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To the Graduate Council:

I am submitting herewith a thesis written by John Marcus Safley, Jr. entitled "Vegetation of the Big South Fork Cumberland River, Kentucky and Tennessee." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Botany.

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VEGETATION OF THE BIG SOUTH FORK
CUMBERLAND RIVER, KENTUCKY
AND TENNESSEE

A Thesis
Presented to
the Graduate Council of
The University of Tennessee

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by
John Marcus Safley, Jr.

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ABSTRACT

The watershed of the Big South Fork of the Cumberland River was studied in the summer of 1969 to determine the relationships existing between soil, site, and vegetational characteristics. Two-hundred-and-seventy tenth acre plots were established wherein trees of overstory size (greater than 5 inches dbh in 2 inch size classes) and understory size (4 1/2 feet tall; 1-5 inches dbh) were measured; herbs, shrubs, seedlings, and vines were sampled within one-hundredth acre subplots. Various soil and site characters were measured for each plot.

Soils were found to be stonier, deeper, and less sandy on lower slope positions in gorge and mountain areas; upslope soils were sandy, shallow, and less stony due to colluvial action and erosion. Available water was assumed greatest in draws and on lower slope positions where soils were deeper and less sandy. Soils were deeper on north rather than south-facing slopes. Twenty-two forest types distinguished on the basis of aspect, proximity to drainage, slope position, and ridge-draw location were described for the basin. These were primarily oak-dominated except on shallow soils where pines had established; hemlock was prevalent in protected coves. Instability of forest types has been related to death of the American chestnut and to repeated logging and strip mining. Increased available water was associated with greater basal area, greater total plot density, and increased understory plot density. Stands with longest periods of growth have

higher densities, greater basal area, and less herbaceous cover.

Forest taxa have segregated on the basis of soil and site factors as they relate to moisture and available water.

TABLE OF CONTENTS

SECTION	PAGE
I. INTRODUCTION.	.1
II. REVIEW OF SELECTED LITERATURE	.2
III. THE STUDY AREA.	11
Location.	11
Climate	11
Geology	13
Physiography.	14
Soils	15
Flora	17
Vegetation.	19
Human History	23
IV. METHODS	28
V. RESULTS AND DISCUSSION.	33
Vegetation Types.	33
Gorge Vegetation - Associated Soil and Site Char-	
acteristics	35
Plateau Surface Vegetation, Associated Soil and Site	
Characteristics	85
Mountain Vegetation; Associated Soil and Site Char-	
acteristics	98
Environment and Vegetation Comparisons by Correlation .	.113
Stepwise Multiple Regression Analysis	.125

SECTION	PAGE
V. CONCLUSIONS	.141
VI. SUMMARY	.145
LITERATURE CITED.	.147
APPENDIX.	.159
VITA.	.161

LIST OF TABLES

TABLE	PAGE
I. Forest Communities of the Study Area Arranged by Aspect, Topography, and Position	34
II. Composition of the River Birch Forest Type	36
III. Soil-Site Characteristics of the River Birch Forest Type .	37
IV. Composition of the Tulip Poplar-Sweetgum Forest Type . . .	39
V. Soil-Site Characteristics of the Tulip Poplar-Sweetgum Forest Type.	40
VI. Composition of the Redcedar Forest Type.	42
VII. Soil-Site Characteristics of the Redcedar Forest Type. . .	43
VIII. Composition of the White Oak-Chinquapin Oak Forest Type. .	45
IX. Soil-Site Characteristics of the White Oak-Chinquapin Oak Forest Type.	46
X. Composition of the Tulip Poplar-Eastern Hemlock Forest Type	48
XI. Soil-Site Characteristics of the Tulip Poplar-Eastern Hemlock Forest Type.	50
XII. Composition of the White Oak-Virginia Pine Forest Type . .	53
XIII. Soil-Site Characteristics of the White Oak-Virginia Pine Forest Type.	54
XIV. Composition of the Shortleaf Pine-White Oak Forest Type. .	57
XV. Soil-Site Characteristics of the Shortleaf Pine-White Oak Forest Type.	58
XVI. Composition of the White Oak-Virginia Pine Ridge Forest Type	61

TABLE

XVII.	Soil-Site Characteristics of the White Oak-Virginia Pine Ridge Forest Type.	62
XVIII.	Composition of the Northern Red Oak-Chestnut Oak-White Oak Forest Type.	64
XIX.	Soil-Site Characteristics of the Northern Red Oak-Chestnut Oak-White Oak Forest Type.	65
XX.	Composition of the White Oak-Hemlock-Chestnut Oak Forest Type.	68
XXI.	Soil-Site Characteristics of the White Oak-Hemlock- Chestnut Oak Forest Type	70
XXII.	Composition of the White Oak-Beech Forest Type	72
XXIII.	Soil-Site Characteristics of the White Oak-Beech Forest Type	74
XXIV.	Composition of the White Oak-Chestnut Oak Forest Type. . .	76
XXV.	Soil-Site Characteristics of the White Oak-Chestnut Oak Forest Type.	77
XXVI.	Composition of the Virginia Pine-White Pine Forest Type. .	80
XXVII.	Soil-Site Characteristics of the Virginia Pine-White Pine Forest Type	81
XXVIII.	Composition of the Virginia Pine-White Oak Forest Type . .	83
XXIX.	Soil-Site Characteristics of the Virginia Pine-White Oak Forest Type.	84
XXX.	Composition of the Northern Aspect White Oak Forest Type .	86
XXXI.	Soil-Site Characteristics of the Northern Aspect White Oak Forest Type.	87

TABLE	PAGE
XXXII. Composition of the Southern Aspect White Oak Forest Type.	89
XXXIII. Soil-Site Characteristics of the Southern Aspect White Oak Forest Type	90
XXXIV. Composition of the Virginia Pine-White Oak-Blackjack Oak Forest Type	93
XXXV. Soil-Site Characteristics of the Virginia Pine-White Oak-Blackjack Oak Forest Type	94
XXXVI. Composition of the Virginia Pine Forest Type.	96
XXXVII. Soil-Site Characteristics of the Virginia Pine Forest Type.	97
XXXVIII. Composition of the Beech-White Oak-Sugar Maple Forest Type.	99
XXXIX. Soil-Site Characteristics of the Beech-White Oak-Sugar Maple Forest Type	100
XL. Composition of the White Oak-Beech Forest Type.	102
XLI. Soil-Site Characteristics of the White Oak-Beech Forest Type	103
XLII. Composition of the Chestnut Oak-White Oak-Beech Forest Type	106
XLIII. Soil-Site Characteristics of the Chestnut Oak-White Oak- Beech Forest Type	107
XLIV. Composition of the Chestnut Oak-Northern Red Oak Forest Type	109
XLV. Soil-Site Characteristics of the Chestnut Oak- Northern Red Oak Forest Type.	110

TABLE

XLV.	Soil-Site Characteristics of the Chestnut Oak- Northern Red Oak Forest Type.	.110
XLVI.	Simple Linear Correlations Among Site Variables	.115
XLVII.	Simple Correlations Among Soil Variables.	.117
XLVIII.	Simple Correlations of Soil-Site Variables.	.118
XLIX.	Simple Linear Correlations Between Soil-Site and Vegetation Variables.	.120
L.	Simple Linear Correlations of Soil-Site-Vegetation Variables with I.V. 200 of Selected Taxa.	.122

I. INTRODUCTION

A vegetation-site interrelation study was undertaken in the summer of 1969 within the Big South Fork watershed of the Cumberland River, Tennessee and Kentucky. Few vegetation studies have been conducted within the Cumberland Plateau and Cumberland Mountains of Tennessee, but such studies have been extensive in Kentucky and provide a basis for understanding vegetation types occurring in Tennessee. Vegetation within the watershed was compared to descriptions from adjacent areas as none existed from the study area.

The study has been stimulated and supported by the U. S. Army Corps of Engineers, who have proposed construction of a flood control-hydroelectric power project within the watershed. The United States Department of Agriculture, the United States Department of the Interior, and the Corps of Engineers have completed a joint study of alternatives to the Corps' high dam at Devils Jumps, west of Strunk, Kentucky (U. S. Army Corps of Engineers, et al., 1970). Alternatives range in scope from establishment of a national park to establishment of a national recreation area. The beautiful landscape in this rugged area argues for some form of public use.

These investigations contribute to the understanding of the role of soil, site, and historical causes upon the vegetation pattern and enables prediction of forest characteristics in comparable, unsampled areas. This study summarizes much previous ecological research and characterizes the major landscape units of this watershed which units must be considered in ultimate planning of the watershed usage.

II. REVIEW OF SELECTED LITERATURE

Many factors affect the growth of vegetation on the landscape. The relative growth rates of tree taxa on specific sites for specific periods of time have been used as an indicator of site quality for those taxa. Coile (1952) proposed that site quality should be the production capacity of an area of land on the basis of each tree taxon or forest culture type. Site factors, as they affect the amount and kind of growing space used by tree roots, and soil properties largely determine the site quality. Site quality is expressed as site index for productivity indication. Although site index provides an integration of all site factors, it does not consider intrinsic growth rate, density, history of the stand, or other influencing factors (Ovington, 1965).

Opening of the canopy by cutting has been a natural as well as manageable phenomenon. Beck (1970) stated that use of release treatments in the Bent Creek Experimental Forest near Asheville, North Carolina, resulted in the immediate response of northern red oak seedlings to canopy opening. These seedlings remained viable for up to six years prior to release. Trimble and Hart (1961) found that cuttings which removed 75-plus per cent of the sawtimber volume favored establishment of yellow poplar. In the same northern hardwood stands, light cuttings favored oak, red maple, and beech regeneration. On a 55-year-old, undisturbed hardwood stand in central Pennsylvania, Ward (1966) found 12,000 sprouts and seedlings per acre in advance reproduction. Logging on replicated plots had little or no

effect on reproduction establishment over a two-year period. Merz and Boyce (1958) observed reproduction of Liriodendron tulipifera in 90-plus year second growth stands in southeastern Ohio at rates more than twice in a clearcut block as in a heavily cut block. Light cutting was favorable to oaks, with oaks comprising 73 per cent of all reproduction in those stands. Heavy cutting of upland hardwoods demonstrated that density of yellow poplar was related to slope position and degree of cutting. Karnig and Stout (1969) found growth rates of dominant red oaks to be greater in heavily thinned stands than in undisturbed areas. This flush of growth has been related to the release of nutrients by mineralization following cutting of forest ecosystems (Bormann, et al., 1968).

Clark (1970) commented that the amount of oak in a new stand depends directly on advance reproduction; the latter is dependent upon the fraction of full sunlight reaching the forest floor and the site aspect. Partial cutting, light burning, and grazing resulted in the greatest advance reproduction. In a study of reproduction of oaks in the Arkansas Ozarks, Arend and Jullander (1948) observed that seedling species diversity decreased from mixed oak stands to stands dominated by white oak. This was due to decreased light intensity and deeper litter in the white oak stands. The failure of pine seedlings to establish themselves under hardwood forest canopies has been found to be evoked by low light intensities as it affects photosynthesis (Kramer and Decker, 1944; Korstian, et al., 1952). Other researchers have reported enhanced survival of oak seedlings in moderate to high light intensities (Kuenzel and McGuire, 1942; Carvell and Tryon, 1961). Caplenor (1965) also reported enhanced

natural regeneration in opened and cut-over sections of the Fall Creek Falls area of the Cumberland Plateau.

Coile (1937) stated that the humus type developed in any specific locality is a function of chemical composition, physical character, amounts of fresh organic debris, and the temperature-moisture regime under which it decomposes. The role of litter in species regeneration has been recognized by many researchers (Minckler and Jensen, 1959; Barrett, 1931; Lutz and Chandler, 1946; Ward, 1961). Litter depths of greater than 1.0 inch were found important to the regeneration of Quercus velutina, Quercus alba, and Quercus rubra in southern Illinois by Minckler and Jensen. Barrett found that litter depths of less than 1.0 inch facilitated the reproduction of Quercus prinus. Hosner and Minckler (1960) evaluated reproduction of eighteen bottomland hardwood taxa along streams of southern Illinois. The taxa were able to germinate and survive under a wide range of conditions, but reproduction was less where litter was deep, where there was a dense ground cover, or where the overstory was sparse. Clark (1970) and Boyce and Parry (1958) reported that yellow poplar seed germinates best on scarified soil where seed are in physical contact with mineral soil. Clark cited 3,000 versus 30,000 seedlings in undisturbed and scarified seedbeds, respectively. He found, however, that natural seeding provided adequate forest stocking. Korstian (1927) investigated several factors controlling germination and mortality of oaks in North Carolina. He found that natural regeneration was facilitated if the soil was not compacted, and if there were sufficient litter to prevent water loss and to equilibrate soil temperatures. In a study of litter characteristics in east

Tennessee, Blow (1955) concluded that the average amount of water held by litter under field conditions was approximately 135% of its oven dry weight.

Many early investigators noted differences in environment and vegetation related to aspect (Shreve, 1924; Cottle, 1932; Aikman and Smelser, 1938; Potzger, 1939). These investigators found, in general, higher soil and air temperatures, greater evaporation, and generally drier conditions on slopes with southern aspects. More mesophytic taxa inhabited the northern slopes while more xeric taxa predominated on southern exposures. Mowbray and Oosting (1968) observed species segregation on the North Carolina Blue Ridge along environmental gradients controlled by aspect and slope position. However, they found that these interacted with topographic form and the integrated effects were reflected in site moisture regime. Shortleaf pine establishment in old fields of the Piedmont Plateau is dependent upon an adequate seed source. Site factors (except as they control available moisture) seem to have no effect (McQuilkin, 1940). Braun (1942) found oak-chestnut, oak-hickory, and oak-pine communities on the south-facing slopes of the Cumberland Mountains. Beech and white oak communities occupied the lower slopes of the southern exposures. The Mixed Mesophytic community occupied the coves and mid-slope positions on all aspects and extended to the upper north-facing slopes. Smalley (1967) observed that in 22 stands of mixed red oaks in northern Alabama, tree height was related positively to north aspect and middle to lower slope position. On 26 white oak plots, however, site quality was related to slope position and total slope length. Kucera (1952) observed aspectual difference

in the dominant tree species of a valley in central Iowa. Quercus borealis var. maxima was dominant on the south-facing slope while Quercus borealis var. maxima and Tilia americana were codominant on the north-facing slope of the valley. Cantlon (1953) studied north and south-facing slopes in New Jersey where he found more taxa on northern slopes as well as greater tree density and total basal area. In a study of growth rates of Quercus alba, Quercus velutina, and Quercus stellata on north and south-facing slopes in Missouri, Nash (1959) found that each showed greater diameter increases on the northern aspects when compared to rates from southern aspects over a 10 to 15 year period.

Height growth studies of Liriodendron tulipifera, Quercus coccinea, Quercus alba, and Pinus echinata on the uplands of the Virginia-North Carolina Piedmont often produce correlations between site index and soil-site characteristics (Della-Bianca and Olson, 1961). The best predictability came from equations with height of yellow poplar as the dependent variable. An increase in slope per cent favored the productivity of Quercus velutina and Quercus coccinea; site index of each increased with increased distance from the ridge. Site indices of the other taxa increased on those sites favorable to yellow poplar production. Hannah (1968) found increasing slope steepness not significantly affecting height growth in white oak in southern Indiana. He found, however, that slope steepness was inversely related to black oak site quality. Smalley (1967), in a study of upland oaks in northern Alabama, observed white oak height in 26 plots to be related to slope position and total slope length. Carvell and Tryon (1959) reported abundant oak reproduction

on the middle one third of slopes in West Virginia. In an investigation of site index of white oak in North Mississippi and western Tennessee, McClurkin (1963) found slope position (lower, middle, and upper slope) to be significantly correlated with height growth: height increment increased on the middle and lower slopes. Hebb (1962) studied the productivity of tulip poplar, sweet gum, white oak, southern red oak, and cherrybark oak on sites in West Tennessee. He found that topographic position was a significant factor in estimation of volume of merchantable boles. Smalley (1969) reported on the growth of tulip poplar in plantings in northern Alabama. Trees were planted in 50 foot wide clearings across a draw from the top of the north-facing slope to the top of the opposite south-facing slope. The trees (at age 10 years) were tallest in the bottoms (30.10 feet) with heights decreasing to 21.6 feet on the upper north slope and to 14.4 feet on the upper south slope. Total tree height was related to soil moisture in per cent of oven dry weight with a correlation $R = 0.823$ (significant at the 0.01 level). Fraser (1954) studied the effects of minor topographic relief as it is expressed by moisture gradient. The distribution of tree taxa in relation to this gradient was then observed. Maximum relief in the study area was 62 feet and moisture content was rated from dry to wet on a 1 to 6 scale. Beech and sugar maple were found to be rated 1-2; both Tilia americana and Quercus borealis var. maxima were rated 3; Fraxinus americana and Ostrya virginiana were found in conditions 4-5; and, Acer rubrum was found in moisture conditions 5-6. Sweetgum comprised 68 per cent of the understory seedlings on wet sites of the New Jersey coastal plain but only 27 per cent of the same measure on the moist sites (Clark, 1970).

Scholz (1937) observed that northern red oak and chestnut oak on the Black Rock Forest cove areas exhibited more rapid growth on clay loam than on clay soils. Coile (1950) related the effect of soil characteristics to the development of hardwood understories in pine stands of the Piedmont Plateau. He found sweetgum density greater on coarse textured soils while dogwood was more abundant on the fine textured substrates. Allen (1960) observed that site index of shortleaf pine was correlated significantly with the amount of clay in the subsoil and the ratio of subsoil to surface soil clay. Coile and Schumacher (1953) found decreased indices of loblolly pine and shortleaf pine in Piedmont stands on soils with high clay per cent in the subsoil. Heavy subsoil restricted root penetration. In a study relating site index to soil and topography, Phillips (1966), observed that tulip poplar grew best on well-drained, deep surface soils overlying loamy or moderately loamy, fine textured subsoils. These fine sand soils had adequate soil moisture during most of the year. Within the same study, Phillips found that 87 per cent of the variation in sweetgum site index was accounted for by these soil characters: per cent clay in the B₂ horizon, per cent of fine sand in the B₂, and the amount of subsoil silt.

Cooper (1960) found that differences in soil weathering and formation on slopes of north and south exposure in Michigan were the product of different microclimatic regimes. The solum was shallowest at the crest of south slopes and deepest on the north-facing slopes; higher soil temperatures, cycles of freeze and thaw, wetting and drying, on the south-facing slopes increased biotic and geochemical activity resulting in breakdown of larger soil particles and a

concomitant clay accumulation in the B. Gaiser (1951) measured the site index of white oak on soils of southeastern Ohio and found it highest on lower slopes with northeastern exposure. He found the best growth on sites with the thickest A horizon, indicating white oak grows best on substrates with relatively high available water. Schneider, et al., (1966) monitored soil moisture in 9 feet of soil profile under old growth hardwood forest over 3 water years. The forest was dominated by American beech and sugar maple. They reported that soil moisture fluctuations were the most severe in the upper 3 feet of the profile; this same zone was found to have little recharge and was driest in late summer. Karnig and Lyford (1968) found that after 5 years of oak mortality studies in the Harvard Black Rock Forest, certain oak taxa which grew best in dry to mesic conditions were most affected by drought. There was a decrease in scarlet oak basal area from 35.0 to 9.7 square feet per acre; chestnut oak exhibited a decrease from 13.6 to 12.8 square feet per acre. Northern red and white oak were unaffected. Drought mortality occurred primarily on thin solum which measured less than 24 inches in depth where the scarlet and chestnut oaks were densest. In a study of second growth tulip poplar in Tennessee, Kentucky, Indiana, Illinois, and southern Ohio, Auten (1945) found that this taxon grew best on sites with moist but well drained soils on north-facing slopes. Site index was, he observed, directly related to increase in A_1 depth and depth of the soil to bedrock.

Soil characteristics pertaining to the availability of water appear to be the most important environmental factors influencing site index. Foster (1959) studied the possibility of using sugar

maple site index as an indicator of white pine site index on New England sites. He observed significant changes in sugar maple site index with increased A_1 thickness, elevation decrease, lower slope position, increased depth to a compact horizon and an increased moisture equivalent. Nash (1963) found five independent variables adequate to explain 78 per cent of the site index of shortleaf pine in Missouri. Best growth was achieved with 0-25 per cent slope steepness, northern aspect; on soils with a sandy to silty clay B horizon, with 20 per cent stone content or less, with middle to upper slope position, and with friable to moderately heavy consistence. Carmean (1965) reported that the site index of black oak in southeastern Ohio increased with increased depth of the A horizon and with increased steepness of slopes on fine textured soils with restricted internal drainage; site index decreased with increased stone volume on medium textured soils. Arend and Jullander (1948) observed high site indices of black oak and hickories associated with deep, well drained, limestone derived soils; medium oak sites included ridges and upper slopes with shallow soils or those on a southern to western exposure. Oaks of the poor sites with thin soil were post oak, black oak, and blackjack oak. Site index of oaks of the Appalachians of Maryland and West Virginia were researched by Trimble and Weitzman (1956). Site index increased on deep soils of the north and east-facing slopes as the per cent of slope increased, oak site index decreased. Oak site index in the Ridge and Valley region of Maryland and West Virginia was accounted for by stand age (explaining over half the total explained variance), aspect, slope position, thickness of the A and B soil horizons, and the pH of the A_2 horizon.

III. THE STUDY AREA

Location

The Big South Fork is the third largest Cumberland River tributary. This tributary has a total drainage area of 1,382 square miles of which 404 are in McCreary, Pulaski, and Wayne counties, Kentucky, and 978 are in Anderson, Campbell, Fentress, Morgan, Pickett, and Scott counties, Tennessee. The basin lies between 36 8' and 37 0' north latitude, 84 14' and 85 1' west longitude. It is mapped on twenty U.S.G.S. 7.5 minute topographic quadrangles (centering on the Honey Creek and Barthell SW quadrangles) and the Corbin Army Map Service 1:250,000 scale topographic map. The Big South Fork is formed in the western portion of Scott County, Tennessee, by the confluence of the Clear Fork and New River. It flows in a northerly direction for approximately 77 miles before joining the Cumberland River at Burnside, Kentucky (U. S. Army Corps of Engineers, et al., 1970).

Climate

The climate of the Big South Fork area is controlled by the interaction of air masses entering the area with the topographic variation exhibited by the gorge plateau and mountains topography (USDA, 1941). Precipitation varies between the windward and leeward sides of the mountains from about 48 to 56 inches per year on the plateau to a Cumberland Mountain high of 56 inches eastward to a Great Valley low of 40 inches near Centersville, Green County, Tennessee. The prevailing winds are from the west and north.

Weather data from the basin are sparse. A precipitation record at New River of 31 years (USDA, 1941) indicated a 50.3 inch-per-year average. The winter months, December through March, averaged 4.0 to 5.37 inches; the spring and summer months range from 4.2 to 4.8 inches; and September through October ranged from 2.6 to 3.1 inches of precipitation. The New River station has been discontinued and a station established at Oneida. For the period 1952 to 1960 the average precipitation at the Oneida station was 49.75 inches (Dickson, 1960).

The mean maximum and minimum temperatures in January are 50° and 29° Fahrenheit; in July, these temperatures are about 89° and 65° Fahrenheit within the basin (interpreted from maps, Dickson, 1960). Absolute maximum and minimum temperatures at Burnside, Kentucky, at the mouth of the Big South Fork are 108° F and -22° F, respectively (USDA, 1941). The annual average snowfall is about 10 inches and the number of days with snow cover number about 15 (USDA, 1941). The average freeze-free period on the southeastern plateau in Kentucky is 166 days (Anderson, 1959) while the average freeze-free period on the plateau in Tennessee is about 180 days (Dickson, 1960).

According to Thornthwaite (1948, 1955) the area falls in the $B_{4r}B'_2b'_3$ climate type which is humid with little or no water deficiency and mesothermal with intermediate summer thermal efficiency.

During the 214 day crop season at Crossville, Tennessee, on the Cumberland Plateau about 50 miles south of the basin, droughts of 10, 20, 40, and 60 days have 58, 39, 14, and 4 per cent chance of occurrence, respectively, in soils with a 4 inch soil moisture base (Knetsch and Smallshaw, 1958).

The importance of microclimate in control of temperature was found by Shanks and Norris (1950) in a small valley about 60 miles to the southeast. They found mean north-south facing slope temperatures differing by 3° F in autumn. Franzmeier, et al., (1969) found a 1.5° C soil temperature difference due to aspect in McCreary County, Kentucky, and noted lower slopes more shaded, cooler, and more moist.

The climatic history of this area must be inferred from geologic deposits outside the basin. The long, warm climatic period of the Tertiary has been well documented to the west and south (Berry, 1916). Pleistocene cooling is suggested to the east in Shady Valley Bog from pollen profiles (Barclay, 1957), from the mammal remains at Saltville, Virginia (Ray, et al., 1967), and from patterned ground at high elevation (Clark, 1968). Post-Pleistocene warm and/or dry periods are suggested at Shady Valley (Barclay, 1957).

Geology

The Big South Fork drainage basin is underlain primarily by bedrock of Pennsylvanian age. These strata, representing a column varying from about 3,400 to 4,100 feet thick, are essentially flat-lying, and consist of alternating beds of sandstones, conglomerates, clayey to sandy shales, coals, and minor beds of siltstones (Wilson, et al., 1956). Sandstones and conglomerates comprise one-third to one-fourth of the column (Luther, 1967). Pennsylvanian stratigraphic groups exposed in the basin are the Gizzard, Crab Orchard Mountains, Crooked Fork, and lower Slatestone to the west with gentler topography and Indian Bluff, Graves Gap, Redoak Mountain, Vowell Mountain, Cross Mountain, and upper Slatestone to the east in mountainous

topography; these are roughly separated by a fault which passes northward from near Sunbright to near Winfield, Tennessee (Wilson, et al., 1956). A few miles of the deeply entrenched Big South Fork and larger tributary valleys north of the Clear Fork and New River confluence have exposed a Mississippian bedrock. These are the Pennington Formation (a limestone) and the Newman limestone.

Physiography

The Big South Fork drainage basin occupies parts of the Cumberland Plateau and Cumberland Mountain sections of the Appalachian Plateau Province (Fenneman, 1938). The primarily Pennsylvanian strata noted above have been faulted and eroded in the Cumberland Mountain section into a complex series of mountain ridges extending in many directions, mostly interconnected and occupying one contiguous area sometimes referred to as the Wartburg Basin (Wilson, et al., 1956). Mountain peaks extend to 3,543 feet at the junction of Cross and Vowell Mountains on the Anderson-Campbell County boundary, west of Briceville, Tennessee; slopes drop precipitously to 1,200 to 1,500 feet elevation. Higher ridges are 0.5 to 2.0 miles apart, but in minor draws, the ridges are sometimes as close as 100 feet.

The Cumberland Plateau section here is a submaturely dissected surface of which much area lies at approximately 1,500 to 1,800 feet elevation; major streams have entrenched to elevations of from 700 to 800 feet above mean sea level. Undulating to rolling uplands occupy much of the area, but intensely dissected topography occurs along the Big South Fork and its tributaries.

Dissection resulting in mountain carving and plateau reduction

is of post-Schooley age, having begun in the late Miocene when moving water breached the resistant sandstone caprock. The presence of extensive sandstone beds in both the mountains and plateau resulted in numerous cliffs and, due to continued erosion, cobbles and boulders to 40 feet diameter are strewn down the slopes. Many middle and lower slopes are chiefly comprised of colluvial material. Valley bottoms are covered with gravelly to sandy alluvial deposits. There is little flood plain within the gorges.

Soils

The soils of the study area are derived chiefly from the sandstones and shales comprising the main area or underlying bedrock as well as the limestone and alluvium of the main gorge bottom. Soils of the residual and colluvial slopes are classed as Ultisols and Inceptisols in the Seventh Approximation Classification (Soil Survey Staff, 1967). Soils of the nearly level uplands are Ultisols and those of the alluvial bottoms are Entisols and Inceptisols. The soils of uplands and slopes are on varying slopes (5 to 50 and greater per cent), shallow to bedrock (2 to 4 feet), acid (pH 4.0 to 5.5), and infertile; soils are, in places, both sandy and have a medium to high stone content. Ultisols are chiefly on south-facing and upper north-facing slopes presumably as a result of more rapid weathering; argillic subsurface horizons are diagnostic for these soils (Austin, et al., 1948; Hubbard, et al., 1950; Byrne, et al., 1970). Alluvial soils are young and horizon development is absent to weak.

