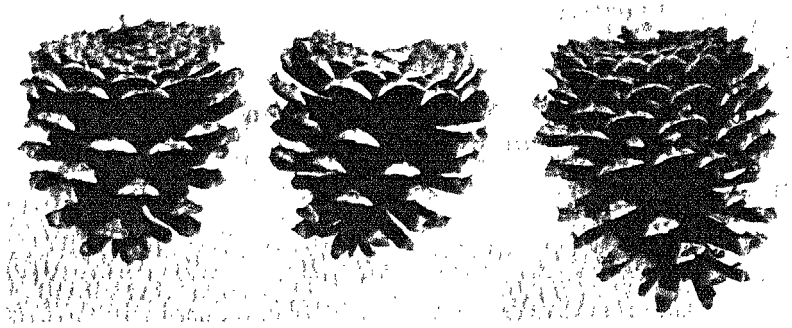
NATURAL HYBRIDS

among Pond, Loblolly, and Pitch Pines



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U. S. FOREST SERVICE RESEARCH PAPER NE-67
1967

NORTHEASTERN FOREST EXPERIMENT STATION, UPPER DARBY, PA.
FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE
RICHARD D. LANE, DIRECTOR

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Contents

INTRODUCTION

NATURAL hybrids or intergrades between pond and loblolly pines *(Pinus serotina* X *taeda)* occur in Delaware and Maryland, and hybrids or intergrades between pitch and pond pines *(P. rigida* X *serotina)* are found in New Jersey, Maryland, and Delaware. Hybrids between pitch and loblolly pines *(P. rigida* X *taeda)* are somewhat rare, but are known in New Jersey and Maryland. This paper describes the characteristics of the intergrades and of the parent species, and discusses the value of distinguishing intergrades and species in forestry practice.

Several natural interspecific hybrids have been recorded among closely related species of pines. And additional natural hybrids may be expected because so many artificial crosses have been made. However, interspecific hybridization in nature is the exception, not the rule. For, if crossing between two species were common, the populations of offspring would be so variable or so intermediate that taxonomists could distinguish only a single species.

Differences in geographic distribution or in time of pollination usually serve as a barrier to the crossing of closely related species of pines. For example, natural hybrids between jack pine *(Pinus banksiana* Lamb.) of the northeastern United States and Canada and lodgepole pine *(P. contorta* Dougl.) of western North America were observed by Moss *(20)* in central and northwestern Alberta, where the ranges of the parent species overlap. However, geographic isolation has prevented extensive crossing.

Differences in the usual time in pollination have limited the amount of hybridization between longleaf pine *(P. palustris* Mill.) and loblolly pine *(P. taeda* L.) in the southeastern United

States. Hybrids between these two species were reported first from Louisiana by Chapman *(1)*; afterwards they were found in North Carolina and Texas, and they have been produced artificially. Similarly, loblolly pine sheds its pollen 3 to 4 weeks before pond pine, according to Dorman and Barber *(5)*; thus natural hybridization is limited between these species.

REVIEW OF LITERATURE

Silvical characteristics, including range maps and notes on hybrids, have been summarized for the three species: pond pine *(Pinus serotina* Michx.) and loblolly pine *(P. taeda* L.) by Wenger *(25, 26)*, pitch pine *(P. rigida* Mill.) by S. Little *(15)*. Wenger reported that natural hybrids occurred between the first two where they were closely associated, and that artificial hybrids are growing at the Westvaco Experimental Forest near Georgetown, South Carolina.

These three species can be crossed readily. In his review of hybridization of the southern pines, Critchfield *(4)* reported many successful artificial combinations, though natural hybridization is not conspicuous.

Pitch Pine and Pond Pine

Intergrades between pitch pine and pond pine have long been known, and have affected their separation into distinct species. Sargent *(21)* and Sudworth *(23)* regarded the two as varieties of the same species, although previously both authors had separated them into two species in references published in 1897. As early as 1838, Loudon associated the two, but used the name for pond pine as a species: *Pinus (r.) serotina* Michx. ex Loud. (Arb. Frut. Brit. 4: 2242, figs. 2127-2130. 1838). Pond pine was later reduced to a variety, *P. rigida* var. *serotina* (Michx.) Loud. ex Hoopes (Book Evergreens 120. 1868), as noted by E. L. Little *(11)*.

Clausen *(2)* studied taxonomic relationships of pitch and pond pines after collecting intermediate specimens at West Cape May, New Jersey. Long *(17)* first recorded pond pine in New Jersey in 1909. Regarding pond pine as a subspecies, Clausen *(2,* p. 126) made the combination *P. rigida* subsp. *serotina* (Michx.) Clausen. After examining specimens collected from Massachusetts

to Florida, Clausen concluded that the length of leaves was the best basis for separating the two populations of pitch and pond pines, that this character exhibited a geographical gradient, and that a length of leaves of 15 cm. or more, from southern New Jersey southward, might be considered the arbitrary dividing line. He excluded geographic range as a basis for specific segregation, ignored length of leaf sheaths as repetition of leaf length, and found prickles on cone scales to be tremendously variable.

