at least two stems indicates sprout development.
Specimen Tree No. 27	Section 3-3 shows evidence of a number of sprouts and early crook in the seedling.
Specimen Tree No. 29	Section 29 shows a crook in the stem in early years. Stems of sprout origin are evident as well as adventitious buds.
Specimen Tree No. 32	It is evident there was a crook in the stem and sprouting in early years of this specimen.
Specimen Tree No. 35	Section 2-2 shows crooking of the stem in early years; stems of sprout origin are evident.

(No comments on Specimen Trees 37 and 43 were made by the U. S. Forest Products Lab.)

Comparison Between The Author's Report
and U. S. Forest Products Laboratory Report

Specimen Tree	Author	U. S. Forest Products Laboratory
1	Seedling origin	Single main stem
4	Tree from primary stem	Shows crook of the main stem and lateral adventitious buds
6	Sprout origin	Shows 3 stem structures at one level with one surviving at a slightly higher level
7	Seedling origin	Shows single stem
9	Sprout origin	Section 4-5 indicates crook in earlier years and a number of adventitious buds. Main stem structure shows on Section 3-5
10	Sprout origin	Single stem structure with a crook and a few adventitous buds
11	Sprout origin	Two cross sections of stem structure appear in Section 5-10. Crook and adventitious buds were apparent.
12	Sprout origin	Seven stem structures indicating developed sprouts
13	Sprout origin	Section 1-3 shows single stem structure but the connection between 1-3 and 2-3 not distinct. Adventitious buds are present. Decided crook is present in early years.
25	Sprout origin	Presence of at least two stems indicates sprout development. Crook present in early years
27	Sprout origin	Evidence of sprouts and early crook in seedling
29	Sprout origin	Stems of sprout origin are evident as well as adventitious buds
32	Sprout origin	Sprouting in early years
35	Sprout origin	Stems of sprout origin
37	-	-
43	-	-

Discussion of the Above Comparison of Reports

The Forest Products Laboratory accepted the writer's interpretation of the conditions found in Specimen Trees Nos. 1, 6, 7, 12, 25, 27, 29, 32 and 35. The Forest Products Laboratory does not state whether there is a single stem for Specimen Trees Nos. 4, 9, and 11. There seems to be some uncertainty about conditions in Specimen Tree No. 13. The Laboratory stated, "Section 1-3 shows single stem structure but the connection between 1-3 and 2-3 is not distinct." The crook mentioned for Specimen Tree No. 4, as well as for Specimen Trees Nos. 9, 10, 11, 13, 25, 27, 29, 32 and 35, is the result of two bends in the stem of the tree when it was a small seedling (Figs. 1 and 5A). The writer dissected the crook in Specimen Tree No. 4 to show how it was engulfed in the tree and to determine whether there was any discoloration in the central region of the root crown, such as is characteristic of shortleaf pine trees of sprout origin. There were no traces of more than one stem and no discoloration of the central region of the root crown of Specimen Tree No. 4. The tree developed directly from the seed.

The adventitious buds that the Forest Products Laboratory mentioned for Specimen Trees Nos. 4, 6, 9, 11, 12, 13 and 29 were dormant buds. They had their origin in the axils of leaves. Adventitious buds arise in places other than the axils of leaves. Dormant buds may persist indefinitely and each year elongate to keep the apex at the surface of the bark (Figs. 3, A, A/, and 3A). The Laboratory termed lateral adventitious buds in Specimen Tree No. 4 were the apices of dormant buds. Some of them were 3/16 to almost 1/4 inch in length.

The Forest Products Laboratory stated that section 3-4, Specimen Tree No. 10, shows a single stem. Their interpretation of the results of their examination of Specimen Trees Nos. 9, 11 and 13 seems to indicate that there was some doubt in their minds as to whether these trees were of primary or sprout origin. The central region of the root crown of Specimen Trees Nos. 9, 11 and 13, as well as Specimen Tree No. 10, is more or less reddish to yellowish brown in color which is strik-

ingly similar to the coloration of the central region of the root crown of shortleaf pine that were definitely of sprout origin. Compare Figures 15 and 16 with Figure 13. The reddish to yellowish-brown color in the central region of the root crown was observed only in pine trees that were "littleleafed" and was apparently caused by bacteria and fungi that gained entrance into the root crown through a wound that was, in the majority of cases, made by fire or other agency.

All of the trees that had "littleleaf" symptoms, with the exception of Specimen Trees Nos. 50 and 54, had reddish to yellowish-brown or black discoloration or both in the central region of the root crown. Such discoloration was not found in the trees that developed directly from the seed.

Specimen Trees Nos. 9, 10, 11 and 13 may have developed directly from quite small trees whose vertical stem was wounded and survived. There is also the possibility that the vertical stem of the seedlings from which Specimen Trees Nos. 9, 10, 11 and 13 developed was killed. In which case, Specimen Trees Nos. 9, 10, 11 and 13 were sprout trees. In either case, the reddish to yellowish-brown color in the central region of the root crown resulted from wounds. Apparently Specimen Trees Nos. 9, 10, 11 and 13 were mutilated when they were quite small. It appears that the nature of the wound was not sufficiently distinct to determine the extent of the injury.

The major portion of this investigation was devoted to the study of "littleleaf" of shortleaf pine trees. Dr. Hepting and his co-workers described "littleleaf" as a disease of shortleaf and loblolly pine trees. They have shown, as previously stated, that a fungus, Phytophthora cinnamomi, kills the fine rootlets of shortleaf and loblolly pine trees that become "littleleafed". In the course of his study of "littleleafed" shortleaf pine, the writer sectioned the root crowns of four loblolly and four longleaf pine that had "littleleaf" symptoms. The central region of the root crowns of three loblolly and three longleaf pine trees were yellowish-red to yellowish-brown, which is very similar to the color of the central region of the

root crown of shortleaf pine that are sprout trees. These trees were of sprout origin. One of the loblolly and one of the longleaf pine developed directly from the seed. The central region of the root crown of the loblolly pine was a pale gray color, and in the longleaf pine pale yellow, yet these two trees had "littleleaf" symptoms. Specimen Tree No. 50, a "littleleafed" loblolly pine, had incipient butt rot (Fig. 37) and the innerbark at the base of the bole was being killed by a fungus, P. cinnamomi, and other fungi may have been attacking the finer roots. Specimen Tree No. 54, a "littleleafed" longleaf pine, was being attacked by the shoestring fungus, Armillaria mellea. The root crowns of two "littleleafed" loblolly pine, Specimen Trees Nos. 52 and 53, which stood in a pasture that had been fertilized for the past 10 years, were sectioned. They were mutilated when quite young, apparently by fire, and were of sprout origin. The central region of these sections was light yellowish-red and brown in color. These trees had "littleleaf" symptoms and were slowly dying as the result of chemical injury. Thus, "littleleaf" of pine trees may be caused by one or more of a number of factors of which P. cinnamomi is only one.

Crandall, Gravatt and Ryan (4) described a root rot disease of American chestnut and chinkapin in natural stands and some coniferous and broadleaf nursery stocks that was caused by Phytophthora cinnamomi. They found that in the chestnut and chinkapin trees, symptoms of the root rot vary considerably. In more typical cases, the slow loss of roots is first indicated by a gradual reduction in the size of leaves over a period of several years. This condition was accompanied by a yellowing and slight wilting. The authors made no mention of the reduction in the size of the leaves as being a form of "littleleaf", yet the trees became "littleleafed". They also stated that in some cases there was die back of branches until a few were left that may remain alive for several years. The color of root tissue recently invaded by P. cinnamomi is quite characteristic of the root rot disease. On chestnut it is light brown and green and on the roots of coniferous seedlings,

excepting species of Taxus, reddish brown.

Thirty-nine of the 61 trees that were excavated for this study had "littleleaf" symptoms. The central region of the root crown of 37 of the 39 trees that had symptoms of "littleleaf" was reddish to yellowish brown in color. Two of the 39 Specimen Trees developed direct from the seed. At least 34 of the 37 "littleleafed" pine trees were of sprout origin. Since these trees came from eight different counties in Alabama (Plate 1) and were selected more or less at random, it appears that the vast percentage of shortleaf (and possibly loblolly) pine trees in Alabama that have "littleleaf" symptoms originated from sprouts. With reference to shortleaf pine, Mattoon (8) stated: "Over a large section of the South where burning has long been the custom practically all of the second growth shortleaf pine trees are sprouts." According to Campbell and Copeland (2), "Loblolly pine, which appears to be materially affected by 'littleleaf' only when associated with diseased shortleaf also occurs over much of the range of 'littleleaf'."

It might seem unusual that loblolly pine is "materially affected by 'littleleaf' only when associated" with "littleleafed" shortleaf pine. Judging from what he has seen, the writer believes that loblolly pine trees do not become "littleleafed" because they are associated with shortleaf pine that have "littleleaf". Furthermore, loblolly pine trees that become "littleleafed" are primarily sprout trees, the same as is true for shortleaf pine trees that become "littleleafed".

According to Grano (6), "Loblolly pine should be planted in areas where 'littleleaf' disease is present because the species is more resistant than shortleaf pine to this disease." In view of the fact that there is a much larger percentage of "littleleafed" shortleaf pine than "littleleafed" loblolly pine, it might seem easy to believe that loblolly pine is much more resistant to "littleleaf" than shortleaf pine. The fact that "littleleaf" is much more abundant on shortleaf pine than on loblolly pine is not because shortleaf pine is more susceptible to "littleleaf" than loblolly pine. Shortleaf and loblolly pine that become "little-

leafed" are almost invariably sprout trees. It is not a matter of a difference of susceptibility between shortleaf and loblolly pine that there are more "littleleafed" shortleaf pine than "littleleafed" loblolly pine, but a difference in their habit of growth. The habit of growth of shortleaf pine is such that young trees (Figs. 1 and 1A) can survive fire and mutilation and sprout whereas loblolly pine being straight stemmed are easily killed by fire and other agents when small. Furthermore, loblolly pine as well as shortleaf pine trees planted on sites supporting "littleleafed" trees, or previously occupied by "littleleafed" trees, will not become "littleleafed" unless they are subjected to a killing fire during early life. On the basis of the results of this investigation, "littleleaf" is not a contagious disease.

According to Dr. Hepting and his co-workers, a fungus, Phytophthora cinnamomi, kills the fine roots of shortleaf and loblolly pine that become "littleleafed". Nine of the 12 shortleaf pine specimen trees that developed directly from the seed and were more than 15 years old, came from tracts of shortleaf pine where a large percentage of the trees had "littleleaf" symptoms. The soil conditions where the nine trees were growing were quite similar to those where the trees were "littleleafed". Undoubtedly, there was some contact between the roots of nine healthy trees and those that were "littleleafed". Since it has been shown that P. cinnamomi kills the fine rootlets of shortleaf and loblolly pine that become "littleleafed", it seems that P. cinnamomi should have been attacking rootlets of the nine healthy trees. If so, these nine trees had a vitality whereby they were able to replace the rootlets that were being killed. P. cinnamomi has been found to be relatively common in the soil under stands of pine throughout a considerable area of the Southeast. The writer examined the fine roots of shortleaf pine that were 5 to 10 years old and had developed directly from the seed. They were in stands of shortleaf pine where there was an abundance of "littleleafed" trees. Even though these young trees were in close proximity to "littleleafed" shortleaf pine, their

fine roots appeared to be normal. An examination was made of the fine roots of some young sprout shortleaf pine trees, two of which were Specimen Trees Nos. 36 and 37 that were in Chilton County, Alabama. Their fine roots appeared to be in perfect condition. On September 17, 1955, the writer examined the fine roots of a number of naturally seeded shortleaf in a plantation of shortleaf pine, a description of which follows. Also the rootlets of a number of the planted trees that were five years old were examined. The rootlets of all of these young trees appeared to be in excellent condition. It certainly seems that P. cinnamomi was in contact with the rootlets of these trees.

The Division of Forestry of the Alabama State Department of Conservation, in January 1951, established in Tallapoosa County, Alabama, a 2-acre plantation with one year old nursery grown shortleaf pine seedlings. This plantation is in a large tract of shortleaf pine where about 80 percent of the trees were "littleleafed". The plantation is divided into four one-half acre sections. In Section 1 the trees are spaced 6' x 6'; Section 2, 5' x 5'; Section 3, 4' x 4'; Section 4, 6' x 8'. A number of photographs were taken of different parts of the plantation. September 17, 1955, of which Plates 2 and 4 are representative. On April 17, 1958, a number of photographs were taken from as near as possible the same points as those taken on September 17, 1955, Plates 3 and 5. Prior to establishing the plantation, the area was completely cleared of all woody growth. It was believed when the area was selected for this experiment that Phytophthora cinnamomi was more or less abundant in the soil. The principal aim in establishing this plantation is to note, with adequate fire protection, whether at any time the planted shortleaf pine trees become "littleleafed" and if so, the causal factors.

Judging from the results of this investigation, it becomes evident that shortleaf and loblolly pine in their early life, regardless of their source of origin, were resistant to Phytophthora cinnamomi and other soil dwelling fungi, but by the time they are 20 or more years old, trees of sprout origin apparently

due to a deficiency of nutritives are physiologically weak, their fine roots become infected with P. cinnamomi and other fungi. The natural tendency of sprout trees is to age prematurely. At first they tend to grow more rapidly than seedling trees of similar age, after which there is usually a decided decline in growth rate (Figs. 9, 12, 27, 28, 30, 36 and 45). In reference to hardwoods, Busgen and Munch (1) stated: "Stool and root-shoots have the advantage over seedlings of the ample supplies of nourishment and water from the mother stool and its root system, so that they show from the first a very vigorous growth. . . . Later when the reserves in the root stock are used up and a balance has been established between coppice shoot and the remaining roots, the striking length of the shoots falls off." According to Toumey and Korstian (10), "Trees originating from seed are much longer lived than those derived from stool or root shoots and from suckers and cuttings. For this reason trees of a high forest are much older at maturity than the same species grown as coppice." In reference to hardwood sprouts, Chapman (3) stated: "Sprouts growing more rapidly in the sapling than do seedlings tend to crowd out the latter, but later the seedlings surpass them in rate of height growth and in ultimate dimension and longevity." In view of the fact that sprout hardwoods are shorter lived than hardwoods direct from the seed, it certainly seems to be equally true that pine trees of sprout origin are shorter lived than pine trees that develop directly from the seed. Certain facts apply equally to sprout shortleaf pine and sprout hardwoods. They grow more rapidly in their earlier years than similar aged trees direct from the seed. They tend to mature prematurely.

The results of this investigation clearly indicate that the great majority of naturally reproduced shortleaf pine trees in Alabama are sprout trees. Hence, the vast percentage of the shortleaf pine in this state that become "littleleafed" are sprout trees. Likewise, loblolly pine, with few exceptions, that become "littleleafed" are sprout trees. Fire is the dominating cause of so many

pine trees in Alabama being sprout trees. Fire really predisposes pine trees to become "littleleafed". The curse of fire is not limited to injury to little pine trees, the result of which is sprout trees that can become "littleleafed".

Many factors may contribute to the prematuring and "littleleafing" of pine trees, but fire is the one great agent that predisposes shortleaf as well as loblolly pine to this condition. It is the most common cause of so many shortleaf pine being of sprout origin. This study indicates that the vast percentage of pine trees in Alabama that become "littleleafed" are sprouts. In addition, fire has destroyed the forest litter whereby nitrogen was driven off into the air and the soil robbed of humus. Dr. Hepting and co-workers have shown that where there had been repeated burning, the soil was lacking in humus and nitrogen. They conducted quite a series of fertilizer experiments and found that, "The foliage of 'littleleaf' trees in the early and typical stages returned to normal coloration following heavy nitrogen fertilization and remained so for several years afterwards."

The writer is convinced that had it not been for fire killing small shortleaf and loblolly pine trees and destroying the forest litter, there would be very little, if any, "littleleaf" of pine trees today. He believes that "littleleaf" can be prevented by keeping fire away from seedling pine trees. By so doing, it will be just as practicable to plant and to foster young natural reproduction of shortleaf pine or other species of pine.

Since "littleleaf" is so much more abundant on shortleaf pine than on loblolly pine, it might seem that shortleaf is more susceptible to becoming "littleleafed" than loblolly pine. Shortleaf pine and loblolly pine that become "littleleafed" are almost invariably sprout trees. There are many more shortleaf pine of sprout origin than loblolly pine. The habit of growth of shortleaf pine is such that young trees (Fig. 1) can survive fire and sprout whereas loblolly pine being straight stemmed when young are usually killed by fire.

CONCLUSIONS

1. Shortleaf pine is not the only native pine that has the ability to sprout. Loblolly, longleaf and slash pine will sprout under certain favorable conditions.

2. The absence of twin shortleaf pine trees does not indicate that the stand developed directly from the seed. In all of the stands of shortleaf pine from which pine trees were dug up for this study the writer observed twin shortleaf pine trees only in one stand.

3. Dependence cannot be placed on local opinion as to whether or not a particular stand of pine trees, showing no visible evidence of fire, has been burned over during its early life. This can be determined only by digging up representative trees, carefully sectioning their root crowns, and studying properly prepared sections in the laboratory.

4. In most cases, trees beginning to show signs of senility and early mortality can be rejunevated by proper fertilizing and watering. This is a common practice in saving ornamental trees. Many valuable specimen trees in the City of Montgomery are still growing because of recommendations made to the property owners by the writer.

5. "Littleleaf" is a symptom of a weak or diseased condition in a tree. It may be due to a number of factors.

6. "Littleleaf" of trees is not a contagious disease.

7. When fire kills the vertical stems of a stand of young shortleaf pine trees and the trees become reestablished as a result of sprouting and the stand thereafter is protected, it can be predicted that the stand will show "littleleafing" when the trees reach an age of 20 years or more.

8. A shortleaf pine tree of sprout origin will ordinarily mature at an earlier age than a shortleaf pine tree direct from the seed, of the same age and on the same site.

9. In managing a stand of mixed pine, shortleaf should not be discriminated

against because of "littleleaf", if the site is suitable for the species.

10. By keeping an accurate fire occurrence map, the forest manager can predict when "littleleaf" will appear in the stand, if the shortleaf pine trees are of sprout origin.

11. If planting is necessary in order to establish a new forest on an area which previously supported "littleleafed" trees, shortleaf pine should not be discriminated against in favor of loblolly pine, provided the site is predominately a shortleaf site.

12. If shortleaf pine did not have the ability to sprout, the property owner would probably have a scrub or inferior hardwood occupying the space where the "littleleafed" shortleaf pine is now growing.

13. With absolute fire protection, "littleleaf" will in time practically disappear from the forests of Alabama.

14. Because of several thousand years of burning the woods, first by the Indians and later by the white man, there is a strong possibility that shortleaf pine in the southeastern part of the United States has deteriorated genetically. This species deserves the serious attention of the geneticists. Some indication of the extent of burning the woods by the Indians will be found in an article titled "The Myth of a Natural Prairie Belt in Alabama" by Erhard Rostlund, University of California Berkley, which appeared in the December 1957 issue of Annals of the Association of American Geographers.

15. The vast percentage of shortleaf and loblolly pines that become "littleleafed" are sprout trees.

16. Without exception, the color of the wood in the central region of the root crown of "littleleafed" trees was reddish to yellowish brown. In normal, healthy trees, the color of the wood in this part of the tree is orange or light yellow-brown.

