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Flood Tolerance and Related Characteristics of trees of the Bottomland Forests of the Southern United States

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Paper 2

FLOOD TOLERANCE AND RELATED CHARACTERISTICS OF TREES OF THE BOTTOMLAND FORESTS OF THE SOUTHERN UNITED STATES

J. Sid McKnight, Donal D. Hook, O. Gordon Langdon, and Robert L. Johnson*

2.1 INTRODUCTION

The Southern bottomland forests encompass about 12.5 million hectares (30.8 million acres) from Virginia, south to the sub-tropical hardwood forests of south Florida, west to eastern Texas and Okalhoma, and north up the Mississippi River Valley to southern Illinois and Indiana (Fig. 2.1).

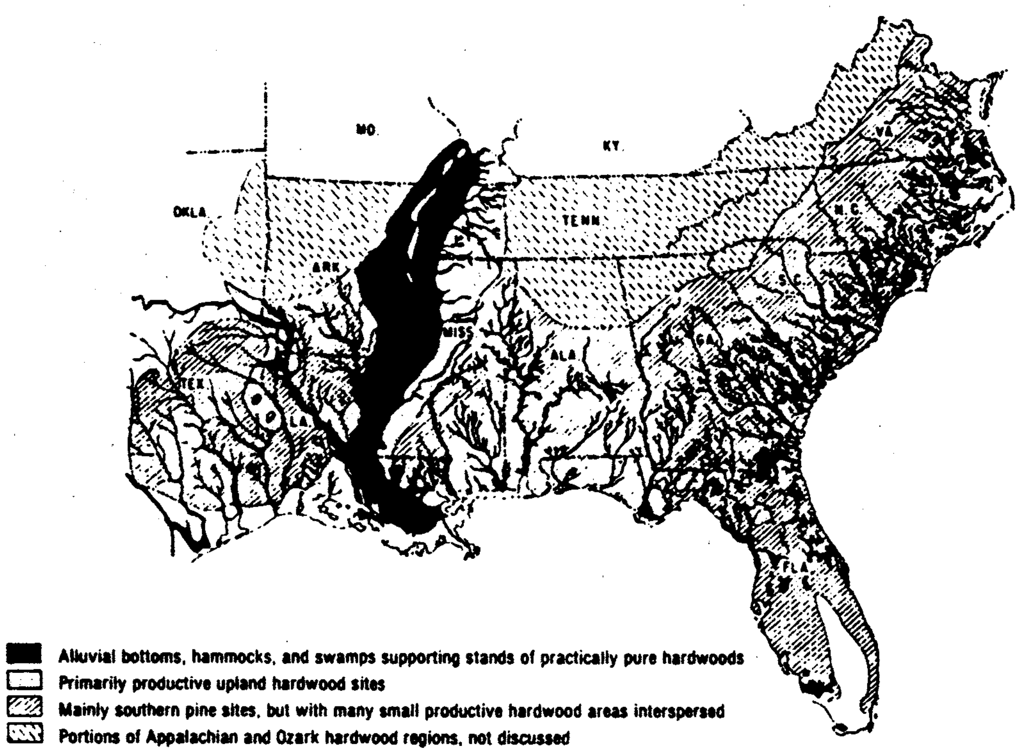

Fig. 2.1. Distribution of bottomland forests in the South (from Putnam et al 1960).

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These forests are found in low-lying areas of the lower Mississippi alluvial plain and the floodplains of the tributaries of the west Gulf Coastal Plain, the east Gulf Coastal Plain, the Atlantic Coastal Plain, the Piedmont, and the Florida Peninsula (Fig. 2.2). Within these major physiographic areas, there are sufficient similarities in the lowland areas to support species which tolerate hydric conditions of varying degrees. Yet differences in geomorphology, physiography, climate, species migration, soils, and soil-water characteristics have resulted in forest associations and types which may be prevalent in one area or region and not in another. The bottomland forest is quite heterogenous and is not dominated by one or two tree species as are most forest types. Various mixtures of the some 70 species of trees in the type occur in the floodplains, alluvial swamps, and bayous, and in the non-alluvial swamps, bayheads, pocosins, ponds, savannahs, and other poorly drained sites.

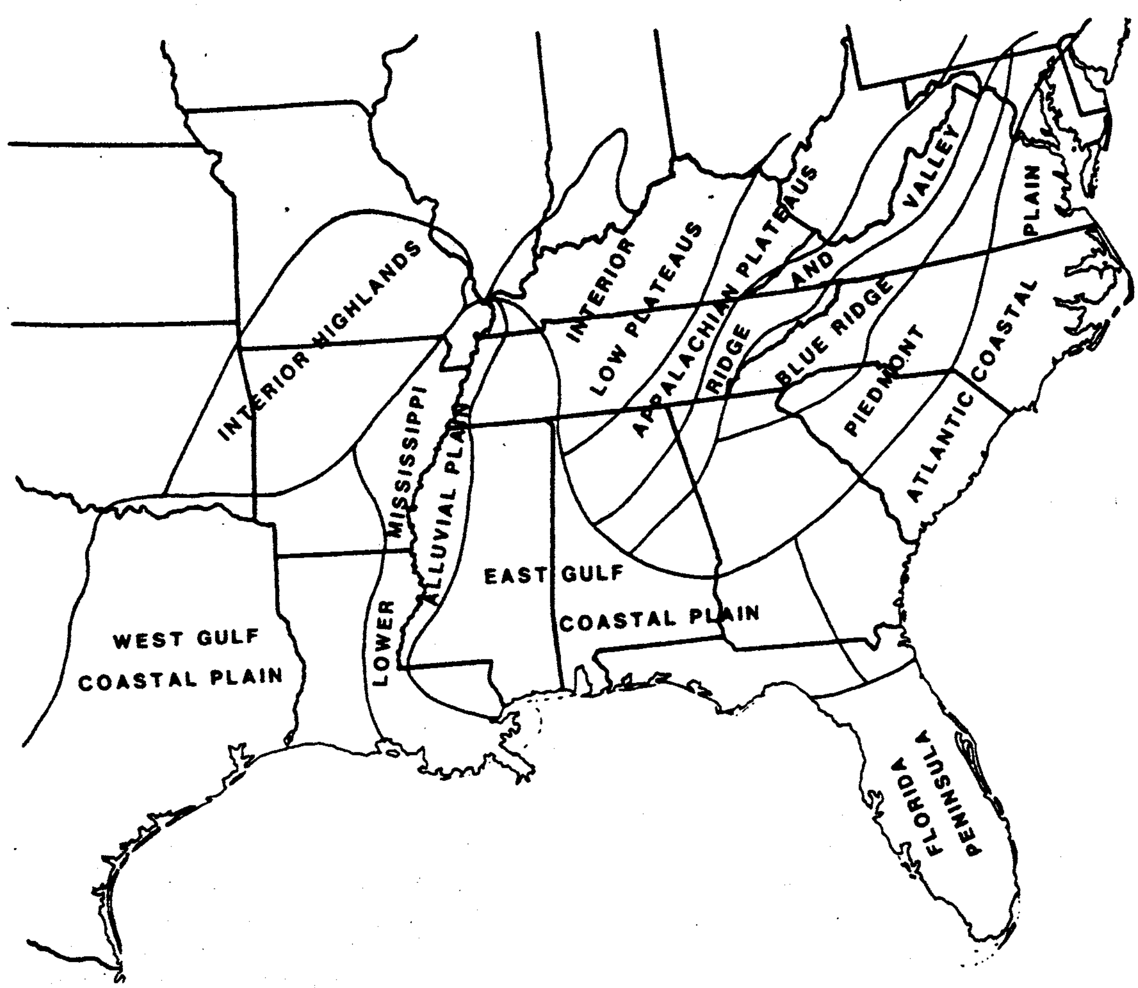

Fig. 2.2. Physiography of the Southern Forest Region (after Fenneman 1938).

The forest coincides rather closely to the Southern floodplain forest which Küchler (1964) describes in his treatise of the "Potential Natural Vegetation on the Counterminous United States." In the Mississippi River and Gulf Coastal Plain, the bottomland forest is intermingled with the potential vegetation regions which are described as the southern mixed forest, the oak-hickory forest, oak-hickory-pine forest, bluestem prairie, and bluestem-sacahuista prairie. In contrast, in the Atlantic Coastal Plain the bottomland is intermingled only with the southern mixed forest and oak-hickory forest (Küchler 1964).

In the western part of the range, the Mississippi River and associated floodplains of the Red and Arkansas Rivers are dominant features. Within these large floodplains both subtle and sharp topographic differences usually result in sites often characterized by such names as new land (point-bars), natural levees, first bottoms, sloughs, swamps, second bottoms or terraces (Putnam et al 1960). Species composition vary on these site types because of differences in time and duration of soil saturation or flooding, soil physical and chemical properties, and the interactions of soils and water. Smaller rivers and streams of the Atlantic and East Gulf Coastal Plain have similar site types, but because of the origin (coastal, mountain, or piedmont) the soil and other characteristics of the site vary considerably from those of the Mississippi River. Other low-lying, wet sites in the coastal plain include non-alluvial headwater swamps, ponds, bays, pocosins, savannahs, and wet flats. These also may differ in their site characteristics from the big river bottomlands.

