CHAPTER 10

SHORTLEAF PINE

Shortleaf pine has the most extensive range to the north and west of the major southern pines, as shown in figure 6. Pitch pine is the only minor species that extends farther north. Adaptability to a wide range of environmental conditions may indicate a range of variability among trees similar to other southern pines. The species is planted less extensively than other southern pines, partly because shortleaf pine in parts of the Southeastern States is susceptible to littleleaf disease, thus making loblolly pine the favored species for planting on high-hazard sites. Shortleaf also grows somewhat slower than other southern pines, which places it at a disadvantage when other species are suitable for planting. Despite all this, interest is apparent in tree-to-tree variation and seed orchards.

Shortleaf pine was included in Mohr's (1897) paper on the timber pines of the southern United States. Mattoon (1915) discussed its economic importance and management. A bibliography contains published material on shortleaf pine by subject (Haney 1962), and the silvicultural characteristics have been described (Fowells 1965).

TREE GROWTH

Shortleaf pine is multinodal in growth habit. It probably exhibits the same wide range in growth rate among trees as other southern pines, although this has not been carefully studied under a wide variety of conditions. Uniformity of growth among trees is not so great that it causes stagnation of stands and becomes a problem in silviculture.

Meyer (1930) has pointed out that the frequency distribution of diameter classes in even-aged stands is a characteristic of the individual species. His studies showed that the relationship of the standard deviation of stem diameter with age in shortleaf pine was curvilinear and increased from 0.88 for stands averaging between 2 and 3.45 inches up to those 14 inches in diameter. The coefficient of variation was linear, decreasing from 41.8 for an average diameter of 3.11 to 25.6 for 13.56 inches. The coefficient of asymmetry increased with diameter, but the coefficient of excess did not. The diameter range of shortleaf pine was found to be somewhat less than that of Douglas-fir and balsam fir but greater than that of slash pine and red spruce. Shortleaf pine was one of the two species which showed a decided tendency to pass from negative asymmetry into positive asymmetry with increase in average diameter. Frequency distribution curves representing the combined effects of genetic and environmental factors on growth may indicate the limits of plus-tree traits.

Length of Growth Period

Although shortleaf pine is multinodal, the pattern of growth varies among trees. Twelve-year-old trees that formed two summer shoots had a height growth period of over 4 months, while those with only one complete elongation had a period of a little shorter than 4 months (Tepper 1963). In certain trees the second growth period produced a longer shoot than the first period.

In seed orchards, active growth for flowering varied widely among clones (Wasser 1967). Thinning affects growth periods of trees, with thinned stands growing 8 to 10 weeks more each year, as shown by a Missouri study (Phares and Rogers 1968). Thinned stands started to grow earlier and did not stop as soon, which probably did not change the proportion of springwood and latewood from that of trees in unthinned stands. Large trees in unthinned stands usually grew 2 to 3 weeks longer than trees of smaller diameter. In thinned stands, however, trees of some of the lower diameter class grew as much as the large-diameter trees, although trees with the most growing space generally had a longer growth period than those with less available space. Large trees in planted stands may have a longer growth period than smaller trees, as indicated by a higher proportion of latewood in annual rings (Hamilton and Mathews 1965). This tendency will be discussed further in the section on tree-to-tree variation in shortleaf pine wood.

Branch growth over the tree crown may not be uniform because of the influence of flowering. In one study shortleaf branches bearing cones made an average of less than two summer shoots, while noncone branches made as many as three shoots (Eggler 1961).

Seedling Growth

Seedling grades reflect differences in vigor of shortleaf pine seedlings as in other southern pines. Both seedling growth and survival in tests in Arkansas, Missouri, Indiana, and Ohio were related to seedling grade (Chapman 1948). In Tennessee, super seedlings, on the basis of growth in nursery beds, outgrew control seedlings over a 10-year period (Zarger 1965). Seventy-one percent of the super seedlings outgrew the average control in volume, only 10 percent of the controls attaining

