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The swamp and mesic forests of the Cumberland Plateau in Tennessee

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To the Graduate Council:

I am submitting herewith a thesis written by Lawrence Roy Smith entitled "The swamp and mesic forests of the Cumberland Plateau in Tennessee." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Ecology and Evolutionary Biology.

H. R. DeSelm, Major Professor

We have read this thesis and recommend its acceptance:

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

To the Graduate Council:

I am submitting herewith a thesis written by Lawrence Roy Smith entitled "The Swamp and Mesic Forests of the Cumberland Plateau in Tennessee." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Ecology.

H. R. DeSelm

H. R. DeSelm, Major Professor

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Graduate Studies and Research

THE SWAMP AND MESIC FORESTS OF THE CUMBERLAND PLATEAU IN TENNESSEE

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Lawrence Roy Smith
December 1977

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ABSTRACT

The swamp and mesic forest communities of the flat to rolling surface of the Cumberland Plateau in Tennessee were studied in the summer of 1976. Objectives were to determine the composition of these communities, and the relationships between and among important overstory taxa, soil, site, and regional variables.

There were 137 plots sampled in nine counties on the Plateau. Eight forest types were described for this area. Red maple, white oak, and blackgum were the most important species in the study area.

Correlation analyses were performed between and among 40 soil, site, regional variables and 10 overstory taxa importance values (I.V.).

Red maple was most important in draw and streamside positions on fine textured soils with a shallow depth to mottling and water.

White oak had its highest importance values on lower and middle slope positions. Like black oak, this species was best developed on the "drier" sites in the study area.

River birch was restricted to forests in narrow bands along small moving streams on well-drained soils.

Sweetgum was not a dominant in any of the community types, but reached its best development on wet flats and draws.

Blackgum attained its greatest importance values in draw positions. Low slope angle and concave horizontal plot shape were important predictors of blackgum I.V.

Tulip popular was sampled on a variety of slope positions, reflected in few significant correlations and a regression equation with a low R^2.

Black oak reached its best development on middle and upper, south-facing slope positions in the study area.

White pine and hemlock I.V.'s were both directly related to more northerly latitudes in this study area. Both species approach the southern limit of their distributions on the Cumberland Plateau.

American holly was a co-dominant with river birch along small streams. Holly is also an important understory taxon in the swamp and mesic forests.

Lower slope positions in this study area were generally flat vertically and concave horizontally. Soils on these sites are deep, fine-textured, have a shallow depth to mottling, and have high available water volumes.

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CHAPTER I

INTRODUCTION

The Cumberland Plateau which extends from Kentucky and Virginia, through the eastern portion of Tennessee, and south into Georgia and Alabama is a southern extension of the Allegheny Plateaus Province. The Plateau is capped by massive sandstones, the resistant character of which is responsible for its high elevation above surrounding territory. The majority of the Plateau is a table land, but numerous deep gorges have been cut into the surface.

Field work was conducted from June through September, 1976. This study, involving C. Ross Hinkle, Gary L. Wade and this author, is part of a larger project which is concerned with the composition and distribution of the extant forest communities on the flat to rolling surface of the Cumberland Plateau in Tennessee. Sampling was conducted in portions of Bledsoe, Cumberland, Fentress, Franklin, Marion, Morgan, Pickett, and Van Buren counties.

The need for such an investigation is great. Vegetation studies have been conducted in the gorges of the Plateau (Clark, 1966; Caplenor, 1965; Sherman, 1958), and in the Cumberland Mountains (Cabrera, 1969; Martin, 1966). With the exception of small areas on the Cumberland Plateau surface studied by Safley (1970) and McCarthy (1976) and an early survey conducted by Braun (1950), no extensive forest community study has ever been undertaken. With the rapid development of the Cumberland Plateau in recent years, and the growing demand for the coal underlying the surface a study of this nature will become increasingly difficult in future years.

This present project involves a study of the swamp and mesic forests of the Plateau of Tennessee, their composition, and relation to soil, site and regional variables. There were 137 plots designated by the author as being dominated by swamp or mesic taxa used in this study. Community types were separated using a clustering technique developed by Orloci (1967).

CHAPTER II

THE STUDY AREA

I. PHYSIOGRAPHY

The Cumberland Plateau has an undulating topography which is submaturely dissected by streams due to the thickness and resistant nature of the capping sandstone. Cutting into the Plateau surface are numerous deep gorges and two prominent valleys--the expansive Sequatchie Valley in the southern portion, and the much smaller Elk Valley to the north. The Cumberland Plateau extends in a northeast-southwest direction from Kentucky and Virginia, through eastern Tennessee, and south into Alabama and Georgia where it grades into the Gulf Coastal Plain. In Tennessee, portions of the Plateau occur in 22 counties and comprise approximately 1,399,700 ha. (Luebke, et al., 1939).
The Cumberland Plateau is a southern extension of the Appalachian Plateaus Province and the boundary between the two is arbitrary. This boundary is generally taken as the area which lies in the drainage basin of the Kentucky River, and south of it (Fenneman, 1938). The percentage of resistant rocks is generally greater south of this boundary, and the topography is, accordingly, less dissected than farther north.

The Plateau is bounded on the east by the striking Cumberland Front or Escarpment which reaches elevations greater than 600 meters. This escarpment is capped by the resistant sandstones of the Pottsville series and is underlain by the much less resistant Bangor limestone which retreats by sapping. The increase in elevation of the escarpment northward conforms roughtly to the increase in thickness of the Pottsville sandstone from about 7 to 107 meters (Hack, 1966).

The western escarpment rises gradually south of the Kentucky River reaching a maximum height greater than 660 meters in the southern part of Tennessee. This escarpment is much more "ragged" in appearance than the eastern front due to numerous valleys, but, like the eastern escarpment, its steepness is due to sapping.

The topography of the Cumberland Plateau and Mountains is generally believed to be the result of an uplift of the Schooley (Cumberland) Peneplain. According to the peneplain concept, this area has undergone three periods of base leveling during which three peneplains or partial peneplains were formed. Of these, the Schooley Peneplain was the first and most complete, and is roughly equivalent to the surface of the Cumberland Plateau (Hack, 1966). This theory was first proposed by Hayes and Campbell (1894) and is supported by Fennman (1938) and Braun (1950). This concept requires several periods of base leveling and uplift and the preservation of exposed surfaces for long periods of time. An alternative theory has been proposed by Hack (1960, 1965, 1966) and supported by Milici (1967) and states that most (or all) traces of past changes that might have been expressed in topography have been destroyed. According to Hack's theory the present topography formed during nearly continuous downwasting of the region.

The Sequatchie anticline extends along the median line of the Plateau in Tennessee and Alabama for more than 3200 kilometers and is broken on the west by a thrust fault. This eroded structure is represented by the Sequatchie Valley (Wills Valley in Alabama) for most of its length where the resistant Pennsylvanian strata along the crest of the anticline have been eroded exposing the less-resistant carbonate rocks. Headward erosion and underground solution of the Missippian beds have formed the valley, which originally formed a range of mountains, now represented by the Crab Orchard Mountains at its northern end (Milici, 1967).

II. GEOLOGY

The rocks capping the Cumberland Plateau are early Pennsylvanian in age, representing the Pottsville series of this system. The escarpments are underlain by Mississippian and Pennsylvania strata above the Fort Payne Formation (Sharp, et al., 1973). These Pennsylvanian strata can be separated into upper and lower groups (Wilson, et al., 1956). The lower, sandy sequence immediately overlies the Mississippian Pennington Formation and can be easily divided into the Gizzard, Crab Orchard Mountains, and Crooked Fork groups. This lower cliff-forming sequence consists of massive sandstones with approximately equal parts of shale, and crops out over more than three-quarters of the area of the Plateau. The equally thick, upper, shaly beds are limited to the northeastern portion of the Plateau in the Cumberland Mountains and contain more coal than the lower groups. These beds are subdivided into six groups (Wilson, et al., 1956). From oldest to youngest they are the Slatestone, Indian Bluff, Graves, Redoak Mountain, Vowell Mountain, and Cross Mountain groups.

The Pennsylvanian strata on the Plateau consist almost entirely of clastic material of various kinds. The most common lithologic types are sandstones, siltstones and shales with associated coal and underclay (Stearns, 1954). These sandstones range from fine-grained, impure sandstones to conglomeratic sandstones with quartz pebbles. Generally, however, most of the sandstones can be classified either as a massive, coarse-grained type or a less massive, fine-grained type. The massive sandstones and conglomerates are generally confined to the three lower groups. The siltstones grade from silty or sandy shales to fine-grained, shaly sandstones. Shales are the most common Pennsylvania rock type and they are generally present in much higher percentages in the six upper groups (Wilson, et al., 1956).

Coal, by far the most important mineral product in Tennessee, is found in every county on the Cumberland Plateau where Pennsylvanian strata occur except Cannon County (Wilson, et al., 1956). In 1968, 77 percent of the strippable coal of the Plateau was produced in Campbell, Anderson, Claiborne, Morgan and Scott counties (Johnson and Luther, 1972).

III. SOILS

Upland soils of the Cumberland Plateau surface are derived mainly from sandstones and shales and are classified chiefly as Inceptisols: Dystrochrepts, and Ultisols: Hapludults and Paleudults (DeSelm and Clark, 1975). Soil survey descriptions for the Plateau have been published for Roane County (Swann, et al., 1942), Rhea County (Hasty, et al., 1948), Cumberland County (Hubbard, et al., 1950), Franklin County (Fox, et al., 1958), Marion County (Elder, et al., 1958), Putnam County (Jackson, et al., 1963), and Warren County (Jackson, et al., 1967). The soils of Cumberland County, exclusive of the Grassy Cove area, are fairly representative of the Cumberland Plateau as a whole (Allred, et al., 1942).

The most extensive soils of the bottomlands and poorly drained depressions include the Pope, Philo, Atkins, and Cotaco series. These soils are derived from alluvial parent materials washed from the uplands underlain by acid sandstone and shales. The first three soil series constitute a catena in which the Pope soil is well-drained, the Philo soil imperfectly drained, and the Atkins soil is poorly drained (Hubbard, et al., 1950).

The Pope series has brown, fine sandy loam A horizons and dark yellowish brown, fine sandy B horizons. These soils occur on stream floodplains with slopes mainly less than 4 percent and are well-drained with slow runoff and moderately rapid permeability. Thickness of the profile ranges from 100 to 130 cm. In forested areas trees include oaks, pine, blackgum and tulip poplar (Hubbard, et al., 1950).

The Philo series occurs in narrow strips on level or nearly level sites (slopes 2 percent or less) on first bottoms near streams. It is intermediate in drainage between the Pope and Atkins series. These soils are formed from alluvium washed from soils derived chiefly from sandstones, siltstones, and shales, and may include minor components from loess, till, or other sources. Grey mottles occur at a depth of 30 to 50 cm. (Hubbard, et al., 1950; Swann, et al., 1942).

The Atkins series consists of grey, poorly-drained soils on the first bottoms and is the most extensive soil of the bottomlands in Cumberland County. Along with the Cotaco series, this soil also occupies considerable acreage in saucerlike depressions near the heads of drainageways (Elder, et al., 1958). These soils are formed in recent alluvium, most of which comes from Hartsells, Wellston, and Muskingum series soils (Jackson, et al., 1963). Due to fluctuations in the water table this soil is frequently saturated; a few areas are swampy most of the year. This soil is waterlogged during the winter and spring and becomes ponded in depressions. Texture is most commonly a very fine sandy loam, but considerable variability in texture exists. The surface soil (0-25 cm.) is light grey mottled and grades into a finer textured material (generally sandy clay) with greater proportions of grey and blue mottlings which continue to increase with depth. On uncleared land there are nearly pure stands of blackgum and red maple (Hubbard, et al., 1950).

The Cotaco series consists of moderately-well to somewhat poorly drained soils with indistinct horizons and occupies higher slope positions than the Philo series (National Cooperative Soil Survey, 1959). Elder, et al., (1958) state that these soils form an intricate pattern with the Atkins series and it is difficult to distinguish between them. In Marion County, these soils occupy narrow bands along intermittant drainageways and poorly-drained depressions (Elder, et al., 1959).

IV. CLIMATE

The Cumberland Plateau extends over 48 kilometers latitudinally and elevation of the surface varies from approximately 420 to 610 meters. Accordingly, differences in climate occur throughout the range of the Plateau. East-west differences also result due to interception of fronts by the north-south orientation of the plateau. The principal source of moist air for this area is the Gulf Region. Air masses crossing the state from west to east cool as they ascend the Plateau resulting in more precipitation on the Plateau than surrounding areas. Average annual precipitation on the Plateau generally ranges from 125 to 140 cm., as compared to 100 to 125 cm. for the Great Valley to the east. Temperatures on the Plateau are generally three degrees cooler than temperatures in the neighboring Great Valley.

Thornthwaite (1948) classifies the climate as humid (B_2 to B_3), mesothermal (B'_2), with a thermal efficiency of 51.9 to 56.3 percent (b'_3 to b'_4), with little or no water deficiency in any season (r).

Mean January temperature ranges from a high of 3.7°C at Sewanee in Franklin County to a low of 2.4°C at Rugby in Morgan County. The highest and lowest mean July temperatures were recorded at the same stations and were 23.8°C and 21.7°C respectively (Dickson, 1960).

Precipitation on the Plateau is fairly well distributed, but may vary greatly during the growing season from year to year. For example, mean yearly precipipitation for Crossville for the years 1930 to 1965, has ranged from a low of 102.87 cm./year to a high of 180.85 cm./year (Vaiksnoras, 1970). Mean yearly precipitation for stations on the Cumberland Plateau range from a low of 131.09 cm./year at Crossville to a high of 151.21 at Cagle in Sequatchie County, the highest elevation station on the Plateau (U.S. Department of Commerce, 1965). The most abundant precipitation on the Plateau usually falls in the months of December to March, with a second maximum in July and August due to thunderstorm activity. Serious drought probabilities on the Cumberland Plateau occurred in only 3 percent of the months in 1931-1969 as compared to 7, 8 and 4 percent respectively for West, Middle and East Tennessee (Vaiksnoras and Palmer, 1973).

V. FLORA

The Cumberland Plateau has a rather extensive flora based on collections at the University of Tennesses, but a county-sized flora has never been compiled. Partial floristic lists have been compiled for small areas, e.g. the gorges of Fall Creek Falls State Park (Caplenor, 1955), and the Fiery Gizzrd Gorge (Clark, 1966). Sherman (1958) studied the floristic elements of five gorges of the Cumberland Plateau.

Species with restricted ranges centering on the Cumberland Plateau, of which *Conradina verticillata* is a Plateau endemic, include: *Ascyrum stans, Cornus stolonifera, Gaylussacia brachycera, Magnolia macrophylla, Pyrus arbutifolia, Ribes curvatum, Spirea tomentosa var. rosea* (Shanks, 1958).

Braun (1937 a,b) stated that the Coastal Plain element is especially well represented on the Cumberland Plateau, especially near its western margin. A majority of these species occupy swamps and wet meadows at the headwaters of streams or on low knobs.

Fowells (1965) reports several tree taxa whose limits of distribution occur on the Cumberland Plateau. Among these are *Pinus strobus* (eastern white pine), which approaches the southern extent of its range and *Celtis laevigata* (sugarberry), which approaches its northern limit on the Plateau counties.

