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# The Silvics and Silviculture of VIRGINIA PINE in Southern Maryland

by Richard H. Fenton and Adna R. Bond

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# The Silvics and Silviculture of VIRGINIA PINE in Southern Maryland

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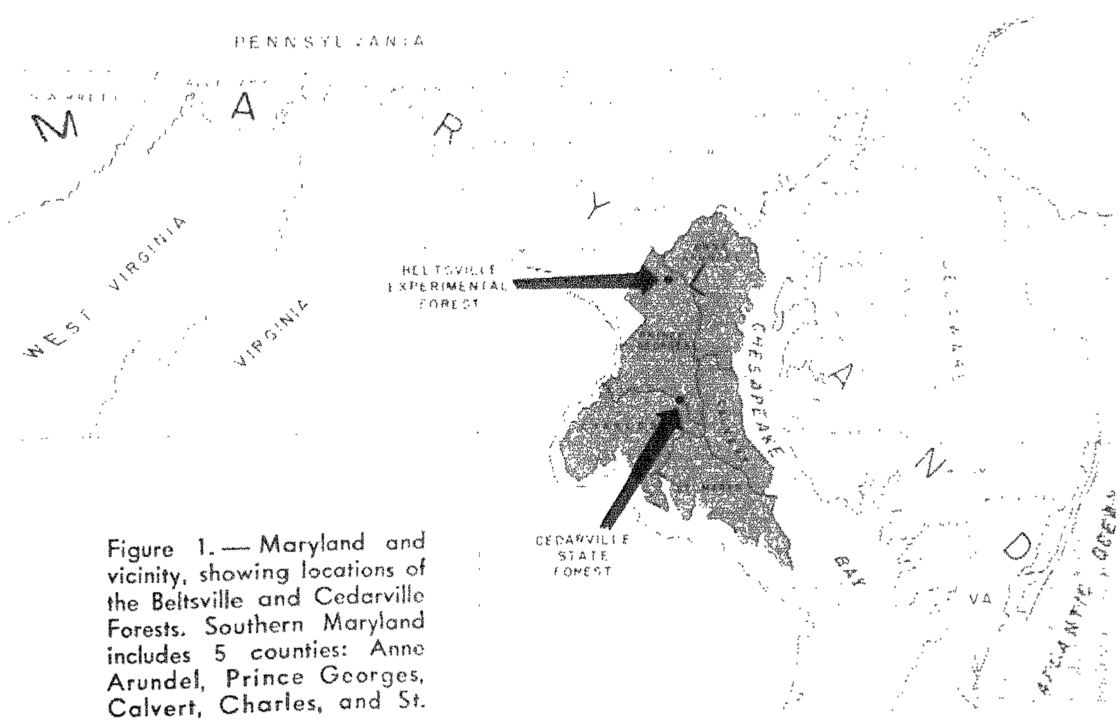



Figure 1. — Maryland and vicinity, showing locations of the Beltsville and Cedarville Forests. Southern Maryland includes 5 counties: Anne Arundel, Prince Georges, Calvert, Charles, and St. Mary's.

# IMPORTANCE AND DISTRIBUTION

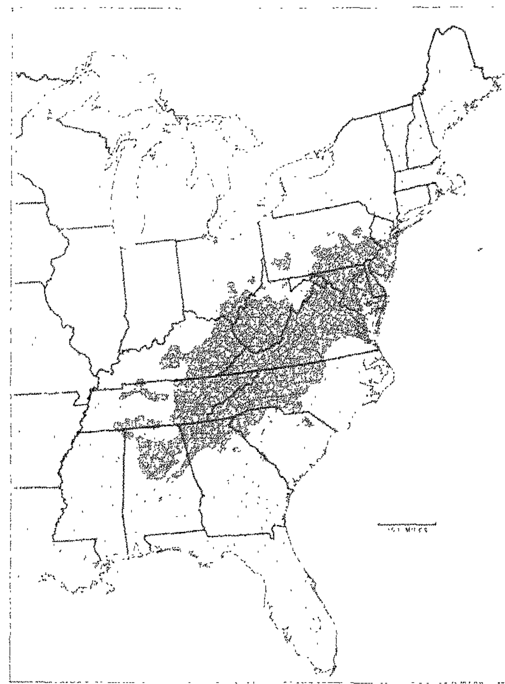
VIRGINIA PINE *(Pinus virginiana* Mill.) is an important forest tree in southern Maryland. The five counties south of Baltimore (fig. 1), which comprise southern Maryland, contain about 825,000 acres of commercial forest land, and Virginia pine accounts for a greater proportion of the cubic volume on this area than any other species (Banks 1953). In the lower counties, especially along the Chesapeake Bay and Potomac River, loblolly pine partially replaces Virginia pine. Elsewhere in southern Maryland, Virginia pine remains the major species.

Although its natural range extends from central Pennsylvania and central New Jersey south to Alabama (fig. 2), Virginia pine becomes of appreciable commercial importance only in fairly restricted areas where climatic conditions, soils, and past land use favor the widespread occurrence and dominance of the species. For example, the natural range covers all of Maryland except possibly Garrett County, but Virginia pine becomes a predominant and important species only in the southern portion of the State. Similarly, the commercial range of Virginia pine in North Carolina is restricted to eastern Mountain and western Piedmont Counties except for a narrow strip extending southeast along the Flat River drainage into Durham County (Slocum and Miller 1953).

Throughout its natural range, Virginia pine is often found in the pure stands that are representative of forest cover type 79, Virginia pine, as classified by the Society of American Foresters (1954). The species is also listed as a major component of two other types: type 77, shortleaf pine-Virginia pine; and type 78, Virginia pine-southern red oak. And Virginia pine is found as a component of several other forest types where its common associates include shortleaf, loblolly, and pitch pines; eastern redcedar; and numerous species of oak and other hardwoods.

Virginia pine, commonly considered one of the less desirable southern pines, first became commercially important in southern Maryland (Sterrett 1911; Besley 1916), where extensive cutting of this species was common at least 50 years ago. In recent years,

Figure 2. — The botanical range of Virginia pine. (Map prepared by Elbert L. Little, Jr., U. S. Forest Service.)



substantial volumes of Virginia pine pulpwood — about 45,000 cords annually — have been shipped from southern Maryland by truck, rail, or water to mills in Pennsylvania, Maryland, and Virginia. Many trees of this species have also been cut for lumber, piling, small poles, and, less commonly, for fuelwood and local-use Christmas trees.

During past cutting operations in southern Maryland, little consideration has been given to reproducing desirable stands. On many sites, relatively pure stands of Virginia and other pines have been replaced after cutting by less valuable pine-hardwood or hardwood stands. As a result, an increase in the proportion of softwoods would be desirable on nearly half of the commercial forest area in southern Maryland. However, poor regeneration following past cuttings has been counter-balanced to a large extent by the development of relatively pure stands on abandoned fields. Thus, in the 5-county area of southern Maryland, the current acreage in Virginia pine is about equally distributed among seedling to sapling, poletimber, and sawtimber stands according to the observations of local foresters and available forest-survey data.

Because Virginia pine is adapted to poor sites and is so abundant in southern Maryland, local foresters have sought methods to favor its reproduction and growth. Cooperative studies to provide such information have been made by the Northeastern Forest Experiment Station and Maryland Department of Forests and Parks; a few studies were made prior to World War II and many in the period 1946 to 1960. Most of this research was done on the Beltsville Experimental Forest in Prince Georges County and the Cedarville State Forest in Prince Georges and Charles Counties (fig. 1). This publication presents the knowledge gained to date from these and other pertinent studies on the silvical characteristics of Virginia pine and appropriate silvicultural methods.

# SILVICAL CHARACTERISTICS

## SUITABLE SOILS[1]

Virginia pine grows well on a variety of soils (Snow 1960). But this species can be considered an economically desirable forest crop only on soils that are too poor for high-quality hardwoods. In other words, only on these poor soils does Virginia pine produce a more valuable timber crop than the associated hardwoods.