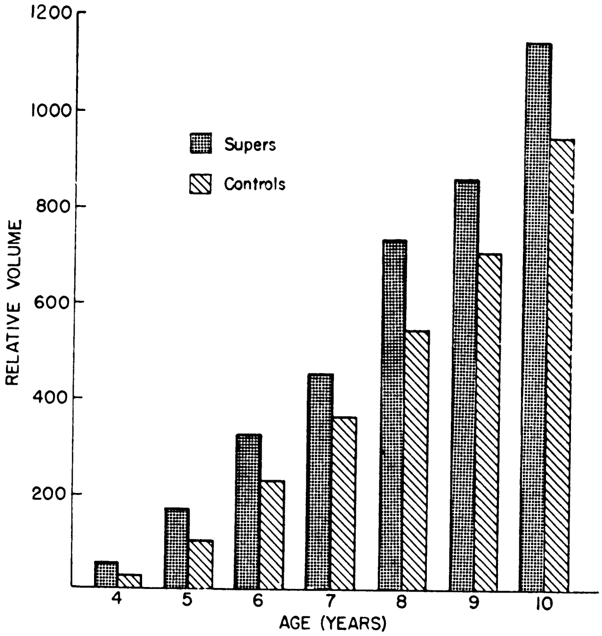

Figure 138.—Volume of shortleaf pine super seedlings exceeds the controls by more than 20 percent after 10 years' growth. (Zarger 1965)

greater height than the average super seedlings (fig. 138).

Measurements of individual shortleaf pine seedlings in a racial variation study showed that taller seedlings after 1 year's growth continued to be significantly taller 5 to 7 years after planting (Lane 1961). Also, Wakeley (1971) found that many of the largest trees at age 30 in a planting study have maintained superior height since early years.

Clones and Families

Grafted clones of shortleaf pine varied in height growth as well as in the ease with which they could be grafted (fig. 139). The tests were made in connection with selective breeding for resistance to littleleaf disease, with all scion material chosen from trees of good growth and form as well as apparent freedom from disease (Zak 1955b; Greene *et al.* 1966).

Control-pollinated progeny of trees selected for resistance to littleleaf (fig. 140) varied from 7.4 to 11.2 feet after 6 years in the field (Bryan 1973). Grafted clones of these trees are shown in figure 139. Families from crosses of trees selected in Georgia were taller than those from clones of selected trees in South Carolina. Seedlings of two selfed families were as tall as or taller than outcrossed families and were more uniform in height, although the number of seedlings in each family was small.

In Texas there was wide variation among families of shortleaf pine trees growing in seed production areas, but the average growth of all families was about equal to that of the controls. Progenies of trees growing in seed production areas were noticeably more uniform than controls (van Buijtenen 1969c). Volume growth among families in cords per acre per year varied from 1.20 to 1.84. One control produced 1.4 cords and the other 1.92 cords, which was the highest in the study, but there was evidence in the seedlot of hybridization with loblolly pine, a faster growing species.

STEM AND CROWN FORM

The stem and crown form of shortleaf pine is better than that of most of the southern pines. The stems are generally straight, with branches small and nearly horizontal. Natural pruning is good. There are differences among trees, but the percentage of trees with one or more undesirable traits is low.

Open-grown shortleaf pine may have a good combination of good traits, as illustrated by the plus-tree selection shown in figure 141. The progeny of trees like this have very good form. Figure 142, on the other hand, illustrates bad traits in both stem and branches. Nearly half the open-pollinated progeny of this tree showed undesirable traits, the remainder becoming typical shortleaf pines (fig. 143).

Selection of trees for both form and growth rate was considered desirable by Bryan (1965) and Zak (1955c) in breeding for resistance to littleleaf, although the complexity of the job was increased. The guide to selection of shortleaf pine and other pine in Tennessee lists desirable traits for all species as well as special traits (Zarger 1958).

Natural hybridization of shortleaf pine and loblolly pine west of the Mississippi is extensive and has been given as the cause of pronounced racial characteristics. These were discussed in the chapters on racial and geographic variation. Hybridization would contribute to variation among trees by creating various intermediate types. The subject has been discussed by Hare and Switzer (1969) and by Bilan (1966). Since shortleaf pine has small branches and good natural pruning in comparison with loblolly pine, certain natural hybrids might have an unusual combination of traits, such as the short needles of shortleaf and large branches and poor natural pruning of loblolly. However, minus trees for crown form might have superior growth rate because loblolly pine grows faster than shortleaf.

Shortleaf pine seedlings have a characteristic crook at the base. It was observed that many seedlings formed incipient crooks during the first sum-

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Figure 139.—Shortleaf pine seed orchard at Athens, Georgia, composed of grafted selections from trees showing resistance to littleleaf and having other desirable characteristics. Grafts made in 1953 and photograph taken in 1973. Each row is from scions from one selection. Note large difference in growth of clones.

