To the Graduate Council:

I am submitting herewith a thesis written by Rogers Menzies Steed entitled "Soil/Site-Forest Cover Relationships within the Hatchie River Floodplain of West Tennessee." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Forestry.

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SOIL/SITE-FOREST COVER RELATIONSHIPS WITHIN THE HATCHIE RIVER FLOODPLAIN OF WEST TENNESSEE

A Thesis
Presented for the
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Degree
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Rogers Menzies Steed

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ABSTRACT

Changing land use along with timber kills due to inundation and sedimentation have resulted in a rapid decline in the bottomland hardwood resource of West Tennessee. Lands which have been cleared or on which drainage patterns are changing depend primarily on soil/site factors when determining tree suitability. The opportunity for obtaining base-line data from undisturbed forest stands is rapidly disappearing due to channelization, sedimentation, impoundment by beaver and man, and land clearing.

Species composition of the forest cover and 44 soil/site variables were sampled on 127 plots from relatively undisturbed bottomland hardwood stands on the Hatchie National Wildlife Refuge. Correlation and stepwise multiple regression were used to support field observations and to identify relationships between and among soil/site variables and the absolute basal area of 33 tree species plus a dead tree category.

The soils of the floodplains of West Tennessee are principally of the Collins-Falaya-Waverly catena and the characteristic which is used to distinguish one series from another is the depth to and degree of gray mottles.

Forest cover was characterized according to six mottling depth classes, each progressively deeper. These

classes were thinner and more detailed than the boundaries used for the drainage classification.

Two broad types were derived, hydroseric and mesic, each of which contained several forest communities. The hydroseric type occupied swamps, sloughs, ox bow lake margins, and low flats which were inundated for extended periods during the year. Three distinct communities, a tupelo gum, a baldcypress, and an overcup oak community, occurred at distinguishable levels of mottling and/or gleying at the soil surface. The mesic type was located on sites which were subject to flooding but were generally free of surface water most of the growing season. The communities were less discrete than those on hydroseric sites, and there was gradual transition from one forest type to another along a hydric gradient as follows: (1) sweetgum-willow oak-overcup oak community, (2) sweetgum-cherrybark oak-swamp chestnut oak community, (3) sweetgum-swamp chestnut oak-water oak-shagbark hickory community, and (4) American beech-yellow-poplar community.

Soil/site variables significant in the regression equations of eight dominant species were: (1) topographic position, (2) microsite, (3-4) texture of the A and C_1 horizons, (5) depth to mottling, (6) depth to gleying, and (7) amount of available potassium at a depth of 30 to 60 cm. These suggest that the degree and duration of flooding for the hydric sites and available moisture for the mesic sites determine species composition. An increase in the change of flooding patterns results in an increase in the number of dead trees as depth to mottling decreased. This indicates that the forest cover on the floodplains of West Tennessee will gradually increase in the hydric type and decrease in the mesic type. Drainage class was too general to be an effective tool in predicting site-type, especially for the hydric communities. However, a more detailed classification using depth to mottling proved to be a good indicator of species composition on these poorly drained areas.

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CHAPTER I

INTRODUCTION

Changing land use in the alluvial valleys of the Mississippi Embayment has resulted in a rapid decline of the bottomland hardwood cover types (Sternitzke, 1975 and 1976). High value and public support of farm prices, and flood control and major drainage projects will continue to diminish this resource.

As early as 1818, fertile bottomlands favored the development of a rich cotton agriculture, and by 1825 the region had become an important cotton growing region. Most of the well drained terraces and second bottoms were cleared for cotton; however, the poorly drained and frequently flooded bottoms were left in hardwoods (Sternitzke, 1955).

Extensive encroachment into the first bottoms began in the 1960's when soybeans became more important in West Tennessee's agricultural system. From 1950 to 1971, the bottomland acreage in timber decreased by one-fourth (Sternitzke, 1955 and Wells, et al., 1974). Although current figures are not available, this trend continues.

Flood control and major drainage projects have also reduced the acreage in bottomland forest. A large portion of Tennessee's bottomland lies beneath Kentucky Lake and other such reservoirs (Sternitzke, 1955). Flood control through channelization started in West Tennessee as early as 1910, and most of the major tributaries of the Mississippi River have been channelized. Only the Hatchie River follows essentially its original course. The Flood Control Act adopted by Congress on June 30, 1948, authorizes the more recent phases of channelization, which are intended to drain 477,423 ha of bottomland hardwoods and permit agricultural development on 24,276 ha (Tennessee State Planning Office, 1977).

Sedimentation from the eroding uplands is further reducing the bottomland hardwood resource. The soils of West Tennessee are primarily derived from loess which, due to its loose, friable, unconsolidated nature and low clay content, is highly erodible. The results of improper agricultural practices on such soils were noted as early as 1860 by E. W. Hilgard:

> It is greatly to be regretted, that circling was not practiced at an earlier date in this region; for large tracts, originally covered (though not to a great depth) with an excellent soil, have already been irrecoverably lost to cultivation by washing. When the surface loam has been penetrated, the latter process goes on with fearful rapidity, and requires the most energetic measures to check it. Not only is the soil, and all that could possibly serve as a foundation for a soil, carried away from the hills, but the materials thus removed cover over the fertile branch bottoms, in company with a flood of sand, which renders them useless for all time to come.

Sedimentation partially blocks most of the major channels and results in increased flooding, impaired drainage, and deposition on the floodplains. A comparison of erosion rates in Table 1 shows that West Tennessee has the highest gross erosion in the Lower Mississippi River Valley Region. Eleven metric tons per ha per year is the soil loss tolerance above which crop productivity cannot be sustained economically over a long period of time. The average rate of erosion in West Tennessee is two and two-thirds times greater than this tolerance limit, and the maximum rate of 493 metric tons per ha exceeds this by 44 times (U.S.D.A., 1977).

Channelization, leveeing and siltation have created a habitat that is well suited for beavers, whose impoundments have caused high mortality in some of the last remaining bottomland forests (Byford, 1974).

Table 1. Erosion rates in Lower Mississippi River Valley Region.*

Area	Million ha	Average Gross Erosion Metric Ton/ha/yr
Obion-Forked Deer	1.29	33.8
West Tennessee	2.75	29.8
Southeast Missouri-Northeast Arkansas	4.09	21.1
Southeast Arkansas-Northeast Louisiana	1.42	22.0
Eastern Louisiana	1.50	18.2
Central & Southwest Mississippi	1.70	17.9
Northwest Mississippi	3.44	16.6
Southcentral Arkansas-Northcentral La.	5.30	3.8

*Land treatment plan for erosion control and water quality improvement. U.S.D.A., November, 1977.

These factors are reducing the state's bottomland hardwood resource at an alarming rate. The Tennessee Division of Forestry estimates that over one-fourth of the state's bottomland hardwoods will be dead by 1980. This is a loss of approximately 80,920 ha of timberlands, valued from $46 million to $72 million (U.S.D.A., 1977). The acreage of dead timber is expected to double within the next 10 years (Young, 1978).*

The objective of this study was to: (1) characterize relatively undisturbed stands of Tennessee's bottomland hardwood resource, and (2) determine relationships between the forest cover and the soil/site variables within the Collins-Falaya-Waverly catena. Forest cover-soil/site relationships on relatively undisturbed bottomland sites provides a useful local management tool. The opportunity for obtaining the needed base-line data is rapidly disappearing.

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*Personal interview with Max Young, Tennessee State Forester, Nashville, 1978.

CHAPTER II

THE STUDY AREA

A. Introduction

Selection of Study Area

The major rivers forming the alluvial valleys of West Tennessee are: (1) the Obion River, which divides upstream into the North, Middle, South, and Rutherford Forks, (2) the Forked Deer River formed by the North, Middle, and South Forks, (3) the Hatchie River, (4) the Loosahatchie River, and (5) the Wolf River. The floodplains associated with each of these rivers varies considerably in the extent of disturbance due to farming, siltation, channelization, and major drainage projects.

As part of this study, a survey was conducted by mail in the autumn of 1977 to determine the degree to which the major floodplains of West Tennessee were disturbed, and to locate relatively undisturbed, bottomland hardwood stands. Evaluation forms listing the major river basins were sent to all local authorities including the Soil Conservation Service, the U.S. Army Corps of Engineers, the Federal Wildlife Refuge, the Tennessee Division of Forestry, the Tennessee Division of Conservation, the Tennessee Heritage Program, the Obion-Forked Deer River Basin Authority, selected private forest consultant firms, and local universities. Personal interviews with knowledgeable individuals and inspection of hardwood stands recommended for study followed.

This survey revealed that the Hatchie River was by far the least disturbed of the major alluvial valleys of West Tennessee. The other valleys were rated as highly disturbed with little agreement as to the relative severity of disturbance. Although isolated stands of healthy hardwoods did exist in these disturbed drainages, flooding patterns of the associated channels had been altered sufficiently to change the topographic-drainage sequence. Only within the Hatchie floodplain was there a significant acreage of hardwoods growing on unaltered sites.

Potential locations of undisturbed stands within the Hatchie floodplain were determined from aerial imagery (NASA, 1974) and from 1/24,000 U.S.G.S. quadrangle maps. The Hatchie National Wildlife Refuge contained some of the largest and the best protected bottomland hardwood stands in West Tennessee. It was selected for this study since it was the only protected area on which the condition of the hardwood stands might approximate that of original stands.

Location

The Hatchie River Basin encompasses 5,675 km^2 in southwestern Tennessee (Figure 1). It occupies portions

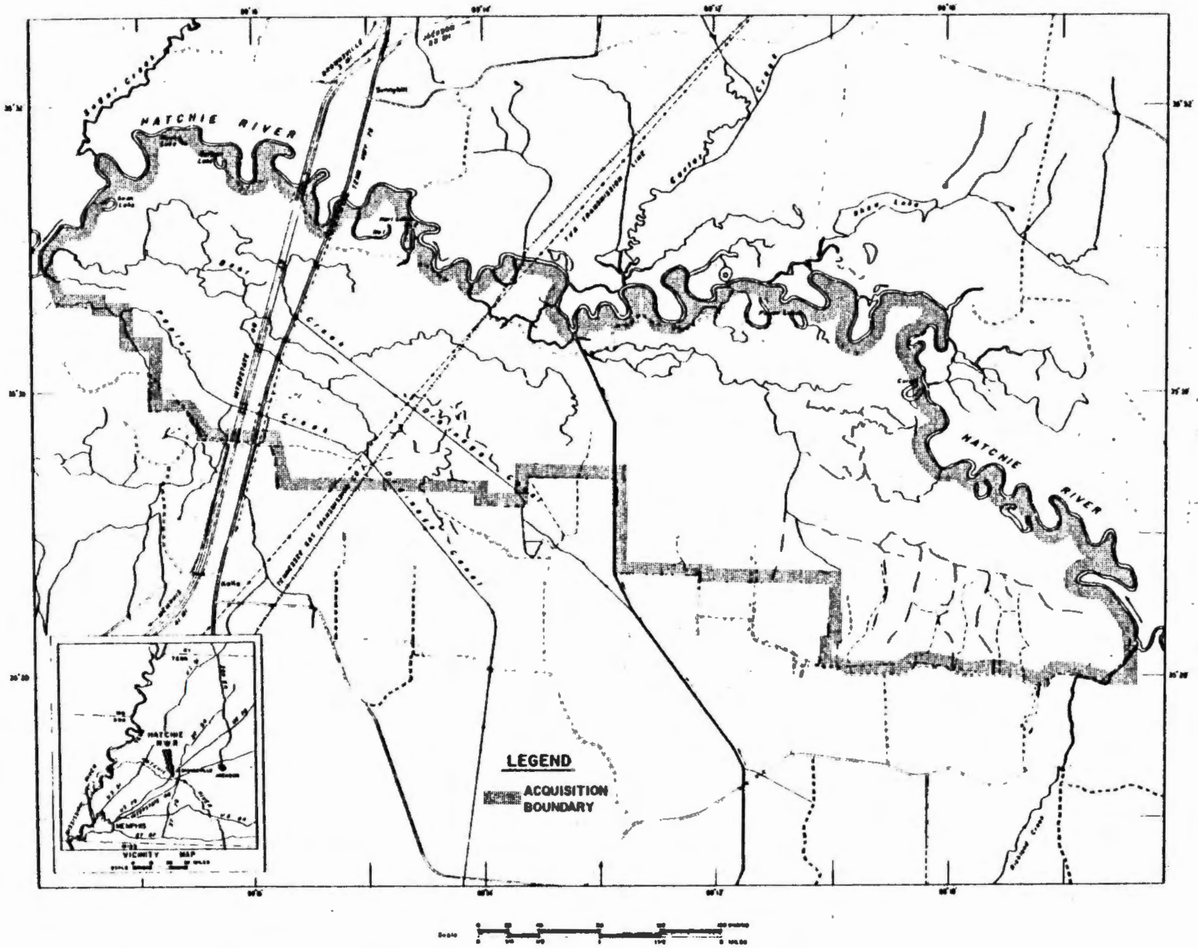

Figure 1. Map of Hatchie National Wildlife Refuge.

of Chester, Fayette, Hardeman, Haywood, Lauderdale, Madison, McNairy, Shelby, and Tipton counties. The basin extends from the Mississippi-Tennessee state line, km 308, in a northwest direction to its confluence with the Mississippi River, km 1,244, approximately 56 km north of Memphis.

The Hatchie National Wildlife Refuge is approximately 61 km east of the Mississippi River in Haywood County (Figure 1). It is bounded on the north and west by the Hatchie River; Interstate 40 and Tennessee Highway 76 transect the area.

General Description

Hatchie National Wildlife Refuge, consisting of 4,532 ha, was established in 1962 under the Migratory Bird Conservation Act. Forests occupy 3,773 ha (83%), agricultural lands make up 607 ha (13%), and the remaining 4% is in grassland and water. Approximately one-half the forest acreage, 1,820 ha, was formerly owned by Powell Tie and Timber Company and was not suitable for this study as it was cut over at the time of acquisition (Stewart, 1976).

Land elevations generally range from a low of 88 m, mean Gulf Sea Level along the Hatchie River to elevations of 114 m in the adjacent foothills near the south section of the Refuge.

Flooding usually occurs during the months of December through May, inundating approximately 72% of the Refuge or 3,273 ha.

Small sloughs are common in the bottoms; they are usually dry during the summer months. Bear Creek and Poplar Creek are the only tributary streams located on the Refuge. Poplar Creek becomes intermittent during the late summer but Bear Creek usually flows throughout the year. Sloughs generally facilitate runoff but increased beaver activity over the past decade has resulted in many being impounded by beaver dams (Stewart, 1976).

B. Climate

The climate of West Tennessee is controlled by the large continental land mass to the north and west and by the waters of the Gulf of Mexico to the south. According to Trewartha (1943) the state lies within the Humid Mesothermal Climates, Humid Subtropical Section, with warm summers and no dry season. Thornthwaite (1948) places the area in his B_2 Humid classification.

In the warmer season prevailing southerly winds from the Gulf of Mexico provide a moist, semi-tropical climate. When the winds are northerly or westerly, the climate becomes hotter and more arid (Dickerson, 1974). In the winter, alternating periods of warm and cold are the rule. This cycle is governed by the origin of the prevailing air mass; cold air moves from Canada, and warm air moves from the Gulf.

The average annual precipitation is 132 cm at Brownsville, Tennessee. October is the driest month with precipitation averaging 5.8 cm, and in January, the wettest month, precipitation averages 16.9 cm. The greatest precipitation occurs during the winter and early spring due to the more frequent passage of large frontal storms. Winter rains commonly last for several days and cover large areas, but are ordinarily gentle. It is rains of this nature that cause the maximum flooding of the Hatchie River. A secondary precipitation maximum occurs in midsummer when thunderstorms of high intensity but small areal extent are common. In the autumn, slow-moving high pressure areas hold precipitation to a minimum. Average annual snowfall varies from 10-12 cm and rarely persists for more than a few days (Dickerson, 1974 and U.S.D.A., 1977).

Severe storms are relatively infrequent, since the study area is east of the center of tornado activity, south of most blizzard conditions, and too far inland to be affected by hurricanes. On the average, four or five tornadoes are reported each year; the greatest frequency is in March. A few hailstorms are observed each year and damaging glazestorms occur every five or six years. Severe thunderstorms with damaging winds are common occurrences during the warm season (Dickerson, 1974).

The mean annual temperature at Brownsville, Tennessee is 16° C. January is the coldest month with an average of 6° C. July is the hottest month with an average of 29° C (Dickerson, 1974). Maximum temperatures of 41° to 43° C have occurred at some time during the months of June through September, and minimums of -24° to -26° C have occurred during the months of January and February (U.S.D.A., 1941). Temperatures of 32° C or above occur on the average of 69 days each year, while temperatures of 0° C or below occur on the average of about 60 days during the year. Temperatures below -16° C rarely occur more than one or two days a year (U.S.D.A., 1971). The average daily minimum temperature during the summer is 20° C, and the daily average maximum is near 32° C. During winter, average daily temperatures range from approximately 0° to 12° C (Flowers, 1964).

The average length of the growing season is approximately 214 days; the average date for the last killing frost in spring is March 29 while the first one in the autumn is October 29 (U.S.D.A., 1941). The soil seldom freezes to a depth greater than 7 cm, and it seldom stays frozen to that depth for more than 5-6 days (Flowers, 1964).

C. Geology and Physiography

The study area lies near the border between two physiographic regions: the West Tennessee Uplands and the West Tennessee Plain (Fenneman, 1938, and Safford, 1869).

These two physiographic regions make up a portion of the eastern half of a geologic unit known as the Mississippi embayment subdivision of the Gulf of Mexico Coastal Plain. It is an area of relatively low elevation and relief, and forms a trough which plunges to the south following the course of the Mississippi River. This basin contains sediments from seas that occupied the area from Late Cretaceous through much of the Tertiary Periods (Miller, 1974).