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A P P E N D I X

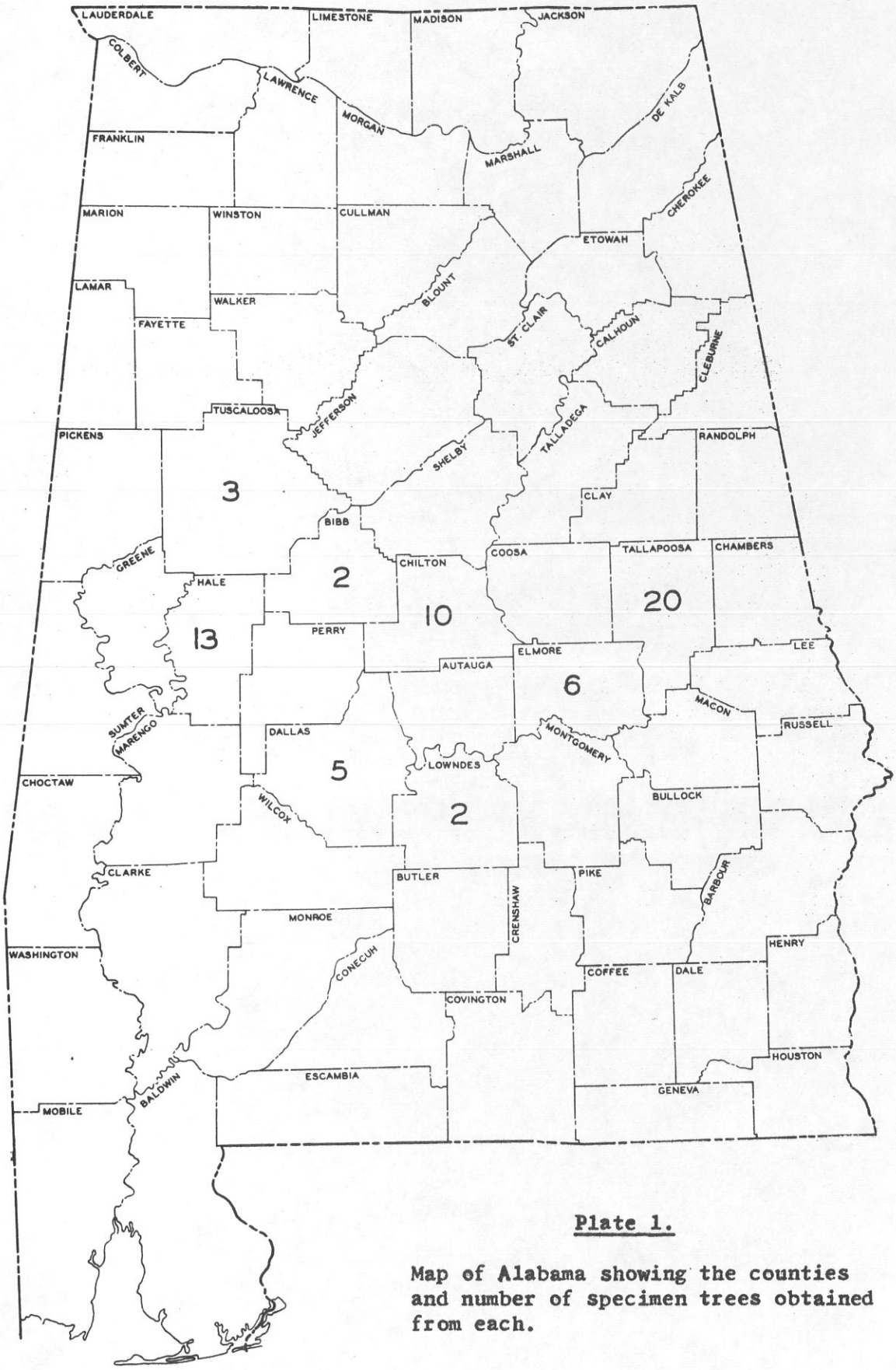

Plate 1.

Map of Alabama showing the counties and number of specimen trees obtained from each.

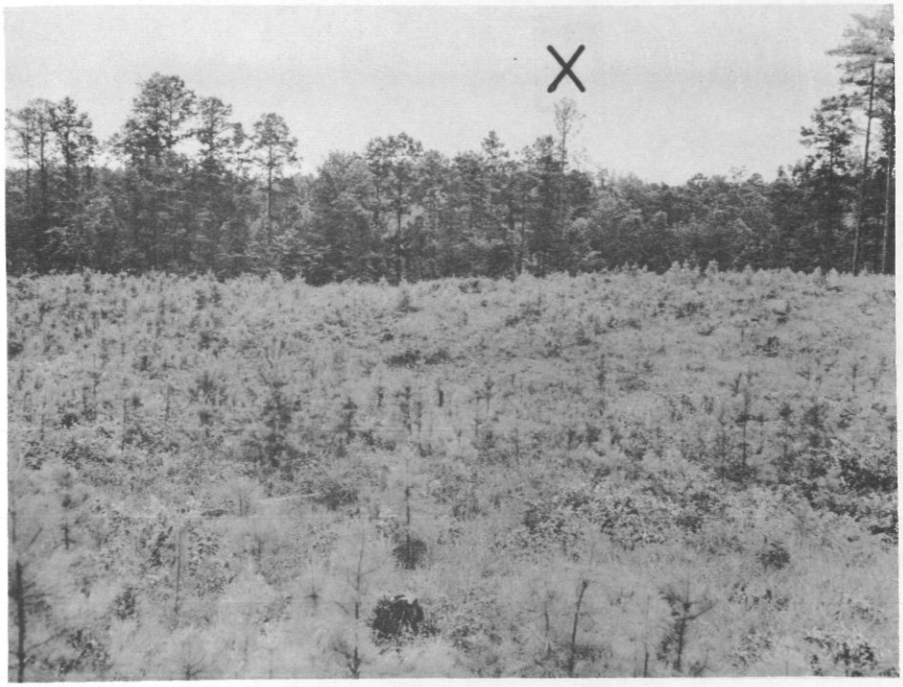

Plate 2.

View of a portion of a 2 acre experimental forest plantation of shortleaf pine on property of Alabama Power Company, Tallapoosa County, Alabama. The area, which supported a natural growth of shortleaf pine - all trees of which showed "littleleaf" symptoms, was clear cut for pulpwood prior to planting. The trees, spaced 4' x 4' and 5' x 5', were planted in January 1951. Photographed September 17, 1955, by Thomas E. McKinney. Average height 4 feet. Survival 97%. Note "littleleafed" shortleaf pine tree marked X in the background.

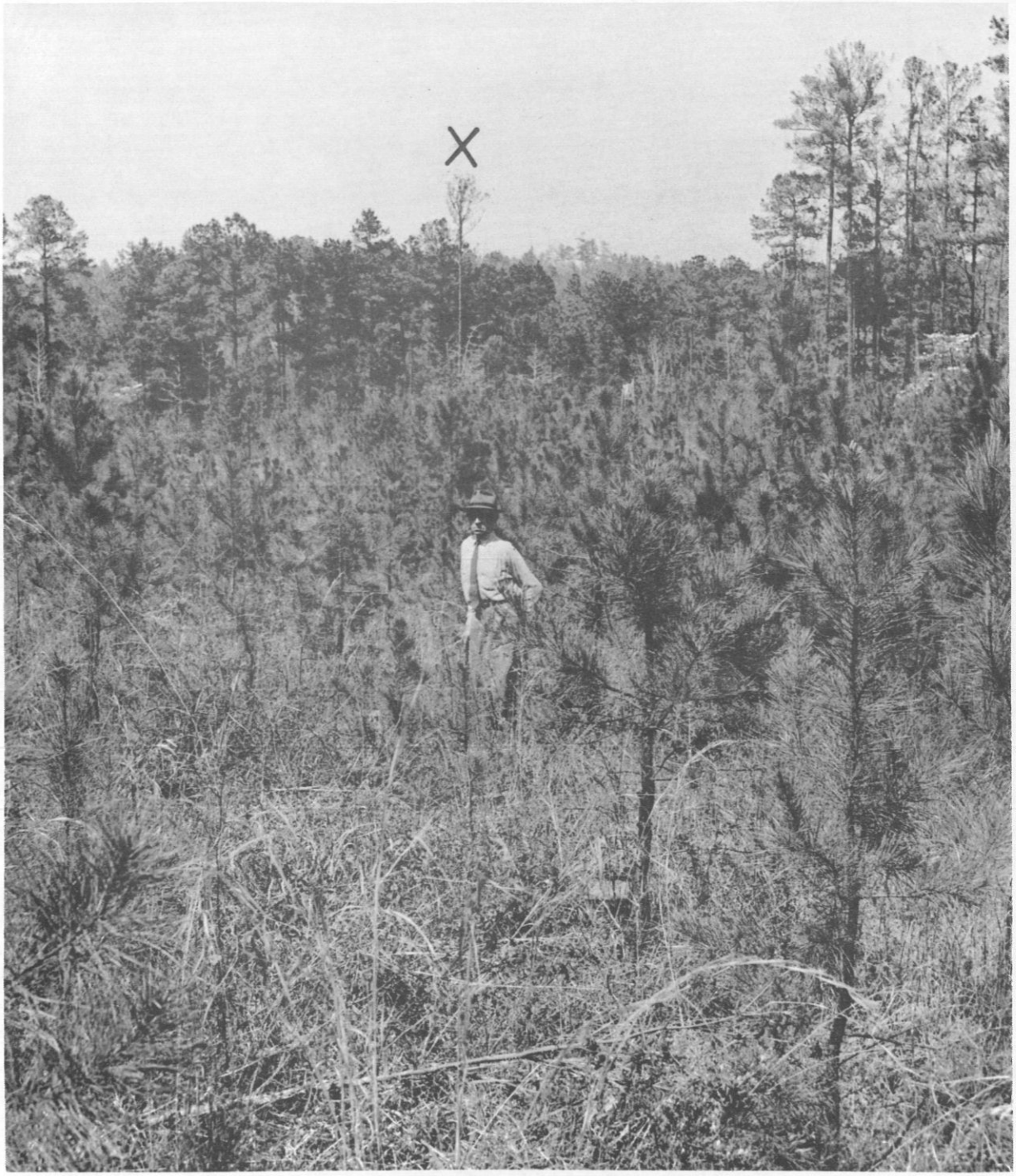

Plate 3.

View of the northeastern portion of the 2 acre experimental forest plantation of shortleaf pine shown in Plate 2. Photographed April 18, 1958, by Thomas E. McKinney from about the same spot. Note "littleleafed" tree marked X in the background. Young planted trees appear healthy in all respects.

Plate 4.

View of a portion of a 2 acre experimental forest plantation of shortleaf pine on property of Alabama Power Company, Tallapoosa County, Alabama. This is the same planting as shown in Plate 2 except on this portion of the plot the trees are spaced 6' x 6'. The average height of the trees is 5.1 feet. Survival is 97%. Note "littleleafed" shortleaf pine in the background and the snag directly back of District Forester Hugh Coker. Photographed September 17, 1955, by Thomas E. McKinney.

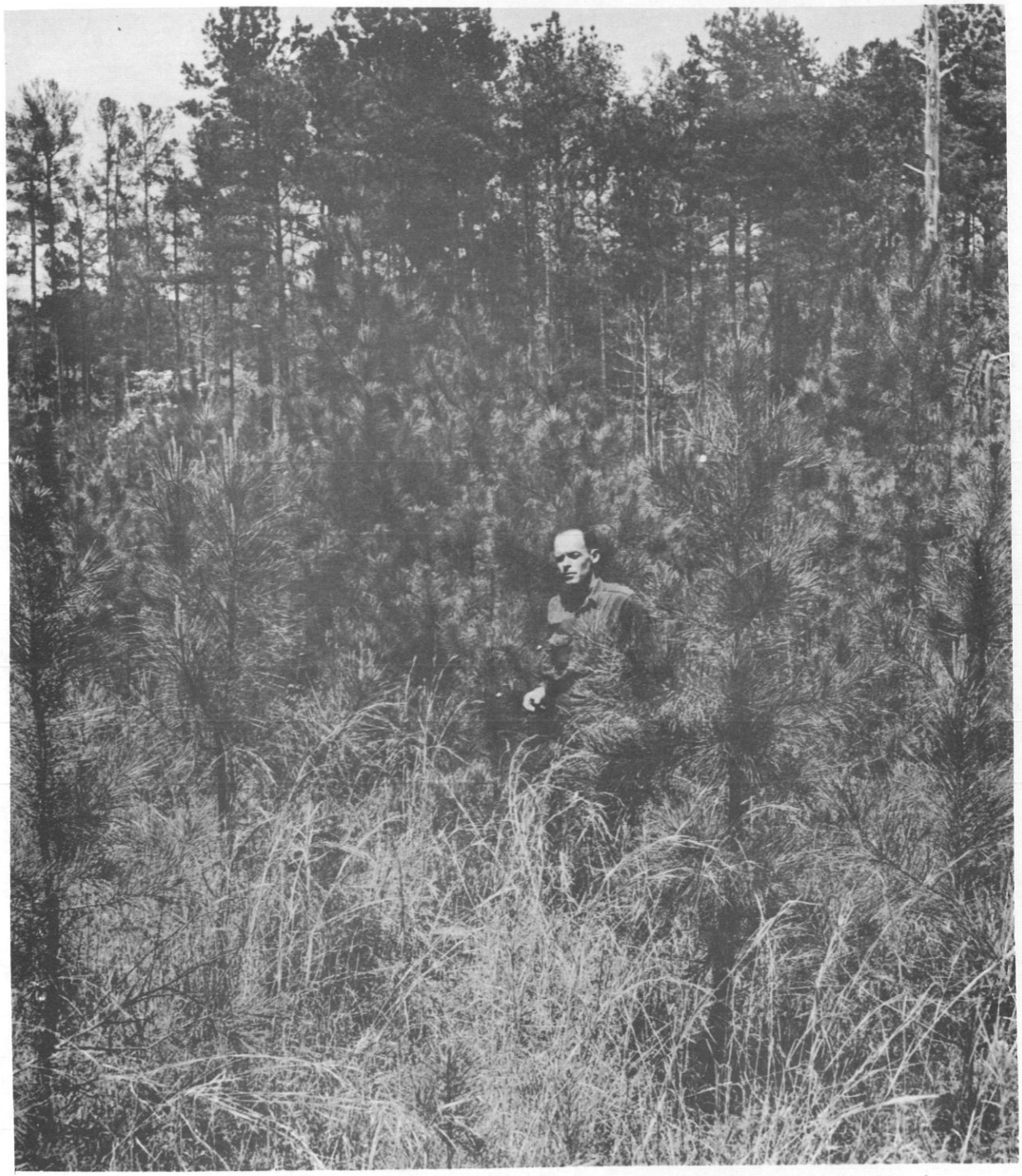

Plate 5.

View of a portion of the 2 acre experimental forest plantation of shortleaf pine on property of Alabama Power Company, Tallapoosa County, Alabama. Photographed April 18, 1958, by Thomas E. McKinney from about the same spot as Plate 4. Trees spaced 6' x 6'. The snag appearing on the right edge of the photograph is the same one that is back of District Forester Coker on Plate 4. Young planted trees appear healthy in all respects.

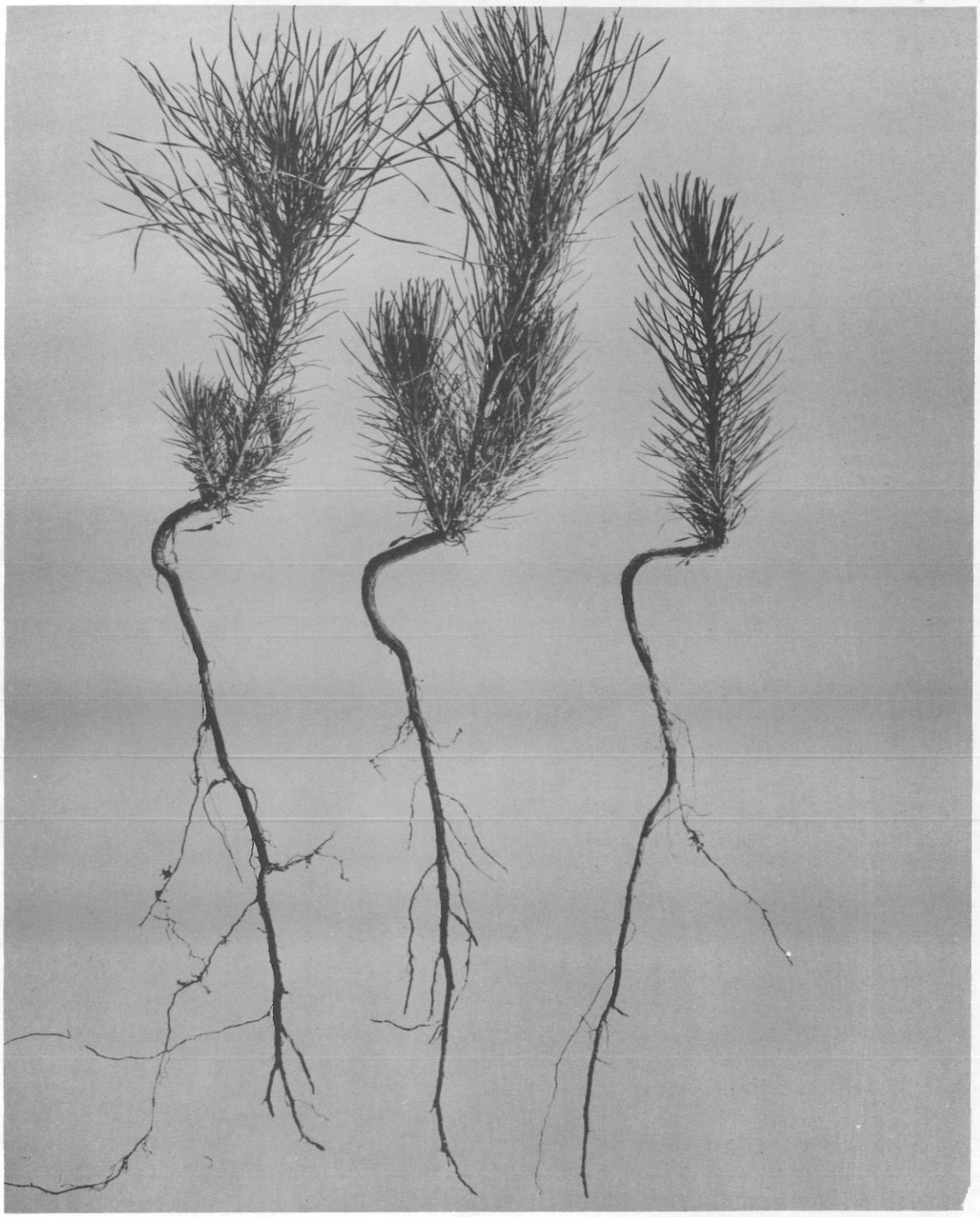

Figure 1.

View of nursery grown seedlings of shortleaf pine, (Pinus echinata (Mill.), almost four months old. The bends or crooks in the stem are peculiar to shortleaf pine. Note the location of the branches at the tip of the horizontal stem. They are from buds that developed in the axils of the lowest primary leaves.

