Liriodendron tulipifera L. Yellow-Poplar

Magnoliaceae Magnolia family

Donald E. Beck

Yellow-poplar *(Liriodendron tulipiferct),* also called tuliptree, tulip-poplar, white-poplar, and whitewood, is one of the most attractive and tallest of eastern hardwoods. It is fast growing and may reach 300 years of age on deep, rich, well-drained soils of forest coves and lower mountain slopes. The wood has high commercial value because of its versatility and as a substitute for increasingly scarce softwoods in furniture and framing construction. Yellow-poplar is also valued as a honey tree, a source of wildlife food, and a shade tree for large areas.

Habitat

Native Range

Yellow-poplar (figs. 1, 2) grows throughout the Eastern United States from southern New England, west through southern Ontario and Michigan, south to Louisiana, then east to north-central Florida (22). It is most abundant and reaches its largest size in the valley of the Ohio River and on the mountain slopes of North Carolina, Tennessee, Kentucky, and West Virginia. The Appalachian Mountains and adjacent Piedmont running south from Pennsylvania to Georgia contained 75 percent of all yellow-poplar growing stock in 1974.

Climate

Because of its wide geographic distribution, yellow-poplar grows under a variety of climatic conditions. Low temperature extremes vary from severe winters in southern New England and upper New York with a mean January temperature of -7.2” C (19” F) to almost frost-free winters in central Florida with a mean January temperature of 16.1” C (61” F). Average July temperature varies from 20.6” C (69° F) in the northern part of the range to 27.2” C (81° F) in the southern. Rainfall in the range of yellow-poplar varies from 760 mm (30 in) to more than 2030 mm (80 in) in some areas of the southern Appalachians. Average number of frost-free days varies from 150 to more than 310 days within the north-to-south range of yellow-poplar.

Effects of temperature and moisture extremes are tempered somewhat by local topography At the northern end of its range, yellow-poplar is usually found in valleys and stream bottoms at elevations below 300 m (1,000 ft). In the southern Appalachians, it may grow on a variety of sites, including stream bottoms, coves, and moist slopes up to an elevation of about 1370 m (4,500 ft). Toward the southern limit of the range, where high temperatures and soil moisture probably become limiting, the species usually is confined to moist, but well-drained, stream bottoms. Optimum development of yellow-poplar occurs where rainfall is well distributed over a long growing season.

Soils and Topography

Yellow-poplar thrives on many soil types with various physical properties, chemical composition, and parent material. Within the major portion of the range of yellow-poplar, these soils fall in soil orders Inceptisols and Ultisols. Exceptionally good growth has been observed on alluvial soils bordering streams, on loam soils of mountain coves, on talus slopes below cliffs and bluffs, and on well-watered, gravelly soils. In general, where yellow-poplar grows naturally and well, the soils are moderately moist, well drained, and loose textured; it rarely does well in very wet or very dry situations.

Studies in locations as varied as the Coastal Plain of New Jersey, the Central States, the Great Appalachian Valley, the Carolina and Virginia Piedmonts, the Cumberland Plateau, and the mountains of north Georgia have isolated soil features that measure effective rooting depth and moisture-supplying capacity as the most important determinants of growth *(13, 18, 25, 30, 35).* These variables have been expressed in quantitative terms such as relative content of sand, silt, and clay; depth of humus accumulation; organic matter content of different horizons of the soil profile; percent moisture retention; available water; and depth to impermeable layers.

The same studies also stressed that topographic features plus latitude and elevation, which partially determine the amount of incoming solar radiation and rate of evaporation or otherwise influence the moisture supplying capacity of soil, are important variables in assessing site suitability for yellow-poplar growth. The best growth usually occurs on north and east aspects, on lower slopes, in sheltered coves, and on gentle, concave slopes.