Sampled areas on the plateau are the Ultisol Hartsell. Hartsells soils are moderately deep, well drained soils developed from

level-bedded, acid sandstone and sandy shale. These soils occur chiefly on slopes of from 2 to 12 per cent steepness. Natural fertility is low, but Hartsells soils have a moderate available moisture capacity. Bedrock is at a depth of about 2 to 4 feet. These soils are generally acid (pH 4.0-5.0) (Hubbard, et al., 1950). On even more level areas, DeKalb and Wellston soils occur (Byrne, Gass, and Losche, 1963).

A recent soil survey of the McCreary-Whitley area, Kentucky, has appeared (Byrne, et al., 1970). Some study samples were located in the Tate-Trappist association. Other associations of the gorge-plateau area are the Tate-Shelocta, Tate Clymer-DeKalb, Clymer DeKalb, Muse-Wellston-Trappist, and the Muse Shelocta. The mountains are referred under the Muse-Shelocta. Flooded bottom soils are those such as Pope and Philo fine sandy loams and limestone foot-slope soils are chiefly Talbott rocky silt loam.

The upland series (above, Tate to Shelocta) occur in the gorge, on the plateau, and in the mountains. They are collectively strongly acid to very strongly acid, shallow (22 inches) to deep (over 47 inches), chiefly sandy loams, stoney in the Tate, varying to silt loams (Shelocta) or silty clay loams (Muse and Trappist). They vary from well to excessively well drained, the Tate Trappist and Shelocta occur on steep side slopes, the DeKalb on ridge tops, and the Clymer, Muse and Wellston on gentler slopes, the last being sometimes derived from loess.

In a recent study of six sites on two slopes in the Plateau of Kentucky and the Cumberland Mountains of Tennessee (the former within, the latter near the present problem area, Franzmeier, et al., (1969)

north slope plateau soils were Shelocta and south slope plateau soils were Shelocta and Trappist (a silt loam). North slope mountain soils were Shelocta and Gilpin, while Shelocta, Berks, and Gilpin occurred on the south slopes. Profiles averaged slightly deeper through the B on the north (114 cm) than south (109 cm) plateau sites and on the north (99 cm) and south (92 cm) mountain sites. Middle slopes were stonier than other slope positions; soils on the south-facing slopes were more clayey than soils of the northern slopes. Available water in these profiles increased from upper to lower slope positions on both aspects with the greatest difference occurring on the northern slopes.

Flora

John Lyon, a nurseryman, made several trips to the "southern mountains" between 1799 and 1814. His itinerary in Tennessee was through the Crab Orchard Mountains to the south of the study area, but he did spend time in the Wartburg Basin (Ewan and Ewan, 1963). His lists of plants offered for sale include species found in the Cumberlands, but these lists fail to state the site of collection.

Augustin Gattinger (1901) notes a distinctive "Cumberland Mountains" flora, but he takes for his example Lookout Mountain, an outlying Cumberland Plateau ridge in southeastern Tennessee. The composition of this flora is not applicable to the Cumberland Mountains or to the Plateau to the north. The greatest difference appears to be the occurrence of loblolly pine on the plateau in Alabama.

Within the limits of the mixed mesophytic forest there have been few floras published. Braun (1937) notes Cumberland Plateau

and Cumberland Mountain flora in which she observes similarities between the taxa of her study area and the taxa present in the Blue Ridge and Coastal Plain Provinces. This similarity bespeaks climatic and physiographic history in common with the first area and the Appalachian flora as a source of flora for the second area. Olson, et al., (1966) enumerated the known vascular plants of Morgan County, Tennessee. Fifty-nine tree taxa were reported among 382 vascular taxa but this number can be considered by no means complete. Caplenor (1965) reported 290 taxa of vascular plants within the gorges of Fall Creek Falls State Park alone.

Rosemary (Conradina verticillata Jennison) (first described from No Business Creek, within the study area) is restricted to four plateau counties in Tennessee (Shanks, 1958), but it also occurs in Kentucky. Shanks also listed seven species with restricted ranges centering about the Cumberland Plateau. These are Ascyrum stans Michx., Cornus stolonifera Michx., Gaylussacia brachycera (Michx.) Gray, Magnolia macrophylla Michx., Pyrus arbutifolia (L.) L.f., Ribes curvatum Small, and Spiraea tomentosa var. rosea (Raf.) Fernald. Sharp, et al., (1960) note 13 dicotyledonous taxa restricted in Tennessee to the Big South Fork area.

Eupatorium luciae-brauniae Fernald is endemic to rockhouses along the entrenched streams of the northern Cumberland plateau (Fernald, 1942). Leucothoe recurva (Buckley) Gray, ranging from Virginia to Alabama in high mountains, has recently been reported for the first time in Tennessee. It was found along Little Clear Creek, Morgan County, Tennessee (Rogers and Bowers, 1969). Calamovilfa arcuata Rogers species novum has been recently described from Daddy's

Creek, a plateau gorge near the study area (Rogers, 1970).

Robinson and Shanks (1959) report 18 species of vascular aquatic plants with ranges in Tennessee restricted to the study area and adjacent mountains. Utricularia subulata L. is one example. Fowells (1965) reports 15 tree taxa whose limits cross the study area. Celtis laevigata Willd. ranging north to the basin, Quercus bicolor Willd. is limited southward here, Populus deltoides var. deltoides Bartr. reaching the eastern edge of its range here, and Tilia heterophylla Vent. reaching its western limit in the study area are examples. The above suggests this area to be one of uncommon speciation and diverse floristic history.

Vegetation

Description of the vegetation of the Cumberland Plateau and the Cumberland Mountains was first attempted by the longhunters as they recounted to those in the coastal colonies the rich forests with cane and interspersed with barrens that they had seen (Haywood, 1823).

Hogue (1955) states that in David Crockett's travel westward, he stopped in Fentress County and spent the year 1817 hunting in the nearby territory. His cabin was reported to have been located in the largest beech forest in the section. The forest is said to have extended for miles up and down the East Fork Valley.

Breazeale (1842) described the Cumberland Mountains thusly:

On the wide spread, lofty and romantic chain of the Cumberland Mountains, are found fertile valleys, broad prairies, extensive glades, and, on many of the loftiest ridges, large bodies of fine arable land, producing, with reasonable cultivation, from thirty to fifty bushels of Indian corn per acre. The greater portion of

the soil, however, is sandy, sterile, and unproductive; except for timber. Dense groves of large and towering pines, poplar, chestnut, hickory, and oak, cover the ridges and highlands; and along the margin of the rivers and large creeks, beech, maple, and sugar-tree are sometimes found; and in many places, groves of buckeye, linn, and birch; but the principal growth along the margin of the streams, is tall white and spruce pine, with dense laurel thickets, and sometimes a narrow cane-brake, as an undergrowth.

Killebrew and Safford (1874) reported that large forests of chestnut grew " . . . on the sandstone soils of the Cumberland Table Land." They also observed that:

On the Cumberland Table Land, a few miles from Wertburg, in the eastern part of Morgan County, is a grove of walnut timber that cannot be surpassed on the continent. In this locality trees 6 feet in diameter rise in princely grandeur to a height of more than one hundred feet. . . .

Quantities of black locust (Robinia pseudoacacia), yellow or shortleaf pine (Pinus echinata), white pine (Pinus strobus), and tulip poplar (Liriodendron tulipifera) were named by them as occurring on the plateau.

The study area is part of the Mixed Mesophytic Forest Region (Braun, 1950). Braun describes the vegetation of this region as predominantly Mixed Mesophytic Forest. The center of best development of this forest was in the Pine Mountain overthrust block (terminology of Wilson and Stearns, 1958). The area is characterized by the prevalence of many deciduous taxa, the number of which make it the most complex and perhaps the oldest association of the eastern Deciduous Forest Formation (Braun, 1942, 1950). It was the center of distribution of all other deciduous forest climaxes (Braun, 1950) and its age dates to the Mixed Tertiary forests that were present in the late Miocene period (Braun, 1947). The uplift of the Schooley Peneplain and the subsequent Harrisburg cycle of erosion greatly

dissected the Appalachian Plateau (Braun, 1947). This precipitated the increased importance of the oak-chestnut community (chestnut now virtually extinct) in those areas of the Southern Appalachians which have remained dissected.

Braun (1942) stated that the area to the west and southwest of the Cumberland Mountains (called the Wartburg Basin, Wilson, et al., 1956) was similar enough both vegetationally and topographically to be included in them. This area of rugged terrain, the dissected peneplain, exhibits site differences resulting from micro and macroclimatic precipitation and temperature differences affecting soil moisture; all modified by aspect, elevation, slope position, and protection. Within this wide range of environments the Mixed Mesophytic forest has produced mesic, stable communities - the association-segregates (Braun, 1935). The association-segregate is a term used to describe the segregated faciations within the range of the Mixed Mesophytic forest. The sugar maple-basswood-buckeye and the white oak-beech segregates are two of the most common within the Cumberland Mountains.

On drier sites, Braun (1942), found other communities such as oak-pine, the oak-chestnut, and the mixed oak forests. These, too, have their origin in the Mixed Tertiary forests as does the Mixed Mesophytic forest.

With increased distance from the Cumberland Mountains the mixed mesophytic forest is progressively more restricted to valleys, coves, and north-facing, or other protected slopes. Within the central portion of the Cumberland Plateau, Caplenor (1965), found mixed mesophytic forest communities within the gorges of Fall Creek

Falls State Park. He described undifferentiated mixed mesophytic, hemlock, hemlock-basswood, hemlock-yellow birch, oak-hickory, and chestnut oak communities. The mixed mesophytic communities occurred on the median sites with respect to protection and moisture availability. Whittaker (1956) states that there is great similarity between the cove hardwood vegetation of the Great Smoky Mountains and the mixed mesophytic forests of the Cumberland Plateau. However, the greater area occupied by the mixed mesophytic in the Cumberlands is the result of greater differentiation of community segregates. In the Smoky Mountain cove forests the beech-dominated communities do not occur as they do in mixed mesophytic forests to the west. Lastly, cove forests in the Great Smoky Mountains are more mesic in composition with segregate mesics comprising more than 90 per cent of the stand (Whittaker, 1956).

Cabrera (1969) described four segregates in the southern Cumberland Mountains. Of the segregates delineated, three appear as definitely mixed mesophytic. He considered these segregates as segments of a vegetational continuum. Martin (1966) reported a tulip tree segregate in the southern Cumberlands which was a remnant of the Mixed Mesophytic forest. Within the Cumberland Mountains and Plateau, forest segregates have been distinguished by available moisture as inferred from site characteristics (Martin, 1966; Cabrera, 1969).

Because of extensive cliff systems associated with the Plateau Braun (1950) placed this area in the "Cliff Section" of the Mixed Mesophytic Forest Region. South of Berea, Kentucky, this section lies along the western margin of the plateau; in Tennessee, however,

it is applied to the entire plateau. The western escarpment, the plateau and its entrenched streams are included in this area. The study area lies in the middle, or most representative part of the section. Braun (1950) found plateau forests to be white oak, chestnut, and chestnut oak dominated, with red oak, black oak, tulip poplar, sour gum, cucumber tree, and shortleaf pine as associate taxa. The Cliff Section displays two unlike forms of mixed mesophytic forest. These are the all-deciduous mixed mesophytic and the hemlock-mixed mesophytic. Association-segregates within these phases is not well defined except on south-facing slopes (Braun, 1950).

Human History

Little is known of prehistoric human inhabitants of the Big South Fork basin. Adjacent areas are known to have been traversed by Paleo-Indians as early as nine or ten millenia ago (Kneberg, 1952). These first human beings were probably Folsom hunters stalking mastodon or other game animals. There were no humans in the Western Hemisphere prior to the last period of glaciation, the Wisconsinan, which ended about 10,000 years ago (Lewis and Kneberg, 1958).

A later culture, the Archaic, is well documented in similar topography at Russell Cave in northern Alabama by 9,000 B.P. (Lewis and Kneberg, 1958). Archaic and Woodland Indian evidence is abundant in the Ridge and Valley Province a few miles to the east of the basin, on the Highland Rim, and in the Central Basin of Tennessee to the west. Their graves and village sites have been documented (Lewis and Kneberg, 1958). Population levels are unknown and their effect upon vegetation near to their villages and far (as is the

basin) is not known. Prior to European exploration, there were about 80 villages of Cherokee in a large area southeast of the basin. The nearest villages were along the Little Tennessee River 55 miles distant. There were populations of Yuchi and Kaskinampo Indians in East Tennessee and on the Cumberland Plateau before the end of the 17th Century. Shawnee lived on the Cumberland River until 1714 when the last bands migrated to South Carolina (Williams, 1937; Swanton, 1946; Swanton, 1922). These tribes were doubtless familiar with the basin. Modern tribes controlling the area at the time of European exploration were Cherokee and possibly Creeks (Lewis and Kneberg, 1958). Evidence of physical occupation of lands within the basin by Archaic, Woodland, and modern Indians is limited to the numerous rock shelters.

Many shelters occurred along the trails crossing the basin. Meyer (1928) described three major trails. The Tennessee River, Ohio, and Great Lakes Trail led northward from southern Tennessee. This trail forked near Wartburg and rejoined just north of New River, Tennessee. The East and West Trail passed from Anderson County, Tennessee, through the basin to the northwest where it left the basin near the site of Jamestown, Tennessee. Three miles east of Jamestown the Chickamauga Trail left the East and West Trail. This path ended near the mouth of Wolf River.

Trail shelters have been found along White Oak Creek, about 7 miles east of Jamestown (Hogue, 1933). These shelters, and others marked as occurring along the gorges of Poplar Cove, Yellow, and Mill creeks where the bluffs and rockhouses formed a series of natural covertures, appear on the map of Indian Trails by Meyer (1928).

Haywood (1843) relates the discovery of furnaces along the Big South Fork in which were found buttons of European origin. He credits construction of these works to the earliest French settlers prior to 1758. Williams (1937), however, raises the possibility that the furnaces predate the French settlers by almost 600 years. He tells of the Cherokee tradition of white people in the area before their occupation of East Tennessee. According to recitals of Welsh bards, Prince Madoc ap Owen Gwyneth and his followers sailed from Wales, discovered, and settled in a new land in and about 1170 A.D. Smelted copper found in southeastern Tennessee has been said to predate the Cherokees (Williams, 1937; Arnow, 1965).

The first recorded explorer in the area was a Canadian named Martin Chartier. He was familiar with the trails in the area by at least 1692. In that year, Chartier and a band of Shawnee Indians left French Lick on the Cumberland River and traveled by water passage to a point below the Falls of the Cumberland (Williams, 1937). Modern settlement of the Big South Fork area began in the years just preceding the Revolutionary War. Judge John Haywood (1843) states that on the second of June in 1769 a company of men from North Carolina, Virginia, and from New River (5 miles from English Ferry) " . . . left for a hunting party into what is now West Tennessee." They crossed the Cumberland Gap to the Cumberland River which they followed southward to the South Fork. They turned down it and came to a barren which was later called Price's Meadow. Still later it was known as Price's Station, a few miles south of the mouth of the Big South Fork in Wayne County, Kentucky.

The outbreak of the Revolutionary War halted westward expansion because of British-inspired Indian attacks. In 1777, only three stations held against the Indian raise--one of these was Price's Station. Settlement began once again in the years following the Revolution as some of the treeless land on the South Fork was offered to war veterans as bounty. This land was later reclaimed by North Carolina and Virginia (Arnow, 1965).

Treaties with Indian tribes opened the land to colonization. The Treaty of Hopewell in 1785 conveyed all lands draining into the Cumberland River from the south to the United States. The Butler and Walton Treaty at Tellico, of October 7, 1798, made the Emory River the northern boundary of Cherokee lands, thereby excluding them from the Big South Fork and other northern lands (Garrett and Goodpasture, 1903). The settlers which followed cleared the forest and tilled both tributary bottomlands and much rolling upland, as well as settling in the fertile coves and benches on or near the main river.

The early 1800's witnessed the increased settlement and growth of agrarian communities. Those counties within the basin were established in the first half of the 19th Century (Foster, 1923). Major industries within the basin were the tilling of the soil, the cutting of trees for export, and the distilling of spirits. Men living on the tributaries of the Big South Fork built flatboats with which they shipped their goods downriver to Nashville. Although the river has many areas of shoals, rapids, and shallows, at flood tide it is navigable for its entire length through Tennessee. Prior to 1879, when the first railroad was built into the area, all trade was by river (Arnow, 1968; Williams, 1937).

With increased lumbering, mining, and some industrialization, most of those persons who once tilled the flatter lands in the gorges abandoned their land. The population of Scott County, Tennessee, increased from about 9,700 persons in 1908 to a maximum of about 17,300 in 1950. Population of that county decreased in the following decade to about 15,400. The 1970 preliminary census count showed another decrease to about 14,300 persons. The same 80 year period witnessed an increase in Morgan County population to a maximum of 15,727 in 1950. The population declined to 12,292 in 1970. Fentress County has shown a peak of about 14,900 in the 1950 census, but has decreased to 11,919 in the last census (U.S. Dept. of Commerce, 1900, 1930, 1951, 1961; Stillwell, 1970).

The primary industries within the basin today are lumber, strip mining for coal, and agriculture. The depletion of coal within the area as well as a decrease in cutting of merchantable timber has contributed, no doubt, to the population decline in Fentress, Scott, and Morgan counties. There is some fledgling tourist-related enterprise within the area, but for the most part the people live close to the land.

IV. METHODS

The large size of the basin made it necessary to limit the field work to that portion of the watershed upstream (south of) the Devils Jumps rapids (river mile 47.9) near Stearns, Kentucky. The area chosen for study was included in the upland Cumberland Plateau, dissected Plateau, and Cumberland Mountains - the latter comprising approximately 20 per cent of the area. The watershed was scouted by automobile to find suitable sampling sites; persons living in the area were interviewed to locate stands with long periods of growth. Within the study area sampling areas were chosen using certain criteria:

1. Sampling areas had to be accessible by road and walking on a one-day basis.
2. Vegetation containing large trees was sampled as these were most likely to be stable and representative of the usual vegetation pattern. These stands were, therefore, subject to verification in the future, and subject to comparison with previous descriptions.
3. Plots were distributed throughout many elevations and aspects in an attempt to observe and quantify those differences in vegetation which result from the action of environmental factors correlated to these intrinsic site properties.
4. Areas close to roads, recent strip mines, or other disturbances were avoided.

Each sample area of subjectively determined, homogeneous

vegetation was sampled using two to several plots, each consisting of two concentric circular areas of 1/10-acre and 1/100-acre. The center of the plot was marked with a strip of red plastic flagging. The plot boundaries were determined after first ascertaining the per cent slope using an Abney level; and using the procedure described by Bryan (1956), the plot radii were established. This procedure adjusts plot dimensions to the slope percentage to bring the plot areas into equality with map area. Field data were recorded on previously prepared forms and recorded separately by plot.

On each 1/10-acre plot, trees 5 inches dbh and over were tallied by taxon in 2-inch diameter classes. Saplings, 1.0 to 4.9 inches in diameter were counted by taxon. A diameter tape was used to check most diameters. Canopy cover, to the nearest 5 per cent, was estimated, and average height of the canopy top was found by means of an Edscorp field range finder.

Shrubs, woody vines, tree seedlings, and herbs were sampled within the 1/100-acre plot by species, and per cent cover was estimated to the nearest 5 per cent. All taxonomic determinations were made in the field except in cases of doubt when voucher specimens were taken for confirmation with specimens in The University of Tennessee Herbarium where the vouchers were deposited. Field determinations of tree species were made using botanical keys by Shanks and Sharp (1950) and by Radford, et al., (1964). Nomenclature follows that in Manual of Vascular Plants (Gleason and Cronquist, 1963).

Plot aspect was found by use of a Silva forester's compass and recorded to the nearest degree. Slope per cent to the nearest per cent was found using an Abney level. Lateral and vertical plot

form was determined by observation and classed as concave, convex, or flat. The overall position of the plot was recorded as ridge, draw, or flat and the plot position marked on the appropriate topographic map.

One or more soil pits were dug to 2 feet in depth within each plot. In each pit the type of humus was estimated (mull, intermediate, or mor), the thickness of humus estimated to the nearest 1/10 inch, and the stone volume within the soil was estimated to the nearest 10 per cent. Texture of the A horizon was estimated by the "feel" method as described in the Soil Survey Manual (1951). A sample of the B horizon was taken for textural estimation in the laboratory. Approximate depth of the solum was found by inserting a steel rod into the soil at various points within the plot to a maximum depth of 48 inches. Depths were recorded to the nearest 1/10 inch. Litter cover within the plot was estimated to the nearest 10 per cent.

Topographic maps provided much information concerning the plots. Elevation was read from the map in the field and recorded to the nearest 20 feet. The shape dimensions (width and height or depth) of the physiographic feature upon which the plot was located were found (width to the nearest 25 feet by architect's rule). Map ridge height/width or draw depth/width ratios were calculated and recorded to the nearest 0.01 and considered internal protection. External protection was calculated as distance from the plot along a line perpendicular to the opposite ridge; this was recorded to the nearest 25 feet. The protection angle to the crest of the opposite

ridge was recorded as the tangent of that angle. The tangent angle a was found using the formula:

$$\tan a = \frac{\text{elevation of ridge crest} - \text{elevation of plot}}{\text{distance from plot to ridge plane}}$$

Distance of the plot from the bottom of the nearest downslope draw was recorded to the nearest 20 feet.

All data were transferred to punchcard layout sheets for card punching. Plant taxa were coded by sequential number and size (dbh, 2-inch size class, cover per cent to the nearest 10 per cent). Fire data were coded as follows: 1, recent; 2, evidence of fire greater than 10 years old; and 3, no evidence of fire. Bole and branch blowdown was coded either 1 or 2, for either none or present. Cutting of trees was recorded as: 1, 1950 to present; 2, evidence of cutting between 1930 and 1950; and 3, evidence from 1900 to 1930. Site variables were treated as follows: plot azimuth was converted according to the method described by Beers, et al., (1966) used to equate aspects with similar environmental effects; the converted value was recorded to the nearest 0.01. Slope angle and position of the plot (feet from the bottom) were recorded as taken. Texture of the B horizon was found by the "feel" method using textural constants provided by Dr. M. E. Springer of The University of Tennessee Agronomy Department. Using a modified method of Longwell, Parks and Springer (1963) available water (inches per solum) was calculated using textural constants as modified by stone percentage and solum depth. Textural constants are listed in Appendix A. Map ridge height/width and draw depth/width were calculated and recorded to the nearest 0.01.

Linear correlation among all variables was performed on the IBM 360 computer using the UCLA correlation with item deletion program BMD03D. Multiple stepwise regression, assuming linearity of factor correlation, was also performed using the UCLA stepwise regression program BMD02R modified for item deletion.

Two hundred and seventy seven sample plots in 26 sampling areas were obtained in the study. These constitute about 1 per cent of the forest area within the study limits with an average of 26.15 overstory stems per 1/10-acre plot. This figure compares with an average density of 10.13 trees per tenth acre in the surrounding counties (T.V.A., 1957; 1960; 1966; 1967). The disproportionately large number of stems per acre can be attributed to infertile soils, slow growth, and young stands.

V. RESULTS AND DISCUSSION

Vegetation Types

The occurrence of Cumberland Mountains, Cumberland Plateau surface, and dissected Plateau South Fork gorge topography within the sample area led to stratification of sampling effort approximately in proportion to my interest in each of these areas. Forty-eight samples in 4 areas in the mountains, 72 samples in 6 areas on the plateau surface, and 157 samples in 16 areas in the gorge were obtained. The landscape characters of aspect (north, east, south, west), slope position (upper, middle, lower), and slope form (ridge, flat, draw) were used to characterize sample locations. Mountain samples were grouped according to aspect, slope position and slope form. Plateau surface samples were grouped by aspect and later by composition. Gorge samples were separated on the basis of slope position and form as well as aspect and streamside position. Samples were later regrouped (using importance value) into vegetation types using the leading dominant and other important taxa, as well as the coefficient of community, as basis for the decision to separate or pool groups of samples. Two hundred and seventy-two out of the 277 sample plots are considered here; anomalous plots are not included. See Table I for a schematic breakdown of the forest communities according to aspect, topography, and position.

Scientific nomenclature is used whenever a taxon first enters the discussion; thereafter, it is referred to by its common name.

Median values of community characteristics have been calculated. In the tables below, numbers larger than the median

TABLE I
FOREST COMMUNITIES OF THE STUDY AREA ARRANGED BY ASPECT,
TOPOGRAPHY, AND POSITION

Position	Aspects	
	North-Facing	South-Facing
Mountains		
Ridge	WO-Be ^a	CO-NRO
Draw	CO-WO-Be, or Be-WD-SM	WO-Hem-CO
Plateau		
Slopes	WO	VP-WO, or VP-WO-BJO
Gorge		
Terraces		
Lower	RB	
Upper	TP-SG	
Calcareous foot slopes		
Lower	Ced	
Upper	WD-CHO	
Main slopes		
Lower	TP-Hem	WO-Be
Middle, draw	WO-VP	WO-Hem-CO
ridge, thin	NRO-CO-WO	WO-CO
ridge, deep	WO-VP	WO-CO
Upper, ridge	as Middle	VP-WP
draw	Slp-WO	WO-Hem-CO
Crest	VP-NO	VP-WO

^aWO, White Oak; Be, American Beach; CO, Chestnut Oak; NRO, Northern Red Oak; Hem, Eastern Hemlock; SM, Sugar Maple; VP, Virginia Pine; BJO, Blackjack Oak; RB, River Birch; TP, Tulip Poplar; SG, Sweet Gum; Ced, Cedar; CHO, Chinquapin Oak; Slp, Short-leaf Pine; WP, White Pine.

are often referred to as "high" while those less than the median are called "low." The medians are: understory density 45; density of dominant (taxa in the type name) in the understory 6; overstory density 22; plot basal area 13 square feet; solum depth 20 inches; stone volume 22 per cent; slope angle 30 per cent.

Gorge Vegetation - Associated Soil and Site Characteristics

River birch type. This forest community occupies the lowest elevations of any type, in the band between the main river and approximately 870 feet elevation. It occurs in the gorge bottom along the main stream on alluvium (Tables II, III). Betula nigra (river birch) is the leading dominant and Platanus occidentalis (sycamore), Liriodendron tulipifera (tulip poplar), and Carpinus caroliniana (American hornbeam) are associates. Twenty-nine taxa are represented in this type including the swamp forest taxa Liquidambar styraciflua (sweetgum) and Populus deltoides (cottonwood) and such mesophytes as Fagus grandifolia (beech).

The important taxa are reproducing well, but five subordinate ones are not reproducing - most of these are intolerant. Seven taxa have not yet entered the overstory, but of these, three are small trees. The substrate here is relatively deep with a thick A and a low slope angle; the substrate is sandy and relatively stony. These factors along with proximity to the water table probably result in a continually moist soil.

This type is described by Braun (1950) as the most common flood-plain vegetation type of the southern portion of the Mixed Mesophytic Forest Region. The Society of American Foresters (1964) recognizes this forest type (number 61) and notes that it ranges from

TABLE II
COMPOSITION OF THE RIVER BIRCH FOREST TYPE. N=9.

