Pinus pungens Lamb. Table Mountain Pine

Pinaceae Pine family

Lino Della-Bianca

Table Mountain pine *(Pinus pungens)* is also called hickory pine, mountain pine, or prickly pine. It is most often small in stature, poor in form, and exceedingly limby. One large tree near Covington, VA, measures 70 cm (28 in) in d.b.h. and 29.6 m (97 ft) tall and has a crown spread of 10.4 m (34 ft). These pines are used locally for fuel and commercially for pulpwood, and they provide valuable watershed protection.

Habitat

Native Range

Table Mountain pine (fig. 1), an Appalachian endemic, grows almost entirely within the range of pitch pine *(Pinus rigida)* and Virginia pine *(P. virginiana),* but is less frequent. In general, Table Mountain pine occupies xeric sites of Appalachian

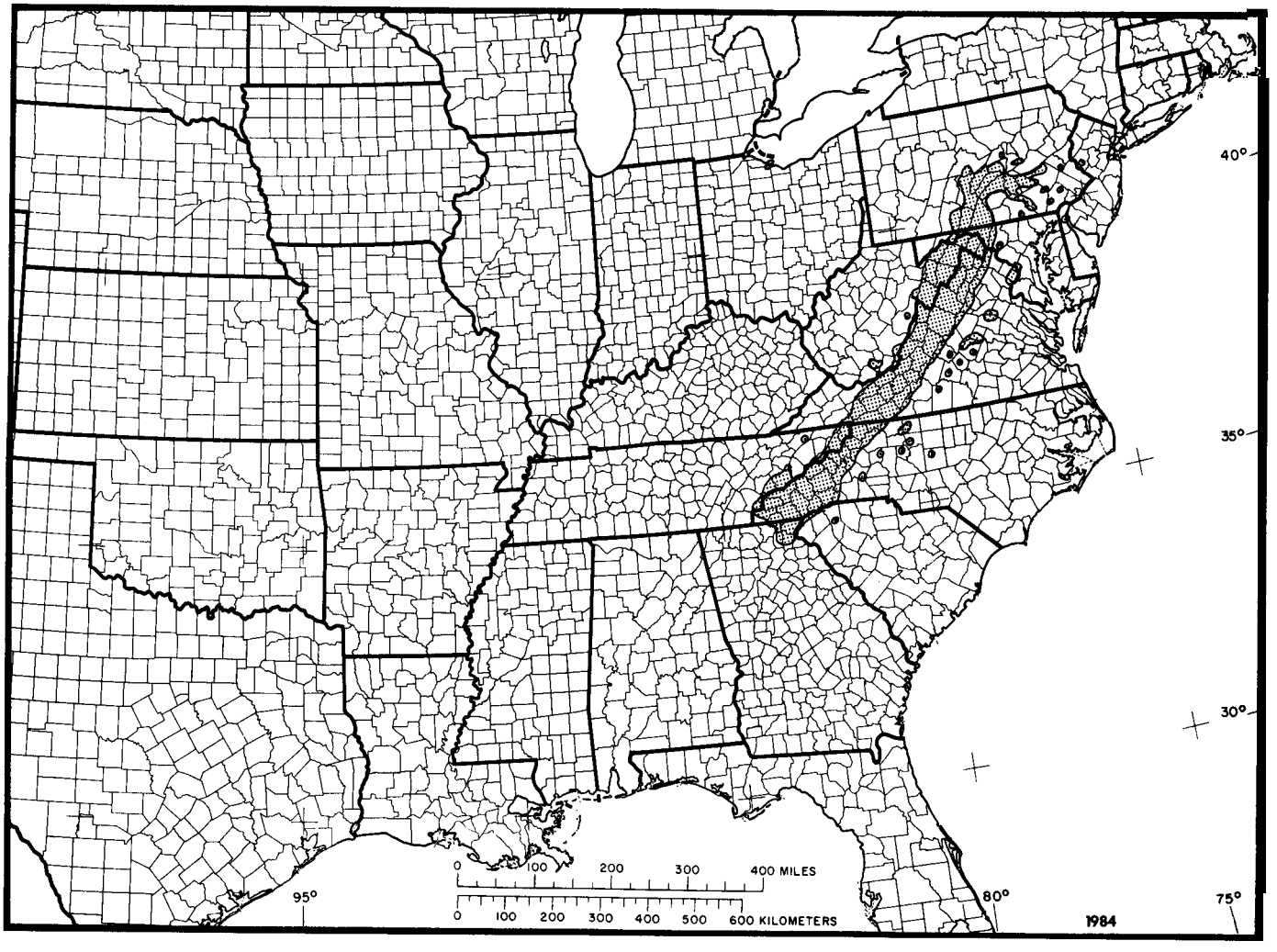

Figure *1-The native range of Table Mountain pine.*

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rocky and shaly mountainous areas from Georgia into Pennsylvania *(8,16,17,29,31)*. It is frequently found on ridges of the precipitous gorges that dissect the Blue Ridge Mountains.

Table Mountain pine is unevenly distributed; its range extends from the Northern Appalachians in central Pennsylvania southwest to eastern West Virginia and southward into the Southern Appalachians, ending on the steep western edge of the mountains of North Carolina and east Tennessee *(1,2,* 6,9, *10,11,19,25,29)*. To the east and south, its range includes the crest and eastern escarpment of the prominent Blue Ridge Front with its numerous rocky gorges and torrential mountain streams. Toward the southern end of its range, Table Mountain pine reaches its highest elevation of 1760 m (5,780 ft) in the Great Smoky Mountains *(8,16,29)*. There are numerous outlying populations of Table Mountain pine to the east and a few to the west of the Appalachians; many outliers are associated with monadnocks which rise considerably higher than the surrounding Piedmont *(5,6,23,24,30)*.

Climate

Precipitation within the range of Table Mountain pine varies with latitude and elevation. Warm season rainfall from April through September varies annually from 460 to 610 mm (18 to 24 in) in Pennsylvania to 690 to 990 mm (27 to 39 in) in the Southern Appalachians (27). Mean annual precipitation ranges from 760 mm (30 in) in Pennsylvania to more than 2030 mm (80 in) in the Great Smoky Mountains. At the northern