The West Tennessee Uplands occupy a north-south oriented belt lying west of and paralleling the Tennessee River. A line running through the towns of Bolivar, Jackson, McKenzie, and Paris form the western boundary. Most of the region is dissected and hilly, some belts of rolling topography occur. Localized swampy conditions occur along many of the streams. Elevations range from approximately 122 m along the Tennessee River to more than 213 m on some of the highest hills. Geologic formations that comprise the area are mostly Cretaceous, Tertiary, and Quaternary gravel, sand, silt, and clay (Floyd, 1965).

The West Tennessee Plain lies between the West Tennessee Uplands and the Mississippi floodplain. It slopes gently westward from an elevation of approximately 135 to 90 m. The gently rolling topography is interrupted by small ridges and drainage divides. Swampy conditions are common in the floodplains. Wind-carried loess was deposited over the area during the Pleistocene and may be as much as 30 m thick along the Chickasaw Bluffs of the Mississippi River. It thins progressively eastward, and once stretched as far east as the Highland Rim (Wascher, et al., 1947). The geologic formations that underlie the loess are sands, gravels, silts, and clays of Tertiary and Quaternary age (Floyd, 1965).

The rivers of western Tennessee characteristically occupy valleys that appear disproportionately large. These valleys are asymmetrical in cross-profile; the floodplains have been developed preferentially in one direction (Russell and Park, 1975).

The Hatchie River drainage pattern consists of a main stream fed by numerous smaller streams which branch alternately (Tennessee Department of Public Health, 1976). The floodplain of the main stream is wide and flat in the downstream part of the basin and narrows to a ridge and valley type of landscape upstream (U.S.D.A., 1971).

D. Soils

Locally derived alluvium underlies the floodplains and partially fills the valleys of the streams of western Tennessee. The lower part is fine to very coarse grained sand with lenses of gravel, and the upper part is fine sand, silt, and clay. Bedding planes are generally indistinct and the sediments are poorly sorted, grading from one lithology to another. Rock fragments, mica, fine-grained heavy minerals, and plant remains occur locally in the alluvium, which ranges from 7 to 9 m in thickness, but locally may be as much as 15 m thick. It is thickest downstream where the floodplains are broadest and thinnest in the headwaters areas where it merges with colluvium (Russell and Parks, 1975).

These bottomland soils are classified as Entisols according to Soil Taxonomy (S.C.S., 1975). Due to their recent development, there are no distinct pedogenic horizons (Buol, et al., 1973). They have slopes of less than 3% and are strongly acid. An A horizon lies over a C horizon and consists of recently deposited mixed silty and sandy alluvium. The characteristic most diagnostic in distinguishing between soils is the depth to mottling (Flowers, 1964; Brown, et al., 1978; and Sease, et al., 1970).

Soils of the floodplains of West Tennessee generally belong to the Collins-Falaya-Waverly catena. Widē, nearly level floodplains of the larger rivers belong to the Collins-Falaya-Waverly association. On smaller streams in first bottoms, the Falaya-Waverly or the Falaya-Waverly-Swamp associations are predominant. The Waverly-Swamp association is common on the swampy first bottoms of small, crooked, winding streams (Brown, et al., 1965, 1973; Flowers, 1964; Sease, et al., 1970).

Textures of the Collins-Falaya-Waverly association are largely silt, silt loam, and silty clay loam. They are segregated primarily on the basis of topographic-drainage position. Gray, poorly drained soils on the lowest parts of the floodplain are Waverly. Common on the higher, better drained flats and ridges, Falaya soils are somewhat poorly drained, and Collins soils are moderately well drained. Narrow ridges that follow the stream channels are the highest, best drained sites on which Collins is the predominant with an occasional inclusion of the well drained Vicksburg soil (Brown, et al., 1973, 1978; Flower, 1964).

Soils of minor importance that occur as inclusions in these associations are: (1) Iuka and Mantachie--recent alluviums having a higher percentage of sand. Iuka soil is moderately well drained and is generally on the ridges next to stream channels. Mantachie is a somewhat poorly drained soil on flats and ridges of the bottoms. They are more often in the Coastal Plain where the parent material has more sand than the loess uplands, and could be described as the Coastal Plain's counterparts to Collins and Falaya, respectively (Brown, et al., 1978). (2) Memphis, Grenada, Calloway, and Henry--developed on terraces and uplands in a thick loess over alluvial material, and differ from the bottomland soils in a number of the soil-forming factors (Jenny, 1941). Drainage ranges from good in the Memphis soils to poor in the Henry. The Grenada, Calloway, and Henry soils have fragipans (Flower, 1973 and Sease, 1970). Upland soils were usually in agriculture and were not sampled.

E. Vegetation

Records of the nature and appearance of the American forests of pre-colonization are meager and fragmentary (Braun, 1950). The early records of the vegetation of the alluvial valleys of West Tennessee are no exception.

In 1721 Pierre Charlevoix, a member of the Jesuit order of France, was sent on an expedition down the Mississippi River by his superiors. Charlevoix was a highly educated man for the time and kept an excellent log of the journey. His description of the floodplain forest of the Wolf River is one of the earliest records (Williams, 1928).

> As to the forest, which almost entirely covers this immense country, there is perhaps, nothing in nature comparable to them, whether we consider the size and height of the trees or their variety . . ., there is hardly any sort of trees which can be mentioned that are not to be found here. There are forest of cypress, eight or ten leagues in extent, all the trees of which are of a thickness proportionable to their height, surpassing everything of the kind we have in France.

Safford (1869) describes the rivers of West Tennessee as long and sluggish which have wide, flat bottoms, filled with heavy timbers, baldcypress being very common.

In the late 1800's, the botanist Augustin Gattinger (1887) collected in West Tennessee. His description is as follows:

> We behold no longer limpid streams, rippling over rocky bottoms, sided by cliffs and bluffs. Instead of them we find lagoons and swampy borders, stretching along muddy-looking waters of sluggish streams. . . . Cypress swamps are along both big rivers (Tennessee and Mississippi Rivers), and many other extensive swamps and swampy lands are along every watercourse. . . . It may, therefore, be expected that a great many more aquatic species and such as inhabit marshy lands exist in this region, than in either East or Middle Tennessee.

Hall (1910) describes the few virgin bottomland forests of Tennessee left in the early 1900's, as being "dense, with tall, clear trees which form an unbroken canopy." He states that sweetgum made up about 50% of the forest and that oaks (cherrybark, pin, willow, and swamp chestnut oak), ash, cottonwood, hickory (shellbark, shagbark, and mockernut hickory), baldcypress, elm, sycamore, soft maple, and tupelo gum were the common associates. Beech occurred only on the drier ridges. The understory was a mixture of scattered hawthorn, holly, dogwood, and young growth of sweetgum, hickory, hackberry, and other trees.

A number of regional divisions of the forest have been proposed for the area (Braun, 1950; Shanks, 1958; S.A.F., 1954; Küchler, 1964; and Bailey, 1976). Although

Braun considers western Tennessee to be a part of the Western Mesophytic Forest Region, she states that the forest found along the alluvial valleys of Tennessee differ but little from the southern part of the alluvial plain of Mississippi and Louisiana. Shanks, using records of woody plants in Tennessee, found that floristic boundaries are strongly correlated with physiographic boundaries. Küchler classifies the study area by its potential dominant forest species of oak-gum-cypress and places it within the Southern Floodplain Forest. Most vegetational groupings have similar boundaries and species distributions, and most place the bottomlands of West Tennessee within the Mississippi alluvial plain. However, the bottomland forests which are bordered by the loess uplands contain an ecotone of the Western Mesophytic Forest and are more diverse than bottoms in the coastal plains which are usually bounded by pines or at best by pine-hardwood uplands (Caplenor, 1968; Putnam and Bull, 1932).

A number of vegetational studies have been conducted in the Reelfoot Lake region. Eyles and Eyles (1943) listed the flora, Gersbacher and Norton (1939) reported on typical plant succession, and Hazard (1933) classified the trees according to drainage-site. Shelford (1954) attempted to reconstruct the development of floodplain communities by studying relatively undisturbed examples at different successional stages in the lower Mississippi Valley near Reelfoot Lake. His order of succession starts with a pure cottonwood-willow type and graded into the hackberry-gum stage. This is marked by a gradual increase of hackberry, sweetgum, sycamore, elm, ash, pecan, boxelder, and overcup oak. Floodplain oak-hickory communities follow and are divided into early oak-hickory and old oak-hickory communities. Overcup oak, pin oak, cherrybark oak, shellbark hickory, shagbark hickory, and pecan characterize the early development while swamp chestnut oak, southern red oak, Shumard oak, bitternut hickory, and pignut hickory increase in numbers as the forest matures. The climax stage of community development is an approximation of the western mesophytic forest of Braun (1950) and is characterized by white oak, northern red oak, chinkapin oak, yellow-poplar, basswood, and American beech.

In more recent studies, Hebb (1960) found that sweetgum was the most common tree of the Wolf River at Ames Plantation; yellow-poplar, cherrybark oak, and baldcypress were common associates. Coleman (1975) reported that in the bottoms of Yellow Creek and Mackeys Creek in Tishomingo County, Mississippi, beech was the most important species on better drained sites, and willow oak and sweetgum dominated the poorly drained sites.

In West Central Mississippi, Caplenor (1968) reported that the forest of bottomland non-loess was dominated by sweetgum, beech, and spruce pine; mockernut hickory, shortleaf pine, laurel oak, white oak, loblolly pine, and slippery and American elm were important associates. In a report on the forest aspect of the environmental impact study of West Tennessee tributaries, Caplenor (1973) divided the floodplain vegetation of the Obion-Forked Deer Rivers into slightly disturbed communities and severely disturbed communities. The slightly disturbed communities were those forests which had been selectively cut over a number of times without destruction of the total forest structure. Dominant species were tupelo gum, baldcypress, green ash, red maple, river birch, sweetgum, elms, overcup oak, swamp chestnut oak, cherrybark oak, pin oak, and willow oak. In severely disturbed communities, the structure and composition of the forest had been destroyed by a combination of channelization, agriculture, and logging. In every case, the number of taxa present was less than half of the number of taxa reported on the slightly disturbed communities. The composition of the dominant species was changed to black willow, cottonwood, boxelder, silver maple, red maple, elms, and sweetgum.

CHAPTER III

SELECTED LITERATURE

A. Topographic Forest Cover Relationships on Bottomland Hardwoods

In 1930, L. G. Romell presented a paper before the New York Section of the Society of American Foresters calling for homogeneous, natural forest types for scientific use in connection with detailed soil studies. He stated that the soil mapping types used for agriculture were often not applicable to forestry since agricultural soils were artificial while forest soils develop under equilibria.

Some of the earliest work on hardwood cover types was completed by Putnam and Bull (1932) in which they characterized the sites of the Mississippi Delta by topography and soil description. The floodplains of most streams of the southern bottomland hardwood region have similar topographic features and distinct species associations (Hosner, 1962). The most obvious topographic classification is into first bottoms and terraces or second bottoms. The first bottoms are active floodplains still subject to flooding. They are lands surrounding tributaries which flood deeply and frequently but drain rapidly. There is little opportunity for weathering and alteration of the soil texture, due to their young age and to the continual deposit of fresh alluvium (Putnam and Bull, 1932). The most common tree species include sweetgum, red maple, green ash, water hickory, sycamore, river birch, elms, water, willow, laurel, and overcup oaks (Hook, 1977). The second bottoms are old floodplains which are inundated only by severe floods. They are no longer being built up by deposition and have soils which show distinct leaching (Putnam and Bull, 1932). The species which inhabit the terraces and smaller streams are more mesophytic: cherrybark, Shumard, swamp chestnut, and white oaks, hickories, beech, and occasionally yellow-poplar (Hook, 1977).

Each of these major topographic features contains sub-divisions due to relief. Braun (1950) recognized swamp forest, hardwood bottoms, and ridge bottoms as the three divisions. The principal trees in the swamp forest are baldcypress and tupelo gum along with silver maple, red maple, and ash. The hardwood bottoms are characterized by sweetgum, red maple, swamp chestnut oak, cherrybark oak, shingle oak, overcup oak, willow oak, elm, hackberry, pawpaw, dogwood, and blue beech. The ridge bottoms are free of water most of the year and include the more mesic oaks and hickories. Often these ridges were originally covered by dense stands of cane (Braun, 1950).

Penfound (1952), in his review of southern swamps and marshes, divided the swamp forest of Braun into deep and shallow swamps. Deep swamps are fresh water, woody communities, with surface water throughout most or all the growing season. They consist of relatively tall, baldcypress, tupelo gum or swamp gum-pondcypress communities with swollen bases and "knees," and abundant epiphytes. Shallow swamps are fresh water, woody communities, the soil of which is inundated for only short periods during the growing season. Typical communities are black willow-sandbar willow, buttonball-dogwood-willow, overcup oak-water hickory, hackberry-elm-ash, maple-red gum-oak, and alder-birch. These deciduous trees or shrubs are without evident hydrophytic characters except for production of water roots in buttonball and willows and swollen bases in green ash.

Beaufait (1956) found that small topographic variations caused relatively large site index changes and further divided the topographic sub-divisions into swamp, slough, low flat, high flat, low ridge, and high ridge. Smith (1957) found that Beaufait's topographic classes were applicable on alluvial soils of the lower Frazier River Valley in British Columbia.

Forest cover types are often described in relation to certain soil/site characteristics. Forest type is defined by the Society of American Foresters (1954) as follows:

> A descriptive term used to group stands of similar character as regards composition and development due to given ecological factors, by which they may be differentiated from other groups of stands. The term suggests repetition of the same character under similar conditions.

The Society of American Foresters (1954) listed a number of cover types in the bottomland hardwood group which will be discussed in detail in a later section. Putnam and Bull (1932) described 16 forest cover types in the Delta bottomlands which are more specific and more useful than the S.A.F.'s cover types for the study area. Putnam later simplifies these into eight broad groups because "long familiarity with the region is necessary before one can recognize them quickly when following a compass line through the forest" (Putnam, 1951). In a survey of 62 bottomland areas in Southern Illinois, 28 separate types were recognized by Hosner and Minckler (1963). However, they recognized only two successional types: (1) the establishment on better drained areas which are subject to flooding but generally free of surface water most of the growing season, and (2) a hydroseric succession starting on poorly drained areas, such as swamps or sloughs. Bedinger (1971) reported that the flood characteristics of a given site could be determined by evaluation of forest species composition. He divided the vegetation of the lower White River Valley, Arkansas into four groups, each group occurring on sites having distinctly different flooding characteristics. On sites flooded 29-40% of the time, the dominant species were water hickory and overcup oak. On sites flooded 10-21% of the time, a more varied flora exists--including Nuttall oak, willow oak, sweetgum, ash, and elm. The third group was subject to flooding at intervals of from two to eight years and was characterized by the more mesic oaks and hickories. The fourth site group, characterized by the presence of blackjack oak, was seldom, if ever, subject to flooding. Hazard (1933) reported that the following forest type sub-division covered practically all of the more common local tree associations of the Reelfoot Lake Region: (1) Submerged River Bottom, (2) Saturated River Bottom, (3) Poorly Drained River Bottom, (4) Well Drained River Bottom, (5) Lower Slope Bluff, (6) Upper Slope Bluff, (7) Ridge Top. The first four sub-divisions belong to the river bottom types and the last three belong to the river bluff types. Although the sub-divisions resulted from variations in soil drainage, the line of demarcation between the two broad forest types was the juncture of the alluvium and loess soil which is somewhat indistinct in places.

Separation into conventional forest cover types is difficult or impossible in most hardwood forests, except for areas too small to map (Putnam, 1960). Small topographic variations result in changes in species composition, and one forest type grades into another as the water table and the flood pattern change. He found that although bottomlands could be classified under some of the existing schemes, local studies were needed to characterize specific areas. Edaphic ecotypes within species as well as changes in flooding tolerance among species from one region to another reduced the usefulness of generalized forest types (Hook, 1977).

B. Soil/Site-Species Relationships

Research on forest soil productivity has emphasized the southern pines with relatively little work on southern hardwoods (Coile, 1960). This situation is reflected in Coile's monograph (1952) on soil site studies in which he summarized the work to that time. For the southern region, practically all studies had been on six species, all of them pines.

Early efforts to include soil characters in site classification were made by Turner (1937) and Donahue (1937). Donahue examined chemical and physical properties in an attempt to explain differences in growth of oaks on two contrasting clay forest soils. His approach failed because inherent moisture conditions of the site were not considered (Broadfoot, 1969). Turner, using a subjective approach, concluded that "soil features influencing available water seem to be more influential than others in determining rate of growth. . . ." The factors he listed as being important for hardwood growth were slope as it affects drainage, exposure, depth of soil, and physical structures of soil horizons.

Putnam (1951) assigned a "comparative growth rate" to bottomland hardwoods; however, he made no attempt to quantitatively classify different sites for a given species. Nelson and Beaufort (1956) pointed out several complications to the application of conventional site index methods to hardwoods. Among these were the prevalence of uneven-aged stands and the occurrence of many stands that were too young, overcut, or otherwise abused. They presented preliminary data from studies made in the Georgia Piedmont indicating that soil-site variables could be used in regression equations to estimate hardwood site index.

Beaufait (1956) reported on an intensive study of the site relationships of willow oak. Eighty-three plots were sampled throughout the South, 50 of which were within the Mississippi River Delta area and 33 were from non-Delta river bottoms. Detailed soil analyses indicated that a number of soil variables were significantly related to site index. In the Mississippi River floodplain, willow oak site index decreased as the percent clay in the 30 to

45 cm layer increased and increased as the basal area and elevation increased. In other river and stream bottoms of the South, he found that the amount of available potassium in the 0 to 15 cm layer replaced the percent clay in the regression equation and was negatively related to site index.