Taxa	Understory ^a Absolute Density	Overstory ^b		
		Fre- quency	IV Mean	IV Range
<i>Betula nigra</i>	23.90	78	62.54	0.00 - 131.50
<i>Platanus occidentalis</i>	7.10	100	45.18	33.90 - 68.50
<i>Liriodendron tulipifera</i>	7.40	67	19.03	0.00 - 42.83
<i>Carpinus caroliniana</i>	29.39	56	13.03	0.00 - 58.52
<i>Liquidambar styraciflua</i>	4.20	44	9.78	0.00 - 43.40
<i>Fraxinus americana</i>	0.90	22	8.34	0.00 - 23.88
<i>Acer saccharum</i>	1.79	33	7.10	0.00 - 39.85
<i>Acer rubrum</i>	4.90	33	6.70	0.00 - 20.82
<i>Quercus alba</i>	1.00	44	5.89	0.00 - 27.51
<i>Amelanchier arboreum</i>	0.90	22	4.74	0.00 - 22.34
<i>Pinus virginiana</i>	0.54	22	4.49	0.00 - 35.89
<i>Fagus grandifolia</i>	1.93	33	3.81	0.00 - 14.32
<i>Populus deltoides</i>	0.00	11	3.25	0.00 - 29.30
<i>Cornus florida</i>	5.12	44	3.04	0.00 - 13.31
<i>Magnolia acuminata</i>	0.33	22	3.01	0.00 - 21.91
<i>Tsuga canadensis</i>	1.84	22	1.76	0.00 - 12.32
<i>Juglans nigra</i>	0.00	11	1.65	0.00 - 14.90
<i>Carya glabra</i>	0.50	22	1.62	0.00 - 7.93
<i>Robinia pseudoacacia</i>	0.00	11	1.33	0.00 - 11.99
<i>Pinus echinata</i>	0.00	11	1.11	0.00 - 10.01
<i>Betula lenta</i>	0.00	11	0.88	0.00 - 7.93
<i>Asimina triloba</i>	2.88	11	0.61	0.00 - 5.53
<i>Juniperus virginiana</i>	0.30	0	0.00	0.00
<i>Cercis canadensis</i>	0.45	0	0.00	0.00
<i>Prunus serotina</i>	0.34	0	0.00	0.00
<i>Tilia heterophylla</i>	0.69	0	0.00	0.00
<i>Ulmus alata</i>	0.34	0	0.00	0.00
<i>Diospyros virginiana</i>	0.66	0	0.00	0.00
<i>Ilex opaca</i>	0.22	0	0.00	0.00

^aAverage stems/sample for understory = 84.9.

^bAverage stems/sample for overstory = 14.2.

TABLE III

SOIL-SITE CHARACTERISTICS OF THE RIVER BIRCH
FOREST TYPE. N=9.

Character	Range	Median	Mean + S.D.
Solum thickness (inches)	16.0 - 60.0	40.0	36.64 $\pm$ 5.14
Thickness of A (inches)	4.0 - 14.0	6.0	7.87 $\pm$ 3.50
Stone (per cent volume)	0.0 - 70.0	40.0	30.50 $\pm$ 22.97
Texture A	7.0 - 23.0 ^a	16.0 ^b	13.60 $\pm$ 5.70
Texture B	8.0 - 21.0 ^a	16.0 ^b	16.20 $\pm$ 4.60
Aspect	0.0	0.0	0.0
Slope (per cent)	7.0 - 35.0	15.0	14.60 $\pm$ 10.20
Feet from river ^c	0.0 - 50.0	40.0	26.60 $\pm$ 23.40

^aSandy loam to silty clay loam.

^bSandy loam.

^cLinear distance.

southern New England to Tennessee, and west to Oklahoma. These types will hereinafter be referred to as SAF Type OO.

In this type river birch saplings number about 24 per plot--a number apparently sufficient to maintain the community. Permanence is also suggested by the absence of fire and blowdown evidence. A mean basal area of 150ft² per acre and tree size to 24 inches dbh reflect adequate soil moisture. Classes 1 and 2 cutting evidence, however, result in great instability as does annual flooding which removes litter, propagules, and may uproot trees.

Tulip poplar-sweetgum type. Upslope from the River Birch Type, and occupying the first terrace positions above the river, the forest is dominated by tulip poplar. In the positions of co-dominant and (or) associate are sweetgum and Juglans nigra (black walnut). Quercus muhlenbergii (chinquapin oak), sycamore, and Amelanchier arboreum (serviceberry) are of secondary importance within this type. Of lesser importance in the overstory are Cercis canadensis (redbud), beech, Juglans cinerea (butternut), and Carya ovata (shagbark hickory) (Tables IV and V). Nineteen tree taxa occur--these primarily mesophytes--all overstory taxa occur in the understory and five additional taxa have entered the community but are not yet 5 inches dbh. The occurrence of Tilia heterophylla and Fraxinus americana here is of interest.

This community was sampled between elevations 820 and 960, but mostly lies at elevations where it received annual flooding. Soil stoniness and shallowness and lack of horizon development, sandy texture and considerable slope angles suggest that this is much less of a hydric site than that of the river birch forest. Reproduction of dominants, basal area averaging 9.66 ft² per plot, and a 17 inch dbh ~~maximum~~ tree size (tulip poplar) with little or no evidence of

TABLE IV
COMPOSITION OF THE TULIP POPLAR-SWEETGUM
FOREST TYPE. N=7.

Taxa	Overstory			
	Understory	Fre-	quency	IV Mean IV Range
	Absolute Density			
<i>Liriodendron tulipifera</i>	16.42	86	55.38	0.00- 84.68
<i>Liquidambar styraciflua</i>	3.00	100	48.46	28.13- 74.38
<i>Juglans nigra</i>	1.14	72	31.09	0.00- 34.73
<i>Platanus occidentalis</i>	2.14	72	17.58	0.00- 22.43
<i>Betula nigra</i>	2.14	86	16.68	0.00- 22.43
<i>Amelanchier arboreum</i>	0.28	43	10.18	0.00- 37.30
<i>Cercis canadensis</i>	2.57	43	5.09	0.00- 12.40
<i>Fagus grandifolia</i>	1.42	14	4.66	0.00-32. 62
<i>Juglans cinerea</i>	0.14	28	4.65	0.00- 22.33
<i>Quercus alba</i>	1.14	28	2.79	0.00- 11.22
<i>Carya ovata</i>	2.42	28	2.86	0.00- 10.23
<i>Cornus florida</i>	7.42	28	2.18	0.00- 11.22
<i>Carpinus caroliniana</i>	14.85	28	1.77	0.00- 13.25
<i>Juniperus virginiana</i>	1.57	14	1.32	0.00- 9.27
<i>Fraxinus americana</i>	1.71	0	0.00	0.00
<i>Tilia heterophylla</i>	0.28	0	0.00	0.00
<i>Ulmus alata</i>	1.71	0	0.00	0.00
<i>Ulmus americana</i>	1.71	0	0.00	0.00
<i>Ulmus rubra</i>	0.57	0	0.00	0.00

^aAverage stems/sample for understory = 55.57.

^bAverage stems/sample for overstory = 26.47.

TABLE V
SOIL-SITE CHARACTERISTICS OF THE TULIP POPLAR-SWEETGUM
FOREST TYPE. N=7.

Character	Range	Median	Mean $\pm$ S.D.
Solum thickness (inches)	4.00 - 10.0	7.00	6.85 $\pm$ 2.20
Thickness of A (inches)	3.50 - 9.7	7.00	6.20 $\pm$ 2.70
Stone (per cent volume)	10.00 - 70.0	20.00	25.70 $\pm$ 19.88
Texture A	17.00 - 23.0 ^a	23.00	21.28 $\pm$ 2.30 ^b
Texture B	18.00 - 21.0 ^a	21.00	20.10 $\pm$ 1.10 ^b
Aspect	0.01 - 1.50	0.03	0.43 $\pm$.70 ^c
Slope (per cent)	10.00 - 24.00	21.00	18.85 $\pm$ 5.60
Feet from river	10.00 - 150.00	150.00	112.85 $\pm$ 63.69

^aFine sandy loam - silt loam.

^bSilty clay loam - silt loam.

^cSouth to west.

fire, blowdown, or cutting suggest relative permanency. The low canopy height (averaging 45.7 feet) and thin litter (averaging 0.63 inches), and an overstory density averaging 26.47 stems per plot suggest youth. Periodic flooding and subsequent removal of litter and older trees could account for the great plot density.

This type is similar to SAF cover type 57. This forest is secondary and contains many of the taxa contained in the swamp forests of the Cumberland Plateau as described by Braun (1950, p. 100) and resembles, somewhat, one noted after cultivation in Fall Creek Falls Gorge by Caplenor (1965).

Redcedar type. This system is found within a narrow elevation band (870 to 1,000 feet) where the entrenched river has exposed Mississippian strata (from about South Fork mile 71 northward). This forest occurs on lower slopes upslope from the tulip poplar-sweetgum type, on the lowest benches of the gorge slopes. Juniperus virginiana (eastern redcedar) is the leading dominant. Associated with redcedar are black walnut, shagbark hickory, and chinquapin oak. River birch and redbud occur within this type throughout its range, with redbud extending farther upslope than river birch (Tables VI and VII). Twenty-two tree taxa occur but only half contribute to the canopy. Of these, most except redcedar and Pinus virginiana (Virginia pine) are mesophytes (the pine not in the canopy).

Redcedar vegetation is common in the southeastern United States. These stands are dissimilar to those on thin limestone soils noted by Quarterman (1950) and Finn (1968) and only grossly approximate the description of SAF type 48: Eastern Redcedar-Hardwood.

TABLE VI
COMPOSITION OF THE REDCEDAR FOREST TYPE. N=6.

Taxa	Understory ^a Absolute Density	Overstory ^b		
		Fre- quency	IV Mean	IV Range
<i>Juniperus virginiana</i>	12.17	100	69.88	44.30 - 95.02
<i>Juglans nigra</i>	3.67	83	42.12	0.00 - 75.62
<i>Carya ovata</i>	3.83	66	25.71	0.00 - 51.97
<i>Quercus muhlenbergii</i>	2.17	83	17.31	0.00 - 30.88
<i>Betula nigra</i>	0.33	17	12.39	0.00 - 34.32
<i>Cercis canadensis</i>	10.33	66	3.96	0.00 - 21.35
<i>Carpinus caroliniana</i>	7.17	50	8.06	0.00 - 21.22
<i>Liriodendron tulipifera</i>	1.50	17	5.24	0.00 - 31.42
<i>Pinus strobus</i>	1.83	33	4.80	0.00 - 14.84
<i>Platanus occidentalis</i>	1.67	33	2.10	0.00 - 6.51
<i>Carya tomentosa</i>	1.71	33	2.10	0.00 - 6.51
<i>Acer saccharum</i>	2.83	0	0.00	0.00
<i>Aesculus octandra</i>	0.83	0	0.00	0.00
<i>Fagus grandifolia</i>	1.83	0	0.00	0.00
<i>Quercus alba</i>	0.17	0	0.00	0.00
<i>Carya</i> spp.	0.33	0	0.00	0.00
<i>Cornus florida</i>	1.67	0	0.00	0.00
<i>Diospyros virginiana</i>	0.66	0	0.00	0.00
<i>Amelanchier arboreum</i>	0.33	0	0.00	0.00
<i>Liquidambar styraciflua</i>	0.17	0	0.00	0.00
<i>Pinus virginiana</i>	0.83	0	0.00	0.00
<i>Prunus serotina</i>	4.67	0	0.00	0.00

^aAverage stems/sample for understory = 56.67.

^bAverage stems/sample for overstory = 21.50.

TABLE VII
SOIL-SITE CHARACTERISTICS OF THE RED CEDAR
FOREST TYPE. N=6.

Character	Range	Median	Mean + S.D.
Solum thickness (inches)	6.50 - 8.00	6.00	6.25 $\pm$ 0.88
Thickness of A (inches)	5.00 - 7.00	5.75	5.83 $\pm$ 0.93
Stone (per cent volume)	10.00 - 70.00	60.00	55.00 $\pm$ 22.60
Texture A	12.00 - 23.00 ^a	23.00	20.67 $\pm$ 4.40 ^b
Texture B	17.00 - 20.00 ^a	20.00	19.16 $\pm$ 1.30 ^b
Aspect	0.08 - 1.71	0.20	0.43 $\pm$ 0.63 ^c
Slope (per cent)	17.00 - 33.00	29.00	27.67 $\pm$ 5.50
Feet from draw	0.00 - 350.00	250.00	225.00 $\pm$ 125.50

^aSandy loam to silt loam.

^bLoam to silty clay loam.

^cSouthwest.

The shallow solum, thin A, high stone percentage and slope angle suggest the aridity of the site; on the other hand, the aspect and slope position would operate here supplying more soil water. It is not known whether underground drainage (increasing aridity) or seepage (supplying soil water) occurs. Soil textures are silty and sandy clay loams; these textures reflect a high available water capacity.

The literature on permanent cedar vegetation is sparse and the juxtaposition of this type with the next community suggests that this one is successional. Mean basal area of 7.80ft^2 per plot, maximum tree dbh (a 20 inch redcedar), low tree height (38.3 feet), and an average overstory density of approximately 17 stems per plot also suggest a youthful stand of probable successional status. The geographic connection of this limestone substrate to areas in Kentucky where red cedar is a common successional taxon lends credence to the above.

White oak-chinquapin oak type. This forest type occurs on the lower slopes within the gorge in a narrow band between the redcedar type below it and the ridge-draw types on the slopes above (Tables VIII and IX). White oak is the leading dominant and chinquapin oak is of second importance. Associated taxa are tulip poplar, beech, sugar maple, and dogwood. Redbud, dogwood, and hornbeam are the most abundant understory taxa, however. Thirty-five tree taxa occur and almost all are mesophytes--certainly the top eight are so classed. Seven taxa do not reach canopy size.

This is one of the variants of the white oak forests which

TABLE VIII

COMPOSITION OF THE WHITE OAK-CHINQUAPIN OAK
FOREST TYPE. N=12.

Taxa	Understory ^a Absolute Density	Fre- quency	Overstory ^b	
			IV Mean	IV Range
<i>Quercus alba</i>	2.33	92	77.80 (37.9) ^c	0.0 - 143.43
<i>Quercus muhlenbergii</i>	0.75	92	27.75 (13.7)	0.0 - 105.66
<i>Liriodendron tulipifera</i>	3.92	50	15.90	0.0 - 106.26
<i>Fagus grandifolia</i>	2.67	25	14.76 (0.4)	0.0 - 105.44
<i>Acer saccharum</i>	11.25	50	8.23 (3.8)	0.0 - 45.07
<i>Cornus florida</i>	6.08	33	3.76	0.0 - 15.46
<i>Ulmus americana</i>	0.92	66	6.86 (1.0)	0.0 - 37.56
<i>Cercis canadensis</i>	3.00	50	6.40	0.0 - 43.99
<i>Platanus occidentalis</i>	0.17	33	5.70	0.0 - 39.43
<i>Juglans nigra</i>	0.00	25	4.70 (3.8)	0.0 - 20.50
<i>Carya tomentosa</i>	1.25	33	4.21	0.0 - 10.62
<i>Prunus serotina</i>	0.00	17	4.14	0.0 - 27.41
<i>Tsuga canadensis</i>	0.92	17	3.83	0.0 - 27.41
<i>Carpinus caroliniana</i>	10.30	33	3.66	0.0 - 16.23
<i>Carya ovata</i>	1.42	42	3.30 (8.1)	0.0 - 11.97
<i>Fraxinus americana</i>	0.92	17	3.22 (8.1)	0.0 - 23.03
<i>Carya cordiformis</i>	0.33	33	2.53	0.0 - 10.72
<i>Carya glabra</i>	2.17	17	2.14 (2.4)	0.0 - 10.72
<i>Tilia heterophylla</i>	0.50	17	1.67	0.0 - 13.33
<i>Quercus rubra</i>	0.42	8	1.67	0.0 - 19.71
<i>Quercus velutina</i>	0.25	17	1.49	0.0 - 10.72
<i>Juglans cinerea</i>	0.17	17	0.96	0.0 - 5.99
<i>Ilex opaca</i>	0.50	8	0.95	0.0 - 11.42
<i>Diospyros virginiana</i>	0.50	8	0.95	0.0 - 11.42
<i>Asimina triloba</i>	2.08	8	0.73	0.0 - 8.76
<i>Liquidambar styraciflua</i>	0.67	8	0.66	0.0 - 7.98
<i>Oxydendrum arboreum</i>	0.67	8	0.60	0.0 - 7.21
<i>Pinus strobus</i>	1.08	8	0.45	0.0 - 5.41
<i>Acer rubrum</i>	3.90	0	0.00	0.0
<i>Amelanchier arborea</i>	0.83	0	0.00	0.0
<i>Betula lenta</i>	0.17	0	0.00	0.0
<i>Juniperus virginiana</i>	0.08	0	0.00	0.0
<i>Ulmus rubra</i>	0.17	0	0.00	0.0
<i>Ulmus alata</i>	0.08	0	0.00	0.0
<i>Magnolia acuminata</i>	0.17	0	0.00	0.0

^aAverage stems/sample for understory = 52.43.

^bAverage stems/sample for overstory = 16.11.

^cRelative density of oak forest on Eden Shale. Braun, E.L. 1950. Deciduous Forests of Eastern North America. Blakiston Company, Philadelphia. Table 20.

TABLE IX
SOIL-SITE CHARACTERISTICS OF THE WHITE OAK-CHINQUAPIN OAK
FOREST TYPE. N=12.

Character	Range	Median	Mean + S.D.	
Solum thickness (inches)	4.00 - 17.50	11.25	11.40 $\pm$	5.50
Thickness of A (inches)	4.00 - 8.00	5.00	5.21 $\pm$	1.20
Stone (per cent volume)	0.00 - 70.00	47.50	50.42 $\pm$	21.20
Texture A	19.00 - 23.00	21.00	21.00 $\pm$	1.86 ^a
Texture B	17.00 - 20.00	20.00	19.00 $\pm$	1.48 ^a
Aspect	0.01 - 1.89	0.24	0.45 $\pm$	0.54 ^b
Slope (per cent)	30.00 - 72.00	53.50	51.25 $\pm$	10.86
Feet from draw	50.00 - 500.00	275.00	276.25 $\pm$	171.54

^aLoam to silty clay loam.

^bSouthwest.

range widely over the eastern United States. White oak with chinquapin are noted on limestone about Lewisburg, West Virginia (Braun, 1950). Braun considers chinquapin oak the ecologic equivalent of chestnut oak in the Western Mesophytic Forest Region and notes its abundance in the Kentucky Bluegrass, the Eden Shale belt, the Nashville Basin, the rolling plateau in Barren County, Kentucky, and elsewhere. An Eden Shale comparison (Table VIII) is far from a close one.

This community occupies an elevation band from 940 to 1,020 feet elevation near the gorge bottom. Shallow soil, thin A horizon, high stone percentage are suggestive of droughty site, but lower slope position (protection and internal seepage), and an average aspect of northeast to east would increase available water. Soil textures (sandy clay loam in the A, silty clay loam in the B) indicate high water holding capacity and the influence of sandy colluvial material from upslope.

Reproduction of dominants in the understory and a wide distribution of tree dbh (largest being a 31.6 inch beech and two 22 inch white oaks) indicate stability. Lack of fire evidence also indicates permanence, but evidence of cutting within the past 40 years and an average overstory density of about 16 stems per plot would indicate past disturbance and instability of the stand. Only the lower portions of this stand are likely to be flooded by seasonal river fluctuations.

Tulip poplar - hemlock type. This forest type occurs on the most mesic sites on both the north-facing ridges and draws within the gorge system. Tulip poplar and Tsuga canadensis (eastern hemlock) are codominants (Tables X and XI) and beech, sugar maple, and white oak

TABLE X

COMPOSITION OF THE TULIP POPLAR-EASTERN HEMLOCK
FOREST TYPE. N=27.

Taxa	Understory ^a Absolute Density	Fre- quency	Overstory ^b	
			IV Mean	IV Range
<i>Liriodendron tulipifera</i>	1.52	67	42.05 (17.4) ^c	0.00 - 99.95
<i>Tsuga canadensis</i>	2.33	67	33.53 (13.4)	0.00 - 112.59
<i>Fagus grandifolia</i>	2.85	70	24.21 (16.5)	0.00 - 90.20
<i>Acer saccharum</i>	7.92	63	17.16	0.00 - 84.57
<i>Quercus alba</i>	1.07	56	10.01 (6.9)	0.00 - 46.80
<i>Liquidambar styraciflua</i>	0.33	11	6.30	0.00 - 60.59
<i>Quercus rubra</i>	0.70	30	6.10 (5.2)	0.00 - 41.88
<i>Carya glabra</i>	0.85	30	4.90	0.00 - 59.55
<i>Acer rubrum</i>	6.11	48	4.66 (10.4)	0.00 - 29.14
<i>Amelanchier arborea</i>	0.63	19	4.18	0.00 - 29.08
<i>Ilex opaca</i>	1.44	22	3.43	0.00 - 9.08
<i>Betula lenta</i>	0.56	33	3.22	0.00 - 32.97
<i>Tilia heterophylla</i>	0.70	26	2.83	0.00 - 50.61
<i>Carya tomentosa</i>	0.85	15	2.73 (0.9)	0.00 - 27.57
<i>Aesculus octandra</i>	1.04	29	2.50	0.00 - 15.72
<i>Oxydendrum arboreum</i>	1.26	26	2.43	0.00 - 18.37
<i>Cornus florida</i>	6.52	33	2.28	0.00 - 42.98
<i>Magnolia acuminata</i>	1.04	7	2.20	0.00 - 35.28
<i>Carpinus caroliniana</i>	3.70	29	3.28	0.00 - 18.18
<i>Juniperus virginiana</i>	0.30	7	2.14	0.00 - 45.75
<i>Cercis canadensis</i>	0.37	7	1.85	0.00 - 47.32
<i>Pinus strobus</i>	0.00	4	1.79	0.00 - 48.29
<i>Carya ovalis</i>	0.00	7	1.66	0.00 - 36.80
<i>Platanus occidentalis</i>	0.18	11	1.24	0.00 - 18.17
<i>Fraxinus americana</i>	0.77	11	1.11	0.00 - 14.95
<i>Ulmus americana</i>	0.88	11	0.92	0.00 - 11.38
<i>Betula nigra</i>	0.00	4	0.78	0.00 - 21.20
<i>Carya cordiformis</i>	0.07	7	0.68	0.00 - 9.67
<i>Ulmus alata</i>	0.04	4	0.65	0.00 - 17.61
<i>Juglans nigra</i>	0.00	4	0.44 (2.6)	0.00 - 11.64
<i>Carya ovata</i>	0.41	4	0.33	0.00 - 5.14
<i>Pinus echinata</i>	0.00	7	0.25	0.00 - 6.80
<i>Quercus prinus</i>	0.15	4	0.22	0.00 - 5.49
<i>Pinus virginiana</i>	0.00	4	0.20	0.00 - 5.28

TABLE X (continued)

Taxa	Understory ^a Absolute Density	Fre- quency	Overstory ^b	
			IV Mean	IV Range
Sassafras albidum	0.11	4	0.16	0.00 - 4.24
Betula lutea	0.37	4	0.14 (1.7)	0.00 - 3.79
Quercus velutina	0.11	0	0.00	0.00
Magnolia tripetala	0.26	0	0.00	0.00
Myssa sylvatica	0.04	0	0.00 (2.6)	0.00
Asimina triloba	0.04	0	0.00	0.00
Magnolia fraseri	0.30	0	0.00 (2.6)	0.00

^aAverage stems/sample for understory = 33.70.

^bAverage stems/sample for overstory = 20.31.

^cRelative density from Table 6, A-3 from Colliers Creek, Black Mountain, Letcher County, Kentucky; Braun, E. L. 1950. The Deciduous Forests of Eastern North America, Blakison Company, New York.

TABLE XI

SOIL-SITE CHARACTERISTICS OF THE TULIP POPLAR EASTERN HEMLOCK
FOREST TYPE. N=27.

Character	Range	Median	Mean + S.D.
Solum thickness (inches)	7.87 - 44 .88	27.55	22.13 $\pm$ 10.80
Thickness of A (inches)	1.00 - 10.10	5.25	5.68 $\pm$ 2.72
Stone (per cent volume)	0.00 - 90.00	30.00	35.56 $\pm$ 25.77
Texture A	7.00 - 23.00 ^a	19.00	17.18 $\pm$ 4.77 ^b
Texture B	8.00 - 21.00 ^a	12.00	13.63 $\pm$ 5.16 ^c
Aspect	1.00 - 2.00	1.87	1.64 $\pm$ 0.33 ^d
Slope (per cent)	5.00 - 80.00	38.00	36.56 $\pm$ 23.05
Feet from draw	0.00 - 550.00	125.00	181.11 $\pm$ 166.38

^aLoamy sand to silt loam.

^bFine sandy loam.

^cSandy loam.

^dNorth to east.

are the primary associated taxa. Within the draws tulip poplar is the leading dominant; however, on ridge positions hemlock assumes first importance. Other associated taxa are Quercus rubra (northern red oak), sweetgum, serviceberry, Tilia heterophylla (basswood), Ilex opaca (American holly), and Aesculus octandra (sweet buckeye). Red maple, dogwood, and sugar maple are the primary understory taxa with sugar maple having the greatest density. Thirty-three taxa are present. This vegetation more closely approximates Braun's hemlock-mixed mesophytic community concept than any other in the present study (see comparison in Table IX, page 46). Most of the taxa occurring here are mesophytes except possibly Carya tomentosa (mockernut hickory), Oxydendrum arboreum (sourwood), certain pines, Ulmus alata (winged elm), Quercus prinus (chestnut oak), Quercus velutina (black oak), and Nyssa sylvatica (black gum). Sweetgum, sycamore, and river birch have a mean frequency of 5 per cent, these on wetter soil. The six taxa not reproducing include three pines, river birch, black walnut, and Carya ovalis (red hickory). Five taxa occur in the understory only.

It seems possible that this community is the same as the SAF type 58: Yellow poplar-Hemlock, known in the Appalachian and Cumberland Mountains between 2000 and 4000 feet. It certainly approximates stands reported in the Cumberland Mountain section of the Mixed Mesophytic Forest Region reported by Braun (cf. my previous Table VIII, page 45). The stands illustrating these communities (Braun, 1950, Table 6) contain 9 to 17 tree taxa in sample sizes of 90 to 292 stems. The present vegetation contains 33 overstory taxa

among 20 stems. Surely this forest is as rich floristically as the richest found by Braun in the Cumberland Mountain Section of the Mixed Mesophytic Forest Region.

This community occurs in the elevation band 860 to 1,320 feet on gorge north facing ridges and draws (Table XI, page 50). Solum depth is about average among all forest types found as is thickness of the A, but stone percentage is high and boulders are frequent on the slopes. Soil textures are sandy suggesting rapid internal drainage. Slope angle (a mean of 36.56 per cent) soil texture, stone content, and shallow soil depth decrease available moisture, but seepage, aspect and lower slope position operate increasing soil moisture.

Reproduction of dominants as well as the considerable geographic distribution of recognizably similar vegetation supports belief that this type is stable. Mean plot basal area of about 23 ft² per plot, an average canopy height of about 80 feet, and tree dbh up to 36 inches support the stability of this type. Most of the plots within this type showed no evidence of fire or cutting in the past 50-plus years, all of which lend credence to the stability of this community on the landscape.

White oak-Virginia pine type. This type is the most common on middle and lower slopes of north-facing gorge draws. It is dominated by white oak with Pinus virginiana (Virginia pine), northern red oak, and hemlock as its major associated taxa (Tables XII and XIII). On the more protected sites, this type is characterized by red maple, beech, Pinus strobus (white pine), and sweetgum as well as oak. In its drier phases the composition includes Quercus

TABLE XII

COMPOSITION OF THE WHITE OAK-VIRGINIA PINE
FOREST TYPE. N=17.

