# *Pinus rigida* Mill, Pitch Pine

**Pinaceae Pine family**

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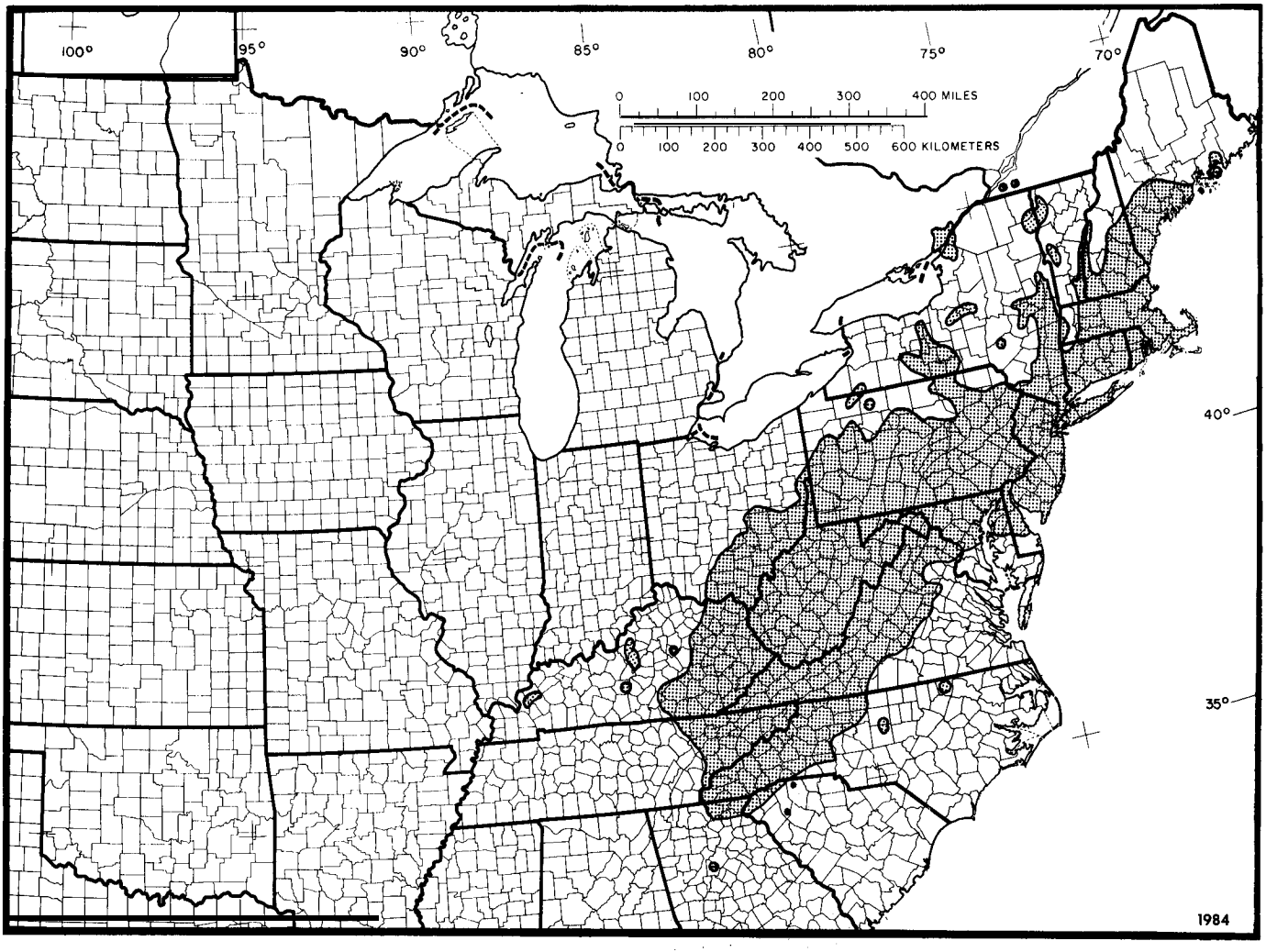
The species name of pitch pine *(Pinus rigida)* means rigid or stiff and refers to both the cone scales *(17)* and the wide-spreading, sharply pointed needles (5). It is a medium-sized tree with moderately strong, coarse-grained, resinous wood that is used primarily for rough construction and where decay resistance is important. One tree in Maine measured 109 cm (43 in) in d.b.h., 29 m (96 ft) tall, with a crown spread of 15 m (50 ft) *(11)*.