Smith (1957) studied growth of black cottonwood on alluvial soils in British Columbia and found no single soil factor was a satisfactory indicator. He felt that the special characteristic of alluvial soils was change largely due to continued deposition during flooding. Another study conducted in young cottonwood stands along streams and rivers in southwestern Alabama found that concentrations of available phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) generally decreased with depth in the soil profile while percentages of coarse soil particles increased. In contrast to willow oak, available soil K in the 0 to 30 cm depth was positively related to the growth of cottonwood and accounted for 94% of the variation in regression analysis (White and Carter, 1970).

In southeastern Georgia, Applequist (1960) reported no clearcut relationships among soil variables and site index of swamp blackgum and tupelo gum. His data suggest two weak trends: as percent sand in the least permeable horizon increased, site index decreased, while clay percentage in the same horizon was positively related.

This suggests that physical soil characteristics which increase the amount of available soil moisture during the growing season increase height growth.

May and Blackman (1963) conducted a soil-vegetation study of two bottomland hardwood soils in the Piedmont Region of Georgia. Differences in species density and heights of dominant trees indicate that available water during critical periods influences species composition and development more than other physical or chemical characteristics.

Using multiple regression, Hebb (1962) reported on the relationship between nine soil-site variables and the height growth of native hardwoods at Ames Plantation in West Tennessee. He found that topographic position and apparent surface drainage were important indicators of the productivity of hardwood sites. Depth to mottling was positively related to the growth of yellow poplar and sweetgum and was highly significant in their regression equations.

Broadfoot has done the most extensive work on soil-site relationships of bottomland hardwoods. He developed a number of methods for estimating site index for selected hardwood species (Broadfoot, 1960, 1964a; Broadfoot and Krinard, 1958). The most precise method for willow oak required the determination of clay content at the 90 to 120 cm depth, depth to mottling, inherent moisture condition (moist or dry), and presence or absence of a hardpan. In another method, clay content and amount of available K in the 90 to 120 cm depth formed the basis for evaluating sweetgum sites. A faster field evaluation can be made for cottonwood by estimating the texture and inherent moisture condition in the top two feet of soil and for willow oak and sweetgum by estimating the soil texture and inherent moisture condition plus the depth to mottling and the presence of a hardpan.

Broadfoot published the soil properties for important Mid-South soils along with the suitability of the soils for selected species of bottomland hardwoods (Broadfoot, 1964b; Broadfoot, et al., 1972). He later estimated the average range in site index for the more important bottomland species by soil series (Broadfoot, 1976).

Direct relationships between soil-site variables and productivity have been disappointing (Broadfoot, 1969). Recent studies have meshed subjective values with objective measures and have developed fairly reliable guides for estimating site quality ratings for several bottomland hardwoods (Baker and Broadfoot, 1977). Under their scheme, four factors (physical condition of the soil, moisture availability during the growing season, nutrient availability, and aeration) are credited with accounting for 35%, 35%, 20%, and 10% of a tree growth, respectively. Within each category pertinent variables are assigned appropriate proportions of the weight assigned to that factor. Values are summed across each of the four soil factors to give estimated maximum tree growth for eight bottomland species at each site.

CHAPTER IV

PROCEDURES

A. Field Methods

Prior to the field work, a map reconnaissance was made to determine the stands which were suitable for the study. The 3,774 total forest ha comprising the Hatchie National Wildlife Refuge was divided into nine compartments based on history of ownership and acquisition. Compartment maps of the Refuge drawn by Clyde A. Stewart with an approximate scale of 1/21,000 were used to locate potential study stands. Only those stands that had not been disturbed by fire, grazing, or cutting within the past 30 years were selected. Over half the forest acreage had been cut prior to acquisition and was unsuitable for study. Compartments one, two, seven, and eight totaling approximately 1,214 ha or about one-third of the total forest acreage were suitable for this study.

Systematic line transects with a random start were established every 800 m (approximately 40 chains). That portion of a transect within 400 m of a major disturbance such as powerlines, highways, or drainage canals were eliminated. Plots were located every 100 m along the transects with small variations in order to keep each plot within a topographic-drainage class. A Silva Ranger compass was used to determine the azimuth, and plot center was located by pacing with periodic checks using a fiberglass tape. A total of 127 plots was established along 12 transects during autumn of 1978.

Soils data were collected near plot center. Topographic position, microsite, and degree of abnormal flooding* were recorded (Appendix, Table 15). A bucket auger 120 cm in length was used to study horizons which were described as to depth, distinctiveness of boundaries, color, degree of mottling and gleying, concretions, structure, and consistence. Texture was determined by the finger test of moist soil samples, and random samples were checked against laboratory samples for accuracy. Drainage and textural classes were determined in the field, and soil samples from depths of 0 to 30 cm, 30 to 60 cm, and 60 to 120 cm were taken for laboratory analyses.

Horizontal point sampling with a prism (basal area factor of 2.5 m^2/ha) was used to sample arborescent vegetation. From plot center, the crown class, diameter breast height, and total height were determined for each "in" tree. The crown classes used were dominant, codominant, intermediate, and suppressed (Smith, 1962). Diameter breast height was estimated and was periodically checked with a

*A recent, obvious change in the flooding pattern of a site due to the activities of man (dikes or roads) or beavers.

diameter tape. Height was estimated with periodic checks using an Abney level. Dead trees were tallied and pertinent comments were recorded in a space provided at the bottom of the data sheet.

The abundance and height of understory trees and shrubs (less than 4 m in height but greater than 1 m) were recorded by species for the immediate area around plot center. The following simplified abundance scale from Acocks (1953) was used in which the distance between members of the same species determined the abundance class: (1) abundant, 15 cm; (2) common, 30 cm; (3) frequent, 1 m; (4) fairly frequent, 5 m; (5) occasional, 15 m; (6) sparse, 25 m; and (7) rare, 60 m. The woody reproduction (less than 1 m) and the herbaceous vegetation were estimated using the Braun-Blanquet (1932) cover-abundance value.

Steyermark (1977) was the primary reference for scientific nomenclature. Other references used for identification of species were Wharton and Barbour (1973), Harlow and Harrar (1969), Radford, et al. (1964), Harlow (1946), and Preston and Wright (1977).

B. Laboratory Procedures

Two hundred and seventy-three soil samples from 91 plots were analyzed by The University of Tennessee Agricultural Extension Service Soil Testing Laboratory in

Nashville for soil water pH and P and K availability.

C. Statistical Analysis

The S.A.S. correlation procedure (Barr, et al., 1976) was used to calculate the correlation coefficients and the corresponding probabilities. Only those coefficients which showed a highly significant correlation ($P = 0.01$) were listed, except for the soil/site-forest cover correlations which used significant correlations ($P = 0.05$).

Stepwise multiple regression analysis was performed on eight selected overstory taxa using the S.A.S. maximum R-square improvement option (Barr, et al., 1976). This technique generates equations using all possible combinations of independent variables (Appendix, Table 15), compares R-square values, and prints out the best one variable model, the best two variable model, etc. Criteria for selecting models were that the reliability of the equation, as determined by an F test, be highly significant ($P = 0.01$) and that the reliability of each partial regression coefficient as determined by an F test be significant ($P = 0.05$). The n-variable model satisfying these above two criteria was chosen if the n+1 variable model did not increase the R^2 by at least 2%. The independent variables for the regression equations are listed in decreasing order based on their Type II sum of squares.

The entire data set (127 plots) was used in the correlation and the regression analysis without sub-division because of the wide overlap of species occurrence within the mottling depth classes. This gave the widest variance in the regression analysis for the variables tested.

CHAPTER V

RESULTS AND DISCUSSION

A. Soil Classification

Introduction

The wide, nearly level floodplain of the Hatchie River is underlain by mineral soils of such recent development that there is little evidence of pedogenic horizons. These young soils are Entisols characterized by stratified alluvium and an ochric epipedon.

Of the 127 plots sampled, 39 were poorly drained and mainly belonged to the Waverly series; 58 were somewhat poorly drained and mainly belonged to the Falaya, 28 were moderately well drained and mainly belonged to the Collins, and 4 were well drained (Table 2). Since these Entisols have few pedogenic horizons, the diagnostic characteristic used to distinguish one series from another is the depth and degree of mottling. A further refinement of this method was used in this study to more discretely define forest communities.

Waverly Series

Thirty-one percent of the plots were poorly drained soils mainly of the Waverly series. They were on poorly drained flats, sloughs, or swamps where the water table

Table 2. Number of soil samples by drainage class and by family particle-size class.

Drainage Class	Family Particle-Size Class					
	Fine-Clayey	Fine-Silty	Coarse-Silty	Fine-Loamy	Coarse-Loamy	Total
Poorly drained	5	28	1	3	2	39
Somewhat poorly drained	-	40	11	3	4	58
Moderately well drained	-	10	11	-	5	26
Well drained	-	1	2	-	1	4
Totals	5	79	25	6	12	127

was at or near the surface all year. Runoff was slow, and permeability moderately slow. The upper 20 cm characteristically had mottles with a chroma of two or less.

This was the finest-textured series in the association; 72% of the poorly drained samples were fine-silty and 13% were fine-clayey (Table 2). During deposition the larger, heavier particles settled near the river channel forming the better drained sites while the smallest particles were held in suspension for a longer period of time and tended to settle some distance from the channel and formed the poorly drained soils (Maddock, 1976).

Table 3 gives the average levels of pH, P, and K from poorly drained soil samples. They were strongly acid (pH; 4.9-5.1) and increased slightly with depth (Table 3). The concentration of available P was low; it averaged 5 ppm in all horizons. Available K was low with a mean for all horizons of 73 ppm; the amount decreased with increasing soil depth.

The Waverly series is a member of the fine-silty, mixed, thermic family of Typic Fluvaquents. A typifying pedon from the study area is as follows:*

A_1 - 0 to 15 cm, brown (10 YR 4/3) to grayish-brown (10 YR 5/2) silt loam; few black concretions; weak, fine, granular structure; friable; clear, smooth boundary.

Table 3. Average pH, P, and K levels from poorly drained soil samples.

Depth of Sample (cm)	No. of Samples	pH--Mean	P(ppm)--Mean	K(ppm)--Mean
0-30	25	4.9 ± .07[a]	5 ± 0.9	99 ± 14.7
30-60	25	5.0 ± .07	5 ± 1.1	69 ± 33.9
60-120	24	5.1 ± .16	5 ± 1.3	51 ± 10.9

[a]Standard error of the mean at 95% level of probability.

*Colors are for moist soils.

C_{1g} - 15 to 60 cm, gray (10 YR 6/1) with many, medium, distinct, yellowish-red (5 YR 5/6) mottles; many hard, black concretions; silt loam; massive (structureless); friable; diffuse, smooth boundary.

C_{2g} - 60 to 120+ cm, light gray (10 YR 7/1) silty clay loam with many, medium, distinct, reddish yellow (7.5 YR 6/6) and yellowish brown (10 YR 5/8) mottles; massive (structureless); friable.

Falaya Series

Almost half of the plots were on somewhat poorly drained soils mainly of the Falaya series. These soils usually were on flats having a slow to very slow runoff. Permeability of the surface layer was moderate and that of the subsoil was moderately slow. The water table fluctuates between the surface in the winter and spring to a depth of 1 to 4 m in the summer, and gray mottles occurred below 20 cm.

Sixty-nine percent of the plots were on fine-silty particle-size class and belonged to the Falaya series, and an additional 19% were on coarse-silty (Table 2). The pH was approximately 5.1, the concentration of available P was about 4 ppm, and the concentration of available K ranged from 64 ppm in the top 30 cm to 36 ppm in the 60-120 cm depth (Table 4).

Table 4. Average pH, P, and K levels from somewhat poorly drained soil samples.

Depth of Sample (cm)	No. of Samples	pH--Mean	P(ppm)--Mean	K(ppm)--Mean
0-30	39	5.1 ± .08[a]	4 ± .4	64 ± 6.4
30-60	39	5.1 ± .06	4 ± .5	43 ± 5.8
60-120	39	5.0 ± .11	5 ± .7	36 ± 4.1

[a]Standard error of the mean at 95% level of probability.

The Falaya Series is a member of the fine-silty, mixed, thermic family of Aquic Udifluvents, and is an intergrade between Udifluvents and Aquents. A typifying pedon from the study area is as follows:*

A_1 - 0 to 30 cm, brown (10 YR 5/3) to dark yellowish brown (10 YR 4/4) silt loam; weak, fine, granular structure; friable; gradual, smooth boundary.

C_1 - 30 to 65 cm, pale brown (10 YR 6/3) with many medium faint light gray (10 YR 7/2) to (10 YR 7/1) mottles; common black concretions; silt loam; massive (structureless); friable; diffuse, smooth boundary.

*Colors are for moist soils.

C_{2g} - 65 to 120+ cm, gray (10 YR 6/1) to light gray (10 YR 7/1) with many, coarse, distinct, brownish yellow (10 YR 6/6) and reddish yellow (7.5 YR 6/8) mottles; silt loam; massive (structureless); friable.

Collins Series

One-fifth of the plots were on moderately well drained soils of the ridges and were mainly of the Collins Series. Runoff was slow; permeability of the surface horizon was moderate while permeability of the subsoil was moderately slow. Gray mottles do not occur in the upper 45 cm, but are common below this level.

Sixty-two percent of the soil samples were coarse-silt or coarse-loam, indicating that the particle-size along with topographic position probably accounts for better drainage in this series (Table 2). The pH and available P remained relatively constant with depth while available K decreased with depth (Table 5).

The Collins series is a member of the fine-silty to coarse-silty, mixed, thermic family of Typic Udifluvents. A typifying pedon from the study area is as follows:*

A_1 - 0 to 30 cm, dark brown (10 YR 3/3) silt loam; weak, fine, granular structure; very friable; common fine roots; gradual, smooth boundary.

*Colors are for moist soils.

Table 5. Average pH, P, and K levels from moderately well drained soil samples.

Depth of Sample (cm)	No. of Samples	pH--Mean	P(ppm)--Mean	K(ppm)--Mean
0-30	23	5.0 ± .08[a]	4 ± 0.5	58 ± 4.4
30-60	23	5.0 ± .07	5 ± 0.7	38 ± 3.6
60-120	23	5.1 ± .08	5 ± 0.9	36 ± 3.3

[a]Standard error of the mean at 95% level of probability.

C_1 - 30 to 52 cm, dark brown (10 YR 4/3) silt loam with common, medium mottles of pale brown (10 YR 6/3); weak, fine, granular structure; very friable; gradual, smooth boundary.

C_{2g} - 52 to 85 cm, light gray (10 YR 7/2) silt loam with many, faint, brownish yellow (10 YR 6/8) and pale brown (10 YR 6/3) mottles; massive; friable; diffuse, smooth boundary.

C_{3g} - 85 to 120+ cm, gray (10 YR 6/1) silt loam with many, medium, distinct brownish yellow (10 YR 6/6) to yellow (10 YR 7/6) mottles; few black concretions; massive breaking into a weak subangular blocky structure; friable.

Vicksburg Series

Only four of the 127 plots were on well drained soils, mainly on Vicksburg, and all were located on ridges of major drainage channels. These soils have no gray mottles within the upper 90 cm. Runoff was slow, and permeability moderate; the majority of the soil samples were coarse textured.

In comparing the well drained Vicksburg soils with the other three drainage classes (Tables 3-6), pH and P levels did not differ appreciably and no trends were evident. However, availabke K decreased as the soil drainage improved and increased as depth decreased.

Table 6. Average pH, P, and K levels from well-drained soil samples.

Depth of Sample (cm)	No. of Samples	pH--Mean	P(ppm)--Mean	K(ppm)--Mean
0-30	4	4.9 ± .13[a]	4 ± 1.0	45 ± 17.4
30-60	4	4.9 ± .24	4 ± 2.3	36 ± 20.9
60-120	4	5.0 ± .35	5 ± 2.7	38 ± 24.7

[a]Standard error of the mean at 95% level of probability.

The Vicksburg series is a member of the coarse-silty, mixed, thermic family of Typic Udifluvents. A typifying pedon from the study area is as follows:*

A_1 - 0 to 45 cm, brown (10 YR 4/3) to dark yellowish brown (10 YR 4/4) silt loam; weak, fine, granular structure; very friable; gradual, smooth boundary.

C_1 - 45 to 97 cm, brown (10 YR 5/3) silt loam; very weak, fine, granular structure; friable; clear smooth boundary.

C_2 - 97 to 120+ cm, yellowish brown (10 YR 5/6) fine sandy loam with common, faint, pale brown (10 YR 6/3) mottles; single grain structure; very friable.

B. Description of Forest Cover

Methods

Bottomland hardwoods in the Hatchie River floodplain occur along an aeration gradient which is reflected by the depth to mottling. The arborescent vegetation of the study area was characterized utilizing six mottling depth classes (M.D.C.), each being progressively deeper. This was a more detailed breakdown than soil series, and although the forest cover groupings which resulted were based on a soil variable

*Colors are for moist soils.

rather than on vegetational clustering, patterns can be identified which resemble forest cover types.

Relative basal area and basal area/ha by M.D.C. are given for each arborescent species according to crown classes (Appendix, Tables 8-13). Understory species (less than 4 m in height but greater than 1 m) which occurred fairly frequently to frequently (located every 1 to 5 m) in a majority of the plots were used to characterize the respective M.D.C. Samples of the herbaceous vegetation were collected, dried, pressed, and identified (Appendix, Table 7). A more complete documentation of this strata (cover-abundance values) was attempted; however, much of the field work was accomplished after leaf fall, making such estimates difficult.

Mottling Depth Class 1

The first mottling depth class was characterized by common to many mottles and/or gleying at the soil surface and was confined to those Waverly soils having the poorest drainage. Sixteen plots were placed in this class and subdivided into three degrees of mottling as follows: (1) complete gleying at the soil surface, (2) partial gleying at the soil surface along with many, distinct mottles, and (3) gleying absent at the soil surface but with common to many gray mottles. Distinct forest cover communities were associated with each of these subdivisions (Appendix, Table 8).