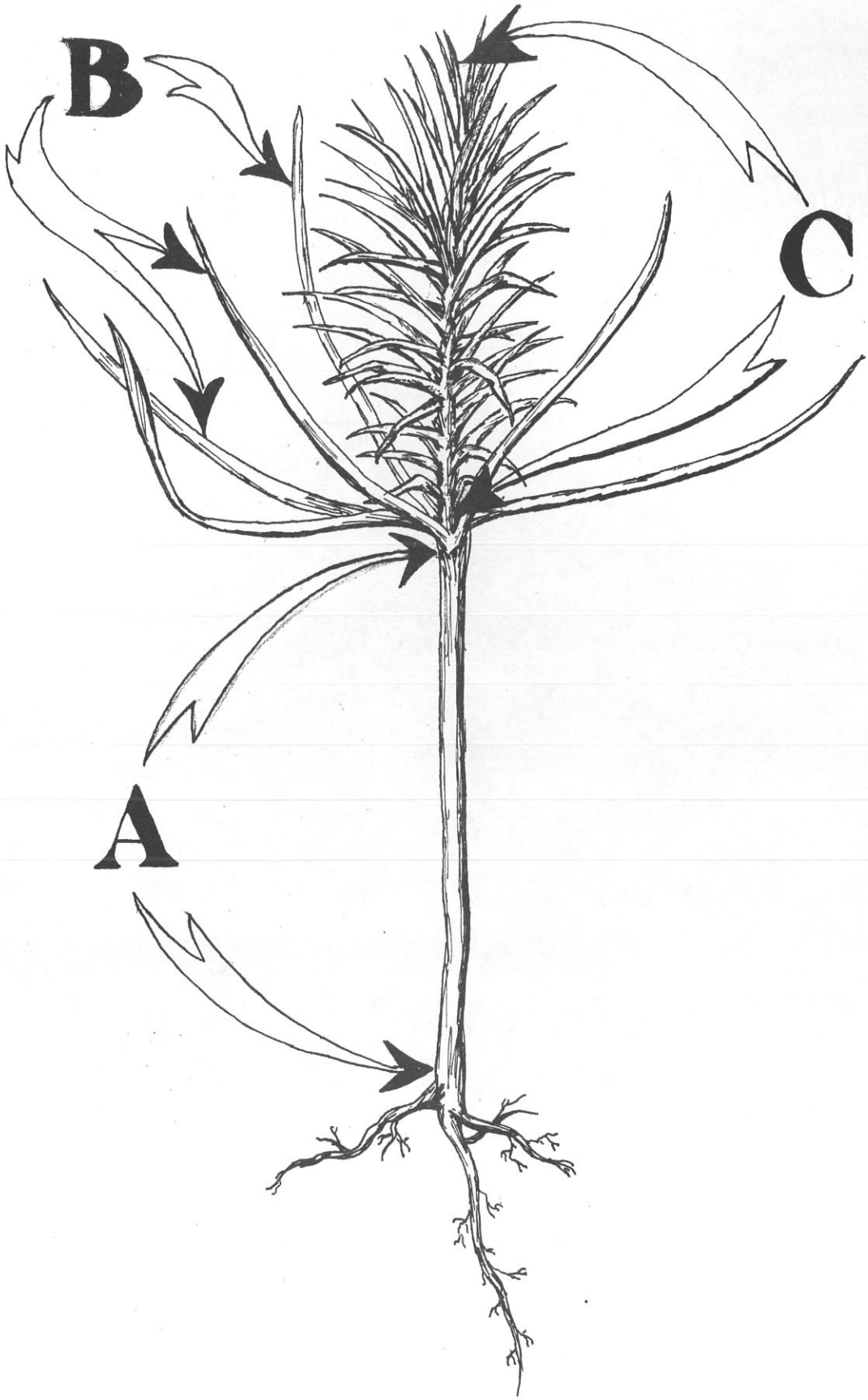

Figure 2.

A diagramatic drawing of a young shortleaf pine seedling: A, hypocotyl; B, cotyledons; C, second growth with primary leaves which are the first foliage leaves.

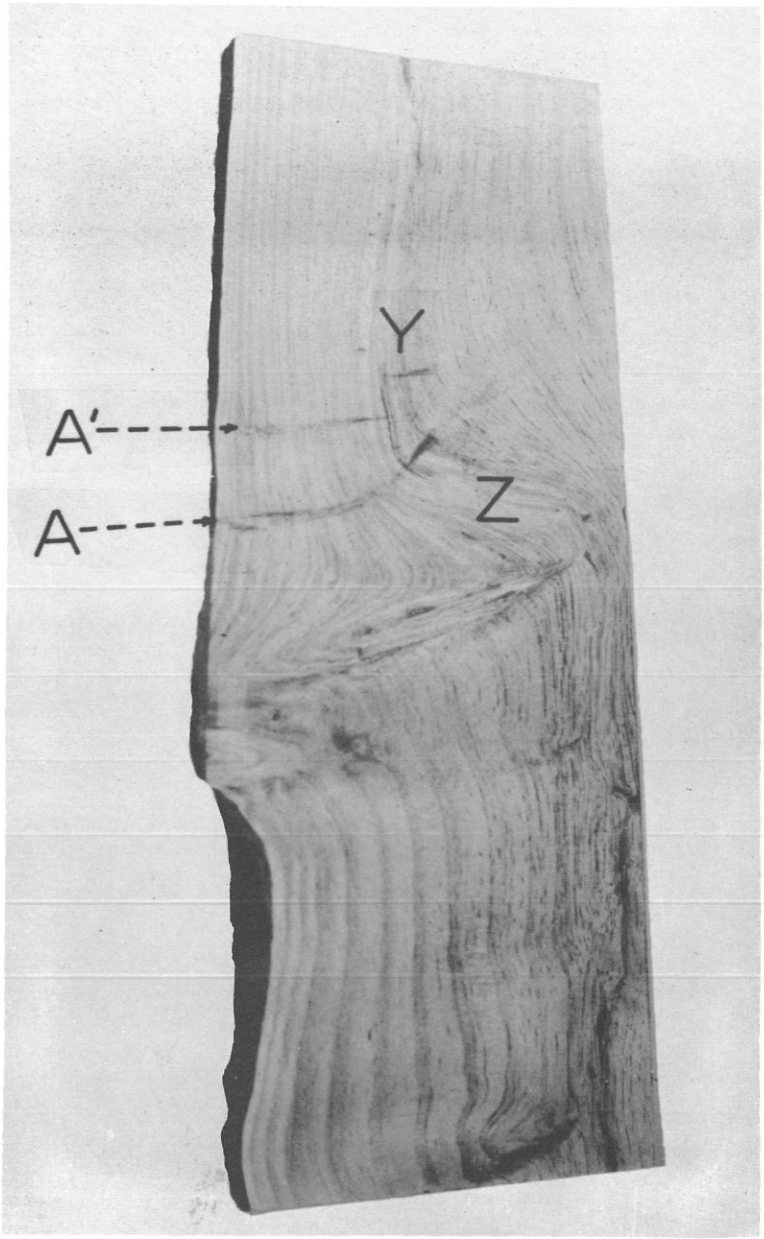

Figure 3.

Photograph of a midlongitudinal section of the root crown of Specimen Tree No. 20, a shortleaf pine about 20 years old, to show horizontal part Z and bends that were derived from the seedlings as seen in Figure 1.; traces of dormant buds at A and A'; Y indicates center of stem.

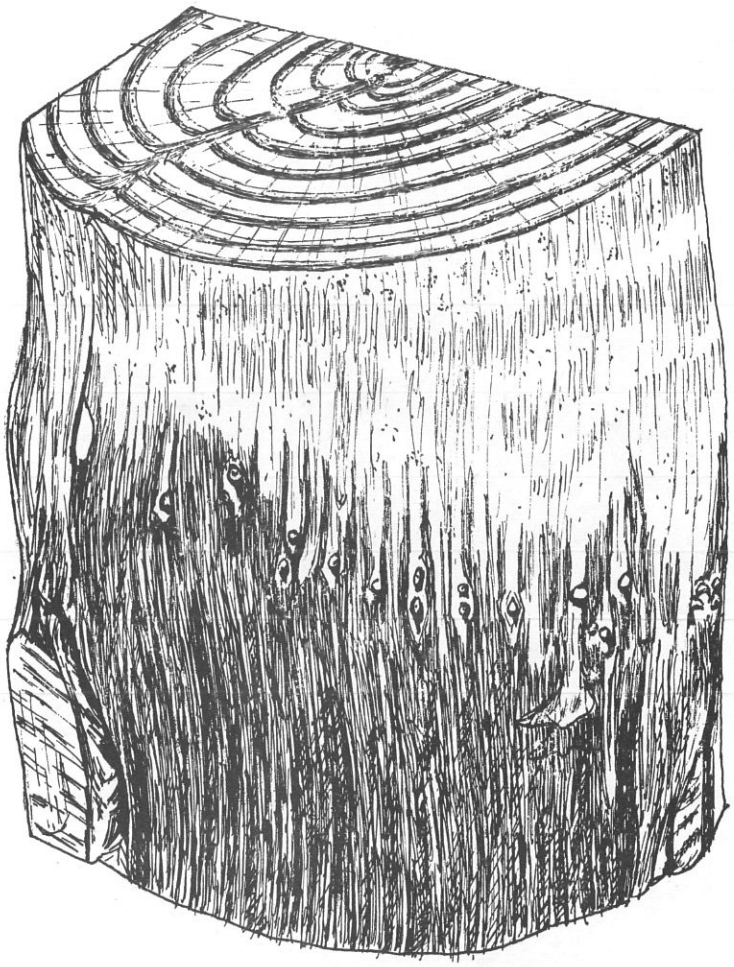

Figure 3A.

Drawing of the bark side of Specimen Tree No. 20, photograph of which is designated Figure 3, to show the apices of dormant buds and their arrangement.

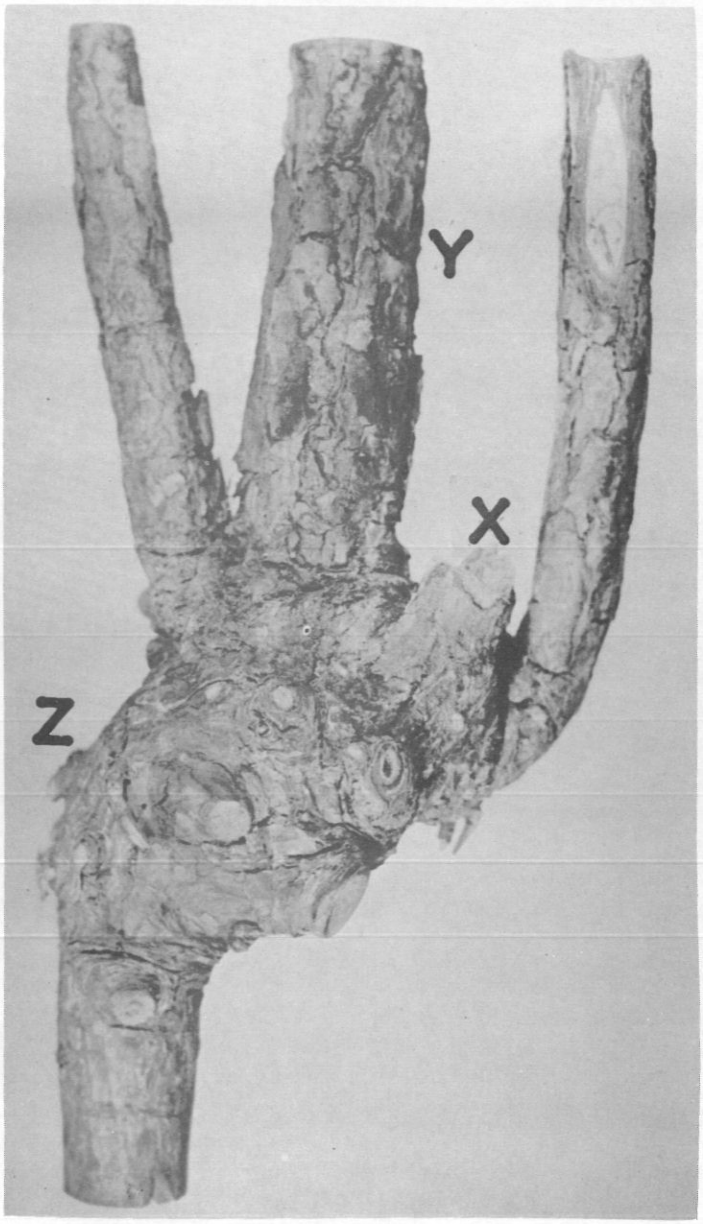

Figure 4.

Photograph of the basal part of a young shortleaf pine, Specimen Tree No. 43, that had been hit by at least two fires. X indicates the stub of what seems to be the first or primary stem which was about 4 years old when killed; Y is the stub of a sprout about 4 years old when killed. The development of two sprout stems followed. They were living when taken down and were 4 years old. Z is the part of the tree derived from the horizontal stem of the seedling tree. This part of the tree was approximately 12 years old at the time the tree was excavated. About 3/4 natural size.

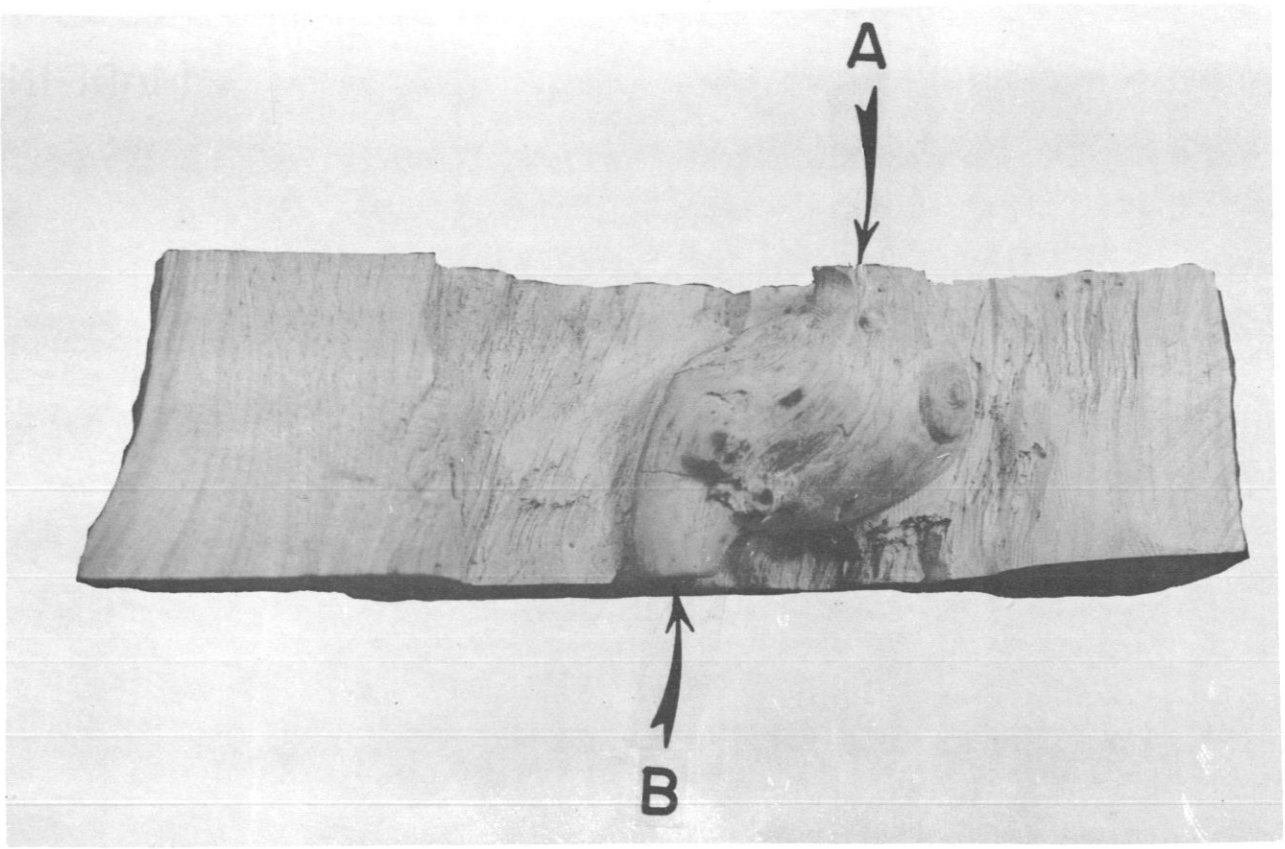

Figure 5.

View of the central region of section 3-3 from Specimen Tree No. 4, shortleaf pine, to show the growth derived from the horizontal stem of the seedling and how it was engulfed in the tree. The horizontal stem was very carefully dissected from the tree. A, vertical stem; B, tap root. About 4/5 natural size.

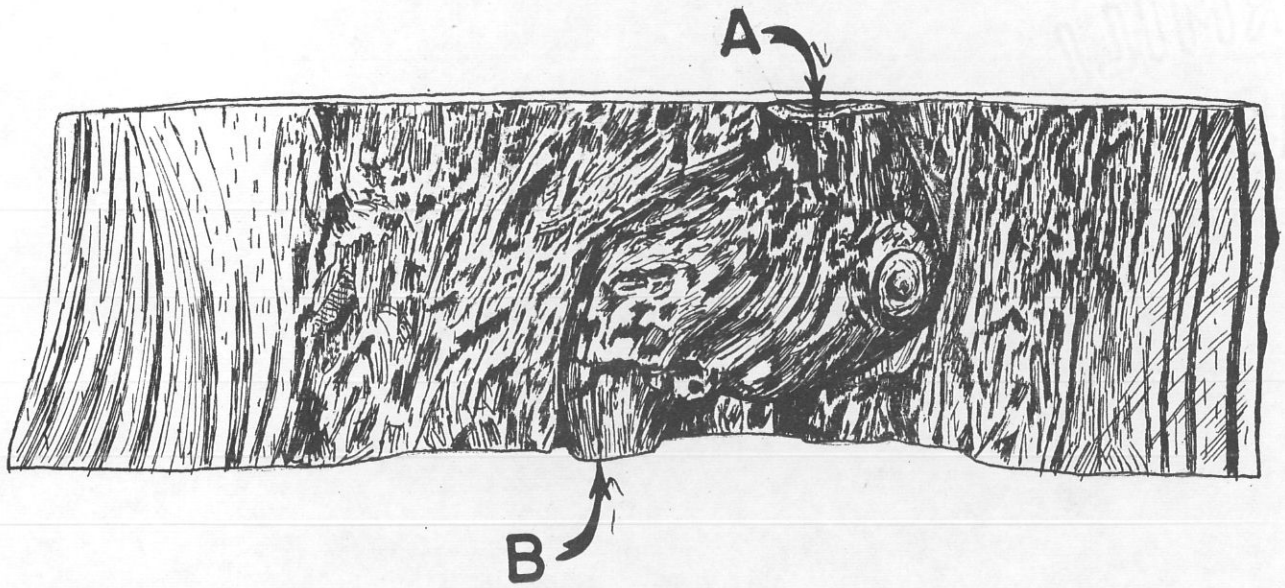

Figure 5A.

Drawing of section 3-3 from Specimen Tree No. 4, shortleaf pine, to show more clearly than does the photograph (Figure 5) the growth derived from the horizontal stem of the seedling and how it was engulfed in the tree. A, vertical stem; B, tap root. About 7/8 natural size.

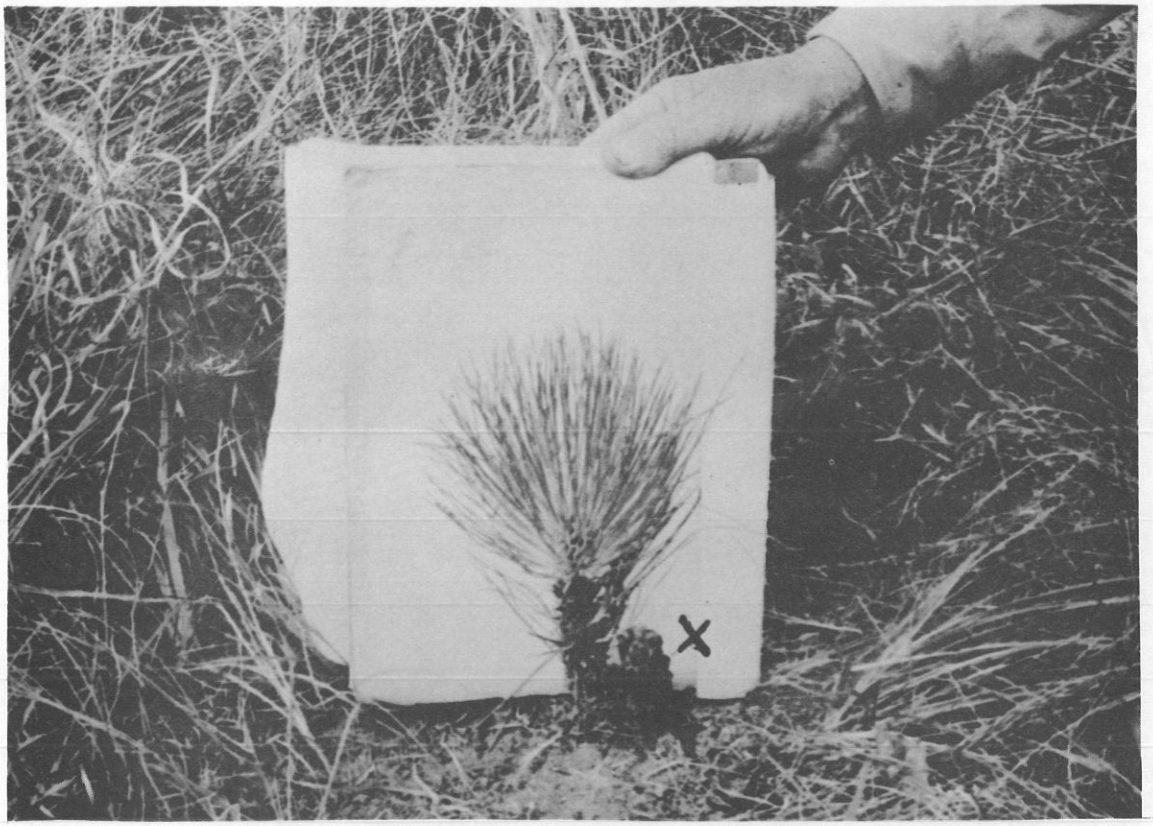

Figure 6.