A palynological study from a small marsh on Lookout Mountain, an outlier of the Cumberland Plateau, revealed high percentages of pine pollen (*Pinus banksiana* and *P. resinosa*), herb pollen, deciduous tree pollen, especially oaks *(puercus)* and a small percentage of *picea* pollen (Watts, 1975). This pine-herb zone covers the time of approximately 20,000-11,000 years B.P. A second zone of late Pleistocene or early Holocene age suggests a mesic forest with large amounts of Fagus, Ostrya/Carpinus, Quercus, and Carya pollen. A third zone, from the late Holocene, implies a more xeric Quercus-Nyssa-Castanea forest.

Pond sediments from White County, Tennessee indicate a predominance of pine and spruce pollen during full Wisconsinan glacial maximum. Approach of the late-glacial was accompanied by the decline of spruce pollen and the appearance of pollen of Jsuga and many deciduous tree taxa including Quercus, Ostyra/Carpinus, Betula, Fagus, etc. (Delcourt, 1977).

VI. VEGETATION

Describing the timber resources upon the Cumberland Table Land in Grundy County, Killebrew and Safford (1874) stated that:

> On the lowlands and in the coves there is an abundance of fine yellow poplar, black walnut, sugar tree, white and black oak, and on top of the mountain there are two kinds of timber of great value-the yellow pine in large quantities, and chestnut oak which grows in great abundance.

Hall (1910), studying the forest conditions in Tennessee said that the predominant trees in the plateau swales were:

> . . . Black, white, spanish, and scarlet oaks, with a varying proportion of hickory . . . Blackgum, post and chestnut oak, chestnut, and shortleaf pine are also sometimes included in the mixture. The swampy bottoms, which are of very limited extent, contain thickets of red maple, blackgum, and sweetgum, often with an undergrowth in which large holly trees are conspicuous.

Braun (1950) included all but the southernmost end of the Cumberland Plateau in the mixed Mesophytic Forest Region. Braun believed that if the entire plateau were dissected to the extent it is farther north, the mixed mesophytic forest would be the prevailing forest type. She stated that the eastern and western boundaries of this region approximate the eastern and western escarpments of the Cumberland and Allegheny fronts, and the indefinite southern boundary is transitional with the Oak-Pine region. The Cumberland Plateau in Tennessee falls within the southern district of her Cliffs Section, named for a steep escarpments which characterize the area. She described a "semi-virgin plateau forest" from Fall Creek Falls in which white oak comprised 83 percent of the canopy and associates included black oak, hickory, tuliptree, chestnut, sourgum, and basswood.

Swamp forests are not well developed on the Plateau. Poorly-drained soils are not extensive and are confined to narrow strips along drainageways or in shallow depressions at the heads of streams. Nearly pure stands of red maple and blackgum are found on these uncleared areas (Hubbard, et al., 1950).

With the exception of general description by Braun (1950), no scientific description has been attempted and no extensive study of the forest vegetation of the plateau surface has been conducted.

Safley (1970) studied the vegetation of the gorges, mountains, and surface of the Cumberland Plateau in the basin of the Big South Fork. Mixed mesophytic forests were confined to the most sheltered sites. He reported a river birch community from the gorge bottom along the main stream. The most mesic forest types from the plateau surface were northern and southern aspect white oak types.

Cabrera (1969) described four segregates of the mixed mesophytic forest community from Ash Log Mountain, in the southernmost portion of the Cumberland Mountains in Campbell County. Also in the Cumberland Mountains, Martin (1966) observed five oak and oak-pine communities from Wilson Mountain, Morgan County, Tennessee.

Vegetation studies have been conducted in the gorges of the Cumberland Plateau in Tennessee, Georgia, and Alabama (Clark, 1966; Caplenor, 1965; Sherman, 1958), but the rolling uplands have not been studied in detail.

VII. HUMAN HISTORY

Evidence of earliest human presence in this area, found in Russell Cave in northern Alabama, indicates the arrival of man at least 9,000-10,000 years B.P. (Lewis and Kneberg, 1958). At the time of the first exploration of this territory by whites, portions of the area were occupied or claimed as hunting ground by Choctaws, Shawnees, Chickasaws, and Cherokees. The Cherokees occupied sections along the Tennessee River and in 1735 were said to inhabit 64 populous towns and old traders estimated that their numbers included about 6,000 fighting men (Bullard and Krechniak, 1956). Due to troubles with Indians, the present area of Tennessee was without a single white inhabitant through the year 1740 (Ramsey, 1860).

In the year 1761, a party of long hunters headed by Elisha Walden explored what is now east Tennessee, including the Cumberland Plateau. The ridge forming the eastern escarpment of the Plateau bears his name (Bullard and Krechnick, 1956).

The North Carolina legislature recognized the need for a road reaching into the "Mero District" (from Walden's Ridge to beyond Nashville) in 1787 and commissioned Peter Avery to construct a trail across the Cumberland Plateau. The Treaty of Hopewell of 1785 allotted this district to the Cherokees who demanded a toll from the white men to use the Avery Trace. Twenty-five families crossed the trail in 1787 but there were many battles with the Cherokee.

After this territory became a state in 1795, pioneers were encouraged to settle west of the Walden Ridge and families travelled into the area from Virginia, Pennsylvania, the Carolinas, and New England (Bullard and Krechniak, 1956). Through the third Tellico Treaty in 1805, the Cherokee signed over the title to all their lands north of the Duck River. By Dearborn's Treaty of 1806, most of the remainder of Middle Tennessee was acquired (Folmsbee, et al., 1969).

In the first quarter century after attaining statehood, numerous roads were constructed on the Plateau and settlements were rapidly established. Cumberland County was established in 1865 from portions of Fentress, Putnam, Roane, Bledsoe, Morgan, and White counties with an original population of 3,460 (Killebrew and Safford, 1874). Though a majority of the inhabitants of this region were farmers, the soils were relatively poor. A common saying at the time was: "the more mountain land a man owns, the poorer he is" (Bullard and Krechniak, 1956).

Lumbering and coal mining were the chief industries at the turn of the century (Hall, 1910). With the coming of the railroads after 1900 the Plateau's timber resources were more fully exploited.

The largest logging operations occurred in the north and northwest part of the region where private railroads were constructed. Safford (1869) estimated the superficial area of the coal fields on the Plateau to be about 5,100 square miles, virtually the entire area of the plateau. The coal mining industry was a major source of employment, luring many workers from their farms. The principal coal mining areas during Safford's time were Tracy City in Grundy County and the Aetna mines in Marion County.

In more recent times, the human impact on the Plateau has increased considerably. Vast tracts of land have been cleared of the natural hardwood vegetation and replaced with pine monoculture. The increasing demand for agricultural land and timber continues to decrease the forest resources of this area. As our nation's need for energy increases, the Plateau coal fields will be more fully exploited.

The scenic nature of the Plateau, with its rolling hills, woodlands, and favorable climate, has resulted in recent development of bankrupt resort and retirement villages.

CHAPTER III

THE VEGETATION

I. FIELD METHODS

Field work for this study was conducted from June through September, 1976. Prior to field work, letters were sent to state foresters, state conservationsists, university and college faculty, private citizens, and others in an effort to locate suitable sampling sites on the Plateau. Many good sites were located in this manner. Topographic maps of the Cumberland Plateau were scanned for potential sampling sites on rolling topography. Gorges and slopes greater than 15-20 percent were not sampled.

Data sheets were prepared specifically for this project and designed to record significant soil and site factors described in the following procedure. Plots were located in homogeneous, uneven-aged stands which were free of obvious signs of disturbance from roads, trails, powerline cuts, and logging. Concentric plots of 0.0405 and 0.004 hectares were used in this study. Plot centers were marked with plastic flagging. Slope angles up and down slope and left and right of the plot centers were measured using a Suunto clinometer. Plot aspect was measured with a Silva Ranger compass to the nearest 5 degrees. The plot radius was adjusted for slope angle (Bryan, 1956) and four points on the plot boundary were flagged. Slope position was recorded and the plot was marked and numbered on the appropriate topographic map. Elevation of each plot was estimated from the topographic map to the nearest six meters and recorded on the data sheet. Thickness and type of litter layer (mull or mor), parent material and bedrock type were noted. A shallow soil pit was dug near the plot center and a bucket auger was used to a depth of 91 cm. to determine the depth to bedrock. Thickness of the A, B, and C horizons was recorded and samples from the upper two bagged. Surface stone and stone volume of the A and B horizons were estimated to the nearest 5 percent. Depth to grey mottles, gleying and/or water was recorded when they occurred. Other relevant information such as the presence or size of chestnut stumps or sprouts was also noted at each plot.

Within each 0.0405 hectare plot the dbh of all arboreal taxa with a diameter greater than 12.70 cm. were measured and recorded by taxon. Arboreal saplings with a dbh from 2.54 cm. to 12.69 cm. were recorded from the larger plot. Subsaplings of arboreal taxa, shrubs and woody vines all less than 1.37 meters tall, were counted and recorded by taxon in the smaller 0.004 hectare plot.

Trees were identified in the field using the Summer Key to Tennessee Trees by Shanks and Sharp (1963).

Shrubs and woody vines were identified using the Wharton and Barbour (1973) manual and Radford, et al. (1968), which all nomenclature follows.

There were 306 plots sampled in this manner and 137 of these were designated as being composed of swamp or mesic taxa by the author and used in the present study.

II. LABORATORY METHODS

Soil bags were opened and samples were allowed to air dry soon after returning to the lab. After drying, pH of each sample was determined for a 1:1 soil-water solution and a 1:2.5 soil-water solution with 1 N KCL added (Jackson, 1968) using a Leeds and Northrup pH meter. Representative soil samples from 10 plots, comprising a wide range of textures, were selected as "standards" for textural determinations using the hydrometer method of Day (1956) modified by M. E. Springer. The remainder of the soil textures were determined using the "feel method" (Soil Survey Staff, 1951). Representative soils from each sample stand were passed through a 2 mm. sieve to determine the course-fragment fraction for each soil sample; the coarse-fragment conversion factors (Soil Conservation Service, 1967) were then calculated for these soils. These conversion factors were extrapolated to the other plot samples in those stands and used in calculations for available water holding capacity.

Distances from the highest point on the ridge and from the bottom of the slope were measured to the nearest meter for each plot from the topographic maps. Plot aspects were transformed by the method of Beers, et al. (1966). Horizontal (across slope) plot shape and vertical (down slope) plot shape were determined from the slope angles to the right and left of the plot center, and from the up and down slope angles, respectively. Yearly potential insolation was determined by plot according to latitude, plot aspect, and slope angle (Frank and Lee, 1966). Mean annual precipitation values are from the nearest station (Dickson, 1960).

Relative basal area (RBA), relative density (RD), and importance value (I.V. 200) were calculated for each overstory taxon by plot. Relative density and frequency were determined for each sapling, subsapling, and woody vine taxon.

Soil, site, and regional data (Appendix, Table 14) were recorded as measured or coded as necessary and punched on computer cards. Importance values of all overstory taxa occurring in greater than 1 percent of the plots were also compiled on data cards. Statistical analyses were performed on an IBM 360/65 computer at the University of Tennessee Computing Center.

Eight vegetation types based upon overstory taxa importance values were determined using a clustering technique developed by Orloci (1967). McCarthy (1976), comparing several classification techniques, found that this clustering program gave very satisfactory results in classifying both real and artificial data sets. This clustering method uses an exclusive classification scheme in which an individual (plot, in this case) is restricted to only one cluster (vegetation type). It is a polythetic agglomerative technique in that each decision to add a plot to a particular cluster is based upon the presence of a number of different species as opposed to a single species. Orloci's technique is an agglomerative rather than a divisive procedure and starts by combining a pair of plots in which the resulting within group sum of squares is minimal and the variance between groups is maximized. Another pair of plots is then combined, or a third plot is combined with an existing pair, depending upon which decision gives the minimal sum of squares for the resulting group (Goodall, 1973). This clustering process continues in successive cycles until the entire data set is combined into a single group.

III. INTRODUCTION TO COMMUNITY TYPES

No virgin stands of timber were sampled during this study. At best, all of these forests are second growth. Most of the trees in these plots have a diameter at breast height of less than 50 cm., but an occasional stem measured greater than 76 cm. The largest tree measured was an 86 cm. tulip poplar.

Evidence of former presence of chestnut in the study area is scant. Only one chestnut stump was found in these plots.

The communities are discussed in the order of their predominance in the study area. The first time a species is mentioned it is referred to by its scientific name, thereafter, common names are used.

IV. RESULTS AND DISCUSSION

White Oak Community

Quercus alba (white oak) is the leading dominant of this type; *Quercus velutina* (black oak) and *Quercus coccinea* (scarlet oak) are the only other species present with importance values greater than 10 (Table 1). Twenty-seven percent of all the study plots belong to this community type. This type occurs most commonly on lower to middle northwest- or southeast-facing slopes generally less than 400 meters from the bottom of the slope. This community

Table 1. Composition of the White Oak Community (N = 37)

				Understory			
	Overstory			Saplings		Subsaplings	
TAXA[a]	RD	RBA	IV	RD	F	RD	F
Quercus alba	46.2	50.9	97.1	16.6	32.4	4.9	27.0
Quercus velutina	12.2	13.8	26.0	2.9	45.9	1.5	13.5
Quercus coccinea	6.7	9.4	16.1	1.0	21.6	0.2	2.7
Oxydendrum arboreum	6.3	2.8	9.1	23.3	59.5	6.0	37.8
Quercus prinus	4.7	3.7	8.4	1.0	21.6		
Pinus echinata	4.7	3.6	8.3	0.3	13.5	0.2	2.7
Carya tomentosa	2.8	2.6	5.4	3.3	43.2	3.7	27.0
Quercus stellata	2.8	1.6	4.4	0.3	8.1		
Acer rubrum	2.8	1.3	4.1	12.9	67.6	26.7	59.5
Carya pallida	1.7	1.7	3.4	1.0	16.2	1.5	13.5
Nyssa sylvatica	1.9	1.2	3.1	4.2	51.4	17.7	64.9
Quercus falcata	1.3	1.7	3.0	0.1	5.4	0.2	2.7
Pinus virginiana	1.7	1.3	3.0	0.4	10.8		
Liriodendron tulipifera	0.8	2.2	3.0	0.1	5.4		
Carya glabra	1.4	0.8	2.2	2.4	37.8	3.3	21.6
Cornus florida	0.6	0.2	0.8	27.5	83.8	22.5	67.6
Carya sp.	0.4	0.3	0.7	0.1	2.7	0.2	2.7
Prunus serotina	0.2	0.4	0.6	0.1	2.7	3.3	8.1
Carya ovata	0.2	0.2	0.4	0.1	2.7	0.4	2.7
Carya ovalis	0.2	0.1	0.3				
Liquidambar styraciflua	0.2	0.1	0.3	0.5	10.8	2.4	5.4

Table 1 (Continued)

TAXA	Overstory RD	Overstory RBA	Overstory IV	Understory Saplings RD	Understory Saplings F	Understory Subsaplings RD	Understory Subsaplings F
Robinia pseudoacacia	0.2	0.1	0.3	0.1	5.4		
Sassafrass albidum				1.2	27.0	3.3	24.3
Amelanchier arborea var. arborea				0.2	8.1		
Acer saccharum				0.1	5.4		
Castanea dentata				0.1	5.4		
Pinus strobus				0.1	2.7	0.2	2.7
Vaccinium arboreum				0.1	2.7		
Fagus grandifolia						0.2	2.7
Stewartia ovata						0.9	2.7
Sorbus arbutifolia var. arbutifolia						0.4	2.7
Ilex opaca						0.2	2.7

Density/Hectare = 334.1 1025.3 4025.4

Basal Area (m^2) Hectare = 23.04

[a]One chestnut stump occurred in these plots.

occurs on the steepest slopes of all the types included here. Over 50 percent of the plot slopes ranged between 11 and 15 degrees. The across slope angle is low and the slopes are generally flat, both vertically and across slope. Litter accumulation is greatest in this type. Soils of the A horizons range in texture from sandy loams to silt loams and the most common B horizon texture is loam (Appendix, Table 16). Soils are most often formed from residuum and are deep, extremely to very strongly acid, with low stone volume throughout the profile. These soils rarely show mottling or gleying and water occurred only once at a depth less than 91 centimeters from the surface.