Tupelo gum (*Nyssa aquatica* L.) was found in almost pure stands in the swamps and deep sloughs which were gleyed to the surface (subclass A). The highest basal area for any one plot found in the study, 70 m^2/ha, occurred in an even-aged stand of tupelo gum in a spring-fed swamp. Soils were silty clay to silty clay loams and had the highest clay content of the study soils. The only associate in the upper canopy was an occasional dominant baldcypress (*Taxodium distichum* (L.) Rich.) while shrub associates included common alder (*Alnus serrulata* (Ait.) Willd.) and Virginia willow (*Itea virginiana* L.).

Penfound (1952) found baldcypress-tupelo gum swamps were deep fresh-water swamps which occurred in the flood-plains of large rivers, especially of the Mississippi River drainage. Tupelo gum may occur in pure stands (Mattoon, 1915), but pure stands usually are the result of selective cutting in cypress-tupelo gum stands (Putnam, 1951). The occasional dominant baldcypress within the stands of the study area suggest that this may have been the case. The Society of American Foresters (1954) recognized a cover type (#103) in which tupelo gum was pure or predominate with baldcypress as an associate. It was considered a climax type on very low, poorly drained flats, deep sloughs and swamps wet most of the year, and was most extensive in the lower reaches of major streams (S.A.F., 1954). Putnam and Bull (1932) recognized a tupelo gum cover type with baldcypress as the chief associate. They stated that the stands tend toward pure tupelo gum and were generally even-aged and dense. This cover type was also described by Hall and Penfound (1939a, 1939b, 1943) and Coleman (1975).

Baldcypress predominated on sloughs which were partially gleyed to the surface (subclass B). Overcup oak (Quercus lyrata Walt.) was the chief associate and tupelo gum, American elm (Ulmus americana L.), and green ash (Fraxinus pennsylvanica var. subintegerrima (Vahl. Fern.) were minor associates. A majority of the dead trees found within this M.D.C., usually overcup oak and American elm, occurred in this subclass. Since beaver cuttings were common, these dead trees were probably a result of abnormal flooding due to beaver dams. Buttonbush (Cephalanthus occidentalis L.) was the most important understory species.

In type 101, Society of American Foresters Forest Cover Types, baldcypress was pure or predominate with tupelo gum, American elm, overcup oak, pumpkin ash (Fraxinus tomentosa Michx. f.), and other wet-site hardwoods as associates. Penfound (1952) reported that buttonbush occurred in the deepest water and may be found in many cypress swamps. Putnam and Bull (1932) described a southern cypress type which occurred on similar sites along with the same assocaites found in the study area. Coleman

(1975) reports a baldcypress community in a wet depression in which the soil was gleyed to the surface.

The low flats and sloughs where the soil matrix was not gleyed to the surface but contained common to many gray mottles were dominated by overcup oak. Its chief associates were baldcypress, American elm, and willow oak (_Quercus phellos_ L. f. Phellos); deciduous holly (_Ilex decidua_ Walt.) was frequent in the understory.

Penfound (1952), Putnam and Bull (1932), and the S.A.F. (1954) recognize an overcup oak-water hickory (_Carya aquatica_ (Michx. f.) Nutt.) cover type on low, poorly drained, impervious clay flats in back-water basins of major rivers throughout the southern forests. Coleman (1975) describes an overcup oak community similar to the forest cover of the study area in which water hickory is replaced by willow oak as the chief associate.

Mottling Depth Class 2

Common to many mottles at a depth of 1 to 15 cm characterized this mottling class. The topographic position occupied by these Waverly soils was almost exclusively flats, and the microsites were flat to slightly concave.

Subdivisions were not apparent and the vegetation did not form recognizable sub-communities as was so evident in M.D.C. 1. Hall and Smith (1955) reported that the component woody species of swamp forest were all water tolerant, but that those of floodplain forests varied considerably in their tolerance to inundation during the growing season. Few of the plots had the same dominant species; however, a trend from hydric to mesic sites was apparent. Baldcypress occurred only on soils in which the depth to mottling occurred within a few cm of the soil surface, while mockernut (Carya tomentosa Nutt.) and shagbark hickory (Carya ovata (Mill.) K. Koch) occurred on soils in which the depth to mottling approached 15 cm. Although the total basal area of the oaks increased as the drainage improved, there was no definite pattern evident in the forest cover.

Sweetgum (Liquidambar styraciflua L.) had the highest basal area and relative basal area for this class, 10.9 m^2/ha and 31.3, respectively. Even though one-fourth of this basal area was in the intermediate or suppressed crown classes, it still was the leading dominant; willow oak, overcup oak, cherrybark oak (Quercus falcata var. pagodaefolia Ell.), water oak (Quercus nigra L. var. nigra f. nigra), and pin oak (Quercus palustris Moenchh.) also occurred to varying degrees. Willow oak, overcup oak, and cherrybark oak were the next in importance after sweetgum with a basal area of 3.9 m^2/ha, 3.0 m^2/ha, and 1.9 m^2/ha (relative basal area of 11, 8.6, and 5.3, respectively). Baldcypress, silver maple (Acer saccharinum L.) water oak, swamp hickory (*Carya leiodermis* Sarg.) and swamp chestnut oak (*Quercus michauxii* Nutt.) were common associates, and American elm, planer tree (*Planera aquatica* (Walt.) J. F. Gmel.), American hornbeam (*Carpinus caroliniana* Walt.), and deciduous holly were frequent understory species. Minor associates include persimmon (*Diospyros virginiana* L.), red maple (*Acer rubrum* L.), green ash, blackgum (*Nyssa sylvatica* Marsh.), pin oak, and mockernut hickory. The second highest relative basal area of dead trees (mostly sweetgum) occurred in this M.D.C.; most of which was a result of impoundment and/or beaver cutting (Appendix, Table 9).

Similar S.A.F. forest cover types are the sweetgum-Nuttall oak-willow oak type (#92) and the swamp chestnut oak-cherrybark oak type (#91). Type 92 is the most widely distributed S.A.F. bottomland type and is considered to be climax. Nuttall oak (*Quercus Nuttallii* Palmer) and willow oak are the most common oaks in the type, but they should be considered only as indicator species, Nuttall oak not always being present. The type is dominated by sweetgum on well drained first bottom ridges and is dominated by willow oak and water oak on clayey soils on first bottom ridges and better drained flats. Nuttall oak dominates on well drained first bottom flats.

The composition varies widely in type 91. Swamp chestnut oak and cherrybark oak are often only indicator species, although they may be the most abundant of the dominant oaks. Other prominent hardwoods are white ash (*Fraxinus americana* L. var. *americana*) and various hickories. Sweetgum may occasionally be of high importance on first bottom ridges. Type 91 is widely distributed throughout the southern forest within the alluvial floodplains of the major rivers; on all ridges in the terraces, and on the best, most mature, fine sandy loam soils on the highest first bottom ridges. It was reported to extend only to a few well-drained first bottom ridges on soils other than sandy loam. Thus, by the S.A.F. criteria, the study area is an exception.

The sweetgum-clay land oak type of Putnam and Bull (1932) is almost identical to this M.D.C. The sites were both flats in first bottoms, where a shallow sheet of water usually stands during the winter. Species composition, predominants as well as associates, were similar except that cherrybark oak was not a component in their type.

Coleman (1975) identified two communities in northeastern Mississippi which were similar to the forest cover on this M.D.C. A swamp chestnut oak-cherry bark oak-sweetgum community occurred on a strongly acid, loam to silt loam of the first bottoms with a medium depth to mottling at 7.5 cm. The understory consisted primarily of American hornbeam and sweetgum. His second community, willow oak-sweetgum, occurred on a strongly acid, loam to silt loam on first bottoms and wet depressions; median depth to mottling was 15 cm.

Mottling Depth Class 3

This mottling class is characterized by common to many mottles between 15 to 30 cm. It was often difficult to distinguish which of these Falaya soils were located on flats and which were on low ridges. While forest cover was similar to that of M.D.C. 2, there was a definite transition to the more mesic species. The hydric bald-cypress and overcup oak dropped from a relative basal area of 12.5 and 7.5 to 0.7 and 3.9, respectively, with overcup oak becoming more important than cypress. The increase in mockernut hickory and shagbark hickory, commonly called "terrace hickories," from M.D.C. 2 to M.D.C. 3 is a definite indication that drainage has improved (Putnam and Bull, 1932). The inclusion of American beech (*Fagus grandifolia* Ehrh.), yellow-poplar (*Liriodendron tulipifera* L.), and white oak (*Quercus alba* L.) also signifies the shift from a hydric to a mesic habitat (Appendix, Table 10).

The most important species in these communities in all the crown classes were sweetgum which had a basal area of 10.8 m^2/ha and a relative basal area of 34.9. Chief associates which occasionally shared predominance were willow oak, cherrybark oak, and swamp chestnut oak.

Minor associates were mockernut hickory, shagbark hickory, blackgum, overcup oak, American elm, and swamp hickory. The primary understory species were sweetgum, planer tree, American hornbeam, and deciduous holly. Beaver damage on these sites was slight; thus, the relative basal area of the dead trees was only 3.7.

The forest cover of this class was diverse, having various combinations of predominant species. Several similar types have been described. S.A.F. types 91 and 92 have been discussed earlier and are similar in species composition and site. The M.D.C. 3 type is best represented by a variant of the willow oak-cherrybark oak-swamp chestnut oak type noted by Putnam and Bull (1932). They describe it as occurring principally on sites having characteristics of soil, moisture, elevation, and overflow intermediate between those of typical flats and typical ridges. Sweetgum, willow oak, cherrybark oak, swamp chestnut oak, Nuttall oak, overcup oak, and water oak are predominant. The occurrence of willow oak with cherrybark oak and swamp chestnut oak with overcup oak together are good indicators of this type (Putnam and Bull, 1932).

Mottling Depth Class 4

The 19 plots placed in this class were on soils having common to many mottles between 30 and 45 cm. The transitional character of this M.D.C. made classification as to Falaya or Collins silt loam difficult. Most of the sampling sites were on ridges with a few on flats, and the microsites were generally level.

Forest cover on these plots was similar to that on M.D.C. 3. However, baldcypress could no longer compete, and other hydric species such as overcup oak and planer tree decreased in relative basal area. The terrace hickories, which serve as good indicators of a change in drainage, increased in relative basal area, and American hornbeam, which is confined to the higher loamy ridges (Putnam and Bull, 1932), reached its maximum basal area on these sites. Species composition was very diverse and predominance was often difficult to determine. Sweetgum had the highest basal area although it had decreased in importance in the dominant and codominant crown classes. Cherrybark oak shared dominance with sweetgum and increased in relative basal area from 6.6 in M.D.C. 3 to 10.0 in this class. The increase in the relative basal area of swamp chestnut oak due to its greater density in the understory suggests that it is reproducing well and may increase in importance in the overstory (Appendix, Table 11).

Chief associates were shagbark hickory, silver maple, water oak, swamp hickory, and mockernut hickory; blackgum, willow oak, and river birch were minor associates. The understory was dominated by American hornbeam and

American elm, occasionally swamp chestnut oak, shagbark hickory, and sweetgum occur.

A sweetgum-loamy ridge oak type noted by Putnam and Bull (1932) conforms well to this class. They describe it as climax on moderately well drained ridges which are distinctly elevated above typical flats. These ridges may be either extensive or much interrupted by intervening low flats supporting a different type. Sweetgum, cherrybark oak, swamp chestnut oak, and water oak are predominant and hickories and blackgum are the chief associates. Any one or two of the predominant species or the chief associates may be prominent on any given area (Putnam and Bull, 1932). The corresponding S.A.F. cover type, swamp chestnut oak-cherrybark oak, has already been discussed.

Mottling Depth Class 5

This class consisted of moderately well drained silt loams having common to many mottles between 45 to 60 cm. The 13 plots in this class were on soils of the Collins series on ridges; microsites were flat to convex.

The forest cover appeared to segregate into two distinct communities--a sweetgum-cherrybark oak community and an American beech-yellow-poplar community. On most sites, sweetgum predominated in the codominant and intermediate crown classes with basal areas of 6.7 m^2/ha and 3.5 m^2/ha, respectively. The chief associate, cherrybark oak, often shared predominance, and occurred with Shumard oak (*Quercus shumardii* Buckl.) and willow oak in the dominant crown class. Other associates were shagbark hickory, swamp hickory, swamp chestnut oak, planer tree, and American elm, which reached its highest relative basal area on these sites.

The beech-yellow-poplar type occurred only on very high loamy ridges located near the main river channel on sites which were rarely if ever inundated during the growing season. American beech was dominant, and yellow-poplar and white oak were chief associates. Cherrybark oak, swamp chestnut oak, and sweetgum were minor associates, but increased in importance as the distance from the river channel increased. The understory species consisted of American holly (*Ilex opaca* Ait. f. *opaca*), eastern hophornbeam (*Ostrya virginiana* (Mill.) K. Koch), stiff dogwood (*Cornus foemina* Mill.), and pawpaw (*Asimina triloba* (L.) Dunal); all of which indicate the improved drainage (Appendix, Table 12).

Forest cover types similar to the sweetgum-cherrybark oak community have been discussed. A difference did exist in the character of the understory; American hornbeam and sweetgum decreased in importance on these well drained sites while vines, especially grape vines (*Vitis* spp.) and greenbriar (*Smilax glauca* Walt.), offered such severe competition that even the overstory would often be pulled down. Dense clumps of pawpaw and cane (*Arundinaria gigantea* (Walt.) Chapm.) distinguished this M.D.C. from the more hydric sites discussed earlier.

Putnam and Bull (1932) listed yellow-poplar, American beech, and eastern hophornbeam in an appendix along with a few other species which occurred so rarely in the bottoms proper that they "hardly warrant more than mention." They were found only on high terraces and on "islands of upland within the Delta region." White oak, American holly, and stiff dogwood were confined to the higher, loamy, better drained ridges in the second or higher bottoms (Putnam and Bull, 1932).

The Society of American Foresters does not list an beech-yellow-poplar cover type, but does identify a beech-southern magnolia (*Magnolia grandiflora* L.) type (#90) which occurs on loess ridges, ravines, and branch bottoms between these ridges. Beech is the indicator species and is often the most abundant. Common associates include sweetgum, blackgum, yellow-poplar, cherrybark oak, willow oak, southern red oak, and hickories.

Coleman (1975) describes a yellow-poplar-beech community which was confined to well-drained minor stream bottoms in northeastern Mississippi. The soils were a strongly acid, silt loam to sandy loam with a median depth to mottling of 75 cm. Yellow-poplar and beech were the dominant overstory taxa with white oak as a chief associate.

Shelford (1954) reported that yellow-poplar-oak communities occurred on the highest floodplain near Tiptonville, Tennessee. Yellow-poplar predominated with chinkapin oak (Quercus muehlenbergii Engelm.), black oak (Quercus velutina Lam.), and white oak. American beech, sugar maple (Acer saccharum Marsh), cherrybark oak, and Shumard oak were associates. This type was the most mesic found in the study area, and represent examples of Braun's (1950) western mesophytic forest.

Mottling Depth Class 6

Eleven plots occurred on moderately well drained to well drained ridges which had a mottling depth between 60 and 120 cm. Originally this was two classes--60 to 90 cm and 90 to 120 cm. However, the small number of samples in the 90 to 120 cm category made this a meaningless class. The soils were silt loam and often underlain by a fine sandy loam. Most of the soils belonged to the Collins series with a few plots on Vicksburg. The microsites were generally flat to convex.

Sweetgum dominated all of the crown classes and reached its maximum relative basal area for the study with 42.1. Water oak, swamp chestnut oak, and shagbark hickory were the chief associates. Minor associates included cherrybark oak, Shumard oak, mockernut hickory, and yellow-poplar. Sweetgum, American hornbeam, swamp chestnut oak, and the hickories dominated the understory; pawpaw and cane appeared in clumps. Although these were the better drained, most productive sites, the average basal area per ha progressively decreased as the depth to mottling increased. This can be explained in part by competing vegetation; approximately 50% of these sites had extensive encroachment from vines (Appendix, Table 13).

C. Correlation and Regression Analysis

Parameters

The vegetation parameters, absolute basal area, importance value (IV), and importance-two value (IV 2), were compared for use in the correlation and regression (Appendix, Table 14). Absolute basal area for such species was found by multiplying the total count of stems per species by the "tree factor" and dividing by the number of plots (Husch, Miller, Beers, 1972). The two importance values for each species were calculated as follows:

$$\text{IV} = \frac{\text{Relative Basal Area} + \text{Relative Density}}{2}$$

$$\text{IV 2} = \frac{\text{Relative Basal Area} + \text{Relative Density} + \text{Relative Height}}{3}$$

where:

$$\text{Relative Basal Area} = \frac{\text{Basal Area of species}}{\Sigma\ \text{Basal Area of all species}} \times 100$$

$$\text{Relative Density} = \frac{\text{Density of species}}{\Sigma\ \text{Density of all species}} \times 100$$

$$\text{Relative Height} = \frac{\text{Height of species}}{\Sigma\ \text{Height of all species}} \times 100$$

To provide standards for comparison within this study and with other studies, relative basal area and absolute basal area are the discussion parameters used. The differences between the parameters for each species were slight, especially for the predominant species. Sweetgum, for example, had a relative basal area of 28, an importance value of 28, and an importance-two value of 28.4. Other predominant species such as overcup oak, cherrybark oak, willow oak, and baldcypress had a relative basal area which was slightly higher than the IV 2 which, in turn, was slightly higher than the IV. The differences were rarely greater than one, and can be easily explained. These species were usually large trees in the dominant or codominant crown classes, and since horizontal point sampling is a type of sampling with probability proportional to size, they tend to have a higher basal area and a low density. The largest differences were found in the understory species because they had a high density and a small basal area and height. The species which occurred most frequently in the understory, American hornbeam, exemplifies this well. It has a relative basal area of

2.3, an IV 2 of 4.7, and an IV of 6.7, giving it the largest range in values of any species.