2.2 PHYSIOGRAPHIC BACKGROUND

During the glacial intrusions and recessions, the Mississippi drainage carried large loads of melt-water and soil material ahead of the ice fronts. It was an overloaded stream, depositing in some places and eroding in others, carrying with it soil from the western plains, the midwest, and the Allegheny and the Appalachian mountains. The river constantly modified its broad valley, leaving isolated backwater swamps and bayous and building ridges and natural levees.

By contrast the development of the coastal plain river and stream bottoms was more uniform. The Atlantic Coastal Plain developed as "a result of continental submergence and emergence with consequent disruption in erosion-deposition cycles" and, therefore, consists of "successions of continental and marine origin landforms of major and minor extent" (Colquhoun 1974). Soil materials were of Appalachian or coastal origin except in the West Gulf Coastal Plain. In the absence of overloads due to glacial melts, the rivers and streams modified the land to a lesser degree than in the Mississippi Valley. Backwater areas are less extensive and the bottoms are not as badly broken up by sloughs and ridges as in the Mississippi floodplains (Braun 1950).

2.3 MIGRATION OF SPECIES

River and stream drainages have served as pathways of migration along which upland species have advanced into the bottomlands. The bottomland forest of the Atlantic Coastal Plain resembles the mixed mesophytic forest of the Appalachian Highlands from which it descended. The Gulf Coastal Plain and the lower Mississippi River Valley differ in that there is more of a mix of species from the mixed mesophytic as well as from the more northerly and westerly forests, such as the beech-maple and oak-hickory forests.

Under the influence of the cooler melt-water and in the absence of competition on newly formed land, it is conceivable the northern species migrated along the ice front toward the Gulf with hybridization occurring when the ranges of parent species met or overlapped (Braun 1950). Several species (e.g. Nuttall oak, cedar elm, pecan, and sandbar willow*) are common in the Mississippi floodplain but are not found in the Atlantic Coastal Plain. The reverse is the case with swamp tupelo, pondcypress, and loblolly-bay which occur in the Atlantic Coastal Plain but not in the Mississippi floodplain.

2.4 SPECIES OCCURRENCE

Close study of natural range maps reveal variations in species occurrence between and within the Atlantic Coastal Plain, the Mississippi floodplain, and the Gulf Coastal Plain regions (Little 1971, 1977). Many species occur in one portion of the bottomland forests and not in another. Forest

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* Scientific and common names of all species referred to are given in Table 2.3.

survey data* on frequency of species distribution are summarized for southern bottomland forests of the Atlantic Coastal Plain and the Mississippi Delta (Tables 2.1 and 2.2). The data show some important contrasts in species occurrence in the bottomland forests between the two regions.

In both regions 12 to 13 species or species groups account for about 90 percent of the trees in the bottomland forests. Yet species composition differs considerably between the two regions. Swamp and water tupelos are most abundant in the Atlantic Coastal Plain accounting for about 25 percent of the trees in this forest. Pondcypress and sweetgum form a distant second and third and having another 25 percent of trees in the bottomland forest of the Atlantic Coastal Plain. Soft maples, red oaks, ash, baldcypress, bays, magnolia, yellow-poplar, loblolly pine, and elm follow in order of decreasing frequency of occurrence with nearly 40 percent of the trees (Table 2.1).

Red oaks are the most abundant species group in the Mississippi Delta, but make up only about 12 percent of the trees growing there. Sweetgum, water tupelo, and baldcypress are next in abundance, and together account for about 30 percent of trees. Hickory and pecan, white oaks, ash, and sugarberry are about equally abundant and account for another 30 percent of the trees in descending order of occurrence. Pondcypress which is abundant in the Florida and Georgia portions of the Atlantic Coastal Plain is seldom found in the Mississippi Delta. Likewise the bays and magnolia are found much more frequently in the Atlantic Coastal Plain than in the Delta. On the other hand, sugarberry is a common species in the Delta, but not in the Atlantic Coastal Plain. The meandering of the Mississippi River forms new sandbars that are quickly forested by willows and to a lesser extent by cottonwoods. Consequently, willow shows up as an important species in the Delta, but not in the Atlantic Coastal Plain.

Large stands of a single species are uncommon in bottomland forests. The exceptions are those having swamp tupelo, water tupelo, baldcypress, or pondcypress, and even these are often a mixture of at least two of these species. In general, as one goes from the hydric to the more mesic bottomland sites, the possible combinations or mixtures of species increase.

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* Collected periodically from randomly located plots throughout the southern bottomland forest region by continuous forest inventories and carried out by the Forest Service's Renewable Resource Evaluation Research Work Units at the Southeastern and Southern For. Expt. Stn. at Asheville, NC, and New Orleans, LA, respectively. Given areas are sampled on about a 10-year interval.

TABLE 2.1

Ranking of species by their frequency of occurrence on southern bottomland hardwood-cypress forest types in the Atlantic Coastal Plain (Florida, Georgia, South Carolina, North Carolina, and Virginia)[a]

Species[b]	Number of[c] trees	Volume of[c] trees
	(Million)	*(Million cu. ft.)*
Swamp and water tupelo	395.3	4,985.8
Pondcypress	197.4	1,588.4
Sweetgum	190.2	2,405.7
Soft maples	140.2	1,498.4
Red oaks	129.7	1,985.3
Ash	85.4	957.7
Baldcypress	77.8	1,266.2
Bays and magnolia	70.0	629.1
Yellow-poplar	47.6	773.6
Loblolly pine	32.9	656.6
Elm	32.2	398.1
Slash pine	29.0	342.9
White oaks	28.9	571.7
Atlantic white-cedar	12.3	122.0
Hickory	11.7	215.7
Sycamore	8.1	183.3
Pond pine	8.1	104.2
Cottonwood	4.0	92.8
Spruce pine	2.3	48.6
Shortleaf pine	2.2	24.2
Beech	1.8	50.9
Longleaf pine	1.7	18.2
Black cherry	1.7	14.9
Eastern redcedar	1.5	10.0
Basswood	1.4	15.3
Hard maples	1.2	16.4
Black walnut	1.2	14.1
Virginia pine	.5	2.9
Black locust	.3	3.5
Other eastern hardwoods	41.8	523.6
Total	1,558.4	19,520.1

[a] Data collected periodically from randomly located plots throughout the southern bottomland forest region by continuous forest inventories and carried out by the Forest Service's Renewable Resource Evaluation Research Work Unit at the Southeastern Forest Experiment Station at Asheville, NC. Given areas are sampled on about a 10-year interval.

[b] Scientific names of species are given in Table 2.3.

[c] Growing stock trees 5.0 inches d.b.h. and larger.

TABLE 2.2

Ranking of species by their frequency of occurrence on southern bottomland hardwood-cypress forest types in the Mississippi Delta area (Arkansas, Louisiana, and Mississippi)[a]

Species[b]	Number of[c] trees	Volume of[c] trees
	(Million)	*(Million cu. ft.)*
Red oaks	83.8	1,197.6
Sweetgum	72.5	792.2
Swamp and water tupelo	70.2	800.2
Baldcypress	60.6	1,093.9
Hickory and pecan	52.2	628.4
White oaks	51.5	601.2
Ash	48.4	501.3
Sugarberry	47.4	484.8
Elm	35.5	343.2
Loblolly pine	30.3	301.5
Willow	30.0	466.8
Soft maples	19.2	121.9
Cottonwood	11.6	286.9
Shortleaf pine	10.9	103.4
Sycamore	6.7	109.3
Persimmon	6.1	34.4
Boxelder	5.1	38.2
Slash pine	5.0	9.7
Black and other locusts	2.8	26.1
Dogwood	2.5	3.2
Beech	2.0	31.4
Yellow-poplar	1.5	44.8
Eastern redcedar	1.4	7.4
Sassafras	1.2	11.5
Black cherry	1.1	6.6
Hard maples	0.8	6.5
Basswood	0.7	6.9
Bays and magnolia	0.2	1.9
Black walnut	0.1	2.2
Other eastern hardwoods	12.2	90.0
Total	673.5	8,153.4

[a] Data collected periodically from randomly located plots throughout the southern bottomland forest region by continuous forest inventories and carried out by the Forest Service's Renewable Resource Evaluation Research Work Unit at the Southern Forest Experiment Station at New Orleans, LA. Given areas are sampled on about a 10-year interval.

[b] Scientific names of species are given in Table 2.3.

[c] Growing stock trees 5.0 inches d.b.h. and larger.

2.5 FLOOD TOLERANCE

The bottomland forests are characteristically subjected to high water table levels, soil saturation, periodic and/or continuous flooding at various times of the year. On these sites, the relative duration and level of flooding plays a key and often critical role in the occurrence and growth rate of tree species and other plants from seed germination, early seedling survival, growth during establishment, and later tree growth.

