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To the Graduate Council:

I am submitting herewith a thesis written by William Haywood Martin III entitled "Some Relationships of Vegetation to Soil and Site Factors on Wilson Mountain, Morgan County, Tennessee." I recommend that it be accepted for eighteen 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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SOME RELATIONSHIPS OF VEGETATION TO SOIL
AND SITE FACTORS ON WILSON MOUNTAIN,
MORGAN COUNTY, 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
William Haywood Martin III
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I. INTRODUCTION

In this study, the forest composition of Wilson Mountain, Morgan County, Tennessee, is described and distribution of tree taxa and site factors are related.

The study arose from the need for geographic knowledge of an area where resource understanding is of great national concern, and to provide data for characterization of local forest and soil resources as an aid in their management. Of further interest is characterization of the genetic and ecological amplitude of forest tree taxa in this area close to the center of Deciduous Forest diversity.

The objectives in this study of the vegetation of Wilson Mountain were: (a) to describe the pattern of tree communities, (b) to analyze the variation in environmental factors which may be responsible for the distribution of tree taxa, (c) to evaluate the degree of correlation between environmental factors and vegetational pattern, (d) to determine if variation in characteristics of overstory and understory tree taxa was related to soil characteristics, slope direction and (or) topography.

Tree vegetation occupying approximately 830 acres of Wilson Mountain was sampled during the summer months of 1965.

II. REVIEW OF SELECTED LITERATURE

Exposure and Topographic Effects on Vegetation and Soil

The importance of slope and exposure in determining vegetational composition has long been recognized. Among the early workers to recognize the influence of slope and exposure on solar radiation and water runoff, and consequently on vegetation was Warming (1909).

Shreve (1924) concluded that differences in vegetation of north-facing slopes and south-facing slopes on desert mountain ranges in Arizona were due to environmental conditions initiated by differences in insolation and soil temperature on the different slopes. The soil temperature was usually higher on the south-facing slopes; soil temperature decreased with an increase in altitude on both exposures appearing to become more important as a factor in effecting vegetational pattern on both slopes as altitude increased.

Turesson (1914) has shown the importance of slope exposure to a single taxon, Pseudotsuga taxifolia, in arid parts of Washington state. In these regions, this taxon occupied the more mesic northern slopes and was entirely absent from the southern exposures.

Cottle (1932) found marked differences in environments and taxa on north and south-facing slopes in southwestern Texas. Water content of the soil on the south-facing slope was 5-16 percent lower than on the north; evaporation was 24-44 percent higher on the south-facing slope; soil temperature at depths of 2 to 12 inches were much higher

on the south-facing slopes. Vegetation cover on the south slope was less than 50 percent of the cover on the north slope; dry matter production on the south slope was 5 percent of that on the north slope. He recognized that several interacting factors produced these conditions; water availability appeared to be the limiting factor.

Aikman and Smelser (1938) studied the effect of exposure on natural vegetation in Iowa. They attributed the differences in the forest communities to exposure differences and varying microclimates. Evaporation was less and soil moisture higher on northern exposures; the percentage of organic matter in the soil was one-third greater on north-facing slopes than on south-facing exposures.

In Indiana, a study by Potzger (1939) indicated a sharp zonation of forest types relative to exposures. The more mesophytic Fagus grandifolia, Acer saccharum, and Liriodendron tulipifera occupied the north-facing slopes and an oak-hickory forest occupied the south-facing exposures. Surface soil had 30 percent, and soil at six inches depth had 28 percent more moisture on the north than on the south-facing slopes. He suggested that differences in wind, insolation, temperature, and humus content of the soil contributed to differences in available soil moisture.

Differences in vegetation on different exposures and slope positions in the Cumberland Mountains were described by Braun (1942). Oak-chestnut, oak-pine or oak-hickory communities occupied upper, south-facing slopes; beech-white oak communities occupied lower

slopes. Mixed mesophytic forests occupied coves and mid-slopes on all exposures, extending to the upper north-facing slopes.

Platt (1951) studied Appalachian shale barrens and plants endemic to them. Shale-barren formation occurred only on slopes, the barrenness becoming more pronounced on south-facing exposures and as degree of slope increased. Trees and shrubs were more abundant on north-facing exposures, but retarded growth was apparent on all exposures within the barrens. This slow rate of growth was attributed to the effect of low soil moisture content. High temperatures at the soil surface and low soil moisture affected distribution of all plants on the barrens.

Cantlon (1953) reported vegetational differences on north and south-facing exposures in New Jersey. The north-facing slope was occupied by more taxa. Further, density and total basal area was greater on the north-facing slope. Different individuals contributed to the differences on the exposures, e.g., Betula lenta contributed almost one-fourth of the density and basal area on the north slopes while Quercus velutina contributed almost one-fourth of the same values on the south slope. From this data, taxa appeared to be restricted to the different exposures. Liriodendron tulipifera contributed to basal area only on the north-facing slope, while Carya tomentosa contributed to basal area only on the south-facing slope. More taxa appeared to be reproducing abundantly on the south-facing slopes than on the north-facing slopes.

Cooper (1961) showed relationships of Raunkierian life-forms to north and south-facing exposures in Michigan. There were no significant differences between the distribution of life forms in the total flora of the north and south slopes, but there were differences in importance of certain life forms on the slopes. Higher values for canopy cover and basal area were obtained from the phanerophytes on the north-facing slopes. Although there were no differences in total numbers of stems on the different slopes, there were significantly more large trees (over 18 in. d.b.h.) on north slopes. There was a greater diversity of taxa on the north-facing slope. Tree reproduction was greater on the south-facing slope, i.e., conditions appeared more favorable for germination and establishment, but mortality following the seedling stage was higher on the south-facing slope.

Nash (1959) studied growth rates of Quercus alba, Q. velutina, Q. stellata on north and south-facing aspects in Missouri. All three taxa showed higher rates of growth on the north-facing exposures when compared to the rates obtained from the south-facing exposures during a 10-15 year period.

The role of topography and exposure as a factor in soil formation, which would affect vegetational patterns, has been discussed by Cooper (1960). His study in Michigan of microclimatic effects on soil formation on north and south-facing slopes indicated differences in soil weathering on the slopes; the solum was shallowest at the top of

the south slopes and deepest on the north slopes. The A₁ horizon was shallowest at the tops of the south slopes. The B horizon on the south slopes contained significantly more silt and clay. It was concluded that higher soil temperatures, cycles of freezing and thawing, and wetting and drying on south slopes increased chemical and biotic activity accounting for the breakdown of larger soil particles, and greater clay accumulation in the B horizons of these soils as well as increased surface removal of soil particles. Gilbert and Wolfe (1959) described different Muskingum fine sandy loam profiles from northeast and southwest-facing sides of Neotoma Valley in Ohio. The profile on the northward-facing side had a deeper A₁ horizon and deeper solum than the opposing southwest exposure. Further, the southwest-facing site was characterized by lower soil-moisture values and cycles of wetting and drying during summer not found on northeast-facing sites. Minckler (1941) found soil moisture to be related to aspect and slope position with a 1.5 percent increase for each 190-foot descent of slopes of 30 percent. Depth of the A horizon was related to aspect, slope percent, and slope position; northerly, gentle and lower slopes had the deeper topsoil.

Site Factors Effecting Regeneration

The ability of a seed plant to become established is dependent on factors such as seed production, seed dispersal and viability, as well as insect, rodent, and bird activity. The ability of a plant to

persist on a specific site is more closely related to environmental conditions. Most studies relating to factors influencing the survival and growth of tree taxa are concerned with the critical, early developmental stages in the life of the plant. Because of the complexity of the total environment and the difficulty in measuring some factors, complete exact quantification of the environment is practically impossible. However, measurements of certain conditions and their interaction with others influencing survival and growth of seedlings may serve in determining future forest communities.

Wood (1938) recognized several factors affecting oak regeneration in New Jersey. Results from experimental plots showed absence of litter or shallow depth of soil cover, high soil acidity, soil infertility, low soil moisture and (or) temperatures late in the spring could be responsible for poor growth rates of young seedlings in a natural habitat.

Several studies have considered light intensity and its interaction with other environmental conditions determining regeneration. Kramer and Decker (1944) concluded insufficient light, affecting photosynthesis, may be a significant factor influencing failure of pine seedlings to become established under a forest canopy in the Piedmont. Pine seedlings appear to be unable to manufacture enough food in the shade to develop sufficient root systems for water absorption during periods of drought, whereas greater photosynthetic efficiency of hardwood seedlings in shade enable them to develop more extensive root systems and

survive drought. Kozlowski (1949) reported that hardwood seedlings were inherently able to photosynthesize at greater rates than pine seedlings at low light intensities; this ability apparently influences root development enabling hardwood seedlings to withstand lower light intensities as well as drought. In North Carolina, Kramer, Oosting, and Korstian (1952) planted pine and hardwood seedlings in forest, forest edge and open field environments. Seedlings of Pinus taeda and P. echinata developed best in open fields and at the forest margin. Quercus alba and Cornus florida grew and developed in all environments. Water was supplied and did not become critical. High mortality rate of the pines in the forest appeared to be affected by lower light intensity. Halls and Homesley (1966) and Shuster (1962) determined that overstory crown cover had more effect on the understory than any other physical site factor in pine-hardwood forests in Texas. In general, production in the understory was inversely related to increase in the overstory cover apparently as a result of a decrease in availability of light, water, and mineral nutrients as crown cover increased. Both studies indicate that hardwood tree taxa would grow and develop in the understory due to shade tolerance and "competitive ability" of the taxa.

Apparently some taxa require higher light intensities. Carvell and Tryon (1961) observed that oak regeneration was highest in stands in West Virginia where more sunlight reached the forest floor. They suggested thinnings of overstory were necessary for establishment of

certain oaks. Foster and Ashe (1908) and Kuenzel and McGuire (1942) noted that Quercus prinus seedlings' abundance and survival was enhanced with increased light intensity. Sholtz (1955) reported that Quercus rubra seedlings developed poorly on sites high in ground cover although seedlings surviving were tolerant to low intensities. Trimble and Hart (1961) reported cuttings that removed 75 percent or more of sawtimber volume favored establishment of Liriodendron tulipifera. Light cuttings enhanced reproduction of oak, Acer saccharum and Fagus grandifolia. Holch (1931) planted seed of Quercus macrocarpa, Carya ovata, Q. rubra, Tilia americana and Juglans nigra on diverse habitats in eastern Nebraska characterized by different exposures, soil temperature, soil moisture and cover. Root and shoot development over a 3-year period was greatest on open sites (south-west exposures) and least in deep shade (north-facing exposure, basswood community). With the exception of Tilia americana, all taxa died in the moist, shaded basswood community. Apparently light quality and intensity limited photosynthetic activity on the site. On the drier sites, development of the taxa was inversely proportional to soil moisture but directly related to light intensity. Boyce and Parry (1958) supported the work of others (Sims, 1932; Carvell and Korstian, 1955) by reporting increased rates of seed germination and decreased mortality of Liriodendron tulipifera occurring in open areas on bare mineral soil. They concluded that natural regeneration of this taxon is probably enhanced in open areas rather than in dense canopies and

on the surface of mineral soil or well-decomposed organic matter. Abundant reproduction of Liriodendron tulipifera occurs in open areas in gorges of the Cumberland Plateau (Caplenor, 1965) and in cut-over regions of the Cumberland Mountains (Braun, 1950). Arend and Julander (1948) studied oak sites in the Arkansas Ozarks. Tree reproduction and species diversity decreased from mixed oak stands to pure stands dominated by Quercus alba. This difference was attributed to decreased light intensity and deeper ground litter in the pure stands.

The many characteristics of the soil, such as chemical composition, depth, texture, structure and soil moisture interacting with other environmental conditions are very often limiting factors determining establishment and survival. Hosner and Minckler (1960) reported on reproduction of eighteen bottomland hardwood taxa (including ash, hickory, oak, poplar, maple, willow) along streams in southern Illinois. In general, the taxa were able to germinate and survive under a wide range of soil and site conditions. With most taxa, less reproduction occurred where litter was deep, ground cover was heavy or overstory was sparse. Seedlings of most taxa studied survived best on soils with higher moisture-holding capacities.

Ward (1961) studied regeneration of Fagus grandifolia from seed and sprouting in Wisconsin and other states. Greater abundance of seedlings in Wisconsin appears to be related to water retaining capacity of the A₁ horizon. Soil chemical analysis (Ca, Mg, K, P)

of Wisconsin soils showed no correlation with seedling numbers. On moist north-facing sites in southern Illinois, hickory and oak seedlings were more abundant on middle slopes than in coves and on lower slopes. Both taxa tended to regenerate best on the drier sites (middle and upper north slopes, south-facing slopes). Conversely, Liriodendron tulipifera appeared on moist sites in open areas (Minkler and Jensen, 1959). Coile (1933) determined H-ion concentrations from soils under seven forest types in the Duke Forest, North Carolina. The results indicated that ranges of pH do not appear to be limiting factors in the distribution of the types. However, H-ion concentration could conceivably affect invasion by hardwoods from forest types developing and reproducing on soils with a low concentration.