Soils considered suitable for Virginia pine in southern Maryland fall chiefly into the Aura, Croom, Beltsville, Lakeland, and Galestown series. Virginia pine should also be favored on some severely eroded phases of Sassafras, Collington, Chillum, Sunnyside, and Westphalia. With the exception of the sandy Lakeland and Galestown series, these soils have characteristically sandy-clay or silty-clay substrata, sometimes cemented or compacted as in the cases of Aura, Chillum, Croom, and Beltsville. Some of these upland soils of southern Maryland tend to be droughty in summer; however, most of them retain some soil moisture in their clayey substrata throughout the year.

Interspersed with the poorer upland soils are moister, more fertile soils where high-quality oaks, yellow-poplar, or sweetgum should be grown. These hardwood sites include (1) the alluvial

[1] R. M. Kirby, soil scientist of the Soil Conservation Service, U. S. Department of Agriculture, Annapolis, Md., assisted in the preparation of this section.

deposits along streams, (2) bottomland soils such as the Freneau, Bibb, and Johnston, and (3) the finer-textured, better upland soils such as Collington and Sassafras. Oaks, yellow-poplar, or sweetgum will not only produce much higher-quality timber than Virginia pine on these sites, but these hardwoods will afford such severe competition that pine cannot be economically favored.

Virginia pine does seed in on abandoned fields of moderately well-drained to poorly-drained soils such as the Beltsville, Elkton, Leonardtown, and Shrewsbury series. However, except for the Beltsville soils, these appear capable of producing good-quality hardwoods; thus, silvicultural efforts after the initial pine crop should usually favor the hardwoods. But on the Beltsville soils, especially on severely eroded sites, a second crop containing a high proportion of pine will probably be desirable — if the most valuable timber yields are to be obtained.

Virginia pine is not adapted to very poorly-drained soils, even those composed of sands and gravels. On poorly-drained sites, loblolly, pitch, or pond pines should be favored on the coarser-textured, less fertile soils and hardwoods on the finer-textured, more productive ones.

## SUCCESSIONAL ROLE

Virginia pine is definitely a pioneer species. It rapidly invades and forms nearly pure stands on old fields, borrow pits, roadside cuts and fills, and other disturbed sites (fig. 3). Severe wildfires that kill the overstory may be followed by dense reproduction of this species (Church 1955a). Some pioneer stands of predominantly Virginia pine also contain appreciable numbers of pitch, shortleaf, or loblolly pine.

In the absence of silvicultural measures, the relatively pure stands of Virginia and other pines are not reproduced, but give way to increasing amounts of hardwoods. Pine stands of sapling or pole size usually contain an understory of small hardwoods: white, black, and southern red oaks as well as hickory and dogwood are common on the drier sites; sweetgum, red maple, blackgum, holly, and bottomland oaks (such as willow and swamp chestnut) become more prevalent in the understory on the moister soils. For example, one Virginia pine stand 22 years old had 1,175 stems of oak species per acre, 150 hickory stems, and 100 stems of other hardwoods in the understory. An older stand on a moister site had an understory made up of 1,860 oaks, 1,040 red maples, 320 blackgums, 540 sweetgums, and 500 stems of other hard-

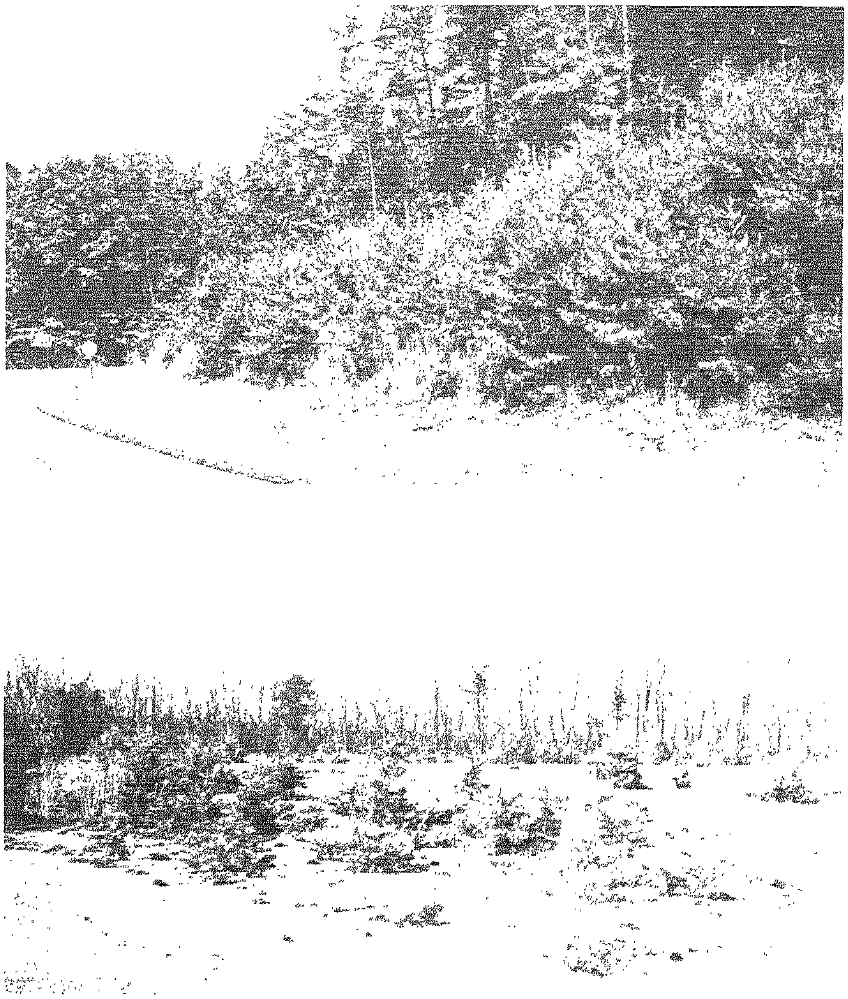


Figure 3. — Virginia pine is usually the first tree species to become established on severely disturbed sites such as this sunny roadside cut (above) or this abandoned borrow pit (below).

woods per acre. Depending on how and when the pine overstory is removed, the next crop on either site may be predominantly hardwoods or a mixture of pine and hardwoods.

Composition of the climax hardwood forest varies with soil-moisture conditions. On the drier sites, the climax should probably be classed as oak-hickory with black, southern red, and white oaks often predominating; some beech would normally occur, too. On the wetter sites, the oaks would yield to more tolerant species such as red maple, blackgum, holly, sweetbay, and beech.

## SEEDING CHARACTERISTICS

### *Seed Production*[2]

Virginia pine is a prolific producer of seed. Open-grown trees bear mature cones when only 5 years old and can continue to produce as long as they live (Sterrett 1911). In exceptionally good seed years, Virginia pine stands may shed as many as 70,000 seeds per acre on adjoining clear-cut strips (132 feet wide). Under one mature uncut stand at Cedarville, the seed catch in a 5-year period varied from a low of 48,000 per acre in 1956 to a high of 996,000 in 1957.

Although no complete failures have been observed, the size of Virginia pine seed crops fluctuates greatly from year to year. In the 11-year-period 1950 to 1960, better-than-average crops were borne at Beltsville in 5 years: 1950, 1953, 1957, 1958, and 1960. At Cedarville, where seedfall was sampled between 1956 and 1960, good crops were produced in 3 years: 1957, 1958, and 1960. Apparently there is no fixed pattern in the occurrence of good seed crops: they may be 1 to 4 years apart.

High stand density may delay cone production (Snow 1960) and also reduce the number of cones borne. Crown release stimulates cone production beginning in about the third growing season after release (Sucoff and Church 1960).