View of a longleaf pine tree that was planted in January 1949 in Conecuh County, Alabama. It was burned in 1951 and a sprout developed. X indicates stub of primary stem. Photographed May 10, 1956, by District Forester Alvin Downing.

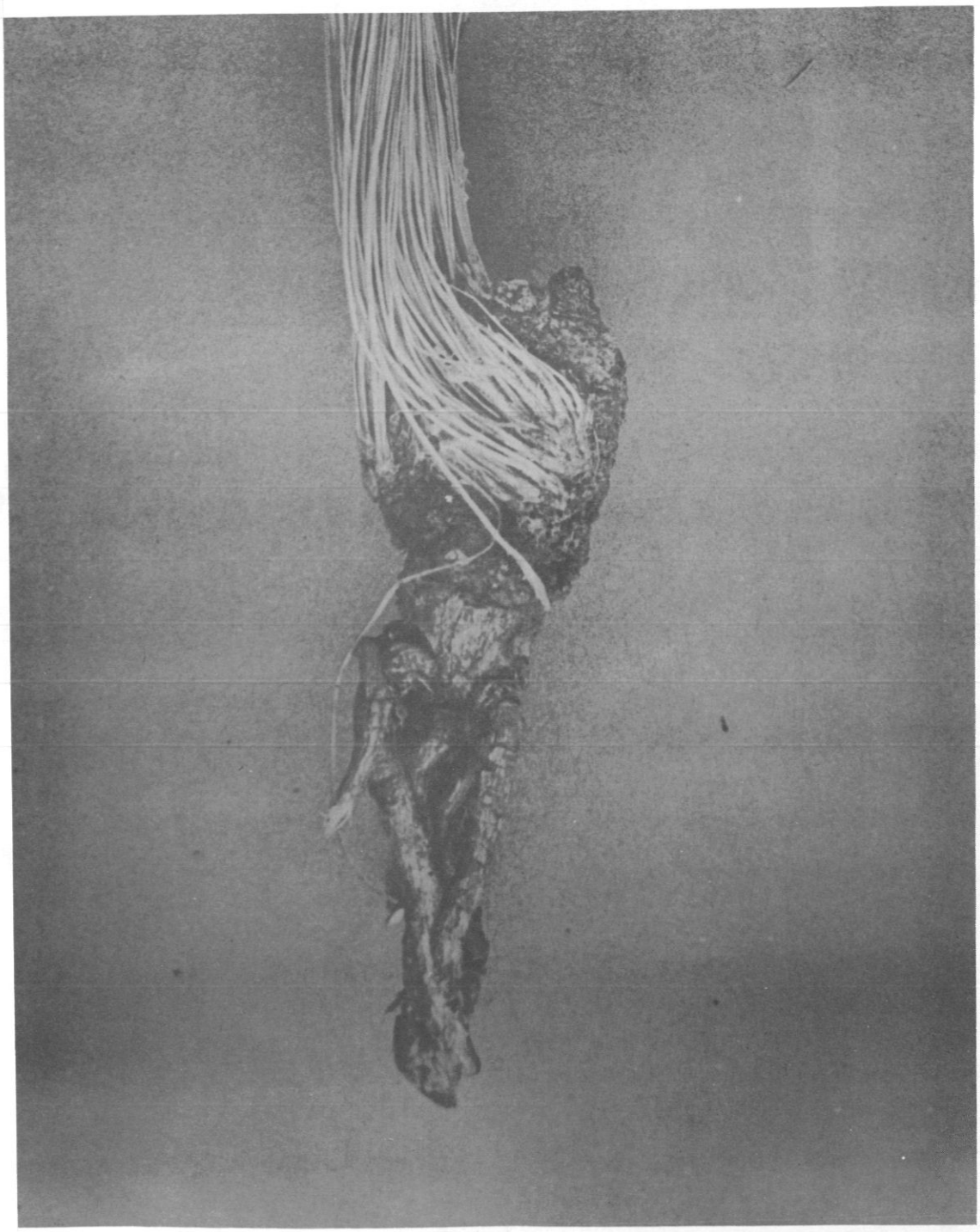

Figure 7.

View of a naturally seeded longleaf pine 2 years after the upper part of the stem was killed by fire. About 3/4 natural size.

Figure 8.

View of the lower portion of the trunk of a slash pine tree that was a 1 year old seedling when planted in Escambia County, Alabama, in January 1949. Soon after it was planted, (within approximately 15 days) the top of the seedling was nipped off by deer. The present tree is of secondary origin. It developed from a small branch or bud that originated in the axil of a primary leaf. Note the slight bend at the base of the bole. Photographed May 7, 1956, by District Forester Alvin Downing. About 1/8 natural size.

Figure 9.

View of section 1-2, Specimen Tree No. 25, shortleaf pine, cut about 2½ inches above the surface of the ground from a tree at least 50 years old that was of sprout origin and in the advanced stages of "littleleaf". The center was dark reddish brown in color which was a continuation of a similar color in the root crown and tap root. The normal color of the heartwood of shortleaf pine is orange or light yellow-brown. Note the width of the first two annual rings and those that were last formed.

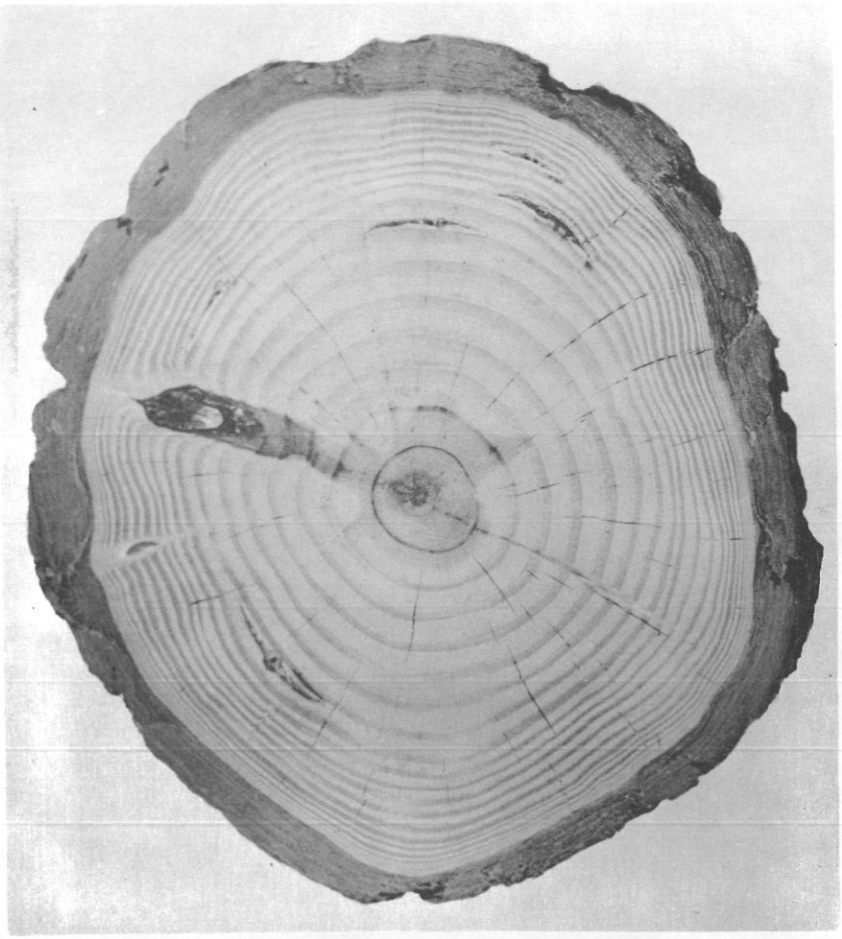

Figure 10.

View of section 1-3, cut just above the surface of the ground, from Specimen Tree No. 23, shortleaf pine, that was a sprout tree about 28 years old and in the advanced stages of "littleleaf". The tree was hit by at least 4 fires. The first fire occurred when the tree was quite young, the second fire about the 9th year, the third fire about the 11th year and the fourth fire about the 14th year. Note the effect of fire upon the rate of growth and the width of the outermost and innermost annual rings.

Figure 11.

View of section 1-2 that was cut midway through the basal part of the stem and root crown of Specimen Tree No. 37, shortleaf pine. The tree was of sprout origin and about seven years old. At X is the stub of the partially decayed basal part of what appears to be the primary vertical stem which was being engulfed in the tree.

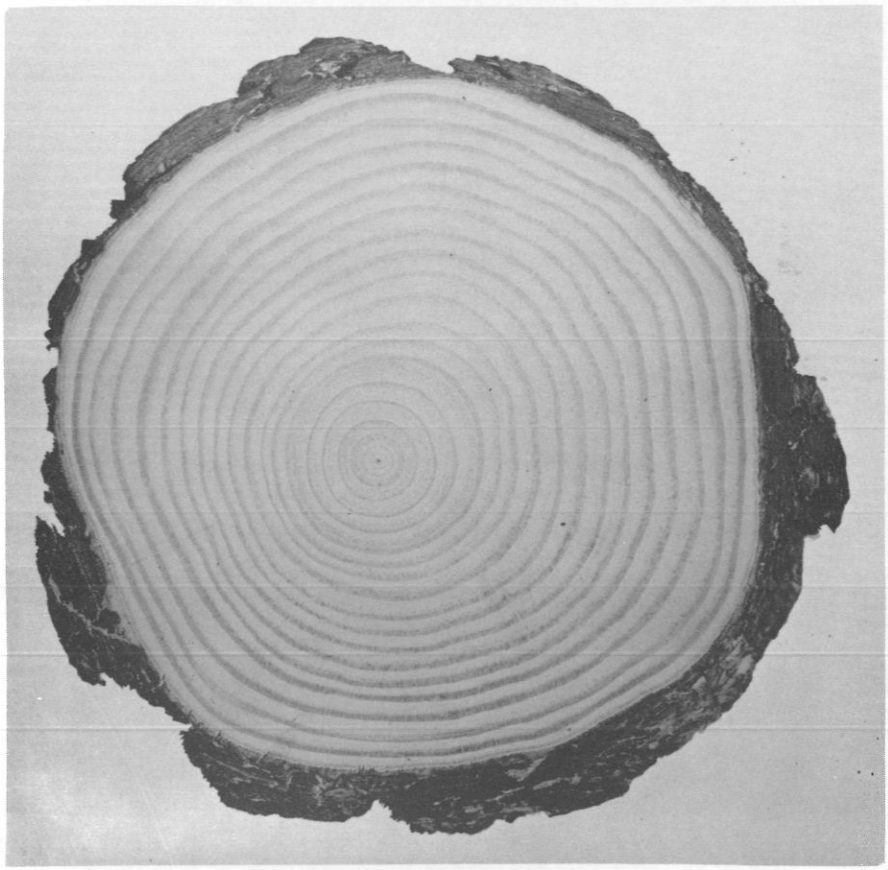

Figure 12.

View of section 1-3, Specimen Tree No. 17, shortleaf pine, that was cut just above the surface of the ground. The tree was about 23 years old and had developed directly from the seed. The tree did not have "littleleaf" symptoms. Compare Figure 12 with Figure 10. Specimen Tree No. 17 grew approximately 50 feet from Specimen Tree No. 23.

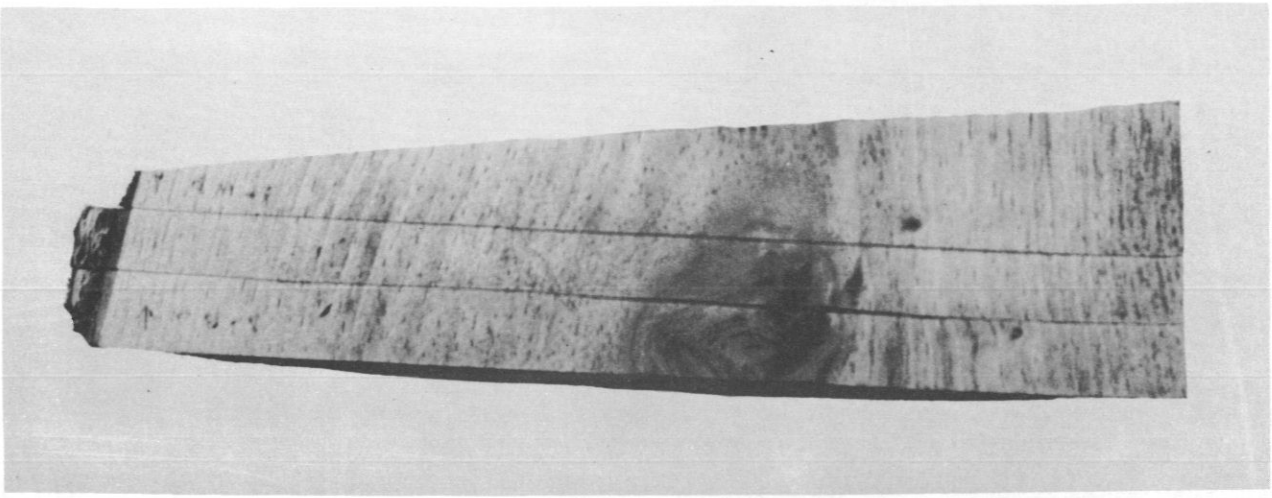

Figure 13.

View of section 3-8, Specimen Tree No. 6, shortleaf pine. The longitudinal cut is about midway of the root crown. The darker colored part seemed to be charred while the surrounding wood was dark reddish brown in color. This color extended down into the central region of the tap root. Specimen Tree No. 6 was of sprout origin and was "littleleafed". Section 3-8 was sent to the U. S. Forest Products Laboratory where it was cut into three parts to facilitate examination by that agency's wood technologist.

Figure 14.

View of section 5-8, Specimen Tree No. 6, that was cut below section 3-8 to show the dark colored center of the tap root which was reddish brown when the section was cut. With age, the color faded to some extent.

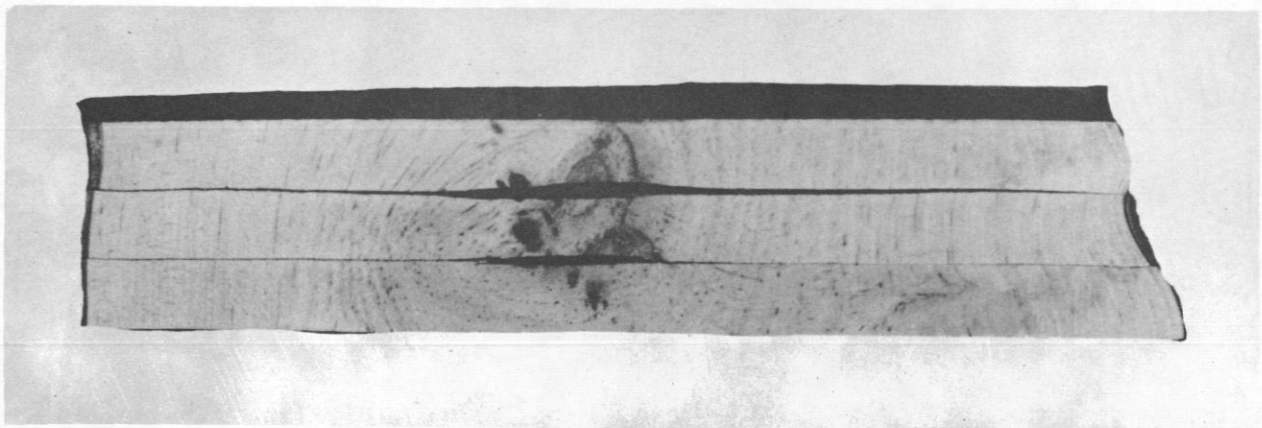

Figure 15.

View of section 4-5, Specimen Tree No. 9, shortleaf pine. The longitudinal cut is across the horizontal part of the primary stem. The black and reddish brown color of the wood in the central part of the section indicates that the tree was injured when quite young. The tree was in the early stage of "littleleaf". Section 4-5 was sent to the U. S. Forest Products Laboratory where it was cross-sectioned for further study.

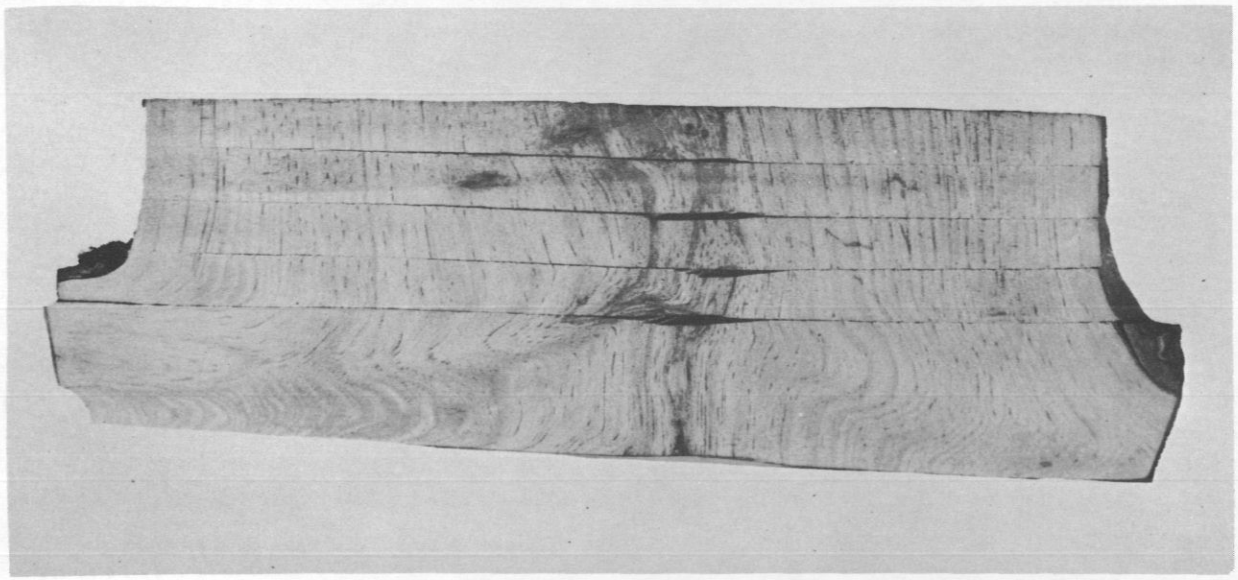

Figure 16.

View of section 3-4, Specimen Tree No. 10, shortleaf pine, about 30 years old that appeared to be in the early stage of "littleleaf". Judging from the dark reddish brown color of the central region of the root crown, the tree was injured when quite young. Section 3-4 was sent to the U. S. Forest Products Laboratory where it was cross-sectioned.