end of the range, average July temperature varies from 21" to 27" C (70° to 80" F); in the Great Smoky Mountains, the range is 15" to 21° C (60" to 70" F). Average January temperatures in Pennsylvania range from -7" to -1" C (20" to 30" F); in the Great Smoky Mountains, 2" to 5" C (35" to 40° F). In Pennsylvania, the average number of frost-free days varies from 150 to 170, and in the mountains of Tennessee, North Carolina, and north Georgia, from 170 to 180.

Soils and Topography

In Pennsylvania, Table Mountain pine grows on substrates of upper Silurian and lower Devonian rocks. Elsewhere it is known to grow on substrates of the Unicoi, Alligator Back, Loudon, Weverton, Erwin, Pottsville, Chemung, Pocono, Portage, and Hampshire or Catskill Formations *(17,31)*. Table Mountain pine is not found over limestone substrates. Although surface rock varies in Table Mountain pine stands in the Great Smoky Mountains, it is often less than 15 percent of total surface cover; however, on narrow ridges, surface rock can range from 35 to 55 percent or more *(16)*. In about half the stands bedrock occurs less than 50 cm (20 in) below the soil surface. Large amounts of gravel and rocks up to 30 cm (12 in) or more commonly occur in the solum; stone content has been found to range from 24 to 59 percent of air-dry weight *(31)*.

Some eleven soil series and rough stony land are associated with Table Mountain pine stands *(16,28,31)*. The most common soil series are Ashe, DeKalb, Ramsey, and Porters. In the Great Smoky Mountains, 57 percent of associated soils are Lithic Dystrochrepts, and 43 percent Typic Dystrochrepts of the order Inceptisols. Generally, A-horizon soils contain an average of 61, 28, and 11 percent sand, silt, and clay, respectively. Most of the B-horizon textures are loams and silt loams; silty clay loam occurs infrequently. Litter depth is about 5 cm (2 in). Organic matter content of the A horizon averages 5.5 percent, and in the B horizon 2.5 percent. Soil pH varies from 4.0 to 4.4 for the A and B horizons, respectively. Water-holding capacity in the solum ranges from 5 to 16 percent. Average nutrient content of a 15-cm (6-in) thick A horizon is as follows: calcium 120 kg/ha (107 lb/acre), magnesium 30 (27), phosphorus 5.8 (5.2), potassium 102 (91), and manganese 40 (36). In the B horizon, nutrient content averages are as follows: calcium 50 kg/ha (45 lb/acre), magnesium 27