In Delaware, where both pitch and pond pines occur, Taber *(24)* described and illustrated the distinguishing characteristics of both. Compared with pitch pine, pond pine had longer needles; shorter, flatter cones; shiny, usually weak-prickled tips of cone scales, and somewhat longer buds.

In North Carolina, Coker and Totten *(3)* were "quite unable to accept" the disposition of pond pine as a variety of pitch pine. They cited differences not only in leaves, cones, and stature, but also in soil requirements and distribution. The regional floras of Fernald *(7)* and Gleason *(8)* also maintained the two as separate species.

In connection with soil requirements, it should be noted that in the Northeast, especially in New Jersey, pitch pine grows on sites commonly considered restricted to pond pine in the Southeast —poorly or very poorly drained sands (such as Leon and St. Johns soils) and peats of the Coastal Plain. Of course pitch pine is also common on ridge sites in both sections, and in the Northeast on sandy or gravelly plains of outwash or other origin.

When revising the Forest Service Check List *(23)*, the senior author retained pond pine as a variety in a preliminary mimeographed edition (1944). Southeastern foresters protested and demonstrated the differences. Accordingly, pond pine was accepted as a species in the 1953 Check List *(13)*.

Pitch Pine and Loblolly Pine

Natural hybrids between pitch and loblolly pines have been relatively unknown because the ranges of the two scarcely meet. However, they do occur.

Artificial hybrids between pitch and loblolly pines were made at the Institute of Forest Genetics, Placerville, California, as early

as 1933 *(6)*. More recently this hybrid has been mass-produced in Korea (where 11,000 to 30,000 pollination bags have been mounted annually), mainly because the hybrids are faster growing than pitch pine and hardier than loblolly pine *(9, 10)*. In test plantings in Maryland and Illinois, the hybrids have had slower growth and less desirable form than typical loblolly stems *(16, 18)*.

FIELD WORK

Natural gradations among these three species have been observed, especially by the second author in his field work over a period of years. For additional comparisons, herbarium specimens were collected by the authors on field trips in September 1959 and in October 1961. On these trips the following foresters of State forestry departments assisted: Charles W. Holsworth in southern New Jersey, William S. Taber in Delaware, and John J. Mohr in eastern Maryland. More specimens were collected in November 1965 at the Beltsville Experimental Forest, U. S. Forest Service, in northern Prince Georges County, Maryland (about 10 miles northeast of Washington, D. C.). Many intermediate trees occur in the Beltsville area.

The herbarium specimens were collected from trees of the three species as well as from trees with the intermediate characteristics of hybrids or intergrades. Representative specimens have been deposited in the herbaria of the U. S. Forest Service and U. S. National Museum at Washington, D. C., Rutgers University, the University of Maryland, and the Institute of Forest Genetics, Placerville, California.

COMPARATIVE CHARACTERS

The main contrasting characters of the three species and their natural hybrids or intergrades are summarized in table 1, which may serve to verify hybrid trees and specimens. The characters of the listed hybrids were taken from specimens that were about equally intermediate between the two species, or that were probably first-generation offspring.

Of course, many of the intergrades do not have equally intermediate characteristics between the two species, but are more like one of the parent species. Such trees may result from subsequent backcrossing (introgression). Even though many of the trees examined fell in this category, their characteristics could not be included in table 1.

Taxonomic characters included in table 1 are limited to those in which two or three species differ, while those common to all parents and progeny are omitted. For the hybrids, characters are indicated by I if intermediate or by the first letter of the epithet of one parent if like that parent. The characters of each hybrid are summarized at the bottom of the table. Thus, the pitch-pond hybrid is intermediate in 10 characters and like pond pine in 2. The pond-loblolly hybrid is like pond pine in 3, like loblolly pine in 3, and intermediate in 15. The pitch-loblolly hybrid is like pitch pine in 8 characters, like loblolly pine in 1, and intermediate in 7. In Mississippi, Mergen et al. *(19)* found that for some characters, loblolly-shortleaf pine hybrids occupy a generally intermediate position betwen the two parent species.

Of course, as table 1 illustrates, pitch pine and pond pine are closely related and have more characters in common with each other than with loblolly pine.

Habit

Typical mature trees of loblolly pine are fairly large and have relatively straight trunks. Many stems, especially of the younger ones, have long sweeps; a typical, pronounced one is shown in figure 1. Dead branches are shed rather rapidly. Typical growth of loblolly pine is appreciably more rapid than the growth of pitch or pond pine on the same site.