Although it is known that leaf litter and humus types affect frequency of reproduction of some taxa, quantitative data is scarce. Korstian (1927) investigated several factors controlling germination and early survival of oaks in North Carolina. Natural regeneration was enhanced if the soil was not compacted. Seedlings survived in greater numbers in partially or selectively cut stands. He concluded that amount of leaf litter on the forest floor is probably the most important environmental factor affecting germination and early survival. Increased litter reduces water loss, equalizes temperature and facilitates root penetration. On moist and dry sites in southern Illinois, regeneration of Quercus velutina, Q. rubra and Q. alba were

more frequent on sites with more than one inch of litter; Liriodendron tulipifera developed best on bare soil or soils with "patchy litter" (Minckler and Jensen, 1959). Barrett (1931) reported leaf litter depths greater than one inch enhanced germination and early survival of Quercus montana.

Lutz and Chandler (1946) discussed the importance of humus in forest production. Although mull types are generally regarded as favorable for the growth of trees, it should be remembered that type of humus layer is not only influencing forest communities; indeed, communities influence the type of humus layer formed on forest floors. Humus layers may change when different taxa occupy the same site. The exact ecological significance of the humus layer affecting forest reproduction may be debated. Observations indicate that reproduction of some taxa may be influenced by humus types. For example, Ward's (1961) study in Wisconsin showed few seedlings of Fagus grandifolia in stands with a mull type humus; highest numbers usually occurred in stands with an intermediate mull-mor type humus.

Consideration of the effect of aspect on reproduction is actually dependent on the summation and interaction of several environmental conditions. Some of these have been mentioned previously. In general, north and east-facing exposures have higher soil moisture, lower air and soil temperatures, less direct insolation and drying winds, less erosion, more litter and organic matter accumulation, thicker soil profiles than south and west-facing exposures. It follows that these

environments may indicate drastic or subtle differences, depending upon degree of difference, in the composition of the taxa regenerating.

Carvell and Tryon (1959) reported an abundance of oak regeneration on the middle third of slopes in West Virginia; the drier ridge exposures were also well-stocked with oak seedlings. Openings in oak-chestnut communities on southwest-facing sites in the Cumberland Mountains caused by the death of Castanea dentata resulted in the development of an understory composed of Quercus prinus, Carya glabra and C. ovata. Seedlings of taxa forming the mixed mesophytic forests in the moist coves and lower slopes were not found in these communities except in mesic situations. Conversely, oak and other taxa of the oak-chestnut community were not becoming components of the mixed mesophytic stands (Braun, 1950). Baldwin (1933) observes that reproduction of Picea glauca and Abies balsamia in New Hampshire was not confined to a single exposure. Seedlings of both taxa were most abundant on north and east exposures, apparently protected from radiation and drying winds.

Soil-Site Index Relationships

Coile (1952) defines site quality as the productive capacity of an area of land for a tree taxon or forest type. Site quality is largely determined by soil properties or other features of the site influencing quality and quantity of growing space for tree roots.

A measure of site quality by foresters is site index (height of dominant and co-dominant trees at a specific age). Although the site index concept has been criticized because density, growth rate, stand history and other site aspects are not considered, site index is still the best known, single indicator of site quality (Ovington, 1965).

Coile (1952) summarized the work of others in describing soil and other factors influencing site index. Characteristics of the soil pertaining to available water appear to be the most important environmental variables influencing site index.

Trimble and Weitzman (1956) studied site index of oaks in the Appalachians in West Virginia and Maryland. They concluded that productivity of most forest land in the region could be estimated from information on aspect of site, position of stands on the slope, percent slope and soil depth to bedrock. Site indexes of oak increase on deep soils of the lower north and east-facing slopes; as slope increased, site index of oak decreased. Humus type and depth as well as soil pH showed some relationship to site index although the relationships did not appear to be useful in estimating production. In the Arkansas Ozarks, Arend and Julander (1948) found that high site indexes of oak were located on deep, well-drained, limestone derived soils. These soils were usually found on lower or long slopes or in valley coves and bottomland on north and east exposures. "Medium" oak sites included ridges and upper slopes often with south and west exposures

and more shallow soils. Predominating trees were Quercus velutina and hickories. "Poor" oak sites occurred on south and west slopes where the soil was shallow; oak taxa associated with this site were Quercus stellata and Q. marilandica and some Q. velutina. A study of height growth of Liriodendron tulipifera, Quercus alba, Q. coccinea, Q. velutina and Pinus echinata in the uplands of the Virginia-Carolina Piedmont did not produce strong correlations between site index and soil-site relationships (Della-Bianca and Olson, 1961). Increase in percent slope appeared to favor productivity of Q. coccinea and Q. velutina and site indexes increased as distance from ridges increased. The best correlations were obtained from equations with height of Liriodendron tulipifera as a dependent variable. Thickness and organic matter content of the A_1 horizon, thickness of the total A horizon and an increasing percentage of sand in the A_2 horizon were positively correlated with Liriodendron tulipifera height growth. In general, site indexes of the other taxa increased on sites where this taxon was present.

Gaiser (1951) studied factors related to Quercus alba site index on upland soils in southeastern Ohio. Site index of the taxon was highest on lower slopes of northeast exposures. Growth was best on sites with the thickest A horizon, indicating that white oak grows best in areas with soils high in available water.

In southeastern Ohio, site index of Quercus velutina increased with increased depth of the A horizon and with increased steepness of

slopes on fine textured soils with restricted internal drainage; poorest growth occurred in areas having the finest textured subsoils. On medium textured, well-drained soils, site index decreased with increased amounts of stone in the subsoil and on upper slopes and ridges. Site index of the taxon increased with depth of the A horizon and on north and east-facing slopes (Carmean, 1965).

Doolittle (1957) formulated a predictive equation for the estimation of Quercus coccinea and Q. velutina site index in the southern Appalachians. The depth of the A horizon was the best single estimate of site index; as depth increased, site index increased. Site index was lower on soils having a higher percent of sand, on sites with a mor humus layer and at lower positions on the slope.

A study of second-growth Liriodendron tulipifera stands in Tennessee, Kentucky and southern portions of Ohio, Indiana, and Illinois was made by Auten (1945). This taxon appeared to grow best (by site index values) on moist, well-drained soils on north-facing exposures; in this region, topographic position on the moist exposures did not appear to effect the site index greatly. Further, site index was directly related to an increase in depth of A₁ horizon and depth of soil to tight subsoil.

Hebb (1962) studied the productivity of hardwoods on certain sites in West Tennessee. The taxa studied were Quercus falcata, Q. alba, Liriodendron tulipifera, Liquidambar styraciflua and Q. falcata var. pagodaefolia. Analysis by multiple regression

indicated topographic position as the variable significantly influencing all the taxa.

Coile (1952) summarizes soil-site predictions for several taxa of southern pine over a wide area. Soil-site relationships to pine are much more comparable to open land conditions than studies conducted in mixed pine-hardwood and hardwood stands.

Coile and Schumacher (1953) found decreased site indexes of Pinus taeda and P. echinata in the Piedmont on typically heavy subsoils (high clay content), probably due to restricted root penetration. Zahner (1958) reported that site quality for Pinus taeda on well-developed zonal soils increases with clay content of the subsoil to a level of about 35 percent clay; on azonal soils, site quality increases with silt-plus-clay to about 65 percent silt-clay.

Foster (1959) summarized research associated with Pinus strobus site index and environmental relationships. He suggested and studied the possibility of using Acer rubrum site index as an indicator of P. strobus site index in New England. Significant changes in site index increased as thickness of the A₁ horizon decreased, elevation decreased, position on slope became lower, the depth to a compact soil layer increased and moisture equivalent increased.

Weitzman and Trimble (1957) used site index of oak stands in West Virginia and western Maryland in studying oak regeneration. On sites where site index was 40-65, oak seedlings and saplings dominated the understory, but at site index 65, oak reproduction began to decrease.

Specifically, Quercus prinus, Q. coccinea and Q. alba reproduction followed this trend, but Q. rubra reproduction decreased as site index decreased. Faster growing or more tolerant species on better sites made conditions less conducive to establishment of oaks.

III. THE STUDY AREA

Location

Wilson Mountain is the western portion of the two-peaked Little Brushy Mountain shown on the Camp Austin and Petros U. S. G. S. Quadrangles, Tennessee. While not named specifically on the map, local and state usage dictates its separation from the other portion of Little Brushy Mountain. It is in Morgan County, Tennessee, approximately six road miles from Wartburg, and lies between $36^{\circ}2'$ and $36^{\circ}3'$ north latitude, $84^{\circ}29'$ and $84^{\circ}31'$ west longitude.

Physiography

Little Brushy Mountain, including Wilson Mountain, is a part of the Cumberland Mountain section of the Appalachian Plateau Province described by Fenneman (1938). It is a southwest extension of Big Brushy Mountain in the Wartburg Basin. This basin is bounded on the northeast by the Jacksboro fault, on the southeast by Walden Ridge, on the southwest by the Cumberland Plateau overthrust system, and merges with the Cumberland Plateau on the west and northwest (Wilson, et al., 1956).

The Cumberland Plateau represents an adjacent and larger portion of the province. The Cumberland Mountain Section is distinguished empirically from the plateau on the basis of altitude and relief. The formation of both sections is a result of uplift of the Schooley Peneplain. Erosion of this peneplain probably did not begin before the

end of the Miocene. Altitudinal differences between the Cumberland Mountains and the adjacent plateau may be due to dissection of the peneplain by erosion of weaker rocks on the plateau and in valleys between the mountains. Warping during uplift of the peneplain, and post-Schooley faulting have been suggested as alternatives explaining the difference (Fenneman, 1938).

Geology

The Pennsylvanian cap rock of the Cumberland Mountains and the adjacent Cumberland Plateau is largely of Pottsville age (Wilson, et al., 1956). In Tennessee, strata of this age are divided into nine groups. The Gizzard, Crab Orchard Mountain, and Crooked Fork groups represent the older strata and consist of massive sandstone and conglomerates with approximately equal proportions of shale. The Slatestone, Indian Bluff, Graves Gap, Redoak Mountain, Vowell Mountain, and Cross Mountain groups, comprising the upper strata, contain a much higher proportion of shales, siltstones, and coal. The sandstone strata are thin and fine-grained (Wilson, et al., 1956).

The Slatestone and Indian Bluff Groups probably occupy Wilson Mountain. The Slatestone Group would comprise the lower and middle strata with its upper edge comprising the Jellico coal at 1900 feet. The sandstones of this group are separated by shales which themselves contain minor sandstone interbeds and coal beds. The Indian Bluff Group would include all the sandstones and shales above the Jellico

and be capped by the Pioneer sandstone at 2260 feet.¹

Soils

Although there has not been a general soil survey of Morgan County, the soils of Wilson Mountain were mapped for the University of Tennessee in 1956 as Muskingum silt loam series by the Soil Conservation Service.

The most common profile developments determined by textural estimates were soils having grayish-brown silt loam A horizons and yellowish-brown silty clay loam B horizons (80.9 percent of the total land area). Soils with textures of loam in the A and B horizons are found on 11 percent of the total land area. The differences in development indicate that the predominating soils are not of the Muskingum series but are probably soils of the Shelocta and Dekalb series.²

The Shelocta series are upland soils common to the Appalachian Plateau Province. Typically these soils have dark grayish-brown silt loam A horizons, and yellowish-brown light silty clay loam B horizons and depth to bedrock of 40 to 60 or more inches. They developed from acid siltstones, shales and sandstones. Coarse fragments in the A and B horizons range from 10 to 45 percent of the total volume.³

¹Personal communication with Stuart Maher, Tennessee Principal Geologist, 1966.

²Personal communication with Dr. M. E. Springer, Associate Professor of Agronomy, The University of Tennessee, 1966.

³National Cooperative Soil Survey, official series description, 1965 (unpublished).

The Dekalb series comprises moderately deep or deep well-drained soils occurring on gentle to very steep slopes on top of and on the sides of dissected plateau and mountain ridges. These soils are derived mainly from sandstone. The A horizon is typically of sandy loam, fine sandy or loam texture and gray, yellowish-brown or brown in color. Textures of the B horizons are sandy loam, fine sandy loam, loam or light sandy clay loam; typically they are yellowish-brown with coarse fragments of channery and stony sizes comprising 15 to 75 percent by volume.⁴

Climate

The climate of the Wilson Mountain area is temperate continental with a wide range of temperature between moderately cold winters and warm summers; the greatest fluctuation in temperature and precipitation occur during the winter and early spring. Thornthwaite's classification (1931) places this area in the Mesothermal BB'rb.