Of the three parameters, absolute basal area was chosen for use in the correlation and regression analysis for the following reasons: (1) Although the differences were slight, basal area favors the large, commercially important trees. (2) The importance values are ratios and require additional calculations (must be converted to logarithms). (3) Basal area is used more extensively in forestry and is more familiar to the field forester than the importance values.

Site-Site Correlations

The correlation among the four site variables, topographic position, microsite, abnormal flooding, and drainage classification (partial basis for soil series), were all highly significant with the exception of microsites and abnormal flooding (Appendix, Table 16).

As the topographic position changed from swamp to slough to flat to ridge, the microsite changed from concave to convex, the degree of abnormal flooding decreased, and drainage improved. Concave sites had the poorest drainage and convex sites the best. The degree of abnormal flooding decreased as drainage improved and as the topographic position increased in elevation. Thus, the low, poorly drained areas are the first affected by the dikes and dams of man and beaver. With increased flood control and beaver activity, it is likely that the effects of abnormal flooding will be apparent on all the topographic positions in the bottoms.

The absence of significant correlation between microsite and abnormal flooding suggest that microsites are independent of changes in the major drainage pattern.

Site-Soil Correlations

The four site variables were correlated with 40 soil variables (Appendix, Table 17). Since the significant correlations of the topographic position and the drainage class with the soil variables were almost identical, they are discussed together. Microsite and abnormal flooding were considered separately.

Topographic position and drainage class had essentially identical correlations and coefficients of correlation with soil variables. Changes associated with higher topographic position and improved drainage included: (1) increased depth to mottling, (2) gleying, and (3) few concretions, (4) decreased gray colors (chroma), (5) increased clay, (6) decreased sand content, (7) decreased K availability, (8) thicker, (9) darker (value) A horizon, and (10) thinner C horizons. Since depth to mottling, gleying, and few concretions, thickness and value of the A horizon, and the chroma are all related to the level of the water table, high coefficients of correlation were expected. The negative correlation of topographic position and drainage class with percent clay and the positive correlation with percent sand supports the hypothesis that the heaviest particles settle out first on the highest, better drained sites while the smaller particles remain in suspension longer and tend to settle on the poorly drained, low sites. This relationship was apparent when comparing the particle size classes to the drainage class (Table 2).

Several factors may contribute to the greater availability of K on the lower, poorly drained sites. Oxidation-reduction potential decreases during submergence, while pH increases (Bonner and Ralston, 1968; McKee, 1970). The alternate change in redox potential and pH as the water level fluctuates along with the higher percent of acid clays could result in the breakdown of primary minerals, such as feldspars and micas, with the subsequent release of K and other bases. K is highly mobile (Brady, 1974); leaching from the higher, better drained soils may account for higher concentrations on the poorer drained soils. Also, the leaching from the surrounding fertilized fields could result in an increase in K on the bottoms. Although the correlation coefficients were fairly high, the difference between the concentration of available K on the poorly drained soils and the well drained soils (Tables 3 and 6, pages 39 and 44, respectively) was only 30 to 40 ppm.

The more convex microsite was positively correlated with the depth to many mottles and gleying and few concretions, the chroma of the C_1 horizon, the percent silt in the A horizon and the texture, and was negatively correlated with the thickness of the C_2 horizon, the color value (paleness) of the A horizon, the percent clay, and available K. Although the correlation coefficients were lower and significant correlations were fewer, the relationships of the microsite to the soil variables corresponds with those of the two site variables just discussed. The concave microsite corresponds to the poorly drained, low sites while the convex microsite corresponds to the well drained, high sites.

The correlations between abnormal flooding and the soil variables are also similar to those which have already been discussed except that the coefficients are lower and there were fewer significant relationships. The abnormally flooded sites have a shallower depth to mottling and gleying, a grayer C_1 horizon, smaller particles, and a higher concentration of K.

Soil-Soil Correlations

A simple linear correlation matrix was prepared for 40 soil variables (Appendix, Table 18). Many of the significant correlations were apparent from the definition of terms. For example, as the depth to mottling increased, the A horizon thickness increased, and the color value for the A and C_1 horizons decreased (became darker). This was to be expected since the boundary between the A and C horizons was determined by the presence of gray mottles, and since the color value becomes darker as the gray mottles grow fewer and fainter. In another example, the A horizon thickness increased as the C_2 horizon decreased because the samples were taken to a depth of 120 cm and an increase in one horizon was at the expense of another. Such obvious correlations will not be discussed.

Depth to mottling was positively correlated with the depth to few concretions, the percent of silt and sand in the A horizon, and larger particles in all horizons; it was negatively correlated with the percent of clay in all horizons and K availability within the top 60 cm of the soil surface. The mottled condition indicates a zone of alternating redox potential in which iron and manganese concretions form. The depth to mottling is caused by a fluctuating water table and, as was mentioned in site-soil correlations, is related to the topographic position and drainage class. Increased depth to mottling indicates a higher, better drained site which usually has a higher percentage of the coarser sand and silt particles and a lower percentage of the small clay particles. The decrease in K availability as the depth to mottling increased was discussed under the site-soil correlations.

Gleying and concretions are a result of poor aeration and reduction due to a high water table and are correlated with most of the same soil variables as is mottling. This included percentage of clay and silt, texture, and K availability.

An increase in the thickness of the A horizon was associated with an increase in the chroma of all the horizons, a decrease in the percentage of clay in the A and C_1 horizons, and a decrease in the available K within the top 30 cm. A thick A horizon generally indicated a higher, better drained loam to silt loam with fewer mottles and brighter colors in all horizons.

The thickness of the C_1 horizon was positively correlated with the pale colors in the A and C_1 horizons and with the percentage of clay in the C_1 horizons, and negatively correlated with the depth to few correlations, gray colors (chroma) in the C_1 and C_2 horizons, and the available P in the 60 to 90 cm layer.

As the thickness of the C_2 horizon increased, depth to gleying and concretions decreased, the C_1 horizon became grayer, and particle size in the C horizons became smaller while available P in the top 60 cm and the available K in all horizons increased. This suggests poor soil profile development and a higher water table on poorly drained clayey soils.

The color values of the A and C_1 horizons became darker as the depth to mottling increased and became lighter as the percent clay and the thickness of the C_1 horizons increased. All horizons became lighter as the chroma of the C horizons became grayer. These relationships suggest that soils with dark surface horizons are better drained and are probably higher in organic matter. In contrast, as C_2 horizons became lighter, there was an increase in depth to gleying, silt in the A horizons, and sand in the C_1 horizons; as they became darker, there was an increase in the percent clay and sand in the C_2 horizons.

Gray colors (low chroma) were associated with shallow depth to mottling and gleying, thin A horizons, thick C horizons, a decrease in the percent clay, an increase in the percent sand, and a corresponding increase in particle size (textural classifications). Considering that a chroma of 2 or less was the criteria for a mottled or gleyed condition, the first four correlations were in agreement with the definition.

Potassium availability was positively correlated with percent clay in all horizons and negatively correlated with percent silt and sand in some of the horizons. This agrees with the earlier finding that a shift from clayey to loamy texture, which is associated with a change from a low to a high topographic position and an improvement in drainage class, was accompanied by a decrease in the K availability.

The only significant trend which was associated with pH was a negative correlation with percent clay in the C horizons. This could be possible due to the adsorption of hydrogen ions on the colloidal complex. However, the range in average pH on the soil samples was slight (Tables 3-6, pages 39, 41, 43, and 44, respectively).

Soil/Site-Forest Cover Correlations

Simple linear correlations were determined between the absolute basal area (A.B.A.) of all 33 tree species plus a dead tree category and 44 soil/site variables. Due to the weaker relationships detected, the level of probability was decreased from 99 to 95%. Significant correlations were not detected for 11 species while five species had only one (Appendix, Table 19). Insufficient data on sassafras (Sassafras albidum (Nutt.) Nees), shellbark hickory (Carya laciniosa (Michx.) Loud.), and slippery elm (Ulmus rubra Muhl.) eliminated them from consideration. Multiple regression equations were developed for eight of the most important overstory trees; their correlations will be discussed in that section.

Nyssa aquatica. Tupelo gum was positively correlated with A and C horizons thickness and percent silt and darkness of the A horizon, and was negatively correlated with percent clay in the A horizon, and the elevation. Tupelo gum frequency was generally correlated with abnormal flooding and poor drainage. High correlation with the lowest topographic position agreed with field observations that tupelo gum achieved its best growth when inundated on spring-fed areas or on inundated sites with moving water. Correlations with the other soil variables indicated that the basal area of tupelo gum increased when the upper horizons were deep, dark, and silty. On first impression, these soil characteristics suggest a slight improvement in drainage; however, the darker color probably indicates a higher percentage of organic matter.

Hall, Penfound, and Hess (1946) reported that tupelo gum was less tolerant to flooding than baldcypress except in spring-fed swamps with well aerated waters. In another study, Hall and Penfound (1943) reported tupelo gum in a spring-fed swamp in water as much as 2-3 m in depth where the hydroperiod was nearly continuous. Tupelo gum not only tolerates inundation, but was reported to have its best diameter growth when flooded (Hook et al., 1973). In the northern section of the Mississippi Delta, tupelo gum was confined to small, deep sloughs and very wet swamps in pure stands (Putnam and Bull, 1932).

Planera aquatica. Planer tree occurred most often as a part of the understory on swamps, sloughs, and low flats. Negative correlations with topographic position, depth to gleying, and positive correlation with the thickness of the C_2 horizon confirm this relationship.

Putnam and Bull (1932) stated that this species was confined to swamps and sloughs, where it was a common component of scrubby understory of cypress brakes. A study of the effects of flooding on a Kentucky reservoir reported that water elm remained healthy if it was inundated less than 43% of the growing season and that it did not die until it was flooded more than 54% of the growing season (Hall and Smith, 1955).

Diospyros virginiana. Although persimmon was found as an occasional associate on all but the wettest sites, it was confined chiefly to low flats and had its highest basal area in M.D.C. 2. A high coefficient of correlation (.97) with the percent sand in the C_2 horizon along with positive correlations with coarser textural classifications and higher chromas strongly suggest a relationship between the occurrence of persimmon and sites which have a sandy subsoil.

On a study in northeast Mississippi which included 12 bottomland community types, persimmon was found to have its highest importance value and highest relative basal area in the willow oak-sweetgum community. The soil was a strongly acid, silt loam over a fine sandy loam with a median depth to gleying of 15 cm (Coleman, 1975). According to Putnam and Bull (1952) persimmon occurred on low, wet, loamy flats in both first and second bottoms. Bedinger (1971) placed persimmon in his flooding group two, the Nuttall oak group, which characterized sites inundated 10% to 21% of the time. This coincides with Hall and Smith (1955) who found that persimmon remained healthy if flooded less than 31% of the growing season.

Carpinus caroliniana. American hornbeam was consistently the most important understory species except on the wettest sites. Its basal area increased as the percent sand in the C_2 horizon increased and as the color value of the C_2 horizon became paler, and it decreased as the percent clay in the C_2 horizon increased and the chroma became grayer.

On the bottoms of west central Mississippi, American hornbeam was the most common understory species with an importance value twice that of any other species (Caplenor, 1968). Hornbeam was also found to be the most important sapling and sub-sapling in six of Coleman's bottomland communities. In the Mississippi Delta, American hornbeam was usually confined to the loamy ridges (Putnam and Bull, 1932).

Carya leiodermis. An increase in the chroma of the C horizons and an increase in the percent sand in the C_2

horizons were associated with an increase in the basal area of swamp hickory.

It is the most hydric of the hickories found in the study area; its highest basal area was on M.D.C. 2 while shagbark hickory had its highest on M.D.C. 6. Swamp hickory often occurred along with overcup oak and is probably filling a niche similar to that of water hickory (*Carya aquatica* (Michx. f.) Nutt.) of the S.A.F. cover type 92, overcup oak-water hickory (S.A.F., 1954).

Dead trees. The number of dead trees increased as the possibility of abnormal flooding increased and as the depth to many mottles decreased. This indicates that the sloughs and flats of the Waverly and Falaya soils are more susceptible to a change in flooding conditions caused by man and beaver activity, and that a higher percentage of timber kills can be expected on these sites. The only species which was significantly correlated with the number of dead trees was sweetgum. This is in agreement with field observations and suggests that sweetgum should not be favored in forest management on these lower sites.

Correlation and Multiple Regression of Eight Selected Overstory Taxa

Taxodium distichum. Baldcypress was one of the most hydric of the arborescent species in the study area; 82%

of its total basal area occurred in swamps, sloughs, and low flats where the depth to mottling was at the soil surface. Hazard (1933) categorized the trees of Reelfoot Lake, Tennessee, into forest type sub-divisions based on drainage, and baldcypress was the only species which occurred on his lowest sub-division, the submerged river bottom. On the coastal plains of North Carolina, pure cypress communities occur in the quiet waters of ponds and lake borders (Wells, 1928). Baldcypress was dominant in swamps and along lake shores of Indiana on soils which were a gray clay, with many crayfish chimneys (Lindsey, et al., 1961). In the northern portion of the Mississippi Delta, it was confined principally to bayou banks, sloughs, swags and swamps (Putnam and Bull, 1932). Hall, et al. (1939, 1943, 1946) reported that baldcypress was more tolerant to inundation during the growing season than any other woody species.

Certain of the components of the following regression equation indicate this strong affinity for poorly drained soils.

$$\text{A.B.A. m}^2\text{/ha of baldcypress} = 0.668 + 0.0021\,(\text{K60}) - 0.166\,(\text{pH }60) + 0.0081\,(\text{C}_1\text{ Sand}) - 0.0157\,(\text{P }30) + 0.0118\,(\text{C}_1\text{ TEX}).$$

K60 = K of depth 30-60 cm

pH 60 = pH of depth 30-80 cm

C_1 Sand = Percent sand in C_1 horizon

P 30 = P of depth 0-30 cm

C_1 TEX = Texture of C_1 horizon

The relationship between K and baldcypress as indicated by the regression equation is most probably directly related to the site and indirectly related to the occurrence of baldcypress. The positive correlation between K availability and poorly drained soils was discussed under site-soil correlations.

The regression equation indicates that the basal area of baldcypress is negatively related to pH. This disagrees with Monk (1966) who reported that the importance of baldcypress increased with an increase in pH. The otpimum range in pH on sites suitable for baldcypress was reported to be between 5.1 to 7.3 in one study (Broadfoot, et al., 1972) and between 4.6 to 7.5 in another (Williston and LaFayette, 1978). Such wide ranges in pH in baldcypress stands along with the small range in pH on the soils of the study area (Tables 3-6, pages 39, 41, 43, and 44, respectively) decrease the usefulness of this variable as an indicator of baldcypress suitability.

The relationship between the percent of sand in the C_1 horizon and coarse soil textures as shown in the regression equation are not characteristic of poorly drained sites; however, it does agree with the findings of Coleman (1975). His baldcypress communities occurred in a wet depression that had a sandy loam soil at all horizons.

An increase in sand would increase pore size, decrease capillary action, lower water tension, increase drainage, and enable easier root penetration. Mattoon (1915) reported that growth of baldcypress increased as drainage improved.

Decreased available P in the surface horizons with increasing basal area of baldcypress is suggested by the regression equation. The availability of P to plants is determined to no small degree by the ionic form of this element. The ionic form in turn is determined by the pH of the solution in which the ion is found. In highly acid solutions only H_2PO_4 ions are present, and in general this form is considered somewhat more available to plants than the H PO_4 ion which is present in more alkaline solutions. However, in the acid soils of the study area, this relationship is complicated by the presence of soluble iron, aluminum, and manganese which immediately react with the H_2PO_4, rendering the P insoluble. The fixation of P under acid conditions can also occur with hydrous oxides as well as with silicate minerals such as montmorillonite and illite (Brady, 1974).

Quercus lyrata. The one variable model for overcup oak was the only equation meeting the study criteria.

A.B.A. m^2/ha of overcup oak = 0.0012 + 0.0013 (C_1 HORTH)

R^2 = 0.28

C_1 HORTH = C_1 horizon thickness

Overcup oak was largely confined to sloughs and low flats with approximately 82% of its basal area in mottling depth class 1 or 2. This was indirectly supported by the regression equation and by correlation because the thicker the C_1 horizon, the thinner the A horizon, and the higher the water table. It was directly supported by the negative correlations with depth to mottling, depth to gleying, and drainage class. As overcup oak increased in basal area, paler color values of the A and C_1 horizons and grayer chromas of the C_1 horizons also indicate poor drainage. Phosphorus availability was negatively correlated with overcup oak basal area and K availability was positively correlated.

Putnam and Bull (1932) found that overcup oak was well distributed on the lower, wetter, more impervious clay flats in the first bottoms. Fowells (1965) reported that overcup oak was the principal tree on poorly drained backwater flats and was also found on low sites next to sloughs occupied by tupelo gum and baldcypress. Communities on the White River National Wildlife Refuge in Arkansas, which were flooded two or more times during the average summer were made up largely of overcup oak (Shelford, 1954). Coleman (1975) describes an overcup oak community located in a wet depression which had a water table within 30 cm of the surface during mid-July.

According to Bedinger (1971) a water hickory-overcup oak group indicated a site flooded 29% to 40% of the time. This is in agreement with Smith and Hall (1955) who found that overcup oak remained healthy if flooded less than 41% of the growing season.

Liquidambar styraciflua. Sweetgum was the most ubiquitous species in the study area and was the most important species on all sites except for swamps and sloughs. Its relative basal area progressed from a low of 2.7 in M.D.C. 1 to a high of 42.1 in M.D.C. 6, and as indicated by the regression equation, the higher the topographic position, the greater the basal area of sweetgum. The low R^2 suggests the widespread distribution of this species.