How well a tree survives and grows in a hydric habitat may depend on a combination of silvical, morphological, and physiological traits and the adaptive characteristics related to a species' flood tolerance at various periods in its life cycle (Gill 1970; Hook and Brown 1973). Species in bottomland forests differ in their tolerance to flooding and silvical characteristics, all of which may have some influence on their occurrence within the forest (Table 2.3).

A great deal of information on flood tolerance and the rating of species flood tolerance has come from studies involving reservoirs and other flood-control structures (Hall and Smith 1955; Bell and Johnson 1974; Williston 1959, 1962; Harris 1975; Hall et al 1946; Silker 1948; Broadfoot and Williston 1973; Green 1947). These studies, although adding to our knowledge of flood tolerance, may not always reflect an integrated view of the species. Most of the observations were of existing stands which received a sudden shock of continuous inundation. Such studies may not always indicate how a species might perform if it had to start as a germinating seed and progress through various stages in its life cycle while under the influence of intermittent flooding and dry periods. On the other hand, the reverse may, in some instances, be the case. A given species which, under natural conditions does not occur on wet sites, may be able to tolerate the shoreline flooding of a flood-control reservoir for several months of the growing season, and thus be an excellent species for the specific soil and climatic conditions including the more stable water conditions that might exist at the site.

Although water is a dominating environmental factor in the bottomland forest, there tend to be gradients in the water regimes. For broad floodplains, these gradients are often gradual or subtle ones, but on narrow floodplains or at a swamp edge, they are usually much sharper. Harper (1977) has pointed out that even though species tend to be separated out along a moisture gradient, there is considerable overlapping of species occurrence along such a gradient because of the influence of soils and other environmental factors and their interactions with the water regime. This occurs to the extent that it may be difficult (if not impossible) to separate out a given flood frequency along such a gradient. For example, Bedinger (1971, 1979) reported that in the White and Ouachita River floodplains of Arkansas the distribution of species was related to the frequency and duration of flooding. However, major differences in occurrence of dominant species under a given flooding regime were noted by Bedinger for these two floodplains. This serves to illustrate that there are inherent problems in trying to draw species occurrence lines that are based only on duration and frequency of flooding. Exceptions to this are sites flooded more frequently or more continuously during the growing season, such as swamps, ponds, bays, or some sloughs. These sites have species with occurrence related to adaptive flood tolerant characteristics.

2.6 ADAPTIVE CHARACTERISTICS

A plant may have adaptive characteristics that will allow it to survive and grow under flooded conditions but if its seed do not remain viable in water, then the species will not likely become established on sites that are flooded after seedfall. Seed of several swamp species exhibit the characteristic of remaining viable in water for long periods. Swamp and water tupelo and bald- and pondcypress are examples of species with that characteristic. While pumpkin ash, green ash, boxelder, Shumard oak, and cherrybark oak are examples of ones that may, under certain water conditions, lose their viability in a relatively short time (Hosner 1962). Other species, such as cottonwood, willow, and sycamore may germinate under water which is a characteristic that allows these species to establish quickly on sandbars or other freshly deposited sediments when the flood water recedes (Hosner 1957, Briscoe 1959).

Species also show differences in their tolerances as seedlings to complete inundation during the growing season. For example, silver maple and buttonbush seedlings will survive longer periods of inundation than hackberry and cherrybark oak (Hosner 1958, 1960). Baldcypress seedlings will also withstand long periods of inundations as well as shallow flooding (Welch 1931, Bull 1949). Seedlings of different species also exhibit different levels of tolerance to soil saturation or shallow flooding with green and pumpkin ash, water tupelo, and willow being very tolerant and Shumard and cherrybark oak, American elm, sweetgum, hackberry, and yellow-poplar being intolerant (Hosner and Boyce 1962, McAlpine 1961). These flood tolerant characteristics in seedlings are often the factor determining occurrence of a given species on a given site.

Considerable evidence as to why one species is able to grow and often thrive under flooded conditions which are often fatal or injurious to other species has accumulated over the years. Several authors (Gill 1970; Kozlowski 1976; Whitlow and Harris 1979) have reviewed and summarized much of this evidence. Others (Hook and Crawford 1978) have brought together under two covers an authoritative treatment by internationally recognized experts of the processes and effects of anaerobiosis on plants and the anatomical and physiological adaptations to anoxia. Briefly, the anatomical adaptations include the formation of aerenchyma tissue, the development of hypertrophied lenticels, and the production of adventitious water roots with characteristics that facilitate the conduction of oxygen to its roots. These adaptations allow a plant to oxidize the rhizophere. The physiologic or metabolic adaptations include the ability of a plant to utilize anaerobic pathways of respiration and yet not accumulate enough toxic by-products or hormones that would be harmful to the plant or otherwise upset a plant's metabolism.

2.7 DISCUSSION

Observations by the authors over the many years of research and experience in southern bottomland forests indicate that care must be exercised in interpreting and applying results of studies under controlled or reservoir conditions with planted trees. To determine meaningful results applicable to the natural bottomland forest, observations and studies must be conducted under natural flooding regimes and in the communities in which trees occur naturally.

The whole concept of community development in zones of the bottomland forest has not been sufficiently studied in relation to the chronological sequences of flooding events, both in duration and frequency. Many of the stands that we see in bottomland forests today may be the result of logging operations or a long period of dry weather. The ensuing ability of a stand to tolerate subsequent flood conditions is bound to be affected by these and other unusual conditions.

Table 2.3 is an attempt to show some of the individual silvical characteristics of important bottomland species in a fashion that will allow the reader to compare one species with the other as well as view the other characteristics in relationship with flood tolerance within a species. For example, shade tolerance is an important factor in interpreting flood tolerance in stands of timber under natural conditions. In addition, the table displays certain gaps in the knowledge about the flood tolerance of some of the trees of the bottomlands.

Despite the attempt in this table to dissect the forest into its specific trees with their characteristics, it must be recognized that a tree in its natural community may flower, seed, develop and mature differently than will the same tree grown under controlled conditions outside of a natural stand.

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TABLE 2.3

Occurrence, shade and flood tolerance, and reproductive characteristics of the principal species of the southern bottomland forest.

Common and Scientific Name	Occurrence in Bottom Lands	Shade Tolerance	Flood Tolerance[a]	Reproductive Characteristics
ASHES				
Carolina ash (*Fraxinus caroliniana* Mill.)	Common as a small tree on wet sites in bottoms of smaller alluvium bearing and blackwater streams of Coastal Plain and in borders of tidal and muck swamps (Putnam et al 1960).	Intermediate. Seedlings moderately tolerant (Putnam et al 1960).	Tolerant. Seed remain viable in water for months.	Seeds dispersed Oct.-Feb. by wind and water. Seedlings establish on bare, moist soil from April to July, after water recedes. Sprouts prolifically from stumps (Putnam et al 1960).

[a]Definitions used for relative flood tolerance of species included in this table:

Tolerant--species that are able to survive and grow on sites in which the soil is saturated or flooded for long, indefinite periods during the growing season. Species have anatomical and physiological flood tolerant adaptations that allow oxidation of their rhizosphere and control of anaerobic respiration rates in their roots in the presence of low oxygen levels and highly toxic reduced compounds.

Moderately tolerant--species that are able to survive saturated or flooded soils for several months during the growing season but mortality is high if flooding persists or reoccurs consecutively for several years. These species may develop adventitious water roots or other morphological or physiological flood tolerant adaptations, but in combination such adaptations are not sufficient for life in waterlogged soils.

Weakly tolerant--species that are able to survive saturated or flooded soils for relatively short periods of a few days to a few weeks during the growing season, but mortality is high if flooding persists for longer periods. These species do not appear to develop morphological or physiological flood tolerant adaptations.

Intolerant--species that are not able to survive even short periods of soil saturation or flooding during the growing season. These species do not exhibit any pronounced morphological or physiological flood tolerant adaptations.

TABLE 2.3 (Continued)

Common and Scientific Name	Occurrence in Bottom Lands	Shade Tolerance	Flood Tolerance[a]	Reproductive Characteristics
Pumpkin ash (*F. profunda* (Bush) Bush)	Widely distributed on new sediments and in first bottoms and edge of swamps in the Atlantic Coastal Plain and the upper Mississippi floodplain (Putnam et al 1960).	Intermediate (Putnam et al 1960).	Tolerant. Seed remains viable in water for months (Hosner 1962).	Same as for Carolina ash. Trees that develop to 4 feet tall + can survive 20 years or more in nearly full shade.
Green ash (*F. pennsylvanica* Marsh.)	Most common in flats and shallow sloughs. On older sediments or terraces, in flats and shallow sloughs only (Putnam et al 1960).	Intermediate. Seedlings moderately tolerant (Putnam et al 1960).	Moderately tolerant (Bell & Johnson 1974; Broadfoot 1967; Broadfoot & Williston 1973; Dickson et al 1965; Green 1947; Hall & Smith 1955; Hook & Brown 1973; Hosner 1958, 1959, 1960, 1962; Hosner & Boyce 1962; Kennedy & Krinard 1974).	Prolific on bare moist soil in openings. Adequate on any sites not totally preempted by ground cover or dense overstory. Sprouts very prolifically. Seed dispersal is excellent (Wright 1965a).
White ash (*F. americana* L.)	Widely distributed but limited to ridges and high hummocky flats of older alluvium or terraces and to hummocks, outwashes from uplands and creek bottoms (Putnam et al 1960).	Intermediate. Seedlings moderately tolerant (Putnam et al 1960).	Weakly tolerant (Hosner 1962; Yeager 1949).	Seeds dispersed Sept.-Jan. up to 450 feet distance. Seedlings establish on bare, moist, well drained soils. Sprouts prolifically from stumps (Wright 1965b).