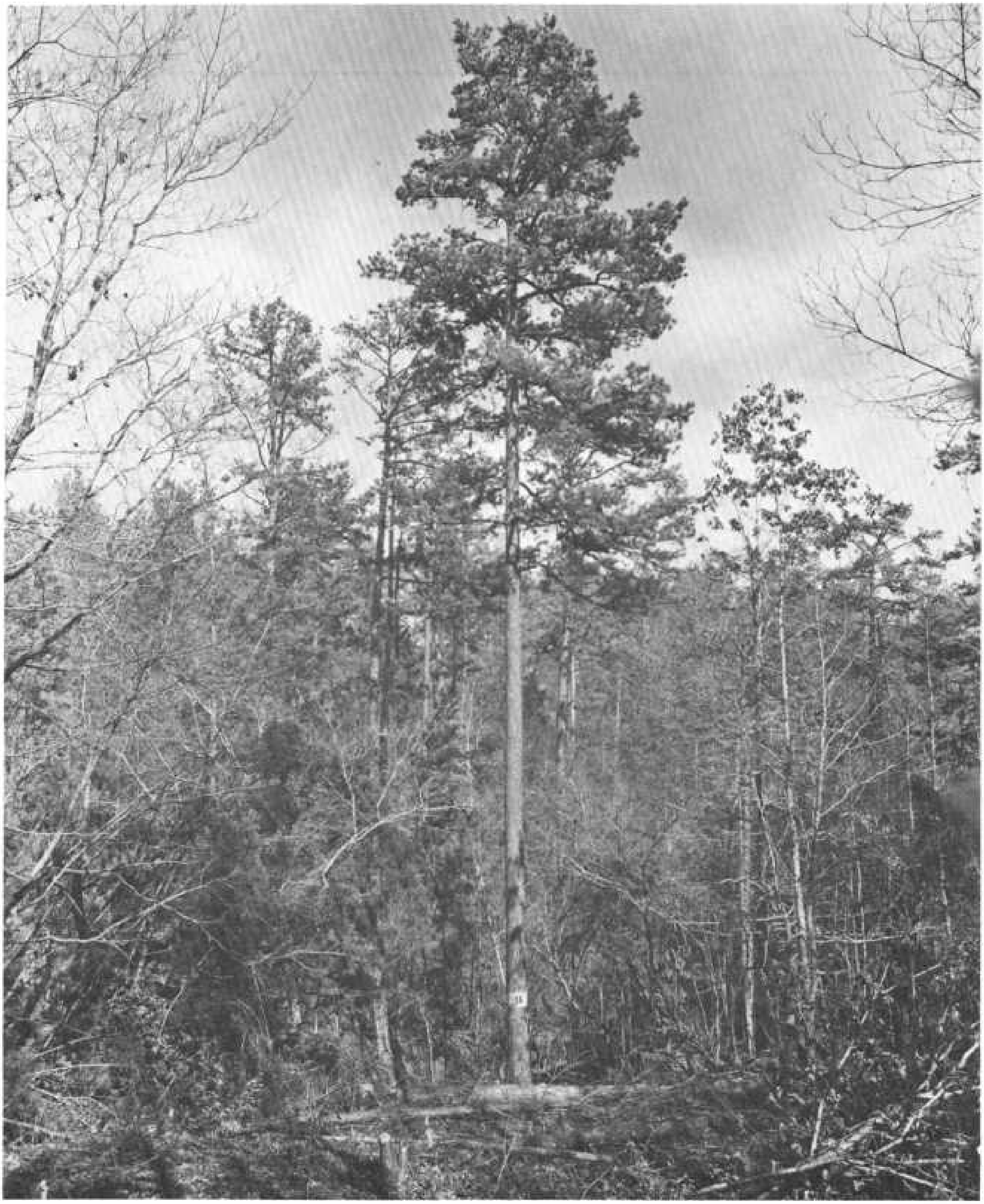

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Figure 140.—Shortleaf pine selected for resistance to littleleaf disease plus a combination of other good traits such as vigor, bole form, self pruning, crown width, and branch thickness. The tree is 107 years old. The stand had been cut to salvage trees dead or dying from littleleaf. (Bryan 1973)

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Figure 141.—Shortleaf pine (*Pinus echinata* Mill.) of good form and high vigor. The tree is 25 years of age, 13.1 inches in diameter, and 62 feet tall. Although it is not growing under competition, the tree is fairly well pruned, and branches are not objectionably large. (Dorman 1952)

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Figure 142.—Shortleaf pine of high vigor but poor form. The tree is 25 years old, 15.6 inches in diameter, and 62 feet tall. Although the crown is slender and the branches are small, there is a strong tendency to crook, and the tree is poorly pruned. (Dorman 1952)

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Figure 143.—Nearly half of 9-year-old open-pollinated progeny of a poor-form shortleaf pine (fig. 142) have recurrent stem and branch crook. The other progeny have normal form.

mer of growth, while others formed them a year or so later (Little and Mergen 1966). However, 2 trees out of 21 observed did not form basal crooks during a 6-year period. The inheritance of basal crook has not been studied. It is thought that survival might be influenced by the crooks because basal dormant buds on seedlings lacking crook would be exposed to and killed by fire.