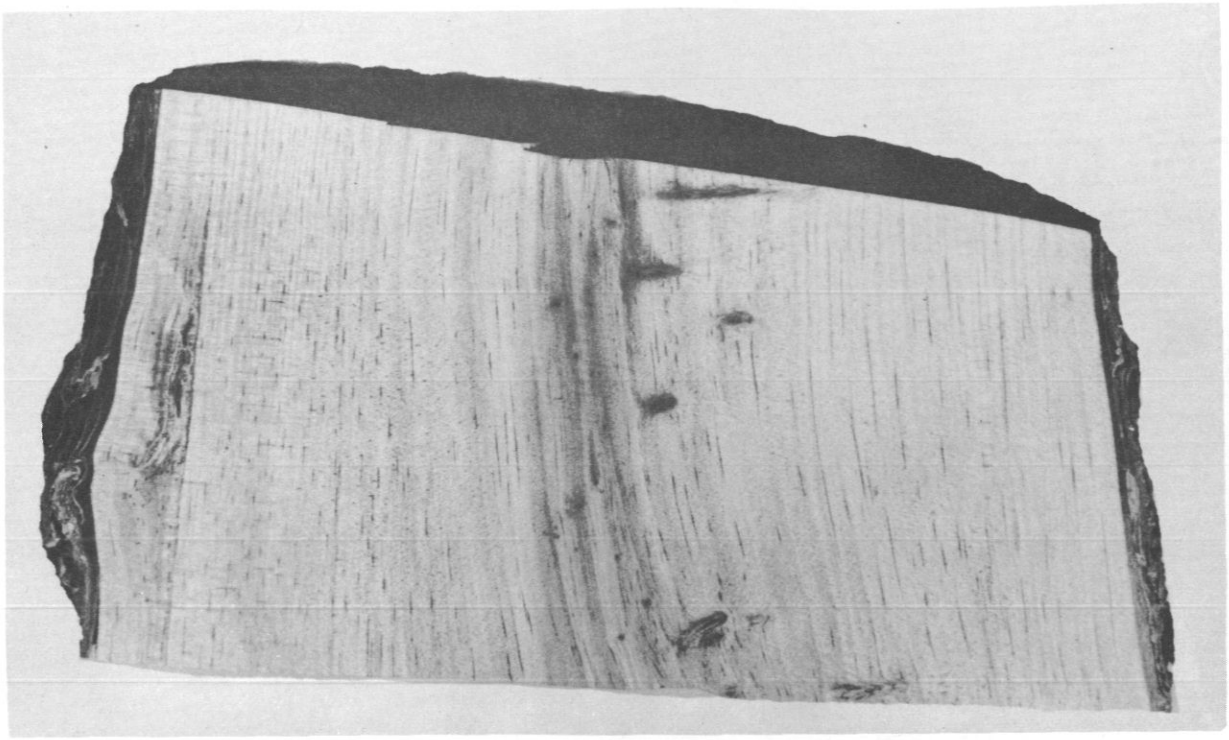

Figure 17.

View of section 2-4, Specimen Tree No. 10, shortleaf pine, cut just below the surface of the ground. The dark central region which was reddish brown in color is a continuation of a similar color in the center of the root crown and the tap root. See Figure 16. The reddish brown color has faded with age.

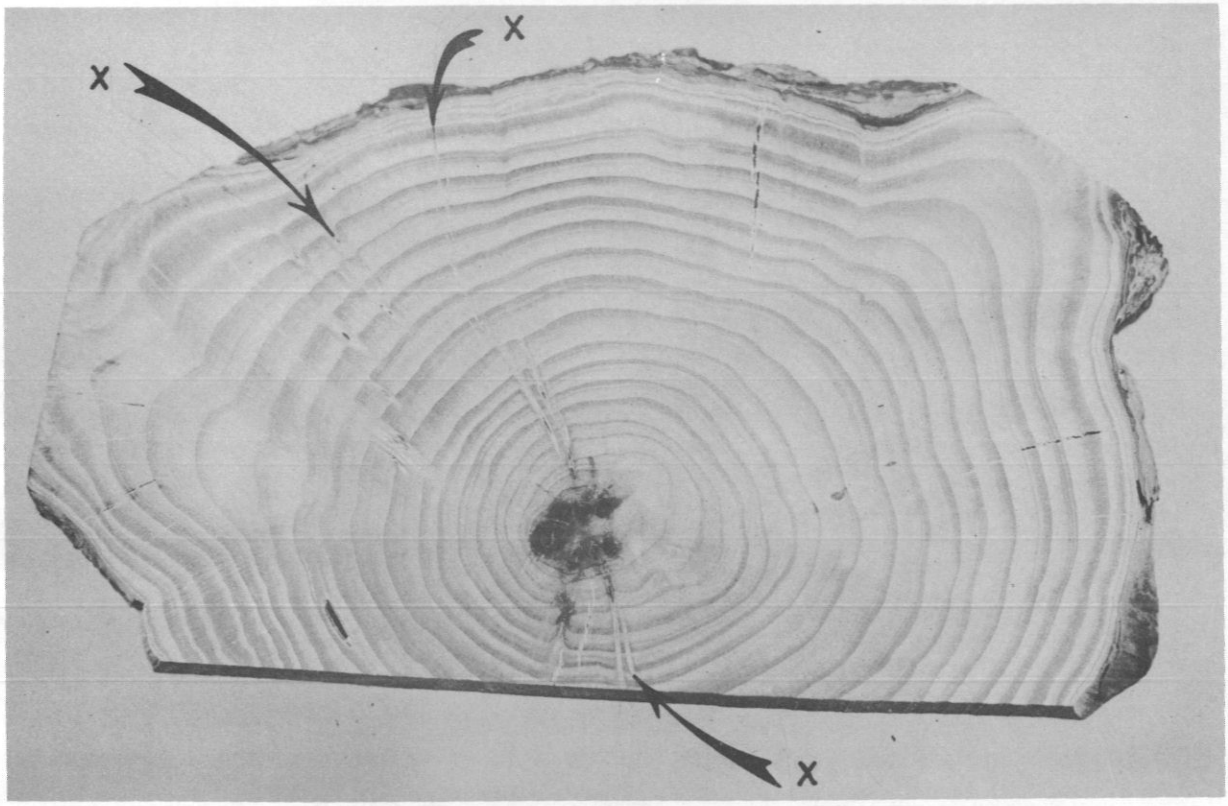

Figure 18.

View of section 3-3 from Specimen Tree No. 12, shortleaf pine. The tree was of sprout origin about 30 years old and was "littleleafed". Section 3-3 was cut from that part of the root crown that was 3 to 4 inches below the surface of the ground. The black center of this section represents the charred remains of a number of stems. Note traces of dormant buds at X. About 1/2 natural size.

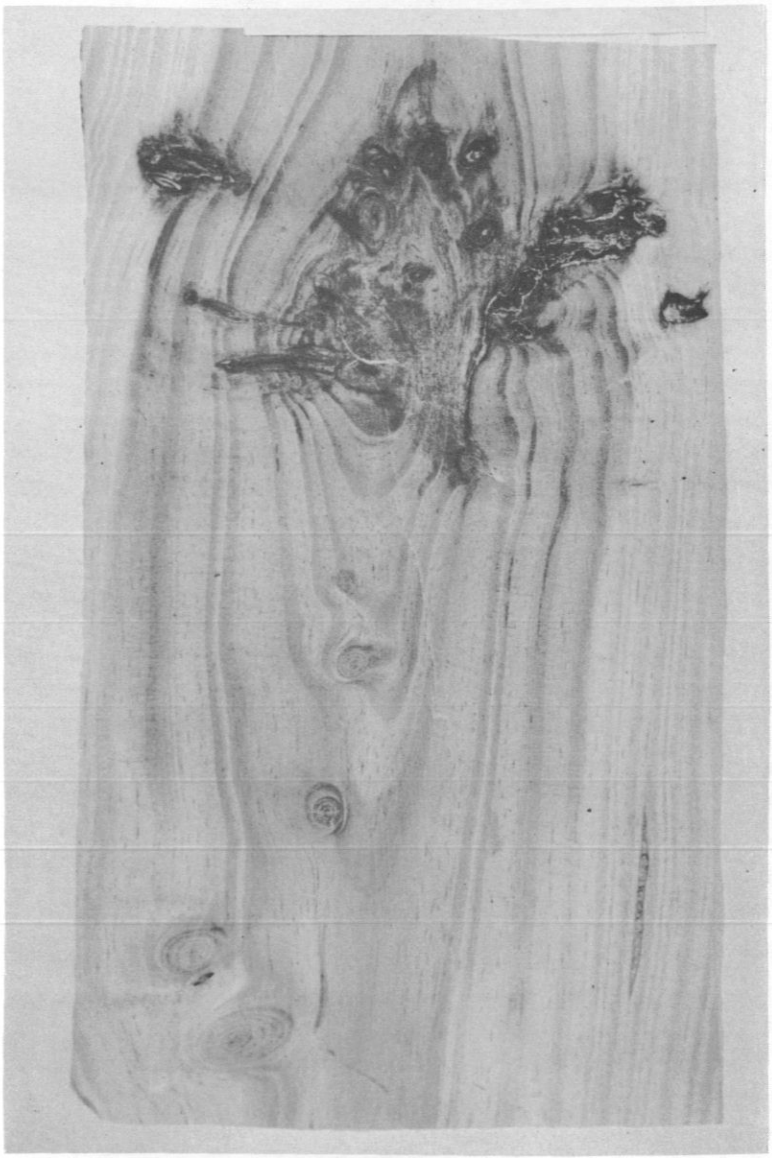

Figure 19.

View of section 3-3, Specimen Tree No. 27, a shortleaf pine about 50 years old that had "littleleaf". The black areas indicate the charred remnants of stems. The dark gray portion was reddish brown when the section was cut. This color is typical of trees that are "littleleafed" and are of sprout origin. There was no external indication that the tree had been burned. About 7/8 natural size.

Figure 20.

View of section 1-3, Specimen Tree No. 32, shortleaf pine, about 65 years old with symptoms of "littleleaf". The tree was hit by at least four different fires. X, the stump of a small tree; Z, the stump of another small tree; XY, a cut across the horizontal stem. Specimen Tree No. 32 was a sprout.

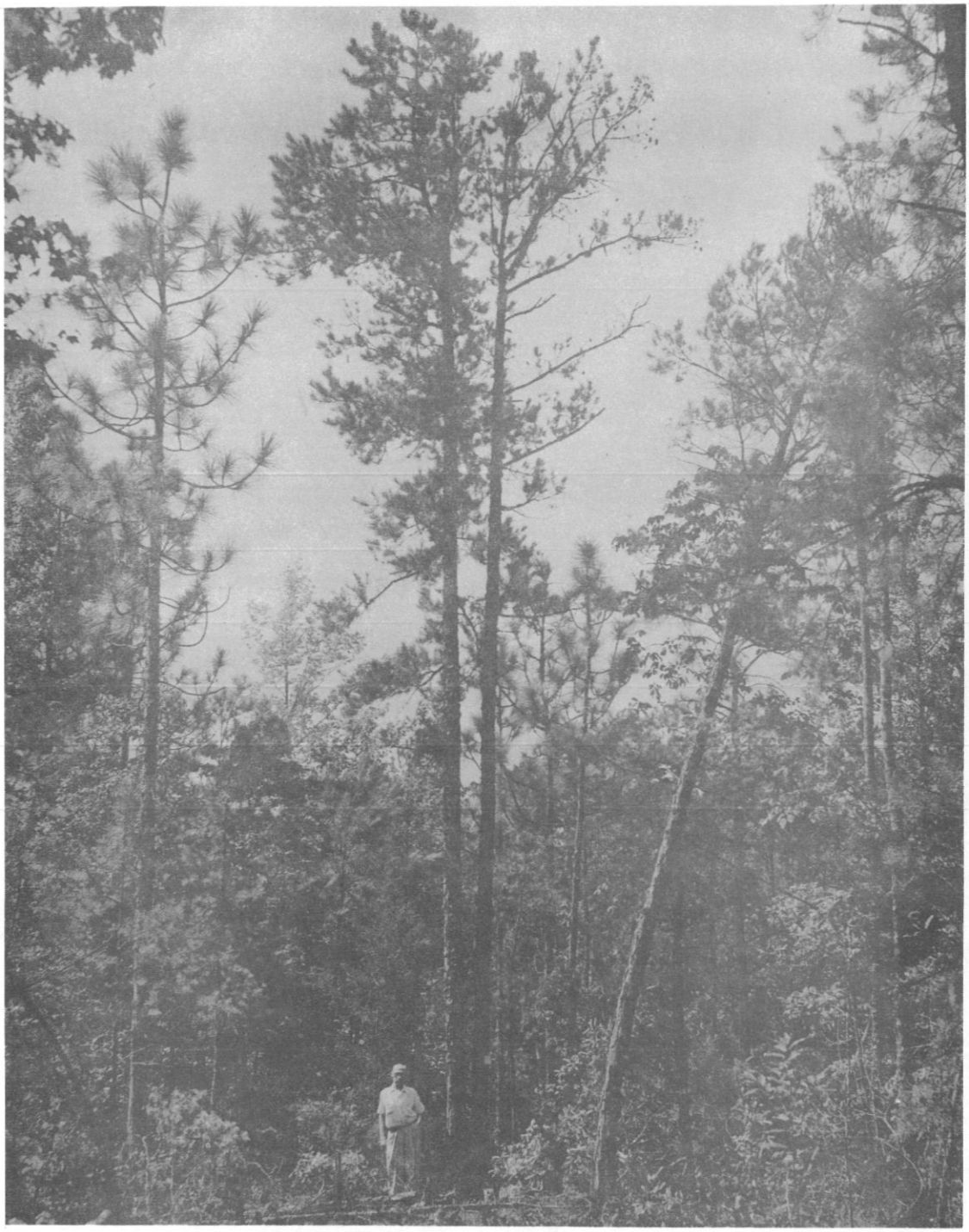

Figure 21.

View of twin shortleaf pine trees, Specimen Trees No. 48 and No. 49; Tree No. 49 on the right was 46 feet in height, 7.3" d.b.h. outside bark, and was "littleleafed"; Tree No. 48 on the left was 48 feet in height, 8.6" d.b.h. outside bark, and appeared to be healthy. The trees, which grew near Weoka, Elmore County, Alabama, were discovered by Charles Walsh in February 1956 and were photographed September 5, 1956, by Thomas E. McKinney.

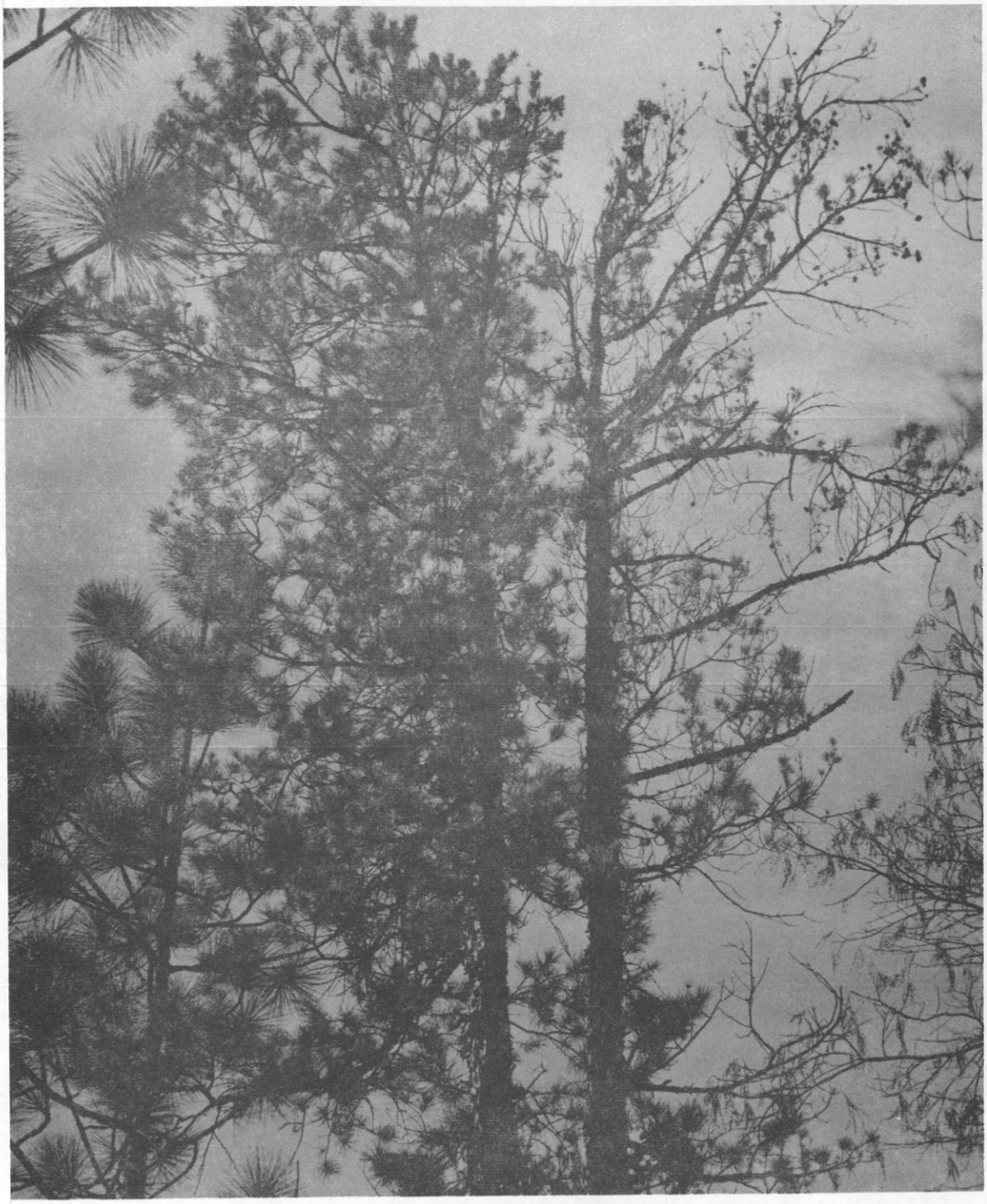

Figure 22.

View of the crowns of twin shortleaf pine trees, Specimen Trees No. 48 and No. 49. (See Figure 21.)

Figure 23.

View of the base of twin shortleaf pine trees, Specimen Trees No. 48 and No. 49 (see Figure 21.), showing their complete union for approximately 10 inches above the surface of the ground. Tree No. 49 ("littleleafed") on the right. Photographed September 5, 1956, by Thomas E. McKinney.

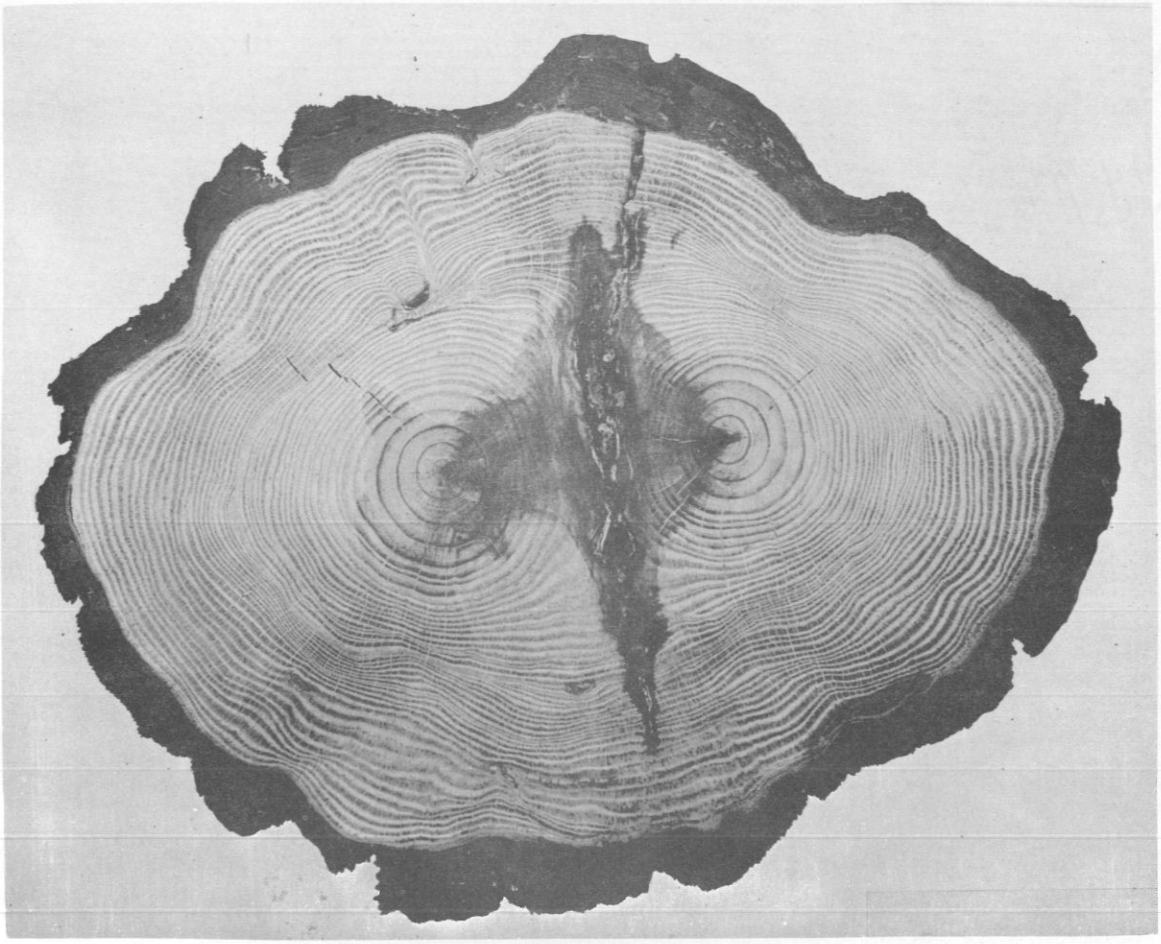

Figure 24.