TABLE 2.3 (Continued)

Common and Scientific Name	Occurrence in Bottom Lands	Shade Tolerance	Flood Tolerance[a]	Reproductive Characteristics
BEECH, AMERICAN (*Fagus grandifolia* Ehrh.)	Widely in creek bottoms and occasionally on ridges of old alluvium or terraces in minor river bottoms (Putnam et al 1960).	Very tolerant (Putnam et al 1960).	Intolerant (Hall & Smith 1955; Hall et al 1946).	Seedfall from Sept.-Dec. Seed dispersal is limited to the crown area. Birds and animals move some seed but devour most. Seedlings establish best in the shade on moist, well drained sites. Sprouts well from roots and stumps up to 4" in diameter (Rushmore 1965).
BIRCH, RIVER (*Betula nigra* L.)	On new river fronts and along banks of minor streams, usually in fringes. Not found below Memphis in Delta but goes to coast along rivers and streams on the Atlantic Coast (Putnam et al 1960).	Intolerant (Putnam et al 1960).	Moderately tolerant (Green 1947; Hall & Smith 1955; McDermott 1954).	Seed dispersed May-June by wind and water. Seedlings establish on moist, well drained mineral soil. Forms dense stands and has rapid early growth from seed (Putnam et al 1960).
BUTTONBUSH, COMMON (*Cephalanthus occidentalis* L.)	In swamps along streams and margins of ponds. Most abundant in Gulf Coastal Plain and Delta (Maisenhelder 1958).	Tolerant.	Tolerant (Green 1947; Hall & Smith 1955; Hosner 1960; Yeager 1949).	Seeds dispersed Oct.-Nov. by wind and water. Many different birds eat the seed. Best seedbed is very moist, unshaded mineral soil. Stumps of all sizes will sprout.
CEDAR, ATLANTIC WHITE (*Chamaecyparis thyoides* (L.) B.S.P.)	Pure stands are found in muck swamps of the eastern Gulf Coast and South Atlantic Coastal Plain (Putnam et al 1960).	Tolerant (Putnam et al 1960).	Moderately tolerant (Little 1950; Silker 1948).	Seed dispersed Oct.-Mar. by wind and may remain viable on the forest floor for several years. Delayed germination of seed is common (Little 1965).

TABLE 2.3 (Continued)

Common and Scientific Name	Occurrence in Bottom Lands	Shade Tolerance	Flood Tolerance[a]	Reproductive Characteristics
CHERRY, BLACK (*Prunus serotina* Ehrh.)	Very sparse but scattered throughout on oldest alluvium and outwashes from uplands. Often in hummocks (Putnam et al 1960).	Intermediate (Putnam et al 1960).	Intolerant (Bedinger 1971; Bell & Johnson 1974; Hall et al 1946; Hall & Smith 1955).	Seeds dispersed Aug.-Nov. Birds and animals can move seeds a long distance. Seeds germinate and establish seedlings in bare mineral soil or in leaf litter. Sprouts from stumps of all sizes (Hough 1965).
COTTONWOODS				
Eastern cottonwood (*Populus deltoides* Bartr. ex Marsh. var. *deltoides*)	Widely distributed but mostly on newly deposited soil along major streams, recently abandoned fields and right-of-ways, clean burns, wet spots in pastures and banks of small drainages and ditches. Sparse on clay soils or dry sites (Putnam et al 1960).	Very intolerant (Putnam et al 1960).	Weakly to moderately tolerant. Seed will germinate in water (Bedinger 1971: Broadfoot 1967; Bull & Putnam 1941; Green 1947; Hook et al 1972; Hosner 1957, 1958, 1959, 1962; Hosner & Boyce 1962; Kennedy & Krinard 1974; Louckes & Keen 1973).	Seeds dispersed May-Aug. largely by wind and water. Seeds often remain viable for less than 2 weeks. Seeds germinate best on moist mineral soil. Can be a million trees/acre. Stumps of up to 12 inches in diameter sprout well (Maisenhelder 1965).
Swamp cottonwood (*Populus heterophylla* L.)	Widely scattered in shallow swamps, in deep sloughs, and along often flooded creek bottoms. Wet spots on low hummocks on the east coast (Putnam et al 1960).	Intermediate (Putnam et al 1960).	Moderately tolerant (Hosner 1962).	Seeds dispersed April-July largely by wind, but also by water. Seeds are short-lived. Bare, moist mineral soil is required for seedling establishment. Early growth is rapid. Stumps up to 12 inches in diameter sprout well (Johnson and Beaufait 1965a).

TABLE 2.3 (Continued)

Common and Scientific Name	Occurrence in Bottom Lands	Shade Tolerance	Flood Tolerance[a]	Reproductive Characteristics
CYPRESS				
Baldcypress (*Taxodium distichum* (L.) Rich. var. *distichum*)	Swamps, deep sloughs, borders of lake beds and poorly drained flats. Low spots and abandoned channels in creek bottoms. Commonly regenerates as dense, even-aged stands, with or without tupelos (Putnam et al 1960).	Intermediate (Putnam et al 1960).	Tolerant. Seeds remain viable in water up to 30 months (Applequist 1959; Bedinger 1971; Demaree 1932; Hall et al 1946; Hosner 1962; Langdon 1965; Louckes & Keen 1973; Mattoon 1915).	Seeds dispersed Nov.-Feb. primarily by water. Seedlings are established when the water recedes. Stumps to 20 inches in diameter may sprout, but sprouting is inconsistent (Langdon 1965; Mattoon 1915).
Pondcypress (*T. distichum* var. *nutans* (Ait.) Sweet)	Shallow piney woods swamps, perched ponds, sloughs, wet flats or Lower Coastal Plain east of the Mississippi River and headwater swamps. These sites are rarely alluvial, usually lack deep muck and often will support slash pine (Putnam et al 1960).	Intermediate (Putnam et al 1960).	Tolerant (Langdon 1965; Mattoon 1915).	Similar to baldcypress.
DOGWOODS				
Flowering dogwood (*Cornus florida* L.)	Rare in bottoms of major rivers. Common in bottoms of minor streams and on better drained sites (Putnam et al 1960).	Very tolerant (Putnam et al 1960).	Intolerant (Hall et al 1946).	Seed dispersed in Nov. by gravity, animals, and birds. Germination and seedling establishment is best on bare mineral soil in the understory or in openings. Some seed germinate the second spring after seedfall. Stumps of all sizes sprout profusely (Putnam et al 1960).

TABLE 2.3 (Continued)

Common and Scientific Name	Occurrence in Bottom Lands	Shade Tolerance	Flood Tolerance[a]	Reproductive Characteristics
Rough-leaf dogwood (*Cornus drummondii* C.A. Meyer)	Very common in the Mississippi Delta and adjacent stream and river bottoms. Grows on dry and very wet sites and on soils that range from sand to clay.	Tolerant.	Tolerant.	Seeds dispersed in fall by gravity, animals and birds. Seedlings establish best on moist soil under partial shade. Prolific stump sprouter.
ELMS				
American elm (*Ulmus americana* L.)	Widely except in swamps. Common on flats in newer alluvium (Putnam et al 1960).	Tolerant (Putnam et al 1960).	Moderately tolerant. Seed remains viable when submerged for a month (Bedinger 1971; Bell & Johnson 1974; Broadfoot & Williston 1973; Hosner 1959, 1960; Hosner & Boyce 1962; McDermott 1954; Noble & Murphy 1975; Yeager 1949; Yelenosky 1964).	Seed dispersed March-June by wind and water. Many birds and animals eat the fruit. Seeds germinate and establish seedlings on the surface of moist mineral soil or on undisturbed humus. Stumps up to 15 inches in diameter sprout profusely (Guilkey 1965).
Cedar elm (*U. crassifolia* Nutt.)	Widely on high flats, poorly drained ridges, usually impervious silty clay soils. Restricted to bottoms of major streams of lower Mississippi Valley and Gulf Coast (Putnam et al 1960).	Tolerant (Putnam et al 1960).	Moderately tolerant (Hosner 1962).	Seeds dispersed in Oct.-Nov. largely by wind and water. Seedlings establish in shade or in openings on the surface of moist, bare mineral soil. Stumps to 12 inches sprout well. Larger stumps are not consistent sprouters.