The United States Weather Bureau at Crossville, Tennessee, on the Cumberland Plateau, approximately thirty-five air miles southwest of Wilson Mountain, is the closest weather station (elevation 1810 feet) and is used here as an indication of the climate of the study area.

For the period 1930-1964, the station reports a mean annual temperature of 55.1° F.; temperatures as high as 102° F. during summer months have been recorded (United States Weather Bureau, 1965).

⁴National Cooperative Soil Survey, official series description, 1963 (unpublished).

In general, precipitation is usually well distributed throughout the year with the least amounts in autumn. Mean annual precipitation is 54.66 inches. An accumulation of .10 inches or more occurs, on the average, 103 days annually. Severe storms are infrequent in this section of the plateau province. Thunderstorms, accompanied by minor windstorms, occur about twice a year. Snowfall (including sleet) is variable; the mean annual total is 11.6 inches. The greatest total snowfall reported was 53.5 inches in 1960; the least, only a trace, in 1951 and 1957 (United States Weather Bureau, 1965).

On the average, the last freezing date in the spring is April 21 and the first freezing date in the autumn is on October 14, an average growing season of 176 days. The freezing date in autumn may range from September 22 to November 11.⁵ Local variations may be caused by direction of slope, effect of relief on air drainage, and variation in elevation. Shanks and Norris (1950) report a 3° F. mean difference in maximum temperature recorded at one foot above ground level at the same elevation on opposing north-facing and south-facing slopes in a relatively small area (less than 350 horizontal ft.²). Temperature differences at this level of the environment may effect plant development at the critical seedling stage such that "length of growing season" could be sharply reduced or extended.

⁵Unpublished freeze data 1921-1950, United States Weather Bureau.

Temperature and precipitation records have been kept since 1958 at the University of Tennessee Forestry Field Station near Little Brushy Mountain (elevation 1340 feet) less than one mile from the study area.⁶ When data is compared with data from the Crossville station covering the same period, temperatures appear to be only slightly above the averages recorded at Crossville and precipitation only slightly below the average for Crossville (Table I).

Vegetation

An early description of the vegetation of the Cumberland Plateau (including the Cumberland Mountains) in Tennessee by Killebrew and Safford (1874) indicated large and abundant trees of oak, hickory, birch, buckeye, chestnut, yellow poplar, basswood, black locust, maple, walnut and sassafras. Concerning Morgan County in particular Killebrew said:

. . . a few miles from Wartburg, in the eastern part of Morgan County, is a grove of walnut timber that cannot be surpassed on the continent. In this locality, trees six feet in diameter rise in princely grandeur to the height of more than one hundred feet and strike the traveler with astonishment at their magnitude. Thickly set upon the soil, in company with massive white oaks, their trunks rise to a height of fifty feet or more without a limb. Remote from market, this valuable timber is scarcely used except for fence rails. The Cincinnati Southern Railroad will probably bring all of this excellent timber into market and make it a source of profit to the owners.

⁶Unpublished data from The University of Tennessee Forestry Field Station 1958-1964; courtesy of J. S. Kring, Associate Professor, Department of Forestry, The University of Tennessee.

TABLE I

MONTHLY AND ANNUAL TEMPERATURE MEANS RECORDED FOR YEARS 1958-
1964 AT CROSSVILLE, TENNESSEE AND THE UNIVERSITY OF
TENNESSEE FORESTRY STATION AT LITTLE
BRUSHY MOUNTAIN, MORGAN COUNTY,
TENNESSEE

Month	Temperature (°F.)		Precipitation (Inches)	
	Forestry Station	U.S.W.B. ^a	Forestry Station	U.S.W.B. ^a
January	35.9	31.1	4.4	4.4
February	39.7	34.1	5.2	5.5
March	46.7	41.7	6.3	7.5
April	57.8	53.9	4.8	5.6
May	66.2	63.1	3.5	3.8
June	73.0	68.9	4.5	5.1
July	75.7	72.1	5.6	5.0
August	75.0	71.9	5.2	4.1
September	68.7	66.6	3.5	4.6
October	58.3	56.3	2.9	3.1
November	48.4	45.9	4.4	4.4
December	38.6	36.1	4.8	4.7
Annual Mean Total	56.8	53.3	54.3	57.4

^aUnited States Weather Bureau, Crossville.

Hall (1910) reported the vegetation of the plateau was predominately mixed deciduous taxa in the coves of mountainous regions; exposed sites being dominated by mixed oak forests, and flat lands and depressions characterized by oaks and hickories.

More recently, the vegetation of areas within the Cumberland Mountains of Kentucky has been described by Braun (1935, 1940, 1942). Because dominance of the stands is shared by a number of taxa of mesophytic character she refers to the forests as Mixed Mesophytic and defines the area as the Mixed Mesophytic Forest Region. This region includes all of the Cumberland Mountains, the southern part of the Allegheny Mountains, and adjacent Cumberland and Allegheny Plateaus (Braun, 1942, 1950). Further, this association is the most complex and oldest association of the deciduous forests of eastern North America, and occupies a central position in the deciduous forests from which all other climaxes of the deciduous forest have arisen (Braun, 1950). Away from the center of its development, this community is restricted to the coves, to valleys, to ravines, and lower north-facing or protected slopes.

Braun (1950) pointed out that in the Cumberland Mountains, the composition and relative abundance of the dominants vary with exposure, soil texture, soil moisture and to some extent with altitude. These environmental differences appear to have segregated certain taxa which express dominance in stable communities. The sugar maple-basswood-buckeye and oak-beech forests exemplify these distinct

communities referred to as association segregates of the Mixed Mesophytic forest.

The oak-chestnut communities occupying the drier sites on southwest exposure and the oak-pine communities occupying shallow, sandy soils were recognized as segregates of other climaxes of the deciduous forest. These communities were designated as local, physiographic climaxes.

Whittaker (1956) states that there is a close affinity of the cove forests of the Great Smoky Mountains to the mixed mesophytic forests of the Cumberland Mountains. Chapman (1957) recognized several forest types on English Mountain in the Blue Ridge Physiographic Province east of the Cumberland Mountains. Relating vegetation type to exposure and depth of soil, he recognized a mixed hardwood forest in the north-facing coves which appeared to be related to mixed mesophytic forest of the Cumberland Mountains. On English Mountain, forest types of the driest and most exposed sites were dominated by chestnut-oak-pine. As the moisture gradient increased, the forest types changed from dominance by Quercus prinus to mixed hardwood. In the Ridge and Valley Physiographic Province of Hawkins County, Tennessee, a mixture of mesophytic woody taxa occupied the coves. Oak-hickory forest (formerly oak-chestnut) occupied the slopes and stands of Pinus echinata or P. echinata mixed with hardwoods occurred on drier uplands and ridges (Wolfe, 1956).

Sherman (1958) studied the vegetation of five gorges on the west front of the Cumberland Plateau from north central Tennessee

into Alabama. In these gorges, mixed mesophytic stands occupied the protected, north-facing, moist habitats and oak-hickory and chestnut oak types occupied sites on upper south-facing slopes. Caplenor (1965) reported that mixed mesophytic communities dominated gorges of Fall Creek Falls State Park (in the central portion of the Cumberland Plateau).

A recent forest inventory conducted in a forest in the southeast region of the Cumberland Mountains a few miles from the present study area indicates that secondary forests are dominated by mixed oak-hickory communities (MacDonald, 1964).

There have been few floristic descriptions of the Cumberland Mountains. Braun (1937) described the flora of the Cumberland Mountains and the Cumberland Plateau in southeastern Kentucky and noted affinities between the flora of this area to the Blue Ridge Province, and the Coastal Plain Province. She interpreted the presence of northern taxa, e.g., Pinus strobus and Betula lutea, as survivors from a Tertiary or Pleistocene flora. The close affinities of the Blue Ridge Province flora to the flora of the Cumberland Mountains indicate that the latter are floristically a part of the former. The flora of Blue Ridge Province is considered older and elements of it have probably migrated to the Appalachian Plateau Province, particularly the Cumberland Mountains, during late Tertiary or early Pleistocene. Flora of the Coastal Plain Province, e.g., Quercus phellos, found on the plateau are probably Tertiary relicts.

A Continuous Forest Inventory, conducted on Wilson Mountain for the purpose of determining timber volumes and reproduction of sawtimber and pulpwood trees, recognized that thirty taxa belong in these categories. For this report, sample locations were determined by a grid system over an estimated 1200 acres and all exposures were sampled.⁷ At present, 382 taxa of vascular plants, including 59 tree taxa, have been reported from Morgan County (Olson, et al., 1966).

Human History

The settlement of Morgan County began soon after the Indian title to the lands was relinquished in the early 1800's. Many of the people who settled in this region were of European origin. The county was established in 1817; Wartburg was established by German and Swiss immigrants in 1845 and became the county seat in 1870 (History of Tennessee, East Tennessee Ed., 1887). The towns have always been few and small. Petros and Coalfield exist because of coal mining operations.

Most of the people live in the valleys of the mountainous portions of the county. The last known inhabitants on Wilson Mountain were members of the John Wilson family (hence the colloquial name for the mountain) who occupied it into the early 1900's. Apparently the Wilsons and others farmed the benches and flatter areas of the mountain as evidenced by many remnants of buildings and fences. A small

⁷Continuous Forest Inventory, Wilson Mountain. 1962. Department of Forestry, The University of Tennessee (unpublished data).

amount of coal mining for local use has been reported as early as 1819 (Glenn, 1925).

Tree size would suggest that most of the forest of Wilson Mountain is secondary although recent lumbering operations have been small. There is no evidence of clear cutting of any large area.

In the early 1900's, the Bryn Mawr Mining and Land Company (now out of business) bought most of Wilson Mountain as well as other tracts of land in Morgan and Scott Counties. Records of lumbering and mining operations are not available during the tenure of the company, but it is probable that some timber was removed. In 1937, the company deeded approximately 8200 acres to the University of Tennessee, including the Wilson Mountain tract. After this acreage was acquired by the University, some timber was sold to local citizens but a development policy formulated in 1949 resulted in management practices which ended lumbering on a large scale (MacDonald, 1964).

Between 1953 and 1958, land was leased to several coal companies for the purpose of strip mining. Most of this mining was done in 1953 when a coal bed encircling the mountain at the 1900' contour was completely removed. Some coal was mined at the 1800' contour but the strip pits are discontinuous. At present, natural vegetation and plantings of Pinus taeda by the University of Tennessee Agricultural Experiment Station are revegetating the strip pits and spoil banks.

The only known incident of fire in the study area per se occurred in 1953. Severe damage to the forest was restricted to the

northwest end of the mountain. Slight butt damage to trees at lower elevations particularly on the southwestern exposure, indicates that small fires of unknown origin have occurred in various isolated areas within the last twenty years.

IV. METHODS

Transects were walked from the base (elevation 1360-1400 feet) to the top of Wilson Mountain (elevation 2260 feet) on both ridges and in draws on northeast and southwest exposures (Figure 1). Twenty transects were established--five each on ridges and draws on each exposure. On each transect an average of ten sample plots were established; these were separated by distances allowing 80-100 feet rise in elevation. Areas within 100 feet of the road and strip mine area were excluded (1600 and 1800-1900 foot contours). In all, 199 sample locations were selected, 102 on the northeast exposure and 97 on the southwest exposure.

At each location, three concentric circular plots were established: 1/5-acre, 1/10-acre, and 1/100-acre. A wooden stake with metal tag locates the plot centers for future studies.

Before establishing plot boundaries, percent slope was determined by clinometer. The plot sizes were determined by using measuring tape and following a method described by Bryan (1956). This technique adjusts plot radii with respect to percent slope (Table II). If actual slope percent was not one of the slope classes indicated, radius was interpolated between classes.

All plot information was recorded on field plot tally sheets which had been designed so that information for each plot could be recorded on a separate sheet (Figure 2). Observations concerning vegetation, site and soil characteristics were recorded by tallying or by



North aspect



South aspect

Figure 1. Wilson Mountain. North and south aspects. (Photographs by H. L. Ragsdale, Fall, 1965.)

