Pinus virginiana Mill. Virginia Pine

Pinaceae Pine family

Katherine K. Carter and Albert G. Snow, Jr.

Virginia pine *(Pinus virginiana)* has a definite place among trees of commercial importance in spite of once being considered a "forest weed" and called scrub pine. Also known as Jersey pine and spruce pine, it does so well in reforesting abandoned and cutover lands that it has become a principal source of pulpwood and lumber in the southeast. Virginia pine is commonly a small or medium-sized tree but a record tree has been measured with 81 cm (31.8 in) in d.b.h. and 34.7 m (114 ft) in height.

Habitat

Native Range

Virginia pine (figs. 1, 2) generally grows throughout the Piedmont and at lower elevations in the mountains from central Pennsylvania southwestward to northeastern Mississippi, Alabama, and northern Georgia. It is also found in the Atlantic Coastal Plain as far north as New Jersey and Long

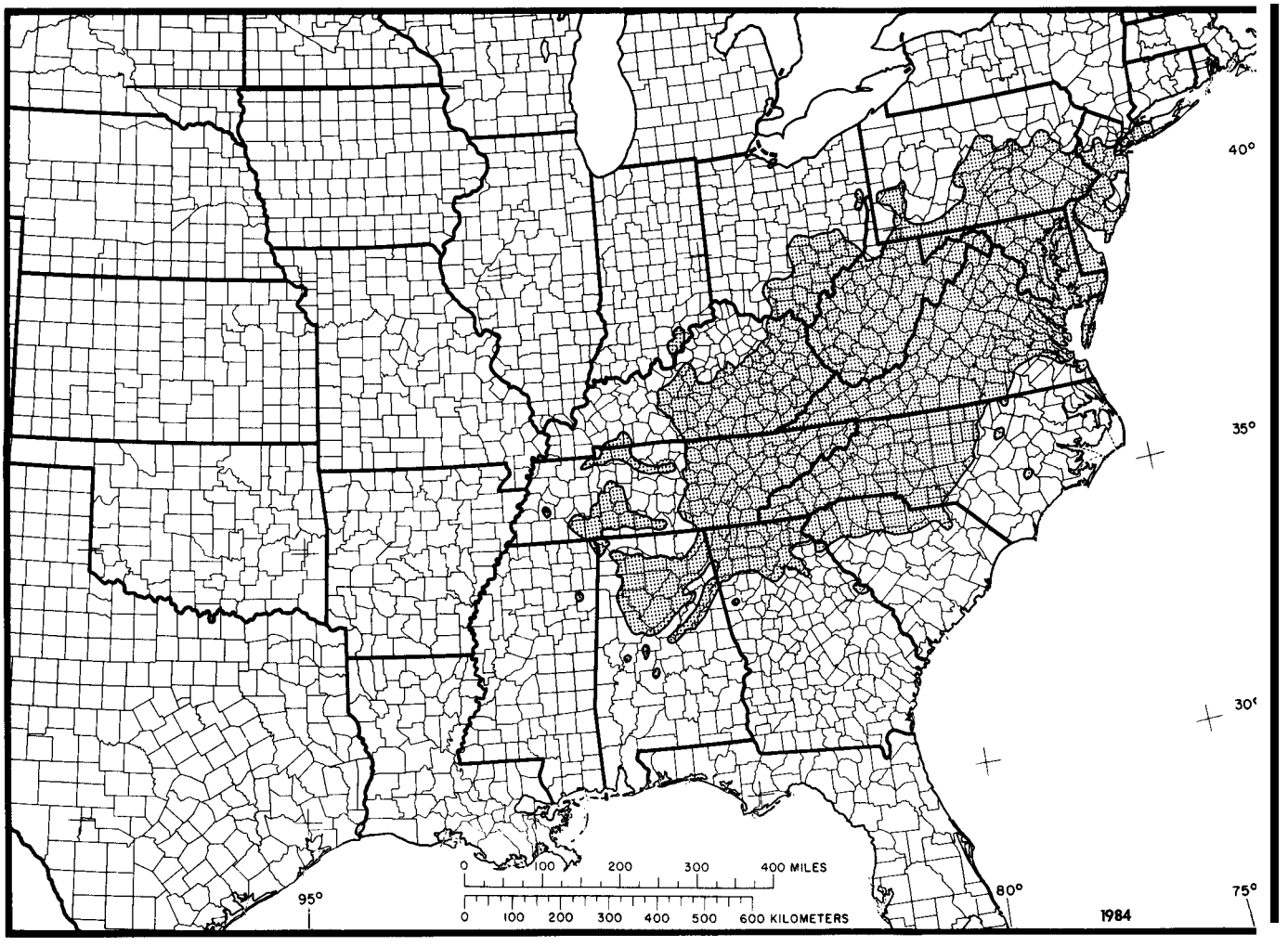

Figure *l-The native range of Virginia pine.*

The authors are Associate Professor of Forest Resources, University of Maine, Orono, and Forest Pathologist (retired), Northeastern Forest Experiment Station, Radnor, PA.

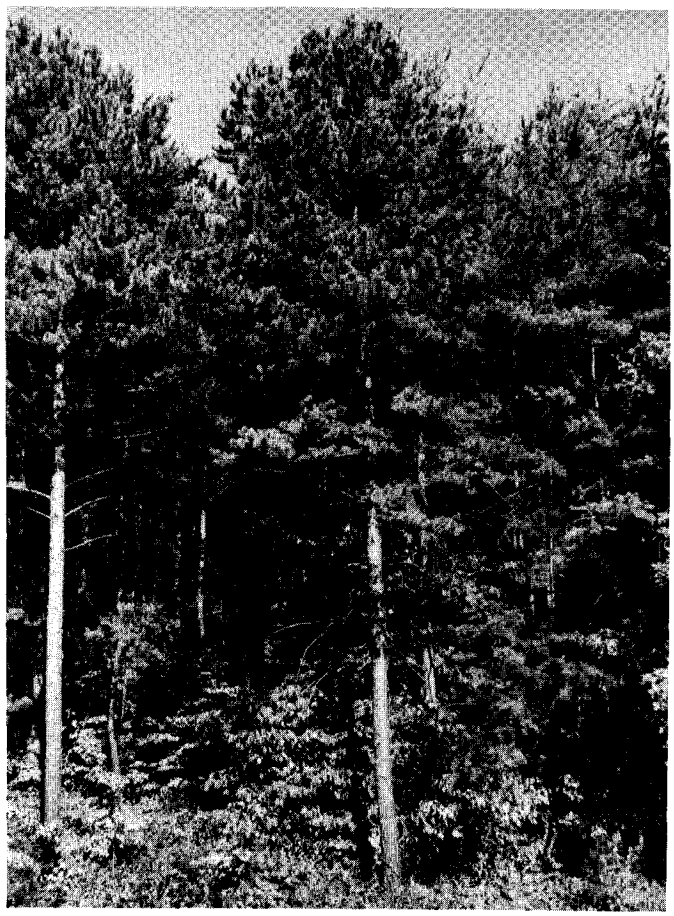

Figure *2-Virginia pine on the George Washington National Forest, VA.*

Island, NY, and extends westward in scattered areas into Ohio, southern Indiana, and Tennessee.

Climate

The annual precipitation in the native range of Virginia pine averages 890 to 1400 mm (35 to 55 in) and is fairly well distributed throughout the year. Rainfall generally is greatest in the southwestern portion of the range. The climate throughout most of this area is classified as humid.

Summer temperatures average about 21" to 24° C (70° to 75" F); winter temperatures range from -4% 4" C (25" to 40" F); and the average number of frost-free days varies from more than 225 on the eastern and southern edge of the Piedmont to 160 days on the more mountainous areas to the west and north.

Soils and Topography

Virginia pine grows well on a variety of soils derived from marine deposits, from crystalline rocks, sandstones, and shales, and from limestone to a lesser extent. These are classified as Spodosols and Inceptisols. After harvesting or fire, these soils are subject to moderate sheet and gully erosion; erosion can become severe on shale soils. On many areas that now support Virginia pine, much of the A horizon is gone because of past erosion under intensive agricultural use.