Taxa	Understory ^a		Overstory ^b		
	Absolute Density	Frequency	IV Mean	IV Range	
<i>Quercus alba</i>	4.00	100	81.87	22.71 - 193.99	
<i>Pinus virginiana</i>	1.00	29	17.03	0.00 - 72.85	
<i>Quercus rubra</i>	0.53	41	13.36	0.00 - 59.63	
<i>Tsuga canadensis</i>	2.65	35	12.35	0.00 - 42.78	
<i>Pinus echinata</i>	0.06	24	8.50	0.00 - 53.50	
<i>Acer rubrum</i>	11.94	35	8.16	0.00 - 42.88	
<i>Fagus grandifolia</i>	0.59	29	7.64	0.00 - 43.84	
<i>Quercus prinus</i>	0.18	18	7.57	0.00 - 35.87	
<i>Cornus florida</i>	7.94	47	7.11	0.00 - 23.11	
<i>Liquidambar styraciflua</i>	0.29	18	6.24	0.00 - 55.44	
<i>Liriodendron tulipifera</i>	0.70	41	5.00	0.00 - 26.52	
<i>Carya tomentosa</i>	1.00	35	4.40	0.00 - 29.51	
<i>Pinus strobus</i>	1.06	29	4.18	0.00 - 27.61	
<i>Oxydendrum arboreum</i>	0.94	29	3.36	0.00 - 19.23	
<i>Juniperus virginiana</i>	0.22	18	2.33	0.00 - 20.52	
<i>Ulmus americana</i>	1.59	12	1.39	0.00 - 21.80	
<i>Amelanchier arborea</i>	0.65	24	1.76	0.00 - 10.02	
<i>Carya glabra</i>	0.65	18	1.75	0.00 - 15.64	
<i>Carpinus caroliniana</i>	3.94	18	1.50	0.00 - 11.92	
<i>Carya cordiformis</i>	0.06	6	1.46	0.00 - 24.83	
<i>Aesculus octandra</i>	0.53	24	1.38	0.00 - 10.29	
<i>Carya ovalis</i>	0.00	6	1.19	0.00 - 20.19	
<i>Asimina triloba</i>	0.65	12	1.04	0.00 - 11.74	
<i>Juglans nigra</i>	0.29	12	0.94	0.00 - 11.93	
<i>Betula lenta</i>	0.30	6	0.70	0.00 - 11.85	
<i>Fraxinus americana</i>	0.70	6	0.67	0.00 - 11.33	
<i>Acer saccharum</i>	2.06	6	0.59	0.00 - 10.10	
<i>Ilex opaca</i>	0.29	6	0.30	0.00 - 5.07	
<i>Tilia heterophylla</i>	0.00	6	0.24	0.00 - 4.09	
<i>Ulmus alata</i>	0.00	6	0.48	0.00 - 3.14	
<i>Diospyros virginiana</i>	0.29	0	0.00	0.00	
<i>Platanus occidentalis</i>	0.18	0	0.00	0.00	
<i>Betula nigra</i>	0.35	0	0.00	0.00	

^aAverage stems/sample for understory = 34.18.^bAverage stems/sample for overstory = 23.31.

TABLE XIII
SOIL-SITE CHARACTERISTICS OF THE WHITE OAK VIRGINIA PINE
FOREST TYPE. N=17.

Character	Range	Median	Mean + S.D.
Solum thickness (inches)	16.00 - 32.00	24.00	24.12 $\pm$ 4.38
Thickness of A (inches)	3.00 - 14.00	6.00	6.74 $\pm$ 3.38
Stone (per cent volume)	10.00 - 60.00	30.00	27.94 $\pm$ 13.18
Texture A	7.00 - 23.00 ^a	20.00	16.06 $\pm$ 3.40 ^b
Texture B	8.00 - 20.00 ^a	17.00	15.41 $\pm$ 4.24 ^c
Aspect	1.00 - 2.00	1.65	1.56 $\pm$ 0.34 ^d
Slope (per cent)	20.00 - 30.00	30.00	40.12 $\pm$ 19.15
Feet from draw	0.00 - 700.00	300.00	244.18 $\pm$ 187.61

^aLoamy sand to silt loam.

^bFine sandy loam.

^cClay.

^dNorthwest to southeast.

prinus (chestnut oak) and Pinus echinata (shortleaf pine). The understory is predominantly represented by red maple and dogwood. There are 33 taxa represented within this type of which nine are rated xerophytic, the rest rated mesophytic. Three taxa--red hickory, basswood, and winged elm--are not reproducing within the stands; however, reproduction of major taxa occurs. Three taxa, Diospyros virginiana (persimmon), sycamore, and river birch, are members of the understory but have not entered the overstory. This may be due to the nature of these sites: too dry for long continued growth of these taxa as the presence of Virginia pine and other xerophytic taxa would indicate.

The relationship of this forest to others reported is unknown. It is superficially similar to SAF Type 52, White Oak-Red Oak-Hickory, but certainly hickories are unimportant here. If the secondary importance of pine (shortleaf and Virginia) is attributed to cutting and momentarily disregarded, then northern red oak, hemlock, red maple, and beech become second in importance. The latter is suggestive, but not very close numerically, to stands at Pickett and Scott County, Tennessee, (Braun, 1950, Tables 14, 15), stands in Eastern Kentucky (Braun, 1950, Table 12), and stands at Gallipolis, Ohio (Braun, 1950, Table 13). White oak dominated forests occur virtually over the entire Eastern Deciduous Forest, but White Oak-Pine types are not reported by Braun (1950).

This community occurs in the elevation range 820 to 1,300 feet, primarily in middle and upper north-facing draws. Here low solum depth (24 inches), average thickness of the A (6.7 inches),

mean stone percentage (27.9), northwest through northeast to southeast aspect, and steep upper slopes make water less available. Fine soil textures, however, aid in retention of soil moisture.

The lack of confirmation of this forest type in other areas suggests that it is successional and thus temporary in nature. The mesophytes--white oak, hemlock, red maple, and musclewood are reproducing well, while beech, red oak, sweetgum, tulip poplar, white pine, American elm, and serviceberry are reproducing poorly. The xerophytes--Virginia pine, shortleaf pine, chestnut oak, sourwood, and redcedar are reproducing inadequately to poorly. This suggests a forest of a temporary nature. The mean plot basal area, 17.37 ft^2 , and plot density (26.64) indicate youthful, successional stands. Large trees (white oak up to 20 inches dbh), however, are indicative of older stands and, in fact, these stands do not show evidence of being cut for over 30 years. The presence of the largest trees may represent the time since cutting or perhaps these are culls left from the last cut.

Shortleaf pine-white oak type. Forests of this type occur on the upper slopes of north-facing gorge draws. Shortleaf pine is the leading dominant with white oak and Virginia pine of secondary importance (Tables XIV and XV). Other taxa associated are dogwood, sweetgum, Carya tomentosa (mockernut hickory), redcedar, and tulip poplar. Twenty-eight taxa occur within this type and seven of them are rated as xerophytes; the remainder have either wide moisture tolerance or are rated mesophytic. This type occupies the driest of the north draws, displaying a much more xerophytic composition

TABLE XIV

COMPOSITION OF THE SHORLEAF PINE-WHITE OAK
FOREST TYPE. N=7.

Taxa	Understory ^a Absolute Density	Overstory ^b		
		Fre- quency	IV Mean	IV Range
<i>Pinus echinata</i>	1.83	83	57.06	0.00 - 112.69
<i>Quercus alba</i>	2.50	83	23.13	0.00 - 37.96
<i>Pinus virginiana</i>	3.83	33	15.94	0.00 - 56.07
<i>Cornus florida</i>	7.00	83	13.12	0.00 - 45.28
<i>Liquidambar styraciflua</i>	0.50	33	10.47	0.00 - 49.58
<i>Carya tomentosa</i>	1.33	66	8.67	0.00 - 25.35
<i>Juniperus virginiana</i>	0.67	33	8.24	0.00 - 36.93
<i>Liriodendron tulipifera</i>	1.00	66	7.82	0.00 - 26.59
<i>Amelanchier arborea</i>	3.50	33	7.29	0.00 - 28.19
<i>Carya glabra</i>	0.33	33	4.99	0.00 - 19.61
<i>Quercus marilandica</i>	3.00	17	3.72	0.00 - 26.06
<i>Oxydendrum abboreum</i>	2.17	50	3.02	0.00 - 9.74
<i>Magnolia tripetala</i>	0.67	33	2.85	0.00 - 11.02
<i>Ulmus americana</i>	4.67	50	2.68	0.00 - 11.39
<i>Pinus strobus</i>	2.17	33	2.44	0.00 - 12.96
<i>Quercus rubra</i>	1.00	33	2.14	0.00 - 13.95
<i>Aesculus octandra</i>	0.33	17	1.37	0.00 - 9.57
<i>Fagus grandifolia</i>	2.50	17	1.18	0.00 - 8.29
<i>Carya cordiformis</i>	0.00	17	1.05	0.00 - 7.35
<i>Carpinus caroliniana</i>	3.00	17	0.51	0.00 - 3.60
<i>Ulmus alata</i>	0.00	17	0.51	0.00 - 3.60
<i>Acer rubrum</i>	11.33	0	0.00	0.00
<i>Ilex opaca</i>	0.17	0	0.00	0.00
<i>Tsuga canadensis</i>	4.33	0	0.00	0.00
<i>Platanus occidentalis</i>	0.50	0	0.00	0.00
<i>Carya ovata</i>	0.17	0	0.00	0.00
<i>Fraxinus americana</i>	0.50	0	0.00	0.00
<i>Nyssa sylvatica</i>	0.33	0	0.00	0.00

^aAverage stems/sample for understory = 52.16.

^bAverage stems/sample for overstory = 33.28.

TABLE XV
SOIL-SITE CHARACTERISTICS OF THE SHORLEAF PINE WHITE OAK
FOREST TYPE. N=7.

Character	Range	Median	Mean $\pm$ S.D.
Solum thickness (inches)	16.00 - 32.0	28.0	26.28 $\pm$ 6.47
Thickness of A (inches)	4.00 - 10.0	6.0	6.01 $\pm$ 1.92
Stone (per cent volume)	10.00 - 40.0	15.0	24.28 $\pm$ 15.12
Texture A	7.00 - 21.0 ^a	17.0	14.71 $\pm$ 6.02 ^b
Texture B	8.00 - 16.0	12.0	12.71 $\pm$ 3.77 ^c
Aspect	1.34 - 2.0	1.8	1.68 $\pm$ 0.27 ^d
Slope (per cent)	20.00 - 39.0	32.0	29.57 $\pm$ 8.10
Feet from draw	300.00 - 1,100.0	450.0	507.14 $\pm$ 268.37

^aLoamy sand to sandy clay loam.

^bSandy loam.

^cSandy loam.

^dNorth to east.

than others although the understory is again dominated by red maple and dogwood. Reproduction as indicated by understory density shows that shortleaf pine is not regenerating well nor are sweetgum and Carya glabra (pignut hickory). Both white oak and Virginia pine are reproducing well among the present dominants, while chinquapin oak, beech and hemlock are entering in the understory. Two taxa (winged elm and bitternut hickory) are members of the overstory but are not reproducing. Seven taxa are present in the understory but have not, as yet, gained overstory size. The presence of a generally mesic understory should suggest successional status for this type; however, higher density of the reproduction of xeric taxa would contra-indicate.

Braun (1950, page 72) describes a physiographic climax of pines (pitch, shortleaf, and Virginia) occurring on sandy soils over sandstone on Pine Mountain and on Cumberland Mountain. In these areas sandstone is exposed on ridge crests and is shallowly covered by sandy soil downslope. SAF type 76, the Shortleaf Pine-White Oak variant, has spotty distribution within this forest cover type which is generally of wide geographic distribution. Braun (1950, Table 8) reports the presence of chestnut oak, Quercus coccinea (scarlet oak), Castanea dentata (American chestnut), and black gum within the Pine Mountain pine forests. Some of these are constituents of cover type 76.

This forest occurs on gentler slopes than does the white oak-Virginia pine type mentioned above. It occurs between 930 and 1,390 feet elevation and is characterized by sandy loams with rapid internal drainage. Soils are thin (averaging 26.28 inches) and have a

24 per cent stone volume. As with the previous white oak-Virginia pine type, little comparison has been found in the literature suggesting its geographic range or successional status. The dominants, including intolerants, are well represented in the understory, but the mixture of mesophytes and xerophytes is unusual.

Mean basal area of 15.60 ft² per plot, large tree size (short-leaf pines up to 20 inches dbh), tree height of about 55.7 feet, and absence of fire or stumps would indicate permanence and a lengthy period of undisturbed growth. However, overstory density has an average of 33.28 stems per plot which would suggest youth.

White oak-Virginia pine ridge type. This forest type bears striking resemblance to the White Oak-Virginia Pine type of the northern draws (above). However, in this type Virginia pine is codominant with white oak (Tables XVI and XVII). This type covers a wide elevation range along the north-facing ridges. On upper ridge positions in areas of thin, sandy solum Virginia pine is dominant with white oak, Quercus prinus (chestnut oak), and blackjack oak comprising a major portion of the stand. On middle to lower ridge positions this type is dominated by white oak in association with shortleaf pine, mockernut hickory, northern red oak, and red maple. On lower ridge sites this type grades into the tulip poplar-hemlock type discussed above. Thirty-six taxa make up the type of which ten are rated xeric or subxeric by Whittaker (1956). Predominance of mesic and submesic taxa appears to be aspect related. Nine taxa have yet to gain overstory status while all overstory taxa are represented in the understory. Dogwood and red maple are the most numerous understory components.

TABLE XVI

COMPOSITION OF THE WHITE OAK-VIRGINIA PINE RIDGE
FOREST TYPE. N=14.

Taxa	Understory ^a Absolute Density	Overstory ^b		
		Fre- quency	IV Mean	IV Range
<i>Quercus alba</i>	7.07	100	52.53	13.12 - 104.92
<i>Pinus virginiana</i>	3.65	64	52.78	0.00 - 141.78
<i>Quercus rubra</i>	3.14	71	18.18	0.00 - 40.79
<i>Carya tomentosa</i>	4.36	43	6.98	0.00 - 29.87
<i>Acer rubrum</i>	11.70	50	6.88	0.00 - 25.47
<i>Liriodendron tulipifera</i>	0.43	14	5.05	0.00 - 48.17
<i>Cornus florida</i>	10.64	43	4.55	0.00 - 29.35
<i>Pinus echinata</i>	0.36	21	4.52	0.00 - 54.49
<i>Fagus grandifolia</i>	1.36	14	3.80	0.00 - 34.61
<i>Quercus prinus</i>	0.07	7	3.73	0.00 - 52.26
<i>Tsuga canadensis</i>	1.79	14	3.68	0.00 - 40.92
<i>Fraxinus americana</i>	0.21	7	3.49	0.00 - 48.83
<i>Carya glabra</i>	1.57	36	3.06	0.00 - 18.15
<i>Liquidambar styraciflua</i>	0.21	7	2.25	0.00 - 31.55
<i>Quercus marilandica</i>	0.43	7	1.86	0.00 - 26.06
<i>Pinus strobus</i>	0.86	28	1.80	0.00 - 8.71
<i>Quercus coccinea</i>	0.43	14	1.53	0.00 - 11.41
<i>Acer saccharum</i>	3.57	7	1.44	0.00 - 20.21
<i>Asimina triloba</i>	0.43	21	1.22	0.00 - 10.69
<i>Quercus muhlenbergii</i>	0.50	7	1.14	0.00 - 15.96
<i>Carya cordiformis</i>	0.14	14	1.01	0.00 - 8.93
<i>Oxydendrum arboreum</i>	2.28	14	0.74	0.00 - 7.18
<i>Sassafras albidum</i>	2.28	14	0.68	0.00 - 5.04
<i>Juglans nigra</i>	0.07	7	0.60	0.00 - 8.47
<i>Aesculus octandra</i>	0.07	7	0.37	0.00 - 5.24
<i>Carya ovata</i>	0.29	7	0.29	0.00 - 4.11
<i>Carpinus caroliniana</i>	0.57	7	0.23	0.00 - 3.22
<i>Disopyros virginiana</i>	1.78	0	0.00	0.00
<i>Magnolia tripetala</i>	0.14	0	0.00	0.00
<i>Platanus occidentalis</i>	0.14	0	0.00	0.00
<i>Cercis canadensis</i>	0.14	0	0.00	0.00
<i>Quercus velutina</i>	0.31	0	0.00	0.00
<i>Ilex opaca</i>	0.29	0	0.00	0.00
<i>Amelanchier arborea</i>	0.21	0	0.00	0.00
<i>Prunus serotina</i>	0.21	0	0.00	0.00
<i>Castanea dentata</i>	0.07	0	0.00	0.00

^aAverage stems/sample for understory = 64.00.

^bAverage stems/sample for overstory = 21.76.

TABLE XVII

SOIL-SITE CHARACTERISTICS OF THE WHITE OAK-VIRGINIA PINE RIDGE
FOREST TYPE. N=14.

Character	Range	Median	Mean + S.D.
Solum thickness (inches)	4.00 - 32.0	25.00	23.08 $\pm$ 8.30
Thickness of A (inches)	2.00 - 9.3	6.00	5.22 $\pm$ 2.17
Stone (per cent volume)	0.00 - 90.0	10.00	18.07 $\pm$ 27.80
Texture A	12.00 - 23.0 ^a	20.00	18.23 $\pm$ 3.96 ^b
Texture B	2.00 - 21.0 ^a	17.00	14.38 $\pm$ 5.35 ^c
Aspect	1.09 - 2.0	1.71	1.59 $\pm$ 0.34 ^d
Slope (per cent)	3.00 - 84.0	18.50	27.15 $\pm$ 27.40
Feet from draw	125.00 - 1,850.0	400.00	569.23 $\pm$ 464.03

^aSandy loam to silt loam.

^bSilty clay.

^cClay.

^dNorth to east.

The Society of American Foresters (1964) does not recognize this type. Braun (1950) found oak-pine and oak-chestnut intergrading communities on Pine Mountain, but white oak is a lesser important oak in these types.

Solum depths vary with slope position--the shallowest occurring on upper ridges. Soils are sandy to clayey with the sand fraction increasing on upper slope positions. Soils are moderately stony with greatest stone volumes in soils of lower slopes. These sites are moderately steep, generally promoting rapid drainage.

Reproduction, as indicated by understory densities, indicates this type to be transitional to a white oak dominated forest. Although importance values of the leading dominants are equal, disparity in understory densities suggests an increasing white oak fraction. Evidence of fire, cutting within the past 20 to 30 years, a mean plot basal area of 17.82 ft², canopy closure of 37.86 per cent, and very dense understory (a mean of 64 stems per plot) suggest the successional nature of this type. Residual beeches attain diameters up to 28 inches dbh; however, the majority of stems are less than 9 inches dbh.

Northern red oak-chestnut oak-white oak type. This forest type occurs on northerly ridges with thinner solum, A horizons, and greater stone volume than does the white oak-Virginia pine ridge type above. It has an elevation range from 1,120 to 1,300 feet. Northern red oak is the major dominant with chestnut oak and white oak the primary associated taxa. Quercus velutina (black oak), red maple, mockernut hickory, and Virginia pine are associated within this type (Tables XVIII and XIX). Twenty-four taxa comprise this

TABLE XVIII

COMPOSITION OF THE NORTHERN RED OAK-CHESTNUT OAK-
WHITE OAK FOREST TYPE. N=5.

Taxa	Understory ^a Absolute Density	Overstory ^b		
		Fre- quency	IV Mean	IV Range
<i>Quercus rubra</i>	1.60	80	72.15	0.00 - 129.02
<i>Quercus prinus</i>	4.80	100	36.08	16.56 - 65.25
<i>Quercus alba</i>	4.00	80	25.99	0.00 - 41.71
<i>Acer rubrum</i>	16.60	60	14.24	0.00 - 31.35
<i>Pinus virginiana</i>	0.60	20	9.97	0.00 - 49.86
<i>Carya tomentosa</i>	1.60	40	7.90	0.00 - 25.39
<i>Tsuga canadensis</i>	6.80	40	6.67	0.00 - 26.30
<i>Quercus velutina</i>	0.00	20	3.75	0.00 - 18.74
<i>Cornus florida</i>	10.60	60	3.70	0.00 - 7.07
<i>Fagus grandifolia</i>	0.00	40	3.36	0.00 - 10.27
<i>Carya cordiformis</i>	0.00	20	3.10	0.00 - 15.48
<i>Liriodendron tulipifera</i>	0.20	20	3.10	0.00 - 15.50
<i>Juniperus virginiana</i>	0.00	20	1.41	0.00 - 7.07
<i>Oxydendrum arboreum</i>	5.80	20	1.36	0.00 - 6.82
<i>Asimina triloba</i>	2.60	20	1.31	0.00 - 6.55
<i>Amelanchier arborea</i>	1.00	20	0.92	0.00 - 4.62
<i>Diospyros virginiana</i>	0.60	20	0.92	0.00 - 4.62
<i>Acer saccharum</i>	0.40	0	0.00	0.00
<i>Aesculus octendra</i>	0.60	0	0.00	0.00
<i>Carya glabra</i>	1.00	0	0.00	0.00
<i>Ulmus alata</i>	0.20	0	0.00	0.00
<i>Ulmus americana</i>	0.20	0	0.00	0.00
<i>Ilex opaca</i>	0.40	0	0.00	0.00
<i>Pinus strobus</i>	0.40	0	0.00	0.00

^aAverage stems/sample for understory = 60.00.

^bAverage stems/sample for overstory = 24.00

TABLE XIX

SOIL-SITE CHARACTERISTICS OF THE NORTHERN RED OAK-CHESTNUT OAK-
WHITE OAK FOREST TYPE. N=5.

Character	Range	Median	Mean + S.D.	
Solum thickness (inches)	10.00 - 16.00	12.00	12.40 $\pm$	2.19
Thickness of A (inches)	2.00 - 5.20	4.00	3.64 $\pm$	1.20
Stone (per cent volume)	15.00 - 60.00	30.00	31.00 $\pm$	17.46
Texture A	7.00 - 21.00 ^a	12.00	13.80 $\pm$	5.36 ^b
Texture B	12.00 - 21.00	16.00	16.20 $\pm$	4.02 ^c
Aspect	1.54 - 1.97	1.64	1.68 $\pm$	0.16 ^d
Slope (per cent)	23.00 - 33.00	28.00	29.00 $\pm$	4.18
Feet from draw	200.00 - 775.00	500.00	525.00 $\pm$	215.06

^aLoamy sand to sandy clay loam.

^bSandy loam.

^cFine sandy loam.

^dNortheast.

type, of which six are xeric or subxeric (Whittaker, 1956). Seven taxa are not represented in the overstory while three overstory taxa (black oak, beech, and bitternut hickory) are not reproducing in the understory. Hemlock, red maple, sourwood, and dogwood comprise the majority of the understory stems. Northern red oak is not reproducing as well as either chestnut oak or white oak.

SAF type 44, chestnut oak, closely resembles this type. It occurs on rocky outcrops with thin soil from southern New England along the mountains to Georgia and Alabama. It frequently follows fire and cutting in types containing a mixture of northern red oak and chestnut oak. Thomas (1966) reports a mixed oak cover type on Chilhowee Mountain which contains chestnut oak, northern red oak, pignut hickory, and white oak as the four most important tree taxa. On Chilhowee, this type occurs principally on northern and eastern slopes.

Forests of this type have shallow soils with thin A horizons and considerable stone. Textures range from sandy loam A horizons to a clayey B. Slopes average 29 per cent facilitating runoff. Soil textures and northern aspects increase water availability within the substrate.

Red oak is not reproducing as well as the other dominant oaks. From this one may infer that this type is successional to the white oak-chestnut oak type (below) which also occupies ridge positions (however with a southern exposure). Successional status is suggested by the dense understory (60 stems per plot), canopy closure of 30 per cent, canopy height of 43 feet, and an overstory density

of 24 stems per plot. Evidence of cutting and fire also substantiate the successional nature of this type.

White oak-hemlock-chestnut oak type. This is the most extensive forest type within the study area. It occurs in south-facing draws of gorges and mountain draws. Outside of the plateau surface, it occupies an elevation range of from 930 to 1,760 feet. White oak is the dominant taxon. In narrow draws with more protection such taxa as hemlock, red maple, beech, and tulip poplar are associated. Where the draws are wider and on upper slopes, chestnut oak, mockernut hickory, white pine, and Virginia pine are primary associated taxa (Tables XX and XXI). Forty-five taxa are represented within this type; seventeen are rated xeric or subxeric (Whittaker, 1956) while the remainder are considered mesic or submesic. Five taxa occur only in the understory; Nyssa sylvatica (sour gum) and sycamore are very minor overstory components but are not reproducing on any study sites. Overstory reproduction is good. Primary understory taxa are red maple, sugar maple, and dogwood. Upper slopes usually have an abundant Kalmia latifolia shrub layer.

This type bears some resemblance to SAF type 53 white oak which is found on upland, loamy soils throughout the Central Forest. Martin (1966) describes a white oak type which occupied lower slopes of ridges and draws of both exposures and upper south slopes. Although some similarity of taxa occurs, the two are not identical. Within the oak-chestnut forest region (Braun, 1950) white oak was a dominant with Castanea dentata (American chestnut) on some exposed southerly slopes. Chestnut oak was a major associate. Ravenel's Woods near Highlands, North Carolina, had a drier chestnut-oak

TABLE XX
COMPOSITION OF THE WHITE OAK-HEMLOCK-CHESTNUT OAK
FOREST TYPE. N=53.

Taxa	Understory ^a		Overstory ^b	
	Absolute Density	Frequency	IV Mean	IV Range
<i>Quercus alba</i>	3.34	83	72.92 (10.5) ^c	0.00 - 165.93
<i>Tsuga canadensis</i>	1.49	47	15.18 (9.0)	0.00 - 80.44
<i>Quercus prinus</i>	1.45	33	14.83 (34.2)	0.00 - 153.85
<i>Acer rubrum</i>	6.79	68	14.25 (7.4)	0.00 - 70.15
<i>Fagus grandifolia</i>	1.86	38	11.45	0.00 - 83.89
<i>Acer saccharum</i>	3.29	43	9.96	0.00 - 65.78
<i>Liriodendron tulipifera</i>	1.08	40	8.40	0.00 - 64.58
<i>Quercus rubra</i>	0.40	32	8.25 (7.4)	0.00 - 60.95
<i>Carya tomentosa</i>	0.62	32	7.24	0.00 - 58.83
<i>Pinus strobus</i>	1.51	24	5.96	0.00 - 47.86
<i>Pinus virginiana</i>	0.23	15	5.43	0.00 - 65.33
<i>Fraxinus americana</i>	0.62	21	4.11	0.00 - 30.93
<i>Carya glabra</i>	0.57	30	3.77	0.00 - 32.61
<i>Carya cordiformis</i>	0.37	34	3.49	0.00 - 25.33
<i>Quercus velutina</i>	1.34	23	3.12	0.00 - 34.45
<i>Carpinus caroliniana</i>	1.32	19	2.66	0.00 - 25.80
<i>Liquidambar styraciflua</i>	0.50	19	2.43	0.00 - 28.62
<i>Quercus coccinea</i>	0.35	9	2.18	0.00 - 35.57
<i>Oxydendrum arboreum</i>	1.84	28	2.14	0.00 - 19.15
<i>Amelanchier arborea</i>	2.04	9	1.74	0.00 - 30.43
<i>Cornus florida</i>	4.00	24	1.55	0.00 - 14.52
<i>Betula lenta</i>	0.62	11	1.46 (5.3)	0.00 - 30.43
<i>Carya ovalis</i>	0.04	8	1.33	0.00 - 41.57
<i>Diospyros virginiana</i>	0.20	6	1.06	0.00 - 30.43
<i>Asimina triloba</i>	0.48	11	0.87	0.00 - 10.88
<i>Betula nigra</i>	0.10	9	0.82	0.00 - 13.77
<i>Aesculus octandra</i>	0.35	6	0.82	0.00 - 28.61
<i>Juglans nigra</i>	0.04	6	0.80	0.00 - 22.30
<i>Quercus stellata</i>	0.15	8	0.77	0.00 - 12.43
<i>Tilia heterophylla</i>	0.35	6	0.71	0.00 - 19.11
<i>Plantanus occidentalis</i>	0.00	2	0.65	0.00 - 33.85
<i>Ulmus americana</i>	0.60	9	0.61	0.00 - 7.92
<i>Quercus marilandica</i>	0.10	2	0.60	0.00 - 31.09
<i>Ilex opaca</i>	0.48	8	0.52	0.00 - 11.13

TABLE XX (continued)

Taxa	Understory ^a Absolute Density	Fre- quency	Overstory ^b	
			IV Mean	IV Range
<i>Magnolia acuminata</i>	0.96	8	0.50	0.00 - 10.69
<i>Carya ovata</i>	0.15	8	0.48	0.00 - 10.54
<i>Cercis canadensis</i>	0.54	4	0.43	0.00 - 20.28
<i>Magnolia tripetala</i>	0.15	2	0.10	0.00 - 5.44
<i>Quercus muhlenbergii</i>	0.08	2	0.09	0.00 - 4.92
<i>Nyssa sylvatica</i>	0.00	2	0.03	0.00 - 1.81
<i>Castanea dentata</i>	0.13	0	0.00 (34.2)	0.00
<i>Pinus echinata</i>	0.02	0	0.00	0.00
<i>Rhamnus caroliniana</i>	0.02	0	0.00	0.00
<i>Sassafras albidum</i>	0.64	0	0.00	0.00
<i>Ulmus alata</i>	0.04	0	0.00	0.00

^aAverage stems/sample for understory = 44.66.