RESISTANCE TO PESTS

Like other southern pines, shortleaf has its insect and disease enemies. It is heavily attacked by tip moth, as is loblolly pine, but probably suffers little loss in height growth. Shortleaf pine is, however, resistant to fusiform rust, which attacks both loblolly and slash pines, and to brown spot, that important enemy of longleaf pine in some parts of the South.

The most critical disease enemy of shortleaf pine is littleleaf disease—so bad that in certain locations loblolly pine is recommended as a replacement species. Figure 135 showed the areas where littleleaf is severe in relation to the location of other pine diseases. Areas with scattered littleleaf or abundant littleleaf have been described in more detail by Campbell *et al.* (1953).

Littleleaf Disease

In certain geographic areas, shortleaf pines over 20 years of age develop thin crown foliage and short yellow needles. Eventually the trees die. The disease symptoms are characteristic of a nitrogen deficiency that develops from repeated destruction of root tips by the soil pathogen, *Phytophthora cinnamomi* Rands, on heavy soils with poor internal drainage and reduced aeration.

During the course of research on the disease, individual trees were observed surviving among dead and dying trees. Selections were made from 1952 to 1955 among surviving trees, not only for

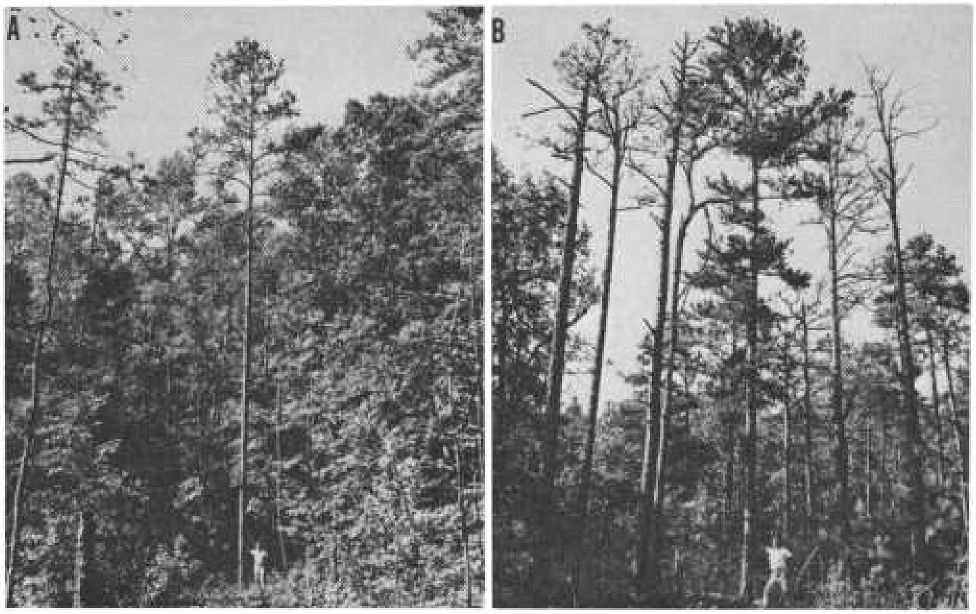

Figure 144. —*A* and *B* show selected shortleaf pines on severe littleleaf areas. Both trees exhibit good form characteristics and apparent resistance to littleleaf. (Zak 1953)

resistance to the disease, but for good growth and crown and stem form (fig. 144) (Zak 1953; Campbell and Copeland 1954).

In controlled tests, open-pollinated seedlings of trees selected for resistance showed good top and root development. The majority of seedlings from susceptible parents exhibited a lack of fine feeding roots and stunted or poorly formed tops (Zak 1955c).

Out of 16 families from control-pollinations tested for resistance in the laboratory, 3 showed pronounced resistance (Bryan 1965). Most of the remaining families died. Progeny of a selfed resistant clone showed rather high resistance. Open-pollinated progeny of the ortet had demonstrated high resistance also.

