

Pinus serotina Michx. Pond Pine

Pinaceae Pine family

David L. Bramlett

Pond pine (*Pinus serotina*), also called marsh pine, bay pine, and pocosin pine, is a medium-sized tree that grows on soils with a high water table. The species name, *serotina*, means "late" and refers to the delayed opening of the cones, up to 2 years before seeds are shed (11). Open cones persist for many years and often become embedded in the growing branches, giving the tree the appearance of being overloaded with cones and a prolific seed producer. One of the largest pond pines grows in North Carolina and measures 94 cm (37 in) in d.b.h., 29 m

(94 ft) in height, with a crown spread of 14 m (46 ft) (7). The wood is coarse-grained, resinous, and of fair quality (2).

Habitat

Native Range

Pond pine (figs. 1, 2) grows from Cape May, New Jersey, southward through the Coastal Plains of Delaware, Maryland, Virginia, North Carolina,

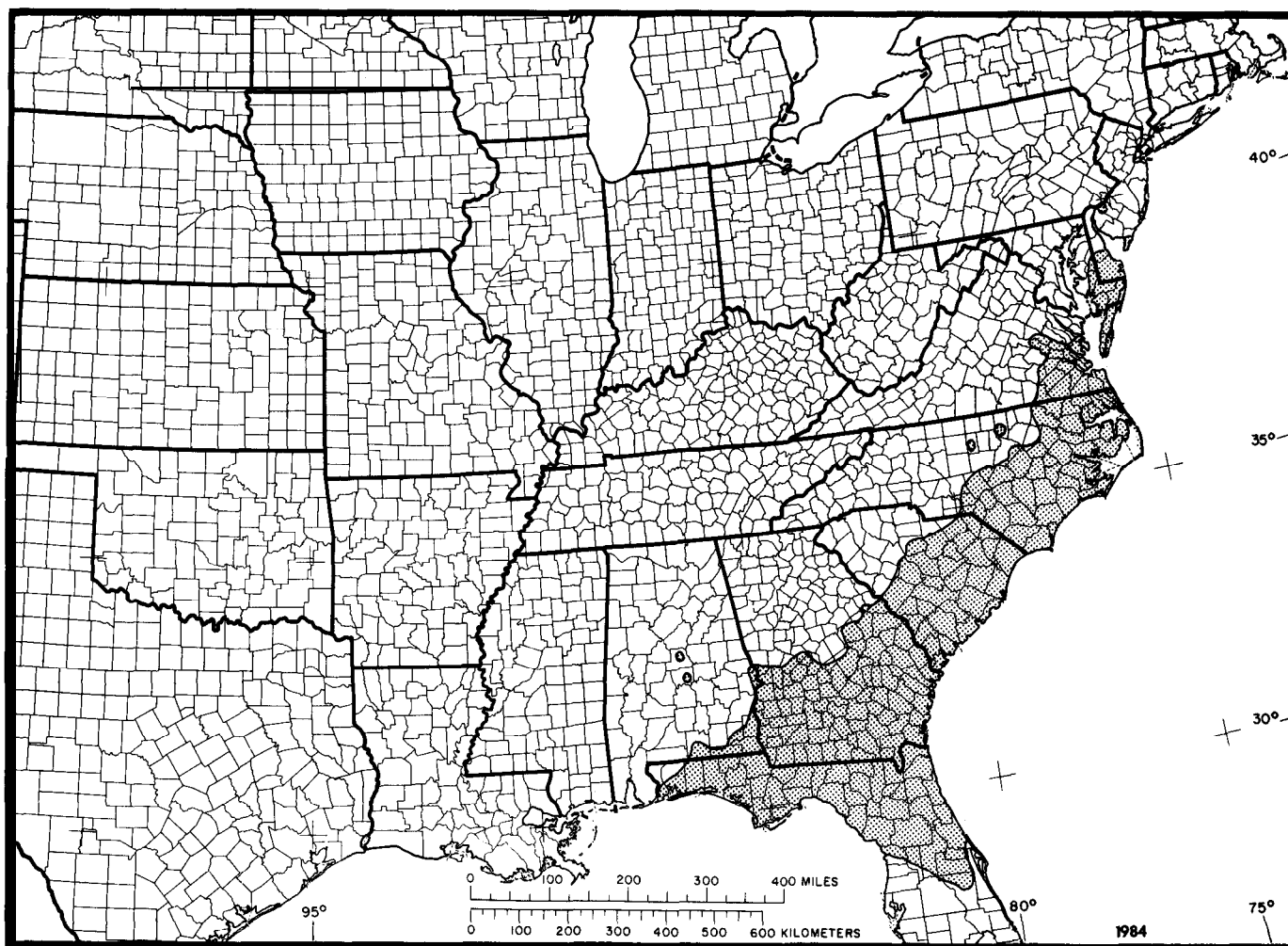


Figure 1-The native range of pond pine.