TABLE 2.3 (Continued)

Common and Scientific Name	Occurrence Bottom Lands	Shade Tolerance	Flood Tolerance[a]	Reproductive Characteristics
Slippery elm (*U. rubra* Muhl.)	Occasionally on banks of secondary streams, mostly in northern and western parts of territory (Putnam et al 1960).	Tolerant (Putnam et al 1960).	Intolerant (Yeager 1949).	Seeds dispersed Apr.-June largely by wind and less by water. New seedlings begin in the shade and in openings from germination on the surface of moist, usually well drained soil. Stumps to 12 inches sprout well. Larger stumps are not consistent sprouters (Scholz 1965).
Winged elm (*U. alata* Michx.)	Widely on ridges and high flats of older alluvial soils or terraces. General in creek bottoms and hummocks (Putnam et al 1960).	Tolerant (Putnam et al 1960).	Weakly tolerant to intolerant (Bedinger 1971; Hall & Smith 1955; Hosner 1962; McDermott 1954).	Seeds dispersed in April by wind and water. Seedlings occur largely in new openings. Stumps to 12 inches in diameter sprout well.
Water elm (*Planera aquatica* J.F. Gmel.)	Widely distributed in swamps, deep sloughs or low, poorly drained flats in bottom lands of the Southeast. Usually found on clay soils covered with water for a portion of the year (Maisenhelder 1958).	Tolerant.	Tolerant (Hall & Smith 1955).	Fruit ripens in April. Seedlings establish after water recedes either in shaded or open areas. Good stump sprouter.

TABLE 2.3 (Continued)

Common and Scientific Name	Occurrence in Bottom Lands	Shade Tolerance	Flood Tolerance[a]	Reproductive Characteristics
GUMS				
Sweetgum (*Liquidambar styraciflua* L.)	On almost all sites but swamps and wettest flats. Best development generally on clay loam ridges of newer alluvium; next best on well drained, silty clay loam flats on newer alluvium and in hummocks (Putnam et al 1960).	Intolerant. Competes with lower vegetation but cannot stand overtopping (Putnam et al 1960).	Moderately tolerant (Bedinger 1971; Broadfoot 1967; Broadfoot & Williston 1973; Hall & Smith 1955; Hook & Brown 1973; Hosner 1958, 1960, 1962; Hosner & Boyce 1962; Kennedy & Krinard 1974; Noble & Murphy 1975).	Prolific seeder. Good seed crop almost every year. Germinates best on mineral soil in full sunlight. Sprouts prolifically from roots and stumps (Putnam et al 1960).
Black tupelo (*Nyssa sylvatica* Marsh. var. *sylvatica*)	Limited to ridges, high flats, and terraces and small creek bottoms (Putnam et al 1960).	Intermediate (Putnam et al 1960).	Weakly tolerant (Bedinger 1971; Hall & Smith 1955).	Seeds dispersed Sept.-Nov. Animals carry some seed; others float. Germination and seedling establishment occurs only on dry soil. Stumps to 12 inches in diameter sprout well.
Ogeechee tupelo (*N. ogeche* Bartr. ex.Marsh.)	Limited to blackwater streams and coastal swamps of South Carolina, Georgia, and northern Florida (Putnam et al 1960).	Intolerant (Putnam et al 1960).	Tolerant (Scheer 1965).	Seeds dispersed Oct.-Dec. Birds and animals may move some seed. Seeds survive in water for several months and will produce seedlings when the water recedes. Sprouts prolifically from stumps (Scheer 1965).

TABLE 2.3 (Continued)

Common and Scientific Name	Occurrence in Bottom Lands	Shade Tolerance	Flood Tolerance[a]	Reproductive Characteristics
Swamp tupelo (*N. sylvatica* var. *biflora* (Walt.) Sarg.)	Most common in non-alluvial swamps and ponds of the Atlantic and Gulf Coastal Plain east of the Mississippi River. Also in seepage areas of upland and on edges of secondary and minor bottoms.	Intermediate. Tolerates dense, codominant, but not overtopping competition. Stagnates in dense stands in ponds and muck swamps. Responds to release (Putnam et al 1960).	Tolerant. Seeds remain viable for months submerged in water (Briscoe 1957; Hall & Smith 1955; Harms 1973; Hook et al 1970a, 1970b; Hook et al 1971).	Good to excellent seed crops. Seeds disperse primarily by birds. Seed does not float. Germinates best in partial shade on a moist seedbed. Stump sprouts produce viable seeds in second year (DeBell & Hook 1969; DeBell 1971; Priester 1980).
Water tupelo (*N. aquatica* L.)	Throughout region but almost exclusively in swamps of floodplains of alluvial streams. Otherwise only in deepest part of non-alluvial swamps with live streams (Putnam et al 1960).	Intolerant. Tolerates codominant, but not overtopping competition. Responds to release (Putnam et al 1960).	Tolerant. Seeds remain viable for months submerged in water (Briscoe 1957; Dickson et al 1965; Hall & Smith 1955; Harms 1973; Hosner 1962; Hosner & Leaf 1962; Hook et al 1970b; Hook et al 1971; Hook & Brown 1973; Kennedy 1970; Shunk 1939).	Good to excellent seed crops nearly every year. Seeds disperse by water and small animals. Requires full sunlight and a moist seedbed for satisfactory germination. Stump sprouts produce viable seed in second year (Priester 1980).

TABLE 2.3 (Continued)

Common and Scientific Name	Occurrence in Bottom Lands	Shade Tolerance	Flood Tolerance[a]	Reproductive Characteristics
HACKBERRY AND SUGARBERRY (*Celtis occidentalis* L. and *C. laevigata* Willd.)	Widely except in swamps. Most common on flats and riverfronts of new alluvium. Sparse on ridges, old alluvium, hummocks and bottoms of former streams (Putnam et al 1960).	Very tolerant. Endures indefinitely in shade of tolerant trees (Putnam et al 1960).	Moderately tolerant to intolerant. Seeds remain viable for months submerged in water (Bedinger 1971; Bell & Johnson 1974; Broadfoot 1967; Green 1947; Hall & Smith 1955; Hosner 1959, 1960; Hosner & Boyce 1962; Yeager 1949).	Seeds dispersed Oct.-Jan. by birds, animals and water. Seedlings frequently occur in nearly full shade. Stumps to 12 inches in diameter sprout well (McKnight 1965a).
HAWTHORN (*Crataegus* L. spp.)	Widely distributed in the South. Dry, sandy, stony ridges to moist river bottoms and in margins of swamps (Halls 1977).	Intermediate to intolerant (Halls 1977).	Moderately tolerant (Bedinger 1971; Hall & Smith 1955; Hosner 1962; Yeager 1949).	Seeds dispersed in the fall and winter. They provide food for many different birds and animals. Does not readily establish seedlings. Once established, though, trees are good sprouters.
HICKORIES AND PECAN				
Water hickory (*Carya aquatica* (Michx. f.) Nutt.)	Widely, but common only on flats, sloughs, and margins of swamps of major alluvial streams. Occasionally on low clay ridges. Most abundant on flats of backwater basins (Putnam et al 1960).	Intermediate (Putnam et al 1960).	Moderately tolerant (Bedinger 1971; Broadfoot 1967; Hall et al 1946; Hosner 1962).	Seeds dispersed Oct.-Dec. by gravity, water, animals, and birds. Seeds may be submerged in water until May or June. Seedlings occur in the understory, but are more common in new openings. Stumps to 20 inches in diameter sprout profusely (Johnson & Beaufait 1965b).

TABLE 2.3 (Continued)

Common and Scientific Name	Occurrence in Bottom Lands	Shade Tolerance	Flood Tolerance[a]	Reproductive Characteristics
Shellbark hickory (*Carya laciniosa* (Michx. f.) Loud.)	Limited primarily to upper Mississippi Delta and Ohio and Missouri River drainages. On river terraces and on loamy flats in second bottoms. Does not thrive in heavy clay soils, but grows well in clay loam or silt loams. It will grow on dry, sandy soils (Merz 1965a).	Very tolerant (Merz 1965a).	Weakly tolerant (Bedinger 1971).	Seeds dispersed Oct.-Dec. by gravity, animals, and birds. Sound seed will not float. Seeds germinate and establish seedlings in the understory and in openings. Persistent stump sprouter (Merz 1965a).
Pecan (*C. illinoensis* (Wangenh.) K. Koch)	Occurrence restricted to Mississippi floodplain and west Gulf areas on recent river fronts with loamy soils. Not native in east Gulf or Atlantic Coastal Plain rivers (Putnam et al 1960).	Intolerant (Putnam et al 1960).	Weakly tolerant (Hosner 1962; Kennedy & Krinard 1974; Louckes & Keen 1973; Noble & Murphy 1975; Yeager 1949).	Seeds dispersed Sept.-Dec. Many different birds and animals eat pecans both on and off the tree. Pecans establish seedlings best an inch or so under the soil. Seeds are usually not submerged in water for long periods. Stumps to 12 inches in diameter sprout well.
HOLLIES				
American holly (*Ilex opaca* Ait.)	Principally in minor stream bottoms. Also on high ridges of oldest alluvium and hummocks (Putnam et al 1960).	Very tolerant (Putnam et al 1960).	Weakly tolerant (Hall & Smith 1955; Yeager 1949).	Seeds dispersed Nov.-Mar. Birds and animals eat much of the fruit. Seedlings appear in the understory and in openings. Stumps of all sizes sprout prolifically.