View of a cross section, cut at the surface of the ground, of twin shortleaf pine trees, Specimen Trees No. 48 and No. 49 (see Figure 21.), showing union. Note the early rapid growth of both stems. Tree No. 49 on the right. Slightly less than 1/3 natural size.

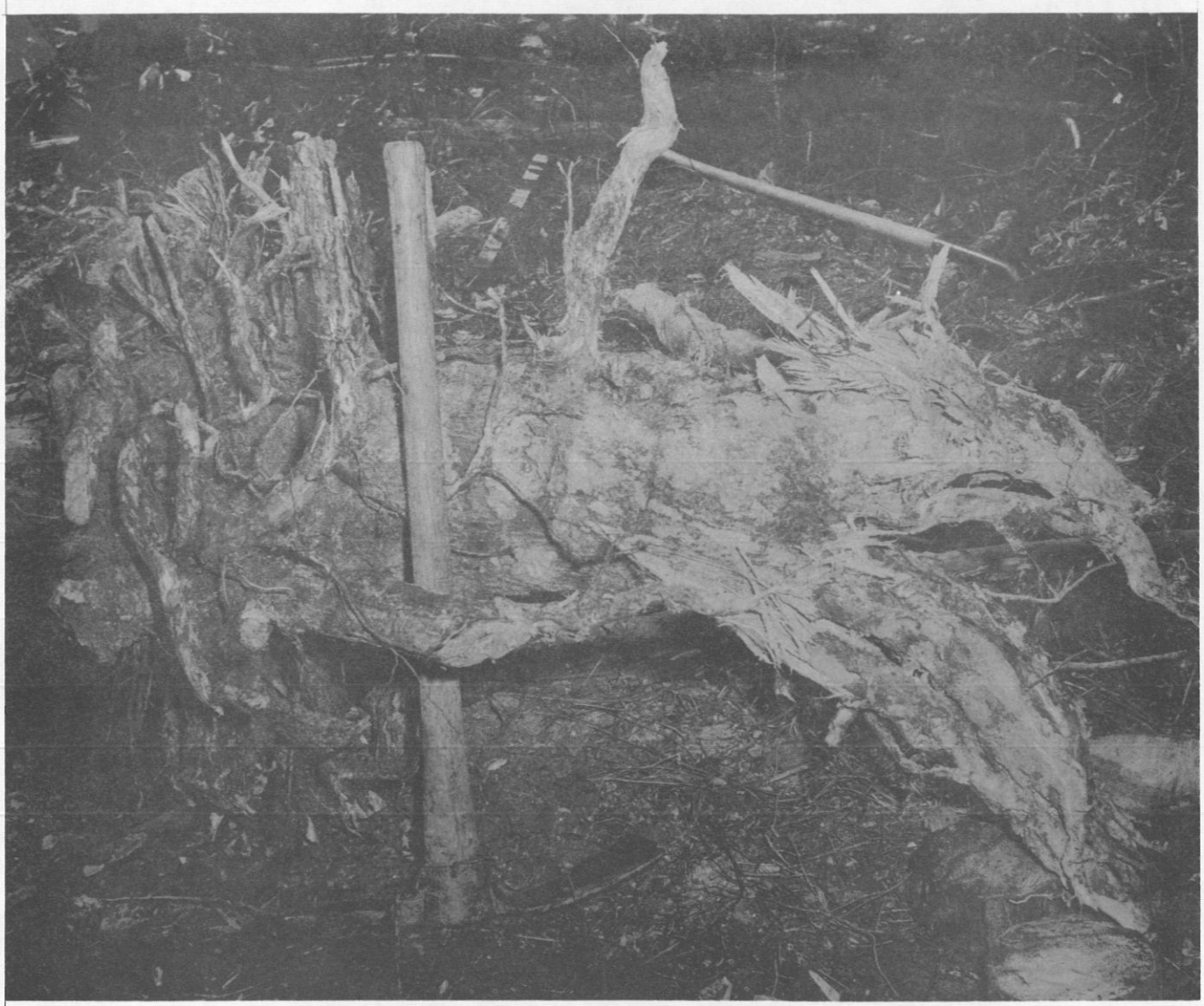

Figure 25.

View of the tap root of twin shortleaf pine trees, Specimen Trees No. 48 and No. 49 (see Figure 21.) taken from the side of healthy Tree No. 48. Note the abundance of roots contrasted with Tree No. 49 as shown in Figure 26. Photographed September 5, 1956, by Thomas E. McKinney.

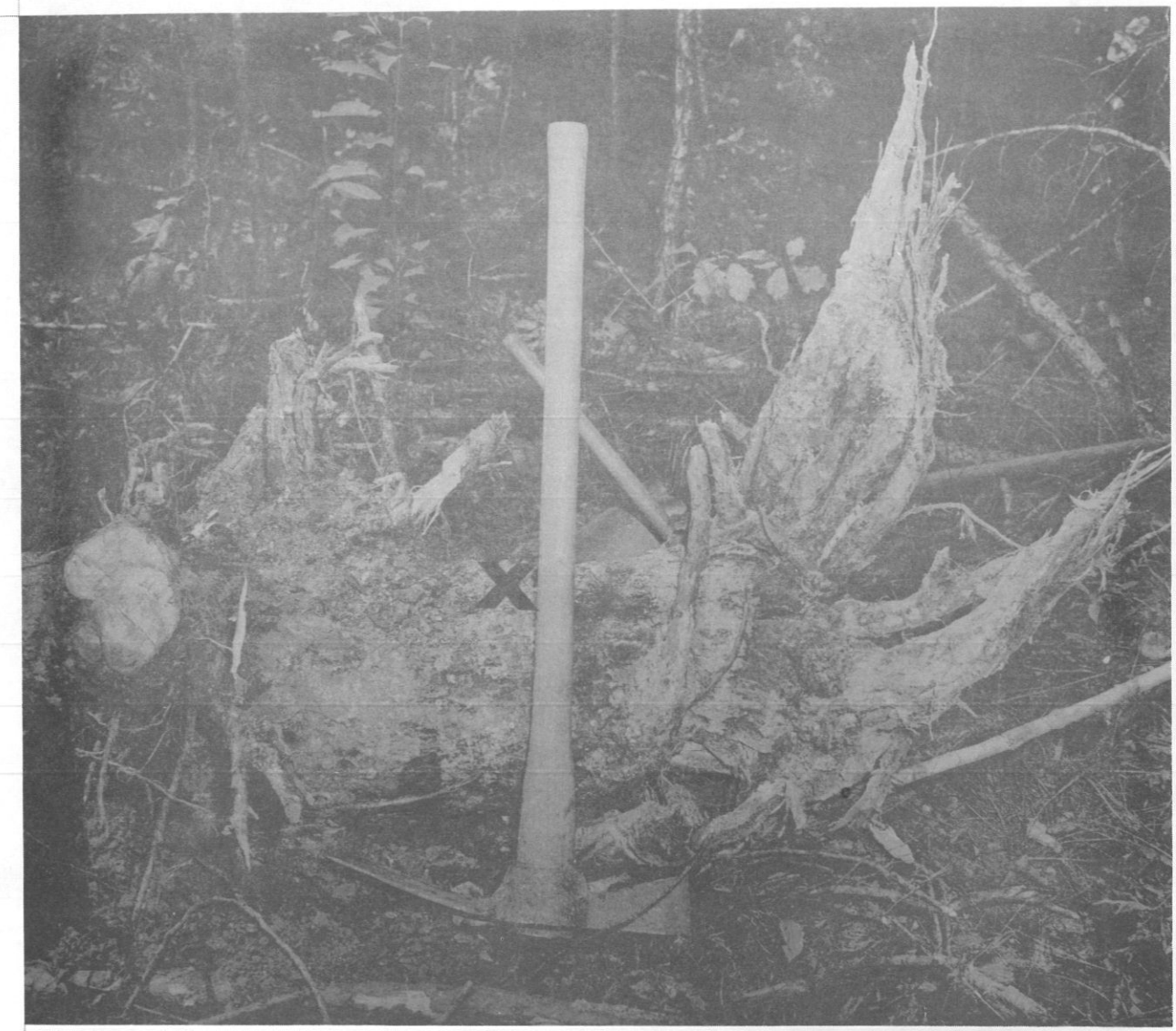

Figure 26.

View of the tap root of twin shortleaf pine trees, Specimen Trees No. 48 and No. 49 (see Figure 21.) taken from the side of "littleleafed" Tree No. 49. Note the paucity of roots as contrasted with the side of Tree No. 48 as shown in Figure 25. Photographed September 5, 1956, by Thomas E. McKinney.

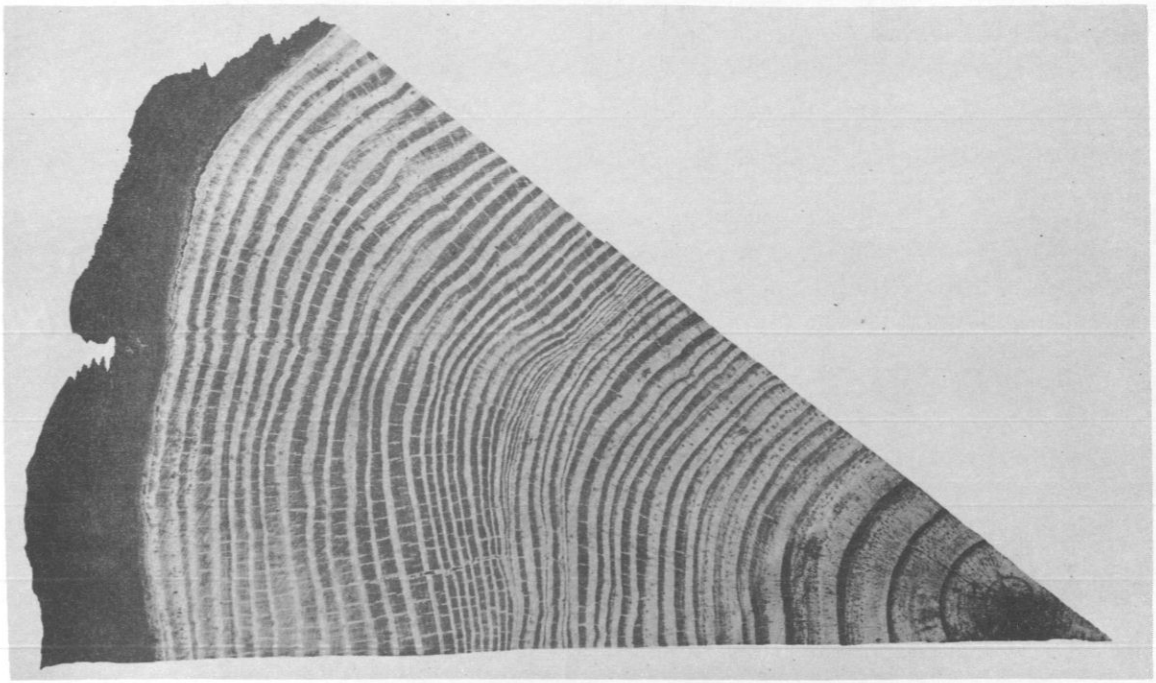

Figure 27.

View of a sector of the section of Specimen Tree No. 48 (see Figure 24 for full section). Note the width of the 1956 annual ring and compare with the width of the 1956 annual ring of Specimen Tree No. 49 as shown in Figure 28. Also, compare the first five annual rings of Specimen Trees No. 48 and No. 49.

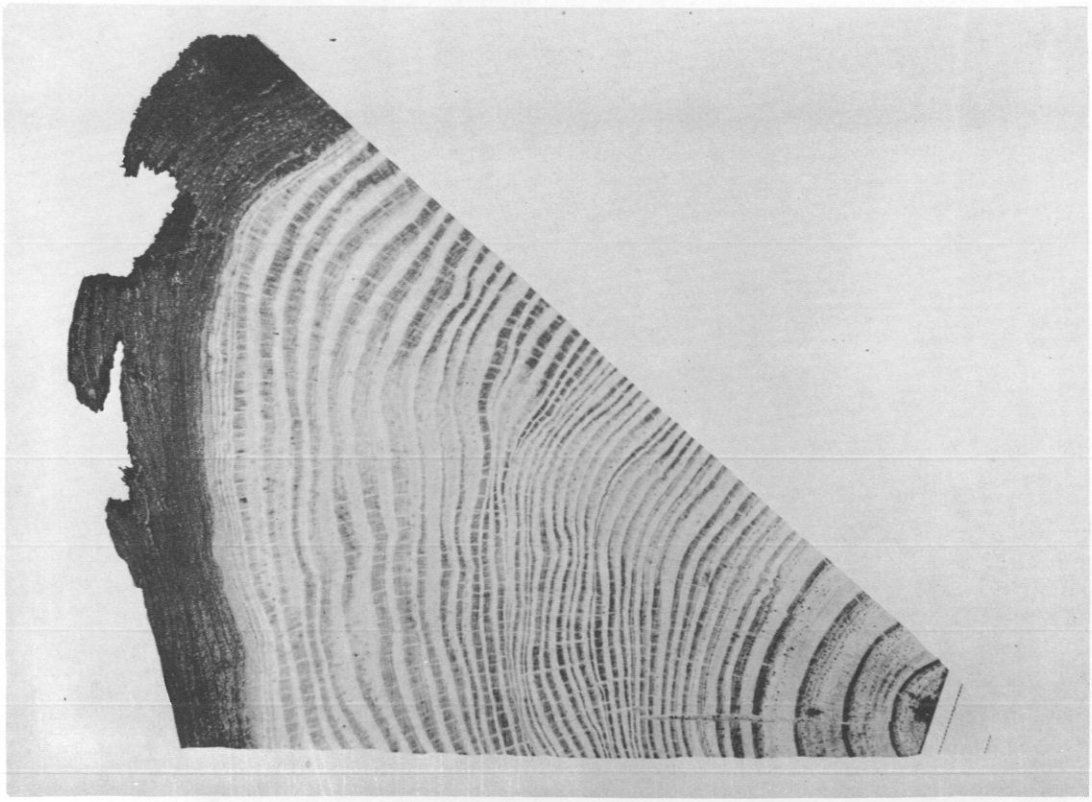

Figure 28.

View of a sector of the section of Specimen Tree No. 49 (see Figure 24 for full section). Note the width of the five outermost annual rings and compare with Specimen Tree No. 48 as shown in Figure 27.

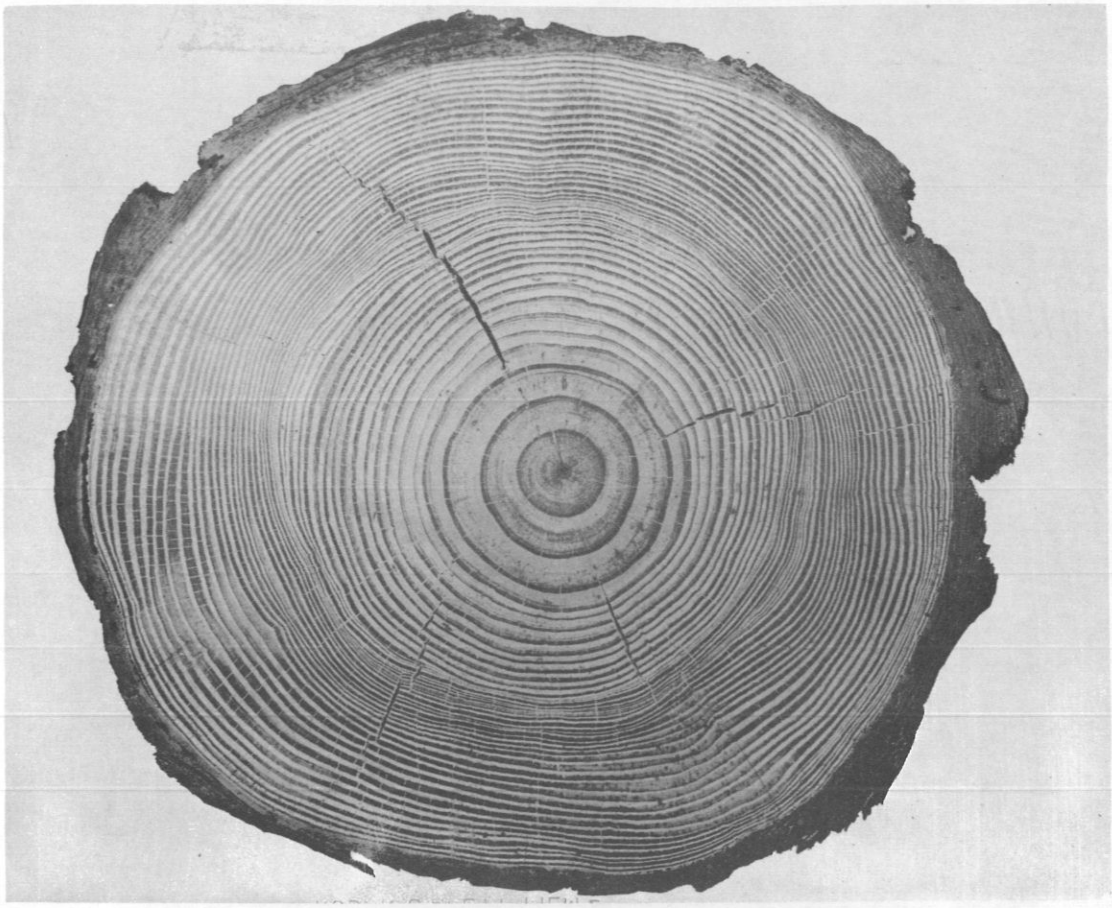

Figure 29.

View of a cross-section of the main stem of Specimen Tree No. 48, five feet above the surface of the ground. About 1/2 natural size.

