The Techniques of Growing Hardwoods

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In the South, high-quality hardwoods grow on river and stream bottoms and other moist, rich sites in the Coastal Plains; true swamps; and the loess bluffs of the lower Mississippi Valley. Fine hardwoods are also produced in the mountains and the Piedmont, but these areas are not discussed in this article. Landowners and forest managers recognize that a considerable portion of the present hardwood resource exists on sites that are not the best for growing hardwoods. Primarily, such sites are found in the uplands of the Coastal Plains, well suited to pine growth.

The southern hardwoods are extremely diverse in species, sites, technical qualities, and uses. For example, certain species occur on certain sites. Some species occur in even-aged stands; most grow in mixed many-aged communities. The landowner should study the varying factors entering into hardwood management but recognize that sound judgment, experience, and professional advice can increase returns from management.

How Hardwoods Start

Hardwood stands usually reflect the varying tolerances and growth rates of the species that compose them. They also show the influences of fire and other calamities, past logging or

Above average, mixed stand of uneven-aged bottomland hardwoods along the Obion River in western Tennessee

agricultural use of the land, flooding, sedimentation, or erosion. Most stands are hodgepodges of species and age classes ranging form seedings to mature trees. But some even-aged stands are composed of hardwoods so intolerant of shade that they rarely grow in other environments. Some hardwoods, intolerant of shade but tolerant of other growing conditions, may or may not form even-aged or pure stands.
adequate advance reproduction of sapling size and desirable

Because most of the useful species are intolerant of shade, species seldom develop except in openings large enough to provide sunlight for a substantial part of the day. A few species, especially Nuttall oak, willow oak, laurel oak, and overcup oak, will germinate profusely beneath a complete canopy, but the seedlings die back to the rootcollar within three years unless they are released.

Others, such as the ashes and most oaks, germinate more or less plentifully throughout the stands, and scattered individuals or groups may develop for some years in the partial light of small openings. Without release, they dwindle away before reaching pole size. Still other species, such as the tupelos, yellow-poplar, and sweetgum, germinate sparsely and endure briefly under any closed overstory, although they may start profusely in small openings where the ground is bare and wet, and survive so long as a little top light is available.

Cottonwood and willow characteristically originate and develop in almost pure stands of even age. They require absolutely bare, muddy, mineral soil for the first few weeks of growth. They will tolerate only very limited overhead cover and then only briefly. They endure long flooding and silt deposition.

The tolerant species grow poorly under shade but persist. They develop quickly when released, thus preventing reproduction of intolerant species that may be more desirable. Nevertheless, when given an equal start in the open, more desirable intolerant species will outgrow less desirable tolerants. The more tolerant species, many of which are not favored in management, are sugarberry, mulberry, beech, dogwood, holly, magnolia, the bays, red maple, boxelder, the elms, osage-orange, persimmon, and the hickories.

Baldcypress, a coniferous species usually growing in close association with hardwood forests, often occurs in dense, even-aged stands, either pure or mixed with tupelos. Both baldcypress and tupelo will regenerate well only in swamps where seedbeds are moist, where competitors are unable to cope with flooding, and where ground cover is limited to annual herbs. Seeds will germinate even if high water persists as late as midsummer. When the trees have grown above seasonal high water, they develop rapidly with good sunlight. Some swamps exhibit tupelos in association with sweetbay, which is usually the younger component of the stand.

Even-aged stands of sweetgum often come in on old fields and other areas where mineral soil is exposed. Sweetgum seedlings can withstand heavy competition from weeds. In addition, many even-aged sweetgum stands are of sprout origin, most often from trees killed back by fires or floods.

Oaks and some other species have developed even-aged stands due to species characteristics and the forces of nature. Examples are pin oaks in wet flats where the stands originate from sprouts or where seed has been moved to a favorable position by floodwater, and yellow-poplar originating where fire or clearcutting has bared the soil for germination of seed recently cast or even stored in the litter for one to four years.

How Hardwoods are Used

The fundamentals of utilizing and marketing hardwoods fall into patterns, many unique or different from those for softwoods. The requirements of hardwood utilization profoundly affect the objectives of management and the type and intensity of forestry.

Hardwood timber products range from extremely valuable face veneers to dunnage. Beauty, hardness, and texture are sought in lumber and veneers. Most hardwood timber is initially roughsawn for ultimate use by manufacturers of products using clear wood taken from between defects in the rough-sawn stock.Another demand is growing rapidly: hardwood pulps are considered indispensable today in book, printing, and writing papers, stiff board, corrugating medium, and tissue. A small portion of hardwood timber is used for structural purposes, mainly by railroads and in local construction.

Demand for all hardwood timber is expected to increase. The U.S. Forest Service predicts that by 2000 A.D. the annual consumption of domestic hardwoods for lumber will have risen 51 percent, for veneers 189 percent, and for pulpwood 372 percent.

Table 1 summarizes the primary uses of hardwoods and may serve as a guide to planning for management. Each broad use class comprises several categories of products, and there are grades within each product category. Markets should be studied and logging coordinated to move each piece into the outlet that will return the greatest profit.

The methods and equipment for logging southern hardwoods reflect the variety of species, sites, and utilization. Because the large trees are usually the most valuable and the tops are often heavy and lopsided, skillful felling is required to avoid breakage and loss of value. Dropping a tree on a large limb can split the trunk, and improper undercutting or backsawing will pull splinters that destroy much of the value of the butt log.