Residual stands adjacent to clear-cut strips produce substantial amounts of seed for restocking the cutover areas. At Beltsville for example, seedfall was measured on NE-SW strips cut through two mature stands with these results:

- On 3-chain-wide strips in stand A, annual seedfall was 18,000, 11,600, 6,400, and 40,000 seeds per acre during a 4-year period, an average of 19,000 per acre per year.
- On 2-chain-wide strips in stand B, annual seedfall was 14,200, 54,900, 8,200, 21,000, 70,200, 20,900, and 61,500 seeds per acre during a 7-year period, an average of nearly 36,000 per acre per year.

Scattered seed trees may rank higher in seed production than residual strips of trees. In a 45-year-old Beltsville stand, 31 seed trees per acre left after cutting produced an annual average of 102,000 seeds per acre, or 3,500 seeds per tree, over a period of 5 years. In another portion of the same stand, 11 remaining seed trees per acre produced an annual average of 92,000 seeds per acre, or 8,400 per tree, over the same 5-year period.

[2] Numbers of seeds mentioned in this section include both sound and unsound seed.

## *Seed Viability*

The viability of Virginia pine seed varies greatly. At Beltsville, seed viability was associated with size of seed crop. During good seed years, about 80 percent of the seed was viable; in poor seed years, only about 20 percent was viable. In 1956, an unusually poor seed year, the viability of a sample of seed was 2 percent.

## *Seed Distribution*

In southern Maryland, seed dispersal of Virginia pine begins between mid-October and early November. Most of the seeds become viable at least 8 weeks earlier (Church and Sucoff 1960). Although dispersal continues until late May or possibly longer, 60 to more than 95 percent of the sound seeds fall before January 1. Both the beginning of seedfall and its rate differ appreciably from year to year (Sucoff and Church 1960). Dispersal is modified in occasional trees by the presence of serotinous cones that remain closed for a year or more.

Distribution of the seed is greatly influenced by the force and direction of the winds that occur on dry days during the period of heavy seed dispersal. In a 3-year study at Beltsville, the ratio among the numbers of seeds that fell on the north, east, south, and west sides of a seed source was about 2 : 4 : 4 : 1, respectively.

The amount of seedfall decreases rapidly with increased distance from the source. Traps at 100 feet from the edge of a stand commonly catch only 6 to 16 percent as many as do those at 10 feet. At 150 feet no sound seeds may be caught on the north or west sides of a good source, only about 1,000 per acre on the south side, and 2,600 on the east side (Sucoff and Church 1960).

# SEEDLING ESTABLISHMENT

## *Seed Germination*

Although the best germination of Virginia pine seed occurs on a seedbed of mineral soil, a thin layer of litter is also fairly satisfactory. Light sod, such as that found during the early stages of succession on abandoned fields, is also a suitable seedbed, but dense sod is not a favorable medium (Sterrett 1911; Bramble 1947). Sowers found very poor germination and survival of direct-seeded Virginia pine on an undisturbed heavy sod.[3]

[3]Correspondence in the files of the Northeastern Forest Experiment Station from David W. Sowers, Jr., of the West Virginia Pulp and Paper Company.

In cutover areas, the seedling catch is usually largest in spots where the forest floor has been appreciably disturbed by logging and mineral soil has been exposed. Light winter fires that precede seedfall or controlled slash fires after logging usually improve the seedbed for Virginia pine reproduction, too. Either logging or fire disturbance may result in germination that is 2 to 4 times that found on undisturbed seedbeds and 2-year survival that is 4 times as much (Sucoff 1961b).

## *Seedling Survival*

Virginia pine seedlings require an appreciable amount of light for good survival and growth. With low light intensities such as those found under well-stocked Virginia pine stands, few seedlings survive beyond their first growing season. Even partial shade hinders growth: although the seedlings may survive for several years, they become deformed and eventually succumb, partly because of competition from more tolerant hardwoods and shrubs (Fenton 1960) (fig. 4). For maximum growth, Virginia pine seedlings require direct sunlight.

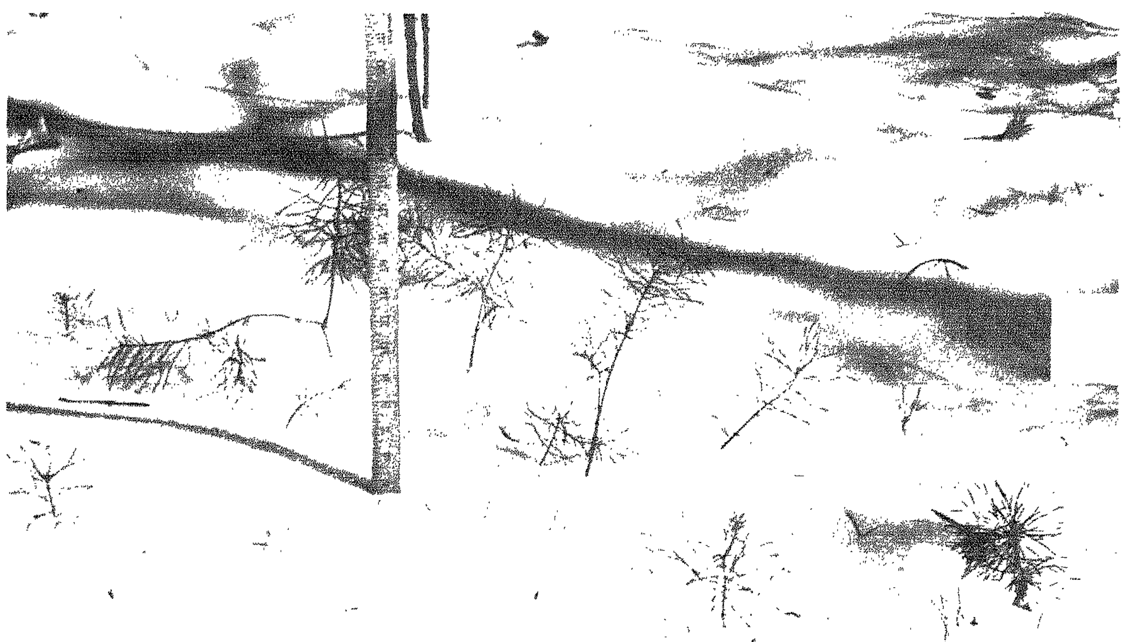


**Figure 4. — Sparse foliage and stunted growth are typical of suppressed Virginia pine seedlings, like these.**

# GROWTH AND YIELD

## *Height Growth*

Unhindered by competition from other species, Virginia pine seedlings on favorable seedbeds reach 4 to 8 inches in height during their first year. At 10 years of age, dominant pines on the better sites average 17 feet in height (Sterrett 1911). On most of the sites in southern Maryland, dominant Virginia pines 50 years old have heights of 55 to 70 feet; however, there are some less productive sites where the tree heights are somewhat less. The specific factors that affect the site quality for Virginia pine in this area and their relative importance are not known at present.

Like other southern yellow pines, Virginia pine often has more than one flush of height growth during a growing season. Some seedlings and older trees may exhibit only one flush, but vigorous

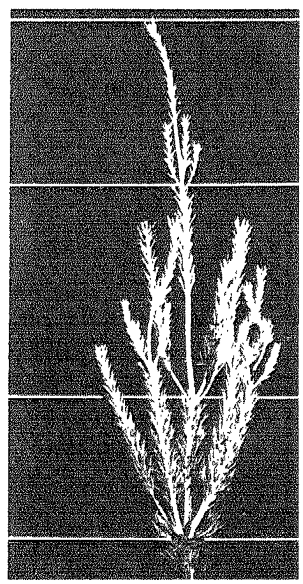


Figure 5. — By early June, three growth flushes and 84 percent of the seasonal height growth had already been completed by this vigorous Virginia pine sapling.

seedlings and saplings often have 3 and sometimes 2 or 4 elongations of the terminal shoot. Height growth of these vigorous stems may not cease until early September whereas the height growth of slow-growing trees terminates much earlier. However, observations at Beltsville indicate that on most trees — even the vigorous ones—about 85 percent of the height growth occurs between mid-April and mid-June (fig. 5).