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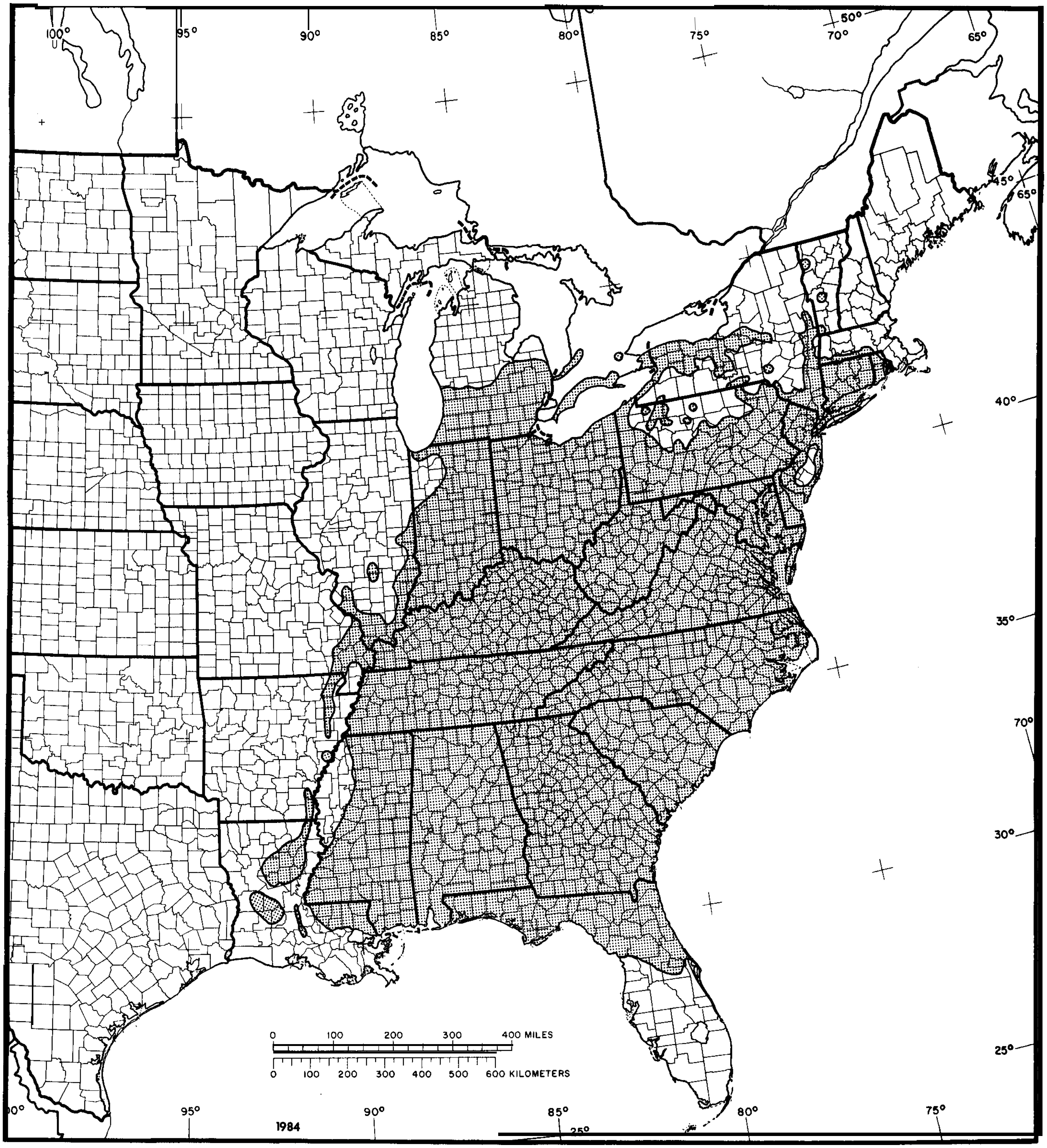

Figure 1-The native range of yellow-poplar.

Figure 2—*Open-grown yellow-poplar.*

Low levels of soil nutrients-most frequently nitrogen-have occasionally been linked to slow rates of growth for yellow-poplar. Also, naturally occurring levels of phosphorous and potassium can limit growth. However, soil physical properties far overshadow chemical properties in determining distribution and growth of yellow-poplar.

Associated Forest Cover

Yellow-poplar is a major species in four forest cover types (Society of American Foresters) (14): Yellow-Poplar (Type 57), Yellow-Poplar-Eastern Hemlock (Type 58), Yellow-Poplar-White Oak-Northern Red Oak (Type 59), and Sweetgum-Yellow-Poplar (Type 87). It is a minor species in 11 types: Eastern White Pine (Type 21), White Pine-Hemlock (Type 22), White Pine-Chestnut Oak (Type 51), White Oak-Black Oak-Northern Red Oak (Type 52), White Oak (Type 53), Northern Red Oak (Type 55), Beech-Sugar Maple (Type 60), Sassafras-Persimmon (Type 64), Loblolly Pine (Type 81), Loblolly Pine-Hardwood (Type 82), and Swamp Chestnut Oak-Cherrybark Oak (Type 91).