Figure *2-A stand of Table Mountain pine (dark diagonal band near center of photo) in northwestern North Carolina at an elevation of 1035 m (3,400 ft), on a micaceous formation. Soils are shallow on this xeric southwest-facing site. The pines are extremely limby, about 20 cm (8 in) in d.b.h., and 8 m (25 ft) tall.*

(24), phosphorus 7.6 (6.8), potassium 76 (68), and manganese 24 (21). Nitrate and ammonium of the A horizon amount to 2.0 and 19 p/m, respectively; B-horizon values are slightly less. Generally, Table Mountain pine stands grow on soils that have minimum profile development and are shallow, stony, strongly acid, excessively drained, infertile, and of low productivity.

Table Mountain pine can grow over a wide range in elevation. Known extremes are 46 m (150 ft) in Delaware and 1762 m (5,780 ft) in the Great Smoky Mountains *(16,31)*; most often it occurs between 305 and 1220 m (1,000 to 4,000 ft) above sea level. In the Great Smoky Mountains, elevation affects the distribution of Table Mountain pine and Table Mountain pine-pitch pine stands *(8,16,29)*. Above 1060 m (3,480 ft) Table Mountain pine-pitch pine stands were mostly restricted to south-facing ridges; with increasing elevation, pitch pine decreased in abundance. Dominance of Table Mountain pine stands occurred at elevations above 1300 m (4,270 ft). On typical sites, the southwest-facing aspect is of critical importance to the presence of Table Mountain pine (fig. 2) although the species can and does grow on other aspects *(16,17,31)*. Slopes on which it occurs in the Great Smoky Mountains average 42 percent ***(16).***

Table Mountain pine has been found growing on an island in the Susquehanna River in southern Pennsylvania where the roots were continuously washed by water. It has also been seen around bogs on Mount Pisgah, NC, and at Big Meadows, Shenandoah National Park, VA (31).

Associated Forest Cover

In Table Mountain pine stands of the Great Smoky Mountains associated tree species are red maple *(Acer rubrum)*, blackgum ***(Nyssa sylvatica),*** sourwood ***(Oxydendrum arboreum),*** pitch pine *(Pinus rigida)*, and chestnut oak ***(Quercus prinus).*** In Table Mountain pine-pitch pine stands, additional associated species include scarlet oak *(Q. **coccinea),*** American chestnut ***(Castanea dentata),*** and black locust ***(Robinia pseudoacacia) (16).***

Table Mountain pine is also a minor associate in five forest cover types: Pitch Pine (Society of American Foresters Type 45), Shortleaf Pine (Type 75), Chestnut Oak (Type 44), White Pine-Chestnut Oak (Type 51), and Virginia Pine-Oak (Type 78) ***(13).*** In the Shortleaf Pine type, Table Mountain pine is included only in the mountains; other associates are pitch pine, eastern hemlock ***(Tsuga canadensis),*** black, white, southern red, scarlet, chestnut, post, and blackjack oaks ***(Quercus velutina, Q. alba, Q. falcata, Q. coccinea, Q. prinus, Q. stellata,*** and Q. *marilandica*, respectively), hickories ***(Carya*** spp.), and blackgum. In the Virginia Pine-Oak type, associated species in the foothills include shortleaf pine *(Pinus **echinata)*** and pitch pine, black, white, scarlet, chestnut, post, and blackjack oaks, hickories, and blackgum *(13,30,31)*.