Twenty-two of the 32 tree species in this community occur in the overstory. All but five of the overstory taxa occur in one or both of the understory layers. Statistics calculated for the understory indicate that white oak is reproducing well and is present in over 25 percent of the plots in both understory layers. This species has the third highest sapling density. *Oxydendrum arboreum* (sourwood) and *Cornus florida* (dogwood) are both very important in the understory but are not prominent overstory species. *Acer rubum* (red maple) and *Nyssa sylvatica* (blackgum) occur in over 50 percent of both understory layers, although these species are most important on lower, wetter slope positions in the study area.

Twelve taxa of shrubs and woody vines occur in the subsapling layer. Three species of Smilax sum to a relative density of nearly 45 percent (Appendix, Table 15).

Safley (1970) reported both a northern and southern aspect white oak type from the Cumberland Plateau surface. There is a 75 percent agreement between the tree taxa in Safley's northern aspect type and this white oak community. Hinkle (1975) described a white oak-black oak community at Cumberland Gap which had an overstory and understory very similar to this type. The major difference between his community and the present type was the increased importance of black oak in the overstory of his type. The Society of American Foresters (1954) describes a white oak type (SAF Type 53) in which white oak is pure or predominant. This forest type spreads throughout the Central States and extends into the northern and southern forests.

Draw Position Red Maple Community

Red maple is the leading dominant in this community and blackgum and white oak are the major associates (Table 2). All but one of the 15 overstory species occur in the understory. Twenty-seven percent of the study plots occur in this community.

This community is best developed in draw positions (lower, mid, and upper) located on flat or a northeast facing slopes (Appendix, Table 16). Soil profiles are

Table 2. Composition of the Draw Position Red Maple Community (N = 37)

				Understory			
	Overstory			Saplings		Subsaplings	
TAXA	RD	RBA	IV	RD	F	RD	F
Acer rubrum	51.9	53.4	105.3	39.4	61.1	15.6	37.8
Nyssa sylvatica	20.2	17.0	37.2	15.0	80.6	21.4	48.6
Quercus alba	13.4	14.3	27.7	12.0	75.0	2.8	21.6
Liriodendron tulipifera	3.7	6.4	10.1	3.0	27.8	4.1	13.5
Liquidambar styraciflua	3.9	4.0	7.9	1.8	13.9	2.0	5.4
Oxydendrum arboreum	2.1	0.9	3.0	12.0	75.0	12.5	48.6
Quercus velutina	1.2	1.0	2.2	0.3	2.8	0.2	2.8
Quercus coccinea	0.7	0.9	1.6	0.1	2.8		
Pinus strobus	0.9	0.4	1.3	5.3	16.7	0.5	5.4
Quercus stellata	0.5	0.5	1.0	0.3	2.8		
Carya tomentosa	0.4	0.5	0.9	0.6	2.8		
Quercus prinus	0.4	0.3	0.7				
Pinus echinata	0.3	0.2	0.5	0.5	2.8		
Cornus florida	0.3	0.1	0.4	5.3	52.8	6.9	35.1
Pinus virginiana	0.1	0.1	0.2	0.5	5.6		
Ilex opaca				1.1	13.9	1.8	5.4
Carya glabra				0.6	13.9	1.0	10.8
Prunus serotina				0.5	5.6	2.5	8.1
Sassafras albidum				0.5	11.1	0.2	2.7
Magnolia tripetala				0.3	2.8		

Table 2 (Continued)

				Understory			
	Overstory			Saplings		Subsaplings	
TAXA	RD	RBA	IV	RD	F	RD	F
Quercus marilandica				0.3	5.6		
Quercus falcata				0.1	2.8		
Diospyros virginiana				0.1	2.8		
Carya pallida				0.1	2.8		
Alnus serrulata				0.1	2.8	6.0	8.1
Acer saccharum				0.1	2.8		
Amelanchier arborea var. arborea				0.1	2.8	1.0	5.4
Hamamelis virginiana						4.0	2.7
Sorbus arbutifolia var. arbutifolia						17.3	13.5
Asimina triloba						0.2	2.7

Density/Hectare = 489.9 679.6 2496.7

Basal Area (m^2)/Hectare = 29.4

greater than 91 cm. deep and are formed mainly from alluvium. Textures of the A horizons range from loam to clay loam-silty clay loam; textures of the B range from sandy loam to clay. The most commonly occurring A horizon texture is loam; in the B horizon silty loams are predominant. In over 50 percent of the plot soils water occurs at a depth less than 62 cm. from the surface. Soils are chiefly very strongly acid.

This community is reproducing successfully. In decreasing order the most frequent species of the sapling layer are blackgum, white oak, sourwood, and red maple. Red maple is the most frequent taxon in the sapling layer.

Species of Rhododendron (azalea), Viburnum, Vaccinium and Smilax make up over 80 percent of the relative density of the shrubs and wood vines (Appendix, Table 15).

The Society of American Foresters (1954) lists red maple as being a major component in three cover types and as an associate species in 51 others, but none resemble this type in species composition. E. Lucy Braun (1950) stated that during her time red maple prevailed in the swamp forests on the poorly drained spots on the Cumberland Plateau in Tennessee (southern district of her cliffs section). She stated that formerly these swamp forests probably resembled the swamp forests farther north (middle district of cliffs section). There, Quercus palustris (pin oak) and Liquidambar styraciflua (sweetgum) dominated the forests; the major constituents included red maple, sourgun (blackgum), Quercus bicolor (swamp white oak), Quercus imbricaria (shingle oak) and Quercus michauxii (cow oak).

Red Maple-Blackgum Community

Red maple and blackgum are almost equally important in this community accounting for over 50 percent of the overstory importance value. White oak, sweetgum, and Liriodendron tulipifera (tulip poplar) are important associates (Table 3). Slightly more than 20 percent of the study plots belong to this type, which includes 29 tree taxa; of which 20 occur in the overstory. Eighty percent of the canopy taxa were sampled in one or both of the understory layers. Red maple, sourwood, blackgum, and white oak have the highest sapling densities. Sourwood has the highest subsapling density, followed by blackgum, red maple, and tulip poplar. Eleven taxa were sampled in the shrub and woody vine layer. Those with the highest densities are Vaccinium spp., Similax rotundifolia (roundleaf greenbriar), and Rhododendron canescens (wild azalea) (Appendix, Table 15).

This community reaches its best development on middle and upper draw positions on all aspects (Appendix, Table 16). Soils are deeper than 91 cm. in all but one of

Table 3. Composition of the Red Maple-Blackgum Community (N = 28)

				Understory			
	Overstory			Saplings		Subsaplings	
TAXA	RD	RBA	IV	RD	F	RD	F
Acer rubrum	26.2	26.8	53.0	28.7	100.0	13.6	13.5
Nyssa sylvatica	26.0	25.9	51.9	15.4	78.6	13.6	11.5
Quercus alba	16.2	12.0	28.2	15.4	89.3	3.5	4.8
Liquidambar styraciflua	11.4	14.6	26.0	6.1	46.4	3.5	4.8
Liriodendron tulipifera	4.6	7.2	11.8	2.8	42.9	11.1	7.7
Oxydendrum arboreum	5.6	2.2	7.8	19.5	96.4	21.5	19.2
Quercus coccinea	2.7	4.3	7.0	0.2	3.6		
Pinus echinata	1.7	2.4	4.1				
Pinus strobus	1.0	0.9	1.9	0.8	10.7		
Quercus prinus	1.0	0.4	1.4	0.1	3.6	0.7	2.0
Pinus virginiana	0.8	0.6	1.4	0.1	3.6		
Fraxinus americana var. biltmoreana	0.2	0.9	1.1	0.1	3.6		
Tsuga canadensis	0.6	0.4	1.0			0.4	1.0
Quercus falcata	0.4	0.3	0.7	0.4	10.7		
Carya tomentosa	0.4	0.3	0.7	1.0	17.9	1.1	2.9
Carya glabra	0.4	0.3	0.7	0.2	7.1		
Carya ovalis	0.2	0.2	0.4	0.1	3.6		
Cornus florida	0.2	0.1	0.3	4.8	53.6	7.9	10.6
Fagus grandifolia	0.2	0.1	0.3				

Table 3 (Continued)

TAXA	Overstory RD	Overstory RBA	Overstory IV	Understory Saplings RD	Understory Saplings F	Understory Subsaplings RD	Understory Subsaplings F
Quercus velutina	0.2	0.1	0.3	0.5	7.1	0.4	1.0
Quercus rubra				0.4	7.1		
Quercus stellata				0.2	3.6		
Ilex opaca				2.4	7.1	0.7	1.0
Magnolia tripetala				0.5	3.6		
Alnus serrulata				0.1	3.6	12.2	4.8
Amelanchier arborea var. laevis				0.1	3.6	2.9	4.8
Carpinus caroliniana				0.1	3.6		
Sorbus arbutifolia var. arbutifolia						5.4	5.8
Hamamelis virginiana						1.1	2.9
Castanea dentata						0.4	1.0

Density/Hectare = 424.3 687.1 2470.0

Basal Area (m^2)/Hectare = 28.5

the plots, and are derived from various parent materials. Textures of the A horizons range from a sandy loam to silt loams. The most common A horizon texture is a loam. The most commonly occurring B horizon texture was again a loam, with the textural range extending from loamy sand to clay. Grey mottles occur at a depth less than 65 cm. in greater than 50 percent of the plots; water occurred in approximately 40 percent of the plots within 85 cm. from the surface.

The Society of American Foresters (1954) does not recognize a red maple-blackgum type similar to this community due to the small area of these communities. Hinkle (1975) observed a red maple-blackgum-hemlock community which was best developed along streams in coves with northerly aspects and suggested this type was a disturbed form of his Hemlock-Rhododendron community. Braun (1950) stated that red maple and blackgum are constituents of the swamp forests of the Plateau in which pin oak and sweetgum are most abundant.

McCarthy (1976) described a Red Maple-Blackgum forest type which occurs at lower elevation sites with moderately rocky, sandy soils in Fentress County. He stated that these stands are relatively open and have been heavily disturbed recently. Using the community coefficient of Jaccard (Mueller-Dombois and Ellenberg, 1974), there is a 44.1 percent similarity between tree taxa in McCarthy's type and the present red maple-blackgum community.

White Oak-Red Maple Community

White oak and red maple are the co-dominants in this community and blackgum is the only important associate. Fourteen of the 25 tree taxa present in this community occur in the overstory. Of those canopy taxa, 13 were sampled in one or more of the understory layers (Table 4). Red maple, white oak, sourwood, and dogwood have the highest sapling densities, in that order. In decreasing order, blackgum, red maple, *Sorbus arbutifolia* var. *arbutifolia* (red chokeberry) and dogwood have the highest densities in the subsapling layer. Species of *Rhododendron*, *Viburnum and Smilax* form over 80 percent of the relative density of the shrub and woody vine layer (Appendix, Table 15).

This community reaches its best expression on mid to upper draw positions, where over 70 percent of the plots of this type occur. Plots in this type also occur on lower slope and streamside positions on all aspects (Appendix, Table 16). Soils are deep and have well differentiated horizons. Textures of the A horizon range from sandy loams to silt loams. The most common textural range is from loam to silt loam. Textures of the B vary from loams, which occur in over 60 percent of the plots, to clay loams. More than 70 percent of the plot soils show signs of grey mottling, and water occurred at a depth less than 61 cm. from the surface in more than a

Table 4. Composition of the White Oak-Red Maple Community (N = 12)

				Understory			
	Overstory			Saplings		Subsaplings	
TAXA	RD	RBA	IV	RD	F	RD	F
Quercus alba	44.4	38.0	82.4	18.3	100.0	4.4	25.0
Acer rubrum	28.7	35.2	63.9	31.7	83.3	21.9	41.6
Nyssa sylvatica	14.5	15.4	29.9	11.5	58.3	28.9	25.0
Oxydendrum arboreum	3.6	3.1	6.6	14.9	83.3	4.4	25.0
Quercus prinus	1.9	2.3	4.0	1.1	25.0		
Liquidambar styraciflua	1.9	2.1	4.0	0.7	8.3	0.9	8.3
Quercus falcata	1.0	1.9	2.9	0.4	8.3		
Liriqdendron tulipifera	1.0	0.5	1.5	2.1	25.0	3.5	25.0
Pinus virginiana	0.5	0.5	1.0	0.5	8.3		
Carya tomentosa	0.5	0.5	1.0	0.5	16.6	0.9	8.3
Quercus coccinea	0.5	0.5	1.0				
Quercus stellata	0.5	0.1	0.6	0.2	8.3		
Quercus velutina	0.5	0.1	0.6	0.5	8.3	1.7	16.6
Amelanchier arborea var. laevis	0.5	0.1	0.6	0.2	8.3	0.9	8.3
Cornus florida				14.9	75.0	13.2	25.0
Carya glabra				1.1	16.6		
Ilex opaca				0.5	8.3		
Sassafras albidum				0.5	8.3		
Fraxinus americana var. biltmoreana				0.2	8.3		

Table 4 (Continued)

TAXA	Overstory			Understory			
				Saplings		Subsaplings	
	RD	RBA	IV	RD	F	RD	F
Sorbus arbutifolia var. arbutifolia						14.0	16.6
Prunus serotina						0.9	8.3
Juniperus virginiana						0.9	8.3
Ilex opaca						0.9	8.3
Alnus serrulata				0.2	8.3	1.7	8.3
Alnus sp.						0.9	8.3

Density/Hectare = 434.5 897.4 2346.5

Basal Area (m^2)/Hectare = 27.9

third of the plots. The soils are predominately very strongly acid but one plot had a mildly alkaline (pH 7.5) A horizon and a medium acid (pH 6.0) B. Soils are derived from various parent materials ranging from alluvium to colluvium-residuum.