TABLE II
ADJUSTED CIRCULAR PLOT RADII (IN FEET) FOR
SLOPES MEASURED IN PERCENT

Slope Class in Percent	1/100-acre	1/10-acre	1/5-acre
0	11.78	37.24	52.66
20	11.90	37.61	53.18
40	12.23	38.65	54.65
60	12.72	40.22	56.87
80	13.33	42.14	59.59
100	14.01	44.29	62.62
120	14.72	46.54	65.82
140	15.46	48.84	69.07

1-2 Transect _____ 3-9 Date _____ 10-12 Plot _____ 13-15 Thickness of A _____
 16 Slope Direction _____ 17% Slope _____ 18 Slope Direction _____ 19 Slope Form _____
 20-21 pH _____ 22 Thickness of Ao _____ 23 Type of Ao _____ 24 Texture of A _____
 25 Texture of B _____ 26 Depth to Rock _____ 27% Stone _____ 28 Canopy Closure _____
 29% Shrub Cover _____ 30 Fire Damage _____

Species 31-32	Reproduction Class				DBH Classes															
	33-34	35-36	37-38	39-40	41	43	45	47	49	51	53	55	57	59	61	63	65	67		
	I	II	III	IV	42	44	46	48	50	52	54	56	58	60	62	64	66	68		
					5	7	9	11	13	15	17	19	21	23	25	27	29	31+		
01 Dogwood																				
02 Shortleaf Pine																				
03 Virginia Pine																				
04 White Pine																				
05 No. Red Oak																				
06 Scarlet Oak																				
07 White Oak																				
08 Black Oak																				
09 Blackjack Oak																				
10 Chestnut Oak																				
11 So. Red Oak																				
12 Red Maple																				
13 Sugar Maple																				
14 Yellow Poplar																				
15 Sweet Gum																				
16 Black Gum																				
17 Sourwood																				
18 White Ash																				
19 Black Locust																				
20 Sassafras																				
21 Black Walnut																				
22 Pignut Hick.																				
23 Mockernut Hick.																				
24 Shagbark Hick.																				
25 Btrnut Hick.																				
26 Mulberry																				
27 Beech																				
28 Biltmore Ash																				
29																				
30																				
31																				
32																				
33																				
34																				
35																				
36																				
37																				
38																				
39																				

Figure 2. Field plot tally sheet.

coding (University of Tennessee Agricultural Experiment Station, Department of Forestry Continuous Forest Inventory Work Plan, 1962). The card column, plot data coding and the characteristics recorded constitute Appendix A, page 124.

A list of tree taxa expected to be present in the study area was included on the individual plot sheet with space provided to record additional taxa (Figure 2).

On 1/5-acre plots trees were counted by taxon and d.b.h. recorded by 2-inch diameter classes (Figure 2). On 1/10-acre plots "shrub" cover (shrubs and trees less than 5 in. d.b.h.) was estimated to the nearest class (Appendix A). On 1/100-acre plots stems less than 5 in. d.b.h. were counted by taxon in the height classes 3-10, 10-20, 20-30, and 30-40 feet. No distinction was made between seedlings and seedling sprouts. If a group of sprouts indicated growth from a common base, only the largest sprout was counted.

On each 1/100-acre plot, the following procedures were used in recording soil and physical characteristics (see Appendix A pertaining to coding of the respective measurements): Exposure or aspect was determined with a hand compass to the nearest 45 degrees; slope position was estimated by referring to the topographic map and by using an airplane altimeter. The altimeter was adjusted twice daily at known elevations. Slope form was determined by inspection. Percent canopy closure by trees 5 in. d.b.h. and larger was obtained by ocular estimate. Fire damage was estimated by the amount of apparent damage to older trees within the 1/5-acre.

All information on soil properties were obtained in the field with the exception of pH values and certain textural estimates. Humus type was classified according to degree of incorporation into mineral soil. Stone volume was estimated by digging a small pit. Depth and number of pits within a plot depended upon the amount of loose rock present; if it appeared that stone percent was over 20, a larger pit was dug to see if a more accurate estimate could be obtained. In some sample areas, two or three pits were dug to check the first estimate.

Depth to rock was determined by using a soil auger. If rock was encountered, three different places within the 1/100-acre were bored to determine if bed rock was reached or if the auger had struck loose rock. If depth deviated less than 3 inches between borings, the mean value was recorded.

Soil samples to be analyzed for pH were composited from three samples collected from the top six inches of the mineral soil. In the laboratory, samples were air-dried, mortared and passed through a 2 mm. seive and pH determined at 1:1 on a Leeds and Northrup pH meter. The meter was standardized at 4.0 and 7.0 every 10 samples and the scale read to the nearest tenth.

Soil texture estimates of the A and B horizon were made in the field by "feel" following the technique outlined by the USDA Soil Survey Staff (1951). Soil samples of the A and B horizons were collected whenever textural estimates could not be made in the field. The texture

of these samples were either estimated by Dr. M. E. Springer, using the field method mentioned above, or by the hydrometer method of mechanical analysis modified by Day (1956).

Field determinations of tree taxa were aided by use of keys by Shanks and Sharp (1963) and by Strasbaugh and Core (1952). Taxonomic nomenclature follows Gray's Manual of Botany (1950). The common and scientific name of a taxon is given the first time it appears in the written text; the common name is used thereafter.

Field data were transferred to standard forms and data analysis completed by IBM computer 7040 using programs prepared by Computing Center personnel. Statistical analyses included nested analysis of variance (Table III), stepwise linear (simple) and multiple regression.¹

Tables of "F" and "r" (Snedecor, 1956) were used in tests of significance in analysis of variance and regression, respectively. Component of variance analysis (Snedecor, 1956) estimated the amount of variation contributed by exposure and topographic effects in analysis of variance.

¹Analysis of variance from ANCOVAR designed at Brigham Young University; stepwise regressions program was BMDOR, Health Sciences Computing Facility, UCLA.

TABLE III
EXPECTED VARIANCE (MEAN SQUARE) FOR NESTED ANALYSIS OF VARIANCE

Source of Variation	Degrees of Freedom	Expected Variance
Between exposures	$e-1$	$\sum_s^2 + 10\sum_t^2 + 20\sum_p^2 + 100\sum_e^2$
Among paired transects within exposures	$e(p-1)$	$\sum_s^2 + 10\sum_t^2 + 20\sum_p^2$
Among transects within pairs	$ep(t-1)$	$\sum_s^2 + 10\sum_t^2$
Among Samples	$ept(s-1)$	$\sum_s^2$

V. RESULTS AND DISCUSSION

Forest Composition

Taxonomic composition of tree stratum of the study area is expressed as frequency relative to exposure and topography in Tables IV and V. Expressing composition as frequency indicated how widely each taxon is distributed and stand group of heterogeneity. It can be readily seen that few taxa are uniformly distributed. In fact, twenty taxa in the overstory were restricted to north or south-facing exposures (hereafter referred to as north or south slopes), seven were restricted to draws and four were restricted to ridges (Table IV). In the understory, these taxa numbered seventeen, eight and five, respectively (Table V). This indicates that the sites investigated were indeed different from one another and that both the understory and overstory taxa have specific site requirements.

The rather good agreement between frequency values of over- and understory suggests that sample sizes were adequate (Cf. Kershaw, 1964). The overstory sampled was approximately 5 percent of the total study area; understory sample was less than 1 percent.

Forest Types

On Wilson Mountain, forest types of north and south exposures were determined by summing relative density and relative basal area values of all taxa greater than 5 inches d.b.h. occurring on 1/5-acre plots. The maximum value that could be obtained for each plot

TABLE IV
FREQUENCY OF OVERSTORY TREE TAXA RELATED
TO EXPOSURE AND TOPOGRAPHY^a

Taxon	North Ridge	North Draw	North Total	South Ridge	South Draw	South Total	Total Area
<u>Acer rubrum</u>	75.0	82.6	78.4	35.3	69.6	51.5	70.3
<u>A. saccharum</u>	1.8	2.2	2.0	0.0	0.0	0.0	1.0
<u>Aesculus octandra</u>	0.0	19.6	8.8	0.0	0.0	0.0	4.5
<u>Amelanchier arborea</u>	14.2	8.7	11.8	3.9	4.3	3.1	7.5
<u>Betula lenta</u>	0.0	6.5	2.9	0.0	0.0	0.0	1.5
<u>Carpinus caroliniana</u>	0.0	4.3	2.0	0.0	0.0	0.0	1.0
<u>Carya cordiformis</u>	12.5	13.0	12.7	0.0	0.0	0.0	6.5
<u>C. glabra</u>	28.6	37.0	33.3	41.2	50.0	45.4	39.2
<u>C. ovata</u>	3.6	13.0	7.8	0.0	2.2	1.0	4.5
<u>C. ovalis</u>	28.6	54.3	39.2	17.6	19.6	19.5	29.4
<u>C. sp.</u>	5.3	8.9	6.9	0.0	0.0	0.0	3.5
<u>C. tomentosa</u>	10.7	0.0	5.6	13.0	9.8	11.3	8.5
<u>Cornus florida</u>	16.0	13.0	14.7	2.0	2.2	2.1	8.5
<u>Diospyros virginiana</u>	5.3	0.0	2.9	0.0	0.0	0.0	1.5
<u>Fagus grandifolia</u>	8.9	19.6	13.7	0.0	0.0	0.0	7.0
<u>Fraxinus americana</u>	12.5	63.0	41.2	2.0	28.3	14.4	25.1
<u>Juglans nigra</u>	19.5	17.1	16.7	0.0	0.0	0.0	8.5
<u>Liriodendron tulipifera</u>	51.8	78.3	61.8	2.0	28.3	14.4	38.2
<u>Liquidambar styraciflua</u>	2.9	19.6	9.8	3.9	0.0	2.1	6.0
<u>Magnolia acuminata</u>	1.8	6.5	3.9	0.0	0.0	0.0	2.0
<u>M. tripetala</u>	0.0	4.3	2.0	0.0	0.0	0.0	1.0
<u>Nyssa sylvatica</u>	50.0	37.0	44.0	51.0	52.2	51.5	47.7
<u>Oxydendrum arboreum</u>	14.2	8.7	11.8	3.9	4.3	3.1	7.5

TABLE IV (Continued)

Taxon	North Ridge	North Draw	North Total	South Ridge	South Draw	South Total	Total Area
<u>Pinus echinata</u>	16.1	2.2	10.0	74.5	23.9	50.5	29.6
<u>P. strobus</u>	37.5	0.0	15.6	3.9	13.0	8.0	12.1
<u>P. virginiana</u>	1.8	0.0	1.0	3.9	2.2	3.1	2.0
<u>Plantanus occidentalis</u>	3.6	2.2	3.0	0.0	0.0	0.0	1.5
<u>Prunus serotina</u>	30.4	21.4	25.5	0.0	19.5	9.3	7.5
<u>Prunus sp.</u>	0.0	2.2	1.0	0.0	0.0	0.0	0.5
<u>Quercus alba</u>	41.1	36.6	49.0	56.9	71.7	63.9	56.3
<u>Q. rubra</u>	48.2	41.3	46.1	29.4	47.8	37.0	43.7
<u>Q. coccinea</u>	30.4	0.0	26.0	51.0	17.4	35.1	32.0
<u>Q. marilandica</u>	0.0	0.0	0.0	15.7	0.0	9.3	4.5
<u>Q. prinus</u>	64.3	52.2	60.1	74.5	95.7	83.0	76.4
<u>Q. stellata</u>	0.0	0.0	0.0	7.8	0.0	4.1	2.0
<u>Q. velutina</u>	21.4	0.0	11.7	62.7	26.0	47.4	29.1
<u>Rhamnus caroliniana</u>	1.8	0.0	1.0	0.0	0.0	0.0	0.5
<u>Robinia pseudo-acacia</u>	30.3	13.0	22.5	5.9	13.0	9.3	16.1
<u>Sassafras albidum</u>	12.5	6.5	9.8	0.0	0.0	0.0	5.0
<u>Tilia heterophylla</u>	0.0	8.7	4.0	0.0	0.0	0.0	2.0
<u>Ulmus americana</u>	3.6	2.2	2.9	0.0	0.0	0.0	1.5
<u>Ulmus alata</u>	0.0	0.0	0.0	0.0	21.7	10.3	5.0

^aData as frequency in 1/5-acre plots on north ridges, north draws, north exposure, south ridges, south draws, south exposure, total area.