The lower canopy vegetation in Table Mountain pine stands *(8,16,31)* includes rosebay rhododendron ***(Rhododendron maximum),*** Catawba rhododendron ***(R. catawbiense),*** Piedmont rhododendron *(**R. minus),*** mountain-laurel *(Kalmia latifolia)*, mountain winterberry ***(Rex montana),*** hobblebush ***(Viburnum alnifolium)***, blueberries *(Vaccinium* spp.), sawbrier ***(Smilax glauca),*** greenbrier ***(S. rotundifolia),*** fetterbush *(Pieris floribunda)*, white-alder ***(Clethra acuminata)***, black huckleberry ***(Gaylussacia baccata)***, bear huckleberry ***(G. ursina),*** wild grape *(Vitis* spp.), and male blueberry ***(Lyonia Zigustrina).*** Mean shrub cover in the Great Smoky Mountains amounted to 65 percent in Table Mountain pine stands and 84 percent in Table Mountain pine-pitch pine stands.

Bear oak ***(Quercus ilicifolia)***, mapleleaf viburnum ***(Viburnum acerifolium),*** and low sweet blueberry ***Naccinium angustifolium)*** are most important stand components only in the northern part of the range of Table Mountain pine. Among tree species, black oak is important only in the north; blackjack oak and sourwood, in the south. Black birch ***(Betula Zenta)*** is an associate only on rocky, nonshale areas, but Virginia pine is an associate at lower elevations, especially on shale. The evergreens, trailing arbutus ***(Epigaea repens)*** and galax ***(Galax aphylla),*** are important only south of Virginia. Understory species in Table Mountain pine stands stabilize the shallow soil surrounding the pines.

Life History

Reproduction and Early Growth

Table Mountain pine needs stand and site disturbance, light, and heat for successful regeneration. In closed stands on western and northern exposures, Table Mountain pine cones are distinctly serotinous, but on southerly and easterly exposures many cones open soon after maturing. A large number of closed cones remain on the trees from 5 to 25 years and the retained seeds remain viable for 9 or more years *(21,32)*. After logging, residual trees are exposed to increased light and heat favorable for cone opening and seed dissemination. Often as much as 80 percent of the reproduction on logged-over areas is Table Mountain pine. In undisturbed stands, pine reproduction is periodic and often in scattered

patches *(16,29,31)*. In Table Mountain pine-pitch pine stands under undisturbed conditions, especially without fire, successional trends toward increases in red maple, blackgum, and various oaks have been noted in the Great Smoky Mountains, with successional change strongest at lower elevations. In addition, the typical heavy heath layer in such stands results in low seedling densities and a lack of high frequencies for any species. Maintenance of natural Table Mountain pine stands can be most often ascribed to periodic fire. On very dry sites, the pines may represent an edaphic climax *(4,7,8,16,29,31)*. Other natural agents that lead to regeneration establishment are soil creep, cloudbursts, and forms of windthrow *(17)*.

Flowering and Fruiting-Table Mountain pine is monoecious. Cones are commonly seen on trees of sapling size and minimum seed-bearing age is 5 years. In northwestern North Carolina, pollen release at 457 m (1,500 ft) elevation begins the last week of March and ends during the first week of April; at 762 m (2,500 ft), pollen release begins about the second week in April and ceases near the end of the third week. Growth and reproductive activities of Table Mountain pine generally occur as early as, or earlier than, those of associated species *(31)*. Table Mountain pine is reproductively isolated from other pine associates by early pollen release, so hybridization is restricted.

The staminate cones of Table Mountain pine are a reddish purple *(31)*. The pollen is very large for eastern pines, being 50.2 ± 4.6 μ in inside diameter. The cone is heavy and egg shaped; the scales are much thicker at the ends and are armed with stout, hooked spines. Young ovulate strobili have a peduncle about 1 cm (0.4 in) long which is visible at maturity; as branch diameter increases, cones appear sessile (32). From two to seven cones are often arranged in whorls on branches, around the stems of saplings, or on leaders *(21,25)*. Cones average 72 mm (2.8 in) in length, ranging from 42 to 103 mm (1.7 to 4.1 in); 54 mm (2.1 in) in width, ranging from 33 to 75 mm (1.3 to 3.0 in); and 64 cm^3 (3.9 in^3) in volume, ranging from 27 to 134 cm^3 (1.6 to 8.2 in^3). Cone dimensions and degree of serotiny decrease with increased elevation. Cones are largest at northern latitudes. In general, cones at higher elevations are well developed. Immature cones are deep green to brown, ripe cones are lustrous light brown, and old cones retained on branches are gray. Cones ripen in autumn of the second season; cone opening depends upon the degree of serotiny.