Safley (1970) described two white oak types from the Cumberland Plateau surface. Approximately 50 percent of the tree species recorded in his types occurred in this white oak-red maple community. Blackgum, an important associate here, was not a contituent of Safley's types, nor was red maple as important in his communities as here. The Society of American Foresters (1954) describes a white oak-red oak-hickory type (Type 52), of the Central Hardwood Forest, and states that red oak is replaced by black, southern red, and scarlet oaks in the Southern Forest. Common associates include red maple, blackgum, sweetgum and yellow poplar. An understory of flowering dogwood often occurs in this SAF type.

This community is reproducing very successfully and therefore appears to be time stable. This type seems to be transitional between the white oak community which is predominate on lower to upper slope positions and the pure red maple and red maple-blackgum communities which are more important on lower draw and streamside positions.

River Birch Birch-American Holly Community

River birch and American holly are co-dominants of this community. Red maple and blackgum are secondary associates (Table 5). Nine of the 13 tree taxa in this community occur in the overstory. Eight of the nine overstory species occur in the sapling layer, but only four of the canopy species occur in the subsapling layer. American holly and red maple have the highest densities and are the most frequent species in both the sapling and subsapling layers. Parthenocissus quinquefolia (Virginia creeper), Cornus amomum (silky dogwood) and roundleaf greenbriar have the highest densities in the shrub and woody vine layer (Appendix, Table 15).

This community is restricted to flat streamside positions along small moving streams. It was sampled in only one location but other more disturbed stands were observed by the author. Soils are greater than 91 cm. deep, are derived from alluvial parent material and in one-third of the plots the soil horizons are not well differentiated (Appendix, Table 16). Textures of the A and B horizons range from loams to silt loams. The most common A horizon texture is silt loam, the B horizon is commonly loam. There are neither grey mottles nor gleying in any of the plot soils, and water occurs at a depth greater than 91 cm. in all plots.

Table 5. Composition of the River Birch-American Holly Community (N = 9)

				Understory			
	Overstory			Saplings		Subsaplings	
TAXA	RD	RBA	IV	RD	F	RD	F
Betula nigra	36.7	37.4	74.1	6.3	44.4	2.4	11.1
Ilex opaca	36.9	30.1	67.0	47.7	100.0	53.7	77.7
Acer rubrum	14.4	19.3	33.7	18.4	88.9	19.6	33.3
Nyssa sylvatica	6.1	7.0	13.1	6.3	44.4	2.4	11.1
Quercus imbricaria	3.0	4.9	7.9	1.7	22.2		
Liriodendron tulipifera	1.2	0.9	2.1	0.6	11.1		
Ailanthus altissima	1.2	0.3	1.5				
Amelanchier arborea var. laevis	0.5	0.1	0.6	0.6	11.1		
Celtis laevigata				10.3	44.4	2.4	11.1
Ulmus rubra				5.7	33.3	17.1	33.3
Fraxinus americana var. biltmoreana				0.6	11.1		
Cornus florida				0.6	11.1		
Prunus serotina				0.6	11.1	2.4	11.1
Asimina triloba				0.6	11.1		

Density/Hectare = 452.8 477.5 1125.1

Basal Area (m^2)/Hectare = 38.1

The four most important canopy species occur in both the sapling and subsapling layers, suggesting the stability of this community. Celtis laevigata (sugarberry) is the third most important sapling species and also occurs in the subsapling layer, but does not occur in the overstory. This species may become more prominent in the community with time.

Safley (1970) reported a river birch type which had roughly three times the number of taxa in the overstory as this present community. His type occurred along the main stream in the Big South Fork gorge bottom. In his type, American holly was restricted to the understory and shingle oak was absent entirely. This present community is undoubtedly a variant of the Society of American Foresters's (1954) River Birch-Sycamore type (Type 61) which extends from southern New England to Tennessee and west to Missouri and Oklahoma. Braun (1950) stated that river birch communities on the Cumberland Plateau follow the streams in narrow strips.

Streamside Red Maple Community

Red maple is the major dominant in this type and is present in pure stands in two of the six plots. White oak is the only other overstory species with an importance value greater than 10 (Table 6). Four of the five overstory taxa in this type occur in the understory layers.

Table 6. Composition of the Streamside Red Maple Community (N = 6)

				Understory			
	Overstory			Saplings		Subsaplings	
TAXA	RD	RBA	IV	RD	F	RD	F
Acer rubrum	86.3	95.2	181.5	24.4	83.3	4.5	33.3
Quercus alba	8.9	3.5	12.4	4.4	66.7		
Nyssa sylvatica	3.2	0.9	4.1	40.4	83.3	22.7	50.0
Oxydendrum arboreum	0.8	0.2	1.0	2.2	50.0	13.7	33.3
Tsuga canadensis	0.8	0.2	1.0				
Cornus florida				13.2	50.5	12.1	33.3
Liriodendron tulipifera				9.8	33.3	16.7	33.3
Prunus serotina				4.4	33.3	28.8	33.3
Pinus strobus				0.6	16.7		
Pinus virginiana				0.6	16.7		
Alnus sp.						1.5	16.7

Density/Hectare = 506.6 716.3 2758.0

Basal Area (m^2)/Hectare = 34.4

Species of Viburnum and Euonymus are the most important taxa in the shrub and woody vine layer (Appendix, Table 15).

This community is best developed on streamside positions (Appendix, Table 16). Soils are uniformly deep (>91 cm.) with thin 0 horizons. Textures of the A horizons are predominately loam; textures of the B horizons range from loamy sand-sandy loam to clay-silty clay loam. No stone is present in the soil profile. Water occurs in two-thirds of the plot soils at a depth less than 91 cm. from the surface.

Blackgum has the highest density and shares the greatest frequency with red maple in the sapling layer. Tsuga canadensis (hemlock) is the only canpoy taxon absent from that layer. Prunus serotina (black cherry) has the highest density in the subsapling layer. The stability of this community is questionable. Although red maple is reproducing successfully, it appears doubtful that it will continue to exist in almost pure stands on these sites. With time this community will probably continue to be dominated by red maple since it is the most prevalent species in the study area, but blackgum and white oak may increase their importance as associates.

No other community descriptions are known which resemble this type. The Society of American Foresters (1954) describes three cover types in which red maple is a co-dominant and very many more where it is an associate. However, none of those types or their variants have a species assemblage like this community. Cain and Penfound (1938) described a red maple swamp forest on Central Long Island in which red maple contributed 89 percent to the total basal area of the community.

This community is probably a streamside variant of the red maple-blackgum community which is best developed in draw positions. All canopy species in this type also occurred in the red maple-blackgum community.

White Pine Community

Pinus strobus (white pine) is the leading dominant in this community. Red maple, white oak and hemlock are important associates of the overstory. Thirteen of the 18 tree species occur in the overstory (Table 7). Red maple, white oak, sourwood and dogwood have the highest sapling densities and together make up more than 70 percent of the density of that layer. Only six of the canopy species were sampled in the subsapling layer; sourwood and hemlock have the highest densities.

This community is best developed on upper draw positions at the northern portion of the Plateau in Tennessee. Plot shapes are generally flat and are located predominately on north-facing slopes (Appendix, Table 16). Soils are greater than 91 cm. deep and generally very

Table 7. Composition of the White Pine Community (N = 6)

				Understory			
	Overstory			Saplings		Subsaplings	
TAXA	RD	RBA	IV	RD	F	RD	F
Pinus strobus	33.6	55.9	89.5	3.9	66.7	7.0	50.0
Acer rubrum	19.4	15.2	34.6	26.7	100.0	9.3	50.0
Quercus alba	12.6	8.5	21.1	19.8	100.0		
Tsuga canadensis	11.8	4.2	16.0	9.3	66.7	16.3	33.3
Nyssa sylvatica	4.2	3.8	8.0	4.6	83.3	2.3	16.6
Oxydendrum arboreum	5.0	3.0	8.0	12.8	100.0	32.6	50.0
Carya glabra	4.2	2.0	6.2	4.3	33.3		
Liriodendron tulipifera	1.7	2.8	4.5	0.4	16.6		
Pinus virginiana	2.5	1.2	3.7				
Quercus coccinea	1.7	2.0	3.7				
Quercus prinus	1.7	0.4	3.1	1.2	16.6		
Pinus echinata	0.8	0.5	1.3				
Carya tomentosa	0.8	0.5	1.3	4.3	33.3	2.3	16.6
Cornus florida				10.8	33.3	9.3	50.0
Ilex opaca				1.5	50.0	9.3	33.3
Quercus velutina				0.4	16.6		
Amelanchier arborea var. arborea						9.3	33.3
Sassafras albidum						2.3	16.6

Density/Hectare = 489.9 1160.9 2429.0

Basal Area (m^2)/Hectare = 40.7

strongly acid. Stone volume is generally low, but reaches 20 percent or more in two of the B horizons. One-half of the plot soils show signs of gleying or mottling and have a depth to water less than 81 cm.

The successional status of this community is not certain. White pine averaged 1.7 and 0.5 stems per plot in the sapling and subsapling layers, respectively. Hemlock and many hardwood species, especially red maple, white oak, and sourwood had much higher sapling densities which may be indicative of increasing importance of these species with time.

The Society of American Foresters (1954) describes a White Pine-Hemlock type (Type 22) which is similar to this community. Associates common to both communities include red maple, tulip poplar and white oak. This SAF type is reported to occur southward into the mountains of Tennessee and North Carolina. Braun (1950) stated that white pine is frequently associated with tulip poplar on the slopes of gorges on the Plateau.

Tulip Poplar Community

Forests of this type occur primarily on lower and middle draw positions. It is a rare type, having been sampled in only four plots. This community is characterized by the dominance of tulip poplar; major associates are white oak, red maple, and black gum (Table 8). Only 11

Table 8. Composition of the Tulip Poplar Community (N = 4)

	Overstory			Understory			
				Saplings		Subsaplings	
TAXA	RD	RBA	IV	RD	F	RD	F
Liriodendron tulipifera	30.7	64.3	95.0			6.7	25.0
Quercus alba	22.7	9.6	32.3	12.4	100.0	2.2	25.0
Acer rubrum	14.7	8.0	22.7	17.5	100.0	26.7	25.0
Nyssa sylvatica	14.7	7.6	22.3	13.9	75.0	8.9	50.0
Querus coccinea	2.7	4.2	6.9	2.2	50.0		
Liquidambar styraciflua	2.7	2.4	5.1	2.9	50.0	2.2	25.0
Quercus stellata	2.7	2.0	4.7				
Quercus velutina	1.3	0.3	1.6	2.2	25.0		
Pinus echinata	1.3	0.3	1.6				
Pinus virginiana	1.3	0.3	1.6	1.5	25.0		
Oxydendrum arboreum	5.2	1.0	6.2	17.5	75.0	24.5	75.0
Cornus florida				13.1	50.0	6.7	25.0
Ilex opaca				11.7	25.0	4.4	25.0
Carya glabra				1.5	25.0		
Carya tomentosa				2.2	25.0	2.2	25.0
Fagus grandifolia				0.7	25.0		
Quercus rubra				0.7	25.0		
Sorbus arbutifolia var. arbutifolia						11.1	25.0
Alnus serrulata						2.2	25.0
Hamamelis virginiana						2.2	25.0

Density/Hectare = 463.1 846.0 2778.7

Basal Area (m^2)/Hectare = 45.6

species occur in the overstory. Of these nine were sampled in one or both of the understory layers.

Ilex decidua (possum haw), *Vaccinium* spp., and *Smilax rotundifolia* (roundleaf greenbriar) are the most important shrubs and woody vines of this community (Appendix, Table 15).

Textures of the A horizon are equally divided between loams and silt loams; B horizon textures range from a loam to a silty clay loam (Appendix, Table 16). Soils are generally deeper than 91 cm., are very strongly acid, and are derived from alluvial parent material. Evidence of mottling or gleying was found in only two plot soils. Water occurs in only one plot at a depth less than 91 cm.

This community appears to be successional. Tulip poplar was not sampled in the sapling layer and occurs in the subsapling layer in only one plot. Red maple and sourwood have the highest densities in both understory layers. Blackgum, dogwood, white oak, and American holly are predominent in the sapling layer. Since this community occurs predominately in draw positions, and red maple, blackgum, and white oak are important overstory associates which are reproducing successfully it appears that with time, some combination of these species will dominate these plots at the expense of tulip poplar.

The Society of american Foresters (1954) describes a tulip poplar-white oak-northern red oak type (Type 59) which is irregular in its occurrence in the Southern Appalachians and occurs on northerly flats and coves. A tulip poplar-white oak-blackgum-red maple variant of that type is reported on the wettest sites which tulip poplar will grow in Kentucky and Tennessee. The association of overstory species in that variant is identical to the present community type. Martin (1966) reported a tulip poplar type which occurred on upper slopes and ridges, but was most prominant in protected north-facing draws. However, the common co-dominants and overstory associates of Martin's type are much different from this present community. Safley (1970) described two plateau gorge communities in which tulip poplar is co-dominant. More mesophytic species occurred in his types than in this present community. Hinkle (1975) also reported two communities co-dominated by tulip poplar which occupy the draw and lower slope positions at Cumberland Gap National Historical Park. Caplenor (1965) reported that tulip poplar was the most widespread arboreal species of the vegetation of Fall Creek Falls and occurred in the canopy of all the gorge communities which he studied. Braun (1950) stated that white oak, tulip poplar, and black oak together dominate in the secondary forests of the interstream uplands on the Cumberland Plateau. She stated further that tulip poplar is not reproducing well on the Plateau except on some of the mesic slopes; especially the slopes of east- and northeast-facing coves. McCarthy (1976) described a tulip poplar type which was confined to cove positions on the Cumberland Escarpment. This type occurred on soils derived from limestone parent materials.

CHAPTER IV

CORRELATION ANALYSIS

Correlation analysis is a useful tool for studies in which the variables cannot be controlled by the investigator. Significant correlations are helpful in supporting field observations and are useful in demonstrating relationships which are less apparent. Simple linear correlations were determined between and among all measured and/or calculated soil, site, regional, and vegetation variables in an effort to determine the degree of association between the variables involved. Many of the correlations are intuitively obvious or occur by definition, e.g. latitude and growing season; or distance from the highest point on the ridge and distance from the bottom of the slope, and therefore will not be discussed.

I. SITE AND REGIONAL CORRELATIONS

Correlations indicate greater precipitation southwestward on the Plateau. U.S. Weather Bureau data show that the maximum mean annual precipitation on the Plateau is recorded at Cagle (U.S. Department of Commerce, 1965), the highest station on the Plateau.

Yearly potential insolation, a function of latitude, aspect, and slope angle, was positively correlated with southerly aspects as expected (Table 9).

The positive correlation between aspect and distance from the bottom of the slope was not expected and suggests that more northeast-facing slopes were sampled on the upper slope positions and more southwest-facing slopes were sampled nearer the bottom of the slope.

Correlations with slope position imply that lower slope positions are more concave across the slope and have gentle down slope angles. Correlations also imply that plots which are concave in horizontal shape may also be concave vertically.