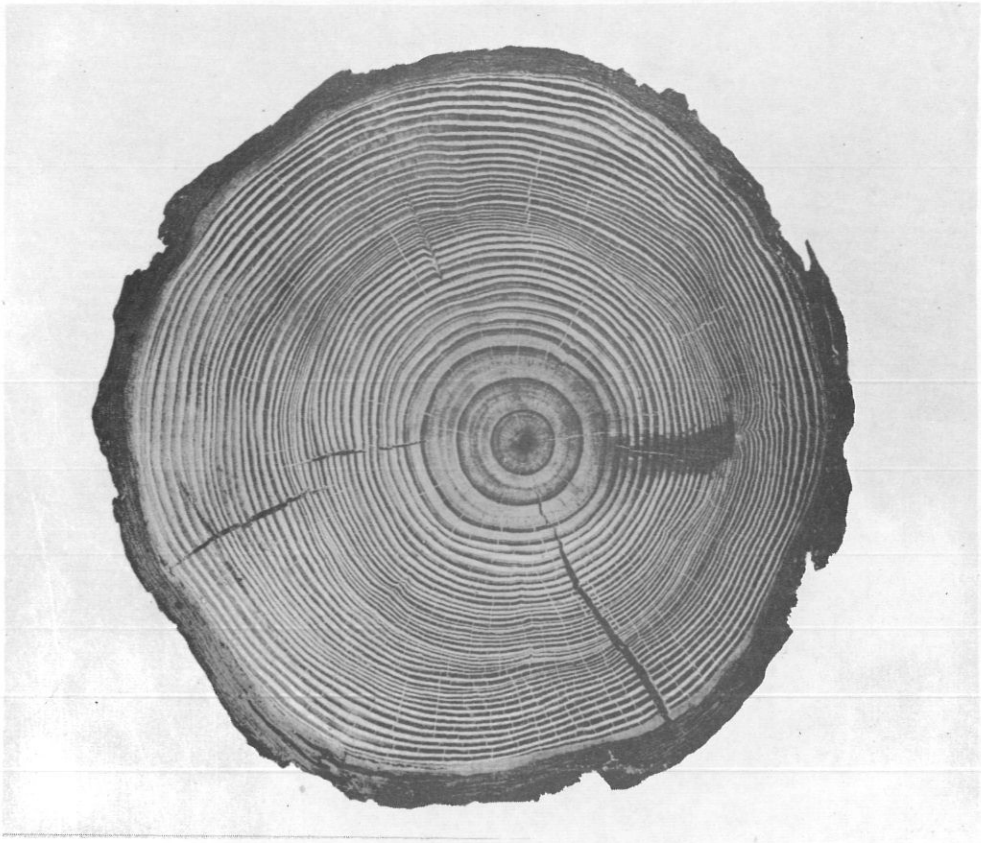

Figure 30.

View of a cross section of the main stem of Specimen Tree No. 49, five feet above the surface of the ground. Approximately 1/2 natural size. About 1941, Tree No. 49 was struck by lightning (see Figure 31.).

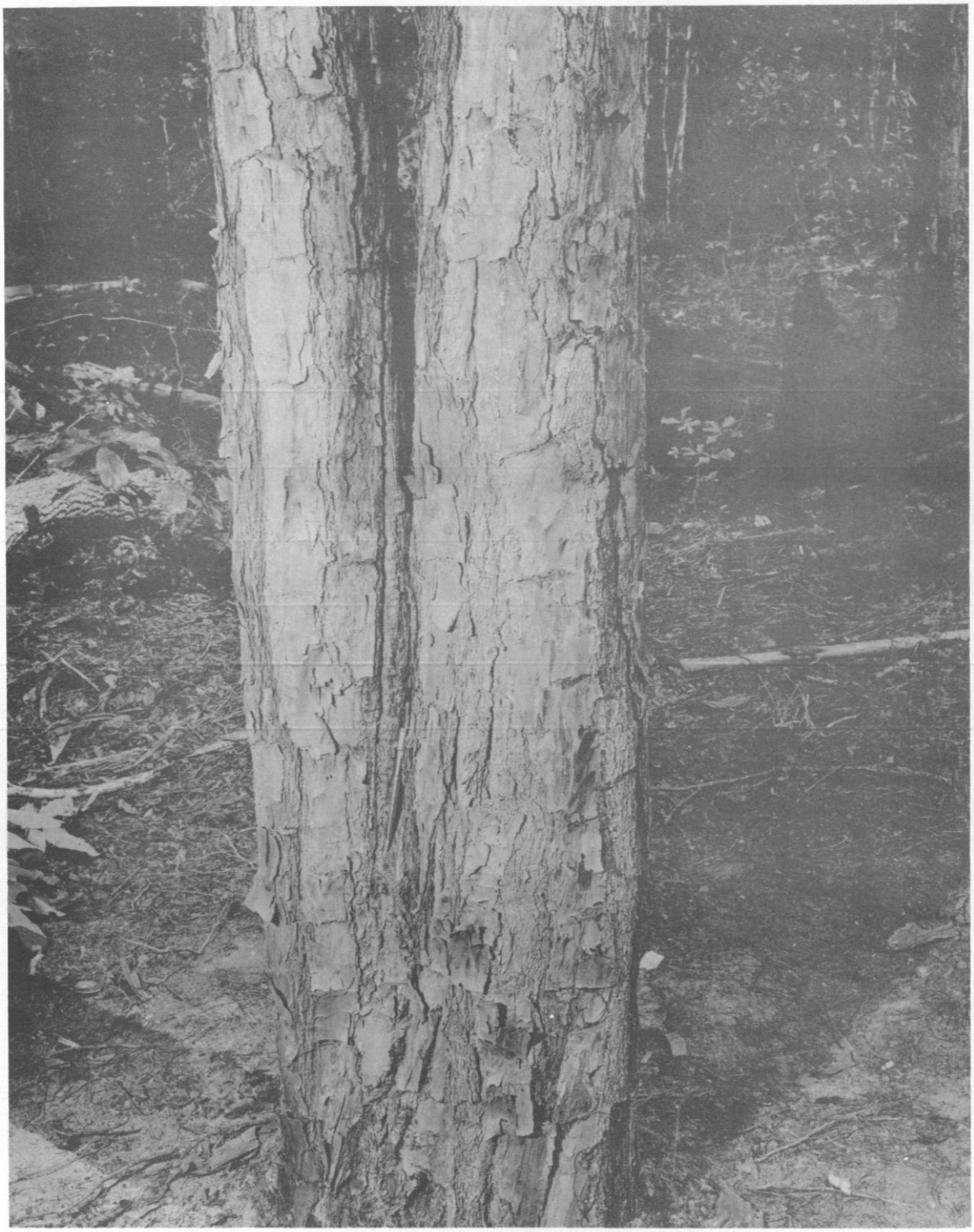

Figure 31.

View of the base of Specimen Trees No. 48 and No. 49 to show lightning scar on No. 49. Evidence of scar appears for approximately six feet on main stem of No. 49.

Figure 32.

View of a midlongitudinal section from twin shortleaf pine, Specimen Trees No. 48 and No. 49. Section was cut from that portion of the stump which extended just above to 14 inches below the surface of the ground. At O, X, Y and Z there are the remains of stubs or basal parts of small trees that were killed by fire. Stubs at X and Z appear to be older than the stubs at O and Y. A represents trace of the basal part of Specimen Tree No. 48; B, the basal part of Specimen Tree No. 49.

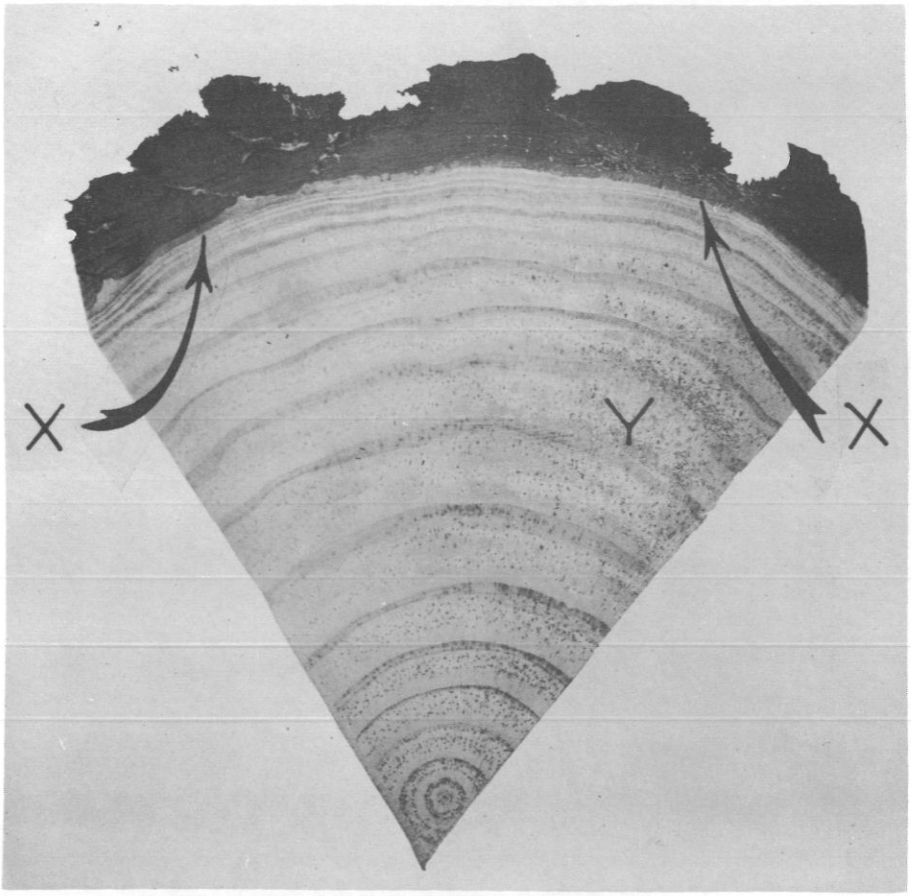

Figure 33.

View of a sector of a section cut at the surface of the ground from an 18 year old loblolly pine, Specimen Tree No. 50, which had "littleleaf" symptoms. The differentiation in color at Y is due to incipient decay. A fungus was infecting the inner bark at X. Note width of first and last annual rings. Tree developed direct from the seed.

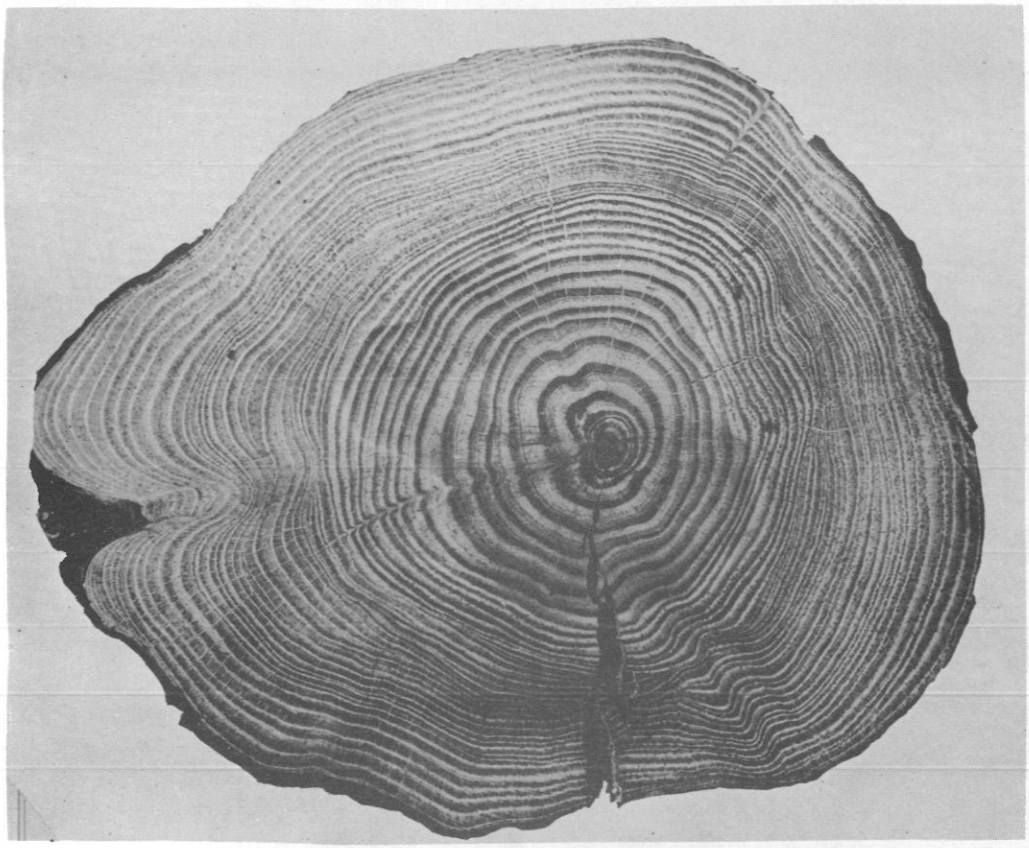

Figure 34.

View of a cross section of the tap root Specimen Trees Nos. 48 and 49. It was cut at X, Figure 26, which was about 18 inches below the surface of the ground. Note there is a single root center.

Figure 35.

View of a midlongitudinal section of the root crown of Specimen Tree No. 50, loblolly pine. The section is 8 inches long. The top of the section was 4 inches below the surface of the ground. X indicates the location of the pith. Tree developed direct from the seed.

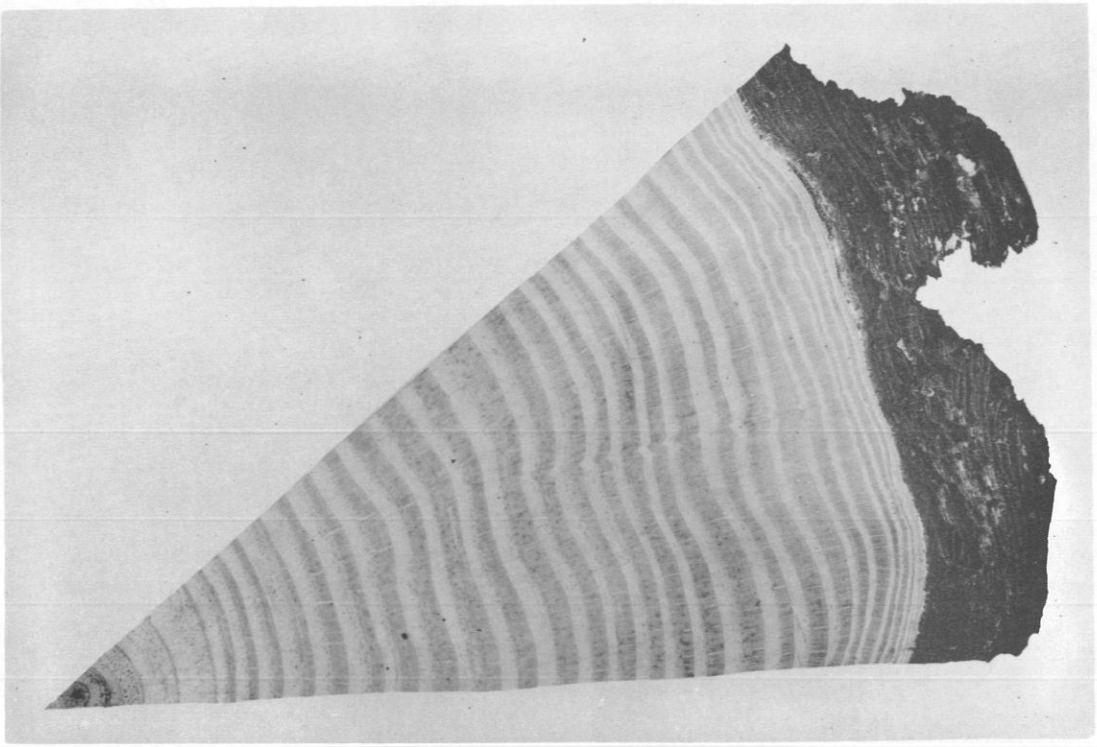

Figure 36.

View of a sector of a section cut from the base of the bole of Specimen Tree No. 51, loblolly pine. Note the rapid growth the tree made during the first five years and the narrow width of the last annual rings. Tree No. 51 was "littleleafed" and was of sprout origin.

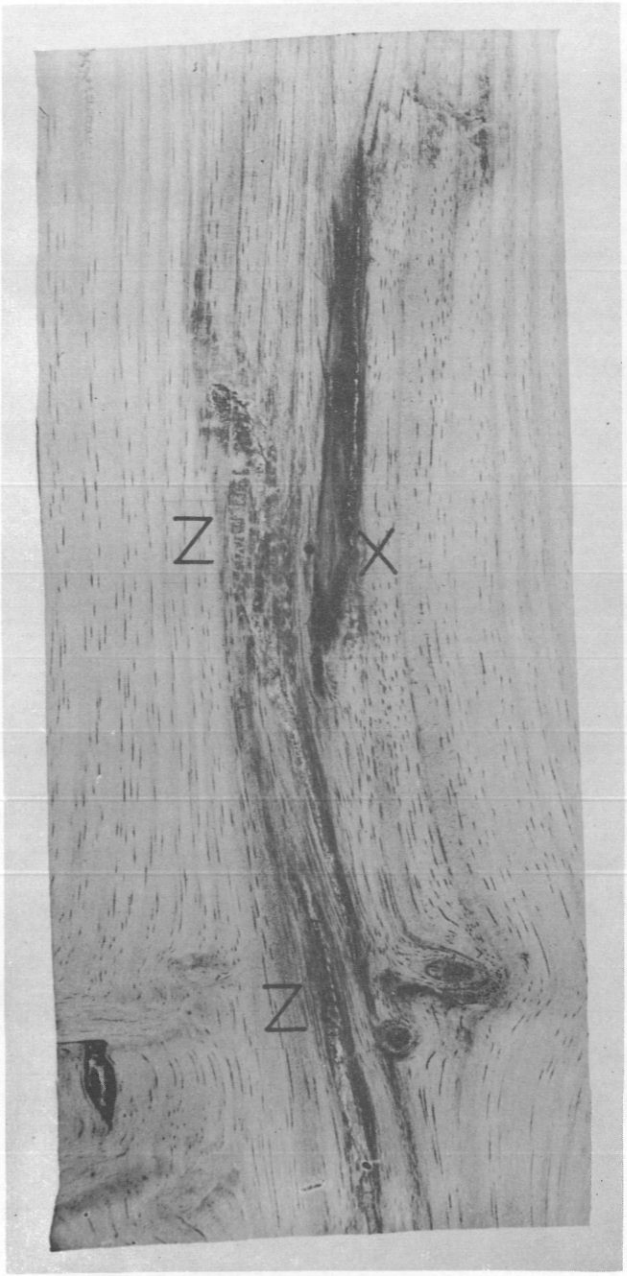

Figure 37.

View of a midsection of that part of the stump of Specimen Tree No. 51, loblolly pine, that extended from 4 to 12 inches below the surface of the ground. At X there is a remnant of a dead stem. Resinous cracks are at Z. The wood bordering the resinous cracks appears to be in the early stages of decay.

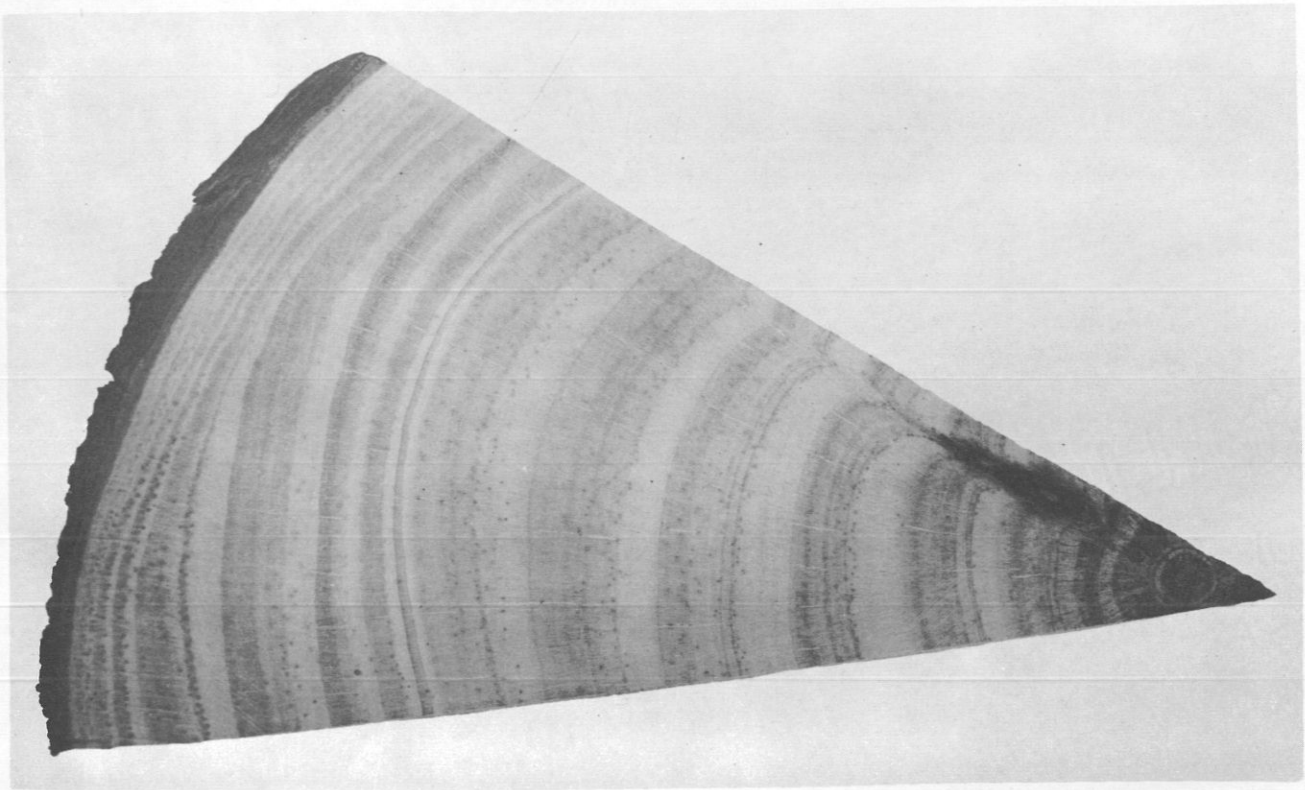

Figure 38.