The species grows best on clay, loam, or sandy loam; it generally does poorly on serpentine soils, shallow shaly soils, and very sandy soils. It thrives only in moderately well drained to well drained soils and is less tolerant of wet sites and impeded drainage than pitch and loblolly pines *(Pinus rigida* and *P. taeda).* Virginia pine generally tolerates soil acidities ranging from pH 4.6 to 7.9 *(39).* Soil beneath a Virginia pine stand was more acidic and contained more organic matter than soil under shortleaf *(P. echinata),* loblolly, or white *(P. strobus)* pine stands (30).

Virginia pine usually is found at elevations of 15 to 760 m (50 to 2,500 ft). It comes in freely on abandoned farmland throughout its range.

Associated Forest Cover

Virginia pine often grows in pure stands, usually as a pioneer species on old fields, burned areas, or other disturbed sites. It is a major species in the forest cover types Virginia Pine-Oak (Society of American Foresters Type 78) and Virginia Pine (Type 79) *(17).* It is an associate in the following cover types: Post Oak-Blackjack Oak (Type 40), Bear Oak (Type 43), Chestnut Oak (Type 44), White Oak-Black Oak-Northern Red Oak (Type 52), Pitch Pine (Type 45), Eastern Redcedar (Type 46), Shortleaf Pine (Type 75), Loblolly Pine (Type 81), and Loblolly Pine–Hardwood (Type 82).

Other than those named in the types, species that commonly grow with Virginia pine in various parts of its range are white oak *(Quercus alba),* southern red oak *(Q. falcata),* red maple *(Acer rubrum),* hickories *(Carya* spp.), blackgum *(Nyssa sylvatica),* sweetgum *(Liquidambar styraciflua),* eastern hemlock *(Tsuga canadensis),* Table Mountain pine *(Pinus pungens),* and eastern white pine *(P. strobus).*

In central Pennsylvania, two ground-cover types serve as indicators of site quality for Virginia pine. The flowering dogwood/clubmoss *(Cornus florida /Lycopodium)* type indicates the better site indexes ranging from 15.2 to 21.3 m (50 to 70 ft); the

bear oak/reindeer moss *(Quercus ilicifolia / Cladonia)* type indicates average and poor site indexes between 9.1 to 15.2 m (30 and 50 ft) *(39)*.

Life History

Reproduction and Early Growth

Flowering and Fruiting-Virginia pine is monoecious. Pollen shedding and female cone receptivity begin about the middle of March in the southern part of the species range, and as late as the latter part of May in the northern part. Virginia pine is wind pollinated and primarily outcrossing, though self-fertilization is possible. Fertilization takes place in early June some 13 months later, when the cones have nearly reached full size. Seeds become viable by middle to late August of the year after pollination but are difficult to extract before cone maturation, which occurs from late September to early November. Unlike many other pines, Virginia pine produces cones in all parts of the crown. Empty cones usually persist on the tree for several years and can remain for as many as 15 years.

Seed Production and Dissemination—Open-grown trees often produce cones as early as 5 years of age, and a few trees have been known to flower at 18 months *(3)*. In dense stands, cone production can be delayed for as many as 50 years. As stands become more open, cone production is accelerated (36). Virginia pine produces some seed each year, with heavy cone crops occurring at intervals of 3 or more years. Good cone crops can be produced in 2 successive years, however, and peak seed years do not necessarily coincide throughout the range. Early cone production is under strong genetic control and can be increased by family selection or fertilization *(7,9)*.

Seed dispersal starts in October and is complete within 3 months, though some seeds may continue to be released until the following spring. Most of the seeds fall within 30 m (100 ft) of trees with an average height of 18 m (60 ft); however, stocking often is adequate at greater distances, particularly on the lee side of a seed source. In the coastal plain of Maryland, seedfall was measured on a 40-meter-wide (132 ft) strip cut through Virginia pine. Over a 4-year period, seedfall per hectare ranged from 15,800 to 98,800 (6,400 to 40,000/acre) *(18)*. The number of clean seeds per kilogram ranges from 100,750 to 200,800 (45,700 to 91,100/lb); the average is 122,100 (55,400/lb) (35).