A.B.A. m^2/ha of sweetgum = 0.0028 + 0.0191 (TOPO)

$R^2 = 0.20$

TOPO = Topographic position

Correlation analysis also showed a strong relationship with better drained topographic positions and showed a negative correlation with pale color value of the A horizon and with the available K in the top 60 cm. Sweetgum was the only species significantly correlated with the number of dead trees, and since the number of dead trees increased as the drainage decreased, it suggested that sweetgum is subject to high mortality rates on the poorly drained to somewhat poorly drained soils.

Smith (1977) reported that on the swamp and mesic forest of the Cumberland Plateau, sweetgum reached its best development on wet clayey or draw positions. Hebb (1962) found that on loess derived soils in West Tennessee, sweetgum growth increased on lower slope positions (bottomland) and on sites with poor surface drainage. In the lower Mississippi Valley, sweetgum site index increased with decreased clay content and with increased exchangeable K in the 90 to 120 cm soil layer. The best growth of sweetgum was on "medium-textured" soils without a hardpan in the top 60 cm, and had moderate to good internal drainage (Broadfoot and Krinard, 1958). In addition to these soil/site properties, Baker and Broadfoot (1977) found a concave microsite, depth to mottling greater than 45 cm, a dark, thick (7.5 cm) A horizon, water table depth between 60 and 180 cm, and pH range of 5.5 to 7.5 as the optimum soil-site conditions for sweetgum growth. Monk (1966) reported that the importance of sweetgum in mixed swamps of north-central Florida decreased with K, P, Mg, Ca and cations milliequivalent and increased with Ca/K and pH. On hardwood tree plantations along the margins of the fluctuating reservoirs on the lower Tennessee River, sweetgum grew best on soils with deep surface layers and permeable subsoils (Silker, 1948). May and Blackman (1963) studied soil-vegetation relationships of two bottomland hardwood soils in the Piedmont of Georgia and reported that sweetgum importance was considerably higher on the well drained Congaree series than on the poorly drained Wehadkee series. On wet soils in the New Jersey coastal plain, sweetgum site index was directly related to high clay and fine sand content and thickness of the B_2 horizon, and the highest site index values occurred on sites with an average depth to water of 50 cm (Phillips and Markley, 1963).

Quercus nigra. The basal area of water oak was evenly distributed between mottling depth classes 2, 3, and 4, giving water oak a fairly wide range of sites, from low flats to low ridges. This is substantiated by Putnam and Bull (1932) who reported that water oak was most common on the border-line sites between typical flats and ridges, but added that it could be found on almost any other site.

A.B.A. m^2/ha of water oak = 0.2904 + 0.0014 (K 60) - 0.0291 (M SITE) - 0.0503 (pH 60)

$R^2 = 0.99$

K 60 = K of depth 30-60 cm

M SITE = Microsite

pH 60 = pH of depth 30-60 cm

This three-variable model has a very high R^2, and suggests that the basal area of water oak is related to a concave microsite, an increase in available K in the

30 to 60 cm layer, and a decrease in the pH in the 30 to 60 cm layer.

Two other relationships are suggested by correlation which were not readily apparent. A decrease in the depth to gleying as water oak basal area increased indicates poorly drained to somewhat poorly drained soils were favored. Since water oak occurred in flats as well as ridges, this probably is due to the effect of the concave microsite. A negative correlation with dark, gray colors and the percent clay in the C_2 horizons and a positive correlation with percent sand in the C_2 horizon and with coarser family textures suggest the same relationship; an increase in the percentage of sand decreases the percentage of clay, resulting in a loamy family texture, and a purer and paler color.

Water oak occurs along small streams on a variety of bottomland soils and occasionally on upland soils (Fowells, 1965). It is a component on a number of forest cover types although it is most common in the sweetgum-water oak type defined by Putnam (1951) and Putnam, et al. (1960). Coleman (1975) described a water oak-willow oak-beech community in which water oak was the leading dominant. The soils had a very strongly acid silt loam A horizon over a sandy loam to loam C horizon with a medium depth to mottling at a depth of 60 cm. Baker and Broadfoot (1977) reported deep (> 120 cm), granular, friable, silt loam, concave microsite, pH of 4.5 to 5.5, depth to mottling greater than 45 cm, and dark, deep (> 15 cm) A horizon as the best soil/site conditions for water oak growth. Bedinger (1971) found that water oak was distributed in two of his flooding groups: the Nuttall oak group, which indicated inundation 10% to 21% of the time, and the shagbark hickory-southern red oak group, which was flooded at intervals of 2 to 8 years. Broadfoot and Williston (1973) reported that water oak all died with four years of partial submersion, and Hall and Smith (1955) found that it died if flooded more than one-fourth of the growing season.

Quercus phellos. Willow oak was located on all sites except swamps and reached its highest basal area on M.D.C. 2 on flats of the Waverly series. In contrast, the regression equation indicated increased willow oak basal area improved with drainage.

A.B.A. m^2/ha of willow oak = 0.0174 - 0.0017 (DEPMOT) + 0.0574 (M SITE)

$R^2 = 0.41$

DEPMOT = Depth to common or many gray mottles

M SITE = Microsite

A negative relationship with depth to mottling and a positive relationship with convex microsites suggest that willow oak prefers sites with improved drainage.

However, correlation analysis indicates that it was most common on somewhat poorly drained sites. A shallow depth to mottling along with a corresponding decrease in the A horizon thickness and paler color values for the A and C_1 horizons all are drainage properties of the typical "pin oak flat."

Putnam and Bull (1932) reported that willow oak was occasional to predominant on flats, local swags, and drains, and was rare on ridges. Beaufait (1956) reported that site quality of willow oak on river and stream bottoms of the South decreased from higher to lower topographic position and decreased with increased K availability. A conflict between site suitability and site index was indicated in these studies. Willow oak growth potential was higher on better drained sites but it occurred most often on somewhat poorly drained flats to ridges. This could possibly be caused by seed distribution, regeneration, and/or competition.

Willow oak remained healthy if flooded less than 31% of the growing season (Hall and Smith, 1955), but died after three years of partial submersion (Broadfoot and Williston, 1973).

Quercus michauxii. Swamp chestnut oak commonly occupied high flats or ridges. A positive relationship with depth to gleying in the regression equation and a positive correlation with the better drained microsites indicate that swamp chestnut oak favors better drained sites.

A.B.A. m^2/ha of swamp chestnut oak = 0.027 + 0.001 (DEPGLEY) - 0.0047 (C_1 SAND) - 0.0011 (DEPMOT)

$R^2 = 0.76$

DEPGLEY = Depth to gleying

C_1 SAND = Percent sand in C_1 horizon

DEPMOT = Depth to common or many gray mottles

A negative relationship with the percent sand in the C_1 horizon and with the depth to mottling in the regression equation, along with a negative correlation with larger particle-size classes of the C_2 horizon are not characteristics of a well-drained site. It appears that the basal area of swamp chestnut oak is related to soil/site conditions intermediate between poorly drained and well drained. Factors which affect the amount of available moisture during critical periods along with the factors which improve drainage determined site suitability.

Fowells (1965) reported that swamp chestnut oak is widely distributed on the best, well drained, loamy, first bottom ridges in the bottomlands of both large and small streams. Shelford (1954) in his attempt to reconstruct undisturbed biotic communities of the floodplains around Reelfoot Lake, Tennessee, found that swamp chestnut oak occurred only on the highest ground and that it belonged to the later successional stages of the oak-hickory floodplain community. Putnam and Bull (1932), however, reported that swamp chestnut oak required abundant moisture and that its best sites were flooded regularly by small streams or subjected to standing water for short periods in late fall and winter. In agreement with this, Hall and Smith (1955) reported that swamp chestnut oak remained healthy if flooded less than 21% of the growing season and that it would not succumb to death until it was flooded more than 34%.

Quercus falcata var. pagodaefolia. Cherrybark oak was a major associate in the dominant and codominant crown classes on all sites except for swamps and sloughs. Its relative basal area was second only to sweetgum on M.D.C. 3, 4, and 5, and it occurred most frequently on the silty ridges.

The regression equation developed for cherrybark oak indicates its preference for a fine textured A horizon and for sandy subsoils which were higher in P.

A.B.A. m^2/ha for cherrybark oak - 0.0008 + 0.0075 (C_1 SAND) + 0.0121 (P 60) - 0.0097 (A SAND)

$R^2 = 0.82$

C_1 SAND = Percent sand in C_1 horizon

P 60 = P of depth 30-60 cm

A SAND = Percent sand in A horizon

Putnam and Bull (1932) reported that cherrybark oak was common throughout the Mississippi Delta and was occasional to predominant on almost all loamy ridges in both first and second bottoms, but was rarely found on clay ridges or flats. Fowells (1965) reported that cherrybark oak was distributed on loamy well drained soils and that it was uncommon on clay or wet, swampy soils. Shelford (1954) found that cherrybark oak outnumbered all other trees on a high ridge near Samburg, Tennessee and considered it a part of the early successional stage of floodplain oak-hickory communities. Cherrybark oak was predominant in the headwaters of Mackey Creek, Mississippi on soils which had a loam to silt loam A horizon over a sandy loam C horizon (Coleman, 1975). As would be expected from a species which favors loamy ridges, it is relatively intolerant to flooding during the growing season. Broadfoot (1973) observed that cherrybark oak which was subjected to partial submersion during the growing season died within the first year.

Carya ovata. Shagbark hickory reached its highest relative basal area on M.D.C. 6, and as suggested by the regression equation, it occurred on the better drained sites.

A.B.A. m^2/ha of shagbark hickory = 0.0773 + 0.0011 (K 60) + 0.0258 (TOPO) - 0.0022 (A CLAY)

$R^2 = 0.82$

K 60 = K of depth 30-60 cm

TOPO = Topographic position

A CLAY = Percent clay in A horizon

Regression analysis related the basal area of shagbark hickory to an increase in the available K in the 30 to 60 cm layer, an increase in the elevation, and a decrease in the percent clay in the A horizon.

The nature of the sites of shagbark hickory indicate that it is most definitely a mesic species. According to Fowells (1965) the sites occupied by shagbark hickory vary greatly over its range. In the Ohio Valley, it grows chiefly in north and east slopes of fertile uplands; in the Cumberland Mountains, it is confined to coves and to north and east slopes; and in the Gulf Coastal Plain, it grows principally on river bottoms. Within the Delta, shagbark hickory is especially common on ridges in the second bottoms, and is conveniently designated by the term "terrace hickory" (Putnam and Bull, 1932). This holds true as far north as the Wabash and Tippecanoe Rivers, Indiana on which shagbark hickory occurred on the terraces (Lindsey, et al., 1961). It was a minor associate in many of the bottomland communities described by Coleman (1975), except for the hydric communities, and reached its highest importance value on the high, loamy ridges in the beech-sweetgum and the sweetgum-blackgum-red maple communities.

CHAPTER VI

SUMMARY AND CONCLUSION

A. Summary

The wide, nearly level floodplain of the Hatchie River within the study area is made up of locally derived alluvium which consists of material eroded from the loess uplands. Due to flooding and deposition, the soils are subject to rapid changes; thus, they are classified as Entisols. Thirty-one percent of the samples were a poorly drained silty clay to silty clay loam mainly of the Waverly series, 46% were a somewhat poorly drained silt to silt loam mainly of the Falaya series, 21% were a moderately well drained silt loam to loam mainly of the Collins series, and 3% were a coarse silt to coarse loam mainly of the Vicksburg series. These soils have no distinct pedogenic horizons and the characteristic which is used to distinguish one series from another is the depth and degree of gray mottles.

Relatively undisturbed bottomland hardwood stands of the Hatchie National Wildlife Refuge were described utilizing six mottling depth classes, each progressively deeper. These classes were narrower and more precise than the drainage classes used to partially define the soil series. Diagnostic criteria are common to many mottles of a chroma of two or less at the following depths:

M.D.C. 1 - 0 cm

M.D.C. 2 - $>$ 0 cm, $\leq$ 15 cm

M.D.C. 3 - $>$ 15 cm, $\leq$ 30 cm

M.D.C. 4 - $>$ 30 cm, $\leq$ 45 cm

M.D.C. 5 - $>$ 45 cm, $\leq$ 60 cm

M.D.C. 6 - $>$ 60 cm, $\leq$ 120 cm

Three distinct communities occurred at distinguishable levels of mottling and/or gleying at the soil surface in M.D.C. 1. Tupelo gum was found in almost pure stands in spring-fed swamps and flowing sloughs which were completely gleyed to the surface. The only associate was an occasional dominant baldcypress along with a shrub cover of common alder and Virginia willow. Baldcypress was dominant on those swamps, sloughs, and oxbow lake margins which were partially gleyed to the surface. Overcup oak was the most common associate and buttonbush was the most important understory species. Low flats and sloughs where the soil matrix was not gleyed at the soil surface but contained mottles with a chroma of two or less were dominated by overcup oak. The chief associates were baldcypress, planer tree, and willow oak with deciduous holly in the understory.

Mottling depth class 2 consisted of poorly drained clay flats, commonly called "pin oak flats." Sweetgum shared dominance with different combinations of willow oak, overcup oak, cherrybark oak, water oak, and pin oak; the forest cover being best described by Putnam and Bull (1932) as a sweetgum-clay land oaks cover type. Baldcypress, silver maple, and swamp hickory were common associates with American elm, planer tree, American hornbeam, and deciduous holly as the common understory associates.

Sites having characteristics midway between typical flats and typical ridges occurred most frequently in M.D.C. 3. Sweetgum predominanted on these Waverly and Falaya soils with willow oak, swamp chestnut oak, and cherrybark oak as chief associates. The decrease in the relative basal area of baldcypress and overcup oak along with an increase in mockernut and shagbark hickories are definite indicators that the drainage has improved. The understory canopy was chiefly composed of sweetgum, planer tree, American hornbeam, and deciduous holly. Both the site and the species composition of this class are similar to the willow oak-cherrybark oak-swamp chestnut oak cover type of Putnam and Bull (1932) with the exception that sweetgum is predominant and not just an associate species. On a few of the better drained ridges, an American beech community occurred in which yellow-poplar and white oak were the chief associates.

The last three mottling classes--4, 5, and 6--were similar in site and species composition. A few high flats with level microsites occurred in M.D.C. 4, but these transitioned into ridges with convex microsites and with a coarser texture as the depth to mottling increased. Sweetgum was the predominant species, reaching its highest basal area on M.D.C. 6. Chief associates were cherrybark oak, swamp chestnut oak, water oak, and shagbark hickory; cherrybark oak reached its maximum relative basal area on M.D.C. 5 while swamp chestnut oak and shagbark hickory along with water oak reached their maximum on M.D.C. 6. The sweetgum-loamy ridge oak cover type of Putnam describes the site and species composition of these communities. The understory canopy was more diverse and mesic than the understories of the lower mottling classes. American hornbeam and American elm occurred frequent to fairly frequent while the importance of swamp chestnut oak, the terrace hickories, and pawpaw increased as the drainage improved. Dense patches of cane occurred on the ridges, and vines, particularly grape vine and greenbriar were often so common that they competed with the overstory canopy. A decrease in the total basal area per ha as the depth to mottling increased was possibly caused by this increase in competition. Occurring on the highest ridges in these classes was an American beech-yellow-poplar community which had an understory of American holly, rough leaf dogwood, and eastern hophornbeam.

Results of this study support the findings of

Hosner and Minckler (1963) that there are two broad types found in bottomland hardwoods: (1) a hydroseric type which starts on poorly drained areas and (2) a mesic type which is subject to flooding but is generally free of surface water most of the growing season.

The hydroseric type consisted of three distinct communities, each of which occurred on different, distinguishable levels of mottling and/or gleying. Although the indirect effects of flooding such as accumulation of carbon dioxide or of toxic products cannot be discounted (Robinson, 1930), the direct effect of anerobiosis is certainly the critical factor in the survival of woody species on inundated sites (Gill, 1970), and results in clearly recognizable communities as described in theory by Clements (1916).

Most of the soil and site variables which were associated with these hydric species supported that they occurred most frequently on poorly drained sites due to their flooding tolerance. A number of the variables, however, such as an increase in the percent silt and a decrease in the percent clay in the A horizon for tupelo gum, an increase in the percent sand in the C_1 horizon for bald cypress, and an increase in the thickness of the C_1 horizon for overcup oak indicate that even these hydric species increase in basal area as the site becomes slightly better aerated.

An increase in the degree of abnormal flooding along with a corresponding increase in the number of dead trees as the depth to mottling decreased suggest that forest management should favor the more hydric species on Waverly and most Falaya soils of the West Tennessee bottomlands in anticipation of further changes in drainage patterns. However, drainage class alone was not precise enough to determine the species suitability on the hydric site; specific depth to mottling and/or gleying being a more precise indicator.

The mesic communities of the second broad type were less than discrete units and transition was gradual from one forest type to another along a hydric gradient (Whittaker, 1970). The Society of American Foresters' cover types were too general to be effective for describing these communities, but the more detailed cover types of Putnam and Bull (1932) proved to be adequate for both site descriptions and species composition. Although sweetgum predominated on all sites, its positive relationship with the higher topographic position as suggested by its regression equation along with a positive correlation with the number of dead trees on the somewhat poorly drained soils implies that sweetgum should not be favored in bottomland forest management except on the ridges. Willow oak, water oak, cherrybark oak, swamp chestnut oak, and shagbark hickory shared dominance with sweetgum to varying degrees on these sites, but no one or two of the soil-site variables were related to each of these species. Topographic position, microsite, texture of the A and C_1 horizons, depth to mottling, depth to gleying, and available K were significant in a number of the regression equations for these species and suggest that the duration of flooding and the amount of available moisture during critical periods are the most important factors affecting their basal area.

The present classification system used by the Soil Conservation Service is inadequate on the hydric sites. Drainage class was not significant in any of the regression equations and was significant with only one soil/site-forest cover correlation. Three distinct hydric communities and the sweetgum-willow oak-overcup oak mesic community occurred on the Waverly series, showing that a more detailed classification is needed for forest management on these sites.

