

## SPECIES-SITE SUITABILITY OF SHORTLEAF, WHITE, AND VIRGINIA PINES

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**ABSTRACT.**—Three important pines of the interior South, shortleaf, white, and Virginia pines, have somewhat different habitat requirements. This paper is a literature review of their natural range, growth rates, and edaphic and climatic requirements for establishment and growth.

**Additional keywords:** Soil-site studies, competition, climate, aspect, parent material.

Foresters often forget that a tree's reason for being is first to survive and secondly to reproduce. To do so, it must avoid the many hazards of the environment, it must gain a degree of dominance over competing vegetation, and it must develop the means for reproduction. While the production of wood products is incidental to the tree, we foresters attempt to match a species with sites where it will economically produce for us.

Three softwood species of the interior South—shortleaf pine, white pine, and Virginia pine—which are the subject of this symposium, produce valuable wood crops. Although they share many environmental requirements, each species reacts differently to the total environment, especially in extreme situations. First, I shall review and summarize the literature for each species with respect to environmental requirements. Then, I shall compare the response of the three species to varied environments.

### Shortleaf Pine

Shortleaf (*Pinus echinata* Mill.) has the widest range of any southern pine. Its range extends from eastern Texas to Long Island, New York, and from southern Ohio to northern Florida. Natural stands occur from nearly sea level to 3,300 feet. Shortleaf grows naturally where mean annual temperature is 48° to 70° F, and rainfall varies from 40" to 55" per year (Fowells 1965). Fletcher and McDermott (1957) found that the northwestern extension of the shortleaf range depends upon a 17-inch minimum winter (November-April) precipitation. Shortleaf pine apparently cannot live in areas with annual rainfall less than 40" (Mohr 1896). Shortleaf is also reported to grow best with a high March to August rainfall (McClurkin and Covell 1965).

The wide natural range of shortleaf has produced considerable genetic variation. If this fact is not taken into consideration, experimental observations from widely separated areas may appear contradictory. Genetic variation

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also requires that one be cautious in planting shortleaf from a distant seed source.

Although shortleaf pine grows best on fertile north aspects and in minor stream bottoms, the species is generally found on dry, often rocky, ridges and south slopes (Racine 1966, Walker and Wiant 1966). Lower slopes are better than upper slopes (McClurkin and Covell 1965) and concave landforms are better than linear or convex landforms (Graney and Ferguson 1971). Della-Bianca and Olson (1961) found that shortleaf site index increased in the descent from ridgetop to stream bottom. Early survival of planted seedlings in eastern Tennessee was best on south slopes because there is less competition there (Minckler 1941). In these same plantations at 20 years old, survival was still the best on south slopes as was total volume. Height did not vary with aspect (Burton 1964).

Shortleaf occurs on soils derived from sandstone, cherty limestone, dolomite, limestone, and granite (Fletcher and McDermott 1957, Minckler 1946) and Coastal Plain sediments. Shortleaf is most often found on well-drained sites although its best growth occurs on soils with imperfect drainage (Fowells 1965). Shortleaf grows poorly both on excessively drained and poorly drained sites (Kormanik 1966). An adverse response to poor drainage may be the reason Della-Bianca and Olson (1961) found site index of shortleaf declined with increasing percent organic matter in the A1 horizon. However, Walker and Wiant (1966) reported that potted shortleaf could withstand flooding for up to 12 weeks.

Several workers found that growth of shortleaf increased as depth of the A horizon increased (McClurkin and Covell 1965, Dingle and Burns 1954). Minckler (1946), however, found little effect due to depth of the topsoil. Fowells (1965) stated that growth of shortleaf is best if there is 9 inches of topsoil or more. Coile (1935) found that 2 to 8 inches was best, and Zahner (1958) reported that growth increased with surface soil depth up to 20 inches.

There is general agreement that sandy loam topsoils are best for shortleaf (Allen,<sup>2/</sup> Fowells 1965, Racine 1966, Mohr 1896). Sands are a poor growth medium for shortleaf pine (Mohr 1896). Subsoil textures should be heavier than topsoils. Coile (1935) recommended that silt plus clay should exceed 60% of the soil composition in the B horizon. Others (Kormanik 1966, Walker and Wiant 1966) recommended sandy clay loam or clay loam subsoils. A high stone content in the B horizon is unfavorable (Graney and Ferguson 1971).