Seed Production and Dissemination-The seeds of Table Mountain pine are more or less triangular (32). They average 5.3 mm (0.2 in) long, 3.1 mm (0.12 in) wide, and 13.8 mg (894 grains) in weight. Wing length varies from 19 to 25 mm (0.7 to 1.0 in) and wings are about 7 mm (0.3 in) wide; they range from a transparent light tan to dark brown. Seed coat roughness varies from smooth to a wartlike surface; the seed coat may be ridged. Cones averaging 58 mm (2.3 in) long and weighing 45 g (1.6 oz) produce about 50 seeds per cone, with an average viability of 81 percent. A bushel of cones contains about 0.18 kg (0.4 lb) of seeds. Cleaned seeds average 75,240/kg (34,200/lb) with a range of 67,540 to 83,600/kg (30,700 to 38,000/lb). A temperature range of 16" to 32" C (60" to 90" F) for 30 days is required to extract seed from cones (26); kiln drying expedites the process. Seed weight without coat is about 7.6 mg (0.0003 oz); these large seeds may have adaptive value in drier regions, giving Table Mountain pine an advantage in establishing seedlings *(31)*. Frosts, drought, and heavy rains exert a greater influence on flower initiation, cone growth, seed development, and viability than tree age *(21)*. Although cones shed their seeds very irregularly, large numbers of seeds are disseminated annually.

Seedling Development-Table Mountain pine seed kept at 24" C (75" F) for 8 hours daylight and at 5" C (40" F) for 16 hours darkness in sand and peat has shown 65 percent germinative capacity with no pretreatment stratification (26). Germination is epigeal. There can be four to nine cotyledons per seedling (32). At 0.5 and 1.5 years, northern sources have a higher rate of water loss at high soil moisture contents than southern sources. Rate of water loss from seedlings with primary needles is greater than from seedlings with secondary needles *(31)*. Growth of seedlings can be increased by adding calcium and magnesium as soil amendments; other fertilizers have not been tried.

Of the three dry-site pines, Table Mountain pine roots are most affected by temperature; it grows a longer root than Virginia pine only between 16" to 28" C (61° to 82" F); pitch pine seedlings have the shortest roots at all temperatures *(31)*. Small top size to root length during seedling establishment would probably be the optimal condition for dry-site survival. Table Mountain pine grows more slowly without mycorrhizae, the root-shoot ratio of nonmycorrhizal seedlings is larger than that of mycorrhizal seedlings. Number of mycorrhizal types was higher in limed than unlimed soil, but liming caused no change in numbers of mycorrhizae *(31)*.

Competition from other vascular plants is probably an important factor in determining the distribution of the species, especially during establishment. Table Mountain pine occurs on areas least favorable for rapid plant growth; these harsher sites seemingly limit its early growth less than that of other species, thus allowing it to develop fast enough to compete successfully for canopy space, minerals, and soil moisture. The roots of very young seedlings are longer than that of pitch pine, and O.&year-old seedlings have lower transpiration rates *(31).* Seedlings of Table Mountain pine develop mature needle fascicles earlier than Virginia pine seedlings.

Another advantage shown by this species is that seedling height growth and twig and needle elongation occur earlier than in pitch and Virginia pine during the period of least drought stress. The ultimate size of Table Mountain pine on xeric sites is constrained less than that of other tree species, allowing the pine to continue to compete, which it could not do on more fertile sites where hardwoods dominate. Growing conditions associated with poor oak growth characterize Table Mountain pine habitat.

Table Mountain pine is regarded as intolerant of shade, even more so than pitch and Virginia pine. The shrub stratum presents greatest competition for seedlings *(16),* and generally, no seedlings of Table Mountain pine occur on sites without exposed mineral soil. Without fire and anthropic disturbances, Table Mountain pine would probably be found only on extremely dry and sterile rock outcrops and steep shale slopes, where the overstory canopy would be quite open and litter cover would never remain complete *(31).*

Vegetative Reproduction-The prominent epicormic sprouts protruding from the bark of pitch pine are absent in Table Mountain pine; also absent are the dormant buds that occur along the bole and branches of pitch pine-an adaptation which allows recovery from defoliation. Table Mountain pine also has fewer basal buds than pitch pine; basal buds sprout after injury to the stem, allowing recovery of saplings after fire injury and animal damage *(31).* Table Mountain pine seedlings of natural origin usually have a crook just above or just below ground level which may serve to protect the basal buds against fire.