TABLE V
FREQUENCY OF UNDERSTORY TREE TAXA RELATED
TO EXPOSURE AND TOPOGRAPHY^a

Taxon	North Ridge	North Draw	North Total	South Ridge	South Draw	South Total	Total Area
<u>Acer rubrum</u>	73.2	78.3	73.5	76.5	63.0	69.1	71.4
<u>A. saccharum</u>	1.8	4.3	2.0	0.0	0.0	0.0	1.5
<u>Aesculus octandra</u>	0.0	15.6	6.8	0.0	0.0	0.0	3.5
<u>Amelanchier arborea</u>	8.9	21.7	14.7	9.8	2.0	6.2	10.0
<u>Betula lenta</u>	0.0	6.5	2.9	0.0	2.2	1.0	2.0
<u>Carpinus caroliniana</u>	3.5	17.4	9.8	0.0	0.0	0.0	5.0
<u>Carya cordiformis</u>	10.7	10.9	10.8	0.0	0.0	0.0	5.5
<u>C. glabra</u>	39.3	37.0	38.2	41.2	50.0	43.3	40.7
<u>C. ovata</u>	1.8	0.0	1.0	0.0	0.0	0.0	0.5
<u>C. ovalis</u>	21.4	30.4	25.5	9.8	8.7	9.3	17.6
<u>C. sp.</u>	3.5	4.3	3.9	0.0	0.0	0.0	3.5
<u>C. tomentosa</u>	10.7	4.3	7.8	15.7	17.4	16.5	12.3
<u>Castanea dentata</u>	12.5	17.4	14.7	0.0	0.0	0.0	7.5
<u>Cornus florida</u>	76.4	89.0	82.3	43.1	65.1	49.4	66.3
<u>Diospyros virginiana</u>	2.0	0.0	1.0	2.0	0.0	1.0	1.0
<u>Fagus grandifolia</u>	16.1	19.6	17.6	2.1	0.0	1.0	9.5
<u>Fraxinus americana</u>	23.2	67.4	43.1	2.0	32.6	16.5	30.1
<u>Juglans nigra</u>	0.0	2.2	1.0	0.0	0.0	0.0	0.5
<u>Liriodendron tulipifera</u>	19.6	28.3	22.5	3.9	17.4	10.3	16.6
<u>Liquidambar styraciflua</u>	2.9	19.6	9.8	11.8	15.2	13.4	14.1
<u>Magnolia acuminata</u>	0.0	4.3	2.0	0.0	0.0	0.0	1.0
<u>M. tripetala</u>	0.0	13.0	5.9	0.0	0.0	0.0	3.0
<u>Morus alba</u>	7.1	13.0	9.8	0.0	2.2	1.0	5.5

TABLE V (Continued)

Taxon	North Ridge	North Draw	North Total	South Ridge	South Draw	South Total	Total Area
<u>Nyssa sylvatica</u>	51.8	41.3	42.2	78.4	65.2	71.1	56.3
<u>Oxydendrum arboreum</u>	55.2	23.9	44.1	56.8	45.6	51.5	45.7
<u>Pinus echinata</u>	0.0	4.3	1.9	17.6	2.2	11.4	6.5
<u>P. strobus</u>	25.0	0.0	13.7	7.8	0.0	4.1	9.0
<u>Prunus serotina</u>	21.4	30.4	25.5	5.9	52.1	27.8	26.6
<u>Quercus alba</u>	12.5	13.0	12.8	29.4	47.8	31.4	24.1
<u>Q. rubra</u>	28.6	32.6	29.4	25.5	32.6	30.9	30.1
<u>Q. coccinea</u>	19.6	0.0	10.8	25.5	10.9	18.6	14.6
<u>Q. marilandica</u>	0.0	0.0	0.0	7.8	0.0	4.1	2.0
<u>Q. prinus</u>	53.6	52.2	53.0	56.9	67.4	60.8	56.8
<u>Q. stellata</u>	0.0	0.0	0.0	3.9	0.0	2.1	1.0
<u>Q. velutina</u>	17.9	2.2	9.8	43.1	30.4	37.1	23.1
<u>Rhamnus caroliniana</u>	7.1	10.9	8.8	0.0	0.0	0.0	4.5
<u>Robinia pseudo-acacia</u>	12.5	10.9	11.8	43.1	47.7	45.3	28.1
<u>Sassafras albidum</u>	23.1	30.4	26.5	3.9	2.2	3.1	15.1
<u>Tilia heterophylla</u>	0.0	2.2	1.0	0.0	0.0	0.0	0.5
<u>Tsuga canadensis</u>	0.0	2.2	1.0	0.0	0.0	0.0	0.5
<u>Ulmus americana</u>	0.0	2.2	1.0	0.0	0.0	0.0	0.5
<u>Ulmus alata</u>	0.0	0.0	0.0	3.9	26.0	14.4	7.0

^aData as frequency in 1/100-acre plots on north ridges, north draws, north exposure, south ridges, south draws, south exposure, total area.

was 2.00; the taxa forming 50 percent of this value were designated the dominant or codominants by plot. Only taxa selected for analyzing vegetation characteristics were considered; Acer rubrum (red maple) and Nyssa sylvatica (black gum) are common throughout but are not ordinarily considered upland dominants of wide importance. Within types, isolated stands were noted that were not characteristic of the surrounding vegetation; these were considered segregates or transitional to another forest type and are not included in Figure 3.

Chestnut Oak Type. This is the most common forest type in the study area. In general, it occupies the middle and lower slopes of the ridges and draws on the north exposure and the middle and upper slopes in the draws on the south exposure. Although Quercus prinus (chestnut oak) is common throughout, on the north exposures, Pinus strobus (white pine), Q. rubra (northern red oak), Q. coccinea (scarlet oak), Carya glabra (pignut hickory), Liriodendron tulipifera (tulip poplar) and Fraxinus americana (white ash) are associates and (or) codominants with chestnut oak; Prunus serotina (black cherry), Oxydendrum arboreum (sourwood) and Cornus florida (dogwood) commonly contribute to total density and basal area. On the south slopes, this type occupies the middle and upper slopes of the draws and upper slopes of the ridges; chestnut oak is dominant in over 55 percent of the sampled area. Pignut hickory, Q. velutina (black oak), or Q. alba (white oak) are the usual codominants and C. tomentosa (mockernut hickory) is an occasional codominant. Q. marilandica (blackjack oak)

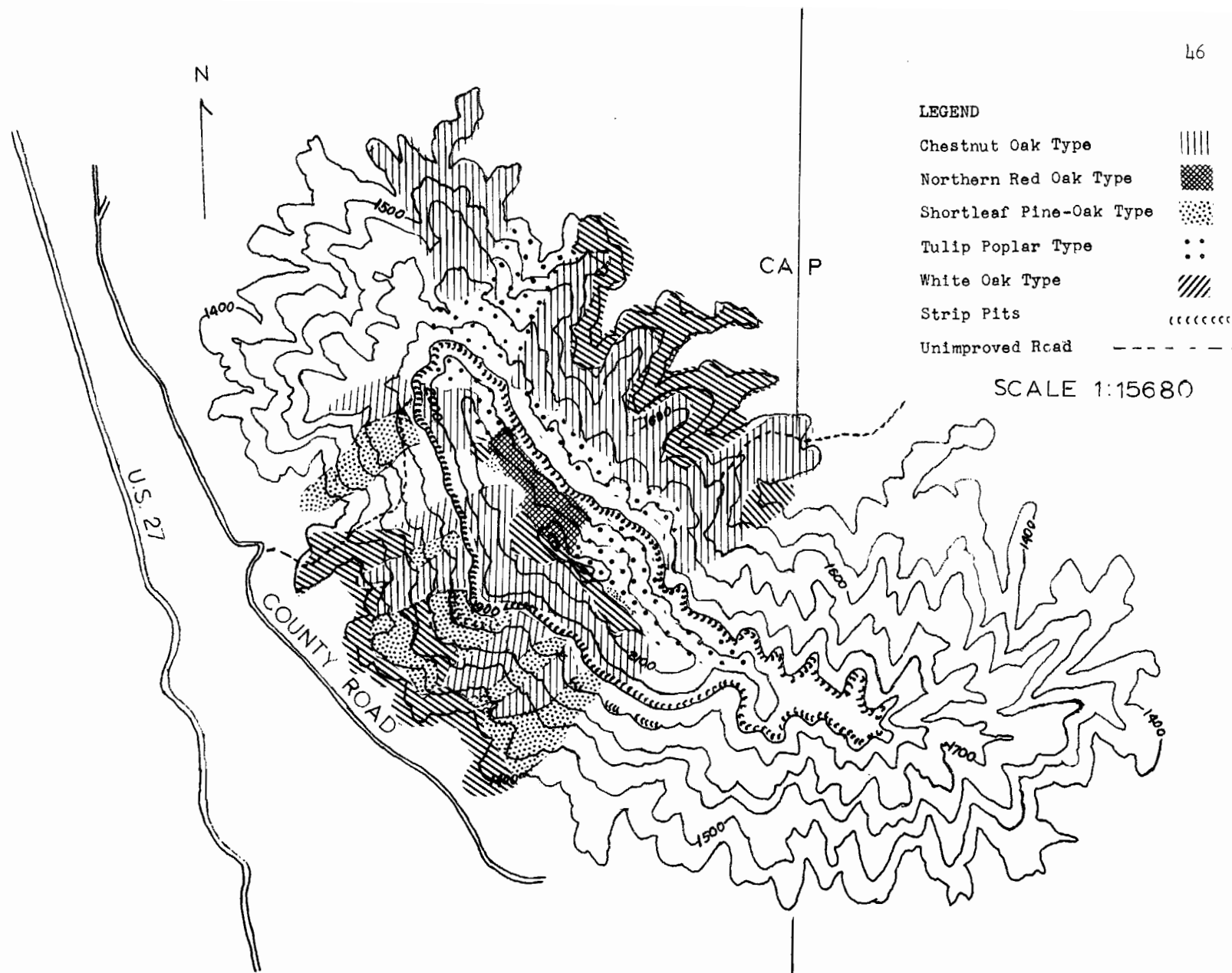


Figure 3. Forest types of Wilson Mountain, Morgan County, Tennessee; CA and P denote adjacent boundaries of Camp Austin and Petros, Tennessee U. S. G. S. quadrangles.

and Q. stellata (post oak) are minor constituents located on exposed, open sites on ridges shows rock outcrops.

Tulip Poplar Type. This type occupies portions of the upper slopes on ridges and extends into protected draws of the north exposure. Within this type is the greatest diversity of taxa. White ash and Carya ovalis (sweet pignut hickory) are common codominants with Liriodendron tulipifera (tulip poplar); northern red oak, white oak, and chestnut oak may also be codominant. Tilia heterophylla (basswood), Aesculus octandra (buckeye), Juglans nigra (black walnut), C. cordiformis (bitternut hickory) and Sassafras albidum (sassafras) occur in the draws on upper slopes but are not major constituents.

Northern Red Oak Type. This type occupies the uppermost slopes on the north exposure where ridges and draws are not sharply defined. Scarlet oak, chestnut oak, pignut hickory, and sweet pignut hickory are codominants with northern red oak; bitternut hickory and Magnolia acuminata (cucumber-tree) are minor constituents. Total basal area per plot is highest on this type.

White Oak Type. This type occupies the lower slopes of the ridges and draws on both exposures and a portion of the uppermost south slopes where it apparently merges with the Northern Red Oak and Tulip Poplar Types. Chestnut oak, northern red oak, scarlet oak, Fagus grandifolia (beech) and Liquidamber styraciflua (sweet gum) are codominants on the lower north slopes. White pine Pinus

echinata (shortleaf pine) and tulip poplar also contribute to the total density and basal area. Sweet gum and beech are restricted largely to this type on the north. Chestnut oak is codominant with white oak on the lower slopes of the south ridges, but white oak is clearly the dominant on lower slopes in the draws. White oak is codominant with pignut hickory, sweet pignut hickory, and black oak on the uppermost south slopes.

Shortleaf Pine-Oak Types. Shortleaf pine is dominant in 50 percent of the plots occupied by this type. In most stands chestnut oak, scarlet oak, black oak or blackjack oak occur with pine as codominants or constituents. Pinus virginiana (Virginia pine) and mockernut hickory are codominants in isolated cases. The type occurs exclusively on slopes of ridges on the south exposure and in isolated stands on top of the mountain. The occurrence of the type at the top is apparently a result of invasion of shortleaf pine onto fields abandoned at the turn of the century, and does not appear to be a permanent forest type; hardwood taxa presently occupy the understory.

Diameter Distribution

The French forester de Liocourt was first to recognize an inverse geometric relationship of numbers of trees to diameter class in uneven-aged forests (Meyer and Stevenson, 1943). This relationship is important when it is realized that growth and structure of tree communities is continuous only when larger trees, which eventually die,

are replaced in time by trees with small diameters but capable of eventually forming the overstory. The distribution of trees by diameter class within the study area follows this relationship (Table VI). It can be seen that percentages of trees decreases rapidly as class size increases. When related to exposure and topography, varying diameter distribution reflects relative rates of growth, although it is recognized that tests for statistical significance have not been run and tree age has not been considered.