View of a sector of a cross section cut at the surface of the ground from the bole of Specimen Tree No. 52, loblolly pine about 25 years old. The tree made a rapid increase in diameter up to 1952 when there followed an abrupt decline in rate of growth. Tree had "littleleaf" symptoms.

Figure 39.

View of a midsection of that part of the stump of Specimen Tree No. 52, loblolly pine, that extended from 2 to 11 inches below the surface of the ground. Traces of pith at X; Y, a remnant of a stem; Z, what appears to be a secondary stem. Tree had "littleleaf" symptoms and was evidently of sprout origin.

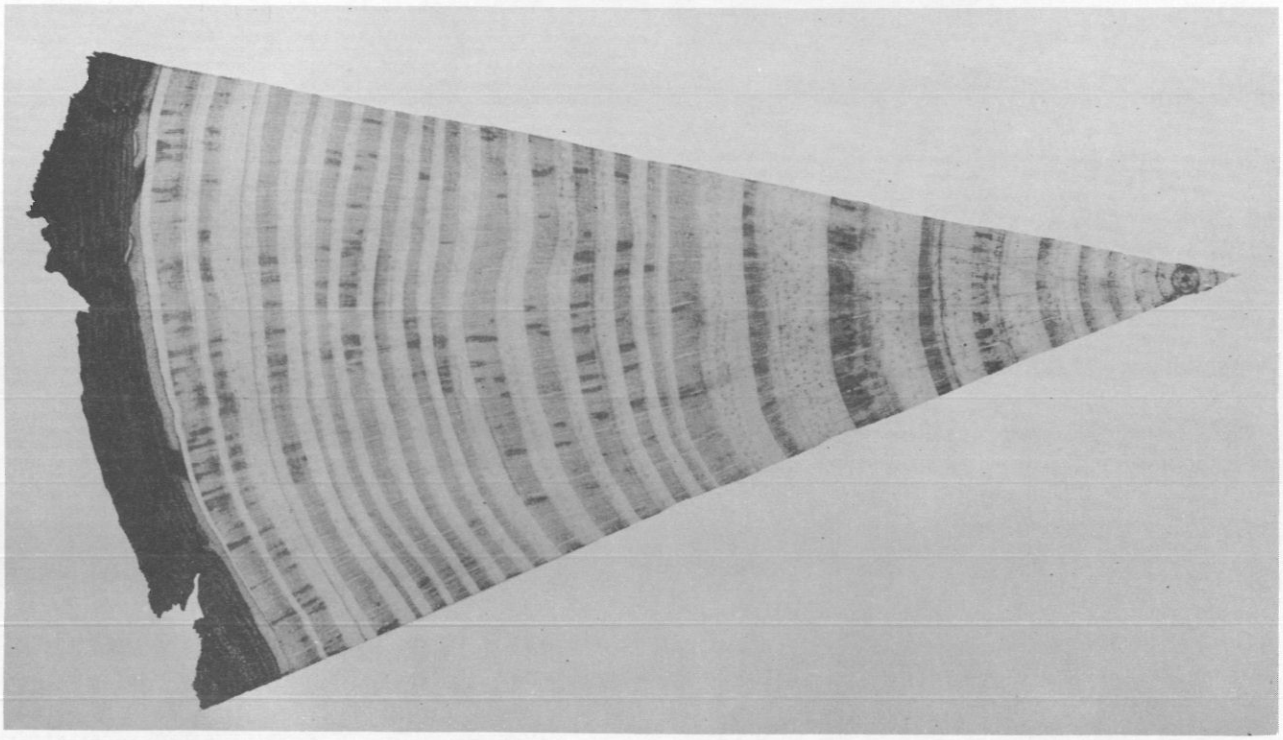

Figure 40.

View of a sector of a cross section cut at the surface of the ground from the bole of Specimen Tree No. 53, loblolly pine, about 25 years old. Note the large amount of late summer wood. Tree had "littleleaf" symptoms.

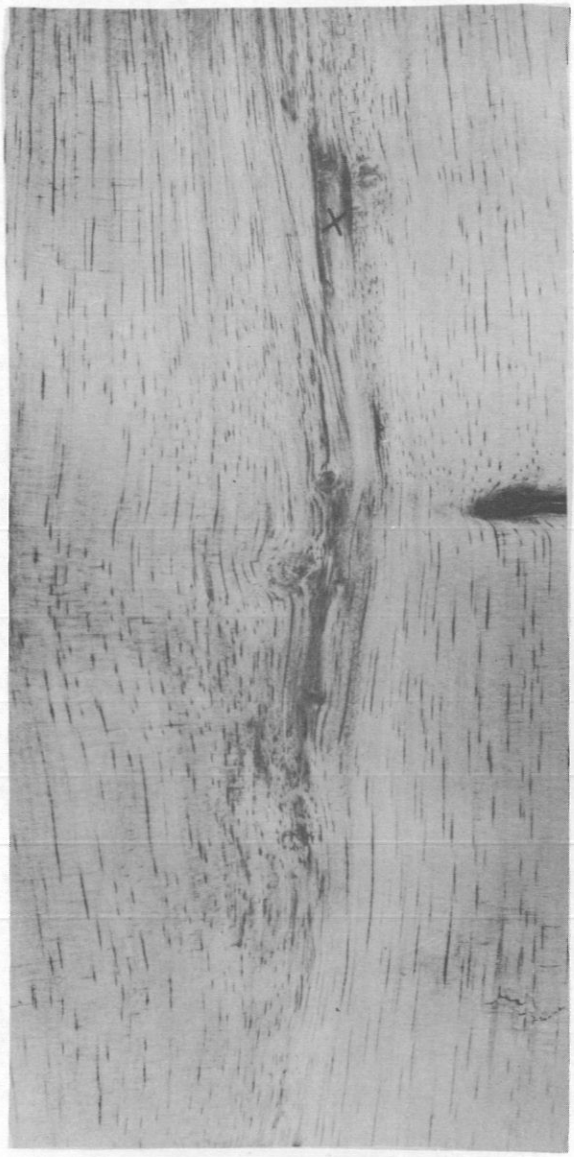

Figure 41.

View of a midsection of that part of the stump of Specimen Tree No. 53, loblolly pine, that extended from 2 to 11 inches below the surface of the ground. X indicates what appears to be the remnant of the primary stem.

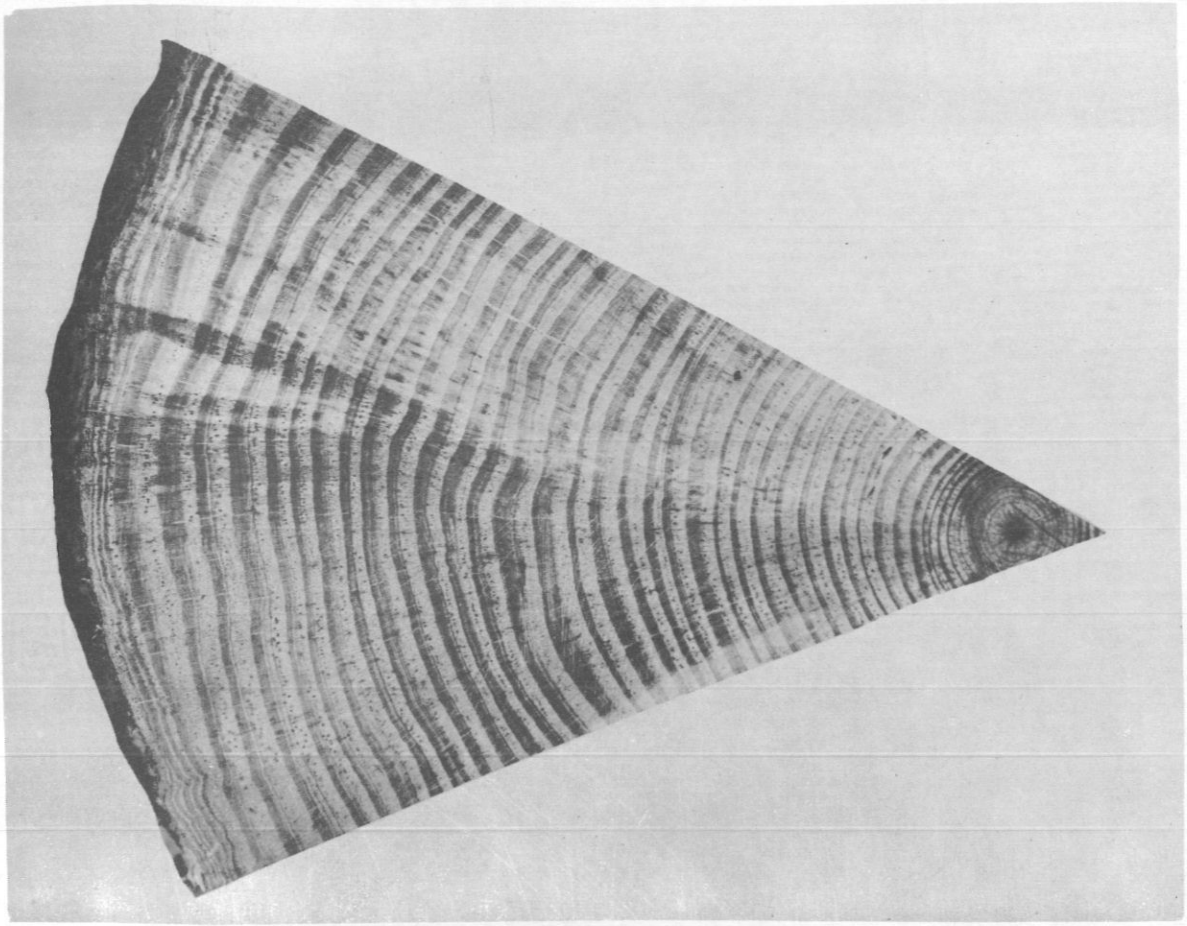

Figure 42.

View of a sector of a cross section cut just above the surface of the ground from the bole of Specimen Tree No. 54, longleaf pine. The tree was at least 50 years old and showed symptoms of "littleleaf". The tree was infected with the shoestring fungus, Armillaria mellea (Fr.). The darker colored portion of the section is due to blue stain caused by a fungus after the stump of the tree had been dug up. The shoestring like bodies, called rhizomorphs, do not appear in the illustration. However, they were quite profuse on the larger roots and on the base of the bole below the surface of the ground.

Figure 43.

View of a midsection of a portion of the bole, root crown and tap root of Specimen Tree No. 54, longleaf pine, showing the direct connection between the stem and tap root.

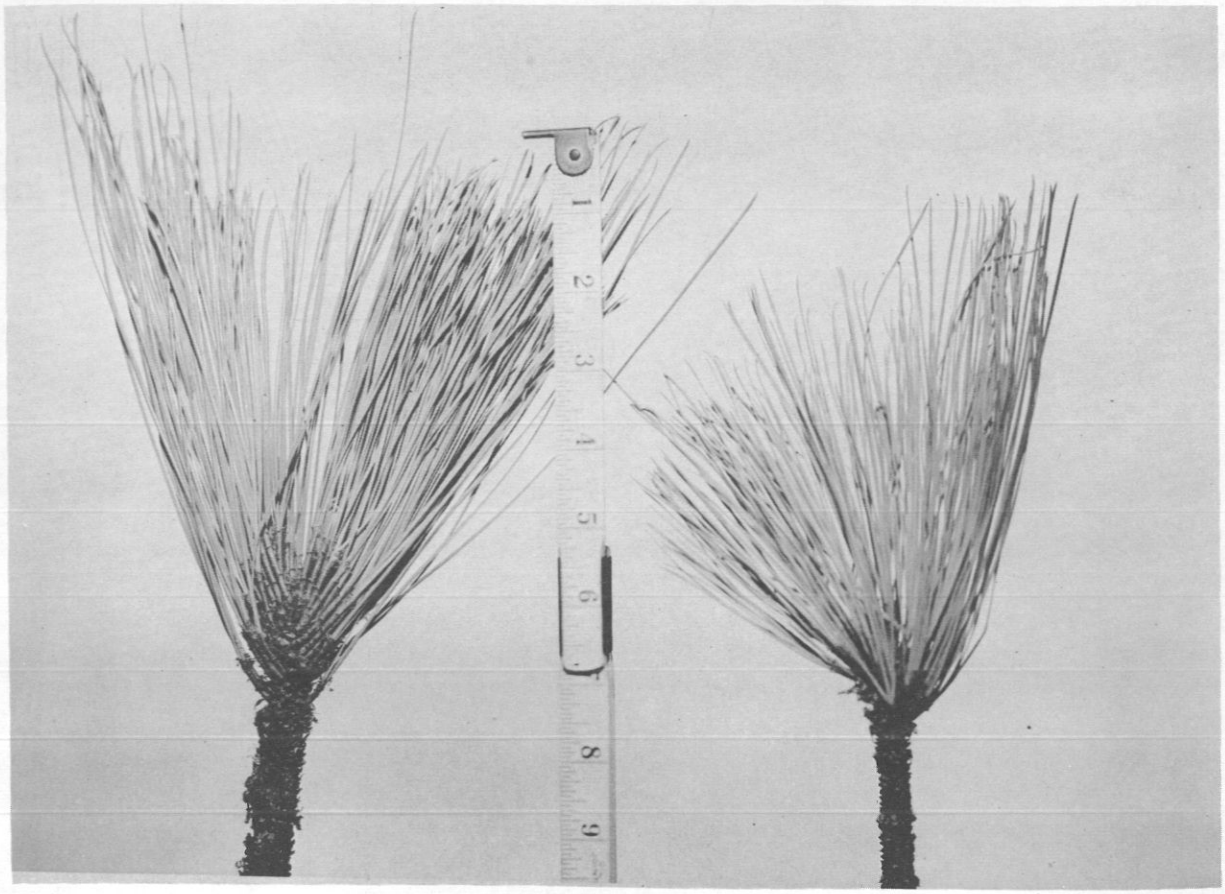

Figure 44.

View of typical needles from Specimen Tree No. 55, longleaf pine. Those on the right were from the lower part of the crown and were slightly yellow. Those on the left were from the topmost branch of the crown and were not quite as yellow. They were collected September 20, 1956. Tree had symptoms of "littleleaf".

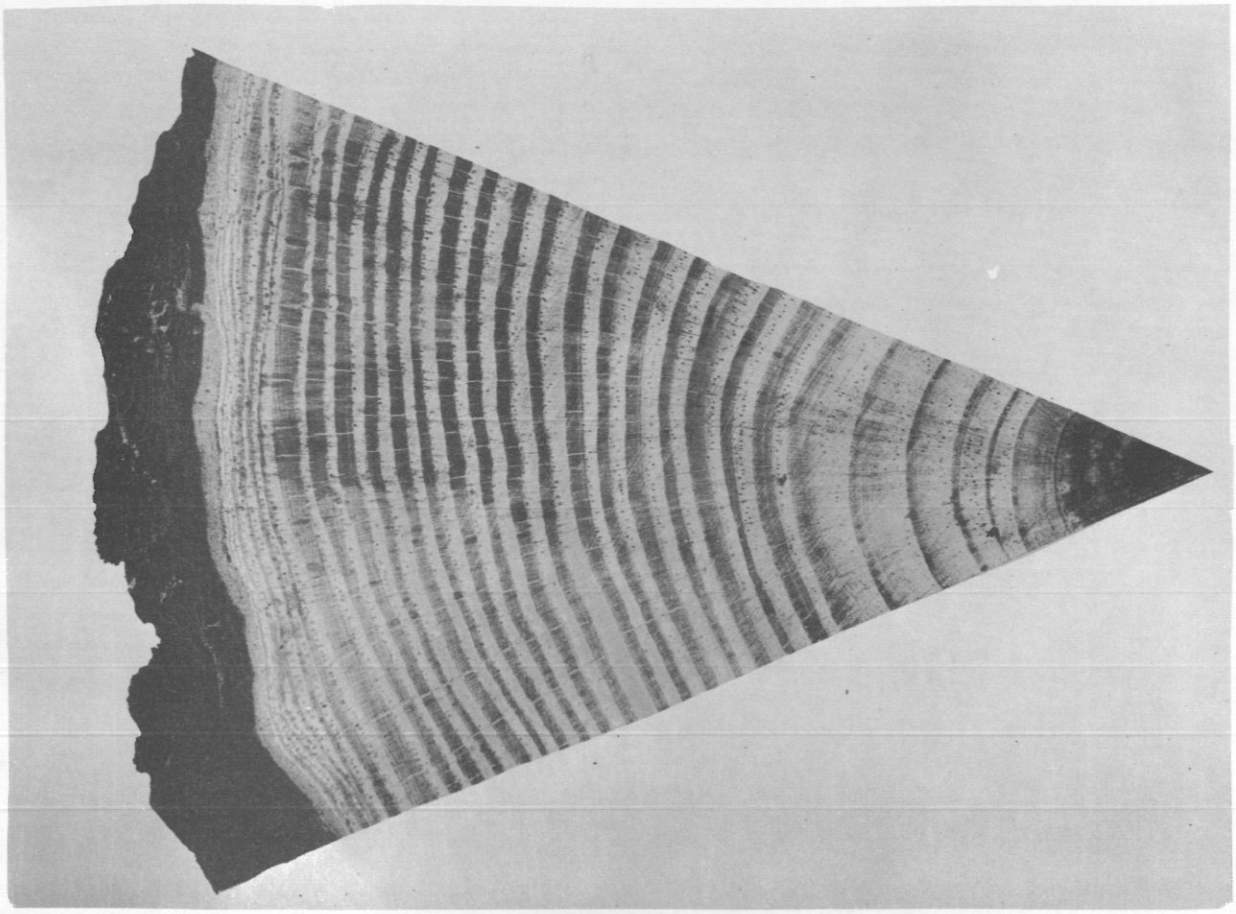

Figure 45.

View of a sector from a cross section cut at the surface of the ground from the bole of Specimen Tree No. 55, longleaf pine, about 32 years old. The darker portion of the wood appears to be in the early stages of decay. The tree had "littleleaf" symptoms. It was severely injured by fire in February 1953. Increase in diameter growth had slowed down abruptly 2 years before the fire.

Figure 46.

View of section 2-4, a midsection that was cut from that part of the stump of Specimen Tree No. 55, longleaf pine, that extended to $10\frac{1}{2}$ inches below the surface of the ground. At X is the remnant of a stem which may have been the stem of the seedling. Z marks what appears to be the remains of a needle fascicle. Compare Figure 46 with Figure 43.