Logs are usually bucked when the trees are felled, although in some localities long lengths are skidded and occasionally hauled to the mill. Common lengths are 12, 14, and 16 feet, and the expectation is to produce 40 to 50 percent of 14- and 16-foot lumber. Short bolts are the rule for pulp and chemical wood, and tree lengths for piling. Veneer, staves, and specialties may be handled as either logs or bolts.

Beginning Management

The first step in hardwood management does not differ from that in most forest land management: it is to find out what there is to work with, then plan a course of action. Once a hardwood forest area is delineated, a simple reconnaissance is all that is needed to obtain the information for beginning management. This preliminary survey may furnish enough information to tell whether a logging operation is needed or can be sustained, particularly on small properties. A diagnostic tally or inventory made especially for the purpose of sale will, however, furnish a sounder basis for establishing policies and priorities. Description of such an inventory procedure can be found in *Agriculture Handbook 181,* available from the U.S. Department of Agriculture.

Early reconnaissance should locate concentrations of especially valuable timber and open or nonproductive areas. Damage to growing stock by fire, storms, insects, and livestock, together with relative density of cull or weed trees, should also be determined.

For stands or small forests regarded as operable, a clear picture of logging and marketing conditions should be obtained. At what seasons can the stands be worked? The answer will depend upon drainage, soil conditions, and accessibility. When and how frequently do floods occur? What, if any, logging will be done by the landowner and what is best contract-logged? What markets or uses are in prospect? The answers to these questions, provided by the landowner and his

TABLE 1
Utility Classes for Southern Hardwoods[1]

Product	Primary form	Value	Minimum scaling diameter	Species	Markets
VENEERS					
Face	Logs and bolts	Highest	24 to 30 inches for slicing, 16 to 18 for turning.	Sweetgum, maples, ash, pecan, sycamore, walnut, cherry, and all but water oaks. Prime logs of other cabinet woods on occasion.	Good but widely dispersed and highly discriminating markets always available. Highest quality imperative. Very long hauls the rule.
Commercial	Logs and bolts	High to very high.	12 inches; very rarely 10.	Yellow-poplar, sweetgum, tupelos, cottonwood, sweetbay, sycamore, but occasionally also the maples, the oaks (except for water oaks), ash, soft elm, magnolia, and most other species.	Same as for face veneer but in less degree.
Package	Logs and bolts	Medium	12 inches, occasionally 10.	Most soft-textured species, but especially sweetgum, the tupelos, yellow-poplar, cottonwood, sycamore, sweetbay, and soft elm.	Concentrated in fruit- and truck-farming districts. Good where within reach. Quality generally comparable to factory lumber logs.
COOPERAGE					
Tight	Usually bolts	Medium to very high	14 inches	White oaks principally. Minor amounts of red oaks, gum, ash, and sycamore.	Widely scattered and mostly migratory. Very good if present. Highest quality material is demanded, but by short lengths. Sometimes hauled far to central plant.
Slack	Bolts and logs	Low to medium	12 inches, occasionally 10.	Principally sweetgum, soft elm, hackberry, and sycamore, but most other soft species are still used.	Few and scattered. Tend to be independent as to log supply. Use dwindling in competition with paperboard and veneer.
LUMBER					
Factory	Logs	Medium to high	12 inches; 10 for certain species, superior quality, or special cases.	Oaks, sweetgum, the tupelos, and ash are backbone of trade, but all species are taken.	Almost universal outlet for reasonably good timber. Mills accumulate logs from wide radius. Structural and local-use production incidental.
Structural	Logs	Low to medium	Generally 10 inches; special situations, 8.	Mostly oaks and gums, with minor amounts of the other firm to hard species for railroad items, etc. Most soft species may be but seldom are made into standard structural boards.	Generally available but erratic. Usually small local or migratory mills selling through jobbers and producing mill-run factory lumber, often incidentally to pine lumber.
Shipping container	Logs and bolts	Low	8 to 10 inches	Soft-textured hardwoods preferred but hard species also used.	Localized in relation to industrial or farm market, usually in conjunction with package veneer.
Local-use	Usually logs	Very low to low	About 8 inches	Anything that is mostly sound and somewhat straight.	Active but erratic in better developed agricultural and industrial areas where timber is scarce.
DIMENSION STOCK AND SPECIALTIES	Usually bolts	High to very high.	Generally 10 inches but variable with species and product—dogwood 4½ or 5 inches.	All staple species for furniture. Oaks, hickories, ash, dogwood, and persimmon for handles, vehicle and implement parts, athletic goods, textile-mill specialties, etc.	Production of furniture dimension from round timber is largely limited to Piedmont and east coast. Other specialty markets are widely scattered, mostly migratory in cycles, and often restricted to small amounts. Persimmon limited to Memphis, Tenn.
PILING	Piece	Medium to high	5 to 8 inches	Most hard or tough, firm species for either subsurface or temporary purposes. Especially baldcypress in Mississippi Valley.	Irregular, dependent on local construction, except baldcypress. Handled largely through jobbers but often directly with construction contractors.
POSTS AND PROPS	Piece	Low to medium	3 inches	Principally the oaks, but all strong, firm woods for mine props and temporary posts. Without preservative treatment only naturally durable species—Osage-orange, mulberry, baldcypress, sassafras, and white oaks—have reasonable service life.	Almost strictly local and special in mining and agricultural areas. As yet, little commercial use is made of preservatively treated hardwood posts, but an increased demand might provide an outlet for thinnings. Practically all species treat well.
CORDWOOD					
Pulpwood	Bolts	Low	4 inches; occasionally 5.	Greater demand for the soft-textured woods, principally sweetgum, the tupelos, and cottonwood. Now much oak is used at a few points and most other species used in many localities.	Volumes increasing. Handled by dealers. Often shipped great distances.
Chemicalwood	Bolts and sticks	Very low	4 inches; diameters 7 inches and larger must be split.	Principally the oaks and hickories.	Very meager. The few important users supply themselves largely from landclearing operations and improvement of their own forests.
Fuelwood	Bolts, poles, and chunks	Lowest	Variable but as low as 2 inches.	Principally oaks, hickories, and ash, but all species are used to some extent.	Although a tremendous aggregate volume is used by farmers and others, practically no commercial market exists.