^bAverage stems/sample for overstory = 19.79.

^cRelative density from Table 44 (1), page 221, Braun, E. L. 1950.
The Deciduous Forests of Eastern North America, Blakison Company, New York.

TABLE XXI

SOIL-SITE CHARACTERISTICS OF THE WHITE OAK-HEMLOCK-CHESTNUT
OAK FOREST TYPE. N=53.

Character	Range		Median	Mean + S.D.	
Solum thickness (inches)	6.00-	45.60	20.20	21.73 $\pm$	9.11
Thickness of A (inches)	0.50-	8.00	4.00	4.14 $\pm$	1.79
Stone (per cent volume)	0.00-	80.00	30.00	35.29 $\pm$	24.56
Texture A	2.00-	23.00 ^a	17.00 ^b	14.98 $\pm$	6.19
Texture B	2.00-	23.00	17.50	14.60 $\pm$	6.51
Aspect	0.00-	1.09	0.32	0.40 $\pm$	0.33 ^c
Slope (per cent)	22.00-	90.00	44.00	47.06 $\pm$	15.96
Feet from draw	0.00-	1,050.00	125.00	190.00 $\pm$	262.93

^aSand to silt loam.

^bFine sandy loam.

^cSouthwest.

forest on gentle southwest slopes (Braun, 1950) (Table XIX, page 65). Shifting of dominance since the demise of chestnut might account for the composition of present day upper slope forests.

Soils of this forest type are typically thin with thin A horizon and a sandy loam texture throughout the solum. Stone volume varies; much more stone is found on lower slopes. Slopes are steep, conducive to downslope water movement.

Reproduction of dominants and the wide distribution within the study area supports the belief that this forest type is stable. Mean plot basal area of about 15 ft² per plot, an average canopy height of 70 feet, and tree dbh to 30 inches (beech) suggest the stability of this type. All but a few plots lacked evidence of fire and evidence of cutting was over 40 years old, suggestive of time for forest stability.

White oak-beech type. This type occupies lower portions of south-facing ridges and leads within the gorges between 900 and 1,120 feet elevation. White oak is the leading dominant with beech co-dominant. Red maple, mockernut hickory, and black oak are some of the associated taxa (Tables XXII and XXIII). On sheltered leads beech and red maple are more pronounced, while on more exposed slopes black oak and mockernut hickory are the major associates. Red maple and dogwood are the primary understory taxa with scattered musclewood and sourwood trees throughout the type. Sugar maple is another understory taxa of some importance. There are 35 taxa represented within this forest; 19 taxa are rated xeric or subxeric (Whittaker, 1956). The presence of mesic and submesic taxa is indicative of the relative slope position of this type as it affects

TABLE XXII

COMPOSITION OF THE WHITE OAK-BEECH FOREST TYPE. N=15.

Taxa	Understory ^a Absolute Density	Fre- quency	Overstory ^b	
			IV Mean	IV Range
<i>Quercus alba</i>	5.73	100	78.47 (41.8) ^c	23.22 - 158.97
<i>Fagus grandifolia</i>	5.20	80	42.40 (30.1)	0.00 - 67.69
<i>Acer rubrum</i>	9.80	53	13.66 (6.5)	0.00 - 42.83
<i>Carya tomentosa</i>	0.40	33	6.43	0.00 - 12.41
<i>Quercus velutina</i>	0.73	20	6.20 (2.6)	0.00 - 44.55
<i>Acer saccharum</i>	4.90	20	5.77	0.00 - 41.60
<i>Pinus strobus</i>	0.60	40	4.05	0.00 - 24.58
<i>Quercus prinus</i>	1.67	33	4.53	0.00 - 19.74
<i>Amelanchier arborea</i>	1.47	20	3.70	0.00 - 22.16
<i>Quercus rubra</i>	0.53	27	3.43 (1.3)	0.00 - 18.70
<i>Cornus florida</i>	7.27	33	3.43	0.00 - 12.94
<i>Carya glabra</i>	1.53	33	3.01	0.00 - 18.70
<i>Juniperus virginiana</i>	0.67	13	2.84	0.00 - 22.29
<i>Magnolia acuminata</i>	1.80	13	2.81	0.00 - 21.64
<i>Liriodendron tulipifera</i>	0.93	20	2.76 (5.2)	0.00 - 24.43
<i>Quercus coccinea</i>	0.13	7	2.36	0.00 - 35.42
<i>Aesculus octandra</i>	0.20	13	2.22	0.00 - 18.53
<i>Betula nigra</i>	0.07	7	1.72	0.00 - 25.75
<i>Quercus muhlenbergii</i>	0.53	7	1.32	0.00 - 19.74
<i>Fraxinus americana</i>	0.33	13	1.15	0.00 - 9.05
<i>Asimina triloba</i>	0.27	13	1.10	0.00 - 8.29
<i>Juglans nigra</i>	0.27	13	1.03	0.00 - 8.02
<i>Oxydendrum arboreum</i>	3.07	7	0.78	0.00 - 11.74
<i>Liquidambar styraciflua</i>	0.73	7	0.66	0.00 - 9.87
<i>Tsuga canadensis</i>	2.40	13	0.64	0.00 - 5.87
<i>Ulmus rubra</i>	0.27	7	0.61	0.00 - 9.21
<i>Ilex opaca</i>	0.60	13	0.52	0.00 - 4.01
<i>Ulmus alata</i>	0.00	7	0.28	0.00 - 4.28
<i>Carpinus caroliniana</i>	2.20	0	0.00	0.00
<i>Carya cordiformis</i>	0.13	0	0.00	0.00

TABLE XXII (continued)

Taxa	Understory ^a Absolute Density	Fre- quency	Overstory ^b	
			IV Mean	IV Range
<i>Carya ovata</i>	0.27	0	0.00	0.00
<i>Cercis canadensis</i>	0.07	0	0.00	0.00
<i>Diospyros virginiana</i>	0.07	0	0.00	0.00
<i>Pinus virginiana</i>	0.13	0	0.00	0.00
<i>Ulmus americana</i>	0.40	0	0.00	0.00

^aAverage stems/sample for understory = 47.86.

^bAverage stems/sample for overstory = 21.30.

^cRelative density from page 62, Braun, E. L. 1950. The Deciduous Forests of Eastern North America, Blakiston Company, New York.

TABLE XXIII
SOIL-SITE CHARACTERISTICS OF THE WHITE OAK-BEECH
FOREST TYPE. N=15.

Character	Range	Median	Mean + S.D.
Solum thickness (inches)	8.00 - 34.00	28.00	21.47 $\pm$ 9.66
Thickness of A (inches)	3.00 - 7.30	4.00	4.44 $\pm$ 1.34
Stone (per cent volume)	0.00 - 40.00	20.00	22.00 $\pm$ 13.06
Texture A	12.00 - 23.00 ^a	20.00	20.20 $\pm$ 2.56 ^b
Texture B	8.00 - 21.00 ^a	18.00	17.40 $\pm$ 4.12 ^c
Aspect	0.07 - 0.91	0.36	0.44 $\pm$ 0.33 ^d
Slope (per cent)	20.00 - 57.00	50.00	44.20 $\pm$ 11.48
Feet from draw	50.00 - 490.00	275.00	302.00 $\pm$ 126.32

^aSandy clay to silt loam.

^bSilty clay loam.

^cFine sandy loam.

^dSouthwest.

available water. Shrub cover is low; occasional Kalmia occur on the thinner soils. This type grades into the previous one on the most protected sites.

Braun (1950) describes a white oak-beech forest on lower, southern slopes at low elevations within the Cumberland Mountains. It is suggested that due to composition and position, this type is transitional to the beech-sugar maple ravine type. Martin (1966) reported a white oak-dominated forest on lower south ridges, however, chestnut oak was codominant.

Substrates are typically thin, stony, and with a thin, silty clay loam A horizon. B horizons are mostly sandy loams. Slopes are steep, averaging 44 per cent.

Dominant taxa are reproducing well, as are most other taxa. Only Ulmus alata (winged elm) is not reproducing of the 28 overstory taxa. Seven taxa have not reached overstory size. Reproduction of dominants, a long history (40 plus years) of uninterrupted growth, and a mean basal area of 11.45 ft² per plot indicate forest stability. Mean canopy height is 56 feet; however, in more protected and moister sites some trees are 80 to 90 feet tall. Relict beech trees have largest dbh within this type (to 33 inches).

White oak-chestnut oak type. Forests of this type occupy steep, south-facing gorge ridges. They occur primarily on middle slope positions but also do occur in lower slope positions where the solum is thin or the site more exposed. White oak is predominant and with chestnut oak comprises over one half of the forest composition. Major associates are mockernut hickory, red maple, white pine, scarlet oak, and black oak (Tables XXIV and XXV).

TABLE XXIV

COMPOSITION OF THE WHITE OAK-CHESTNUT OAK FOREST TYPE. N=11.

Taxa	Understory ^a		Overstory ^b		
	Absolute	Density	Frequency	IV Mean	IV Range
<i>Quercus alba</i>	4.91		100	86.26	45.53 - 133.56
<i>Quercus prinus</i>	2.00		77	22.29	0.000 - 47.15
<i>Carya tomentosa</i>	3.09		88	18.28	0.00 - 39.97
<i>Acer rubrum</i>	8.73		66	9.56	0.00 - 26.11
<i>Pinus strobus</i>	1.82		45	9.20	0.00 - 35.36
<i>Quercus coccinea</i>	0.91		23	8.76	0.00 - 44.79
<i>Quercus velutina</i>	1.18		45	7.77	0.00 - 42.28
<i>Juniperus virginiana</i>	0.82		23	5.46	0.00 - 23.13
<i>Cornus florida</i>	6.18		55	5.12	0.00 - 14.97
<i>Carya glabra</i>	0.91		23	4.83	0.00 - 29.13
<i>Pinus virginiana</i>	0.18		18	4.83	0.00 - 34.73
<i>Quercus rubra</i>	0.91		23	3.46	0.00 - 14.38
<i>Juglans nigra</i>	0.18		23	2.37	0.00 - 16.44
<i>Cercis canadensis</i>	2.54		18	1.95	0.00 - 14.25
<i>Oxydendrum arboreum</i>	1.64		23	1.66	0.00 - 6.86
<i>Carya cordiformis</i>	0.64		18	1.60	0.00 - 7.19
<i>Acer saccharum</i>	4.54		18	1.48	0.00 - 7.19
<i>Ulmus americana</i>	0.82		9	1.16	0.00 - 12.77
<i>Quercus stellata</i>	0.54		9	1.12	0.00 - 12.34
<i>Liriodendron tulipifera</i>	0.64		9	1.06	0.00 - 11.63
<i>Quercus muhlenbergii</i>	1.00		9	0.99	0.00 - 10.85
<i>Carya ovata</i>	0.36		9	0.47	0.00 - 5.15
<i>Quercus marilandica</i>	0.27		9	0.35	0.00 - 3.87
<i>Diospyros virginiana</i>	0.64		0	0.00	0.00
<i>Ilex opaca</i>	0.18		0	0.00	0.00
<i>Tsuga canadensis</i>	0.18		0	0.00	0.00
<i>Fraxinus americana</i>	0.09		0	0.00	0.00
<i>Carpinus caroliniana</i>	1.64		0	0.00	0.00
<i>Fagus grandifolia</i>	0.64		0	0.00	0.00
<i>Tilia heterophylla</i>	0.27		0	0.00	0.00
<i>Prunus serotina</i>	0.09		0	0.00	0.00
<i>Amelanchier arborea</i>	1.09		0	0.00	0.00
<i>Asimina triloba</i>	0.09		0	0.00	0.00
<i>Nyssa sylvatica</i>	0.18		0	0.00	0.00

^aAverage stems/sample for understory = 42.55.^bAverage stems/sample for overstory = 23.14.

TABLE XXV
 SOIL-SITE CHARACTERISTICS OF THE WHITE OAK-CHESTNUT OAK
 FOREST TYPE. N=11.

Character	Range	Median	Mean + S.D.
Solum thickness (inches)	8.00 - 26.80	16.00	16.26 $\pm$ 5.40
Thickness of A (inches)	2.50 - 7.10	5.00	4.79 $\pm$ 1.30
Stone (per cent volume)	5.00 - 70.00	20.00	33.18 $\pm$ 26.29
Texture A	12.00 - 21.00 ^a	19.00	18.10 $\pm$ 3.36 ^b
Texture B	8.00 - 23.00 ^a	17.00	17.64 $\pm$ 3.75 ^c
Aspect	0.00 - 0.45	0.23	0.20 $\pm$ 0.15 ^d
Slope (per cent)	20.00 - 76.00	45.00	50.18 $\pm$ 17.18
Feet from draw	150.00 - 500.00	300.00	338.64 $\pm$ 127.16

^aSandy clay to silt loam.

^bSilty clay.

^cFine sandy loam.

^dSouthwest.

Thirty-four taxa make up the over and understory of which 11 are found only in the understory. Of the overstory taxa, 13 are rated xeric or subxeric (Whittaker, 1956); the remainder are mesophytic. Of those taxa restricted to the understory, five are xeric or subxeric.

Martin (1966) found chestnut oak codominant with white oak on lower slopes of south ridges in the southern Cumberland Mountains. Braun (1950) described white oak communities within the transition belt between the oak-chestnut and the mixed mesophytic region. Martin (1966) reports a white oak-chestnut oak codominance on lower south slopes of Wilson Mountain. With death of the chestnut, there has been noted replacement by chestnut oak on dry sites in the Great Smoky Mountains (Woods and Shanks, 1959). Although chestnut was not seen in the understory, it could have been overlooked, and its demise may have been a factor in development here.

Soils of this forest are thin, very stony (up to 70 per cent), and have a thin, sandy A horizon with a sandy loam B. This forest type is found between 1,020 and 1,450 feet elevations.

Reproduction of overstory taxa, mean canopy height (57.82 feet), and a mean basal area of 12.68 ft² per plot suggest permanence. However, cutting within the last 40 years, the death of the chestnut, and an overstory density of about 23 stems per plot indicate instability. This type is, doubtless, transitional and still undergoing shifting of dominance.

Virginia pine-white pine type. This forest type is found on the upper slopes of south-facing gorge ridges. It occurs between 1,120 and 1,300 feet elevation. Virginia pine and white pine are co-dominant on the lower slopes of its range but the uppermost

forests are primarily Virginia pine dominated. Some associated taxa are chestnut oak, mockernut hickory, white oak, and northern red oak (Tables XXVI and XXVII). Twenty-three taxa comprise the forests with 14 taxa rated xeric or subxeric. Six taxa are present in the understory only. The understory is dominated by red maple and dogwood. Shrub cover is dense with stands of Kalmia latifolia and Viburnum sp. predominating.

This type is similar to the SAF type 79 Virginia pine. It is widely distributed throughout the Piedmont Plateau south to Georgia and westward to eastern Kentucky and Tennessee where it occurs on dry slopes below 2,000 feet. This type is temporary. Braun (1950) describes Virginia pine-dominated stands on upper sandy slopes in the Cumberlands, but white pine is absent from these forests.

Soils are thin and only moderately stony. Both A and B horizons are usually sandy loam but textures range considerably.

There is abundant understory regeneration of all major taxa. Proximity of these stands to the gorge crest has made access easier to loggers. Mean basal area of 15.75 ft² per plot would indicate permanence; however, high understory density (49.6 stems per plot), low canopy height (54.5 feet), and recent logging disturbance (within the past 30 years) suggest this type is not permanent. If left uncut, it might be expected to stabilize with a Virginia pine dominated forest type of somewhat similar composition to the present forest.

Virginia pine-white oak type. The gorge crest is forested with this vegetation. It occurs on all aspects and varies only in understory composition from northern to southern aspects. Virginia

TABLE XXVI
COMPOSITION OF THE VIRGINIA PINE-WHITE PINE
FOREST TYPE. N=10.

Taxa	Understory ^a Absolute Density	Overstory ^b		
		Fre- quency IV	Mean	IV Range
<i>Pinus virginiana</i>	3.70	70	62.54	0.00 - 143.46
<i>Pinus strobus</i>	1.60	60	33.35	0.00 - 101.88
<i>Quercus prinus</i>	1.60	70	24.03	0.00 - 51.46
<i>Carya tomentosa</i>	2.40	50	17.93	0.00 - 51.36
<i>Quercus alba</i>	1.90	70	15.46	0.00 - 41.91
<i>Quercus rubra</i>	0.70	30	8.79	0.00 - 40.52
<i>Quercus coccinea</i>	0.60	30	7.13	0.00 - 40.47
<i>Cornus florida</i>	10.10	60	3.72	0.00 - 14.58
<i>Asimina triloba</i>	0.90	30	3.69	0.00 - 22.05
<i>Fagus grandifolia</i>	2.00	20	3.71	0.00 - 19.68
<i>Carya glabra</i>	0.20	20	2.15	0.00 - 14.70
<i>Acer rubrum</i>	13.60	20	2.04	0.00 - 14.30
<i>Pinus echinata</i>	0.40	10	1.91	0.00 - 19.14
<i>Sassafras albidum</i>	3.50	10	1.75	0.00 - 17.52
<i>Quercus stellata</i>	0.20	10	1.54	0.00 - 15.46
<i>Tsuga canadensis</i>	0.30	10	0.69	0.00 - 6.90
<i>Quercus velutina</i>	1.00	10	0.67	0.00 - 6.74
<i>Aesculus octandra</i>	0.10	0	0.00	0.00
<i>Amelanchier arborea</i>	0.20	0	0.00	0.00
<i>Oxydendrum arboreum</i>	1.30	0	0.00	0.00
<i>Acer saccharum</i>	1.10	0	0.00	0.00
<i>Quercus muhlenbergii</i>	0.30	0	0.00	0.00
<i>Magnolia tripetala</i>	0.20	0	0.00	0.00

^aAverage stems/sample for understory = 49.60.

^bAverage stems/sample for overstory = 24.31.

TABLE XXVII
SOIL-SITE CHARACTERISTICS OF THE VIRGINIA PINE-WHITE PINE
FOREST TYPE. N=10.

Character	Range		Median	Mean $\pm$ S.D.	
Solum thickness (inches)	12.00 -	28.00	19.00	19.80 $\pm$	4.16
Thickness of A (inches)	3.00 -	6.00	5.50	4.91 $\pm$	1.33
Stone (per cent volume)	0.00 -	65.00	10.00	21.50 $\pm$	20.14
Texture A	7.00 -	21.00 ^a	12.00 ^b	13.60 $\pm$	5.27
Texture B	7.00 -	21.00	12.00	12.10 $\pm$	5.57
Aspect	0.07 -	0.99	0.43	0.48 $\pm$	0.30 ^c
Slope (per cent)	15.00 -	57.00	25.50	37.60 $\pm$	19.20
Feet from draw	120.00 -	1,000.00	725.00	548.00 $\pm$	390.29

^aLoamy sand.

^bSandy loam.

^cSouthwest.

pine and white oak are codominant with pines predominant toward the gorge. Forests of this type are found between elevations of 1,180 and 1,560 feet where it grades into the Virginia pine-white pine type on its lower edges (Tables XXVIII and XXIX). Nineteen taxa compose this type which makes it the most floristically depauperate of any vegetation type within the gorge. Of the 19 taxa, 11 are considered xeric or subxeric by Whittaker (1956). Mesic taxa (viz., white pine, hemlock, sweetgum, tulip poplar, and the maples) have secondary importance on the more north-facing sites while dogwood and mockernut hickory are found throughout. Kalmia forms much of the shrub layer. Two taxa, black cherry and sourwood, have yet to attain overstory size.

SAF type 78 Virginia pine-southern red oak most closely approximates this forest type except for the lack of southern red oak here. Thomas (1966) describes an oak-pine cover type on Chilhowee Mountain, which occupies much the same type of crest position as does the Virginia pine-white oak type; within the Basin, however, oak is predominant. Martin (1966) found Virginia pine and mockernut hickory codominant in occasional plots in the southern Cumberland Mountains. Within her discussion of forests of eastern United States, Braun cites no instance of this type of forest. The admixture of white oak with Virginia pine is not discussed.

Gorge crest soils are thin with thin sandy loam A and B horizons. There is little stone due to colluvial action and slope position. Slopes are moderately steep and runoff is rapid.

All overstory taxa with the exception of white pine, bitternut hickory, and tulip poplar are reproducing. Those taxa restricted to

TABLE XXVIII

COMPOSITION OF THE VIRGINIA PINE-WHITE OAK FOREST TYPE. N=8.

Taxa	Understory ^a Absolute Density	Overstory ^b		
		Fre- quency	IV Mean	IV Range
<i>Pinus virginiana</i>	8.38	87	72.55	0.00 - 112.35
<i>Quercus alba</i>	1.00	62	40.30	0.00 - 103.99
<i>Quercus prinus</i>	3.62	62	28.66	0.00 - 76.65
<i>Quercus coccinea</i>	2.50	50	14.04	0.00 - 51.07
<i>Quercus stellata</i>	1.00	50	8.12	0.00 - 23.17
<i>Pinus strobus</i>	0.00	12	6.42	0.00 - 51.36
<i>Quercus velutina</i>	0.88	12	5.28	0.00 - 42.28
<i>Tsuga canadensis</i>	0.62	25	4.84	0.00 - 31.81
<i>Carya glabra</i>	0.12	12	4.23	0.00 - 33.82
<i>Carya tomentosa</i>	2.50	25	3.39	0.00 - 22.37
<i>Cornus florida</i>	3.88	25	3.15	0.00 - 12.66
<i>Carya cordiformis</i>	0.00	25	2.54	0.00 - 13.97
<i>Acer rubrum</i>	12.25	25	2.27	0.00 - 12.57
<i>Juniperus virginiana</i>	0.12	12	2.05	0.00 - 16.43
<i>Quercus marilandica</i>	0.75	12	0.73	0.00 - 5.86
<i>Liriodendron tulipifera</i>	0.00	12	0.72	0.00 - 5.74
<i>Liquidambar styraciflua</i>	0.25	12	0.70	0.00 - 5.59
<i>Oxydendrum arboreum</i>	0.75	0	0.00	0.00
<i>Prunus serotina</i>	0.12	0	0.00	0.00

^aAverage stems/sample for understory = 33.50.^bAverage stems/sample for overstory = 24.00.

TABLE XXIX
SOIL-SITE CHARACTERISTICS OF THE VIRGINIA PINE-WHITE OAK
FOREST TYPE. N=8.

Character	Range		Median	Mean + S.D.	
Solum thickness (inches)	10.00 -	26.00	23.00	20.00 ±	6.42
Thickness of A (inches)	0.80 -	6.00	3.50	3.24 ±	1.51
Stone (per cent volume)	0.00 -	30.00	5.00	10.00 ±	12.53
Texture A	12.00 -	20.00	12.00 ^a	13.62 ±	3.11
Texture B	8.00 -	20.00 ^b	12.00	13.13 ±	5.22
Aspect	0.03 -	1.80	0.16	0.52 ±	0.76 ^c
Slope (per cent)	20.00 -	45.00	32.00	33.25 ±	9.27
Feet from draw	125.00 -	2,000.00	600.00	796.88 ±	656.08

^aSandy loam.

^bSandy clay to silty clay loam.

^cSouthwest.

understory size are reproducing, but Prunus serotina (black cherry) has low frequency. From these data it is suggested that the dominants (excluding Virginia pine) will sort themselves by competition into a related, but unknown, Virginia pine community. A mean overstory density of 24 stems per plot, mean basal area of 10.98 ft² per plot, and a mean canopy height of 45.4 feet suggest the youth and transitory nature of this type.

Plateau Surface Vegetation, Associated Soil and Site Characteristics

Northern aspect white oak type. North-facing plateau slopes, except for uppermost ridges and slopes, are forested by this type. It occurs on the plateau between an elevation of 1,300 and 1,600 feet. White oak is the leading dominant; northern red oak, sugar maple, and chestnut oak are secondary associates within the type. There are 26 taxa within the understory and overstory of this type. Thirteen taxa are rated mesic or submesic by Whittaker (1956); six taxa are rated subxeric. Toward upper slope positions the subxeric and xeric taxa gain importance; however, the understory (primarily red maple, dogwood, and white oak) is fairly uniform throughout (Tables XXX and XXXI). This type grades into the Virginia pine-white pine type of plateau ridges (see below).

Martin (1966) reports that white oak-dominated north slopes (both ridges and draws) occur within the Cumberland Mountains. Braun (1950) states that white oak forests occur on the Allegheny Plateau which are secondary in nature due to the activities of man. The Society of American Foresters (1964) describes a white oak type (Type 53) which is relatively permanent but which occurs in scattered stands. Floristically they are similar, but the vegetation here is

TABLE XXX

COMPOSITION OF THE NORTHERN ASPECT WHITE OAK FOREST TYPE. N=15.

Taxa	Understory ^a		Overstory ^b	
	Absolute Density	Frequency	IV Mean	IV Range
<i>Quercus alba</i>	6.33	87	73.65	0.00 - 126.72
<i>Quercus rubra</i>	1.66	80	19.48	0.00 - 37.10
<i>Acer saccharum</i>	2.13	40	15.74	0.00 - 77.25
<i>Quercus prinus</i>	0.33	47	15.27	0.00 - 94.87
<i>Pinus virginiana</i>	0.66	47	13.35	0.00 - 54.19
<i>Acer rubrum</i>	7.33	53	13.33	0.00 - 94.50
<i>Liriodendron tulipifera</i>	2.20	33	9.22	0.00 - 66.32
<i>Liquidambar styraciflua</i>	1.47	40	7.82	0.00 - 48.55
<i>Carya tomentosa</i>	0.67	47	5.46	0.00 - 25.47
<i>Carya cordiformis</i>	0.00	20	4.14	0.00 - 33.32
<i>Oxydendrum arboreum</i>	1.60	33	2.85	0.00 - 11.32
<i>Asimina triloba</i>	0.33	7	2.78	0.00 - 41.67
<i>Cornus florida</i>	13.13	20	2.25	0.00 - 21.23
<i>Amelanchier arborea</i>	0.93	13	2.14	0.00 - 26.55
<i>Quercus coccinea</i>	0.00	13	1.88	0.00 - 19.41
<i>Pinus echinata</i>	0.07	7	1.47	0.00 - 22.07
<i>Carya glabra</i>	0.73	13	1.16	0.00 - 10.92
<i>Betula lenta</i>	0.60	13	1.09	0.00 - 9.10
<i>Carpinus caroliniana</i>	0.47	13	0.68	0.00 - 5.34
<i>Sassafras albidum</i>	0.33	7	0.54	0.00 - 8.15
<i>Pinus strobus</i>	0.33	7	0.37	0.00 - 5.62
<i>Quercus velutina</i>	0.30	0	0.00	0.00
<i>Castanea dentata</i>	0.07	0	0.00	0.00
<i>Aesculus octandra</i>	0.07	0	0.00	0.00

^aAverage stems/sample for understory = 41.44.^bAverage stems/sample for overstory = 21.23.

TABLE XXXI

SOIL-SITE CHARACTERISTICS OF THE NORTHERN ASPECT WHITE OAK
FOREST TYPE. N=15.