Nash (1963) maintained that soil moisture is the principal limiting factor for shortleaf in Missouri. This is probably true for most of the western portion of the shortleaf range and for shallow, sandy, or rocky areas elsewhere. Coile (1948) found that site index of shortleaf increased with the imbibitional water value of the subsoil in the North Carolina Piedmont.

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<sup>2/</sup> Allen, J. C. Site index relationships of loblolly, shortleaf, and Virginia pines on the Cumberland Plateau and Sand Mountain. Unpubl. Prelim. Rep., Tennessee Valley Auth. Div. For. Release. 1961.

A friable subsoil is better for shortleaf than a plastic subsoil (Coile 1952, Fowells 1965, Turner 1938). Natural shortleaf usually occurs in areas with low pH (Racine 1966). Conversely, high pH can be detrimental to the species (Fowells 1965). Shortleaf is not usually found growing in soils with high Ca (Mohr 1896). Indeed, liming has been shown to reduce the growth of shortleaf in southern Illinois (Gilmore 1974).

Mohr (1896) and Turner (1938) believed that shortleaf was not sensitive to nutrient deficiencies. However, Walker and Wiant (1966) reported that shortleaf usually responded to nitrogen and occasionally to phosphorus.

Minckler (1946) found that 5-year-old plantations of shortleaf on old fields of Norris Lake Watershed in east Tennessee had grown as well on eroded areas as on uneroded areas. A Soil Conservation Service study, however, showed that eroded areas averaged 10 points lower in site index than uneroded areas (USDA-SCS 1957).

Shortleaf was the best pine for planting on strip-mined land in southern Illinois (Boyce and Neebe 1959). For planting in southern Ohio, Finn (1958) recommends moderately acid spoils. Limstrom (1960) observed better growth and survival on graded than ungraded spoils.

The incidence of littleleaf disease (Phytophthora cinnamomi Rands) is related to soil properties. The disease is associated with soils having poor internal drainage (Copeland 1949). Zak (1961) found that excessive water in the root zone was the principal antagonizing property rather than low oxygen.

#### White Pine

Eastern white pine (Pinus strobus L.) is basically a northern species. Its range surrounds the Great Lakes, covers the northeastern United States, and extends south along the cool, moist Cumberland-Appalachian systems into eastern Tennessee, western North Carolina, and north Georgia.

In the southern portion of its range, white pine grows at 2,000 to 4,000 feet (Walker 1967). Farther north, it grows at lower elevations. Abundant precipitation, especially during the warm season, is necessary for best growth. Across the range of white pine, precipitation varies from 20 inches in northern Minnesota to 80 inches in north Georgia (Fowells 1965). Fowells (1965) reports mean July temperatures of 62° to 72° F as necessary for white pine. In Tennessee and North Carolina, however, the range of white pine terminates between the 76° and 78° mean July isotherms (USDA 1941).

In the northern part of its range, white pine grows best on south and west aspects (Hannah 1971). In the southern states, it does best on north and east aspects (Walker 1967). Minckler (1946) reported high seedling mortality when white pine was planted on southerly aspects in eastern Tennessee.

White pine grows on practically all types of parent material within its natural range (Fowells 1965). Walker (1967) mentions schist, gneiss, and granite as important parent materials. Minckler's Norris Watershed plantations of white pine had better volume and height at 20 years on soils derived from limestone and dolomite than from shale (Burton 1964).

In the southern part of its range, white pine grows best on imperfectly drained soils, along rivers and streams. White pine grows somewhat more slowly on well-drained sites but still competes successfully with Virginia and pitch pines (Walker 1967). Planted white pine in Ohio and Indiana grew progressively better as soil texture became coarser (Gaiser and Merz 1953). Fowells (1965) found that site index increased as soil texture became coarser. In neither of the preceding cases, however, were the soils very sandy. Asahi (1953) reported that white pine was suitable for planting on most soils except very clayey ones. Gaiser and Merz (1953) also found that growth increased as moisture equivalent and wilting point decreased. Fowells (1965) found similar trends with site index. Growth of white pine decreased with increased plasticity and density of the subsoil (Fowells 1965, Minckler 1946).