Seed and cone insects can severely reduce the yield of viable seed. Seed yields from cones from which insects were excluded by wire screens were twice as high as those from unprotected cones (8). Major insect pests are two types of seedbugs: the shieldbacked pine seedbug *(Tetyra bipunctata)* and the southern pine seedbug *(Leptoglossus corculus)*. Several types of coneworms *(Dioryctria* spp.) and cone borers *(Eucosma* spp.) also infect Virginia pine. The Virginia pine sawfly *(Neodiprion pratti pratti)* and Nantucket pine tip moth *(Rhyacionia frustrana)* can destroy young conelets *(16)*.

Seedling Development-An exposed mineral soil seedbed is essential for successful establishment of seedlings. In one study area in the southern Appalachians, all regeneration of Virginia pine over a 120-year period was related to site disturbances by fires or logging *(1)*. Such site disturbance can result in two to four times as much germination as on undisturbed seedbeds, and 2-year survival that is four times as great *(41)*.

Exposing wet Virginia pine seeds to artificial light before sowing greatly increases germination. Maximum germination is obtained by exposing seeds that have been soaked in water for 24 hours to 30 minutes of red light. The stimulus to germination by this exposure can be reversed by treatment with far-red light (39). Germination is epigeal (35).

Seedlings require direct sunlight for best growth. Even partial shade reduces growth, and seedlings do not survive under full shade. Given adequate light and a good seedbed, however, several thousand seedlings per hectare can become established. Precommercial thinning at age 5 has been recommended to prevent stagnation in heavily stocked seedling stands *(11)*.

Virginia pine seedlings grown in containers in the greenhouse can be used to advance growth and cone production by 1 year compared to the use of bare-root stock (6). Extra light from an incandescent source coupled with a high level of nutrition can quadruple height growth in one season. Long photoperiods also induce other effects such as increased internodal length, accelerated cycles of bud formation, and breaking of bud dormancy (39).

The balance and relative abundance of inorganic elements in the soil solution also are important to the establishment and growth of Virginia pine. In basic nutrition studies in irrigated sand cultures, symptoms of deficiency appeared when either potassium or magnesium was supplied at 0.01 milliequivalent (meq) or less per liter. Amounts adequate for healthy height growth were 0.35 meq of calcium and 2 meq of magnesium per liter. The adequacy level for potassium was between 0.1 and 1 meq; the

minimum levels for nitrogen and phosphorus were 1.78 and 0.03 meq, respectively (39).

Virginia pine seedlings are more tolerant of low soil moisture than most other pines. Although they may survive when moisture is low, their rate of growth is slower on dry sites. Seedlings reach a height of 10 to 20 cm (4 to 8 in) in the first year when growth conditions are favorable. At the end of 10 years, the average height may reach 5 m (17 ft) on the better sites.

Many species of mycorrhizae representing nine genera ***(Amanita, Boletus, Cenococcum, Gomphidius, Lepiota, Paxillus, Rhizopogon,*** *Russula,* and ***Scleroderma)*** are known to form associations with the roots of Virginia pine (23).

Vegetative Reproduction-Sprout growth on Virginia pine is rare. Occasionally, cut stubs produce a few short-lived sprouts from dormant buds. Rooting of cuttings from 7- and &year-old Virginia pine is most successful (72 percent rooted) when cuttings were taken in December and treated with 0.2 percent indolebutyric acid before being placed in a mist chamber *(40)*. Cuttings from l-year-old seedlings also can be rooted, but those taken from mature trees fail to root (25).

Grafting generally is about 65 percent successful when dormant scions are grafted onto dormant rootstock. The side-veneer graft technique is most commonly used, but other methods also are successful. Virginia pine grafts are more susceptible to mold than grafts of the other southern pines (25).

Clonal plantlets can be obtained from tissue cultures when cotyledons from Virginia pine embryos are used. However, the rooting techniques necessary for commercial production of these plantlets have not yet been developed (10).