[1]Putnam, J. A., Furnival, G. M., and McKnight, J. S. 1960. Management and inventory of southern hardwoods. U.S. Dep. Agr., Agr. Handbook 181, 102 pp., illus.

forester, should be clearly and systematically recorded for future reference.

Protection

All southern hardwoods are subject to the same kinds of damage. When all forest boundaries are established, a reasonable next step in management is to protect the property from fire, theft, and trespass. In this respect, managing hardwood forests is not strikingly different from managing pine, but a few differences deserve mention.

Seasonal or periodic droughts occasionally create conditions that allow hot fires to kill young trees and damage larger hardwoods on sites that are usually too moist to burn. Wounds on hardwoods provide entry for rots which advance up the main trunk at the rate of one to two feet per decade. A stand may be riddled with heart rot and still appear healthy to casual view.

It is important to eliminate fires completely. The landowner must stay alert during periods of high fire danger. Sometimes fires start in pine forests on dry sites, gain momentum, and sweep through adjoining hardwoods on wetter locations.

Hardwood lands are especially subject to pressure from hunters. Most fires started by hunters are accidental and are caused by the escape of small fires built for warmth or to smoke game out of den trees. Leasing to hunting clubs or allowing hunting by permission has helped some landowners.

Protection of hardwood forests from diseases and insects is, so far, largely a matter of prevention. Elimination of fire will greatly reduce damage by heart rots, the most costly diseases. Deadening or harvesting trees that are infested by trunk-boring insects, or whose vigor is so low that attack is likely, will probably be beneficial.

Hardwood regeneration can be threatened by uncontrolled grazing and browsing of animals. Hogs eat mast from oaks and hickories and have been known to pull up the seedlings and eat the roots. Cattle and deer nip the current season's growth on trees under five feet tall. This browsing always reduces growth, and often kills the trees. Cattle and deer seem to prefer certain species, such as sugarberry, elm, and green ash, although when food is scarce and animal stocking heavy they browse all species. Large concentrations of both cattle and hogs probably retard growth of larger trees by compacting the soil and reducing water percolation.

Too little is known about the acreage needed per animal to eliminate grazing and browsing problems on regenerating stands. The best advice at present is to control sharply, or prevent entirely, animal use. Fencing may be justified.

In wide areas of the South beavers have created nuisances by flooding wide areas of bottom land and thus drowning out good hardwood timber. If their activity is detected, the state game and fish agency should be consulted for advice on ridding the property of the animals.

Improving Abused Stands

The landowner will usually find that through the years fire, high-grading, liquidation cuts, or other destructive influences have created a forest with a high proportion of stems that are undesirable as future growing stock. Low-grade, overripe, overcrowded, damaged, or cull trees (and all classes of trees of undesirable species) will be occupying space that once supported and should again support valuable timber. The first positive step the landowner can usually take after arranging for protection is a general improvement or cleanup of his forest.

In many instances the ownership will allow, in whole or in part, a commercial improvement cutting to remove over-mature, damaged, and dying trees of salable size and quality. Some growing-stock trees may also be harvested to make stand openings for regeneration and provide enough timber so that buyers will be interested. For a cut to be profitable, commercial loggers must be able to harvest at least 600 to 800 board feet per acre.

No cutting at all is usually better than premature harvest of a large component of desirable growing stock, just to make a sale. Such cutting should always be considered only as a last resort. Unless the forest has been extremely run down by unmanaged cutting and fires, there is usually a nucleus of good growing-stock trees in groups or patches. Often such trees are producing quality growth at a relatively high rate of interest, and their presence allows the landowner at any time to take advantage of the ever-increasing stumpage prices for hardwoods.

After a cutting, cull and weed trees should be killed to create, enlarge, or clear openings for reproduction. Such trees are usually numerous in stands that have never been under management. Killing them makes room for desirable trees at small cost, and provides more growing space for trees already established.

The ax-frill and the injection method are now most commonly used for killing culls and are particularly useful where vines and understory brush are thick. With the frill method, overlapping downward chopping cuts are made on a stem as low as practicable, after which the frill is filled immediately with a 2,4,5-T ester-diesel oil mixture or 2,4,5-T amine-water mixture. Generally, a 1 to 24 mixture is used when the chemical contains 4 pounds of acid equivalent per gallon. The concentration is usually stated on the container.