Character	Range	Median	Mean + S.D.
Solum thickness (inches)	14.00 - 30.40	22.80	21.15 $\pm$ 5.18
Thickness of A (inches)	1.00 - 5.00	2.50	3.10 $\pm$ 1.83
Stone (per cent volume)	0.00 - 40.00	10.00	13.67 $\pm$ 14.82
Texture A	7.00 - 23.00 ^a	20.00	19.07 $\pm$ 3.59 ^b
Texture B	8.00 - 21.00	20.00	18.93 $\pm$ 3.24 ^c
Aspect	1.16 - 1.92	1.57	1.61 $\pm$ 0.22 ^d
Slope (per cent)	5.00 - 28.00	20.00	18.60 $\pm$ 7.84
Feet from draw	50.00 - 1,500.00	150.00	301.67 $\pm$ 366.75

^aLoamy sand to silt loam.

^bLoam.

^cLoam.

^dNortheast.

believed successional and much more widely distributed.

The forest substrate is mostly silty clay loam with widely varying stone content. Slopes are gentle. Neither the A horizon nor the solum is deep, but soil texture and gentle slopes on the northern aspects maintain high soil moisture levels.

All but four taxa are represented within the overstory; of these four, black oak has the greatest chance of entering the overstory. Two overstory taxa are not reproducing in the understory. Reproduction, as indicated by understory presence, is abundant among stand dominants. Maximum tree size of 34 inches dbh (white oak), mean basal area of 12.52 ft² per plot, and an absence of fire evidence suggest stability. However, cutting disturbance within the past 30 to 40 years, mean canopy height of 53 feet, and an overstory density of about 21 stems per plot suggest its instability and disclimax nature.

Southern aspect white oak type. South-facing plateau slopes are forested by this type. It occurs between 1,300 and 1,640 feet elevation on all slope positions-- areas of recent disturbance excepted. White oak is dominant, but the associated taxa are shifted from north to south slopes. Sugar maple, chestnut oak, northern red oak, and black oak are the primary associates. There are 28 taxa within this type of which six are restricted to understory status. Twelve taxa are rated xeric or subxeric (Whittaker, 1956). Sugar maple, white oak, post oak, and persimmon comprise the main portion of the understory. Black walnut is the sole overstory taxa without understory representation (Tables XXXII and XXXIII).

As in the northern aspect type above, this forest also appears

TABLE XXXII

COMPOSITION OF THE SOUTHERN ASPECT WHITE OAK FOREST TYPE. N=16.

Taxa	Understory ^a		Overstory ^b		
	Absolute	Density	Frequency	IV Mean	IV Range
<i>Quercus alba</i>	1.50		94	79.29	0.00 - 160.05
<i>Acer saccharum</i>	2.19		56	22.44	0.00 - 54.24
<i>Quercus prinus</i>	0.38		69	17.08	0.00 - 49.40
<i>Quercus rubra</i>	0.19		44	15.55	0.00 - 58.07
<i>Quercus velutina</i>	0.06		38	7.40	0.00 - 48.64
<i>Acer rubrum</i>	0.75		19	6.98	0.00 - 64.63
<i>Fagus grandifolia</i>	0.19		12	6.71	0.00 - 96.71
<i>Diospyros virginiana</i>	1.00		31	5.46	0.00 - 29.55
<i>Quercus stellata</i>	1.25		12	5.32	0.00 - 48.15
<i>Carya cordiformis</i>	0.06		25	5.22	0.00 - 22.49
<i>Quercus coccinea</i>	0.12		6	5.06	0.00 - 80.96
<i>Pinus virginiana</i>	0.56		38	4.62	0.00 - 17.17
<i>Liquidambar styraciflua</i>	0.88		12	4.28	0.00 - 58.51
<i>Pinus strobus</i>	0.56		19	3.90	0.00 - 23.93
<i>Amelanchier arborea</i>	0.38		19	2.50	0.00 - 19.71
<i>Tilia heterophylla</i>	0.12		19	2.17	0.00 - 28.90
<i>Oxydendrum arboreum</i>	0.06		12	2.14	0.00 - 20.03
<i>Carya tomentosa</i>	0.12		19	2.13	0.00 - 15.82
<i>Betula lenta</i>	0.38		6	0.63	0.00 - 10.03
<i>Juglans nigra</i>	0.00		6	0.55	0.00 - 8.75
<i>Carya ovata</i>	0.12		6	0.55	0.00 - 8.75
<i>Carpinus caroliniana</i>	0.06		0	0.00	0.00
<i>Liriodendron tulipifera</i>	0.25		0	0.00	0.00
<i>Carya glabra</i>	0.12		0	0.00	0.00
<i>Sassafras albidum</i>	0.19		0	0.00	0.00
<i>Prunus serotina</i>	0.06		0	0.00	0.00
<i>Fraxinus americana</i>	0.25		0	0.00	0.00
<i>Ilex opaca</i>	0.25		0	0.00	0.00

^aAverage stems/sample for understory = 13.34.^bAverage stems/sample for overstory = 17.75.

TABLE XXXIII

SOIL-SITE CHARACTERISTICS OF THE SOUTHERN ASPECT WHITE OAK
FOREST TYPE. N=16.

Character	Range	Median	Mean + S.D.
Solum thickness (inches)	12.00 - 29.20	19.40	20.65 ± 5.83
Thickness of A (inches)	1.20 - 4.00	2.00	2.28 ± 0.89
Stone (per cent volume)	0.00 - 40.00	12.50	14.38 ± 10.78
Texture A	7.00 - 21.00 ^a	20.00	17.31 ± 4.19 ^b
Texture B	7.00 - 21.00	18.00	16.62 ± 4.47 ^c
Aspect	0.02 - 0.66	0.36	0.37 ± 0.24 ^d
Slope (per cent)	7.00 - 70.00	12.00	17.06 ± 15.37
Feet from draw	0.00 - 1,400.00	350.00	470.31 ± 424.97

^aLoamy sand to sandy clay loam.

^bFine sandy loam.

^cClay.

^dSouthwest.

to be a variant of type 53 white oak (Society of American Foresters, 1964). The southern aspect white oak differs from the northern aspect type in expression of dry site taxa and in minor soil-site differences.

Soils are thin as is the A horizon. Stoniness is highly variable but rarely exceeds 25 per cent. Stone varies with slope per cent, with less tone on steeper slopes. Plateau slopes appear to have steeper south faces with greater variation than do north slopes. A horizons tend toward sandy loams, but B horizons have argillic textures.

Reproduction (indicated by understory density) is not great. Only white oak, sugar maple, persimmon, and post oak are reproducing well throughout the type. Other taxa are few and scattered. Low reproduction density, a mean canopy height of 51.88 feet, low mean plot basal area (11.18 ft^2), and overstory density of 17.75 stems per plot suggest recent and repeated disturbance and youth. Average time since cutting is 30 years, but two stands showed evidence of cutting within the past 10 years. These factors coupled with dry south slope effects produce many small stems and scrubby vegetation--as is suggested by average density and low stand height.

Virginia pine-white oak-blackjack oak type. This forest type occurs on midslope southern aspects following recent disturbance (since 1930). All sites are exposed (protection distance averages 6,700 feet), between 1,450 and 1,600 feet elevation. Virginia pine is the leading dominant, comprising almost one half of the type importance value. White oak and Quercus marilandica (blackjack oak) are of secondary importance with shortleaf pine, white pine, and post

oak scattered throughout the stands. Twenty taxa compose the type, but six taxa are restricted to the understory while one overstory taxon is not found in the understory (persimmon). Twelve taxa are rated xeric or subxeric (Whittaker, 1956), indicative of the xerophytic nature of this type (Tables XXXIV and XXXV).

This forest type can be considered the same as or a variant of type 79 Virginia pine (Society of American Foresters, 1964). Type 79 is widely distributed throughout the Piedmont Plateau and westward through the Appalachians to eastern Kentucky and Tennessee where it is a pioneer type on dry sites. Type 79 is temporary except in cases of continued disturbance or excessive water shortage. Virginia pine occurs in the Mixed Mesophytic Forest Region as a physiographic climax (Braun, 1950), but the presence of cutting evidence of recent age suggests this plateau type is a seral rather than an edaphic community.

Slopes are gentle with average solum depth (26 inches) and thin A horizons. Stone per cent is highly variable but averages about 14 per cent. Both A and B horizons vary in texture, but the average texture for both is silty clay.

Abundant reproduction of Virginia pine and reproduction of other major taxa indicates stability. Canopy height averages 63.33 feet which is tall for the basin forests in general. These factors plus tree size up to 30 inches dbh (Virginia pine) suggest stability. However, the following factors indicate the youth of this type: mean understory density of 55 stems per plot, mean overstory density of 36 stems per plot (most less than 9 inches dbh), and mean basal area of 23.07 ft² per plot. This would indicate a successional character

TABLE XXXIV

COMPOSITION OF THE VIRGINIA PINE-WHITE OAK-BLACKJACK OAK
FOREST TYPE. N=6.

Taxa	Understory ^a		Overstory ^b	
	Absolute Density	Frequency	IV Mean	IV Range
<i>Pinus virginia</i>	15.00	100	90.38	9.66 - 146.13
<i>Quercus alba</i>	5.50	100	38.44	6.39 - 57.05
<i>Quercus marilandica</i>	1.00	66	21.87	0.00 - 11.13
<i>Pinus echinata</i>	0.67	50	18.28	0.00 - 85.51
<i>Pinus strobus</i>	1.00	66	15.90	0.00 - 35.50
<i>Quercus stellata</i>	1.33	83	12.41	0.00 - 20.44
<i>Acer rubrum</i>	11.17	50	8.39	0.00 - 15.09
<i>Carya tomentosa</i>	2.17	33	4.73	0.00 - 15.09
<i>Quercus prinus</i>	0.33	17	1.93	0.00 - 11.60
<i>Quercus velutina</i>	1.83	17	1.47	0.00 - 8.83
<i>Cornus florida</i>	6.00	17	0.92	0.00 - 5.53
<i>Diospyros virginiana</i>	0.00	17	0.71	0.00 - 4.24
<i>Liquidambar styraciflua</i>	2.83	17	0.66	0.00 - 3.98
<i>Juniperus virginiana</i>	0.17	17	0.46	0.00 - 2.77
<i>Acer saccharum</i>	0.50	0	0.00	0.00
<i>Asimina triloba</i>	2.17	0	0.00	0.00
<i>Fagus grandifolia</i>	0.17	0	0.00	0.00
<i>Corydendrum arboreum</i>	0.33	0	0.00	0.00
<i>Quercus coccinea</i>	0.33	0	0.00	0.00
<i>Sassafras albidum</i>	0.50	0	0.00	0.00

^aAverage stems/sample for understory = 51.17.

^bAverage stems/sample for overstory = 36.07.

TABLE XXXV

SOIL-SITE CHARACTERISTICS OF THE VIRGINIA PINE-WHITE OAK-
BLACKJACK OAK FOREST TYPE. N=6.

Character	Range	Median	Mean + S.D.	
Solum thickness (inches)	12.00 - 32.00	27.00	26.00 $\pm$	7.12
Thickness of A (inches)	1.00 - 6.00	4.50	3.67 $\pm$	1.63
Stone (per cent volume)	0.00 - 60.00	10.00	15.17 $\pm$	22.45
Texture A	17.00 - 20.00	19.00	18.67 $\pm$	1.36 ^a
Texture B	17.00 - 21.00 ^b	18.00	18.67 $\pm$	1.97 ^a
Aspect	0.00 - 1.00	0.24	0.33 $\pm$	0.38 ^c
Slope (per cent)	8.00 - 20.00	14.00	14.00 $\pm$	5.37
Feet from draw	75.00 - 850.00	700.00	541.67 $\pm$	347.37

^aSilty clay.

^bFine sandy loam to sandy clay loam.

^cSouthwest.

of this type with instability under continuing disturbance and canopy opening.

Virginia pine type. Upper south slopes and hill crests on the plateau surface are forested by this type between 1,500 and 1,650 feet elevation. Sites of this type have the thinnest soils of any plateau forest. Virginia pine is dominant, occurring in almost pure stands on some of the most exposed sites. White pine and sugar maple are major associates with various dry oaks on thicker soils. Twenty taxa comprise the type of which ten are rated xeric or subxeric (Whittaker, 1956). All taxa are reproducing, however, four have not yet gained overstory size (Tables XXXVI and XXXVII).

This forest can be considered a typical example of type 79 Virginia pine (Society of American Foresters, 1964). Braun (1950), Martin (1966), Thomas (1966), and Lipps (1966) have described pine growth on dry sites within the southern Appalachians. The role of Virginia pine as invader on dry sites and old fields is known and its tolerance to high light intensities, drought tolerance, and ability to survive and reproduce in areas of disturbance and canopy opening. In this respect it is successional and transient except in areas of frequent disturbance or exceptional water stress where it forms a permanent community.

Soils are shallow with thin A horizons and no stone. Slopes are gentle and runoff is doubtless slow. This is suggested by the soil textures: sandy clay loam A and silty clay loam B due to illuviated material.

This plateau type has been maintained by repeated cutting and drought conditions due to canopy opening and thin solum. Canopy

TABLE XXXVI

COMPOSITION OF THE VIRGINIA PINE FOREST TYPE. N=7.

Taxa	Understory ^a Absolute Density	Overstory ^b		
		Fre- quency	IV Mean	IV Range
<i>Pinus virginiana</i>	2.57	100	121.97	73.79 - 163.36
<i>Pinus strobus</i>	2.00	86	21.63	0.00 - 54.58
<i>Acer saccharum</i>	2.28	71	10.63	0.00 - 28.19
<i>Quercus prinus</i>	0.57	28	7.22	0.00 - 33.63
<i>Carya tomentosa</i>	1.28	57	6.08	0.00 - 20.83
<i>Carya ovata</i>	0.71	43	5.57	0.00 - 16.81
<i>Quercus marilandica</i>	1.43	28	5.02	0.00 - 19.59
<i>Liquidambar styraciflua</i>	2.57	57	4.20	0.00 - 13.80
<i>Juniperus virginiana</i>	0.86	43	4.14	0.00 - 13.56
<i>Pinus echinata</i>	0.00	14	3.18	0.00 - 22.29
<i>Acer rubrum</i>	10.43	43	2.37	0.00 - 6.00
<i>Quercus alba</i>	1.00	28	2.22	0.00 - 9.91
<i>Cornus florida</i>	4.43	28	2.17	0.00 - 11.23
<i>Quercus stellata</i>	1.00	28	2.16	0.00 - 7.56
<i>Carya cordiformis</i>	0.57	14	0.89	0.00 - 6.24
<i>Fagus grandifolia</i>	1.71	14	0.56	0.00 - 3.94
<i>Carya ovalis</i>	0.14	00	0.00	0.00
<i>Diospyros virginia</i>	0.14	0	0.00	0.00
<i>Oxydendrum arboreum</i>	0.14	0	0.00	0.00
<i>Quercus rubra</i>	0.14	0	0.00	0.00

^aAverage stems/sample for understory = 36.85.^bAverage stems/sample for overstory = 21.38.

TABLE XXXVII
SOIL-SITE CHARACTERISTICS OF THE VIRGINIA PINE
FOREST TYPE. N=7.

Character	Range	Median	Mean + S.D.
Solum thickness (inches)	10.00 - 28.00	14.00	18.28 $\pm$ 7.95
Thickness of A (inches)	3.00 - 5.50	4.00	4.00 $\pm$ 0.87
Stone (per cent volume)	0.00 - 0.00	0.00	0.00 $\pm$ 0.00
Texture A	19.00 - 23.00 ^a	20.00	21.00 $\pm$ 1.91 ^b
Texture B	17.00 - 21.00 ^a	20.00	20.00 $\pm$ 1.41 ^c
Aspect	0.03 - 0.44	0.23	0.20 $\pm$ 0.14 ^d
Slope (per cent)	6.00 - 15.00	8.00	9.28 $\pm$ 3.40
Feet from draw	0.00 - 2,500.00	1,100.00	1,142.86 $\pm$ 865.27

^aFine sandy loam to silt loam.

^bSandy clay loam.

^cSilty clay loam.

^dSouthwest.

height is about 70 feet but plot overstory densities of over 21 stems indicate youth of the type. Mean basal area of about 12 ft² per plot also indicates youth.

Mountain Vegetation; Associated Soil and Site Characteristics

Beech-white oak-sugar maple type. Forests of this type occur in draws of northern aspect at elevations from 1,260 to 1,600 feet. At this elevation the forest grades into the chestnut oak-white oak-beech type (see below). Beech, white oak, and sugar maple are co-dominant; eastern hemlock, Carpinus caroliniana (American hornbeam), serviceberry, shagbark hickory, and northern red oak are major associates of this type (Tables XXXVIII and XXXIX). Twenty-seven taxa constitute the type; of this number, 17 are rated mesic or submesic (Whittaker, 1956) making this the most mesic of the mountain types studied in terms of floristic composition on moist, but well drained, sites. Four taxa are restricted to understory status and two subxeric taxa (black oak and white pine) are not reproducing in the understory. Both Acer spicatum (striped maple) and Acer pennsylvanicum (moosewood) contribute to the shrub layer. The understory varies from dogwood, red maple, hornbeam, serviceberry along the lower portions of the forest range, to persimmon, sugar maple, and dogwood at higher elevations.

Braun (1950) described a beech-sugar maple community of the Cumberland Mountains (Table 3, areas 4, 5, Braun, 1950), a community of ravines and lower north slopes which this type approximates but does not closely resemble. Caplenor (1965) described mixed mesophytic stands in Fall Creek Falls State Park, Tennessee, which contained 37 taxa in the tree layer--dominants of this type were the

TABLE XXXVIII
COMPOSITION OF THE BEECH-WHITE OAK-SUGAR MAPLE
FOREST TYPE. N=9.

Taxa	Understory ^a		Overstory ^b	
	Absolute Density	Frequency	IV Mean	IV Range
<i>Fagus grandifolia</i>	2.67	100	45.69	17.36 - 94.52
<i>Quercus alba</i>	1.67	56	24.69	0.00 - 92.79
<i>Acer saccharum</i>	2.77	66	22.84	0.00 - 65.89
<i>Tsuga canadensis</i>	1.11	44	18.56	0.00 - 55.19
<i>Carpinus caroliniana</i>	5.22	22	13.33	0.00 - 60.74
<i>Amelanchier arborea</i>	0.11	33	10.96	0.00 - 47.06
<i>Quercus rubra</i>	0.77	33	8.02	0.00 - 32.77
<i>Acer rubrum</i>	5.33	44	6.95	0.00 - 17.46
<i>Magnolia acuminata</i>	0.11	33	6.72	0.00 - 26.61
<i>Quercus prinus</i>	0.11	22	6.61	0.00 - 37.64
<i>Cornus florida</i>	2.22	44	5.63	0.00 - 17.65
<i>Oxydendrum arboreum</i>	0.77	11	5.26	0.00 - 47.31
<i>Betula lenta</i>	0.67	33	4.30	0.00 - 15.08
<i>Carya tomentosa</i>	0.22	11	3.32	0.00 - 29.93
<i>Liriodendron tulipifera</i>	0.67	22	3.01	0.00 - 13.92
<i>Carya cordiformis</i>	0.11	33	3.00	0.00 - 11.99
<i>Quercus velutina</i>	0.00	11	2.90	0.00 - 26.11
<i>Carya glabra</i>	1.00	22	2.10	0.00 - 11.91
<i>Fraxinus americana</i>	0.11	22	1.83	0.00 - 10.95
<i>Diospyros virginiana</i>	2.33	11	1.18	0.00 - 10.95
<i>Pinus strobus</i>	0.00	11	1.10	0.00 - 9.87
<i>Tilia heterophylla</i>	0.11	11	1.01	0.00 - 9.08
<i>Carya ovata</i>	0.00	11	0.86	0.00 - 7.71
<i>Platanus occidentalis</i>	0.22	0	0.00	0.00
<i>Prunus serotina</i>	0.55	0	0.00	0.00
<i>Sassafras albidum</i>	0.33	0	0.00	0.00
<i>Ulmus americana</i>	1.33	0	0.00	0.00

^aAverage stems/sample for understory = 31.71.

^bAverage stems/sample for overstory = 19.40.

TABLE XXXIX

SOIL-SITE CHARACTERISTICS OF THE BEECH-WHITE OAK-SUGAR MAPLE
FOREST TYPE. N=9.

Character	Range	Median	Mean + S.D.
Solum thickness (inches)	8.00 - 35.20	12.00	16.18 $\pm$ 11.13
Thickness of A (inches)	1.50 - 7.00	4.00	4.26 $\pm$ 2.32
Stone (per cent volume)	0.00 - 60.00	40.00	33.33 $\pm$ 25.98
Texture A	7.00 - 23.00 ^a	12.00	13.56 $\pm$ 6.95 ^b
Texture B	7.00 - 21.00	19.00	13.00 $\pm$ 7.92 ^b
Aspect	1.00 - 1.71	1.34	1.40 $\pm$ 0.21 ^c
Slope (per cent)	7.00 - 62.00	38.00	36.56 $\pm$ 22.12
Feet from draw	0.00 - 850.00	200.00	240.56 $\pm$ 252.22

^aLoamy sand to silt loam.

^bSandy loam.

^cNortheast.

same (except Betula lutea at Fall Creek Falls) as in the study area.

Soils are of variable thickness in the type dependent on stone content. A and B horizons are mostly sandy loam textures. Slopes are steep which accounts for the thin litter and rapid drainage.

Reproduction of dominant taxa, lack of understory xeric species, and lack of cutting disturbance within the past 40 years suggest stability. Low mean canopy height (54.44) can be accounted for by thin substrate and slow growth. Overstory density (19.4 stems per plot) and understory density (32 stems per plot) suggest youth, but a mean basal area of 11.23 ft² per plot indicates maturity.

This type can be expected to stabilize, barring disturbance, into a beech-sugar maple mesic community (white oak is not reproducing as well as the other present codominants).

White oak-beech type. This forest type occurs on the lower half of north-facing ridges and leads from 1,500 to an elevation of 1,600 feet. At this elevation it merges with the chestnut oak-white oak-beech type. White oak is dominant (comprising over one half of the stand) with beech, mockernut hickory, and northern red oak of secondary importance. Sourwood, pignut hickory, black walnut, and bitternut hickory are scattered throughout this type (Tables XL and XLI). Only 14 taxa compose this type, one of which is restricted to understory status. Three canopy taxa (northern red oak, black walnut, and bitternut hickory) lack representation in the understory. Nine taxa are rated mesic or submesic (Whittaker, 1956) indicating the effects of aspect and slope position. Dogwood and red maple are major understory taxa.

TABLE XL

COMPOSITION OF THE WHITE OAK-BEECH FOREST TYPE. N=4.

Taxa	Understory ^a		Overstory ^b	
	Absolute Density	Frequency	IV Mean	IV Range
<i>Quercus alba</i>	3.50	100	118.32	41.50 - 165.42
<i>Fagus grandifolia</i>	0.75	25	21.73	0.00 - 86.93
<i>Carya tomentosa</i>	0.50	75	19.01	0.00 - 26.01
<i>Quercus rubra</i>	0.00	50	17.38	0.00 - 20.31
<i>Oxydendrum arboreum</i>	2.75	75	7.40	0.00 - 20.13
<i>Carya glabra</i>	0.25	50	6.65	0.00 - 17.95
<i>Juglans nigra</i>	0.00	50	4.08	0.00 - 10.68
<i>Carya cordiformis</i>	0.00	50	3.93	0.00 - 8.37
<i>Acer saccharum</i>	4.25	25	3.70	0.00 - 14.80
<i>Acer rubrum</i>	14.50	25	3.54	0.00 - 14.17
<i>Liquidambar styraciflua</i>	1.00	50	2.36	0.00 - 4.78
<i>Cornus florida</i>	6.50	25	1.20	0.00 - 4.78
<i>Magnolia acuminata</i>	0.55	25	1.13	0.00 - 4.51
<i>Asimina triloba</i>	0.75	0	0.00	0.00

^aAverage stems/sample for understory = 35.25.^bAverage stems/sample for overstory = 27.06.

TABLE XLI
SOIL-SITE CHARACTERISTICS OF THE WHITE OAK-BEECH
FOREST TYPE. N=4.

Character	Range	Median	Mean + S.D.	
Solum thickness (inches)	8.00 - 22.00	16.00	15.50 ±	5.70
Thickness of A (inches)	2.50 - 4.00	3.50	3.38 ±	0.75
Stone (per cent volume)	0.00 - 30.00	22.50	11.25 ±	14.36
Texture A	18.00 - 21.00	18.00	18.75 ±	1.50 ^a
Texture B	16.00 - 21.00 ^b	20.50	19.50 ±	2.38 ^c
Aspect	1.45 - 1.94	1.92	1.81 ±	0.24 ^d
Slope (per cent)	4.00 - 45.00	9.00	16.75 ±	18.98
Feet from draw	100.00 - 700.00	412.50	406.25 ±	245.27

^aLoam.

^bClay to sandy clay loam.

^cSilty clay loam.

^dNortheast.

Martin (1966) found white oak-dominated communities on lower north slopes in the southern Cumberland Mountains, with chestnut oak, northern red oak, scarlet oak, beech, and sweet gum codominants. Braun (1950) described white oak-beech dominated, low elevation forests in the Cumberland Mountains. These forests, however, are usually south-facing and have a more equitable white oak-beech composition. A derivative of the white oak-beech segregate, the type within the study area appears to be similar to those white oak communities in the Ridge and Valley Province and the Allegheny Plateau and Mountains to the west (Braun, 1950). SAF type 52 white oak-red oak-hickory is quite similar to this type, especially in southeastern Pennsylvania where associates include pignut hickory, shagbark hickory, mockernut hickory, red maple, beech, and dogwood.

Sites of this type typically have shallow soil with thin A horizons and little stone. Slopes are moderately steep. A and B horizons have sandy loam to sandy clay loam textures, and the fines increase the amount of available water in the soil.

Mean understory density (35.25 stems per plot), mean overstory density (27.0 stems per plot), mean basal area of 16.77 ft² per plot, cutting between 1930 and 1950, and open canopy (canopy cover averages 36.25 per cent) suggest youth. The high canopy (averaging 61.25 feet) can be attributed to relict trees spared by loggers (certainly beech trees whose dbh ranged up to 34 inches can be considered as such). The reproduction of white oak suggests a continued dominant role within the type and future stabilization as a white oak dominated forest.

Chestnut oak-white oak-beech type. This type is found on steeper slopes and upper slope positions on northern ridges and draws between 1,400 and 2,040 feet. Chestnut oak, white oak and beech are codominant; hemlock, mockernut hickory, and tulip poplar are associated throughout the type. Buckeye, red hickory, sourwood, black oak and red maple have uneven distribution with Virginia pine expressed only on ridge crests and sandy sites with greatest exposure (Tables XLII and XLIII). Of the 25 taxa in this type, eight are restricted to the understory and five have only overstory status. Seven taxa are xeric in nature (Whittaker, 1956); however, four others (hemlock, beech, post oak, and shagbark hickory are characteristic of xeric sites within the basin. Red maple is the most numerous understory taxon.

Type 44 chestnut oak (Society of American Foresters, 1964) resembles this type. It occurs on thin soils from southern New England to Georgia and Alabama. Although it is permanent in some localities, it often follows clearcutting in types containing a mixture of red oak and chestnut oak. Braun (1950) describes a faciation of the oak-chestnut forest in which chestnut oak totally replaces chestnut and mixed mesophytic indicator taxa are absent or occasional. Lipps (1966) described a chestnut oak-dominated forest in north central Georgia; however, this type had a much drier aspect than does the basin type.

Forest sites are typically steep with stone content ranging from 0 to 90 per cent. Large boulders are scattered over the slopes. Mineral soil is shallow as is the A horizon. Soil textures range

TABLE XLII

COMPOSITION OF THE CHESTNUT OAK-WHITE OAK-BEECH
FOREST TYPE. N=6.