Sapling and Pole Stages to Maturity

Growth and Yield-On average sites, well-stocked stands can have as many as 3,950 stems per hectare (1,600/acre) at 20 years of age. The number drops to about 500/ha (200/acre) in 70-year-old stands. The site index for Virginia pine is the average height of dominant trees measured at age 50 years. In North Carolina, the average merchantable volume per hectare for site index 18.2 m (60 ft) land is 112 m^3 (1,600 ft^3/acre) at 20 years and 354 m^3 (5,050 ft^3/acre) at 70 years (36). Volumes for Maryland are intermediate between the higher values for North Carolina and the lower values for Pennsylvania. In a regional study extending from Maryland to South Carolina, merchantable volumes per hectare for fully stocked, pure, 60-year-old stands ranged from 155 m^3/ha (2,210 ft^3/acre) for site index 16.8 m (55 ft) land to 602 m^3/ha (8,600 ft^3/acre) for site index 24.4 m (80 ft) land *(31).*

On the best sites, trees can reach a height of 37 m (120 ft) at maturity, but the average height ranges from 15 to 23 m (50 to 75 ft) at age 50. An annual growth rate of 6 m^3/ha (1 cord/acre) is possible over a large portion of its natural range.

Because Virginia pine is shallow rooted and subject to windthrow and to damage from ice and snow, thinning is not recommended in older stands. In one thinned 17-year-old stand the diameter growth of trees was 50 percent greater than that of controls; however, there was no overall stand response because of frequent windthrow in the thinned stand. Windthrow is not serious in younger stands, which can be thinned safely, but the growth response in these stands may not be sufficient to replace the volume removed by the thinning (19).

Virginia pine planted on old fields grows well. One plantation in Iowa had a mean annual height growth of 0.6 m (1.9 ft) after 15 years. This growth was better than that of five other pine species planted on the same sites. The mean annual diameter growth was 8.6 mm (0.34 in) during the same period (39). Plantations in the Cross Timbers area of Oklahoma survived well when moisture was adequate during the year of establishment (32). In the Cumberland Plateau, planted Virginia pine on site index 21.2 m (70 ft) produced a merchantable volume of approximately 140 m^3/ha (2,000 ft^3/acre) at age 20 (37).

In central Tennessee, Virginia pine outperforms shortleaf and loblolly pines on dry ridges and on warm slopes with shallow soil (38). On these sites it is estimated to produce approximately 56 m^3 more per hectare (800 ft^3 or 4,000 fbm/acre) than shortleaf pine, on a 50-year rotation (22). On good sites in the Piedmont or on cove sites in the southern Appalachians, however, growth of Virginia pine is inferior to the other southern pines. Natural pruning in Virginia pine is slow because the branches are resinous.

Rooting Habit-Virginia pine is a shallow-rooted species and losses from windthrow are likely to occur if old stands are thinned excessively (5).

Reaction to Competition-Being intolerant of shade, Virginia pine is a transitional type and is eventually replaced by more tolerant hardwood species. It is a pioneer species, coming in after fire, and on eroded areas or wornout old fields. Compared with associated pines, it is generally more successful on poorer sites. Virginia pine seedlings cannot become established under the shade of an existing

stand, so hardwoods invade the understory. These hardwoods become dominant and gradually take over the area in succeeding generations, unless fire or other factors retard them (39).

Damaging Agents-Heart rot due to ***Phellinus pini*** often is present in stands more than 60 years old, but it is rare in stands less than 50 years of age. In a severe case, as much as 34 percent of the trees in a 59-year-old stand were infected *(36)*. Partly because of its susceptibility to heart rot, pulpwood rotations generally are preferred to saw-timber rotations in Virginia pine.

The other serious disease of Virginia pine is pitch canker ***(Fusarium moniliforme*** var. ***subglutinans),*** which enters twigs or stems through small wounds and causes a heavy exudation of pitch. The canker enlarges rapidly and eventually girdles the twig or stem. Seedlings infected with pitch canker have a mortality rate of about 90 percent *(15)*. Some variation in susceptibility to pitch canker appears to have a genetic basis *(2)*.

Other diseases usually cause little loss of growth in Virginia pine. Stem cankers ***(Atropellis tingens),*** eastern gall rust ***(Cronartium quercuum),*** a stem rust *(C. comptoniae),* root rot ***(Heterobasidion annosum),*** and butt rots ***(Poria subacida, Phaeolus schweinitizii)*** occasionally infest Virginia pine.