On bottom lands and on the better drained soils of the Coastal Plain, yellow-poplar grows in mixture with the tupelos *(Nyssa* spp.), baldcypress *(Taxodium distichum),* oaks *(Quercus* spp.), red maple *(Acer rubrum)*, sweetgum *(Liquidambar styraciflua)*, and loblolly pine *(Pinus taeda).* In the Piedmont, associated species include oaks, sweetgum, blackgum *(Nyssa sylvatica)*, red maple, loblolly pine, shortleaf pine *(Pinus echinata),* Virginia pine *(P. virginiana),* hickories *(Carya* spp.), flowering dogwood *(Cornus florida)*, sour-wood *(Oxydendrum arboreum),* and redcedar *(Juniperus virginiana).*

At lower elevations in the Appalachian Mountains, yellow-poplar (fig. 3) is found with black locust *(Robinia pseudoacacia),* white pine *(Pinus strobus),* eastern hemlock *(Tsuga canadensis)*, hickories, white oak *(Quercus alba)*, other oaks, black walnut *(Juglans nigra),* yellow pines, flowering dogwood, sourwood, sweet birch *(Betula lenta)*, blackgum, basswood *(Tilia americana),* and Carolina silverbell *(Halesia Carolina).* At higher elevations, associated species include northern red oak *(Quercus rubra),* white ash *(Fraxinus americana),* black cherry *(Prunus serotina),* cucumber tree *(Magnolia acuminata)*, yellow buckeye *(Aesculus octandra),* American beech *(Fagus grandifolia),* sugar maple *(Acer saccharum),* and yellow birch *(Betula alleghaniensis).* Trees associated with yellow-poplar in nonmountainous areas of the North and Midwest include white oak, black oak *(Quercus velutina)*, northern red oak, ash, beech, sugar maple, blackgum, dogwood, and hickories.

Pure stands of yellow-poplar occupy only a small percentage of the total land within the range of the species, but they are usually on productive sites that include some of the most valuable timber-producing forests in eastern North America. It has been repeatedly observed in the southern Appalachians that the percentage of yellow-poplar increases noticeably with increasing quality of the site. Where yellow-poplar grows in pure, or nearly pure, stands on medium and lower quality sites, it probably originated on abandoned old fields.

Life History

Reproduction and Early Growth

Flowering and Fruiting-Yellow-poplar has a singly occurring, perfect flower 4 to 5 cm wide (1.5 to 2 in), with six petals varying in color from a light yellowish green at the margin to a deep orange band

Figure *3-Even-aged stand* ***of*** *yellow-poplar with some hickory on Nantahala National Forest, NC.*

at the center. Yellow-poplars usually produce their first flowers at 15 to 20 years of age and may continue production for 200 years ***(29,311.*** Flowering occurs from April to June depending on location and weather conditions. The flowering period for each tree varies from 2 to 6 weeks depending on the size and age of the tree and number of flowers per tree. Pollination must occur soon after the flowers open while the stigmas are light colored and succulent; brown stigmas are no longer receptive to pollen. Normally the receptive period is only 12 to 24 daylight hours. Insects are important pollinators; flies, beetles, honey bees, and bumble bees (in decreasing order of abundance) were observed on opened flowers. However, uncontrolled insect pollinations do not result in effective pollination of all stigmas, and a great deal of selfing occurs (7). Higher percentages of filled seed result from cross-pollination and crosses among widely separated trees (37). By controlled cross-pollination, as many as 90-percent filled seed per cone was obtained; the highest percentage for an open-pollinated tree was 35 percent. Cross-pollinated seedlings tended to be more vigorous than seedlings obtained from open pollination.

Seed Production and Dissemination-The conelike aggregate of many winged carpels ripens and matures from early August in the North to late October in the South. In the Piedmont of North Carolina, seedfall begins in mid-October and reaches its peak early in November. High seedfall occurs during dry periods with high temperatures, while periods of heavy rainfall result in low seed dissemination rates. Viable seed is disseminated from mid-October to mid-March; the percentage of viability, which ranges from 5 to 20 percent, is about equal throughout the period.

Yellow-poplar is a prolific seeder, and large crops are produced almost annually *(29,31).* In North Carolina, a 25-cm (10-in) tree produced 750 cones with 7,500 sound seeds, and a 51-cm (20-m) tree produced 3,250 cones with 29,000 sound seeds. A seedfall of 741,000 to 1,482,000/ha (300,000 to 600,000/acre) is not uncommon. Measurement of the **1966** seed crop in 19 southern Appalachian stands showed an average of 3.7 million seeds per hectare (1.5 million/acre). Seed size is highly variable, the number per kilogram ranging from 11,000 to 40,000 (5,000 to 18,000/lb). In general, southern seeds are larger than northern ones.

The individual, winged samaras may be scattered by the wind to distances equal to four or five times the height of a tree. In southern Indiana, a seedfall pattern was shown to be oval, with the center north of the seed tree. Prevailing south and southwest winds occasionally carried seeds more than 183 m (600 ft). Distribution of filled seeds occurred in satisfactory numbers-2,470 to 24,700/ha (1,000 to 10,000/acre)—as far as 60 m (200 ft) from a good seed tree in the direction of the prevailing wind and 30 m (100 ft) in all other directions.