Taxa	Understory ^a Absolute Density	Fre- quency	Overstory ^b	
			IV Mean	IV Range
<i>Quercus prinus</i>	1.33	66	55.13	0.00 - 117.21
<i>Quercus alba</i>	1.17	83	33.51	0.00 - 51.78
<i>Fagus grandifolia</i>	0.67	83	32.60	0.00 - 51.69
<i>Tsuga canadensis</i>	1.33	38	11.39	0.00 - 68.32
<i>Carya tomentosa</i>	0.50	50	10.13	0.00 - 25.15
<i>Liriodendron tulipifera</i>	1.33	33	9.31	0.00 - 30.59
<i>Quercus velutina</i>	0.00	17	7.61	0.00 - 45.65
<i>Acer rubrum</i>	9.33	17	3.59	0.00 - 21.53
<i>Aesculus octandra</i>	0.00	33	3.53	0.00 - 11.46
<i>Carya glabra</i>	0.33	33	3.00	0.00 - 10.14
<i>Carpinus caroliniana</i>	1.33	33	2.98	0.00 - 9.57
<i>Quercus rubra</i>	0.00	17	2.89	0.00 - 17.32
<i>Oxydendrum arboreum</i>	1.00	33	2.15	0.00 - 7.02
<i>Sassafras albidum</i>	1.00	33	2.15	0.00 - 7.02
<i>Carya ovata</i>	0.00	17	1.84	0.00 - 11.07
<i>Fraxinus americana</i>	0.00	17	1.41	0.00 - 8.44
<i>Liquidambar styraciflua</i>	0.00	17	1.33	0.00 - 7.98
<i>Carya cordiformis</i>	0.17	0	0.00	0.00
<i>Pinus virginiana</i>	0.67	0	0.00	0.00
<i>Betula lenta</i>	0.17	0	0.00	0.00
<i>Cornus florida</i>	1.50	0	0.00	0.00
<i>Pinus strobus</i>	0.33	0	0.00	0.00
<i>Quercus stellata</i>	0.17	0	0.00	0.00
<i>Acer saccharum</i>	1.33	0	0.00	0.00
<i>Amelanchier arborea</i>	0.67	0	0.00	0.00

^aAverage stems/sample for understory = 17.83.

^bAverage stems/sample for overstory = 24.33.

TABLE XLIII

SOIL-SITE CHARACTERISTICS OF THE CHESTNUT OAK-WHITE OAK-BEECH
FOREST TYPE. N=6.

Character	Range	Median	Mean + S.D.
Solum thickness (inches)	10.00 - 22.00	12.00	14.60 $\pm$ 5.90
Thickness of A (inches)	1.00 - 6.00	3.80	3.27 $\pm$ 1.81
Stone (per cent volume)	0.00 - 40.00	20.00	21.67 $\pm$ 16.02
Texture A	8.00 - 21.00 ^a	16.00	15.17 $\pm$ 6.55 ^b
Texture B	17.00 - 21.00	19.00	18.83 $\pm$ 1.72 ^c
Aspect	1.00 - 1.98	1.97	1.65 $\pm$ 0.50 ^d
Slope (per cent)	27.00 - 55.00	46.00	43.00 $\pm$ 11.76
Feet from draw	50.00 - 1,150.00	150.00	312.50 $\pm$ 420.63

^aSandy clay to sandy clay loam.

^bClay.

^cSilty clay.

^dNortheast.

from loamy sand on ridge crests to sandy clay loams downslope and in the B horizon. Drainage is doubtless rapid both overland and internally.

These forest stands are young as evidenced by recent stumps and dense over and understories (17.83 and 24.33 stems per acre, respectively). Low canopy height can be attributed to recent cutting and slow growth rates due to drought on the site. Reproduction suggests that stabilization will occur as a chestnut oak or mixed oak-hickory community.

Chestnut oak-northern red oak type. South-facing mountain ridges within the sample area are forested by this type. Elevation of the type varies from 1,400 to 2,000 feet. Together, chestnut oak and northern red oak make up over one half of this forest. Associated taxa are white oak, sourwood, and Virginia pine on xeric sites; red maple, white ash, and hornbeam occur on more mesic sites. Red maple, dogwood, and chestnut oak dominate the understory (Tables XLIV and XLV). Twenty-five taxa comprise the type with seven taxa rated xeric or subxeric (Whittaker, 1956). There is a heavy ericaceous shrub layer.

This type is a variant of type 44 chestnut oak (Society of American Foresters, 1964), but equal dominance by two taxa as dissimilar as chestnut oak and northern red oak is not usual, nor is it expected. It appears in no other description except as possibly the result of chestnut replacement by these taxa. Braun (1950) describes an oak-chestnut forest in which chestnut was associated with both chestnut oak and northern red oak in low elevation (below 2,000 feet) stands in the oak-chestnut forest region.

TABLE XLIV

COMPOSITION OF THE CHESTNUT OAK-NORTHERN RED OAK
FOREST TYPE. N=9.

Taxa	Understory ^a		Overstory ^b		
	Absolute	Density	Fre- quency	IV Mean	IV Range
<i>Quercus prinus</i>	3.78		55	65.88	0.00 - 156.86
<i>Quercus rubra</i>	1.11		66	53.69	0.00 - 178.72
<i>Quercus alba</i>	1.22		42	19.92	0.00 - 65.45
<i>Oxydendrum arboreum</i>	1.11		55	9.53	0.00 - 11.89
<i>Pinus virginiana</i>	0.22		11	6.80	0.00 - 61.23
<i>Acer rubrum</i>	5.89		42	5.60	0.00 - 32.55
<i>Fraxinus americana</i>	0.11		22	5.35	0.00 - 34.69
<i>Carya cordiformis</i>	0.00		33	5.24	0.00 - 18.70
<i>Prunus serotina</i>	0.33		22	4.96	0.00 - 26.08
<i>Carpinus caroliniana</i>	0.44		22	4.82	0.00 - 22.71
<i>Quercus stellata</i>	0.22		11	3.73	0.00 - 33.57
<i>Carya tomentosa</i>	0.55		22	3.48	0.00 - 17.18
<i>Carya ovata</i>	0.00		22	3.38	0.00 - 18.58
<i>Pinus echinata</i>	0.11		11	3.10	0.00 - 27.89
<i>Pinus strobus</i>	0.11		11	2.88	0.00 - 25.93
<i>Carya glabra</i>	0.11		22	2.41	0.00 - 11.35
<i>Cornus florida</i>	3.88		33	2.32	0.00 - 7.79
<i>Liriodendron tulipifera</i>	0.00		11	2.07	0.00 - 18.66
<i>Juglans nigra</i>	0.00		11	1.42	0.00 - 12.79
<i>Quercus marilandica</i>	0.22		11	1.35	0.00 - 12.19
<i>Acer saccharum</i>	0.00		11	0.65	0.00 - 5.82
<i>Betula lenta</i>	0.22		0	0.00	0.00
<i>Liquidambar styraciflua</i>	0.44		0	0.00	0.00
<i>Cercis canadensis</i>	0.88		0	0.00	0.00
<i>Aesculus octandra</i>	0.11		0	0.00	0.00

^aAverage stems/sample for understory = 20.11.

^bAverage stems/sample for overstory = 18.11.

TABLE XLV

SOIL-SITE CHARACTERISTICS OF THE CHESTNUT OAK-NORTHERN RED OAK
FOREST TYPE. N=9.

Character	Range	Median	Mean + S.D.
Solum thickness (inches)	14.80 - 24.00	18.00	18.98 $\pm$ 2.86
Thickness of A (inches)	1.00 - 5.00	3.00	2.67 $\pm$ 1.22
Stone (per cent volume)	10.00 - 50.00	30.00	34.44 $\pm$ 14.01
Texture A	12.00 - 20.00	17.00 ^a	14.67 $\pm$ 3.39
Texture B	12.00 - 21.00 ^b	12.00 ^c	13.89 $\pm$ 3.76
Aspect	0.43 - 0.82	0.71	0.70 $\pm$ 0.13 ^d
Slope (per cent)	19.00 - 56.00	35.00	39.11 $\pm$ 12.72
Feet from draw	50.00 - 1,600.00	170.00	377.22 $\pm$ 497.66

^aFine sandy loam.

^bSandy loam to sandy clay loam.

^cSandy loam.

^dNorthwest - Southeast.

Sites of this forest are usually steep with shallow soils and extremely thin A horizons. Soil textures are mostly sandy to fine sandy loams with much stone in the profile. Drainage is believed to be quite rapid.

Cutting since 1930 stimulates red oak growth (Beck, 1970) and suggests youth, but plot densities are somewhat low for basin forests (20.11 stems per plot understory and 18.11 stems per plot overstory) suggesting a stable forest. Mean canopy height (55.56 feet) and a mean basal area of 10.16 ft^2 per plot could be the result of slow growth rates. These plots had an average of four chestnut stumps or snags per plot indicating former chestnut prominence. All these suggest current stability and reproduction of forest dominance, not to mention effects of chestnut replacement on stand composition.

Discussion. Basin forests are in a stage of flux. Forest composition has been disturbed many times in the past 70 years. The death of chestnut trees eliminated up to one quarter of the canopy trees in the Cumberland Mountains (Braun, 1950); such opening of the forest results in re-establishment of dominance among existing trees. In chestnut oak communities within the study area, the effects of this replacement are apparent. Effects in other types are not possible to deduce.

Continued logging and strip mining operations have also affected forest composition. Removal of prime timber by clear cutting methods has resulted in dense growth and unstable forest types. Many of the forest types appear to be influenced by cutting. Other than the obvious effect of removing forests prior to opening the strip mine, spoil banks have covered or partially destroyed forested areas

within the basin. Although these areas were avoided in sampling, the scrub oak and pine vegetation that has resulted is similar to that growing on the driest gorge rim sites.

Residual trees (those spared in logging operations due to bole defect) are commonplace, but these are not of great size. Diameters rarely exceed 10 inches except on steep slopes, on moist sites, or in inaccessible areas. Although the forest has been cut severely and burned in various places, from the density and basal area measures, we have seen that less undisturbed forests exhibit less change and may be approaching stability. The basin appears to be transitional between the Mixed Mesophytic Forest Region, the Western Mesophytic Forest Region, and the Oak-Chestnut Forest Region. There appears to be a truly drought-tolerant sugar maple within the basin, hemlock grows on most sites (as does white oak), pines are not confined to dry sites (due especially to cutting) and forest types are present which appear to be stable yet have no counterpart in the Mixed Mesophytic Forest Region.

As a measure of forest composition, the importance value (relative density plus relative basal area) allows the researcher to rank taxa on the basis of plot dominance; to compare plots of similar aspect, slope position, and site; and, to piece the landscape together by discrete type. However, as has been shown above, these types are not truly discrete but can be seen in terms of a "continuum" (Curtis and McIntosh, 1951) in which expression of dominants is related to microclimate and water regime. Succession is not static, neither are climax forests, for as trees die or fall, new openings

are available for new taxa. Patterned landscapes are often changing landscape--as is the land of the Big South Fork.

Environment and Vegetation Comparisons by Correlation

Linear correlations between vegetation, soil, and topographic parameters were examined to determine which factors were mutually associated. Simple correlations point out relationships between landscape features, of which some are casual.

Soils, just as the vegetation, are an integrator of all factors--geologic, biotic, topographic, physiographic, climatic--which have acted within the area through time (Jenny, 1941). Therefore, separation and quantification of solum and vegetation characteristics prove useful in ascertaining kinds and degrees of relationships existing within the system. Causality is not necessarily implied. Relationships of soil and site properties are usually considered independent variables influencing vegetation. However, these properties interact and thus are not truly independent. Results of this study show this well.

Three topographically diverse areas are grouped together in the correlation analyses. Thus, mountains, plateau surface, and gorge which have somewhat different lithology, topography, soil development, elevations, and microclimates may lose characteristics and casual relationships when grouped. Nevertheless the basic similarities argue for examination of the correlations. It is my assumption that the landscape surfaces involved are old and that many equilibria have developed: deeper, more clayey, less stony, more organic soil down slope, for example.

Among site on site correlations, elevation groups all plots into a continuous linear series, hence higher elevations (negative on slope angle, Table XLVI) show the effects of gentler upper gorge and plateau surface slopes. The convex rounding of upper gorge slopes and plateau surface also appears as positive vertical form. The gradual decrease upward in sharpness of lateral ridges and draws appears as negative height or depth of ridge or draw and negative width of ridge or draw. Sandier soils upwards are suggested by negative available water on elevation.

Aspect's negative relation to height or depth of ridge or draw and height/width ratio suggests that south facing lateral ridge-draw systems are best developed.

As explained in Methods, feet from draw means overland distance to drainage measured to separate low areas in the gorge, on the plateau, or in the mountains. Plateau and upper gorge slopes include lower angles, hence steep slope angle is negative on feet from draw (slope position). Upper slope positions, then, are negative on the distance to the opposite ridge (protection).

Vertical form, coded toward convex, being negative on protection angle, lower on high slopes, follows from the above. High slope position (feet from draw) also increases with distance from adjacent ridge (positive on protection distance.) High slope position's positive relation to width of topography appears to be the opposite of negative elevation on width.

Protection angle and distance (low angle and great distance on high slopes) is logically positive on height of lateral ridge or depth of lateral draw and height/width.

TABLE XLVI

SIMPLE LINEAR CORRELATIONS AMONG SITE VARIABLES. N=277.

Site Variables	EL A	S%	LF	VF	FD	PD	PD	H/D	W	H/W	AW
Elevation (EL)		-0.14*	0.16*	0.20**	-0.39**	0.41**	-0.16*	-0.25**			-0.16*
Aspect (A)								-0.19*		-0.16*	
Slope % (S%)					-0.29**		-0.26**				
Lateral form (LF)				0.65**							
Vertical form (VF)						-0.14*					
Feet from draw (FD)						-0.26**	0.32**		0.24**		
Protection angle (PA)							-0.41**	0.28**		0.33**	
Protection distance (PD)											
Ht./Depth of R/D (H/D)									0.29**	0.52**	
Width of R/D (W)										-0.26**	
Height/Width Ratio (H/W)											-0.16*

*Significant at P = 0.05.

**Significant at P = 0.01.

Lateral ridge height or draw depth and height/width correlations are rational as is the latter's correlation to available water (based upon soil texture and stone content).

Simple linear correlations among soil variables were few (Table XLVII). The expected textural correlation between A and B appeared as does the relation: increased stone with increased sandy soil. Also appearing is the negative relation of stoniness to solum depth and the positive relation of the latter to thickness of the A. Litter relations are of interest: depth is greater with a thicker A (lower slopes), on stonier profiles (less contact with decay organisms), with more types, and with a sandy B (negative) (cf. McCracken, Shanks, and Clebsch, 1962). The interaction of soil and site variables is of great interest (Table XLVII). Elevation, which is in most plots a function of slope position shows negative correlations with litter depth, probably a function of lower productivity on more exposed upper slopes, solum depth, thickness of the A and stone percentage. The depth and thickness are no doubt colluvial (also reported downslope by Franzmeier, et al., 1969) and downslope stoniness must be colluvial also; this also reported by Franzmeier, et al., (1969). The positive relation of thickness of A on aspect (positive on north east) is also reported by Franzmeier, et al. (1969), and suggests accelerated downslope movement and thus thinner soils on south slopes. Down-slope colluvial stone is also supported by: slope angle (lower slope position) on stone percentage. Slope angle positive on litter depth suggests a steep slope--low position correlation (Table XLVIII). The negative relation of A thickness and vertical form suggests draw soils are deeper than

TABLE XLVII
SIMPLE CORRELATIONS AMONG SOIL VARIABLES. N=277.

Soil Variables	LT	LD	SD	TH.A	St%	TA	TB
Litter type (LT)							-0.15*
Litter depth (LD)				0.22**	0.20**		
Solum depth (SD)				0.43**	-0.31**		
Thickness A (TH.A)							
Stone % (St%)							-0.14*
Texture A (TA)							0.63*
Texture B (TB)							

*Significant at $p = 0.05$.

**Significant at $p = 0.01$.

TABLE XLVIII
SIMPLE CORRELATIONS OF SOIL-SITE VARIABLES

Site	LT	LD	SD	Th.A	St%	TA	TB
Elevation		-0.34**	-0.14*	-0.35**	-0.30**		
Aspect				0.20**			
Slope %		0.27**			0.24**		
Lateral Form							
Vertical Form				-0.15*			
Feet from Draw			-0.15*		-0.17*		
Protection Angle		0.23**	0.14*		0.37**		
Protection Distance		-0.21**		-0.15*	-0.20**		
Height/Width Ratio							-0.16*
Available Water			0.41**	0.73**	-0.47**	0.48**	0.27**

*Significant at P = 0.05.

**Significant at P = 0.01.

LT = Litter type; LD = Litter depth; SD = Solum depth; Th.A = Thickness of A; St% = Stone %; TA = Texture A; TB = Texture B.

ridge soils. High protection angle here means low slope (gorge) position, hence the positive relations to humus depth solum depth and stone percentage. The negative relation of protection distance to humus depth, thickness of A and stone percentage suggests this expresses an upper slope position effect. Height or depth/width ratio being negative on B texture suggests that steep sided ridges and draws are less likely to accumulate clay in the B than shallower slopes. Available water correlations (positive and negative), are to be expected from clayey A and B (positive), stone per cent (negative), and increasing elevation (negative), thick A and deep solum (positive).

The correlation of soil and site to vegetation variables reveals significant findings (Table XLIX). Litter depth is related to many vegetation variables positively--these probably a function of greater production and litter input; a thick A probably supports high plot density and overstory basal area. The relation of stone volume to vegetation is doubtless its confounding with slope position, solum depth and A thickness. The relation of the texture of A and B to understory density (positive) and shrub-vine-tree seedling cover (negative) is obscure. In the first case, no doubt water availability is operating, but if so, it should also do so for other density measures. In the second case, high shrub-vine cover on low site positions and/or low cover on high positions are suggested. The exposure with higher elevations causing negative density and other relationships through drought is to be expected. Positive correlation of north aspect to both increased density and basal area is

TABLE XLIX

SIMPLE LINEAR CORRELATIONS BETWEEN SOIL-SITE AND VEGETATION VARIABLES. N=277.

Soil-Site	PDU	PDO	TPD	TPBA	THP	HC%	HSP.	S-V-TS%	S-V-TS Sp.
Litter type									
Litter depth	0.31**	0.21**	0.32**		0.23**	0.18*		0.14*	
Solum depth									
Thickness A	0.21**	0.15*	0.22**	0.22**					
Stone %	0.18*		0.18**		0.25**	0.28**	0.17*		
Texture A	0.14*								
Texture B									-0.14*
Elevation	-0.34**	-0.15*	-0.32**		-0.26**	-0.23**	-0.28*		
Aspect		0.17*		0.30**					
Slope %					0.20**		0.16*	0.20**	
Lateral form									
Vertical form									
Feet from draw				-0.15*	-0.17*		-0.20**		
Protection angle	0.14*	0.16*	0.16*		0.18**	0.16*	0.25**		
Protection distance	-0.22**		-0.20**		-0.35**	-0.24**	-0.26**	-0.22**	
Ht./Depth of R/D									
Width of R/D	0.24**		0.24**		0.17*	0.17*			
Height/width ratio									
Available water	0.16*		0.17*	0.20**					

*Significant at $p = 0.05$.**Significant at $p = 0.05$.

PDU = Plot understory density; PDO = Plot overstory density; TPD = Total plot density; TPBA = Total plot basal area; THP = Total herbs/plot; HC% = Herb cover per cent; HSP = Herb species; S-V-TS% = Shrub-vine-tree seedling cover %; S-V-TS Sp. = Shrub-vine-tree seedling species.

Simple linear correlations between the IV 200 of selected taxa and soil, site, and vegetation variables show many effects (Table L). Some of these relationships also appear in the multiple regression discussed later. Significant relationships of sugar maple suggest that, regarding moisture, draw position (positive height or depth/width) outweighs the negative (thin) A effect. The deep shade it casts probably causes low understory density (this causing low plot density). Low canopy height is not understood.

The good correlations of river birch are related to its virtual restriction to the gorge bottom floor plain and terrace. Even so, several are not understood: negative on canopy cover, positive on protection distance and north (positive) aspect. Positive width of ridge-draw apparently means the gorge terrace was wider than most side slope ridges and draws. Beech's relation to A texture suggests less sand in lower slope positions, but if so, then such positions are more often flat to convex than concave. Tulip poplar's negative relation to slope steepness denies slope position (lower slopes are steepest) but its positive relation to available water suggests it.

Virginia pine occurs widely over most elevations and aspects in the area. It is most important, however, on upper slopes (positive on feet from draw and protection distance), on shallow slope angles (negative), and on major side ridges (positive on height and width of ridge). Fire was often observed but the trees respond to the water in the less stony soils by good height growth, but as in most pine stands, herb taxa were few.

TABLE L

SIMPLE LINEAR CORRELATIONS OF SOIL-SITE-VEGETATION VARIABLES WITH I.V. 200
OF SELECTED TAXA

Variables	AS N=91	BN N=15	FG N=88	LT N=97	PE	PV N=14	QA N=213	QP N=89	QR N=96	TS N=69
Litter type										0.26*
Litter depth		0.53*					-0.16*	-0.28**		-0.28*
Solum depth		0.54*					-0.20**			
Thick. A	-0.22*	0.73**					-0.16*			
Stone %										
Texture A			0.24*				0.14*		-0.27**	
Texture B							0.20**			
Elevation		-0.67**						0.56**		
Aspect		0.78**					-0.14*			0.27*
Slope %				-0.27**		-0.27*				
Lateral Form			0.22*						0.22*	
Vertical Form										
Feet from draw						0.38**			0.23*	
Protection angle							-0.18**			
Protect. distance		0.64*				0.66**		0.36**		
Ht. or dpth. of R/D						0.23*	-0.14*			
Height/Width ratio	0.22*						-0.14*			
Width of R/D		0.62*				0.30*		-0.29**		
Available water				0.34**		0.24*				
Fire						0.27*				
Blowdown										
Cutting							-0.14*	-0.33**		0.30*
Canopy cover		-0.60*					-0.17*			0.32*
Canopy height	-0.22*					0.32**	-0.18**	-0.32**		0.13*

TABLE L (continued)

Variables	AS N=91	BN N=15	FG N=88	LT N=97	PE	PV N=14	QA N=213	QP N=89	QR N=96	TS N=69
Plot dens. under.	-0.33**						-0.27**	-0.25**		
Plot dens. over.									-0.23*	
Total plot density	-0.32**						-0.30**	-0.26**		
Total plot B.A.							-0.28**			
Total herbs/plot										-0.28*
Herb cover%							0.17*			-0.31*
No. herb spp.						-0.37**				
S-V-TS cover %										
S-V-TS spp. no.										

AS = Acer saccharum; BN = Betula nigra; FG = Fagus grandifolia; LT = Liriodendron tulipifera; PE = Pinus echinata; PV = Pinus virginiana; QA = Quercus alba; QP = Quercus prinus; QR = Quercus rubra; TS = Tsuga canadensis.

*Significant at $p = 0.05$.

**Significant at $p = 0.01$.

The most abundant hardwood in the study area was white oak. It was dominant in 77 per cent of the plots. Usually its stands were not recently cut, but canopy cover and height were low, understory and total density were low; basal area was low, but herb cover was relatively high. Stands were on gentle south aspect side slopes especially on mid to high positions (negative protection angle). Humus, solum, and A depths were low, but low sand A and B favor white oak growth.

Chestnut oak was not as recently cut as other taxa, probably because of low density at times of cutting. Its greatest importance was on upper (positive protection, distance and elevation) narrow leads (negative ridge-width). Wind and gravity removal of litter or low site production resulted in low (negative) litter depth.

Correlations of northern red oak scarcely help in understanding this taxon: low (negative) plot density, upper slope positions on ridges on sandy A horizon soils.

Stands with hemlock had, as reported by Braun, little herb cover (negative) and a mor humus of shallow depth (less than 0.8 inches compared to about 1.5 inches reported under a stable hemlock stand in the Smoky Mountains by McGinnis, 1958). Cutting evidence was present but not recent, percentage closure and canopies were high, and importance increased on northern aspects.

Examination of the correlation matrices is a tool to verify or deny information acquired from the literature or from personal observation. Within non-homogeneous areas, such as the study area, it becomes rather difficult to separate or evaluate significant r

values unless one has benefit of field experience. Confounding of correlation exists between variables which are not truly independent. This, at best, indicates environmental interrelation. This interrelatedness is, however, partially masked by not separating the study area into homogeneous groups. The problem area of this study was treated as a unit, because of underlying unity of lithology, microclimatic variance, and vegetation.

Field observations of the Big South Fork area as a whole were borne out by the simple correlations. Protection, aspect, slope steepness, colluvial stoniness, and soil textures were assumed, at first, to be independent for analysis purposes. Their interrelation on the landscape was affirmed by the large number of significant correlations.

Stepwise Multiple Regression Analysis

Ten important forest overstory tree taxa were selected for examination using multiple regression techniques to relate soil and site variables to the importance value (IV 200), relative basal area (RBA), and relative density (RD) of each taxon. All effects of variables were assumed to be linear and additive for regression analyses. The equation selected includes independent variables contributing 1 per cent or more to R^2 .

This technique has also been used by Martin (1966), who used absolute density and basal area per taxon as independent variables. While his study was also conducted in primarily secondary Cumberland Mountain vegetation, his sample number (199) was smaller and evenly distributed in north- and south-facing ridges and draws. His plot

size (1/5-acre) was larger than that used in the present study.

The independent variables selected by the computer for inclusion in the IV equations are often ones which have been previously noted as with significant linear correlations. The reason for the differences are seldom apparent.

The absolute restriction of river birch to the gorge bottom is well borne out in the equations below:

$$1. \text{ RBA} = 20.306 + 0.00081X_{14} - 0.3113X_7 - 0.7143X_9 + 1.351X_3 - 10.571X_2 - 0.25X_{10}$$

$$R^2 = 0.987; \quad \bar{Y} = 9.586; \quad \text{S.E.E.} = 0.0801$$

$$2. \text{ RD} = -13.430 + 0.00112X_{14} - 0.5246X_7 - 0.488X_5 + 0.1883X_{15} + 16.823X_8 + 0.24363X_{13} + 0.0245X_6$$

$$R^2 = 0.984; \quad \bar{Y} = 5.708; \quad \text{S.E.E.} = 1.01$$

$$3. \text{ IV} = -11.564 + 0.00201X_{14} - 0.601X_7 - 0.234X_9 - 0.0304X_{10} + 5.889X_3 - 0.1726X_5 - 44.365X_2 + 0.1389X_{15}$$

$$R^2 = 0.985; \quad \bar{Y} = 15.29; \quad \text{S.E.E.} = 0.188$$

In each equation above, variables X_{14} (high protection angle) and X_7 (sandy soil in the B) account for 60 to 70 per cent of the variation. Southerly aspect (negative X_9), deeper solum (positive X_3), thin humus (negative X_2), and low slope angle (negative X_{10}) appear in two equations. The solum depth effect is obvious but litter depth and aspect are not. Fewer stones (negative X_5) may well result in more available moisture and higher stand density, but greater protection distance (positive X_{15}) is less understood. The latter variable, however, accounted for only 3.5 per cent of the variation in importance value. Increased relative density is also positively correlated

to clayey soil (positive X_6), but elevation and distance from draw (in this case the river) (positive X_8 and X_{13}) are not fully understood unless one considers the relatively narrow elevation band these stands occupy. In general, most of the above independent variables are characteristics of the very special gorge bottom site and are not necessarily thought to limit river birch universally. Few of them (only three of them) appeared also as significant correlations. Aspect in particular is perplexing (negative, south facing) in the correlations and positive here (north) in this I.V. regression. The river birch-sycamore forest cover type (S.A.F., 1964) is widely distributed in eastern United States and this birch is a dominant in seasonally flooded forests on the Plateau surface and elsewhere in Tennessee.