## Habitat

### Native Range

Pitch pine (fig. 1) grows over a wide geographical range-from central Maine to New York and extreme southeastern Ontario, south to Virginia and southern Ohio, and in the mountains to eastern Tennessee, northern Georgia, and western South Carolina. Be-

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cause it grows mostly on the poorer soils, its distribution is spotty.

In the Northeast, pitch pine is most common on the sandy soils of Cape Cod, Long Island, and southeastern New Jersey, and in some sections of sandy or shallow soils in Pennsylvania *(19).*

### Climate

The climate in the range of pitch pine is humid. Average annual precipitation is usually between 940 and 1420 mm (37 and 56 in) and is well distributed throughout the year. Length of the frost-free season ranges from 112 to 190 days and temperatures range from winter lows of -40" C (-40" F) in the northern part of the range to summer highs of more than 38" C (100" F) in most sections (9).

### Soils and Topography

Pitch pine is usually restricted to the less fertile soils-those of shallow depth, or of sandy or gravelly texture. Many of the northern stands are found on sandy outwash plains of glacial origin. The species also occupies sandy and gravelly soils of alluvial and marine origin. In the highlands of northern New Jersey, southern New York, Pennsylvania, and south through the mountains, it is most common on steep slopes, ridges, and plateaus where the soils are shallow.

Generally, pitch pine grows on Spodosols, Alfisols, Entisols, and Utisols. In southern New Jersey, the pH of the A and B horizons range from 3.5 to 5.1, and in northern New Jersey, from 4 to 4.5 *(9).*

Pitch pine grows on sites with a wide range of moisture conditions. In southern New Jersey it is found on excessively drained, imperfectly drained, and poorly drained sands and gravels, as well as on muck soils in the white-cedar swamps. Even in the hilly regions it grows on both well drained and excessively drained slopes and in the swamps (9).

In New England it is most common in the coastal districts and in river valleys. In New York it is not common above 610 m (2,000 ft), but in Pennsylvania it grows at all elevations up to the highest point in the State, 979 m (3,213 ft) *(13).* In the Great Smoky Mountains and vicinity, pitch pine is found at elevations between 430 and 1370 m (1,400 and 4,500 ft). In hilly sections, pitch pine often occupies the warmer and drier sites, those facing south or west *(9).*

### Associated Forest Cover

Pitch pine is the major component of the forest cover type Pitch Pine (Society of American Foresters Type 45) and is listed as an associate in nine other types (8): Eastern White Pine (Type 21), Bear Oak (Type 43), Chestnut Oak (Type 44), White Pine–Chestnut Oak (Type 51), White Oak-Black Oak–Northern Red Oak (Type 52), Shortleaf Pine (Type 75), Virginia Pine-Oak (Type 78), Virginia Pine (Type 79), and Atlantic White-Cedar (Type 97). In addition to the species named in the types, pitch pine associates are Table Mountain pine *(Pinus pungens),* gray birch *(Betula populifolia),* post oak *(Quercus stellata),* blackjack oak *(Q. marilandica),* scarlet oak *(Q. coccinea),* southern red oak *(Q. falcata),* various hickories *(Carya* spp.), blackgum *(Nyssa sylvatica),* red maple *(Acer rubrum),* and eastern hemlock *(Tsuga canadensis).*

According to the Forest Survey, pitch pine types cover 9 900 ha (24,500 acres) in New Hampshire, 85 400 ha (211,000 acres) in Massachusetts, 1200 ha (3,000 acres) in Rhode Island, possibly 44 500 ha (110,000 acres) in New York, more than 121 400 ha (300,000 acres) in Pennsylvania, and more than 283 300 ha (700,000 acres) in New Jersey. Other Northeastern States contain fewer hectares of this species, though about 187 400 ha (463,000 acres) in Maryland and 346 000 ha (855,000 acres) in West Virginia were classified in the Forest Survey as having pitch pine-Virginia pine-hardwood stands. However, in these two States, the Virginia pine *(Pinus virginiana)* component greatly exceeds pitch pine in most stands *(9).*

Usually, the most common shrubs growing with pitch pine on upland sites are lowbush blueberries (often *Vaccinium vacillans* or *V. angustifolium)* and black huckleberry and dangleberry *(Gaylussacia baccata* and G. *frondosa).* Some stands include bear oak *(Quercus ilicifolia),* dwarf chinkapin oak *(Q. prinoides),* and mountain-laurel *(Kalmia latifolia).*