Mature stems of pitch pine are of medium size or relatively small. Their crowns are often irregular; the branches are often gnarled and twisted, especially on open-grown trees that have been subjected to adverse environmental conditions. Suppressed trees, stems damaged by past wildfires, or those released by heavy cuttings usually have drooping, slender branches along the lower boles. The boles of large, stand-grown trees may appear fairly clear; but dead branches, being more resinous, are retained longer

Table 1. – *Comparison of contrasting characters of the three pine species and their natural hybrids*

Character	*Pinus rigida* (pitch pine)	*Pinus rigida* X *serotina* (pitch-pond hybrid pine)	*Pinus serotina* (pond pine)	*Pinus serotina* X *taeda* (pond-loblolly hybrid pine)	*Pinus taeda* (loblolly pine)	*Pinus rigida* X *taeda* (pitch-loblolly hybrid pine)
Trunk:						
Leaves on short twigs	Present.	Present.	Present.	Usually absent (I).	Absent.	Usually absent (I).
Buds	Usually resinous.	Usually resinous.	Usually resinous.	Usually resinous (S)	Usually non-resinous, shiny.	Resinous (R).
Leaves:						
Length	6-14 cm.	10-17 cm. (I).	11-20 cm.	12-21 cm	12-22 cm.	10-19 cm. (I).
Width	1.1-1.6 mm.	1.4-1.6 mm. (I).	1.6-1.8 mm.	1.4-1.6 mm. (I).	1.1-1.3 mm.	1.1-1.5 mm.
Stiffness	Slightly stiff.	Slightly stiff.	Slightly stiff.	Flexible to slightly stiff (I).	Flexible	Slightly stiff (R).
Marginal teeth	Fine.	Fine to stout (I).	Stout.	Fine (T).	Fine	Fine
Resin canals	2-6 (11), small.	3-9, mostly small.	3-9, mostly small.	4-5, mostly small (I)	2-4 (6), large and small.	2 large and 0-2 small (I).
Cones:						
Length	4-7 cm.	4.5-6.5 cm. (I).	4.5-6 cm.	7-9 cm. (I).	7-11 cm.	5-6 cm. (R).
Width closed	2.5-3.5 cm.	3.5 cm. (I).	4-5 cm.	3.5-4.5 cm. (I).	3.5 cm.	3.2-3.5 cm.
Width open	4.5-5.5 cm.	5-6 cm. (I).	5.6-7 cm.	5.5-6 cm.	6-7.5 cm.	4.5-6 cm. (I).
Shape closed	Narrowly ovoid.	Ovoid (I).	Ovoid to subglobose.	Conic or narrowly ovoid (I).	Conic.	Conic (T).
Shape open	Ovoid, mostly longer than broad, broadest below middle, flattened at base.	Ovoid, almost as broad as long, flat at base (I).	Nearly hemispherical, broader than long, broadest at flat base formed by reflexed scales.	Ovoid, broadest below middle, flattened at base (I).	Ovoid, broadest below middle, not flat at base	Ovoid, flattened at base (R).

Dehiscence	Early or late.	Early.	Late (serotinous) to early	Early to late (I).	Early.	Early.
Persistence	Persistent.	Persistent.	Persistent.	Partly persistent (I).	Usually deciduous.	Persistent (R).
Phyllotaxy	Normal.	Intermediate (I)	High order, many scales.	Intermediate (I).	Normal.	Normal.
Cone scales:						
Width	7-10 mm.	6-10 mm.	6-10 mm.	9-13 mm. (I).	12-15 mm.	8-13 mm. (I).
Keel	Prominent.	Weak on basal scales (S).	Weak on basal scales.	Weak on basal scales (S).	Prominent.	Prominent.
Prickle	About 2 mm. long, small, slender, sharp, persistent.	About 1-2 mm. long, small, slender, mostly persistent (I).	About 1 mm. long, or less, small, slender, weak, often deciduous.	About 2-3 mm. long, or less, small, slender, sharp, persistent (I).	About 2-3 mm. long, including broad umbo, large, stout, persistent.	About 2 mm. long, small, slender, sharp, persistent (R).
Prickle on basal scales	Almost same size.	Smaller (S).	Smaller.	Smaller (S).	Almost same size.	Almost same size.
Color of apophysis	Tawny yellow, slightly shiny or dull.	Tawny yellow, slightly shiny or dull.	Tawny yellow, slightly shiny.	Tawny yellow, dull (I).	Nut brown, dull	Tawny yellow, slightly shiny or dull (R).
Seed:						
Length with wing	15-21 mm.	19-24 mm.	21-24 mm.	24-27 mm. (I).	27-28 mm	21-22 mm. (I).
Length of body	4-5 mm.	5 mm.	5 mm.	6-7 mm. (T).	6-7 mm	4.5-6 mm. (I).
Shape of body	3-angled.	3-angled.	3-angled.	Rhomboid or ovoid (T).	Rhomboid or ovoid.	3-angled (R).
Summary	—	10 I, 2 S.	—	3 S, 15 I, 3 T.	—	8 R, 7 I, 1 T.

Figure 1.—Comparative size and form of loblolly pines (left) and of pitch-loblolly hybrids (right) 17 years after planting. Note the sweep, relatively clear length, and large size of the loblolly pine stem by the man in the left photograph, in contrast to the short crooks, dead branches, and cones on the hybrid stem in the right foreground.

than in loblolly (fig. 1). Usually, too, small clusters of needle fascicles still occur at many of the lower nodes or at the base.