### *Mortality*

Mortality is high in densely stocked Virginia pine stands partly because of rapid crown differentiation and the resulting early suppression of many stems. Seedling stands may contain 10,000 stems per acre, sapling stands about 5,000. However, in typical stands, the number dwindles to 1,000 or so at 20 years of age, to 300 at 50 years, and to about 170 stems per acre at 70 years (Church 1955b). Apparently in some stands, such as Slocum and Miller (1953) describe in North Carolina, the reduction in number of stems is slower than that reported by Church.

### *Volume Growth and Yield*

A yield table for average site conditions in southern Maryland indicates that cubic volume increases in unmanaged stands at a fairly uniform rate until the trees are about 40 years old. By then, the average tree size is 7 to 8 inches in d.b.h. and the merchantable stand volume is about 2,800 cubic feet per acre. The volume increase becomes slower after the stands reach 40 years old; and at 70 years the average stand contains only about 3,550 cubic feet of merchantable pulpwood (Church 1955b). Because of the decline in merchantable cubic-foot growth rates after 40 years, Virginia pine stands are frequently clearcut for pulpwood shortly after they reach this age.

The effects of stand density, site, and age on the cubic-foot yields of Virginia pine have been described by Nelson, Clutter, and Chaiken (1961). These authors show that density as expressed in basal area per acre has a significant influence on final yields: for example, stands 50 years old on 65-foot sites have about 480 more cubic feet per acre at 100-percent density than at 60-percent density. Based in part on plots located in southern Maryland, these data should reasonably provide more precise estimates of growth and yield than can be obtained from Church's study mentioned above.

If grown to about 70 years of age, Virginia pine stands do produce a reasonably large cut of sawtimber; but the trees are small, usually 9 to 15 inches in d.b.h., and have coarse, persistent branches. Under standards of utilization typical of southern Maryland, these stands yield 12,000 to 15,000 board feet per acre.

### *Maximum Size and Longevity*

Although Harlow and Harrar (1950) give the maximum size of Virginia pine as 3 feet in diameter and 100 feet tall, the largest tree recorded in Maryland was only 28 inches in diameter (Dixon 1961). Maximum heights in Maryland are usually 80 to 85 feet.

Compared to its common pine associates — shortleaf, pitch, and loblolly — Virginia pine is short-lived, seldom surviving beyond 90 years in the Beltsville area.

### *Pathological Rotation*

Heart rots, especially by *Fomes pini,* have an important influence upon the desirable rotation age for Virginia pine under management for sawlogs. From experience at Beltsville, Fenton and Berry (1958) suggested that 70 years was the maximum desirable rotation because reductions in merchantable volume due to heart rot became excessive in older stands. However, shorter sawlog rotations may be desirable in certain areas: Slocum and Miller (1953) found that 23 to 34 percent of the trees in some North Carolina stands only 56 to 59 years old were infected by heart rot. In growing Virginia pine for pulpwood to the generally accepted rotation age of 40 to 45 years, heart rot is usually not prevalent.

## DAMAGING AGENTS

### *Snow and Ice*

Storms that deposit wet snow or ice sometimes severely damage untreated or uncut Virginia pine stands. Reproduction 3 to 7 feet tall may be temporarily prostrated, but most of the stems usually recover. Saplings about 10 years old are more severely damaged (fig. 6); but poles and sawtimber trees generally suffer little or no damage when growing in relatively undisturbed stands (Fenton 1959).

The susceptibility of Virginia pine to snow and ice damage is considerably higher in disturbed stands than in undisturbed stands, and this fact limits the use of thinning and partial harvest cuttings. Trees of sapling size and larger are so vulnerable after release by thinning or other cutting that several authors (such as Slocum and Miller 1953) hesitate to recommend these practices.

### *Wind*

Wind may severely damage Virginia pine stands after they have been opened up by cutting. While losses in these stands are most spectacular in hurricanes, normal winds also cause appreciable damage. For example, Hurricane Hazel in 1954, which hit the Beltsville Forest with sustained winds of 66 m.p.h. and gusts

Figure 6. — A heavy wet snow has almost completely destroyed this clump of Virginia pine saplings on the Beltsville Experimental Forest. Pole-sized trees are only slightly damaged.

of 98 m.p.h., caused losses of more than 150 cubic feet per acre in the residual stands of alternate-strip cuttings. However, normal winds produced almost equivalent losses in similar stands over a 2-year period (Fenton 1955).

Scattered seed trees are also very susceptible to wind damage. When 15 or 45 seed trees were left per acre at Beltsville, 50 and 55 percent, respectively, were lost, chiefly to windthrow over an 8-year period. On the deeper soils of the Cedarville Forest, seed-tree losses have been lower.

## *Fire*

Virginia pine is readily killed by fire because its bark is relatively thin; young trees are particularly susceptible. The thicker bark of shortleaf, pitch, pond, or loblolly pines may at times give enough additional protection so that certain fires in mixed stands eliminate only the Virginia pines (Slocum and Miller 1953). However, in New Jersey, pole-sized Virginia pine stands have been prescribe-burned with light winter fires, and occasionally burned by light wildfires, without killing any of the overstory.

Virginia pine is also much more subject to killing by crown scorch than are associated pitch, pond, and shortleaf pines. Sapling or pole-sized stems of the latter three species that have had all their foliage killed by a fire's heat may still recover, largely because they have so many dormant buds along the boles and branches which subsequently produce new foliage. But similar damage to Virginia or loblolly pine normally kills the tree.

Virginia and loblolly pines do not sprout after the stems are killed by wildfire. In this respect, they differ from pitch, shortleaf, and pond pines. Neither Virginia nor loblolly pine retain dormant buds at the base of the stem (in the epicotyl) for more than a few years, nor do they form a basal crook in their stem. In contrast: pitch, shortleaf, and pond pines have basal dormant buds for many years; and when 1 to 9 years old (depending on how fast they grow), these pines usually form a crook at the base of the stem that often protects the basal buds by placing them in mineral soil (Little and Somes 1956 and 1960).

## *Animals*

Deer sometimes browse the terminal shoots of Virginia pine seedlings, and rabbits may clip off the shoots of the smaller seedlings, especially those only 0.5 foot to 2 feet tall. But little reproduction is killed by either deer or rabbits because the seedlings

Figure 7. — When the environment provides favorable rodent cover, mice may completely girdle young Virginia pines.

frequently recover from browsing injury — often by developing new shoots from the needle fascicles. However, if the damage is extremely low — severing the stem at the hypocotyl — no buds will remain as sources for shoot development and the seedling will not recover.

Mice, especially meadow-mice, have been the most damaging animals to Virginia pine reproduction in the Beltsville area. Where a thick, matted cover of grasses and weeds has provided an attractive environment, mice have often been highly destructive of natural or planted seedlings. The damage, usually confined to winter, is done by chewing enough inner bark to girdle the tree (fig. 7). Probably because of thinner bark, Virginia pine seedlings generally suffer more damage than loblolly and pitch pines (Church 1954). In a 6-year-old mixed planting, 33 percent of the Virginia pines were completely girdled and 27 percent were partially girdled compared to 3 and 15 percent, respectively, of the loblolly pines (Fenton 1962).

## *Disease and Insects*

From an economic standpoint, *Fomes pini* is the most important fungus that attacks Virginia pine in southern Maryland. Minor diseases of Virginia pine in this area include the globose gall rust *(Cronartium cerebrum)* and witches' broom. Even though the globose gall rust causes some deformity to both branches and stems as well as some mortality, it is of little importance. Other diseases that attack Virginia pine, including a root rot *(Fomes annosus)* and a butt rot *(Polyporus schweinitzii)*, have so far been of little consequence in southern Maryland.