It has been suggested that not all trees in the field have mycorrhizae and that those with abundant development of mycorrhizae may have less susceptible root tissue exposed to *P. cinnamomi* than trees with few or no mycorrhizae (Marx and Davey 1967). Shortleaf pine seedling roots with mycorrhizae were observed to be resistant to infection, whereas nonmycorrhizal short roots and lateral root tips were highly susceptible.

Fusiform Rust

Shortleaf pine is generally resistant to fusiform rust, a serious enemy of slash and loblolly pines, and is a favored species to hybridize with slash pine for studies of inheritance of resistance. Hybrids of shortleaf and slash pines have good growth and form but do not outgrow slash pine.

In studies with shortleaf × slash hybrids, not only did some artificially inoculated seedlings develop fusiform rust galls, but there were large differences in the proportion of galled seedlings among various crosses. In three crosses where a particular shortleaf pine tree was either the male or female parent, the proportion of galled progeny was much higher than in three crosses where the tree was not involved. Work with additional trees has indicated that the variation among trees in ability to transmit resistance is fairly common (Jewell 1961, 1966; Schmitt 1968).

Comandra Blister Rust

A blister rust, new since 1951 to the southern pine region, has been observed on shortleaf pine in Arkansas and loblolly pine in Tennessee. Caused by *Cronartium comandrae* Pk., the disease is potentially harmful. In Arkansas, incidence of infection of shortleaf pine 1 to 10 years old varied from a trace to more than 68 percent (Wolfe 1970). Inheritance of susceptibility has not been studied.

Dwarf Needles

Three-year-old shortleaf pine trees in Texas, in August 1959, were observed with many fascicles in which all or nearly all of the needles were 0.33 to 1.0 inch long, in contrast to normal lengths of 3 to 5 inches (Young 1961). Trees were only about half of normal size when most of their fascicles became dwarfed. Further observations (Young 1963) indi-

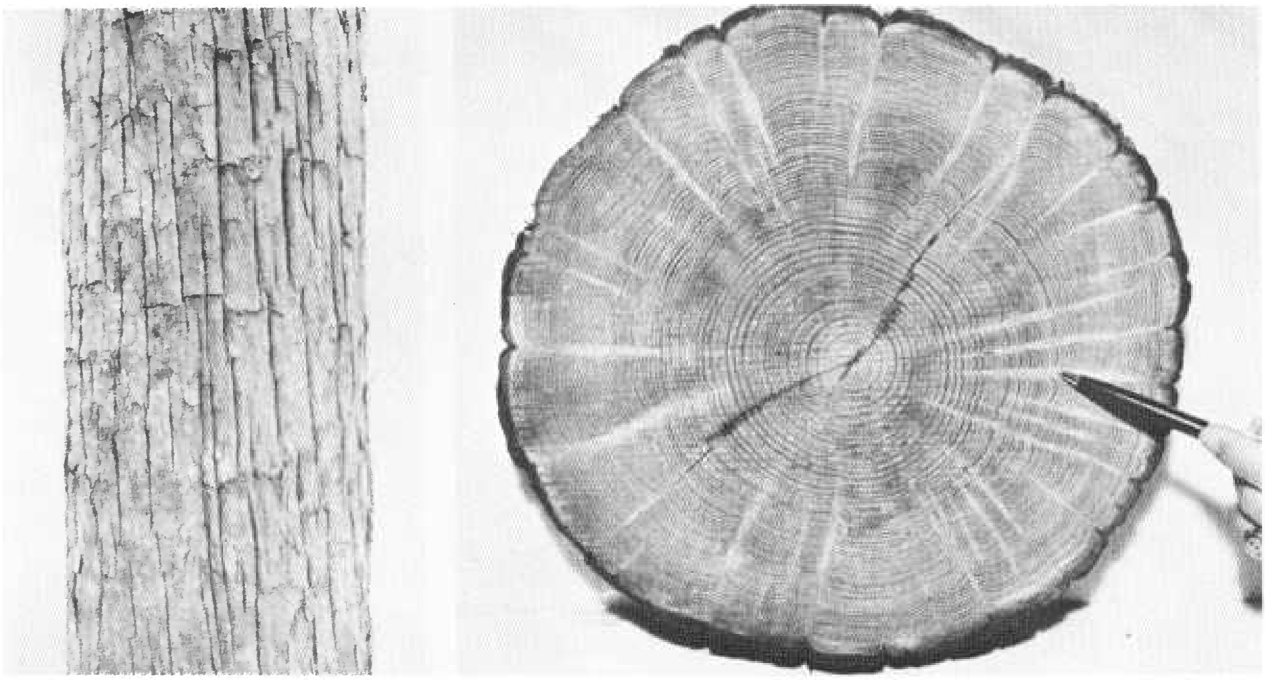

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Figure 145.—Several trees with these extremely wide ray-like structures in the wood have been observed near Crossett, Arkansas, by the USDA Forest Service. Shortleaf pines having this wood characteristic show long fissures in the trunk bark.