Lowland sites where pitch pine predominates have a variety of shrubs. Common ones include sheep-laurel *(Kalmia angustifolia),* leatherleaf *(Chamaedaphne calyculata),* staggerbush *(Lyonia mariana),* inkberry *(Ilex glabra),* dangleberry, highbush blueberry *(Vaccinium corymbosum),* and swamp-honeysuckle *(Rhododendron viscosum) (9).*

## Life History

### Reproduction and Early Growth

**Flowering and Fruiting-Pitch** pine is monoecious; pistillate flowers often occur on higher

branches than the staminate flowers, but some shoots may have both types of flowers. The pistillate flowers grow in one cluster and less commonly in two clusters on a shoot, the latter as a result of polycyclic winter buds *(15)*. Staminate flowers are yellowish, sometimes purplish, when mature, and 13 to 25 cm (about 0.5 to 1 in) long. The mature pistillate flowers are green but often show some red. They are borne on stout stalks and are 8 mm (0.33 in) long without the stalk, 20 mm (0.8 in) with the stalk. In southern New Jersey, the staminate flowers of pitch pine are visible by the third week of April; pistillate flowers usually by May 1. Pollen shedding usually occurs during the second or third week of May (9).

Cones reach full size, 4 to 7 cm (1.5 to 2.8 in) long, and mature at the end of the second summer. Mature cones are 2.5 to 3.5 cm (1.0 to 1.4 in) wide when closed, 4.5 to 5.5 cm (1.8 to 2.2 in) wide when open. Closed cones are narrowly ovoid; open cones are ovoid and flattened at the base.

**Seed Production and Dissemination—** Vigorous open-grown basal sprouts start bearing mature cones when only 3 years old. Of 400 planted 2-year-old seedlings, two bore a total of three mature cones at the end of their second growing season in the plantation (2). Potted seedlings may be even more precocious, occasionally bearing female flowers in 12 months. However, mature cones are not usually borne on open-grown trees until they are 8 to 12 years old. Shade-grown trees produce cones at a later date *(19)*.

Although pitch pine is reported to bear good crops of cones at approximately 3-year intervals, production may be irregular. In southern New Jersey, good to excellent crops have occurred at intervals of 4 to 9 years. Occasionally, poor crops are borne in two successive years, although usually a poor crop is followed by fair to excellent crops for 1 to 3 years (9).

Pitch pine seeds are three-angled and 4 to 5 mm (0.16 to 0.20 in) long, although with the wings they are 15 to 21 mm (0.6 to 0.8 in) long. Because they differ in size, the number of seeds per unit of weight varies widely- from 97,700 to 181,200/kg (42,500 to 82,200/lb). In nursery practice fresh seeds need no stratification before sowing, and seeds are merely pressed in the soil at rates that produce 320 to 380 seedlings/$m^2$ (30 to 35/$ft^2$) (27). While northern nurseries usually leave the seedlings in the seed bed for 2 years, southern nurseries lift year-old seedlings for planting.

Seed dissemination is variable, depending on the length of time that cones remain closed after maturity. On some trees, the cones open soon after maturity; at the other extreme, some cones remain closed for many years, until the heat of a fire opens them or until the trees are cut. Trees of the latter type are characteristic of the areas with a long history of wildfire.

Cone behavior is thought to be an inherited characteristic, but in southern New Jersey, groups of trees with different cone behavior are not widely separated geographically.

When cones open soon after maturity, seed dispersal begins about November 1 and ends in April in southern New Jersey *(18)*. The pattern of dispersal seems similar to the pattern for shortleaf pine *(Pinus echinata);* in one study this species dropped 69 percent of its seed the first month, and 90 percent during the first 2 months. In New Jersey, probably about 90 percent of the seeds dispersed from a pitch pine source fall on the east side because the prevailing fair-weather winds are from the west (9).

On trees showing cone behavior between the two extremes, the cones open erratically within a few years after maturity. Apparently there is no fixed pattern of when, what, or how many cones open.

Although equipped with large wings, pitch pine seeds usually are not carried very far by wind. On the leeward of one stand, all natural reproduction in an abandoned field was within 90 m (300 ft) *(9)*.

**Seedling Development-Although** it was reported that seeds from trees less than 8 years old are usually sterile, other data do not support the generalization. In a cutting test on 200 seeds from 3-year-old sprouts, 94 percent were sound. In another study, 52 percent of the seeds in two cones from 4-year-old seedlings germinated within 9 days *(9)*.