Sapling and Pole Stages to Maturity

In an average stand of Table Mountain pine in the Great Smoky Mountains, the species dominates the overstory except that about 8 percent pitch pine is present *(16).* Within such stands, the canopies are typically discontinuous and are composed of short, small-crowned trees of poor form. A maximum age of 250 years seems reasonable for Table Mountain pine (a counted age of 227 years has been recorded), a maximum diameter of 94.5 cm (37.2 in) and a maximum height of 29 m (95 ft) have been reported *(31).* The general canopy height in the Great Smoky Mountains ranges from 8 to 12 m (26 to 39 ft), with a majority of canopy stems under 25 cm (9.8 in) d.b.h.; rarely are stems larger than 35 cm (13.8 in). Elsewhere, trees are generally less than 20 m (66 ft) tall and 40 cm (15.7 in) d.b.h. *(7,15).* Live crowns often average more than 60 percent of total height, and limb-free bole length averages 12 percent *(31).*

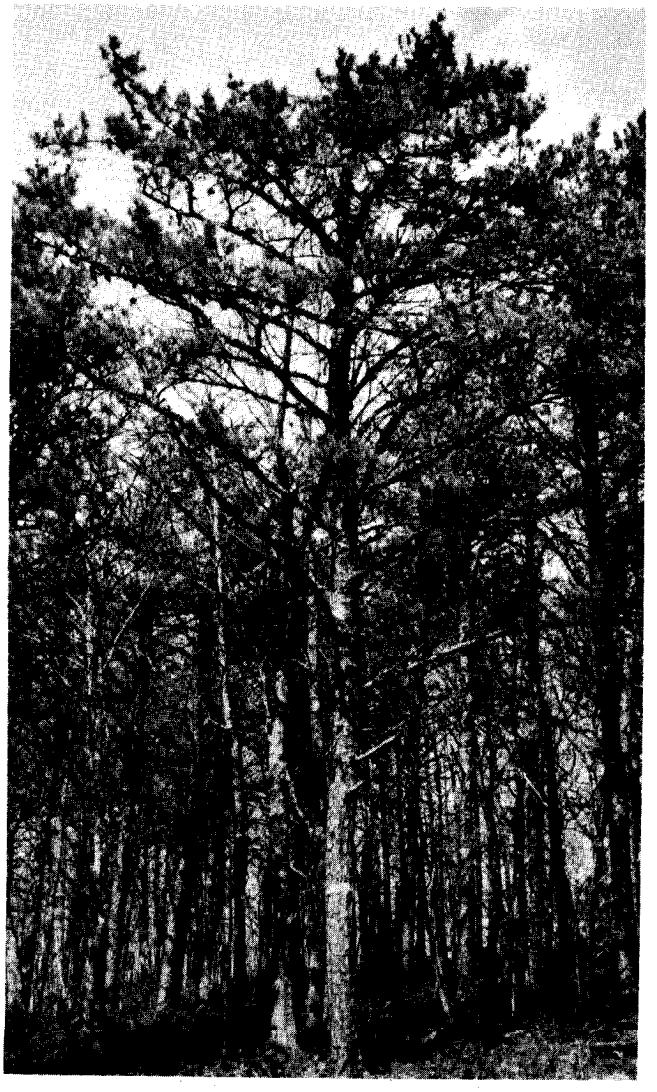

Figure 3—*Stand of Table Mountain pine.*

Table l-Inventory of Table Mountain pine growing stock combined for Virginia, North Carolina, Tennessee, and Georgia *(20)*