cated that the symptoms varied in severity with season and were most marked near the margins of the south and west stands. In the summer, new shoots remained slender, whitish in color, often curved, and 2 to 8 inches long. By August, they had needles ¼ to ¾ inch long. There was no indication as to why all trees were not affected. As the condition was not thought to be littleleaf disease, a virus was suspected. No tests of inheritance have been made.

WOOD PROPERTIES

The wood of shortleaf pine cannot be distinguished from that of other southern pines. Probably much of the variation and inheritance data obtained from studies of slash and loblolly pines is applicable to shortleaf pine.

Shortleaf pine has a wide latitudinal, longitudinal, and elevational range, but it does not seem to have developed greater intraspecific variation than other southern pines. In fact, a few studies have indicated less geographic variation than in species not so widely distributed.

Variation studies in wood properties are largely phenotypic, although one study was made of tracheid length among randomly selected clones. Unusual trees near Crossett, Arkansas, have been found with wide rays (fig. 145).

Wood Specific Gravity

Statewide samples of shortleaf pine in Mississippi indicated specific gravity varied from 0.3 to a high of 0.8 and averaged 0.51 (Mitchell and Wheeler 1959b). Tree age varied from 5 to 65 years. Specific gravity values included extractives and regional differences. The range in specific gravity and shape of the frequency distribution curve were within limits of those for other species.

Shortleaf pine plus trees for southern National Forest seed orchards averaged 0.514 in specific gravity, and the comparison trees for the same location 0.520—not significantly different. Trees totaled 2,449, with an average age of 58 years and d.b.h. of 12.2 inches. Specific gravity range was from 0.37 to 0.72, with a mean of 0.52 and a standard deviation of 0.043. The range in values among trees was for a larger geographic area but was roughly comparable to that for other major southern pines (Saucier and Taras 1969).

Shortleaf pine planted in 12 southern Illinois counties averaged 0.439 specific gravity, based on increment cores at breast height. The minimum value was 0.368 and the maximum 0.500 (Gilmore *et al.* 1961). Inasmuch as the planted trees were of unknown seed source, additional samples were taken from a natural stand of trees averaging 0.516, with a standard error of 0.005. Increment core specific gravities ranged from 0.438 to 0.588 for trees 55 to 144 years, averaging 112 years. The results substantiated those from the 1961 study that shortleaf pine wood in southern Illinois is lighter than that from trees of comparable age in Mississippi. The Mississippi study was done by Mitchell and Wheeler (1959b).

Differences among trees have been noted in the relationship of whole-tree specific gravity to increment core specific gravity at breast height, but the correlation coefficient for young trees was 0.80. Regression of tree specific gravity on the product of core specific gravity at 1 foot and 4.5 feet increased the correlation coefficient to 0.85 (Gilmore *et al.* 1961). Somewhat larger differences were observed by Christopher and Wahlgren (1964), Wahlgren and Fassnacht (1959), and for slash and longleaf pines by Taras and Wahlgren (1963). Thus, for accurate estimates of whole-tree specific gravity for individual trees, larger samples are required than one increment core at breast height.

The relationship between growth rate and wood properties has long been a major concern among foresters for each species with which they have to work. And these relationships have been difficult to study because of the large number of variables involved. The results of a Georgia study of five spacings and the effect on ring width, specific gravity, and latewood percent contribute to our knowledge of relationships. Values for these wood properties increased as crown size increased. Of particular significance was the observation that in the four outer rings of the 15-year-old trees, latewood percent was 43.22 and 43.51 for codominant and dominant trees, respectively, but only 40.41 percent for intermediate and suppressed trees. Specific gravity of intermediate and suppressed trees was 0.487, codominant trees 0.506, and dominant trees 0.505. These figures may indicate, but not prove, that the more vigorous trees have a longer growth period in the fall than other trees, which would result in a high proportion of latewood. This subject was discussed in the section on variation among trees in length of growth periods in shortleaf pine. Trees could vary also in the time at which latewood formation began in the late spring, which would affect latewood percent also, but the subject has not been carefully studied. However, formation of latewood fibers has been observed to start at distances that varied from 53 to 60 percent (average 57 percent) of ring width (Jackson and Morse 1965a).