Yellow-poplar seeds retain their viability in the forest floor from 4 to 7 years *(11).* Large quantities of seeds in the forest floor are capable of producing seedlings when suitable environmental conditions exist. In West Virginia, a study in three 40-year-old stands with 101 to 470 yellow-poplar trees per hectare (41 to 190/acre) showed from 240,000 to 475,000 sound seeds per hectare (97,000 to 192,000/acre) in the forest floor *(17).* These seeds produced between 138,000 to 190,000 seedlings per hectare (56,000 to 77,000/acre) when transferred to an open area and kept well watered.

Seedling Development-Yellow-poplar seeds must overwinter under natural conditions, or be stratified under controlled conditions, to overcome dormancy. Under controlled conditions, stratification in moist sand within a temperature range of 0" to 10° C (32" to 50" F) for periods of 70 to 90 days resulted in satisfactory germination. However, seedling yield increases with increasing time of stratification. Germination is epigeal.

Germinating yellow-poplar seedlings need a suitable seedbed and adequate moisture to survive and become established. Seed germination and seedling development is better on mineral soils or well-decomposed organic matter than on a thick, undecomposed litter layer.

Scarification and fires, which put seeds in contact with mineral soil, increases the number of seedlings established significantly *(10,331.* Under normal conditions, however, the site disturbance caused by logging the mature stand is the only seedbed preparation needed to provide enough yellow-poplar seedlings for a new stand. In Indiana, 1 year after cutting, there were 9,900 yellow-poplar seedlings per hectare (4,000/acre) on a plot that was clearcut, and 12,000/ha (4,800/acre) on partially cut plots. In western North Carolina, more than 124,000 seedlings/ha (50,000/acre) followed both clearcuts and partial cuts that removed as little as one-third the basal area (26). On occasional sites, deep accumulations of litter may require some seedbed treatment, particularly on the drier sites dominated by oaks or beech, and both disking and burning have proven effective. These treatments have also been recommended for sites with few seeds in the forest floor, especially if the site is covered with dense herbaceous growth.

Yellow-poplar seedlings reach maximum or near-maximum photosynthetic efficiency at relatively low light intensities, as low as 3 to 10 percent of full sunlight *(29,31).* Growth was poor, however, under an overstory canopy where the amount of sunlight reaching the forest floor was limited to 1.33 percent; where herbaceous cover existed, it was only 0.13 percent. Sufficient sunlight can be admitted by various cutting practices. Harvest cuts ranging from removal of 30 percent of basal area to complete clearcuts have resulted in establishment and growth of large. numbers of seedlings. Clearcutting, seed-tree cutting, and shelterwood cutting have all been used successfully to regenerate yellow-poplar *(26,28,38,45).* However, when partial cuts such as shelterwood are used, height growth is severely limited by the overstory. Seedlings in clearcuts may be two to three times taller than seedlings under a shelterwood after the first 5 to 10 years.

The minimum size opening that can be used to regenerate yellow-poplar is fairly small *(10).* Numbers of seedlings per hectare vary little in openings of 0.12 to 12.36 ha (0.05 to 5 acres). Opening size, however, does affect growth significantly. Both diameter and height are retarded in openings smaller than 1.24 to 2.47 ha (0.5 to 1 acre).

Season of logging, though not of critical importance, does have some effect on establishment and growth of yellow-poplar seedlings *(40).* In West Virginia, Ohio, and Indiana, summer logging produced fewer seedlings than logging at other times of the year. Apparently, in summer-logged stands most of the seeds did not germinate until the following year, and these small seedlings were not as well able to compete with the rank vegetation that started the previous year. Nevertheless, cuttings in summer months usually have produced sufficient seedlings where a good seed source previously was present. If seed supply is expected to be scarce, logging in fall, winter, or early spring might be advisable.

After germination, several critical years follow. During this period sufficient soil moisture must be available, good drainage and protection against drying and frost heaving are necessary, and there must be no severe competition from nearby sprout growth. In a study in which various mulches were used to induce soil temperature variation, seedlings grew faster in warm soil than in cool soil. Soil temperatures as high as 36.1" C (97" F) had a beneficial effect on seedling growth. Yellow-poplar seedlings normally survive dormant-season flooding, but it was found that l-year-old seedlings were usually killed by 4 days or more of flooding during the growing season (23). This vulnerability during the growing season explains why yellow-poplar does not grow on flood plains of rivers that flood periodically for several days at a time. After the first growing season, vegetative competition may become the most important factor affecting survival and growth. Reducing competition by cutting, burning, disking, or by using herbicides may be needed to assure success.

On favorable sites the success of regeneration can usually be determined by the size and vigor of the seedlings at the end of the third year. Height growth during the first year ranges from a few centimeters to more than 0.3 m (1 ft) on the best sites. With full light, rapid height growth begins the second year, and at the end of 5 years trees may be 3 to 5.5 m (10 to 18 ft) tall. During its seedling and sapling stages, yellow-poplar is capable of making extremely rapid growth. An ll-year-old natural seedling 15.2 m (50 ft) tall has been recorded.