Pond pine may be somewhat intermediate in size, but in nearly all respects resembles pitch pine more closely than loblolly pine. Mature pond pines tend to have open crowns with stout branches, often drooping at the ends.

Stems of both pitch pine and pond pine are typically crooked

and irregular in form. The crooks in young trees differ appreciably from the long sweep common in loblolly; the crooks in pitch and pond pine are short and irregular (fig. 1). Many, of course, are eventually overgrown so that—unless site, environment, past history, or treatment are too adverse—older trees of both species may have relatively straight stems.

Vegetative Reproduction

Pitch pine and pond pine both have the vigorous vegetative capacity of sprouting, especially after fires. These two species and their hybrid have characteristic short twigs and leaves along the trunk. Loblolly pine and some of its hybrids with the other two species lack these features.

Leaves or Needles

Pitch pine is distinguished from pond pine partly by the shorter leaves, but their hybrid is intermediate. Pond pine, loblolly pine, and their hybrid have long leaves. The leaves of pond pine measure slightly wider than those of the other two species; however, the hybrids are intermediate.

Pitch pine, pond pine, and their hybrids have slightly stiff or rigid leaves, although loblolly pine and some of its hybrids have flexible leaves. The difference in flexibility can be distinguished by touch: clusters of needles at the end of a branch or terminal of pitch pine or pond pine tend to prick the skin when a hand is held against them, whereas needles of loblolly pine bend and feel soft against the palm.

Typical foliage of loblolly pine is also lighter in color than that of the other two species.

Needle Anatomy

Pitch pine, pond pine, and their hybrid are not distinguishable in needle anatomy according to microscopic examination of freehand cross-sections. All are characterized by three usually small medial resin canals in the angles, and usually 1 to 6 additional small, medial, or medial and internal canals. Loblolly pine differs slightly in having usually fewer, but larger resin canals (mostly more than 40 microns in diameter) 2 or 3 medial in angles, and sometimes more.

Cones

Cone characters are basic in classification within the genus *Pinus*. Representative cones of these three species and their three hybrids are shown in figure 2. Pond pine is recognized by its distinctive broad egg-shaped to nearly spherical cone, which remains attached for several years, usually closed *(26)*. The numerous closed cones, weathering to gray on the older branches, resemble eggs or balls, and form an important characteristic in distinguishing this species. Even the specific epithet, meaning late, refers to the cone, which typically remains closed until opened by a fire to release the seeds.

The other two species differ from pond pine in cone characters. Loblolly pine has longer cones, and pitch pine has narrower cones than either loblolly or pond pine. The open cone of pond pine is nearly hemispherical, broader than long, and broadest at the flat base formed by reflexed scales. Open cones of the other two species are usually longer than broad, and widest below the middle. The broad cone of pond pine has a high order of phyllotaxy in the middle portion, that is an efficient arrangement with numerous scales.

The mature cone of loblolly pine is dull nut-brown in color at the ends or apophyses of cone scales, while the color in the other species is tawny, often slightly shiny, yellow. The prickle on cone scales of loblolly pine is unusually large and stout; the prickle of pond pine is small, slender, weak, and often deciduous, especially on the basal scales. In pitch pine the prickle is intermediate between the other two species.

Time of cone opening or dehiscence is early or soon after maturity in loblolly pine and its hybrids, but variable in the other two species. Pond pine trees growing in swamps usually have closed cones, although some on dry sites have cones that open, either soon after maturing or over a period of several years. These variations and similar ones in pitch pine apparently represent local or geographical adaptations to differences in frequency of fires.

Cone production and retention also differ among the three species. Both pitch pine and pond pine produce cones at an earlier