A study in Missouri has indicated that shortleaf pine wood density is not affected by ring growth. Wood specific gravity increased over the 40-year period of growth but was not greatly affected by growth rate of 8 to 40 rings per inch. Fiber length and width and cellulose content were unaffected by growth rate, but form class was somewhat improved (Ralston and McGinnes 1964).

As mentioned earlier in this section, shortleaf pine plus trees selected for superior growth and other traits averaged about the same specific gravity wood as the comparison trees in the same stand (Saucier and Taras 1969).

Tracheid Length

The pattern of tracheid length during formation of an annual ring varies from tree to tree. In the shortleaf pines studied, it increased through the early wood to maxima at distances of from 47 to 64 percent of the annual ring and averaged 57 percent; the pattern also varied in different amounts with ring number from the pith. The trees varied, too, in distance within the annual ring at which latewood fibers started (Jackson and Morse 1965a).

Mean tracheid length varied significantly among and, for certain clones, within 7-year-old clonal lines of shortleaf pines (Greene and Carmon 1962). Estimates of tracheid length were based on samples of the springwood of first-order branch wood. Differences in tracheid length were small, 1.16 to 1.23 mm, among the seven clones studied.

Extractives

Large differences occur among trees in the extractive content of the wood. Depending on the species, the amount of wood substance in the major southern pines is overestimated by approximately 6.0 to 7.5 percent when the determination of specific gravity is based on unextracted increment cores. However, the correlation coefficient for the relationship between extracted and unextracted specific gravity is high, 0.79 (Taras and Saucier 1967) and 0.86 (Posey and Robinson 1969). Extractive content of 140 trees averaging 62 years old was 6.72 percent, but the coefficient of variation was high, 76 percent, in contrast to 61 percent to 83 percent for slash, loblolly, and longleaf pines. Average extractive content among species, however, was not significantly different. As Kurth (1933) and Posey and Robinson (1969) point out, age of tree influences extractive content more than any other variable, and ether-extractive content increases from the bark to the pith. Trees of rapid growth show a higher extractive content than those of slow growth.

SEED AND SEED PRODUCTION

Shortleaf pine has small cones and seed compared with other major southern pines, with number of seed per pound varying from 36,500 to 62,500, and averaging 48,000. Certain trees flower and produce normal seed at 4 years (Greene 1966a), and others several years later. Some mature trees bear relatively few cones, while others fruit heavily nearly every year (Perry and Coover 1933). Cone size, shape, and weight as well as seed and wing color and germination percent differ greatly from tree to tree. Color of seedcoat may vary from pale red-brown to black. Many factors influence seed production and quality; seed averaged 57 percent sound in three good crop years, but only 41 percent in 7 poor years (Bramlett 1965). Among 10 mature trees in Virginia, sound seed, total developed seed, percentage sound seed, and seed efficiency per cone differed significantly between trees and years over a 6-year period (Bramlett 1972); for all trees, the yield of sound seed per cone varied from a low of 1.6 in 1968 to a high of 25.6 in 1969 and averaged 12.1 per cone; cone dimensions remained relatively stable over the 6-year period.

Time of pollen shedding has been observed to vary among clones in a seed orchard, maximum pollen-shed in certain clones passing before it started in others. The time of initiation of active growth varied widely for both female and male flowers among clones (Wasser 1967). Thus, time of flowering might be an important factor in seed quality in an orchard with a small number of clones. Seed from seed orchards will not represent a uniform mixture from all clones if there is variation among them in volume and quality of seed.

MONOTERPENE CONTENT OF OLEORESIN

Percentage of terpene components varied over a wide range among individual trees throughout the shortleaf pine range (fig. 146) (Coyne and Keith 1972). The average coefficients of variation for alpha- and beta-pinene were 18 percent and 20 percent, respectively. As shown by the frequency histograms, the medians for amount of the terpenes fell in the 45 to 50 percent range. Minor oleoresin components of camphene, myrcene, limonene, and beta-phellandrene usually made up less than 4 percent of the volatile fraction. The average coefficient of variation for camphene was 47 percent and the other three minor components 81 to 87 percent. At 3 geographic locations, myrcene exhibited a wide range of variation among trees, as did limonene at 3 locations and beta-phellandrene at 6 locations among the 15 locations sampled. The frequency histograms showed normal distributions for both alpha- and beta-pinenes but skewed distributions for the other four components. Although the stands were sampled rangewide, there were only minor relationships between terpene concentrations and geographic location; consequently, the estimates largely reflect differences among individual trees. Additional results of the study were discussed in the chapter on geographic variation.