The principal forest insects that cause significant damage to Virginia pine are the southern pine beetle ***(Dendroctonus frontalis), Ips*** spp., and pine sawflies, the Virginia pine sawfly *(Neodiprion pratti pratti)* and the redheaded pine sawfly *(N. lecontei).* ***Trees*** under stress of lightning, fire, or logging injury are more susceptible to insect attack than sound healthy trees (39).

The pales weevil ***(Hylobius pales),*** which feeds on and often kills small seedlings of several pine species, can greatly reduce the regeneration of Virginia pine. Attacks are most likely on recently cutover areas where pine roots provide the food needed to build up a large larval population.

Girdling by meadow mice can cause considerable damage in young trees. In Tennessee, they have reportedly caused heavy mortality in 8- or g-year-old plantations *(26)*. In Maryland and Iowa, they have shown a strong preference for Virginia pine over other pine species (39).

Young Virginia pines are particularly vulnerable to fire because of their thin bark and their lack of longlived dormant buds at the base, along the bole, and in the crown. Fire reduces the Virginia pine component in stands where this species is mixed with pitch, shortleaf, or loblolly pines.

The species also is sensitive to several air pollutants. Of 18 pine species tested, Virginia pine was most sensitive to ozone; 69 percent of the seedlings suffered foliar damage. Polluted air containing sulfur dioxide and oxides of nitrogen also reduced terminal growth, with most damage occurring between the 4th and 13th weeks after budbreak. Dormant seedlings are resistant to ozone pollution *(14,33)*.

Special Uses

Of the southern conifers, Virginia pine is most preferred as a Christmas tree. If families with desirable traits are selected and appropriate cultural practices are used, marketable Christmas trees can be produced in as few as 3 years, although the usual rotation age for Virginia pine Christmas trees is 5 to 10 years *(4,24)*.

In the Eastern and Central States, Virginia pine performs well when planted on strip-mined sites. In a study in West Virginia, Virginia pine survived well, grew quickly, and encountered no serious pests 14 years after being planted on a mined site (43). It is also a satisfactory species for the reclamation of spoil banks in the Southeast (27).

Because the wood of older trees is frequently softened by fungal decay, Virginia pine provides nesting habitat for woodpeckers. Leaving old, decayed trees near the margins of clearcuts provides nesting sites *(13)*.

Genetics

Population Differences

Most of the variation in Virginia pine is attributable to differences among individual trees or stands rather than to geographic origin, though it is suspected that populations in the Talladega Mountains of central Alabama and on the deep sands of the mid-Atlantic Coast are distinct ecotypes (25). A rangewide sample of 2,114 trees revealed no evidence of north-south or east-west trends in specific gravity (unextracted wood) *(12)*. In studies of six wood properties of mature Virginia pine in Kentucky and Tennessee, variation usually was greater within a stand than among stands. However, tracheid length increased from south to north within this region (42). Progeny tests of trees from the same locations also revealed significant variation in monoterpene content and in stem volume at age 5. This variation was attributable to difference among stands and among individual trees within stands *(29,34)*. These and other progeny tests indicate that tree improvement

programs for Virginia pine can significantly improve the stem form and growth rate.

Seeds from local sources or from locations with a climate similar to that of the planting site generally produce trees with the best survival and growth rates. Seed from southern provenances produce fast-growing trees on southern sites, but southern trees grow slowly and suffer winter injury when planted in the north *(20,21)*.

Hybrids

Hybrids of Virginia pine and Ocala sand pine *(Pinus clausa* var. *clausa)* can be made under controlled conditions with either species as the seed parent. Controlled crosses of *P. virginiana* with jack pine *(P. banksiana)* and lodgepole pine *(P. contorta)* have not been successful (25).