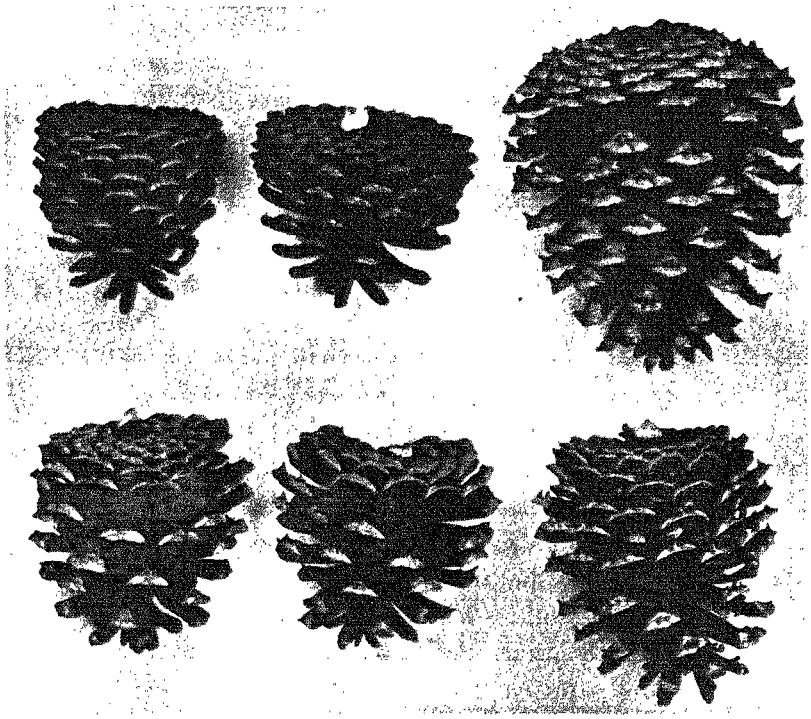

Figure 2. — Cones compared, approximately one-half natural size. Top row: pitch pine, pond pine, loblolly pine. Bottom row: pitch pine X pond pine, pitch pine X loblolly pine, pond pine X loblolly pine.

age than loblolly. Pitch pine may bear mature cones on 3-year-old sprouts or 4-year-old seedlings, but usual cone production on open-grown seedlings does not begin until stems are 8 to 12 years old *(15)*. Pond pine apparently begins cone production at about the same age *(26)*. Although individual trees of loblolly pine less than 10 years old occasionally produce cones, appreciable cone production does not begin until much later *(25)*. Thus an appreciable number of cones on sapling-size stems is characteristic of pitch or pond pine, but not of loblolly. Furthermore, loblolly

usually drops its cones within a year or two after they mature, so that large numbers of old cones are characteristic of pitch and pond pines, but not of loblolly.

Cone characters of the hybrids and their offspring are gradational between species (fig. 2). Some trees may have cones similar in size and shape to loblolly pine, but are like pond pine in type of cone prickles, retention of old cones, and early and abundant fruiting. Possibly because of backcrossing, many of the gradational trees have nearly all the features of one species, with only one or two characteristics of the second species.

BOTANICAL DESCRIPTIONS

The three natural hybrids described below are designated by formulas that will include all recognizable natural and artificial hybrids between the same two parent species *(14)*. Though Latin binary names have been given to most natural interspecific tree hybrids in the past, further use of binomials seems neither useful nor necessary. Most workers in forest-tree-improvement programs in the United States prefer the formulas and oppose binomials for hybrids. Any particular variations of these crosses produced in quantity may be given English variety (cultivar) names as needed and under the International Code of Nomenclature for Cultivated Plants.

Pinus rigida X *serotina* (Pitch Pine X Pond Pine)

Pinus rigida X *serotina*, pitch pine X pond pine, or pitch-pond hybrid pine. Natural hybrid tree with leaves and cones intermediate between *Pinus rigida* Mill. (Gard. Dict. Ed. 8, *Pinus* No. 10. 1768), pitch pine, and *P. serotina* Michx. (Fl. Bor.-Amer. 2:205. 1803), pond pine. Medium-sized tree 9 m. (30 ft.) or more in height and 20 cm. (8 in.) or more in trunk diameter. Bark brownish gray, rough, thick, furrowed into long scaly plates. Trunk bearing leaves on short twigs. Buds cyclindric, acute to acuminate, reddish brown, resinous.

Leaves 3 in fascicle, slightly stiff, 10-17 cm. long, 1.4-1.6 mm. wide, serrulate, green; whitish stomatal rows 13-18 on dorsal sur-

face and 5-11 on each ventral surface. Needle anatomy in cross section: hypodermis biform, of 2-4 layers; endodermis of thin-walled cells; resin canals 3-9, medial or medial and internal, mostly small.

Mature cones sessile or nearly so, 4.5-6.5 cm. long, when closed ovoid and 3.5 cm. wide, when open ovoid, almost as broad as long, flat at base, 5-6 cm. wide, frequently early dehiscent, persistent. Cone scales spreading, lower ones slightly reflexed, mostly 6-10 mm. wide; apophysis keeled though keel weak on basal scales, tawny yellow, slightly shiny or dull; umbo ending in small slender prickle about 1-2 mm. long, mostly persistent, smaller on basal scales. Winged seeds about 19-24 mm. long, including detachable brown wing and 3-angled body 5 mm. long and blackish.

Representative specimens: *Little and Little 17321,* September 23, 1959, Dias Creek, Middle Township, Cape May County, New Jersey; and *E. L. Little, Jr., 21276,* November 8, 1965, Beltsville Experimental Forest, Prince Georges County, Maryland.

Pinus serotina X taeda (Pond Pine X Loblolly Pine)

Pinus serotina X *taeda,* pond pine X loblolly pine, or pond-loblolly hybrid pine. Natural hybrid tree with leaves and cones intermediate between *Pinus serotina* Michx. (Fl. Bor.-Amer. 2: 205. 1803), pond pine, and *P. taeda* L. (Sp. Pl. 1000. 1753), loblolly pine. Medium-sized tree 12 m. (40 ft.) or more in height and 20 cm. (8 in.) or more in trunk diameter. Bark dark gray, rough, furrowed into scaly plates. Trunk usually without short twigs and leaves. Buds cylindric, acute, reddish brown, resinous.