II. CORRELATIONS BETWEEN SOIL AND SITE OR REGIONAL VARIABLES

Correlations with soil profile depth indicate that deeper soils are more common on the southern portions of the Plateau. Deeper profiles also occur on flat, wetter slope positions which are commonly concave in across-slope shape (Table 10). Similar results were reported by Martin (1971) and Finney, et al. (1969) who related deeper profile development to movement and accumulation of colluvial materials in depressions. Hubbard, et al. (1950) reported that the bottomland soils in Cumberland County are derived mainly from alluvial material washed

Table 9. Correlation Matrix of Site and Regional Variables[a]

Site and Regional Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1 Latitude												-0.57	
2 Longitude		(1.00)	(0.71)									0.53	
3 Elevation			1.00	0.26								0.46	
4 Distance from Ridge				1.00	-0.28	0.34					0.17		
5 Distance from Bottom of Slope					1.00	-0.48			0.36			0.26	0.28
6 Slope Position						1.00		0.17	-0.59				
7 Horizontal Plot Shape							1.00	0.22	-0.28	0.63			
8 Vertical Plot Shape								1.00	0.23				
9 Downslope Angle									1.00	0.20			
10 Across-Slope Angle										1.00			
11 Yearly Potential Insolation											1.00		-0.46
12 Mean Annual Precipitation												1.00	
13 Aspect													1.00

[a] All correlation significant at P = 0.05.

Table 10. Correlation Matrix of Soil and Site or Regional Variables[a]

Site Variables	Soil Variables																								
	Soil Depth	O Thickness	A Thickness	B Thickness	Surface Stone	A Stone	B Stone	A Sand	B Sand	A Silt	B Silt	A Clay	B Clay	pH A(H_2O)	pH B(H_2O)	A(KCL)	B(KCL)	Depth to Mottling	Depth to Gleying	Depth to Water	AWHC A	AWHC B	Available Water A	Available Water B	Total Water
Latitude	-0.18		-0.31															-0.29					-0.29		-0.27
Longitude			0.24															0.29							
Elevation			0.24			-0.21	-0.20											0.28		-0.37		0.17	0.21		
Distance from highest point on ridge							-0.22		0.23			-0.25	-0.31		-0.26					-0.30					
Distance from bottom of slope													-0.22									0.17		0.22	
Slope position	0.22		0.19			-0.26	-0.29	-0.34	-0.29	0.33			0.29	-0.21	-0.26	-0.24				-0.37			0.21		
Horizontal plot shape	-0.22																			0.38					
Vertical plot shape														0.20											
Downslope angle	-0.36					0.43	0.37	0.36	0.19	-0.31		-0.21	-0.20	0.22		0.30	0.21	0.33			-0.24		-0.28		-0.20
Across slope angle																				0.39					
Mean annual precipitation			0.51											-0.36	-0.34	-0.19	-0.23					0.31	0.48		0.36
Aspect								0.20		-0.22	-0.22														

[a] All correlations are significant at P = 0.05.

from the uplands and are deeper than soils farther upslope.

Correlations with thickness of the A horizon imply thicker horizons southward on the Plateau, and in areas with increased mean annual precipitation values. Thicker A horizons may be the result of increased weathering due to greater precipitation on the southern portion of the Plateau. Thickness of the A horizon also increases on lower slope positions.

Stone volume in both the A and B horizons is greater on upper slope positions with steeper down slope angles.

Correlations between soil separates and site variables indicate that sandier soils predominate on steeper, higher, more northerly slope positions. Silt percentages of the A and B horizons are greater on more southerly aspects on flat, lower slope positions. Correlations between clay and site variables are not understood. Negative correlations between B horizon clay were found with both distance from the highest point on the ridge and distance from the bottom of the slope. Further correlations indicate increased clay content in the B horizon on lower slope positions with small down slope angle. Lipps (1966) found that with increased slope angle, clay percentages were lower in both the A and B horizons.

More acid soils occur on gentle, lower slopes in areas which receive greater mean annual precipitation.

Leaching of soluable bases are a probable cause for the greater acidity of these soils. Martin (1971) observed less acid soils on steeper slopes in the Great Valley. He attributed the decreased acidity to contributions by vegetation, additions of bases through weathering of calcareous bedrock, and/or presence of clay minerals with relatively high cation exchange capacity in these soils.

Depth to water is negatively correlated with distance from the highest point on the ridge and slope position; and is positively correlated with the across-slope positions which are commonly concave across the slope.

Available water in the A horizon and total available water increase southward on the Plateau and on lower slope positions with gentle or no slope angle. These results are most probably a reflection of thicker A horizons and deeper soil profiles on these sites.

III. SOIL CORRELATIONS

Soil correlations indicate that deeper soils contain less stone and sand throughout the profile, and more silt in the A horizon (Table 11). Available water in the A and B horizons and total available water increases with increased profile depth as expected.

Correlations suggest that the acidity of a soil profile increases with increasing thickness of the A

Table 11. Correlation Matrix of Soil Variables[a]

Soil Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1 Soil Depth	1.00					-0.25	-0.31	-0.28	-0.19	0.21													0.27	0.41	0.52
2 O Horizon Thickness		1.00											0.30												
3 A Horizon Thickness			1.00											-0.21		-0.17	-0.25						0.96		0.28
4 B Horizon Thickness				1.00	-0.18	-0.21						0.23									0.24			0.68	0.50
5 Surface Stone					1.00																				
6 Stone Volume A Horizon						1.00	0.73																		
7 Stone Volume B Horizon							1.00														-0.62	-0.36	-0.23	-0.34	-0.43
8 Sand in A								1.00	0.62	-0.89	-0.34	-0.55	-0.52								-0.44	-0.39		-0.37	-0.43
9 Sand in B									1.00	-0.51	-0.69	-0.39	-0.69												
10 Silt in A										1.00	0.39		0.32									0.19			
11 Silt in B											1.00														
12 Clay in A												1.00	0.52							0.30	-0.22				
13 Clay in B													1.00	0.18	0.22		-0.30				-0.27				
14 pH (H_2O) A														1.00	0.65	0.88	0.58						-0.21		
15 pH (H_2O) B															1.00	0.59	0.47		0.38						
16 pH (KCL) A																1.00	0.62						-0.18		
17 pH (KCL) B																	1.00		0.31				-0.25		-0.22
18 Depth to Mottling																		1.00	0.67						
19 Depth to Gleying																			1.00		0.39				
20 Depth to Water																				1.00					
21 AWHC A																					1.00	0.28	0.31	0.33	0.45
22 AWHC B																						1.00		0.77	0.79
23 Available Water A																							1.00		0.36
24 Available Water B																								1.00	0.89
25 Total Available Water																									1.00

[a] All correlations are significant at P = 0.05.

horizon. This may be the result of increased leaching of soluable bases from these soils. Earlier soil-site correlations imply that thicker A horizons occur on the southern portion of the Plateau, which receives more precipitation throughout the year.

Increased stone volume decreases available water holding capacity of the A and B horizons. Available water is also directly related to horizon thickness and profile depth and is negatively correlated with stone volume.

Since the percentages of sand, silt, and clay sum to 100, an increase in one of the soil separates decreases one or both of the others. Textural correlations support this, i.e. increased sand percentages decrease the silt and clay fractions in the A and B horizons. Silt content of the A horizon is positively related to clay in the B horizon; perhaps due to translocation.

Water acidity (pH H_20) of the A and B horizons decreases with increased clay percentage of the B horizon. However, salt pH (KCL) of the B horizon decreases with increasing clay in the B. M. E. Springer (personal communication) attributed this phenomenon to the fact that these soils are so low in bases that the K^+ ion salt solution replaces H^+ ions from the clay particles resulting in more H^+ being measured.

Clay percentage of the A horizon is directly related to the available water holding capacity of the A horizon, but is inversely related to thw AWHC of the B. The mean clay percentage of the B horizon is greater than that in the A. At the higher percentages, which reach 60 percent in some plots, an increase in the clay fraction decreases the available water holding capacity of that horizon (Longwell, et al., 1961).

The direct correlation between depth to gleying and water pH of the B horizon implies that more saturated soils are more acid. It is commonly assumed that saturated soil solutions are more acid than well-aerated solutions of the same soil (van Breeman, 1975).

IV. CORRELATIONS BETWEEN VEGETATION AND SITE OR REGIONAL VARIABLES

Red maple is one of the most common tree taxa encountered in the swamp and mesic forests of the Plateau. It is the most important species in 50 percent of the plots. The importance value of red maple is directly related to increased distance from the ridge, larger across slope angle, concave horizontal plot shape, and is related to small down slope angle (Table 12). Soil correlations suggest that red maple is tolerant of a shallow depth to gleying and shallow depth to water (Table 13). McDermott (1954) has shown that red maple seedlings are very tolerant of temporary conditions of saturated soil, which

Table 12. Correlation Matrix of Overstory Species IV and Site or Regional Variables[a]

Site or Regional Variables	Overstory Species									
	Red Maple	White Oak	River Birch	Sweet-gum	Black-gum	Tulip Poplar	White Pine	Black Oak	Hem-lock	Holly
Latitude							0.29	-0.24	0.26	
Longitude	-0.17	0.18					-0.28	0.18	-0.23	
Elevation					-0.17		-0.46	0.22	-0.38	
Aspect						-0.24	-0.20			
Distance from Top of Ridge	0.24	-0.21	0.24					-0.22		0.28
Distance from Bottom of Slope	-0.28	0.20	-0.28					0.50		-0.18
Slope Position	0.52	-0.55	0.28	0.32	0.37			-0.33		0.24
Horizontal Plot Shape	0.23	-0.21			0.36			-0.20		
Vertical Plot Shape										
Down Slope Angle	-0.52	0.44		-0.27	-0.45			0.52		
Across Slope Angle	0.21	-0.20			0.35					
Yearly Potential Insolation							-0.27			
Mean Annual Precipitation			0.31				-0.23	0.22		0.28

[a] All correlations are significant at P = 0.05.

Table 13. Correlation Matrix of Overstory Species IV and Soil Variables^{a}

	Overstory Species									
Soil Variables	Red Maple	White Oak	River Birch	Sweet-gum	Black-gum	Tulip Poplar	White Pine	Black Oak	Hem-lock	Holly
Soil Depth	0.28	-0.28			0.21					
O Horizon Thickness	-0.32	0.32			-0.35		0.22	0.27		
A Horizon Thickness		-0.33	0.43	0.34	0.18	0.29			0.31	
B Horizon Thickness										
Surface Stone								0.19		
A Horizon Stone	-0.23	0.21			-0.25					
B Horizon Stone					-0.18					
A Horizon Sand	-0.32	0.22		-0.17	-0.23			0.25		
B Horizon Sand	-0.24							0.23		
A Horizon Silt	0.30	-0.21			0.18	0.18				

Table 13 (Continued)

	Overstory Species									
Soil Variables	Red Maple	White Oak	River Birch	Sweet-gum	Black-gum	Tulip Poplar	White Pine	Black Oak	Hem-lock	Holly
B Horizon Silt				-0.31						
A Horizon Clay				0.21	0.27					
B Horizon Clay	0.20	-0.24		0.40						
pH (H_2O) A Horizon				-0.25						
pH (H_2O) B Horizon										
pH (KCL) A Horizon		0.17		-0.30						
pH (KCL) B Horizon				-0.25						
Depth to Mottling		0.37			-0.33					
Depth to Gleying	-0.45	0.48								
Depth to Water	-0.30									

Table 13 (Continued)

	Overstory Species									
Soil Variables	Red Maple	White Oak	River Birch	Sweetgum	Blackgum	Tulip Poplar	White Pine	Black Oak	Hemlock	Holly
Available Water A Horizon		-0.33	0.31	0.19	0.19	0.22				0.29
Available Water B Horizon										
Total Available Water										

[a] All correlations significant at P = 0.05.

implies that this species is able to tolerate winter and early spring flooding conditions on the poorly-drained sites on the Plateau.

Thickness of the O horizon is generally less in stands where red maple is important. In many of these plots the litter layer is patchy or distributed in a thin layer. Patchiness seems to be due to removal of the litter layer by increased runoff after a heavy rainfall. Soil depth and texture of the A and B horizons are directly related to red maple I.V. suggesting increased importance in deeper, finer textured soils. Fowells (1965) stated that red maple is more common when soil moisture levels are extreme--either very wet or very dry. McGahan, et al. (1961) observed increased height growth of red maple on finer textured soils. (Foster (1959), studying the relationships between site indexes of red maple and eastern white pine in New England, found that red maple growth increased with greater soil moisture levels, lower slope positions and thicker A horizons. Fowells (1965) also reported that red maple is a bottomland species in the south and is common in swampy areas and along slow moving streams. Schmelz and Lindsey (1970) considered red maple a dominant in the forests of the floodplains and poorly drained sites in Indiana.

White oak is the second ~~most~~ important species in the forests studied and has the highest importance value in 35 percent of the plots. Correlations between soil variables and white oak I.V. indicate that this species reaches its best development in shallow, coarse-textured soils with thin A horizons and thick litter accumulations (Table 13). Further correlatins suggest that white oak is more important when the soils are well-drained, available water is low and stone volume is increased in the A horizon. Safley (1970) reported that white oak increased in importance with decreased soil depth, low sand percentages throughout the profile and thinner A and O horizons. Various authors have reported that the site index of white oak increases with thicker A horizons (Hannah, 1968; Carmean, 1965; Doolitte, 1957). Studying the vegetation of Cumberland Gap, Hinkle (1975) observed high white oak basal area on sites with low sand percentages in the A and B horizons. Hannah (1968) found that white oak growth was slow on sandy soils and increased stone volume decreased site quality of that species in southern Indiana.

Correlations between site variables and white oak imply increased importance on steeper, upper slope positions which were flat or convex in shape (Table 12). Hinkle (1975) and Safley (1970) reported that white oak was best developed on middle to upper south-facing slope positions. Hannah (1968) observed that slope steepness was not a factor in determining site quality calculated for white oak. Increasing distance from the ridge improves the site quality of this species in southern Indiana. On the Allegheny Plateau in southeastern Ohio, Gaiser (1951) found that white oak site quality was highest on the lower slopes and decreased rapidly nearer the ridge.

Significant correlations between soil variables and river birch I.V. are few. These correlations suggest that this species is more important on sites with thicker A horizons and increased water availability in the A horizon (Table 13). River birch importance value was positively correlated with increased distance from the top of the ridge and lower slope (bottomland) positions (Table 12). Safley (1970) reported that river birch was restricted to the flood plains along the Big South Fork gorge bottom. He found that this species is strongly correlated with increased soil depth and thick A horizons.

Correlations with soil separates of the A and B horizons suggest increased importance of sweetgum on soils with high clay content in the A horizon and finer textured B horizons (Table 13). Correlations also imply greater importance values on soils which are less acid and have A horizons which are thick and have high water availability. Site correlations indicate that lower, flatter slope positions favor sweetgum growth (Table 12). Silker (1948) found that on west Tennessee sites with fluctuating water levels, sweetgum grew best on soils with deeper surface horizons and poorest on poorly-drained sites. In Maryland, Trenk (1929) reported that the best sweetgum growth occurred on wet, clayey, alluvial soils. Phillips and Markley (1963) found that sweetgum site index was directly related to the clay percentage and fine sand content of the B_2 horizon.