The most serious insect pest has been the Virginia pine sawfly *(Neodiprion pratti pratti)*, which in several recent years has had a high population level in southern Maryland (McIntyre 1960). Severe and repeated defoliation by this sawfly can cause some loss of growth and scattered mortality in Virginia pine. The Nantucket tip moth *(Rhyacionia frustrana)* annually infests some of the terminal growth, especially of open-grown reproduction, but generally has little lasting effect on growth or form. Probably of greater importance than the tip moth are the bark beetles, both the southern pine beetle *(Dendroctonus frontalis)* and *Ips* spp., because these kill scattered stems or small clumps of merchantable-sized trees. In cutover areas, pales weevil *(Hylobius pales)* may kill advance pine reproduction or freshly planted seedlings; but to date damage by this weevil has not been conspicuous in southern Maryland.

## SUMMARY: SILVICS

The silvical characteristics that form the basis for the silviculture and management of Virginia pine can be summarized as follows:

- Virginia pine is an intolerant tree, adapted to relatively poor soils and unable to compete successfully with associated hardwoods in the absence of severe disturbances.
- It is prolific, producing at least small seed crops annually and heavy crops at irregular intervals.
- Natural reproduction in adequate amounts is limited to disturbed sites near and especially to the leeward of good seed sources.
- Virginia pine stands are subject to damage by fire and, when partially cut, to damage by ice, snow, and wind.
- The stands are relatively free of serious insect pests or diseases, except for heart rots.
- Virginia pine is primarily a pulpwood species because of small size, coarse and persistent branches, and susceptibility to heart rot at a fairly young age.

With these characteristics in mind, let us consider what has been learned in southern Maryland from the silvicultural treatments tried in the Beltsville and Cedarville Forests.

# SILVICULTURAL TREATMENTS

## HARVEST CUTTINGS

Because of Virginia pine's intolerance, inability to cope with hardwood competition, and susceptibility to damage by wind, snow, and ice, some form of even-aged silviculture seems essential for perpetuating this species. And because of the high risk of damage to residual seed sources from climatic elements, the appropriate silvicultural method should provide for rapid regeneration followed by prompt removal of the residual stand. Variations in harvest cuttings that have been tried at Beltsville or Cedarville include (1) clearcutting of strips, (2) clearcutting of patches, and (3) seed-tree cuttings.

### *Strip Clearcuttings*

Two stands of predominantly Virginia pine, 45 and 70 years old, were harvested at Beltsville by clearcutting strips 2 or 3 chains wide, respectively, separated by residual strips 1 chain wide (fig. 8). Both stands were over 30 acres in size, and the strip cuttings on both were about 20 chains long.

Even though the slash on the cutover strips in both stands was broadcast-burned in late summer, and even though trees in the uncut strips shed large amounts of seed on the cutover areas, the amount of pine reproduction was surprisingly low. Two years after cutting there were only 1,350 and 1,000 pine seedlings per acre on the cutover strips of the 45- and 70-year-old stands, respectively, which provided a stocking of 39 and 50 percent based upon milacre quadrats.

Despite the poisoning of hardwoods over 2 inches in d.b.h. at the time of cutting, the cutover strips after 2 years contained 3,600 and 6,300 hardwood stems per acre for the younger and older stands, respectively, which stocked at least 95 percent of the quadrats. Most of these hardwoods were small seedlings, but more than half of them were taller than the associated pine reproduction.

Similar strip cuttings at the Cedarville Forest have been considerably more successful than at Beltsville. Usually the Cedarville

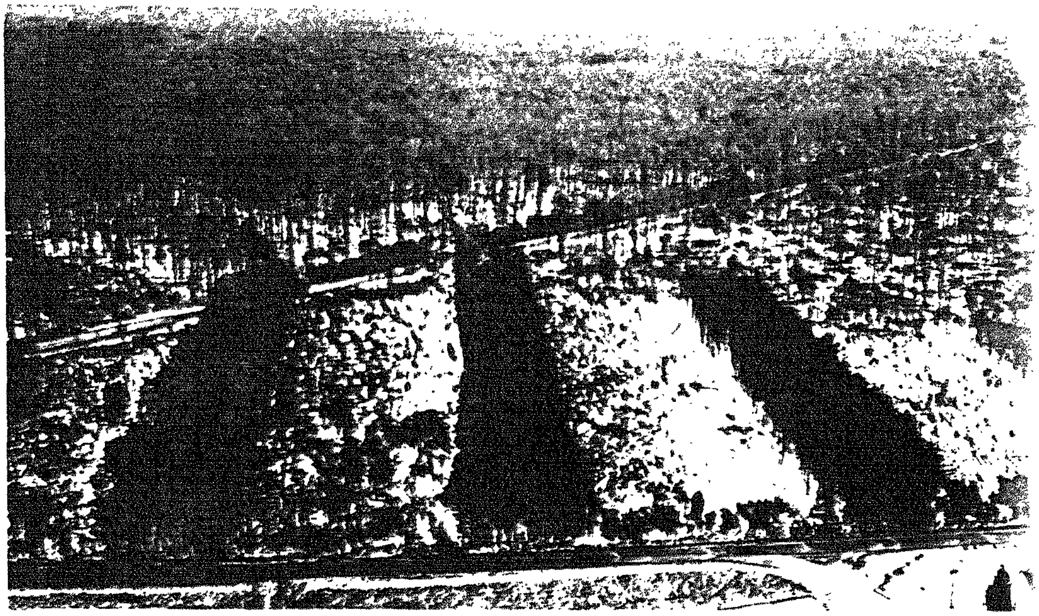


Figure 8. — Aerial view of an alternate-strip cutting in Virginia pine on the Beltsville Experimental Forest.

cuttings have provided 5,000 to 10,000 pine seedlings per acre, stocking 85 percent or more of the quadrats. However, the range in reproduction has been from 2,200 to 16,000 seedlings per acre within 5 years after cutting. With less advance hardwood reproduction than on the Beltsville cuttings, the Cedarville areas have also provided much less hardwood competition for the pine reproduction. A possible reason for the differences in hardwood competition is that the Cedarville soils are lighter and drier than those on the Beltsville Forest.

The system of clearcutting alternate strips presents problems with regard to wind damage in the residual stands and the establishment of reproduction in the leave strips. Wind damage can be reduced by leaving relatively wide strips of residual trees and then removing these trees as soon as adeqnate regeneration is assured, probably after 1 or 2 years when seed trees are to be kept on the leave strips as supplemental seed sources.

For the adequate regeneration of leave strips, Sucoff (1961a) recommended: (1) burning the uncut strips once before seedfall in September or early October, and then (2) harvesting these strips 1 or 2 years later, so that seed from 2 or 3 crops would supply advance or subsequent reproduction. Any fire-killed pines would still be merchantable at the time of the final harvest.

Unfortunately this procedure was never tested at Beltsville: stands on the leave strips were clearcut in October just before a good crop of seed started to fall, but with no prior seedbed preparation. Results on the cutover leave strips were fair, about the same as on the original cutover strips: 1,050 pine seedlings per acre stocking 47 percent of the milacre quadrats with about 4,300 competing hardwood stems per acre.

More pine reproduction was obtained in the Cedarville Forest than in the Beltsville Forest following harvesting of the leave strips, possibly because a few seed trees were left either singly or in small groups (fig. 9). In the first year after cutting, these cutover leave strips had 4,000 to 4,500 seedlings per acre stocking 85 percent or more of the quadrats.

Figure 9. — In alternate-strip cuttings on the Cedarville Forest, reproduction in the final strips was obtained by leaving a few small groups of seed trees when these strips were cut.

The alternate-strip method of harvest cutting has, or may have, two drawbacks:

- Residual strips may suffer appreciable losses, up to about 30 percent of the stems in the Beltsville strips in the 4 to 6 years before the final harvest. Most of these losses are from wind damage. Reducing the interval between cuts to 1 or 2 years would materially decrease the windthrow losses.
- To obtain desirable amounts of pine reproduction on the leave strips, clearcutting of the leave strips probably must be restricted to the late summer and early fall of good seed years, or some seed trees should be left after cutting each strip.