The behavior and duration of height growth of yellow-poplar vary by latitude. In a Pennsylvania study, seedlings had a 95-day height-growth period beginning late in April and ending about August 1. A sharp peak in height growth was reached about June 1. In a northwestern Connecticut study, yellow-poplar had a 110-day height-growth period beginning in late April and ending in mid-August. Ninety percent of this growth took place in a 60-day period from May 20 to July 20, and a sharp peak in height growth was noted in the middle of June. In a study conducted in the lower Piedmont of North Carolina, yellow-poplar had a 160-day height-growth period beginning in early April and ending about the middle of September. Growth was fairly constant, and there was no peak in growth rate during the growing season.

Vegetative Reproduction-Yellow-poplar sprouts arise chiefly from preexisting dormant buds situated near the base of dead or dying stems, or near the soil line on stumps. Sprouts may occur as high as 30 to 38 cm (12 to 15 in) on high stumps, but more than 80 percent arise at or below the soil line (44). The percentage of stumps sprouting and the number of sprouts per stump decrease with increasing stump size. Stumps as large as 66 to 76 cm (26 to 30 in) sprouted 40 percent of the time, however, with an average of eight sprouts per stump. Yellow-poplar of the age and size harvested in second-growth stands sprouts prolifically.

Trees of sprout origin are more subject to butt rot than those of seedling origin (42). Nevertheless, a high percentage of stumps that sprout produce at least one stem that is well anchored, vigorous, and of desirable quality for crop-tree development (20). In this respect, position on stump is important to subsequent development. Sprouts arising from roots or from the stump below groundline usually lack a heartwood connection with the stump heartwood because the roots and below-ground portions of the stump do not normally contain heartwood. Sapwood tissues separating heartwood columns of stumps and sprouts may prevent heart rot fungi, which enters the stump heartwood, from spreading to the heartwood of the sprout.

The initial growth rate of yellow-poplar sprouts far exceeds that of young seedlings. In western North Carolina, the dominant sprout on each of 60 stumps on a good site grew an average of 1.4 m (4.7 ft) per year over the first 6 years (2). At age 24, these sprouts averaged 24.4 m (80 ft) in height and 24 cm (9.6 in) d.b.h. In West Virginia, the dominant stem of each sprout clump grew at the rate of 0.9 m (2.9 ft) per year for 11 years on a medium-quality site for yellow-poplar (44). The rapid, early growth rate begins to drop off markedly somewhere between 20 and 30 years. At this time, seedlings of similar age may catch up and exceed sprouts in rate of height growth.

A number of investigators have attempted to root yellow-poplar cuttings, but most early attempts were not successful. In a more recent study, cuttings were rooted successfully after they were dipped in dolebutyric acid and a mist of water was sprayed over the propagation bed (6). It is not known, however, whether these rooted cuttings would have successfully survived outplanting. Yellow-poplar has been successfully rooted from stump sprouts of 7-year-old trees; soft-tissue cuttings placed in a mist bed began rooting in 4 weeks and successfully survived transplanting. A system of splitting seedlings longitudinally and then propagating the halves was also highly successful. However, splitting seedlings provides only one additional new plant from the ortet, while rooting stump sprouts provides several.

A technique for propagating yellow-poplar by making use of its epicormic branching ability has recently been described (24). Partial girdling into the outer one or two annual rings results in a profusion of epicormic sprouts that can then be rooted in the same way as stump sprouts. This method has the advantage of preserving the selected ortet for repeated use. Experience with this method, however, reveals that not every girdled tree will sprout well. Young trees and trees with low vigor are better sprouters than old trees and rapidly growing trees.

Sapling and Pole Stages to Maturity

Growth and Yield-The mature yellow-poplar has a striking appearance. In forest stands its trunk is very straight, tall, and clear of lateral branches for a considerable height. It is among the tallest of all Eastern United States broadleaf trees. On the best sites, old-growth trees may be nearly 61 m (200 ft) high and 2.4 to 3.7 m (8 to 12 ft) d.b.h., but more often they are from 30.5 to 45.7 m (100 to 150 ft) at

Table 1-Height and d.b.h. of dominant yellow-poplar trees in unthinned stands, by site index *(1,3)*[1]