The author is Plant Physiologist, Southeastern Forest Experiment Station, Asheville, NC.



Figure 2-A group of pond pine (foreground) in Georgia.

South Carolina, and Georgia to central Florida and southeastern Alabama. Within its native range, pond pine is most frequently found on wet or poorly drained sites.

Climate

The climate throughout the pond pine range is mild and humid. Frost-free days range from 210 in the North to 300 in central Florida. The normal January and February daily average temperature is 2° C (35° F) in the northern range, increasing to 16° C (60° F) for the southern range. In July and August, the normal daily average temperature ranges from 29° C (85° F) in the South to 24° C (75° F) in the North. The extremes of temperature within the range have been as low as -23° C (-10° F) and as high as 43° C (110° F). Annual precipitation increases

from 1120 to 1370 mm (44 to 54 in) on a transect from north to south and from 1120 to 1420 mm (44 to 56 in) on an inland to coastal transect. July and August have an average rainfall of 100 to 200 mm (4 to 8 in) per month in contrast to 50 to 100 mm (2 to 4 in) for December and January.

Soils and Topography

The lower terraces of the Coastal Plain in the Southeastern United States are characterized by sandy and organic soils. Typical soils are in the Ultisols order, Aquults suborder, Albaquults and Umbraquults great groups. These soils usually have a dark gray, sandy loam surface soil and a heavy subsoil. The entire area has minor topographic relief and is interspersed with major drainage systems that are frequently very broad. Throughout the region are numerous streams, swamps, pocosins, marshes, and bays that are characterized by poorly developed drainage patterns. The pocosins, in particular, have unique topographic features in the Carolinas. These areas are upland bogs with streams draining from them on all sides. The pocosins have a considerable peat accumulation, frequently as deep as 2 m (6 ft). Also, in the southeastern Coastal Plain there are shallow, poorly drained depressions called bays or ponds. Pond pine is frequently found as the major overstory species in these pocosins and bays in association with a heavy understory of shrubby vegetation.

Although pond pine is most frequently found on poorly drained lands, the species can make excellent growth on mineral soils or on land that is not continuously waterlogged. The slow growth of pond pine is primarily a function of prolonged water saturation and reduced soil aeration. Poor aeration retards decay of organic material and results in the accumulation of muck and peat with high acidity. Although availability of mineral nutrients is usually adequate, nitrogen fixation and nitrification proceed very slowly. Consequently, the amount of available nitrogen is small even though total nitrogen content is high in the undecayed organic matter. Soil saturation also deprives roots of the oxygen required for respiration and growth and tends to keep the soil temperature low (19).

Associated Forest Cover

Pond pine is a major species in the forest cover type Pond Pine (Society of American Foresters Type 98) and is an associate in nine other cover types (5):

81	Loblolly Pine
82	Loblolly Pine-Hardwood
84	Slash Pine
85	Slash Pine-Hardwood
97	Atlantic White-Cedar
100	Pondcypress
102	Baldcypress-Tupelo
103	Water Tupelo-Swamp Tupelo
104	Sweetbay-Swamp Tupelo-Redbay

Other associated tree species are sweetgum (*Liquidambar styraciflua*), red maple (*Acer rubrum*), and loblolly-bay (*Gordonia Zsianthus*).

In the pocosins and very wet areas, a great variety of evergreen shrubs form a dense understory. Laurel-leaf greenbrier (*Smilax laurifolia*) is almost always present on pond pine sites. Switchcane (*Arundinaria tecta*) is locally abundant and, as it sprouts prolifically, it is highly favored by periodic burning. Other frequent shrub species include inkberry (*Ilex glabra*), large gallberry (*I. coriacea*), zenobia (*Zenobia pulverulenta*), swamp cyrilla (*Cyrilla racemiflora*), southern bayberry (*Myrica cerifera*), sweet pepperbush (*Clethra alnifolia*), and saw-palmetto (*Serenoa repens*).