TABLE 2.3 (Continued)

Common and Scientific Name	Occurrence in Bottom Lands	Shade Tolerance	Flood Tolerance[a]	Reproductive Characteristics
Possumhaw (*Ilex decidua* Walt.)	On lowlands, in margins of swamps, stream margins, and in rich upland soils, usually as an understory tree in mixed hardwood forests. Widely scattered throughout region (Maisenhelder 1958).	Very tolerant.	Moderately tolerant (Hosner 1962).	Seeds dispersed Sept.-Mar. Seedlings start in the shade and in openings. Prolific stump sprouter (Halls 1977).
HOPHORNBEAM, EASTERN (*Ostrya virginiana* (Mill.) K. Koch)	Usually an understory tree. On slopes and ridges and occasionally in bottoms.	Very tolerant.	Intolerant (Hall & Smith 1955; Hosner 1962).	Seeds dispersed in the fall. Seedling stands are often very dense in both the understory and new openings. Best seedbed is moist mineral soil. Stumps of all sizes sprout vigorously.
HORNBEAM, AMERICAN (*Carpinus caroliniana* Walt.)	An understory tree found in deep, rich, moist loams along stream margins, swamp margins, and wet bottoms.	Very tolerant.	Weakly tolerant (Hall & Smith 1955; Hosner 1962).	Seeds dispersed from fall to spring. They are moved a short distance by wind, but disseminated largely by birds. Seedlings establish readily on moist, mineral or humus-covered soil in the understory or in openings. Excellent stump sprouter.

TABLE 2.3 (Continued)

Common and Scientific Name	Occurrence in Bottom Lands	Shade Tolerance	Flood Tolerance[a]	Reproductive Characteristics
LOCUSTS				
Honeylocust (*Gleditsia triacanthos* L.)	Scattered widely in large bottoms on all sites except swamps and sloughs. Not in Atlantic Coastal Plain and not common in Mississippi floodplain (Putnam et al 1960).	Intolerant (Putnam et al 1960).	Moderately tolerant (Bedinger 1971; Broadfoot 1967; Hall & Smith 1955; Hosner 1962; Noble & Murphy 1975; Yelenosky 1964).	Seeds dispersed Sept.-Feb. by wind, birds, animals, and sometimes water. New seedlings occur in forest openings, seldom in the understory. Sprouts vigorously from stumps (Funk 1965).
Waterlocust (*G. aquatica* Marsh.)	Scattered widely in nearly all alluvial swamps, sloughs, and wet flats. Scarce in Atlantic Coastal Plain (Putnam et al 1960).	Intolerant (Putnam et al 1960).	Moderately tolerant (Bedinger 1971; Hosner 1962; Yeager 1949).	Seeds dispersed Sept.-Dec. by birds, animals, and water. Germination best on moist mineral soil. Dense stands usually occur only in openings. Sprouts vigorously from stumps (Putnam et al 1960).
MAGNOLIAS AND BAYS				
Loblolly-bay (*Gordonia lasianthus* (L.) Ellis)	Swamps, bays, and wet sites in pine barrens of Coastal Plain.	Intermediate.	Moderately tolerant (Hosner 1962).	Seeds dispersed in the fall. Detailed information on reproduction unavailable.
Redbay (*Persea borbonia* (L.) Spreng.)	Primarily found on wet pine and hardwood flats and bays in Atlantic Coastal Plain. Rare in Mississippi Delta and other alluvial sites. Occurs with loblolly, pond, and slash pines (Putnam et al 1960).	Tolerant (Putnam et al 1960).	Moderately tolerant to tolerant (Hosner 1962).	Seeds dispersed in the fall. The fruit is eaten by game and non-game birds. Germinates in the understory and in forest openings. Fire stimulates seed germination. Good stump sprouter (Halls 1977).

TABLE 2.3 (Continued)

Common and Scientific Name	Occurrence in Bottom Lands	Shade Tolerance	Flood Tolerance[a]	Reproductive Characteristics
Southern magnolia (*Magnolia grandiflora* L.)	Lower Coastal Plain and Mississippi Delta on old alluvium and outwashes. More common in minor or secondary stream bottoms, hummocks and wet flats (Putnam et al 1960).	Tolerant (Putnam et al 1960).	Weakly tolerant to intolerant (Bennett 1965).	Prolific seeder. Seeds dispersed Sept.-Dec. Seeds are part of the diet of a number of different birds and animals. Germination is low; seedlings are scattered--usually in the understory. Good stump sprouter (Bennett 1965).
Swamp bay (*Persea borbonia* var. *pubescens* (Pursh) Little)	Pinebarren swamp--margins and river bottoms in Atlantic and Gulf Coastal Plain.	Tolerant.	Moderately tolerant.	Seeds dispersed in the fall. Fruit is eaten by game and non-game birds. Seedlings establish in the understory and in forest openings. Good stump sprouter.
Sweetbay (*Magnolia virginiana* L.)	Primarily east of Mississippi River in edges of headwater and muck swamps and pocosins (Putnam et al 1960).	Moderately tolerant (Putnam et al 1960).	Moderately tolerant.	Seeds dispersed in Sept.-Nov. Squirrels, other animals, and birds eat the seed, as do cattle. Seedlings start in the shade and in openings (Halls 1977).

TABLE 2.3 (Continued)

Common and Scientific Name	Occurrence in Bottom Lands	Shade Tolerance	Flood Tolerance[a]	Reproductive Characteristics
MAPLES				
Boxelder (*Acer negundo* L.)	Generally on river fronts of major streams, particularly along the Mississippi River south of Memphis, and scattered throughout bottom lands on ridges and high flats of new alluvium, except not common in Atlantic Coastal Plain streams (Putnam et al 1960).	Moderately tolerant (Putnam et al 1960).	Moderately tolerant (Bedinger 1971; Bell & Johnson 1974; Hosner 1958, 1960, 1962; Hosner & Leaf 1962; Hosner & Boyce 1962; Louckes & Keen 1973; Noble & Murphy 1975).	Seeds dispersed Sept.-Mar. by wind, birds, and small animals. Best germination on moist mineral soil in shade or openings. Prolific stump sprouters.
Florida maple (*A. barbatum* Michx.)	Sparsely on high, better drained sites in second bottoms primarily in lower Coastal Plain (Putnam et al 1960).	Tolerant (Putnam et al 1960).	Weakly tolerant.	Seeds dispersed Oct.-Dec. by wind, birds, and small animals. Best germination on moist, mineral soil in shade or openings. Seedlings are scattered. Prolific stump sprouter.
Red maple (*A. rubrum* L.)	Scattered throughout southern bottom land. Most common in low, wet flats and edges of headwater swamps (Putnam et al 1960).	Tolerant (Putnam et al 1960).	Moderately tolerant. Seeds remain viable when submerged in water for one month (Hall & Smith 1955; Hosner 1957, 1960, 1962; Hosner & Leaf 1962; Hosner & Boyce 1962; McDermott 1954; Williston 1959).	Seeds dispersed Mar.-July by wind, water, birds, and small animals. Best germination on moist mineral soil in shade or openings--often after water recedes. Prolific stump sprouter (Hutnik & Yauney 1965).

TABLE 2.3 (Continued)

Common and Scientific Name	Occurrence in Bottom Lands	Shade Tolerance	Flood Tolerance[a]	Reproductive Characteristics
Silver maple (*A. saccharinum* L.)	Riverfronts and stream banks in northern part of Mississippi Delta, especially north of Memphis, and along major streams. Not common in Atlantic Coastal Plain (Putnam et al 1960).	Moderately tolerant to intolerant (Putnam et al 1960; Weitzman & Hutnik 1965).	Moderately tolerant. Seed remain viable when submerged in water for one month (Green 1947; Hosner 1957, 1958, 1960, 1962; Hosner & Leaf 1962; Hosner & Boyce 1962; Louckes & Keen 1973; Yeager 1949).	Seeds dispersed Apr.-June by wind, water, birds, and small animals. Best germination on moist mineral soil--may occur in dense stands particularly in openings. Prolific stump sprouter (Weitzman & Hutnik 1965).
MULBERRY, RED (*Morus rubra* L.)	Scattered widely except in swamps, sloughs, and ridges of old alluvium. Most common on heavy, moist but well drained soils in first bottom (Putnam et al 1960).	Very tolerant (Putnam et al 1960).	Weakly tolerant to intolerant (Yeager 1949).	Seeds dispersed June-Aug. frequently by birds and animals. Seedlings occur in shade or in openings, usually as scattered individuals. Sprouts prolifically from all size stumps (Putnam et al 1960).
OAKS				
Cherrybark oak (*Quercus falcata* var. *pagodifolia* Ell.)	Widely on best loamy sites on all river bottom ridges and better drained creek bottoms and hummocks. Mostly on older alluvium. Occasionally on tight, silty clay, but grows poorly there (Putnam et al 1960).	Moderately intolerant to intolerant (Putnam et al 1960).	Weakly tolerant to intolerant. Seedlings can withstand very little flooding. Viability of acorns greatly reduced by submersion (Briscoe 1961; Broadfoot & Williston 1973; Hosner 1960, 1962; Hosner & Boyce 1962).	Seeds dispersed Sept.-Dec. by gravity, birds, and animals--seldom by water. Seedlings may start in shade, but cannot survive long. Not a good stump sprouter (Lotti 1965a).