	Site index					
	25 m or 82 ft		30 m or 98 ft		35 m or 125 ft	
Age	Height	D.b.h.	Height	D.b.h.	Height	D.b.h.
yr	*m*	*cm*	*m*	*cm*	*m*	*cm*
20	13.4	17	15.8	21	18.6	25
30	18.9	25	22.6	30	26.5	36
40	22.6	30	27.1	37	31.4	43
50	25.0	34	29.9	41	35.1	48
60	26.8	37	32.3	44	37.5	52
70	28.3	39	33.8	46	39.6	55
80	29.3	40	35.1	49	41.1	57
90	30.2	41	36.3	50	42.1	59
100	30.8	42	36.9	51	43.3	60
yr	*ft*	*in*	*ft*	*in*	*ft*	*in*
20	44	6.7	52	8.2	61	9.8
30	62	9.9	74	12.0	87	14.2
40	74	12.0	89	14.5	103	17.0
50	82	13.4	98	16.2	115	19.0
60	88	14.4	106	17.4	123	20.4
70	93	15.2	111	18.3	130	21.6
80	96	15.8	115	19.1	135	22.4
90	99	16.3	119	19.7	138	23.1
100	101	16.7	121	20.2	142	23.7

'Based upon the average height and d.b.h. of the 62 largest trees per hectare (25/acre).

maturity, with a straight trunk 0.6 to 1.5 m (2 to 5 ft) in diameter. Age at natural death is usually about **200** to 250 years. However, some trees may live up to 300 years.

Height and d.b.h. expected of the 25 largest trees per acre in unthinned second-growth southern Appalachian stands are shown in table 1. These data represent an average dominant tree grown under fully stocked stand conditions. The largest trees would be 7.6 to 12.7 cm (3 to 5 in) larger than the average dominant at comparable ages. Table 2 shows selected empirical yields for natural stands *(3,27)*. Mean annual increment in total cubic volume ranges from 5.2 to 11.6 m^3/ha (75 to 165 ft^3/acre), depending on site, at culmination around 70 years of age.

Rooting Habit-Yellow-poplar has a rapidly growing and deeply penetrating juvenile taproot, as well as many strongly developed and wide-spreading lateral roots. It is considered to have a "flexible" rooting habit, even in the juvenile stage.

Reaction to Competition-Although classed as intolerant of shade, yellow-poplar can overcome much competition because it produces numerous seedlings and sprouts, and grows very rapidly. On land of site index 23 m (75 ft) and higher in the southern Appalachians, yellow-poplar has faster height growth than any of its associates except white pine up to 50 years of age (29). If not overtopped, yellow-poplar takes and holds its place in the dominant crown canopy of the developing stand.

Table 2-Empirical yields for unthinned yellow-poplar stands in the southern Appalachians'

Basal area	Volume by age class in years[2]				
	20	30	40	50	80
m²/ha	*m³/ha*				
	Site index 25 m				
15	68	94	110	121	129
25	150	207	243	267	285
35	253	348	409	450	480
	Site index 30 m				
15	82	113	132	146	155
25	181	249	292	321	342
35	304	418	491	540	576
	Site index 35 m				
15	93	129	151	166	177
25	206	283	332	366	390
35	346	477	559	618	656
ft²/acre	*ft³/acre*				
	Site index 82 ft				
65	974	1,341	1,574	1,732	1,847
109	2,147	2,956	3,469	3,818	4,070
152	3,614	4,976	5,839	6,427	6,851
	Site index 98 ft				
65	1,170	1,611	1,890	2,080	2,218
109	2,579	3,551	4,166	4,586	4,889
152	4,341	5,976	7,012	7,718	8,228
	Site index 115 ft				
65	1,333	1,836	2,154	2,371	2,528
109	2,939	4,047	4,749	5,227	5,572
152	4,947	6,812	7,992	8,797	9,378

'All trees 13 cm (5 in) and larger in d.b.h.
'Volume includes wood and bark of the entire bole.

It is often a pioneer on abandoned old fields or clearcut land and may form essentially pure stands on very good sites. More often it regenerates as a mixed type with other species, and it commonly persists in old-growth stands as scattered individuals.

Yellow-poplar expresses dominance well and seldom, if ever, stagnates because of excessive stand density. It prunes very well in closed stands. Although it produces epicormic sprouts when the bole is exposed, this trait is less pronounced than in many other hardwood species. Because of these growth characteristics, yellow-poplar stands can develop and produce considerable quantities of large, high-quality products with no intermediate stand management.

In the seedling-sapling stage, dominant and codominant trees are little affected by thinning or cleaning *(21,39)*. Intermediate or overtopped trees of good vigor respond to release in both diameter and height growth (46). Cultural treatment of seedling-sapling stands is seldom needed or justified, however, except to remove vines *(12)*.