Sugar maple occupies a broad range of sites as the equations below point out:

$$1. \text{ RBA} = 23.981 - 2.0058X_3 - 0.717X_9 + 12.042X_2 - 0.311X_{10} + 2.533X_8$$

$$R^2 = 0.2051; \quad \bar{Y} = 13.80; \quad \text{S.E.E.} = 9.2037$$

$$2. \text{ RD} = 20.416 - 0.43977X_{10} - 1.6355X_3 - 0.06655X_4 - 0.42617X_9 + 0.44672X_{12} + 6.9661X_2 + 1.3913X_8$$

$$R^2 = 0.2187; \quad \bar{Y} = 10.11; \quad \text{S.E.E.} = 8.2486$$

$$3. \text{ I.V.} = 44.311 - 3.6278X_3 - 0.7489X_{10} - 1.1413X_9 + 18.893X_2 + 3.9453X_8 - 0.10272X_4 + 0.8696X_{12}$$

$$R^2 = 0.2343; \quad \bar{Y} = 23.90; \quad \text{S.E.E.} = 16.0434$$

Variables X_3 (shallow solum depth), X_9 (negative, therefore more southerly aspect), X_2 (positive, therefore thicker humus), X_{10} (less steep slopes), and X_8 (increasing plot elevation) appear in

all equations. They account for 74 per cent of the explained R^2 . Convex vertical plot form (positive X_{12}) and thin A horizon (negative X_4) are found in relative density and importance value equations only. These variables place sugar maple at middle elevations, on slopes with thin solum and southerly aspect but accounted for about 20 to 23 per cent of the variability between plots. None of the above variables were significantly correlated with sugar maple I.V. In fact, the correlation height or depth/width interpreted as a concavity is in the regression positive (meaning flat to convex). The discrepancy is not understood. The usual rating of sugar maple as a mesophyte (Braun, 1950; Whittaker, 1956) is supported here by inclusion of low site slope angle, deep humus, low soil stone percentage, and upper elevations (in the mountains, at least, with perhaps more precipitation). This mesophytism is not supported by shallow solum and thin A horizon, convex upslope form, and southerly aspect. A drought tolerant southern ecotype is proposed by Kriebel (1957). Certainly its root aeration requirement (Fowells, 1965) is supported by these factors. Nothing measured here contributes to our understanding of its shade tolerance. The southern aspect relation, in particular, may be the result of a bias incorporated by transforming aspect in degrees to values from 0.00 to 2.00. The axis shift from south-north to southwest-northeast increased the number of plots with "southern exposures" (i.e., 0.00 to 1.00).

American beech, too, occupies a wide range of sites as indicated by the equations below:

$$1. \text{ RBA} = 24.035 - 2.0776X_3 - 0.7176X_9 + 11.335X_2 + 2.693X_8 - 0.30959X_{10}$$

$$R^2 = 0.2055; \quad \bar{Y} = 13.7198; \quad \text{S.E.E.} = 9.3794$$

$$2. \text{ RD} = 20.481 - 0.4448X_{10} - 1.7356X_3 - 0.0649X_9 + 0.5699X_{12} \\ + 0.00182X_{15} + 1.608X_8 - 0.3613X_9 \\ R^2 = 0.2346; \quad \bar{Y} = 10.0684; \quad \text{S.E.E.} = 8.0812$$

$$3. \text{ I.V.} = 44.382 - 3.8019X_3 - 0.7524X_{10} - 1.0829X_9 + 4.2872X_8 \\ + 17.265X_2 - 0.0999X_4 + 1.0771X_{12} \\ R^2 = 0.2342; \quad \bar{Y} = 23.7883; \quad \text{S.E.E.} = 16.0688$$

Variables X_3 (shallow solum depth), X_8 (increasing plot elevation), X_9 (southerly aspect), and X_{10} (decreasing slope steepness) are common to all three equations. Shallow solum and low slope per cent account for about one half of the variation between plots in relative density and importance value. Plot elevations (at least in the mountains where precipitation is increased) and increasing low slope angle supports the usual ranking of beech as a mesophyte but shallow solum does not. Its sensitivity to drought (Fowells, 1965) argues against its importance on southerly aspect as does shallow A (negative X_4) and convex slope (positive X_{12}), shallow solum (negative X_3), and increased distance to protection (positive X_{15}). These results are in contrast to those of Frazer (1954), Whittaker (1956), and mid-western ecologists, who rate beech as a mesophyte, and are more suggestive of the statement of Braun to the effect that beech is less an indicator of mesic conditions than usually thought (personal communication with H. R. DeSelm, August, 1970). Of the two significant site-soil correlations with beech (Table XLIX, page 120) only lateral form (convex) appears in the equation. Virtually an entirely new set of variables appeared for no apparent reasons.

Martin (1966) predicted 11 to 16 per cent of beech density and basal area variation; north aspect, low slope angle, and upper slope position were the independent variables of significance.

Tulip poplar is one of the more important mesophytic trees within the study area. Its equations are as follows:

$$1. \text{ RBA} = 9.3635 + 19.881X_2 - 0.87395X_9 + 0.049872X_7 - 0.71254X_3$$

$$R^2 = 0.2027; \quad \bar{Y} = 15.2363; \quad \text{S.E.E.} = 11.2554$$

$$2. \text{ RD} = 6.8042 + 15.365X_2 + 0.076X_7 - 0.6209X_9 - 0.214X_{10} + 0.03695X_5$$

$$R^2 = 0.2059; \quad \bar{Y} = 11.5132; \quad \text{S.E.E.} = 9.8946$$

$$3. \text{ I.V.} = 16.281 + 35.172X_2 - 1.4944X_9 + 0.12599X_7 + 2.2277X_8$$

$$R^2 = 0.2114; \quad \bar{Y} = 26.7495; \quad \text{S.E.E.} = 20.0139$$

Variables X_2 (thick humus), X_7 (low sand B), and X_9 (southerly aspect) are common to all three equations where they account for 18 to 20 per cent of the variation among plots. One per cent of the variation in relative basal area is accounted for by thin solum (negative X_2); large stone volume (positive X_5) and decreasing slope per cent (negative X_{10}) are restricted to the relative density equation. Increasing plot elevation (positive X_8) is found only in the importance value equation where it accounts for less than 1 per cent of the variation among plots.

The significant correlations low slope angle does not appear in the I.V. equation here but available water as calculated from texture and stone content does. Martin's equations accounted for 34 to 41

per cent of the variations and thick A horizon, upper slope, north aspect, and high pH contributed to the R^2 .

In the equations above, tulip poplar's relative mesophytism (Fowells, 1965) is supported only by the less sandy B, low slope angle, and (in mountain samples) high elevation. South aspect, shallow solum, and increased stoniness are not supported in correlative research on growth by Della-Bianca and Olson (1961), Hebb (1962), Smalley (1969), Phillips (1966), Auten (1945), and others. Shallow solum and stones above are confounded with low slope position. Increase in tulip poplar with opening (Trimble and Hart, 1961; Merz and Boyce, 1958; Ward, 1966) is not supported by the non-significant plot density or poplar relative density.

Northern red oak is another of the mesophytic taxa within the study area. Its equations are below:

1. $RBA = 8.6405 + 21.263X_2 - 0.9336X_9 + 0.0558X_7$
 $R^2 = 0.2078; \quad \bar{Y} = 15.2316; \quad S.E.E. = 11.2625$
2. $RD = 6.9425 + 15.151X_2 + 0.05199X_7 - 0.6118X_9 - 0.21834X_{10}$
 $R^2 = 0.1863; \quad \bar{Y} = 11.3778; \quad S.E.E. = 9.9508$
3. $I.V. = 15.685 + 36.294X_2 - 1.5443X_9 + 0.1306X_7$
 $R^2 = 0.2042; \quad \bar{Y} = 26.6095; \quad S.E.E. = 19.9634$

Variables X_2 (thick humus), X_7 (clayey B) and X_9 (more southerly aspect) are common to all equations where they comprise from 90 to 100 per cent of the total variation accounted for among plots. Gentler slopes (negative X_{10}) are found only in the relative density equation. The effects of thick humus and increased clay fractions are understood. Correlation variables of significance (Table XLIX, page 120) and those used in the I.V. equations above were entirely

different for reasons not clear. Martin's northern red oak equations accounted for 11 to 17 per cent of variation in density and basal area. A thick A horizon, steep slopes, upper slope positions and clay in the B horizon occurred in those equations.

Litter depth and red oak regeneration (and red oak density above) have been shown positively related by Minckler and Jensen (1959). The clay substrate relation is supported by Sholz (1937).

Hemlock, considered a mesophytic taxon, produced the following equations:

$$1. \text{RBA} = 26.76 - 2.7492X_3 - 1.0745X_9 + 3.6873X_8 - 0.2824X_{10} + 10.348X_2$$

$$R^2 = 0.3579; \quad \bar{Y} = 14.2806; \quad \text{S.E.E.} = 8.6473$$

$$2. \text{RD} = 20.22 - 2.0082X_3 - 0.3557X_{10} + 2.0783X_8 - 0.5491X_9 + 0.001297X_{15} + 0.03698X_7$$

$$R^2 = 0.3136; \quad \bar{Y} = 9.5724; \quad \text{S.E.E.} = 6.9771$$

$$3. \text{I.V.} = 47.123 - 4.7326X_3 - 1.6093X_9 + 5.7802X_8 - 0.6348X_{10} + 13.872X_2 + 0.001564X_{15}$$

$$R^2 = 0.3682; \quad \bar{Y} = 23.853; \quad \text{S.E.E.} = 14.1290$$

Independent variables X_3 (decreasing solum depth), X_8 (increasing plot elevation), X_9 (southerly aspect), and X_{10} (decreasing slope per cent) are found in all three equations. Solum depth, aspect, and elevation account for about 66 per cent of the variation among plots in terms of relative basal area and importance value. Increasing humus thickness (positive X_2) is found only in the relative basal area equation. Increasing clay content of the B horizon (positive X_7) accounts for about 1 per cent of the variation in relative density. Both relative density and importance value increase with an increase

in protection distance (positive X_{15}) however, this is only 1 to 4 per cent of the total variation explained.

Increased importance with elevation (at least in the mountains where increased precipitation may be expected), decreased slope per cent, humus thickness, and less sand in the B support the conceptual rating of hemlock as a mesophyte (cf. Whittaker, 1956, Curtis, 1950). Low soil depth, southern aspect, and increased protection distance suggest the opposite.

Only one correlated variable appears in the I.V. regression; this aspect (positive, north) in the correlation and south (negative) in the regression. Braun (1950, page 68 ff.) discusses the role of hemlock within the Mixed Mesophytic Forest Region. Its interpretation as requiring protection is " . . . refuted by its frequent occurrence on west-facing bluffs, and by its association with scarlet oak, black oak, and pitch pine. . . . The southern aspect (cf. relationship) of some . . . hemlock forests is emphasized by the large number of . . . southern species." (viz., area 7, Table 6, C, page 67, Braun, 1950).

The nearly ubiquitous distribution of white oak is evident from the low R^2 and high standard errors below, suggesting a low level of site restriction:

$$1. \text{ RBA} = 9.1808 + 7.7031X_2 - 0.52198X_9 + 0.048822X_7 - 0.14036X_8$$

$$R^2 = 0.1213; \quad \bar{Y} = 15.01818; \quad \text{S.E.E.} = 10.1222$$

$$2. \text{ RD} = 13.258 + 0.88689X_2 - 0.15836X_8 - 0.033721X_6 +$$

$$0.43078X_{12} - 0.062549X_{13}$$

$$R^2 = 0.0335; \quad \bar{Y} = 17.8789; \quad \text{S.E.E.} = 15.3159$$

$$3. \text{ I.V.} = 22.524 + 1.04X_3 - 0.73144X_9 + 8.5355X_2 - 0.30008X_8 \\ + 0.0501X_7 - 0.0594X_6$$

$$R^2 = 0.0665; \quad \bar{Y} = 32.10553; \quad \text{S.E.E.} = 23.5422$$

Low R^2 was also reported by Martin (0.21 for density and 0.16 for basal area). He also reports southerly aspect as an important equation component (Martin, 1966).

Deep solum (positive X_3) and southern exposure (negative X_4) account for about half of the R^2 in the equations above. Several regression coefficients including solum depth, aspect, litter depth, and soil texture also appeared in the correlation matrix. Humus depth (positive X_2) has been noted by Minckler and Jensen (1959) in white oak regeneration; low slope position effects (negative X_8) have been seen by McClurkin (1963), Hebb (1962), Gaiser (1951), and Hannah (1968) to affect regeneration. Other characteristics contribute little to R^2 .

Chestnut oak is a dry phase oak as the following equations point out:

$$1. \text{ RBA} = 24.057 - 2.0555X_3 - 0.6927X_9 + 11.61X_2 + 2.6851X_8 - \\ 0.3166X_{10}$$

$$R^2 = 0.2026; \quad \bar{Y} = 13.7309; \quad \text{S.E.E.} = 9.3368$$

$$2. \text{ RD} = 20.476 - 0.4419X_{10} - 1.7467X_3 - 0.0646X_4 + \\ 0.00182X_{15} + 1.6118X_8 - 0.37268X_9$$

$$R^2 = 0.2364; \quad \bar{Y} = 10.0196; \quad \text{S.E.E.} = 8.0326$$

$$3. \text{ I.V.} = 44.381 - 3.7891X_3 - 0.7564X_{10} - 1.0696X_9 + \\ 4.2812X_8 + 17.419X_2 - 0.1004X_4 + 1.066X_{12}$$

$$R^2 = 0.2340; \quad \bar{Y} = 23.7506; \quad \text{S.E.E.} = 15.9663$$

Variables X_3 (thin solum), X_8 (greater plot elevation), X_9 (southern aspect), and X_{10} (gentle slopes occur in all equations). All these are expected from its sites of best development. Thick solum (positive X_2) is related to increased relative basal area and importance value. Thin A horizon (negative X_4) is related to increased relative density and importance value. Convex vertical slope shape (positive X_{12}) accounted for about 1 per cent of the variation among plots in relation to importance value. Chestnut oak is best expressed on thin soils of upper south-facing slopes. On thicker soils, an increase in basal area is observed while thin surface horizons promote greater density.

Only the litter thickness variable appeared as a significant correlation (Table XLIX, page 120) where it was negative, meaning thin (here positive meaning thick). This is not understood.

Chestnut oak competes well on dry, sandy soils, but reaches maximum size in well-drained coves or bottom sites (Fowells, 1965). On uppermost slopes and ridges in the Rugged Eastern Area of the Mixed Mesophytic Forest Region chestnut oak was the most abundant oak in the oak chestnut communities (Braun, 1950).

Martin (1966) reported a 22 per cent R^2 on chestnut oak density accounted for by a thin A, south aspect, thick litter; and, 11 per cent R^2 on basal area in which thin A, upper slope position, and deep litter were important.

Shortleaf pine is site restricted, as the equations below indicate:

$$1. \text{ RBA} = 10.754 + 0.1331X_4 + 0.0976X_{13} - 0.0026X_{10} + \\ 0.000297X_{14} - 1.5657X_9 + 39.062X_2 - 0.1812X_7 + 0.00408X_{15} + \\ 5.8429X_8 - 3.1958X_3$$

$$R^2 = 0.6638; \quad \bar{Y} = 10.7787; \quad \text{S.E.E.} = 6.0824$$

$$2. \text{ RD} = -6.1501 + 0.00416X_{15} + 0.000853X_{14} - 7.6998X_8 + \\ 0.00144X_6 + 0.1199X_5 - 0.1057X_7 + 1.3013X_3 + 0.0453X_4$$

$$R^2 = 0.6990; \quad \bar{Y} = 6.0872; \quad \text{S.E.E.} = 4.1013$$

$$3. \text{ I.V.} = 6.7716 + 0.00846X_{15} + 0.00139X_{14} - 0.2833X_7 - \\ 1.821X_9 + 18.573X_2 + 0.171X_4 - 0.0884X_6 + 0.387X_{10}$$

$$R^2 = 0.6758; \quad \bar{Y} = 16.8657; \quad \text{S.E.E.} = 8.7417$$

Variables X_4 (increasing thickness of the A), X_7 (sandier B), X_{14} (small increase in protection angle), and X_{15} (large protection distance) are found in all equations. Increasing distance up the slope (positive X_{13}) and a decrease of slope steepness (negative X_{10}) are restricted to the relative basal area regression. Thick litter (positive X_2) and southern aspects (negative X_9) are found in the relative basal area and importance value equations. These indicate slow litter decomposition as the result of acid litter, increased exposure, and sandier, therefore, drier subsoil. Variable X_8 indicates the relative basal area increases with elevation increase while relative density decreases with elevation. This is an expression of better survival on high, light, intensity sites. As solum depth (variable X_3) increases relative basal area decreases and relative density increases. From these equations it appears that shortleaf competes best on upper south-facing slopes where solum is thin and the subsoil is sandy.

Martin (1966) found 29 per cent of density variation accounted for by acid soils, sandy B, and less stony soil, and 27 per cent of the basal area variation was accounted for by acid soil and sandy A and B. Steyermark (1940) observed shortleaf pine in the Missouri Ozarks on acid soils, of upper slopes and narrow ridges. Coile and Schumacher (1955) cited a decrease in shortleaf site index with high subsoil clay due to difficulty of root penetration. These results bear out the previous observations.

Virginia pine is one of the dry site tree taxa found in the study area as the equations show:

$$1. \text{ RBA} = 27.234 - 2.2926X_3 - 1.0219X_9 + 4.1576X_8 - 0.2336X_{10}$$

$$R^2 = 0.2995; \quad \bar{Y} = 13.6937; \quad \text{S.E.E.} = 8.8711$$

$$2. \text{ RD} = 21.150 - 1.8505X_3 - 0.31703X_{10} + 2.4985X_8 -$$

$$0.5311X_9 + 0.00187X_{15}$$

$$R^2 = 0.2921; \quad \bar{Y} = 9.2948; \quad \text{S.E.E.} = 6.97$$

$$3. \text{ I.V.} = 48.375 - 4.1437X_3 - 1.5542X_9 + 6.6519X_8 -$$

$$0.551X_{10} + 0.00283X_{15}$$

$$R^2 = 0.3267; \quad \bar{Y} = 22.9886; \quad \text{S.E.E.} = 14.575$$

Variables X_3 (thin solum), X_8 (increasing plot elevation), X_9 (southerly aspect), and X_{10} (gentler slope) are common to all three equations. Together, these variables account for approximately 90 per cent of the variation among plots. Increasing protection distance (positive X_{15}) is reflected in an increasing relative density and importance value. Thus, Virginia pine is best expressed on upper, south-facing slopes with thin solum and great exposure. Of the five variables in the above I.V. equation, three are supported by

significant independent correlations: feet above draws, low slope angle and protection distance. They support the equation variable combination.

Allard and Leonard (1943) reported Virginia pine occurring on thin sola of the Bull Run Mountains of northern Virginia. The taxon grows best on shallow soils over sandstone (Braun, 1950) in the Cumberland Mountains. Virginia pine's position upon these drier sites is related to its ability to establish under conditions which preclude competition from most deciduous taxa.

Correlation refers to the mutual association between two variables while regression pertains to the nature of relationship the variables have. In the latter, a unit change of the independent variable is related to the amount of change of the dependent variable. Within the scope of this problem, all independent variables were assumed to be linear and non-additive in their relation to the proscribed Y's.

The dissected nature of the problem area produces many micro-climatic regimes. Moisture availability, temperature regime, light intensity, and other variables change with slope position, aspect, solum, and other factors producing a complex environmental sequence. Although the general character of the vegetation is mesic, there occurs all regimes from xeric to subhydric. To attempt to interrelate soil and site variables to vegetation dominants with nothing but subjective observation would be to invite hazardous results and questionable conclusions.

For purposes of analysis, all soil, site, and gross vegetation

characters were assumed to be linear and additive in relationship to the relative basal area, relative density, and importance value of these selected taxa. However, as shown in the number of significant correlations, those variables used as predictors were subject to much confounding, hence relations between X's and Y's may be linear but non-additive.

Therefore, in terms of complex analyses, the number of X variables should be reduced to preclude confounding. In terms of this study, the interrelation of variables served to indicate the complexity of the forest environment. Effects of confounding could be seen in almost every regression as the variables were entered or deleted.

In the regressions above, those taxa which demonstrated the greatest degree of site restriction (viz., river birch, hemlock, shortleaf pine) produced the largest R^2 . On the other hand, the low R^2 of white oak is evidence of its non-restricted habit within the study area. Low R^2 values may be, however, due to measurement of variables other than those indicative of white oak density, basal area, or importance. Certainly, within all equations it can be seen that there is much variation in I.V. per taxa among sites which is not accounted for by the variables used. Low accountability may be due to nonlinearity of relationships between X's and Y's, non-additive nature of some X's, genetic variability within taxa, and lack of complete soil and/or site factor measurement.

In general, these equations point up the site requirement variance for these 10 taxa, reinforcing separation into forest types

and the role of the environment in vegetative cover and its expression. Except in the case of those taxa with site restriction, the equitable conditions of moisture, temperature, and light appear to promote taxa with wide ecological amplitude over much of the area. In this case, community competition could be expected to "sort" those taxa on the basis of site and soil modifications as time goes on. Competition, then, rather than moisture regime appears to be the determining factor for those taxa (white oak, red oak, sugar maple).

V. CONCLUSIONS

Vegetation sampling in the basin of the Big South Fork of the Cumberland River has revealed that the forest vegetation is primarily deciduous with a heavy admixture of pines or cedar on thin soil, exposed sites, or where logging has been recent; hemlock has dominance in draws and gorges, but it is present on more exposed sites. White oak was a dominant occurring in 15 of 22 forest communities, chestnut oak was a dominant in 5 communities, beech a dominant in 3, and northern red oak a dominant in two communities. Redcedar, Virginia, and shortleaf pine were dominant in eight types but in only two, a young cedar stand and the Virginia Pine-White Pine type were conifers the sole dominants. Hemlock occurred in 13 of 22 types but was dominant in only two types. The vegetation resembled that described by Braun in the Cumberland Mountains proper, by Thomas (1966), Martin (1966), Lipps (1966), Caplenor (1965), Cabrera (1968), Fowells (1965), and the Society of American Foresters (1964), but in particular to those described in the Cumberlands by Braun (1950). Mixed mesophytic forests are restricted to the most protected sites within the basin. The vegetation resembled an intermediate in composition between well developed mixed mesophytic and oak-hickory of the Western Mesophytic Forest Region. The wide importance of white oak dominated types is characteristic of the uplands of the adjacent Cliff Section of the Mixed Mesophytic Forest Region (Braun, 1950) and the adjacent Great Valley of East Tennessee (personal communication with W. H. Martin, August, 1970).

The great number of types is due, in part, to the large sample area. Heavy logging and strip mining activities, as well as the death of the American chestnut, have produced unstable secondary growth which is only presently segregating into stable communities.

Two topographic arrangements of types occur within the gorge: one is River birch, Tulip poplar-Sweetgum, Redcedar, and White Oak-Chinquapin Oak occur in a more or less banded pattern parallel to the mainstream on alluvium, terraces, and the latter on limestone footslopes; other gorge types occur perpendicularly to the main drainage sorted primarily as to aspect, sideslope relief, and slope position, presumably these factors cause greater to lesser soil moisture availability.

Plateau surface vegetation patterning is apparently related to aspect and slope position as these affect soil moisture.

Mountain vegetation (sampled here to 2,040 feet) is patterned as are the gorge slopes.

Plots with longest undisturbed periods have higher density and basal area and less herb cover. Increased available water is associated with increased basal area, total density, and understory density. Plots with greatest canopy closure have less understory, less total plot density, and less herb cover due possibly to allelopathy, root competition, and to the exclusion of light.

On lower slope positions, thin soils are the stoniest. Steep slopes have sandy B horizons due to rapid elluviation of clay.

Plots with greatest protection distances have low density probably due to drought conditions.

River birch is restricted to streamside locations on terraces that occur.

Sugar maple occupies sites throughout the basin. It is best developed on moist sites, but it contributes to the canopy on even the driest sites.

Beech is found on diverse sites within the basin to the highest samples at 2,040 feet. It grows best on less sandy-textured soils; however, it, too, grows well on sandy soils. Large beeches within the basin are residuals left from logging.

Tulip poplar grows best on thick humus and a clayey B. It is found primarily in sheltered positions of all exposures.

Northern red oak, like tulip poplar, is best expressed on sites with a thick humus and low sand B. In gorge and mountain sites it grows best in draws or on lower slope positions.

Hemlock occurs in a wide range of sites to the highest plot elevations (2,040 feet). The largest hemlocks occur in the gorge and in mountains where they have much available water or their site has been inaccessible to loggers. Few herbs grow under hemlock stands. Humus is thin and of the mor type. Its importance increases on northern aspects.

White oak occurs everywhere in the basin. It grows best on deep soils with a southern exposure.

The former distribution of chestnut is a puzzle. It occurs today in the mountain and gorge White Oak-Hemlock-Chestnut Oak type where chestnut oak has an I.V. of 15, in the plateau north aspect white oak types where chestnut oak I.V. is 15 and in the gorge White

Oak-Virginia Pine type where the chestnut oak I.V. is only 4.0. Chestnut oak I.V. varies from 0.0 to 66.0 among all types. This rather broad moisture scale persistence does little to support its former great importance in chestnut oak ridge forests reported northward in the Cumberland Mountains (Braun, 1950), or eastward in the Great Smoky Mountains (Whittaker, 1956). The reasons for this particular behavior are unknown.

Shortleaf pine is relatively restricted, competing best on sandy soils with a thick A horizon, much exposure, and upper slope positions.

Virginia pine appears as an invader of forest openings within the study area. Open canopies induced by logging and tree disease are responsible for Virginia pine presence in a wide variety of forest types. Light intensity appears to control its establishment. Virginia pine is most important on upper slopes and ridges with thin sola. Southerly aspect is an important factor in the survival of the taxa.

VI. SUMMARY

The watershed of the Big South Fork of the Cumberland River was studied in the summer of 1969 to determine the relationships existing between soil, site, and vegetational characteristics.

Two hundred and seventy-seven one-tenth acre plots were established in 26 areas within the basin. Trees of overstory size (greater than 5 inches dbh 2-inch size classes) and understory size (4 1/2 feet tall and 1-5 inches dbh) were measured. Herbs, shrubs, seedlings, and vines were sampled in nested one-hundredth acre subplots. Various soil and site characters were measured for each plot.

Soils were found to be stonier, deeper, and to be more clayey on lower slope positions in gorge and mountain areas. Upslope soils were sandy, shallow, and not stony due to colluvial action and erosion. Some plateau surface soils had well developed horizons. Available water was assumed greatest in draws and on lower slope positions where soils were deeper and the clay fraction was greater. Soils were deeper on north rather than south-facing slopes.

Twenty-two forest types were described for the basin. These were primarily white oak-dominated except on shallow soils where pines had established, and in protected coves where hemlock was prevalent. These were distinguished on the basis of aspect, proximity to drainage, slope position, and ridge-draw location. Instability of forest types has been related to death of the chestnut portion of the forest and to repeated cutting and strip mining.

Data analysis was performed by simple correlation, multiple stepwise regression, and importance value groupings.

Increased available water was associated with greater basal area, greater total plot density, and increased understory density. Stands with longest periods of growth have higher densities, greater basal area, and less herbaceous cover. Those forests with greatest canopy closure have less understory, less total plot density, and less herbaceous cover. Forest taxa have segregated on the basis of soil and site factors as they relate to moisture and available water.

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APPENDIX

AVAILABLE WATER HOLDING CAPACITY OF SEVERAL SOIL TEXTURES

<u>Textural Class</u>	<u>Available Water in/in</u>
Sand	0.015
Loamy sand	0.074
Sandy clay	0.085
Sandy loam	0.121
Clay	0.156
Fine sandy loam	0.171
Silty clay	0.180
Loam	0.191
Silty clay loam	0.204
Sandy clay loam	0.209
Silt loam	0.234
Silt	0.256
Very fine sandy loam	0.257

VITA

John Marcus Safley, Jr., was born January 4, 1947, in Milan, Gibson County, Tennessee. He received elementary education in Woodbury and Nashville, Tennessee, and graduated from Hillwood High School in June, 1964. He enrolled at Vanderbilt University in September of the same year and received a Bachelor of Arts degree from the same institution in June, 1968. While enrolled at Vanderbilt University, he was employed three summers as laboratory assistant in the Pharmacology Department of the Vanderbilt Medical School. After graduation he was employed as herbarium assistant for the Vanderbilt Department of Biology.

He entered the Graduate School of The University of Tennessee in September, 1968. He received a Graduate Fellowship from the U. S. Army Corps of Engineers to complete his research. He holds membership in the Association of Southeastern Biologists, the Southern Appalachian Botanical Club, the American Institute of Biological Sciences, and Phi Sigma Honorary Society.

He is married to the former Mary Kendrick Riley of Nashville, Tennessee.