Literature Cited

1. Barden, L. S. 1976. Pine reproduction in the Thompson River Watershed, North Carolina. Journal of the Elisha Mitchell Scientific Society 92:110–113.
2. Barrows-Broaddus, J., and L. D. Dwinell. 1984. Variation in susceptibility to the pitch canker fungus among half-sib and full-sib families of Virginia pine. Phytopathology 74:438–444.
3. Belanger, R. P., and D. L. Bramlett. 19'73. Pollen production on l&month-old Virginia pine seedlings. USDA Forest Service, Research Note SE-195 Southeastern Forest Experiment Station, Asheville, NC. 3 p.
4. Belanger, R. P., and D. L. Bramlett. 1975. Virginia pine as a Christmas tree. USDA Forest Service, Research Note SE-223. Southeastern Forest Experiment Station, Asheville, NC. 4 p.
5. Belanger, R. P., and D. L. Bramlett. 1979. The growth and yield of Virginia pine. p. 108-118 *In* Proceedings, Symposium for the Management of Pines of the Interior South. USDA Forest Service, Technical Bulletin SA-TP2. Southeast Area, State and Private Forestry, Atlanta, GA.
6. Belanger, R. P., D. L. Bramlett, and E. L. Moyer, Jr. 1973. Time schedule of Virginia pine plantations advanced. Tree Planters' Notes 24(2):8–9.
7. Bramlett, D. L. 1971. Correlations between reproductive and vegetative growth in a g-year-old Virginia pine plantation. USDA Forest Service, Research Paper SE-88 Southeastern Forest Experiment Station, Asheville, NC. 6 p.
8. Bramlett, D. L., and E. L. Moyer, Jr. 1973. Seed losses reduced in Virginia pine cones by screen wire cages. USDA Forest Service, Research Note SE-193. Southeastern Forest Experiment Station, Asheville, NC. 4 p.
9. Bramlett, D. L., and R. P. Belanger. 1976. Fertilizer and phenotypic selection increase growth and flowering of young Virginia pine. Forest Science 22:461–467.
10. Brown, C. L., and H. E. Sommer. 1977. Bud and root differentiation in conifer cultures. Tappi 60(6):72–73.
11. Carvell, K. L. 1966. The effect of stand density on the development of Virginia pine in the Ohio River area of West Virginia. West Virginia University Agriculture Experiment Station, Current Report 46. Morgantown. 13 p.
12. Clark, A., III, and H. E. Wahlgren. 1970. Wood density surveys of the minor species of yellow pine in the eastern United States. Part V: Virginia pine *(Pinus virginiana* Mill.). USDA Forest Service, Research Paper SE-64. Southeastern Forest Experiment Station, Asheville, NC. 11 p.
13. Conner, R. H., R. G. Hooper, H. S. Crawford, and H. S. Mosby. 1975. Woodpecker nesting habitat in cut and uncut woodlands in Virginia. Journal of Wildlife Management 39:144–150.
14. Davis, D. D., and F. A. Wood. 1972. The relative susceptibility of eighteen coniferous species to ozone. Phytopathology 62:14–19.
15. Dwinell, L. D. 1978. Susceptibility of southern pines to infection by *Fusarium moniliforme* var. *subglutinans.* Plant Disease Reporter 62:108–111.
16. Ebel, Bernard E., Thomas H. Flannell, Lloyd E. Drake, and others. 1975. Seed and cone insects of southern pines. USDA Forest Service, General Technical Report SE-8. Southeastern Forest Experiment Station, Asheville, NC. 40 p.
17. Eyre, F. H., ed. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 p.
18. Fenton, R. H., and A. R. Bond. 1964. The silvics and silviculture of Virginia pine in southern Maryland. USDA Forest Service, Research Paper NE-27. Northeastern Forest Experiment Station, Broomall, PA. 37 p.
19. Fenton, R. H., and A. R. Bond. 1965. Pre-commercial thinning not recommended for Virginia pine stands in southern Maryland. USDA Forest Service, Research Note NE-40. Northeastern Forest Experiment Station, Broomall, PA. 7 p.
20. Genys, John B. 1966. Geographic variation in Virginia pine. Silvae Genetica 15:72–75.
21. Genys, John B., Jonathan W. Wright, and Donovan C. Forbes. 1974. Intraspecific variation in Virginia pine: results of a provenance trial in Maryland, Michigan, and Tennessee. Silvae Genetica 23:99–104.
22. Henninger, C. M. 1962. Site index of two pines on the Cumberland Plateau in Tennessee. Journal of Soil and Water Conservation 17:175–176.
23. Hepting, George H. 1971. Diseases of forest and shade trees of the United States. U.S. Department of Agriculture, Agriculture Handbook 386. Washington, DC. 658 p.
24. Hu, S. C., and C. W. Brewer. 1978. Shearing is a necessary cultural practice for Virginia pine Christmas tree production. Southern Journal of Applied Forestry 2: 135-136.
25. Kellison, R. C., and B. J. Zobel. 1974. Genetics of Virginia pine. USDA Forest Service, Research Paper WO-21. Washington, DC. 10 p.
26. Loftus, N. S., Jr. 1974. Performance of pine and yellow-poplar planted on low-quality sites in central Tennessee. USDA Forest Service, Research Note SO-176. Southern Forest Experiment Station, New Orleans, LA. 5 p.
27. McMinn, J. W., and W. H. Crane. 1984. Five-year performance of selected woody species on an upper coastal plain spoil bank. Southern Journal of Applied Forestry 8:207–209.