Injectors give good results and require less labor than the axe and frill system. Unmetered injectors are best to apply solutions of 2,4,5-T ester in diesel fuel or 2,4,5-T amine in water. Injections should be spaced no farther apart than 2 inches. Metered injectors are best to apply undiluted 2,4-D amine in jabs spaced about 3 inches apart, as close to the

TABLE 2

Ten-year average diameter growth rates for trees free to grow in unmanaged stands on average bottomlands sites[1]

Species	Diameter Class at beginning of 10-yr. growth time			
	6–12 inches	14–18 inches	20–28 inches	30+ inches
	——— Inches ———			
Sweetgum	2.80	2.85	3.05	2.30
Red oaks	3.60	4.30	4.45	3.25
White oaks	2.40	2.50	2.90	2.70
Ashes	2.05	2.30	2.85	2.65
Tupelos	2.85	3.15	3.25	3.00
Pecan	2.60	3.55	3.60	3.10
Cottonwood	6.30	5.85	6.30	4.65
Willow	3.80	5.45	5.50	4.20
Overcup oak	2.05	2.20	2.10	2.15
Water hickory	1.95	2.00	2.30	2.55
Baldcypress (second-growth)	2.30	2.60	3.20	2.70
Miscellaneous rapid growers[2]	3.20	3.30	3.80	3.70
Miscellaneous slow growers[3]	2.00	2.10	2.50	2.30
Average	2.55	2.80	3.00	2.80

[1] Putnam, J. A., Furnival, G. M., and McKnight, J. S. 1960. Management and Inventory of Southern Hardwoods. U.S. Dep. Agr., Agr. Handbook 181, 102 pp., illus.
[2] American elm, maples, American sycamore, honeylocust, waterlocust.
[3] Cedar elm, winged elm, black tupelo, hickories, sugarberry.

Commercial stand improvement logging is not enough in beginning management of southern hardwood forests. Weeding is essential to make room for desirable tree regeneration

One of the greatest scourges of hardwood forests is fire. Notice rot damage 12 years after tree had been wounded by a woods blaze

groundline as is feasible. The valve on the injector should be set to deliver ½ to 1 ml. of amine with each jab.

Sometimes small trees of undesirable species are numerous in openings created by cutting. If so, they should be killed to prevent them from taking over the site before desirable trees can become established. Basal sprays of one part 2,4,5-T ester and 19 parts of diesel oil are effective on undesirable trees less than 6 inches d.b.h.

As species, site, and time of application cause variation in results, blanket recommendations for time of treatment can not be given. Generally, the time of full leafing in the spring is best, but satisfactory results have been obtained with applications at other seasons.

Thinning

Improvement cuts ultimately will mold a hardwood stand into groups of even-aged trees. Some species—chiefly cottonwood, willow, sweetgum, baldcypress, yellow-poplar, and the tupelos—typically occur in extensive even-aged, almost pure stands.

Although at least one precommercial thinning and weeding is often desirable, the first treatment of an even-aged stand should be a commercial thinning when the dominant trees average 8 to 10 inches d.b.h. Thinning will remove a great number of weakling 6- to 8-inch trees, which are the minimum size to support pulpwooding operations. Most of the dominant trees, if undamaged will be vigorous crop trees left to grow.

Because of inherent growth differences between species, it

would be difficult to estimate the average age at which a natural stand of mixed hardwoods should be thinned. Table 2 lists growth rates for common hardwood species. From this table it can be observed that cottonwood will reach a merchantable size in 5 to 10 years, while it might take a green ash tree 20 to 30 years to reach pulpwood size or produce a minimum log.

A second thinning might be made when the dominants average about 14 to 16 inches d.b.h., and a third when they average 20 to 22 inches. None of the thinnings should create openings large enough for the development of reproduction; their purpose is to enhance the environment for croptree development and improve the quality of the stand. Stands will rarely support hardwood trees, except tupelos and cypress, totaling more than 150 square feet of basal area per acre, and the rate of growth of even codominant stems slows materially when the figure exceeds 110 to 115 square feet.

A final harvest of mature trees, dominants averaging 28 to 34 inches d.b.h., should also favor the establishment and ultimate growth of reproduction.

Choosing Harvesting Systems

During the early stages of management, accumulations of undesirable growing stock and culls must be removed, and balancing harvest against growth may be neither necessary nor desirable. But once the initial improvement cuts have been made, and before a cycle of cutting based on increment is begun, a silvicultural policy must be adopted that will insure good development of immature trees and bring about reproduction when needed.

Five systems of harvest cutting are recognized which will, in varying degrees, regenerate hardwood stands. The systems are (1) single-tree selection, (2) shelterwood, (3) group selection, (4) seed tree, and (5) clearcut.

Single-tree selection—Single, commercially mature, suppressed, or damaged trees are removed at frequent intervals. The amount of cutting is controlled by growth of the stand, as determined by periodic inventories made after the last cutting.

The system opens a stand gradually and therefore tends to favor the development of the usually less desirable tolerant species. Incorrectly applied, it allows weed tree species and culls to accumulate and permits vines and other vegetation to become established in small stand openings.