In general, a higher percentage of trees with larger diameters was recorded on north slopes, particularly in the north draws and on the upper north slopes; conversely, trees in smaller diameter classes were recorded more often on south slopes, particularly on ridges.

Forestry inventory statistics for Morgan County indicate that 43.1 percent of all merchantable timber is in the 5-inch diameter class; 25.9 percent in the 7-inch class; 4.9 percent in the 9-inch class; 8.5 percent in the 11-inch class; 4.2 percent in the 13-inch class; 3.3 percent in the 15-inch and above class (Tennessee Valley Authority, 1961). With the exception of the 7-inch diameter class, more trees are in larger diameter classes on Wilson Mountain than in the surrounding area; all trees 15 inches d.b.h. or above comprised 5.7 percent of all trees over 5 inches d.b.h. The preponderance of smaller diameter classes in Morgan County indicates more disturbance of forest stands than in the study area.

Although soil-moisture determinations were not made, it is well-documented that water availability differs on north and south

TABLE VI
TREE DIAMETER CLASS DISTRIBUTION RELATED
TO EXPOSURE AND TOPOGRAPHY^a

Exposure	Diameter Class													
	5	7	9	11	13	15	17	19	21	23	25	27	29	31+
North ridges	25.5	24.3	17.6	12.7	7.8	5.5	2.6	2.2	.3	.5	.3	.2	.2	.3
North draws	22.2	17.7	18.0	12.4	11.2	7.8	5.1	2.1	1.2	.6	.3	.6	.4	.5
North total	24.1	21.6	17.8	12.6	9.2	6.5	3.6	2.1	.7	.5	.3	.4	.3	.4
South ridges	27.3	28.4	21.9	11.6	5.8	2.6	1.6	.4	.3	.1	.0	.07	.0	.0
South draws	25.0	25.4	18.8	11.4	8.9	6.2	1.8	1.2	1.0	.08	.08	.08	.0	.0
South total	26.3	27.1	20.1	11.5	7.2	4.2	1.7	.7	.6	.1	.04	.07	.0	.0
All trees	25.2	24.4	19.2	12.0	8.2	5.3	2.6	1.4	.7	.3	.2	.2	.1	.2

^aData as percent of trees on north ridges, north draws, north exposure, south ridges, south draws, south exposure, total area.

exposures and effects growth in diameter and height (Potzger, 1939; Cottle, 1932; Cantlon, 1953). Further, Stoekeler and Curtis (1960) recognized that total solar radiation was greater on south exposures, increasing evapotranspiration and decreasing available soil. Timber volume was directly related to soil moisture values. Cooper (1961) noted significantly larger trees on north than on south slopes and Nash (1959) showed that rate of growth of oaks was greater on north exposures.

Differences in soil characteristics, vegetation and topography, within the study area affect water availability. In general, south slopes are steeper than north slopes. Internal drainage and movement of water downslope would affect moisture conditions of the soil profile; drainage and run-off increases as slope increases. Therefore, it is possible that supply of water may often become a limiting factor in rate of growth on south slopes resulting in smaller annual increment.

Trees with the largest diameters, hence largest basal area, were found on upper north slopes. During the sampling period, rainfall was more frequent on these upper slopes than at lower elevations. Apparently, higher land surfaces force warm westerly air to rise, cool, and moisture to condense. Both lower temperatures and higher precipitation would result in lower water stress.

Soil-Site Characteristics

In general, soils tend to be more acid on south slopes, particularly on south ridges (Table VII). One factor apparently contributing

TABLE VII
PERCENT OF pH VALUES (0-6 INCHES) RELATED TO
EXPOSURE AND TOPOGRAPHY^a

pH Value	North Ridge	North Draw	North Total	South Ridge	South Draw	South Total	Total Area
4.2				1.2		1.0	0.5
4.3				5.9		3.1	1.5
4.4				7.8	4.3	6.2	3.0
4.5				9.8	6.5	8.2	4.0
4.6				19.6	2.2	11.3	5.5
4.7	1.8		1.0	15.7	6.5	11.3	6.0
4.8	3.6		2.0	11.8	13.0	12.4	7.0
4.9	18.0		9.8	9.8	13.0	11.3	10.5
5.0	5.4	6.5	5.9	5.9	15.2	10.3	8.0
5.1	21.6	13.0	17.6	5.9	21.7	13.4	15.6
5.2	19.8	8.7	14.7	3.9	2.2	3.1	9.0
5.3	9.0	10.9	9.8		2.2	1.0	5.5
5.4	3.6	10.9	6.9		6.5	3.1	5.0
5.5	7.2	6.5	6.9	2.0	2.2	2.1	4.5
5.6	7.2	2.2	4.9		2.2	1.0	3.0
5.7		6.5	2.9				1.5
5.8	3.6	10.9	6.9				3.5
5.9		4.3	2.0		2.2	1.0	1.5
6.0		8.7	3.9				2.0
6.1		8.7	3.9				2.0
6.2		2.2	1.0				0.5
Median pH value	5.1	5.4	5.2	4.7	5.0	4.8	5.1
Mode pH value	5.1	5.1	5.1	4.6	5.1	5.1	5.1

^aData as percent of samples from north ridges, north draws, north exposure, south ridges, south draws, south exposure, or all samples.

to this difference is increase in amount of pine litter on south slopes. Pine litter is usually higher in organic acids and lower in exchangeable bases than hardwood litter (Lutz and Chandler, 1946); subsequent decomposition of litter could increase hydrogen-ion concentration and at the same time contribute fewer exchangeable bases. Sandy textured A and B horizons occurring on south slopes have fewer colloids and may have a lower cation-exchange capacity than soils on north slopes. Further, the coarseness in texture would result in a faster percolation of water. This faster movement of water through the profile concomitant with fewer absorbing surfaces could result in leaching of bases lowering the pH. Conversely, the increased percentage of higher pH values on north slopes, particularly in north draws, is probably a result of less leaching of bases due to finer texture and predominating hardwood stands contributing litter high in exchangeable bases.

There is more variation in soil texture on south slopes, particularly on south ridges. Although it is obvious that finer textured silt loams and silty clay loams dominate soil profiles (Table VIII and IX), sandier soils are more frequent in both horizons on south ridges. It is possible that sandy soils have developed because of movement of finer particles downslope. Although soils on both exposures have varying amounts of clay, certain soils on south ridges have a higher percent of clay in both horizons; profiles high in clay are located on flattened, lower and middle slopes on south ridges and accumulation of clay on lower slopes may be a result of deposition of fine particles from upslope.

TABLE VIII

TEXTURAL ESTIMATES (A AND B HORIZONS) RELATED
TO EXPOSURE AND TOPOGRAPHY^a

Soil Texture Class	North Ridge	North Draw	North Total	South Ridge	South Draw	South Total	Total Area
A horizon							
Sand							
Loamy sand							
Sandy loam							
Loam	3.6	8.7	5.9	41.2	2.2	22.7	14.1
Silt loam	96.4	91.3	94.1	51.0	97.8	73.2	84.9
Silt							
Sandy clay							
loam							
Clay loam							
Silty clay							
loam				5.9		3.1	1.5
Sandy clay							
Silty clay							
Clay							
B horizon							
Sand							
Loamy sand							
Sandy loam							
Loam	3.6	4.3	3.9	27.5	2.2	15.5	9.5
Silt loam	3.6	2.2	2.9		8.7	4.1	3.5
Silt							
Sandy clay							
loam							
Clay loam	1.8	4.3	2.9	9.8		5.2	4.0
Silty clay							
loam	91.2	89.1	90.2	51.0	89.1	69.1	79.9
Sandy clay							
Silty clay				3.9		2.1	1.0
Clay				7.8		4.1	2.0

^aData as percent of textural estimates on north ridges, north draws, north exposure, south ridges, south draws, south exposure, total samples.

TABLE IX
TEXTURAL ESTIMATES (A AND B HORIZONS OF SAME PROFILE)
RELATED TO EXPOSURE AND TOPOGRAPHY^a

Soil Texture Class ^b	North Ridge	North Draw	North Total	South Ridge	South Draw	South Total	Total Area
Loam Loam	3.6	4.3	3.9	25.5	2.2	14.4	9.0
Loam Clay loam		4.3	2.0	9.8		5.2	3.5
Loam Silty clay loam				5.9		3.1	1.5
Silt loam Loam				2.0		1.0	0.5
Silt loam Silt loam	3.6	2.2	2.9		8.7	4.1	3.5
Silt loam Clay loam	1.8		1.0				0.5
Silt loam Silty clay loam	91.1	89.1	90.2	45.1	89.1	66.0	78.4
Silt loam Silty clay				3.9		2.1	1.0
Clay loam Clay				2.0		1.0	0.5
Silty clay Clay				5.9		3.1	1.5

^aData as percent of textural estimates within a profile on north ridges, north draws, north exposures, south ridges, south draws, south exposures, total samples.

^bFirst textural class of each pair is A horizon, second is B horizon; each pair represents one profile.

A high percentage of the humus on Wilson Mountain is of the mull type (Table X). Mor-type humus develops on north and south ridges under pine overstory, or on north ridges under ericaceous shrub cover (Kalmia latifolia and Vaccinium spp.). Decomposition of organic material probably occurs at a faster rate on south slopes in spite of lower pH of pine and ericaceous litter. However, subsequent mixing of organic matter with mineral soil by animals is impeded.

Thinner O layers are found on south slopes where faster litter decomposition occurs (Table XI). The slower rate on north slopes is probably influenced by lower temperatures and higher moisture content. The difference in north ridges and draws may be due to sampling. Estimates were made on slopes on either side of draws rather than in the middle from which thin O layer could have resulted from downslope water or wind movement into the base of the draw.

Broadfoot and Pierre (1939) recognized that environmental characteristics such as moisture and temperature and different tree taxa effect rate of decomposition. In West Virginia, they observed that oaks and pine litter decomposed slowly in comparison to tulip poplar, black walnut and dogwood. On the cooler, moister north slopes, litter decomposition may have been more rapid in the draws due to the occurrence of litter that decomposes at faster rates, e.g., tulip poplar. On north ridges, litter may persist because of slower decay of oak litter. It is assumed on both slopes that there is little downslope movement of litter.

TABLE X
PERCENT OF HUMUS TYPES REPRESENTED RELATED
TO EXPOSURE AND TOPOGRAPHY^a

Type of Humus Layer	North Ridge	North Draw	North Total	South Ridge	South Draw	South Total	Total Area
Mull	80.4	93.5	86.3	62.7	100.0	80.4	83.4
Mor	5.4	0.0	2.9	27.5	0.0	14.4	8.5
Intermediate	14.3	6.5	10.8	9.8	0.0	5.2	8.0

^aData as percent of north ridges, north draws, north exposure, south ridges, south draws, south exposure, total area.

TABLE XI
THICKNESS OF O LAYER RELATED TO EXPOSURE AND TOPOGRAPHY^a

Thickness of O (Inches)	North Ridge	North Draw	North Total	South Ridge	South Draw	South Total	Total Area
0.0-0.5	8.9	45.7	25.5	74.5	73.9	74.2	48.7
0.5-1.0	50.0	32.6	42.3	23.5	26.1	24.7	35.7
1.0-1.5	35.7	13.0	25.5	2.0	0.0	1.0	13.6
1.5-2.0	3.6	8.7	5.8	0.0	0.0	0.0	3.0
2.0-2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.5-3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0-3.5	1.8	0.0	1.0	0.0	0.0	0.0	0.5
3.5-4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0+	0.0	0.0	0.0	0.0	0.0	0.0	0.0

^aData as percent on north ridges, north draws, north exposure, south ridges, south draws, south exposure, total area.

Soil profiles are deeper on south slopes than north slopes (Table XII). This is contrary to observations by Springer¹ on the Cumberland Plateau and Gilbert and Wolfe (1959) in Ohio. Shallow profiles have developed on mid-slopes of both exposures in the study area. Although south slopes are steeper, the rate of weathering appears to have occurred faster than erosion (barring deposition of loess).

Higher stone estimates were made in plots on north slopes (Table XIII). Although some shallow soils were present on these slopes, stone percent was not related to shallowness. On north slopes physical breaking of rocks from surfaces was followed by movement of rocks downslope. Rock "heaving" would also result in surfacing of stones and their movement downslope would result in accumulation in the north draws. Slow weathering due to cooler temperatures would facilitate persistence of the gravel-size and larger stones noted.

The correlation matrix between soil-site variables substantiates most of these observations and indicates which variations are significant (Table XIV). Further, interpretations from the correlation coefficients indicate a thicker A horizon occurs on north slopes because of less surface removal. Cooper (1960) in Michigan and Gilbert and Wolfe (1959) in Ohio observed thicker A horizons on north slopes.

¹Personal communication with Dr. M. E. Springer, Associate Professor of Agronomy, The University of Tennessee.