In New England, growth of white pine increased with increased pH in the B and C horizons (Mader 1976). Also, Stratton and Struchtemeyer (1968) found that height growth increased with increased pH. Mader (1976) found that better sites for white pine had more soil N and more organic matter in the B horizons than poor sites. He also found that increased organic matter in the A horizon reduced site quality, which raises the suspicion that white pine responds differently in New England than farther south. In Japan, Ca saturation of 25% was optimum and 80% was the upper limit for growth (Asahi 1953).

The consensus of several authors (Gaiser and Merz 1953, Minckler 1941, Fowells 1965) is that white pine growth increases with increased thickness of the topsoil.

White pine has been tried for coal strip mine reclamation. While it is not the most aggressive species in colonizing and stabilizing mine spoils in West Virginia, in many cases white pine may offer the best chance of eventually producing sawlogs. Spoils with pH's of less than 4.0 should be avoided (Brown 1962). On the other hand, experience with white pine on coal spoils in Illinois leads Boyce and Neebe (1959) to doubt that white pine there would ever reach merchantability. Finn (1958) stated that white pine in Ohio does not do well on fine-textured, calcareous spoil bank material.

### Virginia Pine

The natural range of Virginia pine (Pinus virginiana Mill.) extends between the Mississippi River and the Atlantic Ocean. Its northern boundary coincides with that of shortleaf pine. The southern boundary extends only a little way into South Carolina and Georgia, but somewhat further into Alabama.

Virginia pine grows from 100 to 2,500 feet above sea level. Fowells (1965) reported that annual precipitation varies from 35 to 50 inches within the botanical range of Virginia pine. I believe we should add at least 10 inches to the upper end of the scale. Range of frost-free days is 160 to 225.

Virginia pine grows best on north- and east-facing slopes but is more often found on ridgetops and south- and west-facing slopes (Slocum and Miller 1953). The species occurs on crystalline rocks, sandstone, shale and, to a lesser extent, limestone (Fowells 1965). Virginia pine, which is normally found on shallow or exposed soils (Olson and Della-Bianca 1959), will not tolerate very poor drainage (Fenton and Bond 1964, Fowells 1965).

Fowells (1965) reports that Virginia pine grows best on clay, loam, or sandy loam soils but poorly on shaly or very sandy soils. Sandy clay or silty clay subsoils are the most favorable to Virginia pine (Fenton and Bond 1964). Kormanik (1966) found increased growth with decreased 1/3 bar moisture holding capacity in the A2 horizon.

Natural Virginia pine grows best on soils from pH 4.6 to 7.9. Virginia pine commonly grows on old fields with low to medium levels of Ca, P, K, and organic matter (Slocum and Miller 1953). Fowells and Krauss (1959), working with Virginia pine seedlings in sand culture, found that the culture solution should contain from 25 to 100 ppm soluble N and at least 1 ppm P. They also found that Virginia pine could withstand 250 ppm Na without damage.

Virginia pine very often grows on eroded soils (Fowells 1965). Site index will be lower on old fields recently removed from cultivation or severely eroded than on virgin forest soils nearby (Slocum and Miller 1953). Virginia pine is a good species for strip mine reclamation, combining the features of hardiness, rapid growth, and good wildlife cover (Boyce and Neebe 1959). Lorio and Gatherum (1965) observed that survival of Virginia pine on spoil banks was associated positively with cation exchange capacity and associated negatively with soluble salts and nitrifiable N.

#### Comparisons

Shortleaf pine produces excellent sawlogs as well as posts, poles, and pulpwood. On sites where they both occur, shortleaf averages a lower site index than Virginia pine (Doolittle 1958, Olson and Della-Bianca 1959), but shortleaf grows steadily and lives longer.

Through middle Tennessee, shortleaf site indexes on dry sites range from 45 to 70 feet. Site indexes of nearly level to gently sloping upland sites range from 50 to 75 feet. On deep, medium-textured soils of north slopes and minor bottoms, shortleaf site indexes range from 60 to 85 feet (USDA-SCS 1969a, USDA-SCS 1969b). West of the Mississippi River, average site index of shortleaf pine will be about 5 feet less (USDA-SCS 1968).