Some pitch pine seeds may remain viable in the forest floor for 1 year, but there is no evidence that they can lie over for longer periods. In one instance, after heat from a July wildfire had opened many closed cones, most of the seeds germinated the following spring, though a few lay dormant until August and germinated after rains had broken a severe dry period. In another instance, when 2,400 seed spots were sown to pitch pine in late March 1955, delayed germination in the spring of 1956 provided as many as 1.4 seedlings per spot in some treatments *(9)*. Germination of pitch pine seeds is epigeal *(27)*.

Thick litter is unsuitable as a seedbed, even on poorly drained sites. In one study few seedlings were found in July on the thick litter of unburned sites. On similar areas treated with a severe September fire before seedfall, 16,600 to 56,300 seedlings per hectare (6,700 to 22,800/acre) were tallied on very

poorly to imperfectly drained sites, and 2,200/ha (900/acre) on upland sites *(21)*.

Droughts kill many pitch pine seedlings, but those less than 2 years old are most susceptible. A summer drought in 1957 killed 81 percent of the seedlings from a 1956 direct seeding in certain plots, and on comparable sites most of the seedlings started in 1955 survived *(9)*.

At the end of the first year, shaded seedlings on upland sites usually have a height of about 2.5 cm (1 in), and a taproot 8 to 10 cm (3 to 4 in) long with a few laterals. In contrast, vigorous open-grown 1-year-old seedlings on upland sites may have stems 5 to 10 cm (2 to 4 in) high with a maximum height of 13 cm (5 in) and correspondingly greater root systems. On the moister, poorly drained sites, open-grown first year stems are usually 8 to 15 cm (3 to 6 in) high with a maximum height of 20 cm (8 in).

Pitch pine seedlings grow slowly for the first 3 to 5 years and then more rapidly. Some planted stands in Pennsylvania maintained an average height growth of 36 to 48 cm (14 to 19 in) between ages 6 and 17. After a seed-tree cutting in a New Jersey stand, the average height growth of dominant seedlings among the natural pitch pine reproduction was 0.5 and 0.7 m (1.5 and 2.2 ft) during the third and fourth growing seasons after the cutting, respectively *(9)*.

Deer browsing and hardwood competition both reduce pine growth rates. In one study, young pines uninjured by deer grew 0.6 to 1.2 m (2 to 4 ft) more during a 5-year period than those that had their leaders browsed two or more times. In another study, cutting back hardwood sprouts twice resulted, after 6 years, in a 1.2 m (4 ft) increase in the height growth of the largest pines *(9)*.

**Vegetative Reproduction-Among** eastern conifers, pitch pine has an outstanding ability to survive injury. Even if all the foliage is killed by the heat of a fire, the crown can "green up." If 0.6 to 0.9 m (2 to 3 ft) of the terminal shoot is killed, a new one may develop. If the entire stem is killed, sprouts frequently start at the base *(19,25)*. Deer may clip a seedling back to 3 or 5 cm (1 or 2 in) above the ground, and still it may live *(9)*.

Dormant buds capable of active growth when properly stimulated are the key to this recovery. Also, the thick bark gives a relatively high degree of protection to the dormant buds and to the cambium. Both pitch and shortleaf pines have these buds along the bole to an age of 60 years or more, but at such ages only in pitch pine do the buds at the base retain the potential for growth. In seedlings that have not yet developed thick bark, the lowermost buds may be protected by characteristic basal crooks in the stem that bring them into or against mineral soil on upland sites. Such buds often survive fires and produce new shoots *(22,29,30)*.

Pitch pine seedlings that cannot sprout after fires are those occasional seedlings that never develop a basal crook, and around which insufficient soil accumulates to protect the buds; those that started on sphagnum or on the deep humus layer of poorly drained sites, and around which fire burns deeper than the surface where they became established; and those too young to have well-developed basal crooks. Though some open-grown seedlings may develop such crooks in their first year, shade-grown seedlings may take 9 to 10 years *(20,22)*.

The sprouting vigor of older pitch pines varies with their life history. When single stems more than 40 years old are cut, some sprouts start but most die within 2 years. In contrast are the multistemmed stools that characterize some southern New Jersey localities with a history of frequent wildfires; these stools may be 60 to 90 years old and commonly have produced several generations of sprouts. The survival of new sprouts on such old stools may be associated with partial rejuvenation of the root systems *(9)*.