## *Patch Clearcuttings*

In the Beltsville Forest, the clearcutting of square patches, each of about 1/3 acre, was tried in mature Virginia pine stands during a 6-year period. Cutting was done in the winter, the slash was broadcast-burned, and the residual hardwoods larger than 2 inches d.b.h. were poisoned in the following summer. In all patches, pine reproduction outnumbered hardwood seedlings and sprouts 2 or 3 years after cutting; there were about 8,000 pines to 3,400 hardwoods per acre (fig. 10).

Patch cuttings in pine-hardwood stands were markedly less successful than in pure pine. These cuttings were of two types: (1) 1/4-acre areas were clearcut and residual hardwoods larger than 2 inches d.b.h. were killed by chemical applications, and (2) 1-acre

Figure 10. — Most small patch cuttings in pure pine, followed by prescribed burning for slash disposal and seedbed preparation, reproduce well to Virginia pine. Seven growing seasons have elapsed since this patch on the Beltsville Experimental Forest was clearcut.

**Figure 11. — Because no seedbed treatments were applied in this small patch cutting on the Beltsville Experimental Forest, pine reproduction is wholly inadequate. Hardwoods are taking over the site even though a good seed source is nearby.**

areas were treated with a shelterwood cutting that removed about 40 percent of the merchantable volume. In both types of patch cuttings, pine seed trees were left if present or the patches were located on the edge of a pine seed source. Because no seedbed treatments were applied, little pine reproduction was obtained even though pine seedfall amounted to 30,000 seeds per acre annually in the 1/4-acre patches (fig. 11). Two years after cutting, the 1/4-acre patches had only 250 pine seedlings per acre, and the 1-acre patches had hardly any.

Patch clearcuttings in mature pine stands provide more seed than alternate-strip cuttings and, when aided by seedbed treatments, more pine reproduction as well. For example, in one good seed year when alternate cutover strips were receiving 70,000 seeds per acre from the residual pines on leave strips, clearcut patches in a similar pine stand were getting 300,000 seeds per acre.

However, scattered patch cuttings do have serious biological and economic disadvantages. Reproduction within a patch is shaded to some extent by the adjoining older timber and, particularly on the edge of the patch, conditions more favorable for hard-

Figure 12. — Forty-five pine seed trees per acre were retained in this cutting on the Beltsville Experimental Forest, which has adequately regenerated to Virginia pine. But an adjacent cutting leaving only 15 seed trees per acre resulted in equally good regeneration and smaller losses of seed trees due to windthrow.

woods than for pines are created. With patches only 1/3 acre in size, edge effects prevail over a large portion of the total stand.

Even more serious are the economic disadvantages. In the first place, such small units are expensive to log. In fact, several nearby units would have to be cut at the same time to provide a logging chance of interest to a commercial logger; and even then, the stumpage value paid to the owner would usually be less than in larger areas. Furthermore, small scattered units result in expensive cultural operations and costly, inefficient bookkeeping. In all these ways, returns to the timber grower would be markedly reduced.

## *Seed-Tree Cuttings*

Several variations of seed-tree cuttings were tried in pure pine stands of the Beltsville Forest. These differed chiefly in the number of seed trees left; the numbers tested were 5, 15, 25, 40, and 45 seed trees per acre (fig. 12).

Fifteen trees per acre provided a sufficient amount of seed for satisfactory regeneration on favorable seedbeds — 4,600 seedlings per acre stocking 80 percent of the quadrats. Certainly 40 or 45 trees are unnecessary for seed supply. Whether fewer than 15 trees would be adequate is questionable, since their effectiveness varies greatly with size of seed crop, seedbed conditions, and weather conditions during germination and early growth of the seedlings.

Seed trees should be salvaged within a year or so after an adequate amount of pine reproduction is established, or they should be considered as a probable loss on many sites. While the Beltsville cuttings were made under the assumption that the seed trees would survive a subsequent 40-year pulpwood rotation and become quality sawtimber, that assumption proved false. The experience at Beltsville indicates that, in such a period, probably far more than half of these trees would be lost to windthrow, wind breakage, and lightning. In contrast, the deeper-rooted trees left after seed-tree cuttings in the Cedarville Forest usually have had a low mortality rate; but even here the short longevity of Virginia pine will probably not permit the survival of many seed trees through a subsequent pulpwood rotation.

Seed-tree cuttings in pine-hardwood stands gave far less favorable results in securing pine reproduction than did similar cuttings in pine stands. The fault was not in seed production: where 25 pines per acre were left as seed trees after cutting one pine-hardwood stand, seedfall varied from 32,000 to 285,000 seeds per acre annually, or an average over a 4-year period of 121,000. However, hardly any pine reproduction was obtained, because (1) no seedbed treatments were made, and (2) hardwood associates were not adequately controlled.

## *Other Harvest Cutting Methods*

Other possible cutting methods, untried as yet, that might favor the perpetuation of Virginia pine include:

- *Progressive strip cuttings* that start on the south or east side of a stand and progress toward the north or west. With only a year or so between the cutting of adjoining strips, much of the damage from windthrow or wind breakage could be salvaged. In the final strip, as in the Cedarville strip cuttings, seed trees could be left temporarily either singly or in clumps for reseeding. Chief advantages of the progressive strips over alternate strips seem to be: (1) reduced importance of wind damage due to the good opportunities for timely salvage; and (2) in large areas, cutting could be almost continuous since far less reliance is necessary on good seed crops. However, when exceptionally poor cone crops provide small amounts of new reproduction — 1,200 or fewer seedlings per acre — seed trees should be left along the nearest border of the next strip. After a year, these seed trees could be removed during the course of a regular harvesting operation.

- *Shelterwood cuttings* in which possibly half of the stand is cut, followed either by a slash burn or the use of a heavy disk for seedbed preparation. As soon as adequate amounts of pine reproduction had become established, probably in 1 or 2 years, removal of the residual stand would be necessary. However, after the second cut, damage by pales weevil could be excessive —although we have little direct information on this possibility. If serious, such damage could prevent shelterwood cutting from becoming an effective means for reproducing Virginia pine — unless a feasible method of weevil control were developed.

### *Recommended Methods*

For (1) effectiveness in reproducing Virginia pine, (2) feasibility under long-term management, and (3) stumpage returns, the use of seed-tree cuttings in most stands and of progressive strip cuttings (with seed trees in the last strip) in especially extensive stands seems most logical. Where seed trees are left, they may be retained in small clumps and in locations favoring their easy removal, but they should be salvaged where economically feasible as soon as adequate amounts of reproduction become established. An alternative would be: (1) to remove the seed trees after seedfall in the year following the initial cutting, and (2) in 1 or 2 years, to plant any gaps appearing in the pine reproduction. In planting, loblolly pine seedlings might well be chosen in preference to Virginia pine (see later section on conversion to other pines).

## SUPPLEMENTAL REGENERATION MEASURES

### *Seedbed Preparation*

Seedbed preparation is essential in both pure pine and pine-hardwood stands if adequate amounts of Virginia pine reproduction are to be established. Both at Beltsville and Cedarville, regeneration was inadequate where no seedbed preparation measures were applied. But where the seedbed was sufficiently disturbed prior to seedfall, the amount of regeneration varied from barely adequate to highly satisfactory. Sufficiently disturbed seedbeds do not guarantee reproduction, because good seed sources are also necessary; however, they do greatly increase the chances of success from a given amount of available seed.

Final evaluation of the different possible methods for seedbed preparation is not justified at present, but the following comparative statements can be made:

- *Broadcast summer burning of well-cured slash* prepares a highly favorable seedbed and reduces competition from shrubs and small hardwoods. It is most applicable on strip clearcuttings (fig. 13).[4] In seed-tree cuttings, slash should be kept away from the seed trees, and even then an appreciable number of seed trees may be killed. For best results, burning should be done in late summer or early fall, preferably between mid-August and mid-October.