TABLE XII
PERCENT OCCURRENCE OF DIFFERENT DEPTHS TO ROCK
RELATED TO EXPOSURE AND TOPOGRAPHY^a

Depth to Rock (Inches)	North Ridge	North Draw	North Total	South Ridge	South Draw	South Total	Total Area
0-6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6-12	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12-18	3.6	0.0	2.0	2.0	2.2	2.1	2.0
18-24	3.6	6.5	4.9	0.0	0.0	0.0	2.5
24-30	3.6	4.3	3.9	0.0	2.2	1.0	2.5
30-36	3.6	2.2	2.9	3.9	0.0	2.1	2.5
36-42	8.9	6.5	7.8	2.0	2.2	2.1	5.0
42 plus	76.8	80.4	78.4	92.2	93.5	92.8	85.4

^aData as percent of north ridges, north draws, north exposure, south ridges, south draws, south exposure, total area.

TABLE XIII

PERCENT ESTIMATED STONE BY VOLUME RELATED
TO EXPOSURE AND TOPOGRAPHY^a

Percent Stone In Soil (Volume)	North Ridge	North Draw	North Total	South Ridge	South Draw	South Total	Total Area
0-20	85.7	52.1	70.6	86.3	45.7	67.0	68.8
20-40	12.5	34.8	22.5	11.8	54.3	31.9	27.1
40-60	1.8	13.0	6.8	2.0	0.0	1.0	4.0
60-80	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80-100	0.0	0.0	0.0	0.0	0.0	0.0	0.0

^aData as percent of north ridges, north draws, north exposure, south ridges, south draws, south exposure, total area.

TABLE XIV
CORRELATION MATRIX BETWEEN SOIL-SITE VARIABLES^a

Code No.	Soil-Site Variables	Soil-Site Variables ^b									
		1	2	3	4	5	6	7	8	9	10
1	Thickness of A	1.00	-0.52			-0.55	-0.31	-0.19	0.22		
2	Slope direction		1.00			-0.59	-0.47	-0.22	-0.30	-0.19	
3	Percent slope			1.00	-0.28						
4	Slope position				1.00						0.18
5	pH					1.00				0.30	
6	Thickness of O						1.00				
7	Texture of A horizon							1.00		0.53	
8	Texture of B horizon								1.00		
9	Depth to rock									1.00	-0.37
10	Percent stone										1.00

^aCorrelations $>.18$ are included; p of $r >.18 <.01$.

^bVariable code numbers correspond to code numbers in first column.

Slope direction and associated characteristics also contribute significantly to total soil variation.

In the Continuous Forest Inventory, thinner A horizons, shallower soil profiles, higher percentages of stone and sandier soils were reported (unpublished data, Department of Forestry, The University of Tennessee).

Analysis and Interpretation of Vegetation Data

The nested analysis of variance was used in determining if significant quantitative variation existed in vegetation. Three main sources of variation were considered, viz., variation due to exposure, paired transects within exposure, i.e., adjacent ridge and draw, and topography, i.e., ridge or draw effects. Total densities of 1/100 and 1/5-acre plots, total basal area of 1/5-acre plots, total numbers of taxa on 1/100 and 1/5-acre plots contributed to the sums of squares in analyses of general vegetation characteristics. Certain taxa were considered by separate analysis. The taxa were selected for the analysis on the basis of frequency (Table IV, page 41) provided they were important contributors to the overstory or were potential members of a future overstory.

The values contributing to the sums of squares were absolute densities on 1/100 and 1/5-acre plots, and absolute basal area on 1/5-acre plots of the following taxa: shortleaf pine, white pine, northern red oak, white oak, black oak, chestnut oak, red maple, tulip poplar, black gum, sweet pignut hickory, mockernut hickory,

and pignut hickory. The probability of a greater "F" was tested in all analyses at the .01 and .05 levels. The two levels were considered because testing at the .01 level could result in a Type II error (accepting the null hypothesis when in fact it is wrong) when random effects are assumed in the analysis of variance.

In stepwise multiple regression, 12 soil-site variables were selected from information recorded in the field and laboratory and considered independent in an attempt to explain possible relationships affecting the structure of communities. The variables selected were thickness of A horizon, soil pH, thickness of humus layer, texture of A horizon, texture of B horizon, depth to rock, percent stone, slope direction, slope position, percent slope, canopy closure and shrub cover. General characteristics of the communities were selected as dependent variables: total density, 1/100 and 1/5-acre plots, total basal area 1/5-acre plots, total numbers of taxa, 1/100 and 1/5-acre. Taxa considered in the analysis of variance as well as certain additional taxa were analyzed in the regressions. The latter were scarlet oak, sweet gum, bitternut hickory, buckeye and basswood. Although fewer observations were made concerning these additional taxa, their contribution to community structure would be of ecological interest. Absolute densities on 1/100 and 1/5-acre plots and absolute basal areas from 1/5-acre plots of each taxon were considered dependent variables.

Tests of the probability of correlation coefficients greater than .01 were conducted on all regressions. Due to the many degrees

of freedom, this level of probability was chosen as a protection against committing many Type I errors, i.e., reject the null hypothesis when in fact it is true.

Multiple regression is important to an ecological study because relationships between environmental characteristics and measurements of vegetation are not determined by one factor alone. Inferences concerning relationships must consider combinations of environmental factors if an estimate of variation can be considered valid. Therefore, multiple regressions are used to examine the effect of interrelated site factors on forest communities. The stepwise analysis used assumed linear and additive effects. Regressions were not considered unless five variables contributed .10 or more to R^2 , i.e., at least 10 percent of the total variation was explained by the predictive equations.

In many instances, correlation coefficients recorded herein will appear anomalous and statements may appear contrary to tabular values. The reader is referred to the coding in Appendix A since increasing numbers and amounts of values were sometimes coded in numbers of decreasing value.

Characteristics of Vegetation

General characteristics. Total density of the overstory is not significantly different between exposures nor between topographies (Table XV). Determination of components of variance reveals that 90 percent of the variation in total density is located in plots.

TABLE XV
EFFECT OF EXPOSURE AND TOPOGRAPHY ON TOTAL DENSITY, 1/5-ACRE
NESTED ANALYSIS OF VARIANCE

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Square	F ^a	Components of Variance
Between exposures	1	179.5	179.5	0.9 NS	-.32
Among paired transects within exposures	8	1693.2	211.6	2.2 NS	5.90
Among transects within pairs	10	941.5	94.1	1.7 NS	4.00
Among samples	179	9779.0	54.6		90.40
Total	198	12593.2			

^aProbability of F this large <.05 (*); NS--non-significant.

Effects of exposure on basal area are significant but effects due to transect pairs and ridges versus draws are non-significant (Table XVI). The percentage of variation due to exposure effects is high (36.8 percent), but among plot variation is still the major component.

Total density of the tree taxa in the understory is highly significantly different between exposures, but differences within exposures are not related to ridge or draw effects, per se (Table XVII). Just why the density of understory trees should be effected by exposure and overstory trees are not is not fully understood. The among plot variation continues to be the major component of the variation in understory density.

Significant results were obtained in the analysis determining variation in numbers of taxa present on 1/100 and 1/5-acre plots but variation among plots accounted for over 95 percent of the total variation.

These analyses indicate that although exposure or topographic effects account for some variation in vegetation, other environmental variables and inherent characteristics of taxa among plots determine the main source of variation.

Significant correlations occur between different characteristics of the vegetation (Table XVIII). Density of tree taxa on the 1/100-acre plots and shrub cover, the latter a qualitative determination of density beyond the plot boundary, both decrease as density of

TABLE XVI

EFFECT OF EXPOSURE AND TOPOGRAPHY ON TOTAL BASAL AREA, 1/5-ACRE
NESTED ANALYSIS OF VARIANCE

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Square	F ^a	Components of Variance
Between exposures	1	409.6	409.6	9.7 *	36.8
Among paired transects within exposures	8	336.7	42.1	1.6 NS	1.2
Among transects within pairs	10	185.9	18.6	0.7 NS	-0.7
Among samples	179	4604.5	25.7		62.7
Total	198	5536.8			

^aProbability of F this large, $\leq .05$ (*); NS--non-significant.

TABLE XVII
EFFECT OF EXPOSURE AND TOPOGRAPHY ON TOTAL DENSITY, 1/100-ACRE
NESTED ANALYSIS OF VARIANCE

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Square	F ^a	Components of Variance
Between Exposures	1	3917.9	3917.9	40.8 **	38.2
Among paired transects within exposures	8	768.7	96.1	0.6 NS	-2.6
Among transects within pairs	10	1465.1	146.5	1.5 NS	5.2
Among samples	179	17477.6	97.6		59.2
Total	198	23629.4			

^aProbability of F this large, $<.01$ (**); NS--non-significant.

TABLE XVIII
CORRELATION MATRIX BETWEEN VEGETATION VARIABLES^a

Code No.	Vegetation Variables	Vegetation Variables ^b						
		1	2	3	4	5	6	7
1	Canopy closure	1.00			0.36	0.54		0.28
2	Shrub cover		1.00	0.40	-0.35			
3	Total density 1/100-acre			1.00	-0.25		0.55	
4	Total density 1/5-acre				1.00	0.49	-0.22	
5	Total basal area					1.00		
6	Total numbers of taxa 1/100-acre						1.00	
7	Total numbers of taxa 1/5-acre							1.00

^aOnly variables $>.18$ are included; p of $r >.18 <.01$.

^bVariable code numbers correspond to code numbers in first column.

overstory increases. Hall and Homesley (1966) stated that overstory crown cover was the limiting factor in understory development in Texas. An increase in overstory density reduces light intensity, changes light quality, and reduces availability of water and nutrients. Numerous studies indicate that light intensity may be a limiting factor affecting survival and growth. Only taxa inherently able to carry on photosynthesis in light of a lower intensity and (or) of a different quality would become a part of the understory. Those taxa termed "shade tolerant" may require or tolerate low light intensity during early stages of growth. Those taxa considered "intolerant" would have a high mortality rate in areas of high overstory density. A negative correlation does exist between overstory density and numbers of taxa in the understory indicating that increased density (decreased light) produces an environment in which only shade tolerant taxa can survive.

Significant correlations between soil-site and general vegetation characteristics indicate that slope direction contributes the most to variation in vegetation (Table XIX). Values for canopy closure, shrub cover, total density in 1/100-acre plots and total basal area decrease on south slopes. Position on slope affects canopy closure and total basal area; more overstory cover and larger basal areas are indicative of the vegetation on the upper north slopes. Soils on these upper slopes are fine-textured with silt loam A horizons and silty clay loam B horizons. They apparently have a high water-holding capacity. The fine-texture of this soil combined with possible orographic

TABLE XIX

SIGNIFICANT CORRELATIONS BETWEEN SOIL-SITE AND VEGETATION CHARACTERISTICS^a

Soil-Site Variables	Vegetation Variables ^b						
	CC	SC	TD1	TD5	TBA	TN1	TN5
Thickness of A	-0.21		-0.28		-0.24		
Slope direction	-0.22	-0.28	-0.41		-0.26		-0.24
Percent slope							
Slope position	-0.25				-0.34		
pH		0.24	0.33	-0.30			
Thickness of O		-0.19					
Texture of A	0.21						0.22
Texture of B	0.21	0.31			0.18	.20	
Depth to rock							
Percent stone							

^aOnly variables $>.18$ are included; p of $r >.18 < .01$.^bCC--Canopy closure; SC--Shrub cover; TD1--Total density, 1/100-acre; TD5--Total density, 1/5-acre; TBA--Total basal area; TN1--Total number of taxa, 1/100-acre; TN5--Total number of taxa, 1/5-acre.

influence on precipitation could account for significant increases in basal area and subsequently higher cover values.

Texture of the B horizon contributes more often to variation in vegetation than any other soil variable (Table XIX). The positive correlation with basal area reflects more growth on the fine-textured soils; cover indicates the same relationship, although cover is a function of basal area as well as density. The effect of this variable is probably due to the greater supply of soil moisture and nutrients due to a higher water-holding and base-exchange capacity of fine-textured soils. Significantly greater numbers of taxa are represented in the understory on soils with a finer-textured B horizon. An increased amount of available soil water would undoubtedly enhance establishment and early survival of many woody taxa. Conversely, communities developing on coarse-textured soils with a lower supply of water would depend upon the ability of plants to rapidly develop a root system and their intrinsic ability to withstand drought.

Total understory density and total basal area are directly related to soils with a thicker A horizon (Table XIX). Thicker A horizons indicate a higher water-holding capacity. This increase in available water would favor establishment, survival, and an increase in diameter.