Although pitch pine's sprouting ability is an asset in enabling trees to survive fire or other injuries, it is also a liability from the commercial point of view. Apparently the form and growth rate of sprouts decrease markedly with increased age of the root crown after crown age reaches about 20 years. Where wildfires have occurred at frequent intervals, often stands are composed largely of slow-growing sprouts from old stools. In many other stands the stems have been deformed by past fires and manifest boles with many small branches that have developed to replace killed crowns, boles with one or more crooks or forks where terminal shoots have been killed, or trees with flat tops where no leader has developed after the last one was killed.

### Sapling and Pole Stages to Maturity

**Growth and** Yield-Pitch pine (fig. 2) reaches a maximum age of 200 years and a maximum height of 30 m (100 ft) in Pennsylvania *(13)*. Individual trees exceeding 350 years of age have been reported in southeastern New York. In stands it is seldom more than 24 m (80 ft) tall or 61 cm (24 in) in d.b.h.

On the better sites in Pennsylvania, pitch pine maintains an average annual height growth of 0.3 m (1 ft) or more until the trees are 50 to 60 years old. The rate of height growth then starts to decline, and the trees add little to their height after they are 90 to 100 years old. On the best sites, diameter growth

**Figure 2**—*Open-grown pitch pine in Berkshire County, MA.*

is 2.5 cm (1 in) in 5 years at 20 years of age, and falls to 2.5 cm (1 in) in 8 years at 90 years (9).

Total volume in cubic meters is maximum in Pennsylvania at 90 years, when fully stocked even-aged stands yield 210 to 350 $m^3$/ha (15,000 to 25,000 fbm/acre). However, mean annual growth reaches its maximum at about 30 years-3.0 to 5.8 $m^3$/ha (43 to 83 $ft^3$/acre), depending on the site (9).

In closed stands of seedling origin undamaged by fire, pitch pine self-prunes about as well as shortleaf pine, but in understocked stands it tends to produce somewhat larger and more persistent branches than shortleaf. Open-grown trees typically develop large spreading branches, which contribute to the rough appearance that many people associate with the species. Typical pitch pine stands have been burned repeatedly, are understocked, and have suffered fire injury; consequently trees have either retained branches or have developed them from dormant buds along the boles.

Even without the stimulus of fire, pitch pines suddenly released by heavy cutting in a stand may develop branches along the bole. Pruning of living branches also may stimulate the development of new branches from buds or short shoots (9).

**Rooting Habit-Root** development of the older pitch pines varies with the site. On sandy, well-drained soils, trees 10 cm (4 in) and larger in d.b.h. may have vertical roots that reach depths of 2.4 to 2.7 m (8 to 9 ft), but on heavier or wetter soils the root systems are more shallow. However, even in saturated soils where water tables are less than 0.3 m (1 ft) below the surface, pitch pine roots may reach depths of 0.9 to 1.5 m (3 to 5 ft) on sandy sites. There, and in the swamps, pitch pine roots live and grow below the water table, and mycorrhizae occur on some of the submerged roots *(9,22)*.

Possibly because pitch pine roots so deeply, it is relatively windfirm. In Maryland, Virginia pine proved much more susceptible to windthrow than pitch pine *(9)*.

**Reaction to Competition-Pitch** pine is intolerant of shade. On swamp sites, it is less tolerant than Atlantic white-cedar *(Chamaecyparis thyoides)*, and on poorly drained or upland sites it is less tolerant than its common hardwood associates—blackgum, red maple, various oaks, and hickories *(9)*.

In view of its relatively low tolerance and its requirement of mineral soil for germination, pitch pine can best be maintained in stands by even-aged management with seedbed preparation and control of competing hardwoods.

Fire has been largely responsible for maintaining the pitch pine type and also has been responsible for the sprout origin, comparatively slow growth, and poor form that characterize this species. One severe fire may eliminate nonsprouting associates such as white pine *(Pinus strobus)*; repeated severe fires may eliminate such species as shortleaf pine *(P. echinata)* and white oak *(Quercus alba)* which do not produce seed at as early an age as pitch pine and bear oak.

**Damaging Agents-Deer,** rabbits, mice, wind, snow, ice, and salt spray damage pitch pine stands. Damage by deer and rabbits is limited to small seedlings or sprouts. The most common wind damage is breakage of defective large trees. However, severe storms, such as hurricanes, also may cause much windfall damage in the oldest natural stands and in plantations more than 20 years old, especially if the planted trees are infected with root rots. Heavy wet snows or ice occasionally break leaders or branches in trees of all sizes, but open-grown stems with large branches, particularly those 2.4 to 4.6 m (8 to 15 ft) tall, seem most susceptible. Although pitch pine foliage is more resistant to salt-spray damage than that of associated species, hurricanes or gales can deposit sufficient spray to injure or kill its foliage over extensive coastal areas, Few affected pitch pines die however; the chief result is reduction in growth *(4,23,27)*.