Communities on the mesic sites showed a gradual transition from one forest type to another and a further refinement of the Falaya and Collins series would be of little use in determining species suitability. Small topographic changes which occurred throughout the bottoms resulted in a change in species suitability and productivity, and reduced the usefulness of soil mapping units on bottomland sites.

B. Conclusion

The forest cover of the study area can be subdivided into the following two broad types, each of which contains various forest communities:

1. Hydroseric type--distinct communities due to the direct effect of anaerobiosis which occurred on Waverly soils (M.D.C. 1).

    a. Tupelo gum community--occurred in almost pure stands in spring-fed swamps and flowing sloughs which were completely gleyed to the soil surface.

    b. Baldcypress community--dominant on swamps, sloughs, and ox bow lake margins which were partially gleyed to the soil surface.

    c. Overcup oak community--occurred on low flats and sloughs where the soil matrix had common to many mottled with a chroma of two or less at the soil surface but was not gleyed.

2. Mesic type--communities less than discrete units which gradually transition from one cover type to another along hydric gradient and occurred on sites which were subject to flooding but were generally free of surface water during most of the growing season.

    a. Sweetgum-willow oak-overcup oak community--sweetgum showed dominance with willow oak, overcup oak, cherrybark oak, water oak, and pin oak on poorly drained flats. These Waverly soils had common to many gray mottles within the upper 15 cm (M.D.C. 2).

b. Sweetgum-willow oak-cherrybark oak-swamp chestnut oak community--sweetgum predominated on these Waverly and Falaya soils on sites having characteristics midway between typical flats and typical ridges in which the depth to gray mottles occurred from 15 to 30 cm (M.D.C. 3).

c. Sweetgum-ridge oak community--sweetgum shared dominance with cherrybark oak, swamp chestnut oak, water oak, and shagbark hickory, on ridges of Falaya, Collins, and Vicksburg soils in which depth to gray mottles occurred below 30 cm (M.D.C. 4, 5, and 6).

d. American beech-yellow-poplar community--American beech predominated with yellow-poplar and white oak only on the better drained ridges.

Soil/site variables which were significantly related to forest cover suggest that the degree and duration of flooding and the amount of available moisture during critical periods determine species suitability and productivity. An increase in the abnormal flooding due to activities of man and beaver along with an increase in the number of dead trees as depth to mottling decreases indicate that the forest cover on the floodplains of West Tennessee will gradually shift toward the hydric type at the expense of the mesic type. Forest managers should favor a more flood tolerant species in these bottoms than that which presently exists on the site in question, especially on the lower topographic positions. Specifically, sweetgum should be favored only on high flats and ridges which have stable drainage patterns and which are not threatened by beaver activities.

Drainage class was not significantly related to species composition. This, plus the presence of a mesic community on the poorly drained Waverly series, suggests that this series was too broad to be of use in species determination. The Soil Conservation Service classification system is inadequate for identifying species composition on hydric sites. A more detailed breakdown of mottling depth is needed for forest management.

Bottomland hardwood species are site specific; however, interrelationships among variables often make species suitability determination difficult. Although there appears to be no substitute for field experience in relating forest cover to topographic position and internal drainage, these descriptions of relatively undisturbed bottomland hardwoods according to mottling depth and by topographic position can be of assistance in selecting species for disturbed floodplains in West Tennessee on which drainage patterns are changing.

A generalized topographic profile of the Hatchie

River floodplain showing differences in topography, forest cover, and approximate mottling depth is shown in Figure 2.

TOPOGRAPHIC POSITION	RIDGE	FLAT	LOW FLAT	SLOUGH	FLAT	LOW RIDGE	SWAMP (CREEK)	RIDGE	FLAT
FOREST COVER*	A. beech Yellow-poplar White oak Sweetgum Swamp chest-nut oak Cherrybark oak	Sweetgum Cherrybark oak Willow oak Swamp chest-nut oak Water oak Silver maple Swamp hickory Shagbark hickory	Sweegum Willow oak Overcup oak Swamp hickory Baldcypress Silver maple Cherrybark oak	Overcup oak Baldcypress Willow oak	Sweetgum Willow oak Cherrybark oak Swamp chest-nut oak Overcup oak Swamp hickory Water oak Pin oak	Sweetgum Cherrybark oak Swamp chest-nut oak Willow oak Shagbark hickory Water oak Swamp hickory Mockernut hickory	Tupelo gum Baldcypress Overcup oak	Sweetgum Swamp chest-nut oak Water oak Shagbark hickory Cherrybark oak Shumard oak Mockernut hickory Yellow-poplar A. beech	Sweetgum Cherrybark oak Swamp chest-nut Shagbark hickory Water oak Mockernut hickory Blackgum
UNDERSTORY CANOPY	American holly Pawpaw Eastern hophornbeam Stiff dogwood Cane	A. elm A. hornbeam Sweetgum Deciduous holly Swamp chest-nut oak	Planer tree A. elm A. hornbeam Sweetgum Deciduous holly	Planer tree Deciduous holly	Planer tree A. hornbeam A. elm Sweetgum Deciduous holly	A. elm A. hornbeam Grape vine Greenbriar Sweetgum Swamp chest-nut oak Shagbark hickory	Buttonbush Planer tree Virginia willow	A. hornbeam Sweetgum Grape vine Greenbriar Shagbark hickory Swamp chest-nut oak Pawpaw Cane	A. hornbeam A. elm Swamp chest-nut oak Sweetgum Shagbark hickory

TOPOGRAPHIC PROFILE

APPROXIMATE MOTTLING DEPTH (CM)	60	30	7	0	20	50	0	80	40

Figure 2. Generalized topographic profile of the Hatchie River floodplain showing differences in topography, forest cover, and approximate mottling depth.

*In order of decreasing basal area.

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APPENDIX

Table 7. Understory taxa of the study area.

Taxa	Common Name
Alnus serrulata (Ait.) Willd.	common alder, tag alder
Arundinaria gigantea (Walt.) Chapm.	cane
Asimina triloba (L.) Dunal	pawpaw
Aster spp.	aster
Bidens frondosa L.	beggars ticks, sticktight
Bignonia capreolata L.	cross-vine
Boehmeria cylindrica (L.) Sw.	false nettle
Botrychium biternatum (Sar.) Underwood	southern grapefern
Brunnichia cirrhosa Gaertn.	ladies' eardrops
Campsis radicans (L.) Seem.	trumpet vine, trumpet creeper
Carpinus caroliniana Walt.	hornbeam, blue beech
Carex spp.	sedge
Cephalanthus occidentalis L.	buttonbush
Cornus foemina Mill.	stiff dogwood
Crataegus spp.	hawthorn
Cyperus spp.	umbrella sedge
Desmodium glutinosum (Muhl.) Wood	tick trefoil, beggar's lice
Heliotropium indicum L.	Indian heliotrope
Hypericum tubulosum Watt.	Marsh St. John's wort
Ilex opaca Ait.	American holly
Ilex decidua Walt.	deciduous holly
Ipomoea pandurata (L.)	wild potato vine
Itea virginica L.	Virginia willow
Justicia ovata (Walt.) Lindau	water willow
Leersia lenticularis Michx.	catchfly grass
Leersia virginica	cutgrass
Lonicera japonica Thunb.	Japanese honeysuckle
Mikania scandens (L.) Willd.	climbing hempweed
Morus rubra L.	red mulberry
Osmunda regalis L. var. spectabilis (Willd.)	royal fern
Ostrya virginiana (Mill.) K. Kosh	ironwood, eastern hop hornbeam
Peltandra virginica (L.) Schott & Endl.	arrow arum
Pluchea camphorata (L.) DC.	stinkweed, camphor weed
Rhus radicans L.	poison ivy
Rubus spp.	blackberry
Saururus cernuus L.	lizard's tail
Smilax glauca Walt.	catbriar, greenbriar
Tradescantia subaspera Ker.	spiderwort
Uniola latifolia Machx.	spike grass

Table 7 (Continued)

Taxa	Common Name
Viola spp.	violet
Vitis spp.	grape-vine
Woodwardia areolate (L.) Moore	netted chain fern
Xanthium strumarium L.	cocklebur

Table 8. Tree basal area by mottling depth class 1*.

	Relative Basal Area	Basal Area (m^2/ha)	Basal Area of Crown Classes (m^2/ha)			
			Dominant	Codominant	Intermediate	Suppressed
Nyssa aquatica	34.6	15.9		14.7	1.3	
Taxodium distichum	26.1	12.0	2.2	9.2	0.6	
Fraxinus pennsylvanica	1.7	0.8			0.3	0.5
Quercus lyrata	21.7	10.0	0.2	8.0	1.3	0.6
Liquidambar styraciflua	2.7	1.3		1.1	0.2	
Ulmus americana	1.7	0.8				0.8
Quercus phellos	1.7	0.8		0.8		
Quercus michauxii	0.7	0.3		0.3		
Quercus falcata var. pagodaefolia	1.4	0.6		0.6		
Dead trees	1.7	3.6				
Total		46.1				

*n=16.

Table 9. Tree basal area by mottling depth class 2.*

	Relative Basal Area	Basal Area (m^2/ha)	Basal Area of Crown Classes (m^2/ha)			
			Dominant	Codominant	Intermediate	Suppressed
Taxodium distichum	2.9	1.0		0.9	0.1	
Fraxinus pennsylvanica	1.0	0.4		0.4		
Ilex decidua	0.4	0.1				0.1
Quercus lyrata	8.6	3.0	0.1	0.2	0.4	0.3
Planera aquatica	3.7	1.3		0.3	0.9	0.1
Diospyros virginiana	1.4	0.5		0.3	0.2	
Acer rubrum	1.2	0.4		0.3		0.1
Acer saccharinum	2.0	0.7		0.4	0.2	0.1
Liquidambar styraciflua	31.3	10.9		8.1	2.0	0.9
Nyssa sylvatica	1.0	0.4		0.2	0.1	0.1
Platanus occidentalis	.8	0.3		0.2	0.1	
Ulmus americana	5.9	2.1		0.9	0.3	0.9
Quercus nuttallii	.6	0.2	0.2			
Quercus nigra	2.2	0.8	0.2	0.6		
Quercus phellos	11.0	3.9	0.9	2.9	0.1	
Quercus palustris	1.0	0.4	0.4			
Betula nigra	.8	0.3		0.3		
Carpinus caroliniana	3.1	1.1		0.1		0.9
Carya leiodermis	4.5	1.8		1.5		0.1
Quercus michauxii	2.2	0.8		0.6	0.1	
Quercus falcata var. pagodaefolia	5.3	1.9	0.1	1.6	0.1	0.1
Quercus shumardii	1.4	0.5	0.1	0.4		
Carya tomentosa	1.6	0.6		0.4	0.1	0.1
Carya ovata	.8	0.3		0.3		
Dead trees	4.9	1.7				
Total		34.9				

*n=35.

Table 10. Tree basal area by mottling depth class 3.*

	Relative Basal Area	Basal Area (m^2/ha)	Basal Area of Crown Classes (m^2/ha)			
			Dominant	Codominant	Intermediate	Suppressed
Taxodium distichum	0.7	0.2		0.2	0.1	
Fraxinus pennsylvanica	0.2	0.1			0.1	
Ilex decidua	0.7	0.2				0.2
Quercus lyrata	3.9	1.2	0.2	1.0	0.1	
Planera aquatica	4.9	1.5		0.8	0.2	0.6
Diospyros virginiana	1.0	0.3		0.2	0.2	
Acer rubrum	1.5	0.5		0.3		0.2
Acer saccharinum	1.2	0.4		0.2	0.2	
Liquidambar styraciflua	34.9	10.8	0.2	7.8	1.7	1.1
Nyssa sylvatica	4.1	1.3		0.8	0.2	0.3
Ulmus americana	2.2	0.7		0.1	0.3	0.3
Ulmus rubra	0.2	0.1				0.1
Quercus nuttallii	0.5	0.2	0.2			
Quercus nigra	2.7	0.8		0.7	0.2	
Quercus phellos	6.9	2.1	0.2	1.8	0.2	
Quercus palustris	1.0	0.3		0.3		
Betula nigra	0.7	0.2		0.2	0.1	
Carpinus caroliniana	1.5	0.5				0.5
Carya leiodermis	2.7	0.8		0.5	0.2	0.2
Quercus michauxii	6.9	2.1	0.2	1.2	0.5	0.2
Quercus falcata var. pagodaefolia	6.6	2.0	0.2	1.9		
Quercus shumardii	0.2	0.1	0.1			
Carya tomentosa	4.1	1.3	0.1	1.1	0.1	
Carya ovata	4.1	1.3		0.8	0.2	0.2
Fagus grandifolia	1.7	0.5		0.5		
Liriodendron tulipifera	0.5	0.2		0.2		
Quercus alba	0.2	0.1		0.1		
Dead trees	3.7	1.1				
Total		30.8				

*n=33.

Table 11. Tree basal area by mottling depth class 4.*

	Relative Basal Area	Basal Area (m^2/ha)	Basal Area of Crown Classes (m^2/ha)			
			Dominant	Codominant	Intermediate	Suppressed
Fraxinus pennsylvanica	0.4	0.1				0.1
Quercus lyrata	1.7	0.5	0.1	0.3	0.1	
Planera aquatica	2.0	0.7		0.4	0.1	0.1
Diospyros virginiana	0.8	0.3		0.1	0.1	
Acer rubrum	0.4	0.1				0.1
Acer saccharinum	4.6	1.4		1.2	0.3	
Liquidambar styraciflua	31.1	9.9		2.2	2.2	0.8
Nyssa sylvatica	2.9	0.9		0.8		0.1
Platanus occidentalis	0.8	0.3	0.1	0.1		
Ulmus americana	4.1	1.3		0.3	0.4	0.7
Ulmus rubra	0.4	0.1				0.1
Quercus nuttallii	0.4	0.1		0.1		
Quercus nigra	4.6	1.4	0.4	1.1		
Quercus phellos	2.3	0.8	0.4	0.1	0.1	0.1
Quercus palustris	0.4	0.1		0.1		
Betula nigra	2.3	0.8		0.5	0.3	
Carpinus caroliniana	4.1	1.3		0.1		1.2
Carya leiodermis	4.1	1.3		1.2	0.1	
Gleditsia triacanthos	0.4	0.1		0.1		
Quercus michauxii	7.1	2.2	0.1	0.8	0.4	0.9
Quercus falcata var. pagodaefolia	10.0	3.2	0.4	2.8		
Quercus shumardii	0.8	0.3		0.1	0.1	
Morus rubra	0.4	0.1		0.1		
Carya tomentosa	3.3	1.1		0.9		0.1
Carya ovata	5.8	1.8		1.3	0.3	0.3
Carya laciniosa	0.8	0.3		0.3		
Dead trees	3.3	1.1				
Total		31.7				

*n=19.

Table 12. Tree basal area by mottling depth class 5.*

	Relative Basal Area	Basal Area (m^2/ha)	Basal Area of Crown Classes (m^2/ha)			
			Dominant	Codominant	Intermediate	Suppressed
Fraxinus pennsylvanica	0.6	0.2		0.2		
Ilex decidua	0.6	0.2				0.2
Planera aquatica	2.6	0.8		0.6		0.2
Diospyros virginiana	0.6	0.2				
Liquidambar styraciflua	35.9	10.6		6.7	3.5	0.4
Nyssa sylvatica	1.3	0.4		0.2	0.2	
Ulmus americana	8.5	2.5		0.4	1.2	1.0
Quercus nigra	0.6	0.2		0.2		
Quercus phellos	5.2	1.5	0.4	1.2		
Quercus palustris	0.6	0.2		0.2		
Carpinus caroliniana	2.0	0.6			0.4	0.2
Carya leiodermis	2.6	0.8		0.8		
Quercus michauxii	2.6	0.8		0.8		
Quercus falcata var. pagodaefolia	13.7	4.0	0.4	3.5		0.2
Quercus shumardii	4.6	1.3	0.4	0.8	0.2	
Carya tomentosa	0.6	0.2		0.2		
Carya ovata	2.6	0.8		0.6		0.2
Fagus grandifolia	7.2	2.1		2.1		
Liriodendron tulipifera	3.9	1.2		1.2		
Quercus alba	2.0	0.6		0.6		
Dead trees	1.3	0.4				
Total		29.4				

*n=13.

Table 13. Tree basal area by mottling depth class 6.*

	Relative Basal Area	Basal Area (m^2/ha)	Basal Area of Crown Classes (m^2/ha)			
			Dominant	Codominant	Intermediate	Suppressed
Taxodium distichum	.9	0.2		0.2		
Quercus lyrata	2.8	0.7			0.5	0.2
Planera aquatica	1.9	0.5		0.2	0.2	
Diospyros virginiana	0.9	0.2			0.2	
Liquidambar styraciflua	42.1	10.2	0.2	6.6	1.6	1.6
Nyssa sylvatica	1.9	0.5		0.2	0.2	
Platanus occidentalis	0.9	0.2		0.2		
Ulmus americana	1.9	0.5		0.5		
Quercus nigra	15.0	3.6		3.2	0.5	
Quercus phellos	0.9	0.2	0.2			
Quercus palustris	1.9	0.5	0.5			
Betula nigra	1.9	0.5		0.2	0.2	
Carpinus caroliniana	5.6	1.4				1.4
Carya leiodermis	0.9	0.2			0.2	
Quercus michauxii	11.2	2.7	0.2	1.6	0.2	0.7
Quercus falcata var. pagodaefolia	4.7	1.1	0.2	0.9		
Quercus shumardii	3.7	0.9		0.7	0.2	
Carya tomentosa	2.8	0.7		0.7		
Carya ovata	9.3	2.3		1.6		0.4
Sassafras albidum	0.9	0.2		0.2		
Fagus grandifolia	1.9	0.5		0.5		
Liriodendron tulipifera	2.8	0.7		0.7		
Dead trees	2.8	0.7				
Total		24.3				

*n=11.