28. Meier, Richard J., and James F. Goggans. 1977. Heritabilities of height, diameter and specific gravity of young Virginia pine. Forest Science 23:450–456.
29. Meier, Richard J., and James F. Goggans. 1978. Heritabilities and correlations of the cortical monoterpenes of Virginia pine (*Pinus virginiana* Mill.). Silvae Genetica 27:79–84.
30. Metz, Louis J., Carol G. Wells, and Paul P. Kormanik. 1970. Comparing the forest floor and surface soil beneath four pine species in the Virginia Piedmont. USDA Forest Service, Research Paper SE-55. Southeastern Forest Experiment Station, Asheville, NC. 8 p.
31. Nelson, T. C., J. L. Clutter, and L. E. Chaiken. 1961. Yield of Virginia pine. USDA Forest Service, Station Paper 124. Southeastern Forest Experiment Station, Asheville, NC. 11 p.
32. Osterhaus, C. A., and C. W. Lantz. 1978. Pine plantations on the Cross Timbers area of Oklahoma. Southern Journal of Applied Forestry 2:90–93.
33. Phillips, S. O., and J. M. Skelly. 1975. Terminal elongation of several forest tree species as affected by air pollution. p. 154. *In* Sixty-sixth Annual Meeting Abstracts, Proceedings of the American Phytopathological Society, Vancouver, B. C., August 1974. St. Paul, MN.
34. Rink, G., and E. Thor. 1976. Variance components and gains in volume growth of Virginia pine (*Pinus virginiana* Mill.). Silvae Genetica 25:17–22.
35. Schopmeyer, C. S., tech. coord. 1974. Seeds of woody plants in the United States. U.S. Department of Agriculture, Agriculture Handbook 450. Washington, DC. 883 p.
36. Slocum, G. K., and W. D. Miller. 1953. Virginia pine. North Carolina Agricultural Experiment Station, Technical Bulletin 100. Raleigh. 52 p.
37. Smalley, G. W. 1985. Growth of 20-year-old Virginia pine planted at three spacings in Tennessee. Southern Journal of Applied Forestry 9:32–37.
38. Smalley, G. W., and K. Pierce. 1972. Yellow-poplar, loblolly pine, and Virginia pine compared in Cumberland Plateau plantations. USDA Forest Service, Research Note SO-141. Southern Forest Experiment Station, New Orleans, LA. 6 p.
39. Snow, Albert G., Jr. 1965. Virginia pine (*Pinus virginiana* Mill.). *In* Silvics of forest trees of the United States. p. 471–477. H. A. Fowells, comp. U.S. Department of Agriculture, Agriculture Handbook 271. Washington, DC.
40. Snow, Albert G., Jr., and Curtis May. 1962. Rooting of Virginia pine cuttings. Journal of Forestry 60:257–258.
41. Sucoff, Edward I. 1961. Effect of seedbed conditions on regeneration of Virginia pine after logging. USDA Forest Service, Station Paper 147. Northeastern Forest Experiment Station, Broomall, PA. 10 p.
42. Thor, E. 1964. Variation in Virginia pine, Part 1: Natural variation in wood properties. Journal of Forestry 62:258–262.
43. Williamson, R. K. 1978. Followup on trees. Soil Conservation 43(10):9.