By the time stands reach pole size at 20 to 30 years of age, the peak rates of growth and mortality are past and the crown canopy is closed. Crown size on surviving trees is reduced and diameter growth is considerably slowed. Thinnings that salvage or prevent mortality, increase the growth of residual trees, shorten rotations, and increase the yield of high-value timber products are the essence of intermediate stand management. The net result of numerous thinning experiments is that individual yellow-poplar trees tend to use the space and accelerate diameter increment *(4,5,9,29)*. Response occurs across a wide range of sites and stand ages, even in stands as old as 80 years that have never been thinned previously. Total cubic-volume growth is greatest at the highest densities and would be maximized by very light, frequent thinnings that prevent or salvage mortality. On the other hand, board-foot volume growth is maximum at densities well below those that maximize cubic-foot volume growth. Board-foot growth is near maximum over a wide range of density. Thus, there is considerable leeway to manipulate stocking levels to achieve diameter growth and quality goals without sacrificing volume growth of the high-value products.

Damaging Agents-Yellow-poplar is unusually free from damage by pests compared with many other commercially important species. While more than 30 species of insects attack yellow-poplar, only 4 species are considered to have significant economic impact (8). The tuliptree scale *(Toumeyella liriodendri)* causes loss of vigor by removing large quantities of phloem sap. Scale attacks often kill leaders of seedlings and saplings causing them to be overtopped by competitors. The yellow-poplar weevil *(Odontopus calceatus)* feeds on buds and foliage and may occur in outbreaks over large areas. The root-collar borer *(Euzophera ostricolorella)* attacks the phloem tissue at the base of the tree and provides entry points for rots and other pathogens. Attacks by the Columbian timber beetle *(Corthylus columbianus)* do not kill the tree but may degrade the wood. The defect consists of black-stained burrows and discolored wood called "calico poplar."

Fire scars, logging damage, animal and bird damage, top breakage, dying limbs, and decaying parent stumps all provide entry for decay-causing fungi (16). Probably the most common type of decay associated with basal wounding and decaying stumps is a soft, spongy, white or gray rot caused by the fungus ***Armillaria mellea***. A white heartwood rot caused by ***Collybia velutipes*** often is associated with top breakage and dying limbs. Species of the genus ***Nectria*** have been associated with stem cankers. Incidence of this disease and mortality from it was greatest on low-vigor trees.

A canker caused by ***Fusarium solani*** was isolated from large yellow-poplars in Ohio and was shown to cause characteristic cankers through pathogenicity studies. Some mortality results during periods of drought, but *F. solani* apparently is not a virulent pathogen and causes damage only when the host is weakened by unfavorable environmental factors.

Dieback and associated stem canker of yellow-poplar saplings were reported to have resulted in considerable mortality in some stands. A fungus of the genus ***Myxosporium*** was associated with dead bark of infected trees and was shown to cause canker formation after experimental inoculations. Identical dieback symptoms were reported for scattered areas throughout the South. Symptoms included chlorosis of leaves, sparse crown, dieback, trunk and branch cankers, and epicormic sprouting. Several fungal species were consistently isolated from cankered trees, but there was uncertainty about the causative agent. The severity and extent of infection are greater in upland sites than in bottom-land sites. All canker-forming diseases reported for yellow-poplar appear to be confined to, or most severe on, trees that are low in vigor because of drought, poor site, or competition.

A nursery root-rot disease caused by ***Cylindrocladium scoparium*** causes root and stem lesions. It is frequently lethal in nursery beds and causes low survival and poor growth when infected seedlings are outplanted. Extensive root damage and mortality in a 27-year-old yellow-poplar plantation have been reported.

Yellow-poplar logs, especially when cut in warmer seasons, are subject to rapid deterioration because of attacks of wood-staining fungi that feed largely on the starch and sugars in the green sapwood and penetrate deeply while the wood is moist. The most common rapid-staining species is ***Ceratocystis pluriannulata.***

Yellow-poplar seedlings and saplings have thin bark and are extremely susceptible to fire damage.

Even a light ground fire is usually fatal to small stems up to 2.5 cm (1 in) in diameter. These stems resprout after fire, but repeated fires may eliminate yellow-poplar from a site. When the bark becomes thick enough to insulate the cambium (about 1.3 cm; 0.5 in), yellow-poplar becomes extremely fire resistant.

Sleet and glaze storms, which occur periodically within the range of yellow-poplar, may cause considerable damage. Stump sprouts are particularly susceptible to injury, slender trees may be broken off, and tops of dominant and codominant trees are often broken. Top damage is often the point of entry for fungi. Although yellow-poplar usually makes remarkable recovery after such storms, repeated damage can result in a growth reduction and loss of quality.

The leaves, twigs, and branches of yellow-poplar are tender and palatable to livestock and white-tailed deer, and young trees are often heavily browsed. Seedlings are grazed to the ground, small saplings are trimmed back, and even large saplings may be ridden down and severely damaged. In areas where animals are concentrated, young yellow-poplar is frequently eliminated. Rabbits also eat the bark and buds of seedlings and saplings and can be quite destructive at times.