TABLE 2.3 (Continued)

Common and Scientific Name	Occurrence in Bottom Lands	Shade Tolerance	Flood Tolerance[a]	Reproductive Characteristics
Delta post oak (*Q. stellata* var. *paludosa* Sarg.)	Large bottoms of the lower Mississippi Valley only. Well drained silty clay and loam sites of older alluvium (Putnam et al 1960).	Intermediate (Putnam et al 1960).	Weakly tolerant to intolerant (Bedinger 1971; Hosner 1962).	Seeds dispersed in the fall by gravity, birds, animals, and sometimes water. Seedlings are scattered, but most common in openings. Stumps are not good sprouters.
Laurel oak (*Q. laurifolia* Michx.)	Near coast on wet flats, on margin of swamps and occasionally on low clay ridges or even sandy loam ridges of blackwater streams of the Gulf and Atlantic Coastal Plain (Putnam et al 1960).	Intermediate to intolerant (Putnam et al 1960).	Moderately to weakly tolerant. Seedlings tolerant to flooding (Hosner 1962).	Seeds dispersed Sept.-Dec. by gravity, birds, animals, and sometimes water. Seedlings may be dense over small areas either in shade or openings. Sprouts prolifically when cut or burned (Halls 1977).
Live oak (*Q. virginiana* Mill.)	On sandy, well-drained soils of Atlantic and Gulf Coastal Plain, and borders coastal marshes.	Intolerant.	Weakly tolerant to intolerant. Resistant to salt spray (Woods 1965).	Seeds dispersed Sept.-Nov. by gravity, birds, and animals. A favorite food of wildlife. Sprouts abundantly from the root-collar and roots (Woods 1965).

TABLE 2.3 (Continued)

Common and Scientific Name	Occurrence in Bottom Lands	Shade Tolerance	Flood Tolerance[a]	Reproductive Characteristics
Nuttall oak (*Q. nuttallii* Palmer)	Widely on flats, low ridges, shallow sloughs, and near margin of swamps, in recent alluvial sites. On older alluvium mainly restricted to wet, heavy but not impervious sites. Restricted to major streams entering the Gulf and their large tributaries (Putnam et al 1960).	Intolerant (Morris 1965a).	Moderately tolerant. Seedlings killed by high water during growing season. Viability of acorns not reduced by 34 days of submergence (Bedinger 1971; Briscoe 1961; Hosner 1962; Kennedy & Krinard 1974; Morris 1965a).	Starts readily in either shade or openings but soon dies in shade. Persists against all ground cover but heavy peppervine. Many large trees are of sprout origin (Putnam et al 1960).
Overcup oak (*Q. lyrata* Walt.)	Widely on poorly drained heavy soils of major alluvial bottoms. Scattered on better sites, mainly on newer alluvium. Prevalent in shallower sloughs, on margins of swamps, and in backwater areas. Throughout region in all alluvial bottoms and low hummocks but principally in lower Mississippi Valley and Gulf region (Putnam et al 1960).	Moderately intolerant (Putnam et al 1960).	Moderately tolerant. Seedlings among the most tolerant of oaks to water (Hall & Smith 1955; Hosner 1962).	Seed dispersed Sept.-Nov. by birds, animals, and water. Acorns tolerate 4+ months of submergence in water, and germinate best on moist mineral soil. Sprouting restricted to small stumps (Morris 1965b).

TABLE 2.3 (Continued)

Common and Scientific Name	Occurrence in Bottom Lands	Shade Tolerance	Flood Tolerance[a]	Reproductive Characteristics
Pin oak (*Q. palustris* Muenchh.)	Northern Delta and major tributaries. In northern Coastal Plain also. In first bottoms and terraces in wet flats with heavy or impervious soils (Putnam et al 1960).	Intolerant (Putnam et al 1960).	Moderately tolerant. Seedlings among most tolerant of oaks to water (Bedinger 1971; Bell & Johnson 1974; Dickson et al 1965; Green 1947; Hosner 1959, 1960, 1962; Hosner & Boyce 1962; Yeager 1949).	Seed dispersed in Sept.-Dec. by water, gravity, birds and small animals. Can establish dense seedling stands over a wide area. Small stumps sprout vigorously (Minckler 1965a).
Shumard oak (*Q. shumardii* Buckl.)	Mainly on terraces in older alluvium and outwash from upland and well drained creek bottoms and hammocks. Rare on newer soils. Widely distributed but scattered (Putnam et al 1960).	Intolerant (Putnam et al 1960).	Weakly tolerant. Seedlings relatively intolerant to flooding (Bedinger 1971; Hosner 1960, 1962).	Seed dispersed Sept.-Dec. by gravity and animals, largely by squirrels and rarely by water. Establishes as scattered individuals in shade or openings. A poor sprouter (Lotti 1965b).
Swamp chestnut oak (cow oak) (*Q. michauxii* Nutt.)	Common in large creek bottoms and hummocks on best, well drained loamy ridges. Occasionally on a wet, silty clay, high flat. Rarely on best, most mature recent alluvium, but typically a tree of older alluvium sites (Putnam et al 1960).	Moderately intolerant (Lotti 1965c; Putnam et al 1960).	Weakly tolerant. Seedling intolerant to flooding (Hall & Smith 1955; Hook 1969; Hosner 1962).	Seed dispersed Oct.-Dec. by gravity and animals, primarily squirrels. Seed germinates soon after seedfall. Best seedbed is moist and well-drained with a light cover of leaves. Seedlings require full sunlight for best development. Small stumps sprout well (Lotti 1965c).

TABLE 2.3 (Continued)

Common and Scientific Name	Occurrence in Bottom Lands	Shade Tolerance	Flood Tolerance[a]	Reproductive Characteristics
Water oak (*Q. nigra* L.)	Widely on loam ridges in first bottoms and on any ridge and silty clay flats in second bottoms or terraces (Putnam et al 1960).	Intolerant (Putnam et al 1960; Toole 1965a).	Weakly to moderately tolerant. Prolonged submergence of seedlings during growing season will kill the trees (Bedinger 1971; Broadfoot & Williston 1973; Hall & Smith 1955; Hosner 1962).	Seed dispersed Sept.-Nov. by gravity, birds, animals, and water. Seedlings establish best on moist, well-aerated soil. Small stumps sprout readily (Toole 1965a).
White oak (*Q. alba* L.)	Widely on well drained oldest alluvium. Common in better drained creek bottoms in the upper Coastal Plain. Not a primary bottomland species (Putnam et al 1960).	Intermediate (Minckler 1965b).	Intolerant to weakly tolerant. Seedlings intolerant to flooding (Bedinger 1971; Bell & Johnson 1974; Hosner 1962; Williston 1959; Yelenosky 1964).	Seeds dispersed Sept.-Nov. by gravity and squirrels. Seed germinates soon after seedfall. Seedlings may occur in dense stands or scattered individuals in shade or open. Require well drained, aerated soil. Small stumps sprout well (Minckler 1965b).
Willow oak (*Q. phellos* L.)	Widely on ridges and high flats of major streams. Less common in creek bottoms. May form nearly pure stands of poor quality on hardpan terrace soils. Grows best on flats of old alluvium and on clay loam ridges of new alluvium (Putnam et al 1960).	Intolerant (Putnam et al 1960; Toole 1965b).	Weakly to moderately tolerant. Seedlings, among oaks, are one of the more tolerant to water, but prolonged submergence during growing season is fatal (Bedinger 1971; Hall & Smith 1955; Hosner 1962; Hosner & Boyce 1962).	Seeds dispersed Oct.-Dec. by gravity, birds, animals and water. Good seedling crops not unusual. Stumps under 12 inches in diameter sprout well (Toole 1965b).