In general, the advantages of single-tree selection are limited: trees are cut only as they reach maturity, and the system speeds cash returns. It is now agreed that single-tree selection, although used in the past, is not generally a desirable method of reproducing southern hardwoods.

Shelterwood—Under this system, trees are harvested in stages to nurture reproduction. In effect, the procedure is heavy thinning and complete weeding prior to final clearing. It is used most often to regenerate heavy-seeded species, particularly the oaks. After reproduction becomes established, the shelter trees are removed in one or more cuts. The system is not recommended for species that are intolerant in the seedling stage.

Group selection—Group selection amounts to clearcutting in patches ranging from a small fraction of an acre to several acres. Trees around the perimeter of an opening cast seed over the cut area and help in regeneration, yet few growing-stock trees are sacrificed.

Seed tree—This system is adapted primarily to regeneration

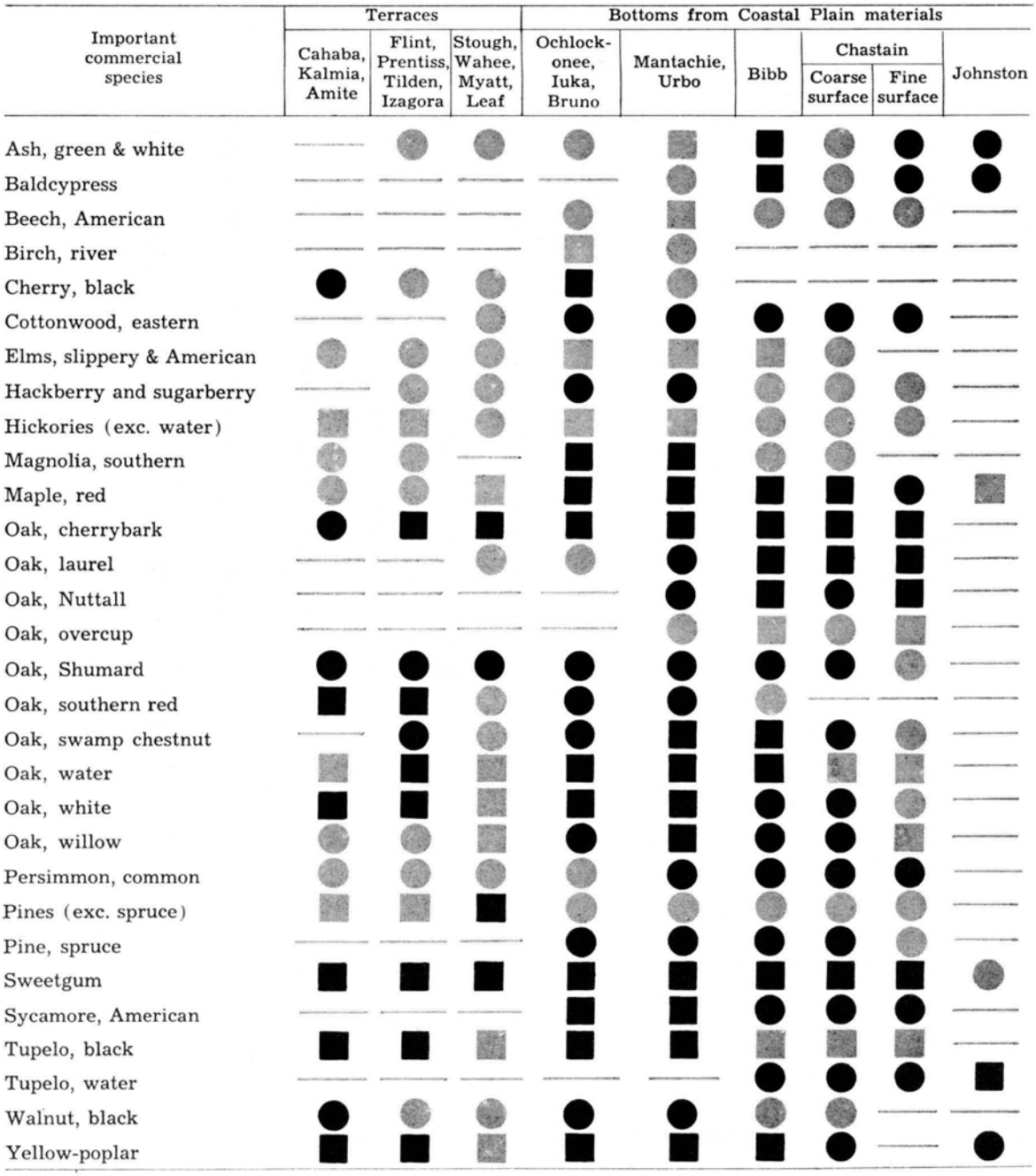
TABLE 3

Expected regeneration following harvest cutting systems in different species associations