Table 14. Absolute basal area, relative basal area, relative density, relative height, importance value, and importance-two value of arborescent species.

Taxon	A.B.A. (sq. m./ha.)	R.B.A.	R.D.	R.H.	IV	IV 2
Nyssa aquatica	2.0	5.9	9.8	4.6	7.9	6.8
Taxodium distichum	1.9	5.5	1.8	5.6	3.7	4.3
Fraxinus pennsylvanica	0.3	0.8	1.5	0.6	1.2	1.0
Ilex decidua	0.1	0.3	4.3	0.08	2.3	1.6
Quercus lyrata	2.5	7.5	3.8	8.1	5.6	6.5
Planera aquatica	1.0	2.9	5.1	2.5	4.0	3.5
Diospyros virginiana	0.3	0.9	0.4	0.9	0.7	0.7
Acer rubrum	0.3	0.8	2.0	0.7	1.4	1.2
Acer saccharinum	0.5	1.5	2.0	1.3	1.8	1.6
Liquidambar styraciflua	9.4	28.0	27.9	29.2	28.0	28.4
Nyssa sylvatica	0.6	1.9	2.8	1.8	2.4	2.2
Platanus occidentalis	0.1	0.4	0.06	0.5	0.2	0.3
Ulmus americana	1.3	4.0	9.0	3.0	6.5	5.3
Ulmus rubra	0.03	0.1	0.4	0.03	2.5	0.2
Quercus nuttalli	0.1	0.3	0.03	0.3	0.2	0.2
Quercus nigra	1.0	2.9	0.8	3.5	1.9	2.4
Quercus phellos	2.0	5.9	1.2	7.4	3.6	4.8
Quercus palustris	0.3	0.8	0.06	1.0	0.4	0.6
Betula nigra	0.3	0.9	0.2	1.0	0.5	0.7
Carpinus caroliniana	0.8	2.3	11.1	0.7	6.7	4.7
Carya leidermis	0.9	2.8	3.7	3.0	3.3	3.2
Gleditsia triancanthos	0.02	0.06	0.03	0.06	0.05	0.05
Quercus michauxii	1.5	4.3	6.1	4.3	5.2	4.9
Quercus falcata var. pagodaefolia	2.1	6.2	2.1	7.6	4.2	5.3
Quercus shumardii	0.4	1.2	0.3	1.4	0.8	1.0
Morus rubra	0.02	0.06	0.01	0.07	0.04	0.05
Carya tomentosa	0.7	2.2	1.3	2.4	1.8	2.0
Carya ovata	1.0	2.9	4.4	2.9	3.7	3.4
Carya laciniosa	0.03	0.1	0.03	0.1	0.07	0.08
Sassafras albidum	0.02	0.06	0.02	.05	0.04	0.04
Fagus grandifolia	0.4	1.2	0.2	1.4	0.7	0.9
Liriodendron tulipifera	0.2	0.6	0.1	0.8	0.4	0.5
Quercus alba	0.1	0.2	0.02	0.3	0.1	0.2
Dead trees	1.5	4.4	10.4	3.5	7.4	6.1

Table 15. Soil/site variables used in correlation and regression analysis.[a]

Variable	Code	Units
*Topographic Position	TOPO	
Swamp		1
Slough		2
Low Flat		3
Flat		4
Low Ridge		5
Ridge		6
*Microsite	MSITE	
Concave		1
Flat		2
Convex		3
Abnormal Flooding	ABFLOOD	
Obvious		1
Possible		2
None		3
*Drainage Class	DRAIN	
Poorly Drained		1
Somewhat Poorly Drained		2
Moderately Well Drained		3
Well Drained		4
Depth to Few Mottles	DEPMOTF	As recorded, centimeters
*Depth to Common Mottles	DEPMOTC	" " "
Depth to Many Mottles	DEPMOTM	" " "
*Depth to Gleying	DEPGLEY	" " "
Depth to Few Concretions	DEPCONF	" " "
Depth to Common or Many Concretions	DEPCONCM	" " "
*A Horizon Thickness	A HORTH	" " "
*C_1 " "	C_1 HORTH	" " "
C_2 " "	C_2 HORTH	" " "
C_3 " "	C_3 HORTH	" " "
Color Value of A Horizon	A VAL	Nearest color value for a 10 YR Hue
" Chroma " " "	A CHR	" " " " "
" Value of C_1 Horizon	C_1 VAL	" " " " "
" Chroma " " "	C_1 CHR	" " " " "
" Value of C_2 "	C_2 VAL	" " " " "
" Chroma " " "	C_2 CHR	" " " " "
" Value of C_3 "	C_3 VAL	" " " " "
" Chroma " " "	C_3 CHR	" " " " "

Table 15 (Continued)

Variable	Code	Units
*Clay in A Horizon	A CLAY	As recorded, percent
*Clay in C_1 Horizon	C_1 CLAY	" " "
Clay in C_2 Horizon	C_2 CLAY	" " "
Silt in A Horizon	A SILT	" " "
" " C_1 "	C_1 SILT	" " "
" " C_2 "	C_2 SILT	" " "
*Sand in A Horizon	A SAND	" " "
*Sand in C_1 Horizon	C_1 SAND	" " "
" " C_2 "	C_2 SAND	" " "
*Texture of A Horizon	A TEX	
Clay		1
Silty Clay		2
Sandy Clay		3
Silty Clay Loam		4
Clay Loam		5
Sandy Clay Loam		6
Silt		7
Silt Loam		8
Loam		9
Sandy Loam		10
Loamy Sand		11
*Texture of C_1 Horizon	C_1 TEX	Same as A TEX
" " C_2 "	C_2 TEX	" " "
*Family Textural Classification	FAMTEX	
Very-Fine Clayey		1
Fine Clayey		2
Fine-Silty		3
Coarse-Silty		4
Fine-Loamy		5
Coarse-Loamy		6
Sandy		7
*pH of Depth 0-30 centimeters	pH 30	As recorded
*pH of Depth 30-60 cm.	pH 60	" "
pH of Depth 60-120 cm.	pH 120	" "
*P of Depth 0-30 cm.	P 30	Parts per million
*P of Depth 30-60 cm.	P 60	" " "
P of Depth 60-120 cm.	P 120	" " "
*K of Depth 0-30 cm.	K 30	" " "
*K of Depth 30-60 cm.	K 60	" " "
*K of Depth 60-120 cm.	K 120	" " "

[a]Those variables marked with an asterisk were selected for use in the regression analysis.

Table 16. Simple linear correlation between site variables.*

	TOPO	MSITE	ABFLOOD	DRAIN
TOPO	1.00	0.55	0.48	0.63
MSITE		1.00		0.35
ABFLOOD			1.00	0.38
DRAIN				1.00

*n=127. All variables significant at P = 0.01.

Table 17. Simple linear correlations between site and soil variables.*

	N	TOPO	MSITE	ABFLOOD	DRAIN
DEPMOTF	13				0.80
DEPMOTC	26	0.69			0.94
DEPMOTM	112	0.61	0.38	0.30	0.76
DEPGLEY	90	0.67	0.42	0.54	0.63
DEPCONF	61	0.48	0.35		0.55
DEPCONCM	62				
A HORTH	121	0.46			0.67
C_1 HORTH	127	-0.28			-0.33
C_2 HORTH	107	-0.38	-0.28		-0.40
C_3 HORTH	19				
AVAL	121	-0.30	-0.29		-0.34
ACHR	121	0.34			0.35
C1 VAL	127				
C1 CHR	127	0.57	0.40	0.37	0.57
C2 VAL	107				
C2 CHR	107	0.30			
C3 VAL	19				
C3 CHR	19				
A CLAY	121	-0.53	-0.37	-0.28	-0.45
C1 CLAY	127	-0.55	-0.36	-0.29	-0.45
C2 CLAY	107	-0.41	-0.37		-0.35
A SILT	121	0.43	0.37	0.37	0.29
C1 SILT	127				
C2 SILT	127				
A SAND	121	0.23			0.31
C1 SAND	127	0.30			0.33
C2 SAND	107				
A TEX	121	0.52	0.34	0.31	0.28
C1 TEX	127	0.65	0.40	0.34	0.44
C2 TEX	107	0.43	0.28	0.25	0.36
FAM TEX	126	0.27			0.30
pH 30	91				
pH 60	91				
pH 120	91				
P 30	91				
P 60	91				
P 120	91				
K 30	91	-0.72	-0.38	-0.57	-0.56
K 60	91	-0.66	-0.33	-0.51	-0.41
K 120	91	-0.50	-0.26	-0.37	-0.30

*All variables significant at P = 0.01.

Table 18. Simple linear correlation between soil variables.ª

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. DEPMOTF	1.00 13		.84 12								-.65 13		-.08 13			.87 13				
2. DEPMOTC		1.00 26	.30 17		[illegible] 13		[illegible] 26		-.62 18			.32 26	-.36 28							
3. DEPMOTN			1.00 112	.37 30	.60 53		[illegible] 108		-.33 102		-.39 108	.33 108	[illegible] 112	.19 112		.19 102			-.31 108	-.36 112
4. DEPGLEY				1.00 30		.38 52	.34 34		-.24 30			.31 34		[illegible] 99	.29 30				-.32 84	.33 30
5. DEPLONF					1.00 31	.69 32	.30 61	-.33 61	-.33 52										-.40 61	-.32 51
6. DEPCONCN						1.00 62			-.30 56											-.31 [illegible]
7. A HORTH							1.00 121		-.38 102			.46 121	-.26 121	.34 121		.28 102			-.36 121	-.30 121
8. C1 HORTH								1.00 127			.37 121		.31 127	-.40 127		-.35 107				.34 127
9. C2 HORTH									1.00 107	-.55 19				-.26 107						
10. C3 HORTH										1.00 19										
11. A VAL											1.00 121			-.23 121					[illegible] 121	[illegible] 121
12. A CHR												1.00 121		.45 121		[illegible] 102	[illegible] 19		-.49 121	[illegible] 121
13. C1 VAL													1.00 127	-.26 127		-.39 107			.35 121	
14. C1 CHR														1.00 127		.33 107			-.45 121	[illegible]
15. C2 VAL															1.00 107	-.36 107				[illegible]
16. C2 CHR																1.00 107		.39 19	-.32 102	[illegible]
17. C3 VAL																	1.00 19			
18. C3 CHR																		1.00 19		
19. A CLAY																			1.00 121	[illegible]
20. C1 CLAY																				1.00 127

Variable	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
1. DEPMOTF																				
2. DEPMOTC																				
3. DEPMOTN	-.39 102	.36 108			.36 108			.28 108	.38 112	.32 102	.28 111							-.46 73	-.32 78	
4. DEPGLEY	-.36 30	.30 34	.43 30					.46 34	.66 30	.38 40								-.34 58	-.46 58	-.34 58
5. DEPLONF		.34 61																		
6. DEPCONCN	-.32 102	[illegible] 121			[illegible] 121	[illegible] 121			.23 62		.32 52									-.36 40
7. A HORTH									.32 121	.26 102	.31 120							-.33 35		
8. C1 HORTH																-.23 91				
9. C2 HORTH									-.34 107	-.21 107					.36 74	.23 74		.33 74	.41 74	.30 74
10. C3 HORTH													-.39 16							
11. A VAL																		.26 35		
12. A CHR	-.32 102	.25 121			.37 121	.31 121		.37 121	.49 121	.23 102	.41 120				-.45 55			-.35 35		
13. C1 VAL	.21 107										-.24 126			-.38 91						
14. C1 CHR	-.26 107				.32 121	.30 127	.30 107	.33 121	.30 127	.33 107	.38 126							-.32 91	-.43 91	-.40 91
15. C2 VAL	-.43 107	[illegible] 102				.24 107	-.31 107										-.32 74			
16. C2 CHR							.70 107			.46 107	.50 106									
17. C3 VAL																				
18. C3 CHR																				
19. A CLAY	.61 102	[illegible] 121			-.31 121	-.28 121		-.63 121	-.64 121	-.52 102	-.43 120							.43 85	.32 85	.35 85
20. C1 CLAY	.50 107	-.44 121	-.40 127		-.34 121	-.37 127		-.62 121	[illegible] 127	-.62 107	-.52 126	-.29 91						.52 91	.54 91	.61 91
21. C2 CLAY	1.00 107	-.43 102	-.28 107		-.39 102	-.32 107	-.32 107	-.52 102	-.30 107	-.43 107	-.60 106	-.41 74	-.43 74	-.28 74	.28 74			.33 74	.43 74	.52 74
22. A SILT		1.00 121	.44 121					.36 121	.31 121	.39 102								-.45 85	-.31 85	-.34 85
23. C1 SILT			1.00 127		-.34 121	[illegible] 127		.29 121	.35 127	.33 107										
24. C2 SILT				1.00 127																
25. A SAND					1.00 121				.37 121	.27 102	.52 120									
26. C1 SAND						1.00 127	.36 107		.33 127		.60 126									-.43 91
27. C2 SAND							1.00 107			.48 107	.70 106		[illegible] 74	.43 74						[illegible] 74
28. A TEX								1.00 121	.33 121	.31 102	.28 120								-.25 35	-.30 35
29. C1 TEX									1.00 127	.33 107	.32 126	[illegible] 91						-.34 91	-.60 91	-.64 91
30. C2 TEX										1.00 107	.39 106	[illegible] 74			[illegible] 74			-.33 74	-.31 74	-.38 74
31. FGATEX											1.00 126		.30 91	.37 91					[illegible] 91	-.42 91
32. pH 30												1.00 91	.53 91	.34 91			-.30 91			
33. pH 50													1.00 91	.33 91			[illegible] 91			
34. pH 120														1.00 91				.30 91	.33 91	
35. P 30															1.00 91	.65 91	.26 91	.30 91	.33 31	.30 91
36. P 50																1.00 91	.33 91	[illegible] 91	[illegible] 91	
37. P 120																	1.00 91			
38. K 30																		1.00 91	.33 91	.51 91
39. K 50																			1.00 91	[illegible] 91
40. K 120																				1.00 91

ªn listed below each correlation coefficient.

Significant at P = 0.01.

Table 19. Simple linear correlation between soil/site variables and absolute basal area of selected taxa.*

Soil and Site Variables	Absolute Basal Area of Taxa (m^2/ha) Nyssa aquatica	Taxodium distichum	Quercus lyrata	Planera aquatica	Diospyros virginiana	Liquidambar styraciflua	Quercus nigra	Quercus phellos	Carpinus caroliniana	Quercus michauxii	Quercus falcata var. pagodaefolia	Carya leiodermis	Carya ovata	Dead trees
TOPO	-.95[a] 6			-.41[b] 32		.32[a] 104								
NSITE										.33[b] 40				
ABFLOOD														-.33[a] 42
DRAIN			-.34[b] 32											
DEPMOTM			-.45[a] 36					-.30[b] 44						-.33[b] 38
DEPGLEY			-.45[a] 36	-.38[b] 28			-.52[b] 16							
A HORTH	.95[b] 1							-.29[b] 43						
C1 HORTH	.91[a] 6		.49[a] 41							.33[b] 40				
C2 HORTH				.39[b] 31										
A VAL	-.98[b] 4		.42[a] 39					.35[a] 43						
A CHR						-.20[b] 103								
C1 VAL			.39[a] 41					.45[a] 45						
C1 CHR			-.45[a] 41		.59[b] 14					.33[b] 40		.44[b] 20		
C2 VAL			-.31[b] 33				-.42[b] 22		-.55[a] 20					
C2 CHR					.76[a] 12		.44[b] 22		.55[a] 20			.65[a] 19		
A CLAY	-.98[b] 4													
C1 CLAY														
C2 CLAY							-.47[b] 22		-.57[a] 20					
A SILT	.98[b] 4	-.55[b] 14												
C1 SILT										-.43[a] 40				
A SAND														
C1 SAND										.46[a] 40				
C2 SAND					.97[a] 12		.56[a] 22		.75[a] 20			.74[a] 19		
A TEX														
C1 TEX														
C2 TEX					.57[b] 12				.63[a] 20	-.42[a] 34		.49[b] 19		
FAMTEX					.57[b] 14		.38[b] 29		.31[a] 23			.56[a] 20		
pH 30														
pH 60											.33[b] 36			
P 30		.70[a] 17		-.47[b] 20										
P 60		.57[a] 17	-.42[a] 32											
P 120			-.45[a] 32											
K 30						-.23[a] 72								
K 60			.33[b] 17			-.23[b] 72		-.35[b] 29						
K 120			.73[a] 17										.47[a] 25	

*n listed below each correlation coefficient.

[a]Significant at P = 0.01.

[b]Significant at P = 0.05.

VITA

Rogers Menzies Steed was born in Jackson, Tennessee, on June 20, 1950. He attended elementary and secondary schools in that city and graduated from Jackson High School in May 1968. He entered Union University, Jackson, Tennessee in August 1968, attended the U. S. Marine Corps Officer Candidate School during the summers of 1970 and 1971, and received a Bachelor of Science degree in Biology and a commission as an officer in the U. S. Marine Corps on May 28, 1972.

From 1972 to 1975 he served as an Engineer Officer in the U. S. Marines, and from 1976 to 1979 he served in the same capacity in the U. S. Marine Corps Reserve in Knoxville, Tennessee. During the summer of 1978 he worked for the U. S. Army Corps of Engineers as Camp Director for their pilot Youth Conservation Corps in the Nashville District. From April to August 1979, he returned to active duty to train officer candidates for the Marines at Quantico, Virginia.

In 1976 the author began taking prerequisite course work for entering The Graduate Program in Forestry at The University of Tennessee, Knoxville and was accepted as a degree candidate in the autumn of 1978. During the summer of 1976 he worked as a senior groundsman for The University of Tennessee Forestry Stations and Arboretum and in 1978 he worked as a Graduate Teaching Assistant for the Department of Forestry, Wildlife, and Fisheries at the University.

He accepted an appointment as a forester with the U. S. Forest Service in the autumn of 1979 and received his Master of Science in Forestry in December 1979.