Leaves 3 in fascicle, flexible to slightly stiff, 12-21 cm. long, 1.4-1.6 mm. wide, serrulate, green; whitish stomatal rows 11-13 on dorsal surface and 7-9 on each ventral surface. Needle anatomy in cross section: hypodermis biform, of 2-4 layers; endodermis of thin-walled cells; resin canals 4-5, medial or medial and internal, mostly small.

Mature cones sessile or nearly so, 7-9 cm. long, when closed conic or narrowly ovoid and 3.5-4.5 cm. wide, when open ovoid, broadest below middle, flattened at base, 5.5-6 cm. wide, early or late dehiscent, partly persistent. Cone scales spreading, lower ones

slightly reflexed, mostly 9-13 mm. wide; apophysis keeled though keel weak on basal scales, tawny yellow, dull; umbo ending in small, slender, sharp, persistent prickle about 2-3 mm. long, smaller on basal scales. Winged seeds about 24-27 mm. long, including detachable brown wing and rhomboid or ovoid body 6-7 mm. long, blackish.

Representative specimen: *Little and Little 17336*, September 24, 1959, 7 miles west of Milton, Sussex County, Delaware.

Pinus rigida X taeda
(Pitch Pine X Loblolly Pine)

Pinus rigida X *taeda*, pitch pine X loblolly pine, or pitch-loblolly hybrid pine. Natural hybrid tree with leaves and cones intermediate between *Pinus rigida* Mill. (Gard. Dict. Ed. 8, *Pinus* No. 10, 1768), pitch pine, and *P. taeda* L. (Sp. Pl. 1000. 1753), loblolly pine. Medium-sized tree 8 m. (26 ft.) or more in height and 15 cm. (6 in.) or more in trunk diameter. Trunk usually without short twigs and leaves. Buds cylindric, acute, reddish brown, resinous.

Leaves 3 in fascicle, slightly stiff, 10-19 cm. long, 1.1-1.5 mm. wide, serrulate, green; whitish stomatal rows 10-15 on dorsal surface and 5-9 on each ventral surface. Needle anatomy in cross section: hypodermis biform, of 2-4 layers; endodermis of thin-walled cells; resin canals medial, 2-4, 2 large at angles and others small.

Mature cones sessile or nearly so, 5-6 cm. long, when closed conic and 3.2-3.5 cm. wide, when open ovoid, flattened at base, 4.5-6 cm. wide, persistent. Cone scales spreading, lower ones slightly reflexed, mostly 8-13 mm. wide; apophysis with prominent transverse keel, tawny yellow, slightly shiny or dull; umbo ending in small, slender, sharp, persistent prickle about 2 mm. long. Winged seeds 21-22 mm. long, including detachable wing and 3-angled body 4.5-6 mm. long.

Representative specimens: *S. Little 4*, February 7, 1962, natural reproduction around loblolly pine plantation, Lebanon State Forest, Burlington County, New Jersey; *E. L. Little, Jr., 21277*, November 8, 1965, Beltsville Experimental Forest, Prince Georges County, Maryland.

The description of *Pinus rigida* X *taeda* is based upon the natural reproduction around a loblolly pine plantation at Lebanon State Forest, Burlington County, New Jersey, and natural hybrids on the Beltsville Experimental Forest in Maryland. The New Jersey plants were compared with artificial hybrids of the same cross made at the Institute of Forest Genetics, Placerville, California, and growing at the Lebanon State Forest.

DISTRIBUTION OF SPECIES AND HYBRIDS

Species

The natural ranges of the three species are mapped in the respective station papers on silvical characteristics *(15, 25, 26)*. Loblolly pine is found on the Coastal Plain or Piedmont from Delaware to Florida and Texas. The published map *(25)* shows loblolly pine's botanical range as extending into northern Delaware, and Taber *(24)* mentions a natural outpost on the banks of the Delaware-Chesapeake Canal in New Castle County. However, its occurrence north of Dover is rare, and in Delaware it is found principally in lower Kent and Sussex Counties *(24)*.

Long *(17)* and others recorded loblolly pines in southern New Jersey, but we wonder whether these trees were planted or descended from planted trees. This species was not reported from New Jersey until 1897, and then only from a few locations in lower Cape May County *(22)*. Because of the natural reproduction near later plantations in other counties of southern New Jersey, the Cape May trees cited by Stone and Long, as well as the occasional stands found there today, may be descended from early ornamental plantings. On the other hand, District Forester Charles W. Holsworth suggests that loblolly pines found west of dwellings at Dias Creek in Cape May County and near Dividing Creek in Cumberland County, both areas not far from Delaware Bay, may form natural outposts of this species.