TABLE 2.3 (Continued)

Common and Scientific Name	Occurrence in Bottom Lands	Shade Tolerance	Flood Tolerance[a]	Reproductive Characteristics
PAWPAW (*Asimina triloba* (L.) Dunal)	Along streams and in bottoms, usually as understory. In lower Mississippi Valley, forms vast, dense thickets on moist bottoms.	Very tolerant.	Intolerant (Hall & Smith 1955).	Seeds dispersed Aug.-Oct. by gravity, birds, and small animals. Seedlings start in the shade and in openings in sometimes dense stands. Stumps of all sizes are good sprouters.
PERSIMMON, COMMON (*Diospyros virginiana* L.)	Scattered widely on wet flats, shallow sloughs, and margins of swamps. Rare in creek bottoms. Grows best in new alluvium in big bottoms. However, it is not primarily a bottom-land species (Putnam et al 1960).	Tolerant (Putnam et al 1960).	Moderately tolerant. Seedlings are relatively tolerant to flooding (Hall & Smith 1955; Hosner 1962; Yeager 1949).	Seeds dispersed Oct.-Dec. by animals and birds that feed on fruit. Seedlings occur in the understory and in openings. They are common on dry sites and old fields. Stumps and roots sprout readily (Morris 1965c).
PINES				
Loblolly pine (*Pinus taeda* L.)	Mainly on terraces and colluvial outwashes of smaller rivers and highest ridges in creek bottoms and at edges and on hummocks in headwater swamps of Atlantic Coastal Plain. Reaches optimum growth on such sites (Putnam et al 1960).	Moderately tolerant to intolerant. Seedlings more tolerant than older trees (Wahlenberg 1960).	Moderately tolerant. Seedlings will survive and grow under soil saturated and flooded conditions (Burton 1971; Hall & Smith 1955; Hunt 1951; Kennedy & Krinard 1974; Pruitt 1947; Ralston 1965; Wahlenberg 1960; Walker 1962; Walker et al 1961; Williston 1962).	Seeds dispersed Oct.-Dec. by wind. Seeds germinate in spring. Best seedling establishment is on a mineral or burned seedbed (Wahlenberg 1960).

TABLE 2.3 (Continued)

Common and Scientific Name	Occurrence in Bottom Lands	Shade Tolerance	Flood Tolerance[a]	Reproductive Characteristics
Pond pine (*Pinus serotina* Michx.)	Occurs along the margins of swamps, wet flats, pocosins, and bays of the east Gulf and Atlantic Coastal Plain (Wenger 1965).	Intolerant (Wenger 1965).	Moderately tolerant (Wenger 1965).	Serotinous cones are opened by heat. Seed dispersed by wind throughout the year. Exposed mineral soil is the best seedbed. Pond pine sprouts readily from seedling stages to advanced ages. Natural regeneration from seed requires measures to open cones and prepare seedbeds (Wenger 1965).
Slash pine (*P. elliottii* Engelm. var. *elliottii*)	In southern Atlantic Coastal Plain and Gulf Coastal Plain. Margins or borders and on hummocks in muck swamps and bays (Putnam et al 1960).	Intolerant (Putnam et al 1960).	Moderately tolerant. Seedlings will survive long periods of flooding and up to a month or so of submersion (Briscoe 1957; McMinn & McNab 1971; Pruitt 1947; Ralston 1965; Walker 1962; Walker et al 1961).	Seeds dispersed Oct.-Nov. by wind. Seeds germinate in winter. Seedling establishment is best on moist, mineral soil.

TABLE 2.3 (Continued)

Common and Scientific Name	Occurrence in Bottom Lands	Shade Tolerance	Flood Tolerance[a]	Reproductive Characteristics
Spruce pine (*P. glabra* Walt.)	East of Mississippi River on well-drained, high ridges of first bottoms and better terrace sites of lower Coastal Plain and some hummocks. Scattered in small stands or pockets (Putnam et al 1960).	Moderately intolerant (Putnam et al 1960).	Weakly tolerant.	Seeds dispersed Oct.-Nov. by wind and water. Seedlings establish best on moist, exposed mineral soil in shade or in openings.
SASSAFRAS (*Sassafras albidum* (Nutt.) Nees)	Scattered widely on well-drained sites. Not a common bottomland species (Putnam et al 1960).	Intolerant (Halls 1977; Putnam et al 1960).	Intolerant (Hall & Smith 1955; Hosner 1962).	Seeds dispersed Sept.-Oct. by gravity and birds. Best seedbed is a moist, loamy soil with leaves and litter. Seedlings often occur in dense stands. They are rapid growers on good soil and in openings. Roots and stumps sprout vigorously (Halls 1977).
SYCAMORE, AMERICAN (*Platanus occidentalis* L.)	Widely on fronts of major streams and on banks of minor streams; elsewhere on bare areas and washes of light, moist soils (Putnam et al 1960).	Moderately intolerant to intolerant (Merz 1965b; Putnam et al 1960).	Moderately tolerant. Seed remain viable when submerged in water one month (Bedinger 1971; Bell & Johnson 1974; Briscoe 1959; Dickson et al 1965; Hook & Brown 1972, 1973; Hook & Scholtens 1978; Hosner 1957, 1959, 1960, 1962; Hosner & Boyce 1962; Kennedy & Krinard 1974; McDermott 1954; Yeager 1949).	Seeds dispersed Jan.-Apr. by wind, water, and sometimes birds. Seedlings establish best on moist mudflats or other exposed mineral soil but will not tolerate prolonged flooding. Stumps sprout prolifically (Merz 1965b).

TABLE 2.3 (Continued)

Common and Scientific Name	Occurrence in Bottom Lands	Shade Tolerance	Flood Tolerance[a]	Reproductive Characteristics
SWAMP-PRIVET (*Forestiera acuminata* (Michx.) Poir.)	Swamps and wet flats, and low-lying areas. Most abundant in northern Delta and Gulf Coastal Plain. Attains largest size in Louisiana (Maisenhelder 1958).	Tolerant (Maisenhelder 1958).	Tolerant (Green 1947; Yeager 1949).	Seeds dispersed June-July by water and birds. Prolonged submergence in water does not reduce viability of seed. The seed is eaten by ducks. Best seedbed is moist mineral soil. Stumps of all sizes sprout prolifically (Maisenhelder 1958).
WALNUT, BLACK (*Juglans nigra* L.)	Mainly in northern parts of region on best-drained loamy sites. Not common in major bottoms except in Delta of Tennessee and Missouri. Typically a creek bottom species (Putnam et al 1960).	Intolerant (Brinkman 1965; Putnam et al 1960).	Weakly tolerant. Walnut seedlings intolerant of water (Bell & Johnson 1974; Hosner 1962; Kennedy & Krinard 1974; Louckes & Keen 1973).	Seeds dispersed Oct.-Nov. by gravity and animals. Seed often remain dormant until second spring after seedfall. Seedlings occur singly or in small patches, mainly in forest openings. Small stumps sprout freely (Brinkman 1965).
WILLOWS				
Black willow (*Salix nigra* Marsh.)	Margins and batture sloughs of larger Coastal Plain rivers and Mississippi River system. Also on ditch banks and swamps during development periods. Abundant in good quality only on Mississippi River system (Putnam et al 1960).	Very intolerant (McKnight 1965b; Putnam et al 1960).	Tolerant. Seed will germinate in water (Green 1947; Hall & Smith 1955; Hosner 1957, 1962; Yeager 1949).	Seeds dispersed Apr.-July by wind and water. Seeds must reach the seedbed in 24 hours. Very moist, exposed and unshaded mineral soil is the best seedbed. Nearly a million trees/acre can start. Stumps of small trees sprout vigorously (McKnight 1965b).

TABLE 2.3 (Continued)

Common and Scientific Name	Occurrence in Bottom Lands	Shade Tolerance	Flood Tolerance[a]	Reproductive Characteristics
Sandbar willow (*S. exigua* Nutt.)	Along river margins on new low bare bars and towheads. Occurs in Mississippi floodplain (Putnam et al 1960).	Very intolerant. Black willow usually shades out sandbar willow in dense stands (Putnam et al 1960).	Moderately tolerant. Seedlings tolerate flooding and sedimentation very well (Hall et al 1946).	Seeds dispersed Apr.-May by wind and water. Pure seedling stands start on moist, unshaded, exposed soil such as sandbars. Stumps and roots sprout prolifically (Putnam et al 1960).
YELLOW-POPLAR (*Liriodendron tulipifera* L.)	Most abundant in Atlantic Coastal Plain and east Gulf Coastal Plain. Mainly on natural terraces of minor streams. Occasionally on margins of muck and headwater swamps (Putnam et al 1960).	Intolerant (Putnam et al 1960; Renshaw and Doolittle 1965).	Intolerant. Seedlings will not tolerate flooding (Hall & Smith 1955; Hosner 1962; Kennedy & Krinard 1974; McAlpine 1959, 1961; Yelenosky 1964). Seedlings of the yellow-poplar swamp ecotype are more tolerant to soil saturation than are seedlings of other ecotypes (Schultz and Kormanik 1975).	Seeds dispersed Oct.-Mar. by wind to distance of four to five times the height of the seed tree. Seeds remain viable in forest floor for many years. Seedlings establish best on moist seedbeds of mineral soil. Seedlings survive only in full sunlight. Stumps will sprout readily (Renshaw and Doolittle 1965).