Blackgum I.V. is directly related to deep soils with thick A horizons and low stone volume in the A and B horizons (Table 13). Correlations also imply greater importance on finer textured soils with a shallow depth to mottling. Blackgum reaches its best development in draw positions. This is reflected in the positive correlations with lower slope positions and concave horizontal plot shape. Martin (1966) found that blackgum was present on all positions and forms of north- and south-facing slopes. Safley (1970) regarded this species as a member of the more xeric vegetation in his study area. Hinkle (1975) reported blackgum as a constituent in both cove and upper slope communities. Fowells (1965) stated that blackgum is adapted to a wide range of sites and will tolerate brief spring flooding on alluvial sites. Best growth in the southeastern United States is attained on well-drained, fine-textured soils on low ridges of second bottoms and on high flats of silty alluvium (Fowells, 1965).

Significant correlations between tulip poplar and soil and site variables are few which suggests the cosmopolitan distribution of this species. Interpretation of these correlations suggests that tulip poplar develops its greatest importance on more southerly exposures (Table 12, page 61) and on soils with high silt percentages in the A horizon (Table 13). Smalley (1969) reported that the average height and dbh of planted tulip poplar in nothern Alabama was greater on north-facing slopes. Auten (1945) found that tulip poplar height was significantly greater on northerly aspects in Tennessee, Kentucky, Illinois, Indiana and Ohio. A study of the undisturbed hardwood and pine-hardwood stands of the Piedmont showed that tulip poplar height was directly related to thickness of the A horizon (Della-Bianca and Olson, 1961). On his study on Wilson Mountain, Martin (1966) found that tulip poplar density was directly related to north slopes and thicker A horizons. In the Great Valley, Martin (1971) reported that the relative basal area of tulip poplar was inversely related to A horizon thickness.

White pine is most important on the northern portions of the plateau in Tennessee (Table 12). Fowells (1965) showed that this species is absent from the southernmost counties of the Cumberland Plateau in Tennessee. Stone volume of the B horizon was the only soil variable significantly correlated (positive) with white pine I.V. (Table 13). Mader (1976) reported that white pine height was directly related to stone volume of the A horizon, but negatively correlated with B horizon stone volume. Martin (1971) found that the greatest concentration of white pine in the Great Valley occurred on relatively mesic sites with deep, silt loam--silty clay soils on gentle slopes. Braun (1950) reported that white pine is not restricted to any particular site in the secondary forests of the Cumberland Plateau.

Correlations between site variables and black oak I.V. suggests that this species is more important on steeper, higher slope positions. Significant soil correlations imply greater black oak I.V. on sites with coarse textured soils with thick O horizons and relatively great stone cover. Black oak importance value was directly related to upper slope positions, steeper slope angle and increased sand content in the A horizon in the Great Valley (Martin, 1971). Similar observations were reported by Martin (1966) on Wilson Mountain. Carmean (1965) reported that black oak site index increased on steeper slopes with fine-textured soils in southeastern Ohio. Hannah (1968) reported that increased slope steepness decreased site quality for that species in southern Indiana.

Hemlock was found to be positively correlated with latitude. No significant correlations occurred between hemlock importance value and soil variables. Hemlock reaches the southern extent of its range on the Cumberland Plateau in northern Georgia and Alabama (Fowells, 1965). At the southern extension of its range its occurrence is restricted to cool moist valleys, and north and east slopes (Frothingham, 1914). Quarterman, et al. (1972), Caplenor (1965) and Braun (1950) have reported that hemlock is abundant in the ravines and gorges of the plateau in Tennessee. Hinkle (1975) found that hemlock reached its best development in the more northerly facing draws.

The importance value of American holly is positively correlated with thickness of the A horizon, distance from the ridge, and slope position. This species was observed to reach its best overstory development along small moving streams on alluvial soils. Like river birch this species was sampled only once in the overstory; along Daddy's Creek in Cumberland County. Holly was a common understory species in the swamp forests of this study area.

CHAPTER V

MULTIPLE REGRESSION ANALYSIS OF SELECTED OVERSTORY TAXA

Stepwise multiple regression analysis was used to develop predictive equations for eight overstory taxa importance values based on selected soil and site variables. Forty independent variables (Appendix, Table 14) were selected on the basis of significant correlation coefficients from the preceding analysis and assumed ecological importance. Multiple regression analysis is a useful tool for a study of this type as a means of determining relationships between species importance and several environmental variables.

The regression equations presented in this discussion list the independent variables in decreasing order based upon their contribution to the regression coefficients. This was determined by dividing the partial sum of squares of each variable by the partial sum of squares for all variables in the equation. All equations are significant at the .01 percent significance level; independent variables in each equation are significant at the .05 percent probability level. The maximum R^2 improvement technique of the SAS Stepwise Procedure (Barr, et al., 1976) was used to calculate the regression equations for this analysis. The n-variable model satisfying the above two criteria was chosen for the discussion if the n+1 variable model did not increase the R^2 by at least 2 percent. The standard error of estimate for each predicted Y was calculated using the following equation (Nie, et al., 1975).

$$S.E.E. = \frac{SS_{error}}{N-k-1}$$

where: SS_{error} = sum of squares due to error.
N = no. of observations.
k = no. of variables in the model.

Red maple is one of the most ubiquitous species in the study area and occurs in the overstory of 75 percent of the plots. This species is most common in draw and streamside positions, as the following equation suggests.

$$I.V. = 172.7 - 0.62\ X33 - 0.30\ X31 - 1.00\ X13 - 2.15\ X10 - 0.73\ X19$$

$R^2 = 0.46$ $\bar{Y} = 74.43 \pm 36.61$, n = 102

Depth to mottling (X31) is the only variable in this equation which was not significantly correlated with red maple importance value in the preceding correlation analysis. Depth to water (X33) and depth to mottling (X31) together account for 59 percent of the variation in R^2 in this equation. Decreased slope angle (negative X10), supports the fact that red maple is commonly found on low, flat sites in the study area. Thin litter accumulation (negative X13) is directly related to red maple importance value. Thin or patchy litter layers on sites where this species is important in the overstory were noticed in the field and attributed to removal of litter by runoff after heavy rains. Decreased sand content in the A horizon (negative X19) accounts for less than 1 percent of the variation in the equation, and implies greater red maple importance value on fine-textured soils. Summarizing, red maple reaches its best development on sites which are flat, have little litter accumulation, on fine-textured soils which have a shallow depth to mottling and water. These variables are characteristic of draw and streamside positions on which red maple attains its greatest overstory importance values.

Martin (1971) found that red maple I.V. and relative density equations were directly related to finer-textured soils and relative basal area was directly related to less relief. Red maple was a relatively unimportant element of the plateau vegetation in Safley's (1970) study area. It never reached dominant or condominant status in the overstory of his communities. Hinkle (1975) reported that red maple was a codominant in one of his vegetation types and a primary associate in another. These communities were best developed in coves. Coleman (1975) reported red maple as a codominant in both an upland and a bottomland community in Mississippi. Red maple was listed as one of the 10 dominants in the mixed mesophytic community in the Fall Creek Falls gorge by Caplenor (1965). He also listed this species as an important associate of the chestnut oak community on southwest-facing talus slopes. Red maple has a wide ecological amplitude as evidenced by its extensive north-south range in eastern North America (Fowells, 1965) and its occurrence in 54 forest types (Society of American Foresters, 1954), but reaches its best development in the mountains of Kentucky and Tennessee (Betts, 1949). Braun stated that red maple is predominant on the poorly drained areas on the Cumberland Plateau. Red maple was classified as a submesic species by Whittaker (1956) and had a wider ecological range than any other taxon in the Smokies due to its array of "high polyploid races." McDermott (1954) observed that red maple seedlings were tolerant of temporary periods (32 days) of saturated soil. Hosner (1960) however, found that red maple seedlings experienced complete mortality during a period of 20 days submergence. Seeds for his study were collected from upland red maples and the author suggested that seeds taken from trees growing in poorly drained areas may have given different results. McGahan, et al. (1961) observed that decreased slope angle significantly increased height growth of red maple in Rhode Island.

White oak is one of the most important taxa in this study area and occurs in the overstory of 81 percent of the plots. White oak is best developed on the "drier" sites in the study area which the following regression equation points out.

$$\text{I.V.} = 121.34 - 9.04\,X7 - 4.88\,X34 - 1.37\,X11 + 0.29\,X33$$

$$R^2 = 0.41 \qquad \bar{Y} = 58.55 \pm 33.44,\ n = 111$$

Higher slope positions (negative X7), lower available water in the A horizon (negative X34), and lower across slope angles (negative X11) were all significantly correlated with white oak in the preceding analysis. Greater than 50 percent of the variation in this equation is explained by slope position. White oak reaches its greatest importance, in these study plots on upper draw to middle slope positions which were generally flat both vertically as well as horizontally. Low available water in the A horizon accounts for over 25 percent of the variation in this equation. Increased depth to water (positive X33) is a function of higher slope position.

Due to the wide distribution of white oak in his study area, Safley's (1970) regression equation for white oak had low predictive value ($R^2 = 0.066$ to 0.121). He stated that deep soil profiles and southern exposures accounted for about 50 percent of the variation in his equations predicting relative basal area, relative density, and importance value. Low slope position was also an important variable in those equations.

Hinkle (1975) also reported low R^2 values predicting importance value of white oak (0.19 and 0.04 for south and north slopes respectively). His equations suggest white oak grows best on the relatively clayey soils on middle to upper south-facing slopes.

White oak was the least site restricted taxa in Martin's (1971) study area which again is reflected in low R^2 values. The two most important variables predicting white oak characteristics were low slope angle (i.e. lower slopes or rolling or flattened topography) and relatively high water availability.

Gaiser (1951) reported that white oak site quality on the Appalachian plateau in the Southeastern Ohio was highest on lower northeast-facing slopes with thick A horizons and relatively high water availability in the A horizon. McClurkin (1963) found that white oak site index was greatest on mid and lower slopes positions and decreased with increasing clay content in the surface soil. On the Cumberland Plateau in northern Alabama, Smalley (1967) reported white oak growth increased on lower, longer slopes. Hannah (1968) found that depth of the total A horizon was the most important variable affecting white oak site index in southern Indiana. White oak growth also improved on soils with decreasing stone content with increasing distance from the ridge and on more gentle, north-facing slopes.

River birch is restricted to sites along small moving streams on the plateau surface which is supported by the following regression equation.

$$\text{I.V.} = -43.00 + 3.72\,X7 + 0.15\,X33 + 0.10\,X31 - 0.31\,X24 + 1.31\,X34$$

$R^2 = 0.27$ $\bar{Y} = 58.00 \pm 14.58$, $n = 9$

In this equation X7 (low slope position, e.g. streamside) accounts for 46 percent of the R^2. Available water in the A horizon (positive X34) and the preceding variable were the only variables significantly correlated with river birch importance value. High water availability in the A horizon is a function of deep horizons, low stone volume, and a high percentage of soils with silt loam and loam textures in plots where this species is most important. Low clay percentage in the B horizon (negative X24) is related to the high silt content and alluvial parent material of these soils. A greater depth to mottling (positive X31) and depth to water (positive X33) together accounted for 30 percent of the variation of river birch importance. The absence of mottles, gleying, and a high water table is probably due to the fact that these deep alluvial soils drain rapidly after flooding.

Safley (1970) reported the river birch was restricted to gorge bottoms in his study area. He did not sample this species on the Plateau surface. He found that river birch importance value was directly related to increased sand content of the B horizon and high protection angle, which together, accounted for 60-70 percent of the variation in his regression equation. Increased relative density was directly related to increased clay in the soil.

River birch occurred along the margin of the Raritan River in New Jersey with a low relative density (Buell and Wistendahl, 1955; Wistendahl, 1958). Lindsey, et al. (1961) found that river birch was unimportant on the Wabash River, and was more common, but never a dominant, along the Tippecanoe River in Indiana. This species existed as the single dominant in stands along streams in Southeast Ohio (McClelland and Ungar, 1970). The authors attributed the river birch dominance to its tolerance of soils of extreme acidity. More than 50 percent of the soils on which river birch was dominant in the present study were extremely acid (pH 4.5). Braun (1961) stated that river birch distribution in Ohio may be associated with the acidity of the soils. Fritts and Kirkland (1960) reported that river birch was an important species along streams draining areas with acid soils in Illinois.

Sweetgum is not a dominant in any of the communities in this study, but reaches its greatest importance in the red maple-blackgum community. The regression equation for sweetgum importance value is as follows:

$$\text{I.V.} = 12.59 - 0.63\ X22 + 2.23\ X26 - 0.84\ X10 + 0.10\ X32$$

$$R^2 = 0.34 \quad \bar{Y} = 38.8 \pm 15.21\ ,\ n = 25$$

Small down slope angle (negative X10), fine-textured B horizons (positive X26), and low silt percentage of the B horizon (negative X22) were all found to be significantly correlated with sweetgum I.V. in the preceding discussion. Low silt content of the B and fine-textured B horizons are almost equally important in this equation and together account for greater than 80 percent of its variation. In the preceding analysis, correlations indicated the sweetgum attained its greatest importance on clayey soils. The indirect relationship between slope angle and sweetgum I.V. supports the fact the sweetgum reaches its best development on wet flats or draw positions. Increasing the depth to gleying (positive X32) increases sweetgum importance. This relationship is not entirely understood. Although sweetgum I.V. was not shown to be significantly correlated with depth to gleying, it grows best on soils with a shallow depth to gleying. High clay content in these soils would also tend to reduce soil drainage resulting in gleyed profiles.

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, Broadfoot and Krinard (1959) found that sweetgum site index increased with decreased clay content in the 3- to 4-foot soil layer. The best sites for growth had "medium-textured" soils without a hardpan in the top two feet, and had moderate to good internal drainage. On hardwood tree plantations along the margins of the fluctuating resevoirs on the lower Teenessee River in Tennessee, sweetgum grew best on soils with deep surface layers and permeable subsoils; poorest growth was on drained sites (Silker, 1948). Minkler (1946) reported good sweetgum growth on plantations in the Great Valley in Tennessee on sites with very friable, gravelly top soil and a loose and friable upper B horizon. For the New Jersey coastal plain on wet soils, Phillips and Markley (1963) reported that sweetgum site index was directly related to high clay and fine sand content in the B_2 horizon and thickness of that horizon. The highest site index values occurred on sites with an average depth to water of 20 inches and with little fluctuation in that level.

The regression equation developed for blackgum suggests its increased importance in draw positions.

$$\text{I.V.} = 32.75 - 1.81\ X10 + 1.10\ X11 - 0.15\ X31 + 0.43\ X14$$

$R^2 = 0.34$ $\bar{Y} = 36.77 \pm 12.72$, $n = 96$

All variables were significantly correlated with blackgum I.V. in the preceding analysis. Low down slope angle (negative X10) is the most important factor in the equation explaining 50 percent of the variation. Greater across slope angle (positive X11), implying concave horizontal plot shape characteristic of draw positions, accounts for 25 percent of the R^2. Shallow depth to mottling (negative X31) and thick A horizons (positive X14), which are directly related to draw positions, complete the equation.