Shortleaf pine is adapted to sites too infertile, dry, and warm for white pine. Shortleaf withstands ice, cold damage, and drought better than loblolly pine, which is often used to replace shortleaf. Shortleaf is thus more suitable to plant at higher elevations and farther north and west than loblolly. Shortleaf cannot survive or compete on many of the droughty and infertile sites inhabited by Virginia pine.

At higher elevations (perhaps 2,500 feet), shortleaf should be planted only on warm exposures. Planting shortleaf many miles north of its natural range is risky. In the southern part of its range, shortleaf has largely been displaced by loblolly except on severe sites or where markets exist for specialty products such as poles.

On favorable sites within its range, white pine outgrows all other conifers both in height and volume. White pine will outgrow the oaks through a wide range of sites and will outgrow yellow-poplar up to site index 95 for both species (Doolittle 1958). In coves and on toe slopes and moderately

well-drained floodplains on the Cumberland Plateau, the Appalachian Valley and Mountains, white pine site index ranges from 85 to 95 feet. Upland soils with adequate moisture holding capacity and moderate slopes have white pine site indexes of 75 to 85, while shallow, rocky, and steep soils may have site indexes of only 55 to 75 feet (USDA-SCS 1969a).

Natural stands of white pine are confined to cool moist areas, which usually mean higher elevations in the interior South. Yet white pine has done very well in Tennessee and other states somewhat removed by elevation and distance from its natural range. However, white pine cannot be expected to prosper in the summer droughts and high temperatures found in the southern areas west of the Mississippi River or on the Coastal Plain.

White pine in the southern states has been relatively free of disease and pests. It has a remarkable ability to shade out understory competitors. Also, it responds to release after persisting in a hardwood understory for many years.

Within its natural range, white pine can be planted or managed on all but the most exposed, rocky, or droughty sites, and very wet areas. We know little of its fertility requirements, but white pine has the reputation of being more nutrient-demanding than shortleaf or Virginia pines and less demanding than yellow-poplar. Survival and growth are probably best on medium-textured soils. Soil texture can be heavy on exposed sites and coarse on moister sites. Eroded areas and depleted old fields generally should not be planted to white pine.

Virginia pine produces an excellent pulpwood. It can also be used for sawlogs and posts. The principal difficulties in its harvesting and utilization are poor form and persistent limbs. The best attribute of Virginia pine is its ability to produce impressive yields on sites where most other species have difficulty just surviving. I have seen Virginia pine with 16-foot sawlogs growing on soil less than 8 inches deep.

In middle and eastern Tennessee, Virginia pine on shallow, rocky, steep, or eroded soils ranges in site index from 45 to 75 feet. Site indexes of level to moderately sloping upland soils more than 20 inches deep range from 50 to 85. On lower slopes and in coves and minor stream bottoms, site index of Virginia pine ranges from 65 to 85 (USDA-SCS 1969a, USDA-SCS 1969b).

Virginia pine is not exacting in its requirements for nutrients or soil physical properties, though better growth can be obtained with abundant nutrients and well-structured, medium- to slightly heavy-textured, and moist soils. Areas with impeded drainage should not be planted to or managed for Virginia pine.

Shallow or rocky ridges and exposed south slopes are excellent areas to plant or encourage Virginia pine. Formerly burned or logged areas with low fertility and eroded old fields support many of our present stands of Virginia pine. Most of these areas will revert to other species in one or two generations unless interfered with (McCormick and Andresen 1963).

I found little information about growing Virginia pine in the highlands west of the Mississippi River. Its drought tolerance and similarity to

shortleaf in natural range indicate that this species could be planted in Missouri and Arkansas.

Three conifers, each with different requirements, present foresters with options for management of many sites in the interior South. Shortleaf takes advantage of disturbance to establish itself across a broad range of sites in the eastern United States. White pine competes successfully with hardwoods in cooler mountainous areas. Finally, Virginia pine grows much better than white or shortleaf on adverse sites.

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