Species associations	*Silvicultural systems*	*Species usually favored*
Sweetgum	Group selection	Sweetgum
	Clearcut	Sweetgum
	Shelterwood	Sweetgum, ash, water oaks
Cottonwood	Seed tree with site preparation	Cottonwood
	Clearcut	Sycamore, sweet pecan, ash, boxelder
Black willow	Seed tree with site preparation	Black willow
	Clearcut	Hackberry, green ash, cypress, American elm, overcup oak, bitter pecan, Nuttall oak, privet
Cypress-tupelo	Group selection	Cypress, tupelo, and sometimes ash, overcup oak, bitter pecan and sweetbay
	Clearcut	Cypress, tupelo, and sometimes ash, overcup oak, bitter pecan or elm, maple, and buttonbush and sweetbay
Sycamore-sweet pecan-boxelder	Group selection	Mixed hardwoods—sweetgum, water oaks, sycamore, sweet pecan, hackberry, ash
	Clearcut	Same as above
Elm-ash-hackberry	Clearcut	Elm, ash, hackberry, Nuttall and willow oak, swamp dogwood, deciduous holly
	Group selection	Elm, ash, hackberry, Nuttall and willow oak
Sweetgum-water oaks	Group selection	Sweetgum, water oaks, ash
	Clearcut	Heavy to sweetgum, but water oaks and ash, also
	Shelterwood	Water oaks, sweetgum, ash
Overcup oak-bitter pecan	Group selection	Overcup oak, bitter pecan
	Shelterwood	Overcup oak, bitter pecan, Nuttall oak, ash
Red oaks-white oaks-mixed spp.	Shelterwood	Red oaks, white oaks, water oaks, hickory, ash, ironwood, sweetgum
	Group selection	Same as above
Beech-oak	Group selection	Red oaks, white oaks, ash, yellow-poplar, sweetgum, ironwood
	Clearcut	Same as above
Boxelder	Clearcut*	Hackberry, elm, sycamore, sweet pecan
Swamp privet	Clearcut*	Ash, hackberry, water oaks, overcup oak, bitter pecan, elm
Swamp dogwood	Clearcut*	Ash, hackberry, willow oak, cedar elm
Blue beech-ironwood	Clearcut*	Mixed hardwoods—yellow-poplar, sweetgum, ash, cherrybark, Shumard, cow, and water oaks

*Large areas without an adequate, effective seed source of better species may require stand conversion (planting or seeding).

TABLE 4
Soil suitability for hardwoods in the Coastal Plain area



POST AND SPECIALTY SPECIES: Black locust and flowering dogwood on moist, well-drained soils; mulberry on all soils.

SPECIES LIMITED COMMERCIALLY OR IN OCCURRENCE: Basswood, pecan, post oak, and silver maple on well-drained soils; shingle oak, sweetbay, and swamp tupelo on poorly drained soils; boxelder, winged elm, honeylocust, black willow, sassafras, American holly, buckeye, chinaberry, and common sweetleaf on all soils.

WEED SPECIES: Blackjack oak and smooth sumac on well-drained soils; planertree, roughleaf dogwood, poison-sumac, and buttonbush on poorly drained soils; eastern hophornbeam, American hornbeam, devils-walking-stick, hawthorn, and flatwoods plum on all soils.

■ Occurs frequently; favor in management.
● Occurs occasionally; favor.
■ Occurs frequently; manage, but do not favor.
● Occurs occasionally; manage, but do not favor.

TABLE 5
Soil suitability for southern hardwoods in the Delta area

Important commercial species [1]	Recent natural-levee soils		Old natural-levee soils			Slackwater soils		Depressional soils	
	Crevasse, Robinsonville	Commerce, Mhoon	Beulah, Bosket	Dubbs, Dundee	Forest-dale	Bowdre, Tunica	Sharkey, Alligator	Ark	Dowling, Souva
Ash, green	●	■	—	●	■	●	■	■	■
Baldcypress	—	●	—	—	●	—	■	●	■
Cottonwood, eastern	■	■	●	●	●	■	■	●	●
Elms, slippery & American	■	■	●	■	■	■	■	●	—
Hackberry and sugarberry	■	■	●	●	■	■	■	■	●
Hickory, water	—	—	—	●	■	●	■	●	■
Honeylocust	●	●	—	●	■	●	■	●	●
Maple, red	—	—	—	●	■	■	■	●	—
Maple, silver	●	■	—	—	—	—	—	—	—
Oak, cherrybark	●	●	■	■	■	●	●	●	—
Oak, Nuttall	—	●	—	●	■	●	■	●	●
Oak, overcup	—	●	—	●	■	●	■	●	■
Oak, Shumard	—	—	●	■	●	●	●	—	—
Oak, swamp chestnut	—	—	●	■	■	●	●	●	—
Oak, water	●	●	■	■	■	■	■	●	—
Oak, willow	—	—	■	■	■	■	■	●	●
Pecan	■	■	●	●	●	●	●	—	—
Persimmon, common	●	●	●	●	■	●	■	●	●
Sassafras	●	—	■	■	●	●	●	—	—
Sweetgum	●	■	■	■	■	■	■	●	●
Sycamore, American	■	■	■	■	●	●	●	●	—
Tupelo, black	—	—	■	■	●	●	●	—	—
Tupelo, water	—	—	—	—	—	—	—	●	●
Willow, black	●	■	—	—	●	—	●	■	■

[1] In this and succeeding tables, common names are according to E. L. Little, Jr., **Check list of native and naturalized trees of the United States (including Alaska).** U. S. Dept. Agr., Agr. Handb. 41, 472 pp. 1953.

POST AND SPECIALTY SPECIES: Black locust, catalpa, and flowering dogwood on moderately to well-drained acid soils; Osage-orange on neutral to alkaline soils; mulberry on all soils.