Life History

Reproduction and Early Growth

Flowering and Fruiting-Pond pine is monoecious. Pollen flight and female flower receptivity occur in late March in Florida and about 1 month later in North Carolina. At any given latitude, pond pine flowering is considerably later than that of loblolly (*Pinus taeda*) or slash (*P. elliottii*) pine. It is possible that in some years the flowering period of pond pine may overlap with other southern pines, but hybridization occurs infrequently. Cones ripen in September and October.

Seed Production and Dissemination-Cone production may begin at an early age in pond pine. In eastern North Carolina pocosins, trees less than 10 years old (d.b.h.) produced an average of eight cones per tree. Cone production increased with age and diameter up to 30 years. Seed trees over 30 years (d.b.h.) produced an average of 175 to 200 cones (19).

Mature cones are normally 5 to 10 cm (2 to 4 in) long and remain on the tree for as long as 10 years. Because the cones are serotinous, only a few seeds are released at maturity each year, and the seed crop of several years may be present in an individual cone bearing tree. Viability does not decrease in cones that remain closed for as long as 3 years. Cones open

gradually over several years, with two seasonal periods of seed dissemination: April through September and October through January (4).

Like other pine species with serotinous cones, pond pine cones open and release seeds soon after exposure to heat from fire. The intensity of heat does not adversely reduce the viability of seeds; even badly charred cones, following wildfires, release seeds that are capable of germination. In an uncut but burned stand of pond pine, 131,000 seeds per hectare (53,000/acre) were trapped in a 6-week period following the burn.

Mature cones can be opened by exposure to 167° to 169° C (333° to 336° F) dry heat for 30 seconds or by immersion in boiling water for a similar period. An average of 75 to 80 developed seeds are produced per cone and 77 percent of these can usually be extracted. Germination of pond pine seed from North Carolina averaged 44 percent of the extractable seed (including both filled and empty seed) after 60 days (19).

Pond pine seeds are relatively small, ranging from 104,000 to 139,000/kg (47,000 to 63,000/lb) and averaging 119,000/kg (54,000/lb). Seeds are winged and can be dispersed a horizontal distance several times the height of parent trees.

Seedling Development-Adequate moisture is normally available for pond pine germination in the peat and organic soils of the Coastal Plain. Seeds also germinate well on exposed mineral soil. Establishment of seedlings, however, is much better if the competition from weeds, grass, and woody vegetation is reduced by mechanical site preparation or by the use of fire. Germination is epigeal.

Without question, fire has been a major influence on the perpetuation of pond pine in coastal regions of the Southeastern United States. The majority of present-day stands date to a previous wildfire. For natural regeneration, prescribed fires reduce the dense understory of shrubs, prepare a seedbed, and open the serotinous cones. Research in eastern North Carolina indicated that seedling establishment was most favorable in plots that were burned before clearcutting. Clearcutting before burning was also favorable for establishment of an adequate number of free-to-grow seedlings (4). In another study, a headfire was more effective than a flanking fire in the establishment of seedlings.

Techniques for the use of successful prescribed fire for the regeneration of pond pine have been outlined (18). Fires must generally be of high intensity to consume understory shrubs, yet not so intense that serious damage or mortality occurs to the overstory pines. There is usually only a narrow range of

weather and fuel conditions where silvicultural objectives and controlled fire can be attained in a given pocosin. Key elements in a prescribed fire plan include light to moderate winds with relative humidities between 35 and 50 percent. The water table also should be close to the surface to prevent spotting and burning of the organic soils.

Seed for regeneration may be provided by seed trees. If seed trees are 23 to 25 cm (9 to 10 in) in d.b.h. and 30 years old, each tree can be expected to produce 5,000 sound seeds. On this basis, 15 to 20 seed trees per hectare (6 to 8/acre) are required to provide adequate seed for establishment. Scarification with fire plows, disks, or logging equipment is sometimes effective in securing seedling establishment but is not as reliable as burning because without heat from a fire seedfall is limited by the serotinous cones of pond pine.