D.b.h. class	Number of trees	Merchantable stem volume in thousands'		Sawlog volume in thousands'	
	thousand	m^3	ft^3	m^3	*fbm*
15 cm or 6 in	5,633	606	21,399	—	—
20 cm or 8 in	4,315	913	32,256	—	—
25 cm or 10 in	2,201	994	35,140	550	96,509
30 cm or 12 in	1,379	858	30,320	588	103,110
36 cm or 14 in	882	660	23,308	557	97,648
41 cm or 16 in	257	242	8,557	226	39,623
46 cm or 18 in	77	104	3,687	113	19,829
51 cm or 20 in (Virginia only)	23	36	1,268	45	7,870
53 to 71 cm or 21 to 28 in (North Carolina only)	22	29	1,016	36	6,400
Total	14,789	[3]4442	[3]1 56,951	2115	370,989

[1] Includes West Virginia.
[2] International 0.25-inch log rule.
[3] An additional 176.8 thousand m^3 (6,243 thousand ft^3) is found in Pennsylvania.

Much of the growth of Table Mountain pine goes into branch production (fig. 3).

Saplings are abundant, amounting to about 2,000 stems per hectare (809/acre) in the stands, and represent some 14 tree species. As in the canopy, Table Mountain pine saplings compose the majority of saplings. Saplings can vary in form from bushlike when open grown to slender, small-limbed trees in dense stands *(16,31)*.

The typical dense heath layer in Table Mountain pine stands severely restricts seedling densities and development and prevents high frequencies for any species. Stands are basically self-maintaining but severe fire is necessary to regenerate them where there is dense heath cover. Stands appearing to be permanent are associated with shallower litter, more rock outcrop, and have less basal area than stands more obviously successional.

Mature pitch pines are more resistant to fire damage than Table Mountain and Virginia pines because they have thicker bark. Table Mountain pines are intermediate in fire resistance and bark thickness. The thin-barked Virginia pines are least fire resistant *(16,31)*.

Growth and Yield-Stand and stocking values for Table Mountain pine are shown in table 1 by diameter classes. The table shows that trees in the largest d.b.h. classes are in Virginia and North Carolina; this peculiarity of distribution of large trees may be due to differences in the time of stand establishment caused by fire or insect kills.

In the southeastern mountains, Virginia has the largest area occupied by Table Mountain pine; the species accounts for 3.4 percent of all trees on the Jefferson National Forest in Virginia *(15)*. Georgia has the least acreage, but average volumes per unit area increase southward from Virginia, with 165.8 m^3/ha (2,368 $ft^3/acre$), to Georgia with 282.0 m^3/ha (4,028 $ft^3/acre$), probably because of more growing season precipitation, higher temperatures, and longer frost-free periods in stands growing farther south. Because of the large area and volume of Table Mountain pine in Virginia, this State grows and cuts more than other States; the species is virtually nonexistent as a viable timber type in South Carolina mountains and is at a very low volume in Georgia *(20)*.

Rooting Habit-Table Mountain pine seedlings are generally anchored into a rock crevice by their taproot *(7,15)*. Secondary or lateral roots then spread through the available soil and litter cover, taking up both moisture and nutrients. Other sinker roots descend into additional crevices, utilizing accumulated soil and the thin skins of finely weathered, nutrient-rich, moist soillike rock which coat the crevice surfaces. In this way the trees can survive on the most xeric sites.

Another adaptation to xeric sites shown by isolated or sparse trees is the production of extremely long branches—even longer than the height of the tree, where the lowermost ones sweep downward, often touching the ground *(31)*. These branches shield the underlying soil, rock, and roots from direct radiation and conserve soil moisture. Under such trees there is more protection against soil creep and the litter cover is relatively stable, with slow decomposition that contributes to available nutrient supplies and permits survival and growth under harshest conditions. Table Mountain and pitch pines are comparable in windfirmness; both surpass Virginia pine in this characteristic (7).

Reaction to Competition-An overview of the natural range of Table Mountain pine indicates that it is not reproducing itself well and that regeneration is extremely scattered in patches in openings. Seedlings grow well, forming a dense sapling stand that attains its maximum growth rate at about age 30 when the trees are about 18 cm (7 in) d.b.h., but thereafter growth is exceedingly slow. Most of the present stands range from 60 to 100 years old; some originated after the severe beetle kills of the late 1800's and the fires that followed *(4,7,15,16)*.