Pond pine is found chiefly on wet soils and in swamps of the southeastern Coastal Plain from southern New Jersey to Alabama and Florida. This range is almost entirely within that of loblolly pine, but smaller. At present the known occurrence of pond pine in New Jersey is limited to Cape May County and to southern

portions of Cumberland County, although Stone *(22)* mentioned that it was also found near Swedesboro in Gloucester County. In Delaware, Taber *(24)* found pond pine growing both on wet sites and on dry, sandy soils—mostly in Sussex County, but to some extent also in Kent County.

Pitch pine is an upland tree of the mountains from northern Georgia northward through Pennsylvania and scattered to the Canadian border and New England. However, it descends to the Coastal Plain and river valleys, especially from New Jersey northward to Maine. Although commonly considered as a tree of shallow soils on ridges, it grows too on imperfectly to very poorly drained sands, even in the Atlantic white-cedar swamps, in the Northeast. It is the commonest pine of the New Jersey pine barrens. Although two publications *(15, 24)* indicate its occurrence in southern Delaware, the authors of this paper did not find typical specimens of pitch pine in the southern part of the state. Typical trees of pitch pine may well be confined to the northern part of the state, possibly as scattered outposts of the greater concentration of this species in the Maryland barrens west of Elkton.

Apparently pitch and pond pines have almost entirely separate ranges, which meet only in narrow restricted areas in southern New Jersey, especially lower Cape May County, and possibly in central Delaware and the central portion of Maryland's Eastern Shore. When maps of these two species are united, a peculiar distribution pattern results *(12,* p. 769).

Pitch and loblolly pines also have almost entirely separate ranges. However, both occur naturally in the upper portion of Maryland's western shore—chiefly in Prince Georges County.

Present distribution patterns of all three species probably were affected by Pleistocene glaciation, though evidence of past distribution is lacking.

Hybrids

Because they are usually geographically separated, pitch and pond pines have relatively few natural hybrids or intergrades. Intergrades can be found in spots in Cape May County, New Jersey, and near Beltsville in Prince Georges County, Maryland.

In Delaware there seems to be a tendency to grade from typical pond pine in Sussex County toward pitch pine in the vicinity of Dover. Whether the decreased length of needles observed on some of the latter trees is evidence of some pitch pine ancestry is questionable. Therefore, on the whole, the hybrids or intergrades between pitch and pond pines are chiefly of taxonomic interest.

A similar difference in geographic ranges has prevented widespread occurrence of natural hybrids or intergrades between pitch and loblolly pines. However, these hybrids do occur in Prince Georges County, Maryland. Other hybrids should be expected wherever loblolly pines have been successfully planted within the range of pitch pine. For example, reproduction developing around the older plantations of loblolly pine in southern New Jersey contains apparent hybrids between these two species.

In contrast, natural hybrids and intergrades between loblolly pine and pond pine are more widespread. They can be found quite commonly throughout southern Delaware: from Marydel and Dover south to the Maryland line, as well as along the dunes below Rehoboth Beach. In Maryland similar hybrids and intergrades are less common, and typical trees of loblolly pine are much more prevalent. However, the hybrids and intergrades have been observed, especially in the vicinity of the Wicomico State Forest, south in the vicinity of the Nassawango Creek to the northern portion of the Pocomoke State Forest. This general section has had more wildfires than usual for the Eastern Shore, and the fires have doubtless played a major role in favoring pond pine and its hybrid since these trees are more fire-resistant, but slower growing, than the typical loblolly pine. In fact, within that general section the prevalence of pond pine and its hybrids is closely associated with the recent fire history.

In both Delaware and Maryland, pond pine and its hybrids or intergrades are not restricted to wet sites, but are found on a wide variety of soils. In much of southern Delaware, hybrids or intergrades between pond and loblolly pines seem more common than typical trees of the latter.

IMPORTANCE IN FORESTRY PRACTICE

The differences between loblolly pine and pond pine are important in the practice of forestry in Delaware and on Maryland's Eastern Shore, mainly because pond pine is slower growing, has less desirable form and clear length than does loblolly. At 50 years on the usual 80- to 85-foot sites, a typical pond pine is 13 to 15 feet shorter, with a smaller diameter than nearby typical loblolly pines (fig. 3). Some of the intergrades or hybrids approach typical loblolly in growth and form, but many are intermediate. Artificially produced pitch-loblolly hybrids have also grown more slowly on the Eastern Shore than regular nursery stock of loblolly: dominant loblolly pine trees (about 125 per acre) at 17 years after planting were 44 or 45 feet tall, and dominant pitch-loblolly hybrids at 17 years were 33 to 37 feet tall (table 2 and fig. 1). In fact, the growth of these hybrids was similar to that of shortleaf pine, a species with a growth rate comparable to that of pitch pine. Obviously forestry practices should favor regular loblolly pine over pond pine or intergrades,