Several fungi that attack pitch pine but usually do not cause serious or extensive damage are stem rusts such as *Cronartium comptoniae, C. quercuum, C. quercuum* f. sp. *fusiforme,* and *C. comandrae (1);* several needle rusts and blights such as nine species of *Coleosporium, Ploioderma lethale,* and *P. hedgcockii;* twig cankers such as *Diplodia pinea;* root rots such as *Heterobasidion annosum;* and trunk rots, chiefly *Phellinus pini.* Heart rot as a result of *P. pini* does not become important in stands until the trees are 75 years old *(3,12).*

Many insects attack pitch pine (6). The most important are the tip moths *(Rhyacionia frustrana* and *R. rigidana),* the pitch pine looper *(Lambdina athasaria pellucidaria),* the sawflies (chiefly *Neodiprion lecontei, N. pratti paradoxicus,* and N. *pinusrigidae),* the southern pine beetle *(Dendroctonus frontalis),* the pine webworm *(Tetralopha robustella),* and the pine needleminer *(Exoteleia pinifoliella).* Loopers periodically cause extensive damage to pitch pine in Massachusetts; in 1954 they defoliated pines on more than 20 230 ha (50,000 acres) of Cape Cod (9).

## Special Uses

Pitch pine was an important tree during the days of wooden ships and iron men. Its coarse-grained wood is only moderately strong but contains a comparatively large amount of resin, weighing about 513 kg/m$^3$ (32 lb/ft$^3$). Consequently, the wood resists decay, which makes it particularly useful for ship building and for rough construction, mine props, fencing, and railroad ties. It is also used for pulpwood, crating, and fuel. At one time the wood was destructively distilled for naval stores *(5,7).*

Pitch pine also serves as a food source for wildlife. Cones of pitch pine often remain on the trees unopened for several years or until the heat from a forest fire opens them. Seeds shed in mid-winter are an important source of food for squirrels, quail, and small birds such as the pine warbler, pine grosbeak, and black-capped chickadee. White-tailed deer and rabbits also browse young sprouts and seedlings *(5,7).*

## Genetics

Based on isozyme analysis, only a small percentage of genetic diversity in pitch pine appears to be due to seed source. Most variation appears to be due to differences between individuals within populations. The dwarf populations of the New Jersey Pine Plains are essentially indentical in genic constitution to tall trees of the Pine Barrens, at least for the allozyme loci sampled. Whatever factors are responsible for the dwarf size of these populations, they have not resulted in detectable changes in allozyme frequencies among populations *(10).*

Provenance/progeny tests of 156 trees in 17 natural stands of pitch pine distributed over the Atlantic coastal plain from Cape Cod, Massachusetts, to Cape May, New Jersey, were established in central New Jersey Trees from southern seed sources grew faster than those from northern seed sources but adaptation of all sources decreased with increasing distance from the seed source. Variation among families within these 17 provenances was negligible *(14).*

There is an apparent contradiction between growth in provenance/progeny trials and isozyme analysis in different populations of pitch pine in central New Jersey *(10).* The isozyme studies seem to indicate that variation is due to differences between individuals, while the provenance/progeny trials suggest that variation in this species is due to seed source and not differences among families within a provenance. Whether to select provenances or individuals within provenances for tree improvement programs therefore is still an open question.

The differing cone-opening characteristics discussed earlier seem to be inherited, and trees at each extreme perhaps should be considered as separate races or ecotypes.

When pitch and shortleaf pines grow together, natural crossing may occasionally occur. Trees with intermediate characteristics have been seen in southern New Jersey, and similar trees have been reported in southern Pennsylvania *(9).*

At Placerville, CA, the Pacific Southwest Forest and Range Experiment Station crossed pitch pine with shortleaf, pond, Table Mountain, and loblolly pines. Pitch x loblolly hybrids *(P. x rigitaeda)* are produced in large quantities in South Korea for commercial plantings. Early field trials in Illinois, Maryland, and New Jersey showed only slight promise (9). With more careful selection of parent trees and extensive screening trials, the Northeastern Forest Experiment Station produced hybrids with exceptionally fast growth, good form, and winter hardiness for much of the natural range of pitch pine *(20,21).*

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