Pond pine seedling growth frequently is limited by excessive soil moisture, low nutrition, and competition from herbaceous and woody vegetation. Under the most severe conditions, seedlings grow only 30 cm (12 in) or less per year. In a pond pine study in a pocosin, seedlings required an average of 18 years to reach a height of 1.5 m (5 ft). The fastest growing seedlings reached this height in less than 10 years (19).

Vegetative Reproduction-Among pine species, pond pine is unique in that it sprouts readily from stumps until quite old. Seedlings or saplings will sprout prolifically when cut, and older trees will sprout vigorously along the stem and branches after intense scorching and defoliation by fire. These sprouts arise from dormant buds in the axils of primary needles of young seedlings. The buds are dormant and are protected by the bark. When the tree is injured, these buds resume growth and may give rise to clusters of buds and numerous short shoots (19).

Not all buds, formed at intermediate and winter-growth flushes, sprout the following spring. Those that do not sprout remain alive; they sometimes develop into short, weak branches and give rise to many lateral buds. They may also put forth secondary dormant buds directly without growing into branches. Buds may also form in needle fascicles, but these are of little importance in the sprouting of pond pine because they are present for only a short time. Thus, pond pine stems and branches bear many clusters of dormant buds that remain alive and capable of sprouting for many years. When trees are defoliated by fire, these buds sprout and give the stems and branches a feathery appearance. Stem

sprouting is one of the primary reasons for the low quality of pond pine in frequently burned areas (19).

Sapling and Pole Stages to Maturity

Growth and Yield-Pond pine grows surprisingly well on the better sites with soils that have good internal drainage. In fact, pond pine may be difficult to distinguish from loblolly pine in the sapling stage when in natural or planted stands on comparable upland sites. More typically, however, pond pine is found in the pocosins where it grows very slowly.

Average sizes of pond pine in a North Carolina pocosin were as follows:

Age yr	Height		D.b.h.	
	m	ft	cm	in
20	8.5	28	14.7	5.8
50	14.9	49	26.4	10.4
100	20.1	66	35.1	13.8

Stands of pond pine normally have low volumes with seldom over 70 m³/ha (5,000 fbm/acre). The trees in these stands usually have been repeatedly burned and have poor form and low quality (19).

A well-stocked stand of pond pine at 50 years of age with a site index of 21 m (70 ft) may be expected to have 25.9 m³/ha (113 ft³/acre) of basal area and 860 trees per hectare (348/acre), with an average d.b.h. of 19.6 cm (7.7 in). The entire stand might have 179 m³/ha (2,560 ft³/acre) of wood inside the bark or 195 m³/ha (31 cords/acre) of merchantable wood. The total wood volume per hectare could also be allocated as 51.8 m³ of sawtimber (3,700 fbm/acre) and an additional 146 m³/ha (23.2 cords/acre) of pulpwood (16).

Pond pine stands with a site index of more than 27 m (90 ft) at age 50 have been measured. These stands could yield 129 m³/ha (9,200 fbm/acre) of sawtimber and 151 m³/ha (23.9 cords/acre) of pulpwood. Subsoil texture is directly correlated with site index. Height growth increases with increasing amounts of fine particles (silt and clay) in the subsoil. Other soil properties that are inversely related to site index include depth to mottling, percent of organic matter in the surface soil, and total depth of organic matter (1).

Rooting Habit-No information is currently available.

Reaction to Competition-Pond pine is classed as a species intolerant of shade. It is almost as intolerant as loblolly pine, but less tolerant than slash pine and more tolerant than longleaf pine (*Pinus*

palustris). Pond pine responds favorably to drainage. In an eastern North Carolina site, basal area and height growth of pond pine were nearly doubled by drainage (6).

On mineral soils, pond pine is an intermediate stage in plant succession. As it is established primarily after fire, it may grow in pure even-aged stands until harvesting or mortality removes the dominant trees. Pond pine stands yield eventually to wetland hardwood species including oaks (*Quercus* spp.), gums (*Nyssa* spp.), hickories (*Carya* spp.), and magnolias (*Magnolia* spp.). In the pocosins, pond pine follows Atlantic white-cedar (*Chamaecyparis thyoides*) when the cedar is killed by fire, but cedar may become reestablished.

Fire maintains pond pine as a subclimax type through sprouting or by stimulating seed dissemination from the serotinous cones. Repeated fires during the dry season, however, may completely eliminate pond pine and produce a grass-sedge bog or savannah. In some large pocosins, woody shrubs, including cyrilla, redbay (*Persea borbonia*), and gallberry may completely dominate the site for a considerable time.