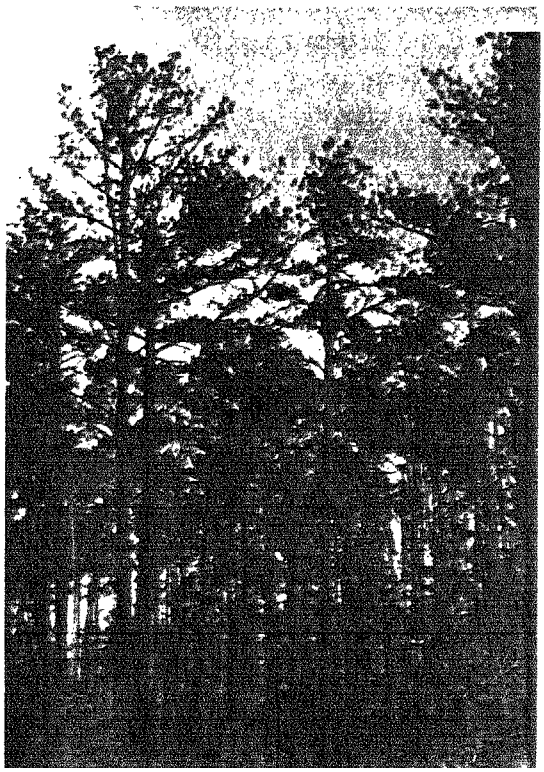

Figure 3. — Comparative heights of loblolly and pond pines. The loblolly pine at the left of the photograph is 87 feet tall; the pond pine in the center is 74 feet tall.

Table 2.—*Size of artificial hybrid pines and ordinary nursery stock 17 years after planting*[1]

Nursery	Stock	Average diameter (b.h.) of all living stems	Largest stems[2]	
			Diameter	Height
		Inches	*Inches*	*Feet*
	WICOMICO STATE FOREST, MARYLAND			
Green Bank, N. J.	Loblolly	9.0	10.4	44
	Pitch (V6) X loblolly (V22)	6.4	8.3	37
	Shortleaf	5.6	7.3	35
Milford, Del.	Loblolly	8.6	10.7	45
	Pitch (V28) X loblolly (V22)	6.1	8.1	36
	Pitch (V27) X loblolly (V22)	6.8	8.1	34
	Pitch (V29) X loblolly (V22)	5.7	6.8	33
	LEBANON STATE FOREST, NEW JERSEY			
Green Bank, N. J.	Loblolly	4.9	5.2	23
	Pitch (V6) X loblolly (V22)	4.2	5.4	22
	Shortleaf	3.7	4.6	23

[1] For a description of this study, see Little and Somes *(16)*. These artificial first-generation hybrids were grown from seeds obtained from the Institute of Forest Genetics, Placerville, California.

[2] At the rate of about 125 per acre.

since favoring loblolly alone would increase the site index by 10 to 15 feet.

In mixed immature stands with a small proportion of pond pine, competition alone will eliminate many stems of the slower growing species. However, any thinnings for pulpwood or other products should discriminate against the pond pines.

In mature stands seed trees should be selected from dominant loblolly pines. Such a procedure would reverse the trend that has been apparent in much of Delaware. There commercial selective cuttings have usually removed the larger pines, principally loblolly, often leaving pond and Virginia pines as the available seed sources.

The importance of differentiating loblolly pine from pond pine and its intergrades cannot be overemphasized in collecting seed for forest nurseries. The prevalence of hybrids and intergrades in Delaware makes the collection of typical loblolly seeds more difficult there than in Maryland. However, few intergrades will be included if collections are limited to large cones with stout

prickles from trees that have few cones older than 1 year, and that have non-resinous buds and relatively long, flexible needles.

On the other hand, the ease with which loblolly can be crossed with pitch pine suggests that perhaps the hybrid should be given greater consideration for planting north of loblolly's natural range. Like the mass-produced hybrids in Korea, some of these hybrids might be expected to be both hardier than loblolly and somewhat faster-growing than pitch pine. The only test plantings to date were of crosses made by the Institute of Forest Genetics of the Pacific Southwest Forest and Range Experiment Station, Placerville, California. On a deeply leached, sandy (Lakewood) soil in New Jersey, these hybrids have had the best survival, 50 percent after 17 years (compared to 41 percent for regular shortleaf stock and 11 percent for regular loblolly stock).

Height and diameter growth of the hybrids has been roughly comparable to both loblolly and shortleaf stocks (table 2), probably because the site is so poor that shortleaf's growth approaches loblolly's. On better soils in southern New Jersey, loblolly pines grow faster: in 29-year-old plantations in one field, dominant and codominant loblolly pines were 57 feet tall; shortleaf pines, 42 feet tall; pitch pines, 41 feet tall. And in natural reproduction around the older plantations of loblolly pine, some of the natural hybrids with pitch pine are growing nearly as fast, and with nearly as good form, as the loblolly pine seedlings. They seem to offer promise that certain of the hybrids would be at least superior to pitch pine seedlings.

These observations suggest that further tests of loblolly-pitch pine hybrids are desirable. Possibly the relatively poor results in the existing trial are due to geographic sources of the parents. Since both species have wide ranges and apparently local geographical races, future tests of loblolly-pitch pine hybrids in the Northeast will be based on Maryland or Delaware sources of loblolly pine and the best local strains of pitch pine.

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