LIMITED COMMERCIALLY OR IN OCCURRENCE: Boxelder on neutral to alkaline soils; bur oak, American holly, winged elm on acid soils; post oak, river birch, hickories (exc. water), and white oak on well-drained acid soils; swamp cottonwood and laurel oak on poorly drained acid soils; black walnut on well-drained soils; chinaberry, cedar elm, buckeye, and Kentucky coffeetree on all soils.

WEED SPECIES: American hornbeam and eastern hophornbeam on acid soils; planertree on wet soils; hawthorn, swamp-privet, redbud, and roughleaf dogwood on all soils.

■ Occurs frequently; favor in management.
● Occurs occasionally; favor.
■ Occurs frequently; manage, but do not favor.
● Occurs occasionally; manage, but do not favor.

of selected light-seeded species over large areas. Generally, 8 to 10 well-spaced seed trees are left per acre. As bare, mineral soil is usually requisite, some form of site preparation is often necessary. To get cottonwood reproduction, for example, the site requires trenching. To date, the seed-tree system has not produced the desired results for species other than cottonwood, and it is not generally recommended.

Clearcut—All merchantable trees are cut over an area of at least 10 acres; the remainder, down to one inch d.b.h., may be killed or removed by some form of site preparation. Clearcutting is best suited where there is no desire to control the type or species of reproduction, or where the trend is toward management in large blocks.

Table 3 summarizes the systems of harvest cuttings as they might apply in favoring certain species. In choosing a system for application the owner must consider not only his policies of financial management but various silvicultural relationships.

Harvesting systems that create large openings may not always favor seedling reproduction of intolerant species. A stand that has been opened gradually by overthinning will have about the same type of reproduction whether the final cut is single-tree selection or clearcutting. The type of reproduction depends on: (1) the suitability of the seedbed in relation to available seed source, (2) the amount and nature of advanced reproduction on the ground, and (3) the sprouting ability of the species removed.

Most intolerant, light-seeded species such as yellow-poplar, sycamore, and sweetgum require a mineral soil seedbed to become established. As long as the canopy is closed, the seedbed will usually be desirable for them, but if the overstory is removed a tree at a time or gradually, enough sunlight filters

through the canopy to allow herbaceous vegetation to develop. This results in an undesirable seedbed. It is true that some trees of intolerant species can become established in these small holes, but inadequate sunlight will limit their development.

Conversely, hickories, oaks, ashes, hackberry, elms, blue beech, and ironwood, among others, may become established and frequently persist in the understory of understocked or disturbed stands. When the overstory is removed, trees of these and similar species usually assume dominance. On the other hand, if larger holes are made in the overstory in one cutting, both the seedbed and the light will usually favor light-seeded, intolerant species.

Sprouts from stumps and roots of cut trees account for a high percentage of the reproduction of sweetgum, green ash, bitter pecan, the hickories, ironwood, and blue beech. Rapid initial growth enables the sprouts to assume a dominant position above new seedlings, and if the sprouts are numerous, even fast-growing seedlings have difficulty in competing.

Artificial Regeneration

Many landowners have open fields, large cleared areas, places where natural regeneration has failed, or tracts that should be converted from one type of forest to another. In many such situations, planting can be successful. Although a great deal remains to be learned about hardwood planting, five major rules have been developed:

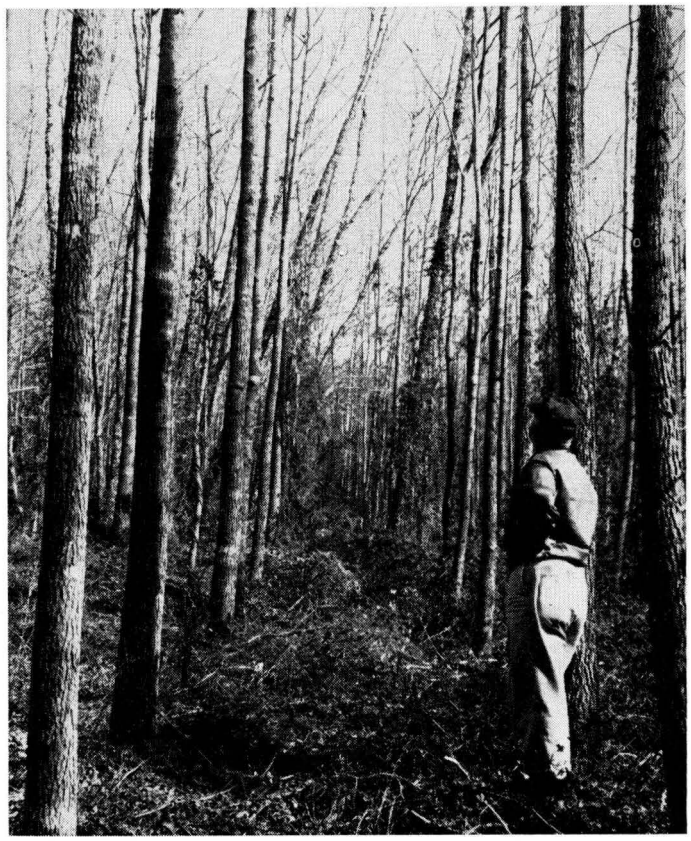
1. *Plant species suited to the site.* Guides have been formulated for some soil areas of the South to aid the landowner in recognizing sites suitable for growing hardwoods. Table 4 lists soils suitable for hardwoods on terraces and bottoms within the Coastal Plain. The Delta soil area is covered by Table 5, and similar tables exist for the Red, Blackland, and Loess soil areas. (See Broadfoot, W. M., in Selected References.) In general, sandy or silt loams are better than coarse sands or heavy clays. Drainage both inside the soil and on the surface is important.