Almost all stands of pond pine originate from natural regeneration and the species has only infrequently been planted. In a study in the South Carolina Coastal Plain, southern pines were planted on a freshly burned site. The planting site was poorly drained, with a seasonably high water table. After 10 years, slash pine trees averaged 3.6 m (11.8 ft), and pond pine 2.3 m (7.5 ft). This study suggested that the growth of pines on the site was limited by poor nutrition and soil aeration (8).

Damaging Agents-The most serious disease of pond pine is red heart (*Phellinus pini*), which is common in most of the older pocosin stands. On the Hofmann Forest in eastern North Carolina, 90 to 95 percent of the older pond pines are infected. *P. pini* is a white rot fungus which occurs relatively high in the bole of the tree. It primarily dissolves the lignin of the cell walls, while cellulose is relatively unaffected. Red heart reduces the value of pond pine lumber to such an extent that many stands of sawtimber-size trees may be sold for pulpwood only; and even pulpwood yields are reduced in the severely infected trees (14).

Pond pine is subject to both fusiform rust (*Cronartium quercuum* f. sp. *fusiforme*) and eastern gall rust (*C. quercuum*), which cause stem and branch cankers on pines and have alternate stages on oaks. In a study of three half-sib families of pond pine, significant differences were observed in rust susceptibility. Pond pine was only half as susceptible to fusiform rust as loblolly pine (13). Comandra blister

rust, caused by the fungus *Cronartium comandrae*, has been found on pond pine planted in Tennessee (3). The needle cast fungus (*Hypoderma lethale*) and brown-spot fungus (*Scirrhia acicola*) sometimes cause browning and foliar damage to needles but severe damage is uncommon. *Coleosporium* spp. may attack the foliage but have little effect on tree growth. Pond pine is also attacked by the southern pine beetle (*Dendroctonus frontalis*), the black turpentine beetle (*D. terebrans*), and engraver beetles (*Ips* spp.).

In natural stands, numerous pests attack cones and seeds and reduce the final seed crop. Specific insects known to damage pond pine cones and seeds are *Dioroctria* spp. and *Leptoglossus corculus*.

During drought periods, the fire hazard of pond pine sites is extremely high because of the heavy fuel accumulation in the dense understory. Dry fuel weights of the understory and litter layer are frequently more than 22.4 t/ha (10 tons/acre). When fires occur in pocosin areas the excessive fuel and large areas of unbroken forest make fire control extremely difficult. Very intense fires consume not only the trees, shrubs, and litter, but the peat soils as well.

Special Uses

Although pond pine has poor form and slow growth, it produces forest stands of pulpwood and sawtimber where other species will not grow. The pocosins and pond pine stands are considered a major wildlife sanctuary for many wetland species,

Genetics

Population Differences

No definite pattern of variation was found in pond pine wood specific gravity or tracheid length associated with geographic area or depth of organic material in the coastal area of North Carolina (12). Differences in both wood traits were noted among individual plots and among individual trees, however.

The average wood specific gravity of unextracted increment cores of 554 pond pine trees was 0.492 with a standard deviation of 0.049, about the same as the variation among trees in other southern pines. The oleoresin of pond pine is unique for the high proportion of limonene and low proportion of alpha- and beta-pinene.

From a study of 30 traits of pond pine and loblolly pine, slight differences were reported in some Coas-

tal Plain trees compared with those from drier, inland areas (10). Both species, however, had a general uniformity in all locations. Pond pine is included in the North Carolina State Tree Improvement Cooperative. First-generation select trees are located in four seed orchards with a total of 12 ha (29 acres) (9).

Races and Hybrids

Distinct races of pond pine have not been identified. Pond pine hybridizes with several southern pines. Although pitch and pond pine are usually separated geographically, they readily hybridize and intergrade when found together in New Jersey and Maryland. When loblolly pine occurs in association with natural hybrids of pitch and pond pines, hybrids of the complex are frequently found (17). Pond pine also hybridizes with loblolly pine, but in most localities the flowering dates are distinct enough to restrict hybridization. Evidence of introgressive hybridization, however, has been found at several locations in the North Carolina Piedmont and Coastal Plain provinces (15).

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