The keys to successful natural regeneration of Table Mountain pine are heat and light *(21)*. It is

classed as intolerant of shade. Even-age management precipitated by clearcutting, or in some cases, a seed-tree cut followed by a hot, fast-moving, prescribed fire to open cones without damaging enclosed seed, should suffice to regenerate it on harsh sites. A severe fire appears necessary for regeneration on sites with a heavy shrub layer *(31).* It has least competition from associated species on shallow soils, erosion pavements, and rocky areas, and it is on such sites that its management can be most successful. On deeper soils, pitch and Virginia pine should be favored; where considerable microclimatic and soil variation occurs, a mixture of all three species would be best adapted to fully utilizing the site and offering protection against fire and other damaging agents. In remote areas where its perpetuation is desirable, small block or strip cuts on rocky southwesterly exposures with natural seedfall should suffice to regenerate it *(7,15,21,31).*

Damaging Agents-Weather-related factors such as high gusty winds, glaze, heavy wet snowfall, cloudbursts, tornadoes, and lightning have been known to damage stands and isolated trees of Table Mountain pine *(7,15,17,31).* The most serious diseases of Table Mountain pine are *Phaeolus schweinitzii,* which causes butt and root rot, and *Phellinus pini*, which causes heartrot in older or damaged trees *(18). Dioryctria yatesi*, a cone-boring insect, can in some years destroy entire local seed crops. Periodically, the southern pine beetle, ***Dendroctonus frontalis,*** decimates entire stands (3). The European pine sawfly, ***Neodiprion sertifer,*** at times defoliates trees of their previous year's needles, but seldom kills the trees. Trees of all sizes, from 3-year-old seedlings to mature specimens, are attacked by the pine twig gall scale, ***Matsucoccus gallicola***, which causes bark to swell and crack, killing foliage and tree.

Special Uses

Table Mountain pine is used commercially for pulpwood, low-grade sawtimber, and firewood *(7,15).* The serotinous cones on many trees make seed available for wildlife on a year-round basis. Many of the short stubby limbs seen on Table Mountain pine are caused by squirrels that prune off the cone-bearing section of the limb to get at seed in the heavily armed cone cluster (22). Also, the heavy heath layer in Table Mountain pine stands provides plentiful wildlife food and cover *(16,31).* The often gnarly Table Mountain pines are a welcome sight on rocky, clifflike areas of the Appalachians, but perhaps the most important use of the species is as protection forest; it stabilizes soil, minimizing erosion and runoff from the vast shale barrens and other rugged topographic features within its natural range *(17).*

Genetics

Population Differences

The length-width ratio of Table Mountain pine needles is higher south of latitude 37" N. than north (31). Stands in which most cones open the first and second year after ripening are in the northern end of its range. Seed weight is negatively correlated with elevation, but seedcoat characteristics and cotyledon number are not. There is no difference in specific gravity (0.470 unextracted cores) of Table Mountain pine over its natural geographic range (12). In the Appalachian Mountains of southwest Virginia, in three stands of Table Mountain pine, as far as 42 km (26 mi) apart, there were significant differences in needle length, number of stomata1 rows, and needle margin serrulations among trees and half-sib progeny within each stand *(14).* In seedlings grown from seed from trees in the three stands, no significant differences among stands were observed for any of the characteristics measured.

Races and Hybrids

Racial variation, if any, among Table Mountain pines is not known.

Two hybrids of Table Mountain pine are known—*Pinus pungens x P. echinata* and *I? pungens x P. rigida*. In the former, the needles are long and there are two or three as in shortleaf pine, rather than the two, mostly intermediate in width, and twisted as in Table Mountain pine (12). Needles of Table Mountain pine are stiff and prickly, while those of shortleaf pine are flexible; the intermediate needles of the hybrid are stiff and short pointed, but not prickly. The cones are small as in shortleaf pine, but intermediate, and more like Table Mountain pine in keel of apophysis and spine length. A *I? pungens x P. rigida* natural hybrid from Pisgah Ridge in Henderson County, NC, had external needle characteristics of Table Mountain pine, a cone intermediate in size and development of apophysis and umbo, and a dense group of short, small-diameter branches about 4.6 m (15 ft) up the bole, suggesting the sprouting characteristics of pitch pine *(31).*

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