When the sap is running in the spring, yellow-poplar is very susceptible to logging damage. If a falling tree strikes a standing poplar, there is often considerable bark loss up and down the bole of the standing tree. Even if the bark appears only lightly bruised, it may subsequently dry up and fall off in long strips.

Frost, especially in frost pockets, can affect the early growth and development of yellow-poplar. Following a late spring frost in a 20-year-old plantation, it was found that leaf mortality varied from 5 to 100 percent of the leaves on the individual trees. Leaf mortality was lowest on trees with a high foliar content of potassium. Frost may also cause bole damage in the form of shake, a separation of growth rings resulting in cull. A weather-induced defect called blister shake, related to frost shake, was described in 30-year-old yellow-poplar trees in West Virginia.

Vines can be extremely damaging to yellow-poplar. Japanese honeysuckle *(Loniceru japonica)*, kudzu *(Pueraria lobata)*, and climbing bittersweet *(Celastrus scandens)* have been known to have deleterious effects on yellow-poplar in isolated cases. However, the most widespread damage throughout the Appalachians results from wild grapevines *(Vitis* spp.) *(36,41)*, particularly on good sites that have been regenerated naturally by clearcutting. Many forest managers and researchers consider grape the most serious threat to production of high-quality yellow-poplar timber in the Appalachian region. Grapevines damage young trees by breaking limbs and tops, twisting and bending the main stem, and intercepting solar radiation. The result is reduced growth, malformation of stem and crown, and sometimes death of the trees. Grapevines also worsen winter storm damage in some areas by furnishing increased surface area for accumulation of ice and snow.

Special Uses

Yellow-poplar is an extremely versatile wood with a multitude of uses. Most important recent uses of the wood have been for lumber for unexposed furniture parts and core stock, rotary-cut veneer for use as crossbands in construction of furniture parts, in plywood for backs and interior parts, and as pulpwood. Considerable attention is being given to its use as structural framing material and for veneers in structural plywood as a substitute for increasingly scarce softwoods.

Yellow-poplar, with its shiny green leaves, distinctive flower, and statuesque appearance, is an excellent ornamental for park and garden where there is adequate space to accommodate its large size. It has distinctive value as a honey tree (25). In one season a tree less than 20 years old reportedly yields 3.6 kg (8 lb) of nectar equal to 1.8 kg (4 lb) of honey. It has nominal value as a source of wildlife food in comparison to some other species, but its seeds are eaten by quails, purple finches, rabbits, gray squirrels, and white-footed mice. Because of its greater volume per acre, which is due to its greater density and height, yellow-poplar on very good sites may produce more dry-weight yield per acre than species such as oak with much denser wood. It may have potential as a producer of wood fiber for energy and other uses.

Genetics

Population Differences

The significant variation in many traits among individual trees, among stands, and between geographic sources of yellow-poplar *(15,29,34)* is of interest to forest managers and users of wood products.

Varying degrees of genetic control have been demonstrated for wood and tree properties such as specific gravity and fiber length; straightness; branch angle; natural pruning ability; leaf, fruit, and seed characteristics; disease resistance; growth of seedlings; and length of growing season. For other important traits, such as the tendency to produce epicormic sprouts, evidence exists that the trait is strongly inherited although this has not yet been demonstrated conclusively.

A growth chamber study revealed that seedlings of northern and southern origin responded very differently to day-length treatments (43). A day length of 18 hours inhibited the northern source but not the southern. The most consistent difference among geographic seed sources has appeared in dormancy relationships. In general, the more northern sources start growth later and cease earlier than the more southern sources. Few studies are old enough to permit good comparisons of volume differences for different seed sources, but significant differences in early height growth have been reported.

While most geographic differences are associated with latitude of source, there are good indications that environmental differences associated with altitude are also important. In North Carolina, a clinal pattern of variation existed from coast to mountain for a number of seed and leaf characteristics *(19)*.

Races

At least one distinct ecotype of yellow-poplar has been confirmed. First evidence came from a plantation near Charleston, SC, where trees from a Coastal Plain source in eastern North Carolina were twice as tall 3 years after outplanting as those from a mountain source in western North Carolina (29). Later, a source from the Coastal Plain of North Carolina performed poorly in comparison to upland sources when planted at a Piedmont location but was far superior to upland sources when planted on organic soils of the Coastal Plain where pH values seldom exceed 4.0 *(19)*. Yellow-poplar of the coastal source has a distinctive leaf pattern and color-rounded lobes and copperish-red leaves. It is apparently adapted to the highly acidic, water-saturated organic soils of the Coastal Plain and is able to withstand periodic inundation without harm (32). Sources with the distinctive leaf characteristics have been found as far south as Florida.

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