2. *Prepare the site.* Planted seedlings or cuttings, in the case of cottonwood and willow, are usually unable to compete with the annual weeds, vines, and shrubs that grow on most good planting sites. Such vegetation must be removed before trees are planted. Bulldozing followed by heavy disking is suitable. In abandoned fields, subsoiling to break up any plow soles is additionally recommended.

3. *Use good stock.* The investment to prepare the site, plant, and care for hardwood plantations is so great that only the best stock should be used. Vigorous seedlings of the best sizes should be selected for planting. If cottonwood cuttings are used, they should be taken from trees of apparently superior parentage. Nurserymen's instructions should be followed for care of stock before it is planted.

4. *Plant properly.* Hardwoods are easily damaged by improper handling and planting. Prolonged exposure of roots, or drying of cuttings, should be avoided. Seedlings should be planted with the rootcallar at the ground level, although most of the stem of a cottonwood seedling may be planted. U- or J-root planting of all seedlings is undesirable.

5. *Care for the plantation.* Cultivating to control weeds is



Above, a successful sweetgum plantation on loess soil in Tennessee. Below, cottonwoods being cultivated after a few weeks of growth to eliminate weeds and provide better moisture conditions for the thrifty trees. If they are to become well established, hardwood plantations in the southern states must be tended with care

TABLE 6
Hardwood and cypress planting information

Species and form of stock	Prune roots to:	Good top Length 2/	Best root-collar diameter	Adaptable to machine planting	Response to fertilizer	Usual first-year growth	Suited to wet sites	Animal damage	Insect damage
Cottonwood cuttings	—	20[3]	⅜-¾	No	Some populus success	Good	No	Deer	Borers, leaf beetles
Cottonwood seedlings	8	15	?	Yes	?	Good	No	Deer, rodents	Borers, leaf beetles
Sweetgum seedlings	8	15	?	Yes	?	Poor	Poor	Rabbits, deer, rodents	Forest tent caterpillar
Green ash seedlings	8	15	?	Yes	?	Good	Yes	Robbits, rodents	Ash borer, fall webworm
Sycamore seedlings	8	15	3/10 and up	Yes	Some	Poor to good	Poor	None?	Sycamore lacebug, bagworm
Sycamore cuttings	—	20[4]	¼-¾	No	?	Poor to good	No	None?	Sycamore lacebug, bagworm
Yellow-poplar seedlings	8	15	¼ or ⅕ and up	Probably	Some	Good	No[5]	Deer, rodents	Tuliptree scale
Oak seedlings	8	15	?	Probably	?	Poor to fair	Nuttall, willow, water, overcup (others, no)	Rabbits, rodents	Twig girdlers, cicadas
Black walnut seedlings	8	15	?	Probably	?	Poor	No[5]	Rodents	Walnut caterpillar
Water tupelo seedlings	8	15	?	Site may prohibit	?		Yes	None?	Forest tent caterpillar
Baldcypress seedlings	8	15	¼ and up	Site may prohibit	?	Fair to good	Yes	Rabbits	Spider mites, bagworm

1/ Bonner, F. T. 1965. Seeding and Planting Southern Hardwoods. Auburn Univ. Hardwood Short Course Proc. 1964: 28-40.

2/ Determined mainly on basis of handling ease. All species can be top-pruned except ash, which forks because of its opposite-bud morphology.

3/ May be shorter on sites where drought never occurs.

4/ Only basal cuttings seem to root well.

5/ Very exacting in site requirements. Plant only on moist, well-drained soils.

very desirable, even necessary, for cottonwood, and it benefits the early growth of all species. The degree of cultivation must be a decision of each landowner, but stinting may jeopardize the entire investment. Cattle and deer must be kept form browsing the young trees.

Table 6 contains summarized planting information about some southern hardwoods. Full recommendations for many species are lacking, but research is underway to fill the gaps in knowledge.

Hardwood plantings on abandoned fields deserve special comment, for it is on such sites that repeated failures have discouraged many landowners. The soils often lack organic matter and are compacted or underlain by hardpans. Good site preparation, which should include deep plowing or subsoiling, will help to reduce the problem but will not eliminate it. If the old fields are on slopes or terraces subject to erosion, nutrient deficiencies may exist. Fertilizer may help but it should be applied only in combination with thorough site preparation and control of competition. Even then, results equal to those obtainable on good forest soils should not be expected.

Optimum spacing in hardwood plantations is still not known. On most southern hardwood sites, spacings of 8 by 8 or 10 by 10 feet are satisfactory. If cultivation is planned, no less than 10 by 10 foot spacing is needed.

Direct seeding of hardwoods is still unproved, but the potential is great. Occasional successes have been reported for oak, black walnut, and yellow-poplar, but failures are more frequent. Bird and animal seed predators remain the chief reasons for failure.

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