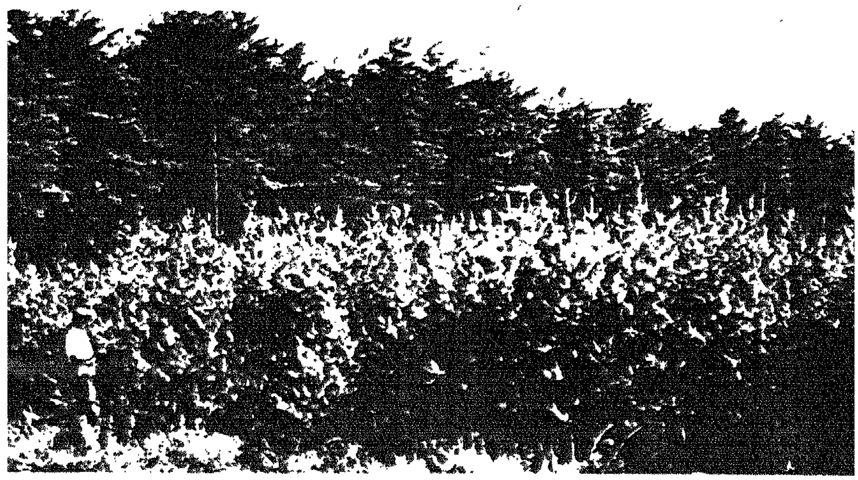


Figure 13. — Excellent Virginia pine reproduction that started on a clearcut strip on the Beltsville Experimental Forest after the slash was broadcast-burned.

- *Light fires under stands* may not be applicable in the Virginia pine areas of southern Maryland. Presumably if these fires could be used in cool fall or winter periods, they might prepare the seedbed and favor the establishment of advance pine repro-

[4] As a standard logging practice, both at Cedarville and Beltsville, operators have been required to fell the trees so that the tops land toward the center of the strip being harvested.

duction without damaging overstory pines. However, in pure pine stands, such fires are not easily applied because of the thin, relatively compact fuel, which does not burn readily except under dry and rather hazardous conditions. For example, an early September fire under one stand was relatively successful in that it resulted in the establishment of 3,000 Virginia pine seedlings in the first year after burning and 7,800 by the fourth year — nearly 4 times the number on an unburned seedbed; but 54 percent of the Virginia pine overstory was killed after 1 year, 67 percent within 2 years, and all by the end of 4 years. Because of the obvious difficulties of providing the proper type of fire as well as the possibility of pales weevil damage to advance reproduction, the use of such fires is regarded as experimental at present in Virginia pine stands (and probably most applicable where hardwood leaves are an important part of the litter).

- *Disking* with a D4 tractor and heavy Rome disk is a third possibility, but also of limited value at present. To date, the only machinery treatments tried in southern Maryland have been with an impractical garden tractor on small plots. Furthermore, a tractor and disk of sufficient size to be feasible in seedbed preparation require room to maneuver, so their practical use would be limited to clearcut areas or to stands where 50 percent or more of the stems had been cut. Because slash and stumps limit the effectiveness of machinery, disking seems to be largely a supplement to burning — to be used in areas where burning is not feasible. Probably the most appropriate areas would be in pine-hardwood stands where the cutting may create relatively little slash.

Of the three alternatives, slash burning after cutting has so far proved to be the most feasible form of seedbed preparation. This burning has cost between $5 and $15 per acre.

## *Control of Competing Vegetation*

Because established hardwood understories are not eliminated by logging or seedbed treatments, further control work is needed on most areas if Virginia pine reproduction is to become dominant. In the past, some release by cutting overtopping hardwoods has been applied, but this is relatively expensive. For example, in the Beltsville Forest such release took 12 man-hours per acre. Even though it was effective, less time-consuming methods are now available.

Mistblower applications of small quantities of herbicide have proved effective for the selective release of other pine species and should be tried in the Virginia pine stands of southern Maryland. The following formulation should be suitable: 2 pounds acid equivalent of the isooctyl ester of 2,4,5-T in an oil-water carrier of 2 quarts of No. 2 fuel oil in 4 gallons of water. This formulation has worked satisfactorily for releasing loblolly and pond pines in eastern Maryland and pitch and shortleaf pines in southern New Jersey. Probably 2 to 5 gallons of spray should be applied per acre, the amount depending upon the density and size of the competing stems. Summer treatments applied before mid-August would probably produce the best results, provided that applications were not made during droughty periods. And care must be taken to avoid drift damage (Little 1963b).

In many stands, some large cull hardwoods may be left after logging, and these should usually be killed. While various methods are possible, treatment with a tree injector that uses small amounts of chemical and carrier seems to be one of the best. For the mixed species common in southern Maryland, the following procedure is recommended:

- Use an ester formulation of 2,4,5-T at a concentration of 80 pounds ahg (acid equivalent per 100 gallons of mixture) in oil.
- Apply about 2 milliliters of the solution per cut.
- Make cuts join to form a complete frill. Keep them low to reduce sprouting (Little 1963a).

In areas where some of the hardwood understory survives mistblowing in sufficient numbers to be a problem, a similar injector treatment is recommended for these smaller stems as well as the large culls.

The need for releasing Virginia pine reproduction after cutting could be avoided to a large extent by the use of conditioning treatments that set back or eliminate competing understory stems prior to harvest cutting. Trials in eastern Maryland and southern New Jersey indicate that mistblower treatments with certain formulations of 2,4,5-T offer the most promise and thus should be tested in southern Maryland.

The most promising formulations for early-season use include the isooctyl ester, the butoxy ethanol ester for aerial application, and the butoxy ethoxy propanol ester, all of these in oil-water carriers. For late-season use, the most promising chemical is the butoxy ethanol ester formulated for an oil carrier. Oil-water treatments would probably be effective from late May through July;

but in August the oil carrier should be used. For most Virginia pine stands, 2 pounds of acid in 4 or 5 gallons of spray per acre will probably be adequate. Again, extreme care should be taken to avoid drift damage outside of the treated area (Little 1963b). And in view of the density of Virginia pine stands, treatments might have to be made with back-pack rather than tractor-mounted machines.

These recommendations on the use of mistblowers for controlling competing vegetation by release or conditioning treatments still need to be tested in southern Maryland; but, although tentative, they are unquestionably more appropriate than any suggestions based upon the early manual and chemical treatments used in the Beltsville studies.

## TREATING IMMATURE STANDS

### *Thinning*

According to the limited available information, thinnings in Virginia pine stands appear to hold some promise only when restricted to relatively young stands and when sufficient numbers of trainers are retained. This deduction is based in part on a study established in the Cedarville Forest in 1938, which involved reductions in stand density of 50 to 75 percent in 15-, 25-, and 30-year-old pure Virginia pine stands. In the first 10 years, Rushmore[5] found that:

- The three age classes showed about equal responses in radial growth, and the radial growth of released crop trees was greater than that of non-released crop trees as shown below:

| *Stand age (years)* | *10-year radial growth (inches at breast height)* | | |
|---|---|---|---|
| | *Released trees* | *Unreleased trees* | *Difference* |
| 15 | 1.10 | 0.70 | 0.40 |
| 25 | .85 | .50 | .35 |
| 30 | .70 | .30 | .40 |

- A heavy glaze storm caused fewer losses among the older crop trees in treatments where trainers had been left than where no trainers were saved.

Rushmore also concluded that heavy thinnings stimulated the growth of the hardwood understory (fig. 14).

Two later thinning studies were established in 7- and 17-year-old Virginia pine stands at Cedarville; in both, the thinning treat-

[5] Rushmore, F. M. Thinning Virginia pine in Maryland — a 10-year experience. 1949. (Unpublished report, Northeast. Forest Expt. Sta.)