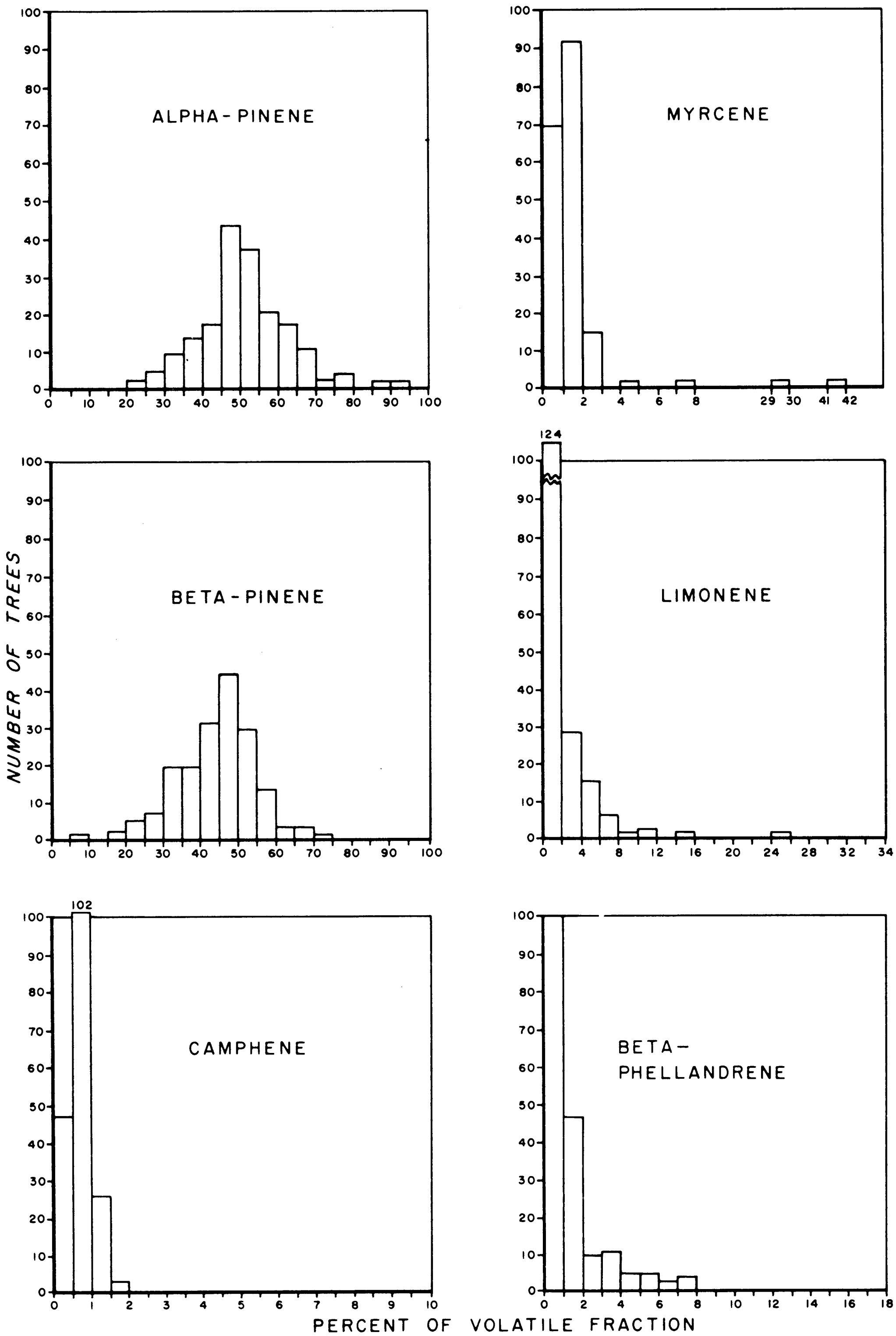

Figure 146.—Frequency distribution of terpene components of shortleaf pine wood oleoresin. Basis, 178 trees. (Coyne and Keith 1972)