Fowells (1965) stated that blackgum grows on a variety of sites from dry uplands to alluvial stream bottoms with an extensive distribution in the eastern U.S. Hinkle (1975) found that blackgum was a codominant taxon in cove and streamside communities as well as on the relatively dry hogbacks of northerly slopes. On the dry slopes, he suggested that blackgum is a replacement species for chestnut. Gemborys and Hodgkins (1971) observed blackgum as an important overstory taxon on the alluvial stream bottoms in southwestern Alabama. This taxon was listed as a major constituent of the vegetation on the poorly drained areas in Indiana (Schmelz and Lindsey, 1970). Martin (1966) reported that blackgum was not restricted in its occurrence. Safley (1970) stated that it was a constituent on the xeric sites in his study area. Martin (1971) found the blackgum relative density, relative basal area, and importance value all increased with finer-textured soils and less acid A horizons. This second variable accounted for 40, 77, and 66 percent of the total R^2 in his equations for R.D., R.B.A., and I.V. respectively.

The regression equation developed for black oak importance value indicates its restriction to drier sites in the study area.

$$\text{I.V.} = 10.52 + 0.03\ X5 + 1.41\ X10 - 0.42\ X21 - 0.06\ X6 + 0.33\ X24$$

$R^2 = 0.48$ $\bar{Y} = 32.88 \pm 13.18$ $n = 34$

Greater down slope angle (positive X10) and increased distance from the bottom of the slope (positive X5) are the variables from this equation which were significantly correlated with black oak I.V. in the preceding analysis. Increased distance from the bottom of the slope, greater slope angle, and more southerly aspects (negative X6), indicators of more xeric conditions, explain 40, 32, and 10 percent of the variation in this equation respectively. The presence of both decreased silt in the A horizon (negative X21) and increased clay in the B horizon (positive X24) in this equation is not understood. Correlations from the preceding analysis imply that these variables are directly related; both variables decrease with higher slope position and steeper slope angle.

Martin (1971) reported increased black oak importance value on soils with greater A horizon sand, increased available water, and decreased slope angle. Relative basal area was directly related to decreased sand content in the A and greater B horizon clay in his study. Martin (1966) observed that black oak had higher basal areas and was more dense on upper, south-facing slopes. Fowells (1965) stated that this species grows on drier sites than white oak, but not as dry as sites where post and blackjack oak commonly grow. Black oak most commonly occurs on dry, sandy, or rocky ridges, but grows best on lower slope positions (Hannah, 1968; Carmean, 1965; Fowells, 1965; Doolittle, 1957). Hannah (1968) and Carmean (1965) also reported an increase in black oak site index on medium-textured soils with thick surface (A_1 + A_2) horizons, less stone volume, and on sites with lower slope angles. The increased growth was attributed to greater soil drainage and aeration (Carmean, 1965). Height growth of this species increases on steeper slopes on the Piedmont (Della-Bianca and Olson, 1961) and on finer-textured soils in northern Alabama (Smalley, 1967). Black oak site quality was also greater on soils with high silt percentage in the B_1 horizon (Hannah, 1968) and on soils with high clay content in the A_2 horizon (Ike and Huppuch, 1968).

The regression equation for white pine importance value is as follows:

$$\begin{aligned} \text{I.V.} = {} & 133.32 + 0.87\ X19 + 7.51\ X25 - 0.001\ X39 \\ & - 0.11\ X31 + 0.32\ X13 + 0.41\ X18 \end{aligned}$$

$$R^2 = 0.28 \qquad \bar{Y} = 45.0 \pm 15.74\ ,\ n = 14$$

Increased O horizons thickness (positive X13), greater stone in the B horizon (positive X18), and decreased yearly potential insolation (negative X39) were significantly correlated with white pine importance value in the preceding analysis. Increased sand content of the A (positive X19) and finer textured A horizons (positive X25) together account for over 60 percent of the variation of the equation, but are conflicting variables. White pine I.V. increases with decreasing yearly potential insolation, a function of increasing latitude. This species approaches the southern extension of its range on the Cumberland Plateau in Tennessee. Shallow depth to mottling (negative X31), reflects white pine's greatest importance in draw positions. Increased stone content in the B horizons, which is as high as 25 percent in some of the plots, and thick O horizons together account for little more than 10 percent of the variation in R^2.

Ike and Huppuch (1968) found that white pine grew best in sheltered coves at low elevations in the Blue Ridge Mountains in Georgia. Growth rate decreased on steeper slopes and on sites with thick litter accumulations. For the unglaciated regions of Ohio and Indiana, Gaiser and Merz (1953) found that white pine site quality increases on coarser-textured soils. Thickness of the A horizon was the most important variable affecting white pine growth in their study. Fowells (1965) stated that white pine grows best on well-drained sandy soils where there is less hardwood competition. Growth is also good on silty soils or loams with good or impeded drainage on sites free of hardwood competition during the period of seedling establishment. Hough (1943) reported white pine growing on poorly drained, clayey soils on the northern Allegheny Plateau. In the Great Valley of Tennessee, planted white pine growth was best on soils with greater than 6 inches of top soil and friable B horizons (Minkler, 1946). Barrett and Goldsmith (1973) found that the amount of available moisture, determined from drainage classes, was the most significant variable influencing white pine growth in New Hampshire. Greatest growth occurred on well drained and moderately well drained (mottling in the lower B and C horizons (Soil Survey Staff, 1951)) soils, poorest on somewhat excessively drained soils. The most important factor influencing planted white pine growth in Vermont at ages 30 and 50 was increased thickness of the A plus upper B horizon (Hannah, 1971). Other variables improving site-index were thin A horizons, south- or northwest-facing slopes, and decreasing clay percent in the B horizon. In natural stands of white pine in Massachusetts, Mader (1976) reported increased growth on soils in the poorer drainage classes, with higher pH of the B or C horizons and with increased clay and silt percentages in A horizons.

Tulip poplar was sampled on a variety of sites in the study area. The low R^2 of the following regression equation suggests the widespread distribution of this species.

$$\text{I.V.} = -15.5 + 0.52\ X14 + 1.77\ X16 + 5.47\ X8$$

$$R^2 = 0.15 \qquad \bar{Y} = 28.3 \pm 17.34\ ,\ n = 40$$

Thickness of the A horizon (positive X14) was the only variable significantly correlated with tulip poplar importance value in the preceding discussion and explained 44 percent of the variation in this equation. Increased surface stone cover (positive X16) is the second most important variable accounting for 37 percent of R^2. Increased horizontal (across) slope shape (positive X8) implies greater tulip poplar importance on plots which are concave across slope, i.e. draw positions.

Safley (1970) described tulip poplar as one of the most mesophytic species in his study area and found that thick humus, low sand percent in the B horizon, and southerly aspects increase the R.B.A., R.D., and I.V. for this species. Increased stone volume and lower slope percent contributed to the relative density regression equation. Martin (1966) reported that thick A horizons, higher slope positions, less acid soils, and northerly aspects increased relative density and relative basal area of this species. Hinkle (1975) reported that concave horizontal slope shape was the most important variable explaining his equations and accounted for 70-75 percent of their variation on the south slope. For the north slopes, increased clay percent in the A, increased stone volume, and higher pH of the B horizon were significant variables in the equations. In this study area tulip poplar was prominent in northerly draws where colluvium was abundant. Martin (1971) reported that regression equations for relative density of tulip poplar suggest its importance on concave slopes with deep soils and a relatively high base status.

Auten (1945) observed increased tulip poplar growth in natural forest stands in the Central States, on sites with deep, permeable, well-drained, but moist soils. Increased depth to tight subsoil (>24 in.) was the most important variable affecting site index. Ike and Huppuch (1968) found that site index of tulip poplar in the Georgia Blue Ridge was greatest in sheltered cove positions; open coves and sheltered side slopes were next best for growth. Tryon, et al. (1960) have shown that thick A horizons, increased depth to tight subsoil, and a greater depth to mottling increases site quality for this species. Lower slopes position, more northerly aspects and greater depth to mottling significantly increased tulip poplar growth in West Tennessee (Hebb, 1962).

CHAPTER VI

SUMMARY AND CONSLUSIONS

Field work for this study was conducted from June through September of 1976. This study is part of a large project involving C. Ross Hinkle, Gary L. Wade, and the author. Three hundred and six circular, concentric 0.0405 ha. and 0.004 ha. plots were sampled during the project, of which 137 were designated by the author as being dominated by swamp or mesic taxa and were used in the present study. Of these plots, 55 percent were draw positions, 19 percent were located along streams and 16 percent were lower and middle slope positions. A total of 40 soil, site and regional variables were measured or calculated and used in correlation and regression analyses.

Eight vegetation types based on overstory importance values were determined using a clustering technique developed by Orloci (1967).

The white oak community was sampled on the greatest number of study plots (27 percent) and occurs most commonly on lower to middle northwest- or southeast-facing slopes. This type appears to be a time-stable community.

The draw position red maple community is also an extensive type, being sampled in 27 percent of the study plots. Red maple is the leading dominant (I.V. = 105.3) and blackgum and white oak are major associates. This community is best developed in draw positions on flat or northeast-facing slopes. This community appears to be reproducing successfully.

The red maple-blackgum community is best developed on middle draw positions. Red maple and blackgum are equally important in the overstory with white oak, tulip poplar, and and sweetgum being major associates. All important overstory species are reproducing successfully.

The white oak-red maple community was sampled most frequently on upper draw positions. Blackgum is the only overstory associate with an importance value greater than 10 in this type. Red maple saplings and subsaplings, as well as subsaplings of blackgum have higher densities than those of white oak which may indicate increased importance of these species with time.

The river birch-American holly community was sampled in only one stand along a small moving stream. This community appears relatively stable, with a possibility of sugarberry and slippery elm becoming important in the overstory with time.

The streamside red maple community was sampled in a total of six plots, two of which were pure stands of red maple. High values of BA/ha and D/ha for this community as well as understory reproduction figures suggest that this community is stable. It is undoubtedly a variant of the draw position red maple community.

The white pine community is restricted to the northern section of the Plateau in Tennessee where it is best developed on draw positions. The large number of relatively small (<25.4 cm.) red maples in the overstory as well as numerous saplings and subsaplings indicate the disturbed nature of this community.

The tulip poplar community is a rare type, sampled in only 4 plots, and occurs on lower and middle draw positions. This type appears to be successional. Tulip poplar was absent from the sapling layer and occurred in the subsapling layer in only one plot. Red maple, blackgum, and white oak will probably increase in importance with time.

Results from simple linear correlation analyses between and among soil and site variables suggest that lower, wetter slope positions have thicker A-horizons and deeper soil profiles. These soils have less stone and sand content throughout the profile and are more acid than soils farther slope. Depths to mottling, gleying, and water are generally shallow. Lower slope positions generally have a flat vertical plot shape but are commonly concave in horizontal slope. Greater sand in the A and decreased silt percentage in the A and B horizons occur on soils on more northerly slopes.

Red maple was one of the most ubiquitous species in the study area occurring in 75 percent of the plots. Multiple regression analysis predicts increased red maple

I.V. on flat sites with little litter accumulation, and on fine-textured soils which have a shallow depth to mottling and water. These independent variables are characteristic of draw and streamside positions on which this species reaches its highest overstory importance values.

White oak was sampled in the overstory of 81 percent of the plots and was best developed on the "drier" sites in the study area. The most important variable explaining white oak I.V. was higher slope positions. The other significant variables imply increased white oak importance on flat sites with low available water in the A horizon and a great depth to water.

Low slope position (e.g. streamside) was the most important variable predicting river birch importance value. This species was restricted to narrow bands along slow moving streams on well-drained soils derived from alluvial parent material. High available water in the A horizon and low clay percentage in the B horizon are functions of high silt content in these soils. Increased depths to mottling and water accounted for 30 percent of the variation in river birch importance.

Sweetgum was not a dominant in any of the communities, but was best developed on wet flats and draws in the red maple-blackgum community. Low silt percentage of the B and finer-textured B horizons were significantly correlated with sweetgum I.V. and are almost equally important predicting sweetgum I.V. Together these variables explain over 80 percent of the variation of the regression equation. The regression equation further suggests increased sweetgum importance on low flat sites, with a great depth to gleying.

Blackgum is best developed on draw positions in this study area. Small down-slope angle and increased across-slope angle were the best predictors of blackgum I.V. They accounted for 50 and 25 percent of the variation in I.V., respectively. A shallow depth to mottling and thick A horizons were also significant predictors of blackgum importance.

Tulip poplar was sampled on a variety of sites, and thus has few significant correlations and a regression equation with a low R^2 for this species. Correlation and regression analyses imply increased tulip poplar importance in draw positions with thick A horizon and high silt content in the A.

Black oak is restricted to "higher" (middle to upper), more south-facing slope positions on sandy soils in the study area. Increased distance from the bottom of the slope and steeper slope angles were the two most important predictors of black oak importance value.

Variables strongly correlated with white pine I.V. are few. Significant correlations suggest greater importance on the northern section of the Plateau in Tennessee on south-facing plots with thick litter accumulations. Increased sand content of the A horizon is the most important predictor of white pine I.V.

Hemlock, like white pine, approaches the southern extent of its range on the Cumberland Plateau, and was best developed in draw positions on the northern portion of the Plateau in the study area.

American holly reached its greatest development as a codominant in the river birch-American holly community along small moving streams. This species is a common member in the understory of several communities in the study area.

The swamp and mesic forests of the Cumberland Plateau are, at best, all second growth forests and are very limited in their extent. These vegetation types are confined to lower slope and concave draw positions, poorly drained upland flats, and are present in narrow strips along streams. Much of these areas have been cleared of the native forests in the past for agricultural reasons. Recent resort development and increasing demand for stripmined coal further threaten these forests. An understanding of the composition of these forests and their relation to the environment is necessary if we are to preserve the remaining forest resources of the Cumberland Plateau.