Figure 14. — Heavy thinnings in young Virginia pine stands will stimulate growth of a hardwood understory: Above, a pole-sized stand after thinning to 800 stems per acre. Below, the same view after 5 growing seasons.

ment reduced the number of stems to 900 per acre from 9,000 and 2,700 stems, respectively. Results in the first 5 years were as follows:

- Stimulation of diameter growth was the same in both age classes:

| Age (years) | 5-year d.b.h. growth (inches) Released crop trees | Unreleased crop trees | Difference |
|---|---|---|---|
| 7 | 1.6 | 1.2 | 0.4 |
| 17 | 1.0 | .6 | .4 |

- While relatively few of the crop trees released at 7 years were lost to wind, ice, and snow, losses among those in the 17-year-old stand amounted to 20 percent in the 5-year period. Hence, basal-area growth of crop trees per acre in the 17-year-old stand was almost the same for the released and unreleased stems. In contrast, the basal-area increase of crop trees per acre in the 7-year-old stand was 21 percent greater for the released stems than for the unreleased stems.

At present it seems inadvisable to recommend thinnings in Virginia pine stands for these reasons:

- While commercial thinnings might be feasible in 20- to 30-year-old stands, the growth per acre of residual crop trees in such stands is often negligible because of losses from wind, snow, or ice.
- Although thinning in young noncommercial stands should produce an appreciable crop-tree response and result in little wind, snow, or ice damage, the effect of such a thinning on final yields is not known. Hence the investment in non-commerical thinning is of questionable value.

## *Pruning*

Because Virginia pine retains its dead branches for an extremely long period (fig. 15), artificial pruning has sometimes been suggested for crop trees of this species.

In one study, Williamson (1953) determined the effects on diameter and height growth of removing about 38 percent of the

Figure 15. — Virginia pine typically has many persistent limbs. To produce clear wood, artificial pruning is necessary.

live crown of 9-year-old crop trees of Virginia pine. The four tested treatments consisted of pruning to about 8 feet above ground, release by light thinning, a combination of pruning and release, and a control. His results were as follows:

| *Treatment* | *5-year growth* | |
|---|---|---|
| | *D.b.h. (inches)* | *Height (feet)* |
| None | 1.4 | 10.9 |
| Pruned | 1.2 | 10.8 |
| Released | 1.9 | 11.0 |
| Pruned and released | 1.7 | 10.8 |

As might be expected, the thinning stimulated diameter growth, while pruning slightly reduced it. Neither treatment had any appreciable effect on height growth.

A more radical type of pruning, bud-pruning, has also been tried on Virginia pine with poor results. Because this method prevented the development of branches, it reduced diameter growth by 60 percent and height growth by 25 percent. It also caused severe crook or sweep in 52 percent more of the pruned trees than of the unpruned. Consequently, bud-pruning of Virginia pine is not recommended (Sucoff 1963).

In fact, it is doubtful whether any pruning of Virginia pine is justified. If the species is grown for pulpwood, pruning is obviously not needed. And if sawtimber is the desired product, conversion of Virginia pine stands at the end of the rotation to other species will probably pay greater dividends than pruning.

## CONVERSION TO OTHER PINES

The associated pine species are more desirable for sawtimber than Virginia pine. Loblolly and shortleaf pines in particular, as well as pitch and pond pines in fairly dense stands, develop much longer clear lengths than Virginia pine. These associated species also grow to greater ages and — especially loblolly and shortleaf — to greater diameters as well with smaller losses due to heart rot than Virginia pine.

Height growth of Virginia pine is comparable to that of shortleaf, pitch, or pond pines on most sites; but Virginia pines are usually 10 to 15 feet shorter than loblolly at 50 years. Only on the poorest soils, where the site index for loblolly is less than 60 feet, does Virginia pine grow as rapidly in height as loblolly pine. Examples of this are the Croom and Aura soils, which have gravelly compacted substrata. Soils more suited to loblolly pine include Sunnyside, Caroline, Lakeland, Galestown, and coarse-textured Sassafras. On these, loblolly usually has a site index of 75 to 85 feet.

So, the replacement of Virginia pine with loblolly pine seems desirable in much of southern Maryland. Though the conversion would be especially desirable for the production of piling and sawtimber, even pulpwood production might be improved. In North Carolina, Miller (1954) found that loblolly pine stands were growing 117 cubic feet per acre annually compared to 92 cubic feet for Virginia pine stands on comparable sites. Observations in southern Maryland indicate that similar differences occur there.

Actual conversion methods will vary with stand conditions. In areas lacking a loblolly pine seed source, the common method is to plant 600 to 800 loblolly pine seedlings per acre the first winter or spring after existing overstories are cut (fig. 16). Where loblolly pines of cone-bearing size occur, their retention as seed trees, along with removal of the Virginia pines, will increase the propor-

Figure 16.—Loblolly pines (1-0) were planted about 8 feet apart in this clearcut patch of a pine-hardwood stand at Beltsville. After three growing seasons, some of the loblolly pines were more than 8 feet tall.

tion of loblolly pine in the reproduction. Total elimination of Virginia pine is not recommended, but the conversion operation should provide a sufficient number of loblolly pines to dominate the next stand.

The extent to which loblolly pine should be favored in the upper portions of Prince Georges and Anne Arundel Counties is questionable. On some sites, loblolly pine might possibly suffer so much repeated winter injury that its long-term growth could be reduced almost to that of Virginia and shortleaf pines. However, some of the loblolly plantations in these two counties appear promising: one 30-year-old plantation in upper Anne Arundel County has dominant trees 12 to 14 inches d.b.h. and 70 to 78 feet tall; another 50-year-old plantation near Bowie, Prince Georges County, has dominant stems of similar diameters and 71 to 84 feet tall.

White pine offers great promise as an alternative species in the upper portions of the 5-county area — from the Cedarville Forest to the Piedmont. The occasional white pine plantations established so far in that area have shown good growth. For example, one 30-year-old plantation in the Cedarville Forest has 233 stems per acre; these stems average 12.5 inches in diameter and 60 feet in height. A comparison of dominant stems among this white pine plantation, an adjacent plantation of loblolly pine, and an adjoining natural stand of Virginia pine — all on similar soils — is given below:

| *Stand* | *Age of stand (years)* | *D.b.h. (inches)* | *Height (feet)* |
|---|---|---|---|
| White pine | 30 | 14-16 | 69-78 |
| Loblolly pine | 28 | 10-12 | 66-76 |
| Virginia pine | 45 | 9-11 | 62-71 |

Although white pine in upper southern Maryland compares favorably with loblolly pine, extensive plantings are not recommended at the present time. In the first place, too little is known about the growth of planted white pine in relation to site factors and about possible disease or insect problems that may arise. Then, too, white pine's growth in the first 3 to 5 years after planting is slow; and wherever a Virginia pine seed source is nearby, the planted white pines will need release from overtopping Virginia pine reproduction. In contrast, loblolly pine can usually compete successfully with volunteer Virginia pine reproduction, so investment costs for release are not necessary.

## SUMMARY: SILVICULTURE

To reproduce Virginia pine, cuttings that create even-aged stands are essential. Alternate-strip cuttings have been successful in the Cedarville State Forest, where seed trees were used to regenerate the final strips, and partly successful at Beltsville. Seed-tree cuttings have been uniformly successful; and in extensive stands, some type of progressive strip cutting is a promising alternative.

Under any method of cutting, seedbed preparation is essential for adequate reproduction. To date, the broadcast burning of slash prior to seedfall has proved to be the most effective and feasible method.

Another necessary step is the control of competing hardwoods. Recommended methods are injector treatments of large, individual trees and mistblower treatments of small stems. While the latter may be applied for selective release in the reproduction stage, conditioning treatments before the harvest cutting seem even more desirable.

At present, thinning and pruning are not recommended for Virginia pine stands. Thinning, although it produces some growth response in fairly young stands, is of unproven long-term value. Pruning is of little benefit in pulpwood production; and for sawtimber production, conversion to other species appears to be a more promising alternative.

Many Virginia pine sites in southern Maryland should be converted to loblolly pine, which grows faster and produces higher-quality piling and sawtimber than Virginia pine. In the upper counties of southern Maryland, some conversion of Virginia pine stands to white pine also seems highly desirable although large-scale plantings of white pine are not recommended at present.

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