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APPENDIX

Table 14. Soil, Site, and Regional Variables Used in Correlation and Regression Analysis

	Variable	Code
X1	Latitude	As Recorded
X2	Longitude	As Recorded
X3	Elevation	As Recorded
X4	Distance from ridge	As Recorded
X5	Distance from bottom of slope	As Recorded
X6	Aspect	Transformed by Method of Beers et al. (1966)
X7	Slope Position	
	Upper Slope	1
	Mid Slope	2
	Lower Slope	3
	Upper Draw	4
	Mid Draw	5
	Lower Draw	6
	Streamside	7
	Wet Flat	8
X8	Horizontal Plot Shape	
	Convex	1
	Flat	2
	Concave	3
X9	Vertical Plot Shape	
	Convex	1
	Flat	2
	Concave	3
X10	Down Slope Angle	Average of up and down slope angles
X11	Across Slope Angle	Average of two across slope angles
X12	Soil Depth	As recorded, 91 cm. maximum
X13	O horizon thickness	As recorded, cm.
X14	A-horizon thickness	As recorded, cm.
X15	B-horizon thickness	As recorded, cm.
X16	Surface Stone	As recorded, nearest 5 percent
X17	Stone volume A-horizon	Same as above
X18	Stone volume B-horizon	Same as above
X19	Sand in A-horizon	As recorded, nearest 2 percent
X20	Sand in B-horizon	Same as above
X21	Silt in A-horizon	Same as above
X22	Silt in B-horizon	Same as above
X23	Clay in A-horizon	Same as above
X24	Clay in B-horizon	Same as above

Table 14 (Continued)

	Variable	Code
X25	Texture of A-horizon	
	Loamy Sand	1
	Loamy Sand-Sandy Loam	2
	Sandy Laom	3
	Sandy Loam-Silt Loam	4
	Loam	5
	Loam-Silt Loam	6
	Silt Loam	7
	Loam-Clay Loam	8
	Sandy Loam-Silty Clay Loam	9
	Clay Loam	10
	Clay Loam-Silty Clay Loam	11
	Sandy Clay Loam	12
	Silty Clay Loam	13
	Silty Clay-Silty Clay Loam	14
	Sandy Clay	15
	Silty Clay	16
	Clay	17
X26	Texture of B-horizon	Same as above
X27	pH (H_2O) of A-horizon	As recorded
X28	pH (H_2O) of B-horizon	As recorded
X29	pH (KCL) of A-horizon	As recorded
X30	pH (KCL) of B-horizon	As recorded
X31	Depth to mottling	As recorded
X32	Depth to gleying	As recorded
X33	Depth to water	As recorded
X34	Available water holding capacity of A-horizon	As recorded, cm. Calculated from Day's method (1956)
X35	Available water holding capacity of B-horizon	As recorded
X36	Available water of A-horizon	As recorded
X37	Available water of B-horizon	As recorded
X38	Total available water	As recorded
X39	Yearly potential insolation	As determined from Frank and Lee (1966)
X40	Mean annual precipitation	As recorded

Table 15. Relative Densities and Frequencies of the Shrub and Woody Vine Taxa of the Swamp and Mesic Forests of the Cumberland Plateau in Tennessee

	Relative Densities and Frequencies[a]															
	I		II		III		IV		V		VI		VII		VIII	
	RD	F	RD	F	RD	F	RD	F	RD	F	RD	F	RD	F	RD	F
Anistostichus capreolata									2.7	11.1						
Calycanthus floridus var. floridus					1.6	7.1									8.3	25
Ceanothus americanus																
Cornus amomum									23.4	11.1	3.3	16.7				
Dioscorea villosa	1.4	2.7	0.9	2.7												
Euonymus americanus			1.5	8.1							30.0	33.3				
E. atropurpureus											6.7	33.3				
Eunonymus spp.	0.7	2.7			8.2	3.6										
Ilex decidua	2.1	2.7			4.9	3.6	1.3	8.3	1.4	11.1					37.5	25
Kalmia latifolia	2.1	5.4	3.3	8.1	[illegible]	7.1					3.3	16.7	8.3	16.7		
Ligustrum vulgare							5.4	8.3								
Parthenocissus quinquefolia			2.4	8.1					20.0	33.3						
Rosa supp.									13.7	11.1						
Rhododendron canescens			6.3	2.7	14.8	25.0	6.7	16.7								
Rhododendren maximum.					0.5	3.6							33.3	16.7		
Rhododendron sp.	7.6	2.7	1.5	5.4			44.6	25.0								
Rhus radicans			1.5	2.7					4.1	22.2						
Rubus supp.			0.9	2.7												
Sambucus pubens			0.9	2.7					4.1	33.3						
Similax bona-nox	2.1	2.7					2.8	8.3								
Smilax glauca	7.6	18.9							6.8	22.2	3.3	16.7				
Smilax rotundifolia	35.2	27.0	7.9	18.9	24.7	57.1	12.3	8.3	13.7	44.4	10.0	3.3			12.5	50
Smilax spp.			14.9	16.2												
Vaccinium stamineum	18.6	29.7	3.3	10.8	13.7	42.9	4.0	16.7	5.5	22.2			41.6	33.3	4.2	25
Vaccinium spp.	8.3	10.8	20.3	21.6	11.0	25.0	8.1	25.0					8.3	16.7	33.2	50
Viburnum acerfolium	0.7	2.7					1.3	8.3								
Viburnum prunifolium																
Vibrunum spp.			32.9	18.9	33.0	10.9	13.5	8.3	43.3	33.3						
Vitus rotundifolia					1.1	3.6										
Vitus spp.									4.1	11.1			8.3	16.7	4.2	25

Table 16. Soil, Site, and Regional Variables Expressed as Percentages of Plots in Each Community

Variables	I	II	III	IV	V	VI	VII	VIII
Latitude								
35.01-35.50	46.7	27.0	40.7	27.3				50.0
35.51-36.00	18.9	16.2		18.2	100.0	83.3		
36.01-36.50	34.4	56.8	59.3	54.5		16.7	100.0	50.0
Elevation(m.)								
401-450	8.1	21.6	18.5	18.2		16.7	100.0	
451-500		18.9						25.0
501-550	37.8	43.2	55.6	54.5	100.0	83.3		
551-600	54.1	16.3	25.9	27.3				75.0
Aspect Transformed								
flat	13.6	32.4	14.8	9.1	100.0	66.7		
0.0-0.50	18.9	32.4	18.5	27.3		16.7	16.7	75.0
0.51-1.00	16.2	10.8	18.5	9.1			16.7	25.0
1.01-1.50	29.7	13.6	33.4	27.3				
1.51-2.00	21.6	10.8	14.8	27.3		16.7	66.6	
Distance from Highest Point on Ridge (m.)								
0-100	29.7			9.1				25.0
101-200	21.6	24.3	14.8	18.2			83.3	25.0
201-300	10.8	24.3	33.3	18.2		16.7	16.7	
301-400	5.4	21.6	33.3	27.2	11.1	16.7		
401-500	16.3	10.8	11.2	9.1	11.1	16.7		25.0
501-600	8.1	8.2	3.7	9.1	22.2	33.3		
601-700	5.4	5.4		9.1	55.5			
701-800	2.7	5.4	3.7			16.7		25.0

Table 16 (Continued)

Variables	I	II	III	IV	V	VI	VII	VIII
Distance from Bottom of Slope (m.)								
0-200	45.9	64.8	48.1	45.5	100.0	83.3	66.7	75.0
201-400	8.1	16.3	22.3	18.2			33.3	25.0
401-600	24.4	18.9	29.6	36.3		16.7		
601-800	8.1							
801-1000	10.8							
1001-2000	2.7							
Horizontal Plot Shape								
Convex	24.3	2.7	3.7				16.7	
Flat	48.6	43.2	22.2	18.2	100.0	66.7	50.0	50.0
Concave	27.1	54.1	74.1	81.8		33.3	33.3	50.0
Vertical Plot Shape								
Convex	18.9							
Flat	70.3	86.5	96.3	72.7	100.0	100.0	66.7	100.0
Concave	10.8	13.5	3.7	27.3			33.3	
Topographic Position								
Ridge	5.4							
Upper Slope	18.9							
Mid Slope	10.8						33.3	25.0
Lower Slope	35.1	2.7		9.1				
Upper Draw	13.6	37.8	33.3	45.5		16.7	66.7	
Mid Draw	8.1	18.9	40.8	27.2		16.7		50.0
Lower Draw	2.7	8.2	11.1	9.1				25.0
Streamside	5.4	18.9	11.1	9.1	100.0	66.7		
Wet Flat		13.5	3.7					

Table 16 (Continued)

Variables	I	II	III	IV	V	VI	VII	VIII
Down Slope Angle %								
0-5	18.9	97.3	96.3	72.7	100.0	100.0	66.7	75.0
6-10	29.7	2.7	3.7	18.2				
11-15	51.4			9.1				25.0
16-20							33.3	
Across Slope Angle %								
-9 - -5	5.4						16.6	
-4 -0	29.8				16.6		8.3	12.5
1-5	51.3	64.9	37.0	45.4	83.4	66.7	33.3	62.5
6-10	8.1	27.0	31.7	27.3		16.7	41.8	25.0
11-15	4.0	5.4	24.0	27.3		16.7		
16-20	1.4	2.7	7.3					
Yearly Potential Insolation (Langley's)								
24001-25000	5.4						16.7	
25001-26000	18.9	2.7				100.0	16.7	25.0
26001-27000	40.6	81.1	92.6	81.8	100.0		66.7	75.0
27001-28000	27.0	16.2	7.4	18.2				
28001-29000	8.1							
Soil Depth (cm.)								
0-31	2.7							
32-61	13.5		3.7	9.1				25.0
62-91	83.8	100.0	96.4	90.9	100.0	100.1	100.0	75.0

Table 16 (Continued)

Variables	I	II	III	IV	V	VI	VII	VIII
Thickness of O Horizon (cm.)								
0-.6	36.1	100.0	85.7	81.8	100.0	100.0	16.7	75.0
.7-1.3	44.4		14.3	18.2			33.3	25.0
1.4-2.0	16.7						16.7	
2.1-2.7	2.8						33.3	
Thickness of A Horizon (cm.)								
0-10	18.9	21.6	20.0	63.6			50.0	
11-20	48.7	35.1	20.0	36.4		66.7	33.0	25.0
21-30	29.7	24.3	40.0		22.2			
31-40	2.7	2.7	16.0		11.1			75.0
41					33.3			
no differentiation		16.3	4.0		33.3	33.3	16.7	
Thickness of B Horizon (cm.)								
0-20	5.4	2.7						
21-40	2.7	2.7	8.4		11.1			
41-60	37.9		25.0	27.3	33.3	33.3	33.3	100.0
61-80	45.9	67.6	45.8	45.4	22.2	33.3	33.3	
81+	8.1	10.8	20.8	27.3			16.7	
no differentiation		16.2			33.3	33.3	16.7	

Table 16 (Continued)

Variables	I	II	III	IV	V	VI	VII	VIII
Available Water A Horizon (cm./cm.)								
0-2.0	10.8	9.7		50.0			40.0	
2.1-4.0	54.1	45.2	41.7	50.0		75.0	60.0	25.0
4.1-6.0	24.3	29.0	16.7		16.7	25.0		
6.1-8.0	8.1	16.1	37.5		16.7			25.0
8.1-10.0	2.7		4.1		33.3			50.0
10.1+					33.0			
Available Water B Horizon (cm./cm.)								
0-4.0	5.4	3.1						25.0
4.1-8.0	16.3	9.4	29.2	9.1	16.7		20.0	25.0
8.1-12.0	27.0	12.5	25.0	36.4	16.7	50.0	60.0	50.0
12.1-16.0	24.3	28.1	16.7	9.1	66.7			
16.1-20.0	24.3	37.5	16.7	36.4		25.0	20.0	
20.1-24.0	2.7	9.4	12.4	9.1		25.0		
Total Available Water (cm.)								
0-4.0	2.7	3.2						
4.1-8.0	8.1							33.3
8.1-12.0	18.9	6.4	16.7	18.2		50.0	60.0	
12.1-16.0	24.4	12.9	25.0	27.3			20.0	33.3
16.1-20.0	10.8	22.6	20.8	9.1	33.3	25.0		
20.1-24.0	35.1	54.9	37.5	45.4	66.7	25.0		33.3

Table 16 (Continued)

Variables	I	II	III	IV	V	VI	VII	VIII
% Stone A Horizon								
0-5	83.8	100.0	96.3	90.0	100.0	100.0	66.7	75.0
6-10	5.4		3.7				16.7	
11-15	2.7							25.0
16-20	5.4							
21-25	2.7						16.7	
26+				9.1				
% Stone B Horizon								
0-5	77.8	100.0	87.4	90.9	100.0	100.0	66.7	75.0
6-10	13.9		4.2	9.1				
11-15	8.3		4.2					
16-20							16.7	
21-25							16.7	
26+			4.2					25.0
Texture A Horizon								
Sandy Loam	8.1		7.5	27.3			16.7	
Loam	64.9	32.4	48.1	18.2	33.3	83.3	33.3	50.0
Loam-si l	5.4	13.5	11.1	36.3			16.7	
Silt Loam	18.9	51.4	33.3	18.2	44.4	16.7	33.3	50.0
cl l-si cl l		2.7						
sa cl l	2.7							

Table 16 (Continued)

Variables	I	II	III	IV	V	VI	VII	VIII
<u>Texture B Horizon</u>								
Loamy Sand	2.7		3.7					
l sa- sa l						16.7		
Sandy Loam	5.6	11.1	7.4					
Loam	69.5	47.4	40.7	63.6	55.5	33.3	40.0	50.0
l-si l	5.6							
Silt Loam	2.7	16.7	7.4	18.2	44.4		40.0	
l-cl l			3.7					
s l-s cl l								
cl l	13.9	8.3	26.0	18.2		33.3	20.0	25.0
cl-si cl l		2.8				16.7		
Sandy Clay Loam		2.8	3.7					
si cl l			3.7					25.0
clay		11.0	3.7					
<u>Depth to Mottling (cm.)</u>								
0-31	2.7	35.1	33.3	60.0		33.3		
32-61		8.1	26.0			33.3	50.0	25.0
62-91		2.7	3.7	10.0				
91+	97.3	54.1	37.0	30.0	100.0	33.3	50.0	75.0
<u>Depth to Gleying (cm.)</u>								
0-31		24.3		9.1			16.7	
32-61		5.4	11.1			50.0	33.3	25.0
62-91	5.4	13.5	3.7	9.1				
91+	94.6	56.8	85.2	81.8	100.0	50.0	50.0	75.0

Table 16 (Continued)

Variables	I	II	III	IV	V	VI	VII	VIII
Depth to Water (cm.)								
0-31		24.3	3.7	9.1			16.7	
32-61		24.3	11.1	27.3		33.3	16.7	25.0
62-91	2.7	5.5	25.0			33.3	16.7	
91+	97.3	45.9	60.2	63.6	100.0	33.3	50.0	75.0
pH (H_2) A Horizon								
4.5	30.6	34.3	40.7	18.2	55.5		16.7	
4.5-5.0	63.9	54.3	55.6	54.5	44.4	100.0	66.7	100.0
5.1-5.5	5.5	11.4	3.7	18.2			16.7	
7.1-7.5				9.1				
pH (H_2) B Horizon								
4.5	8.1	11.4	11.1	9.1	22.2	16.7		
4.6-5.0	83.8	77.2	88.9	72.7	77.7	66.7	100.0	100.0
5.1-5.5	8.1	11.4		9.1		16.7		
5.6-6.0				9.1				

Table 16 (Continued)

Variables	I	II	III	IV	V	VI	VII	VIII
Parent Material								
Colluvium	5.4	13.5	7.4				16.7	25.0
Alluvium	2.7	48.6	25.9	45.5	100.0	67.7	16.7	75.0
Residuum	83.8	18.9	18.6	18.2				
Coll.-All.	2.7	13.5		14.8	18.2		50.0	
Coll.-Res.	5.4	5.5	33.3	18.2		33.3	16.7	

Note:
I. White Oak Community, n = 37
II. Draw Position Red Maple Community, n = 37
III. Red Maple-Blackgum Community, n = 27
IV. White Oak-Red Maple Community, n = 11
V. River Birch-American Holly Community, n = 9
VI. Streamside Red Maple Community, n = 6
VII. White Pine Community, n = 6
VIII. Tulip Poplar Community, n = 4

VITA

Lawrence Roy Smith was born December 13, 1951 in Hartford, Connecticut. He received his elementary education in Columbia Station, Ohio and graduated from Columbia High School in June, 1970. He enrolled at Baldwin-Wallace College in Berea, Ohio in September of that same year and received a Bachelor of Science degree in Biology in June of 1974. The summer after graduation he took courses at Ohio State's Biological Station, the Franz Theodore Stone Laboratory on Gibraltar Island, Lake Erie.

He entered the Graduate Program of the University of Tennessee in April, 1975 and entered the Graduate Program in Ecology in May, 1976.