Increasing pH values apparently influence total density of the younger trees, although factors affecting the positive correlations are not clearly understood (Table XIX). Lutz and Chandler (1946)

assert that forest stands develop on soils with rather wide range of pH; seedlings develop best on soils with pH values between 4.5 and 6.0. Provided this range is applicable in this area it is conceivable that pH and interacting factors associated with hydrogen-ion concentration could influence the number of trees established, although values outside this range represent less than 10 percent of pH values recorded (Table VII, page 52). The negative correlation existing between pH and total density of taxa in the overstory is not clearly understood. Coile (1933) found that pH did not appear to influence distribution of forest types in North Carolina; however, he pointed out that a high H-ion concentration developing under pine stands could affect development of hardwoods in the understory.

Multiple regression equations involving the variables discussed indicate that slope direction accounts for more variation than any soil or site factor (Appendix B, equations 1-5). The equation predicting total density of the understory (1) indicates a decrease in density from north to south slopes and an increase in density on soils with a finer textured B horizon. These two variable account for 20 percent of the variation in density per 1/100-acre.

The equation predicting basal area (3) indicates that basal area is highest on upper, north slopes. In addition, basal area decreases as percent stone in the soil volume increases. Lutz and Chandler (1946) state that rock content greater than 20 percent by soil volume restricts root space and decreases water-holding capacity of the

soil. Since the lowest stone class was 0-20 percent, higher stone classes affect annual increment by replacing water and nutrient-holding clay with stone, enhancing the percolation of water through the profile.

The equation for total density of the overstory (2) indicates that pH is the only site variable contributing more than 2 percent of the variation; variation due to canopy closure and shrub cover are not considered factors effecting density. The reliability of pH as a factor in explaining variation is questionable.

Slope position and texture of the B horizon account for 6 percent of variation in numbers of taxa present in the understory. The equation (4) indicates that more taxa are present on lower slopes with a fine-textured B horizon. Since contribution to R^2 by all variables is low, the equation is of limited value. Total numbers of taxa in the overstory (5) decrease from north to south slopes, but increase on soils with a finer-textured A horizon. Again, a low R^2 value indicates a questionable predictive equation.

Characteristics of overstory taxa. Density and basal area of 12 selected taxa of the overstory were tested for variation between exposures and among ridges and draws. Highly significant differences in density between exposures was indicated for 7 of the taxa. This is of particular interest in view of the lack of significance of exposure on total density. With the exception of pignut hickory, exposure affected either density or basal area of all taxa (Table XX).

TABLE XX

SIGNIFICANT EFFECTS OF EXPOSURE, DETERMINED BY ANALYSIS OF VARIANCE,
ON ABSOLUTE DENSITY, ABSOLUTE BASAL AREA OF SELECTED TAXA^a

Taxon	Density 1/100-acre	Density 1/5-acre	Basal Area 1/5-acre
Shortleaf Pine		**	**
White Pine	*		*
Northern Red Oak			*
White Oak	*	**	*
Black Oak		**	**
Chestnut Oak		**	**
Red Maple	*	**	**
Tulip Poplar	*	**	**
Black Gum	**		*
Sweet Pignut Hickory	*	**	**
Mockernut Hickory		*	*
Pignut Hickory			

^aF < .05 (*); < .01 (**).

Ridges and draw effects were not as pronounced (Table XXI). Shortleaf pine density and basal area were significantly different between exposures and among ridges and draws. Differences in distribution and growth of pignut hickory were not affected by exposure, but there were highly significant differences within a changing topography (Table XXI). Distribution and size of other taxa was affected by exposure and topography, e.g., black oak, mockernut hickory. Although mean squares were not broken into components of the total variance, among plot variation contributes the most variation.

More specific information concerning relative density and basal area which may determine where the above differences have their origin appears in Tables XXII and XXIII. Shortleaf pine contributed to over one-fourth of the density and one-fifth of the basal area on south ridges and 3 percent of the density and basal area on the north ridges, but less in draws. Relative density and basal area of black oak and black gum is greater on south slopes; black oak is restricted to ridge position, but black gum appears throughout. Although scarlet oak was left out of the analysis of variance design, restriction to ridges is apparent. Conversely, white ash, buckeye, basswood, bitternut hickory, and beech are restricted almost exclusively to north draws and contribute small percentages to total density and basal area.

Relative density values of these taxa (Table XXII, page 79) are higher than similar values from the Continuous Forest Inventory (unpublished data, Department of Forestry, The University of Tennessee).

TABLE XXI

SIGNIFICANT EFFECTS OF RIDGES AND DRAWS, DETERMINED BY NESTED ANALYSIS
OF VARIANCE, ON ABSOLUTE DENSITY AND BASAL AREA OF SELECTED TAXA^a

Taxon	Density 1/100-acre	Density 1/5-acre	Basal Area 1/5-acre
Shortleaf Pine		**	**
White Pine	*	*	*
Northern Red Oak			
White Oak			
Black Oak		*	*
Chestnut Oak		*	
Red Maple			
Tulip Poplar			
Black Gum			
Sweet Pignut Hickory			*
Mockernut Hickory		**	**
Pignut Hickory	*	**	**

^aF < .05 (*); < .01 (**).

TABLE XXII

MEAN DENSITY AND RELATIVE DENSITY OF SELECTED OVERSTORY TAXA
RELATED TO EXPOSURE AND TOPOGRAPHY (1/5-ACRE)

Taxon	Position						
	North Ridge	North Draw	North Total	South Ridge	South Draw	South Total	Total Area
	Mean Density ^a						
	28.0	21.0	24.0	28.0	23.0	26.0	25.0
Relative Density ^b							
Shortleaf Pine	2.8	<1.0	2.0	25.8	3.0	15.0	12.0
White Pine	3.2	<1.0	1.9	<1.0	<1.0	<1.0	1.3
Northern Red Oak	5.5	3.9	4.8	2.5	3.5	3.0	3.9
Scarlet Oak	5.9	0.0	3.2	4.6	<1.0	2.9	3.0
White Oak	5.8	4.9	5.4	10.2	14.8	12.4	8.8
Black Oak	1.5	0.0	<1.0	7.4	3.0	5.3	3.0
Chestnut Oak	25.1	14.6	20.4	29.6	44.0	36.5	28.2
Red Maple	13.6	15.8	14.6	3.1	7.5	5.2	10.0
Tulip Poplar	9.3	16.5	12.6	<1.0	2.2	1.2	7.0
Sweet Gum	<1.0	3.4	1.7	<1.0	2.8	1.6	1.7

TABLE XXII (Continued)

Taxon	Position						Total Area
	North Ridge	North Draw	North Total	South Ridge	South Draw	South Total	
	Mean Density ^a						
	28.0	21.0	24.0	28.0	23.0	26.0	
	Relative Density ^b						
Black Gum	3.3	2.6	3.0	3.5	4.5	3.9	3.5
White Ash	1.2	8.5	4.5	<1.0	1.8	<1.0	2.7
Sweet Pignut Hickory	3.2	6.0	4.5	1.5	<1.0	1.1	2.8
Mockernut Hickory	<1.0	0.0	<1.0	1.1	1.9	1.5	<1.0
Bitternut Hickory	<1.0	1.1	<1.0	0.0	0.0	0.0	<1.0
Beech	<1.0	2.3	1.3	0.0	0.0	0.0	<1.0
Pignut Hickory	1.8	3.2	2.5	3.3	3.6	3.4	2.9
Buckeye	0.0	1.8	<1.0	0.0	0.0	0.0	<1.0
Basswood	0.0	<1.0	<1.0	0.0	0.0	0.0	<1.0

^aData as mean total density per 1/5-acre on north ridges, north draws, north exposure, south ridges, south draws, south exposure, total area.

^bData as percent of total density per 1/5-acre on north ridges, north draws, north exposure, south ridges, south draws, south exposure, total area.

TABLE XXIII

MEAN BASAL AREA AND RELATIVE BASAL AREA OF SELECTED OVERSTORY TAXA
RELATED TO EXPOSURE AND TOPOGRAPHY (1/5-ACRE)

Taxon	Position						Total Area
	North Ridge	North Draw	North Total	South Ridge	South Draw	South Total	
	Mean Basal Area ^a						
	17.2	18.2	17.6	14.6	14.9	14.8	
Relative Basal Area ^b							
Shortleaf Pine	3.2	1.3	2.3	22.5	2.1	12.8	7.4
White Pine	4.5	<1.0	2.6	<1.0	1.4	1.0	1.8
Northern Red Oak	9.3	4.4	7.1	2.2	5.1	3.6	5.4
Scarlet Oak	6.6	<1.0	3.8	5.2	2.5	3.9	3.9
White Oak	7.1	5.6	6.4	10.2	13.7	11.9	9.1
Black Oak	1.3	0.0	<1.0	7.5	2.4	5.1	2.9
Chestnut Oak	27.2	17.6	22.9	28.5	41.8	34.8	28.7
Red Maple	10.2	9.4	9.8	3.1	6.2	4.6	7.3
Tulip Poplar	10.0	19.7	14.4	<1.0	1.6	1.1	7.9
Sweet Gum	<1.0	3.0	1.6	1.6	2.3	1.9	1.8

TABLE XXIII (Continued)

Taxon	Position						Total Area
	North Ridge	North Draw	North Total	South Ridge	South Draw	South Total	
	Mean Basal Area ^a						
	17.2	18.2	17.6	14.6	14.9	14.8	
Relative Basal Area ^b							
Black Gum	3.3	1.4	2.5	5.7	5.0	5.3	3.9
White Ash	<1.0	8.7	4.4	<1.0	2.4	1.1	2.8
Sweet Pignut Hickory	2.9	7.8	5.1	1.5	1.3	1.4	3.3
Mockernut Hickory	<1.0	0.0	1.0	1.5	1.9	1.7	<1.0
Bitternut Hickory	<1.0	<1.0	<1.0	0.0	0.0	0.0	<1.0
Beech	<1.0	2.7	1.5	0.0	0.0	0.0	<1.0
Pignut Hickory	1.8	4.5	3.0	3.8	5.1	4.4	3.7
Buckeye	0.0	1.4	<1.0	0.0	0.0	0.0	<1.0
Basswood	0.0	2.0	<1.0	0.0	0.0	0.0	<1.0

^aData as mean total basal area (ft.²) per 1/5-acre on north ridges, north draws, north exposure, south ridges, south draws, south exposure, total area.

^bData as percent of basal area per 1/5-acre on north ridges, north draws, north exposure, south ridges, south draws, south exposure, total area.

The highly significant differences in density and basal area of chestnut oak due to exposure are reflected in relative basal area and density. The taxon contributes 35 percent to the total basal area and density on south slopes and less than 30 percent on north slopes. Preponderance of chestnut oak and shortleaf pine on middle slopes of the south exposures indicates that these taxa can develop on sites where less soil moisture limit growth of other taxa. A higher relative density and basal area in south draws suggests that although chestnut oak can occupy and dominate the exposed ridges, the moist sites are also open to this taxon.

Virtual absence of tulip poplar on south slopes further illustrates the significance of exposure effects on this site-sensitive tree.

Highly significant correlations of density (Table XXIV) and basal area (Table XXV) by taxon with general characteristics of the vegetation are few. Total density of the overstory is positively correlated with the density of several taxa, but overall variation in total density remains obscure. The analyses of variance and multiple regressions indicate significant but low order relationships between total density and soil or site variables. The correlations of northern red oak, red maple, tulip poplar, and sweet pignut hickory densities and basal areas with numbers of taxa in the overstory indicate that these taxa are best represented on north slopes, particularly in the north draws, where vegetation is diverse.

TABLE XXIV

SIGNIFICANT CORRELATIONS BETWEEN VEGETATION VARIABLES AND DENSITY BY TAXON (1/5-ACRE)^a

Vegetation Variables	Correlations by Taxon ^b																	
	SLP	WP	NRO	SO	WO	BO	CO	RM	TP	SG	BG	SPH	MH	BH	Be	PH	Bu	Ba
Canopy closure	-0.22							0.22	0.23					0.18				
Shrub cover												0.18						
Total density, 1/100-acre	-0.28		0.27	-0.25		-0.25	-0.29	0.24	0.20			0.24						
Total density, 1/5-acre	0.37			0.29		0.32	0.42	0.20				0.29						
Total basal area			0.24						0.34									
Total numbers of taxa, 1/100-acre	-0.22							0.32										
Total numbers of taxa, 1/5-acre	-0.14		0.28					0.21				0.35				0.21	0.21	

^aOnly correlations $>.18$ are included; p of $r >.18 <.01$.^bSLP--shortleaf pine; WP--white pine; NRO--northern red oak; SO--scarlet oak; WO--white oak; BO--black oak; CO--chestnut oak; RM--red maple; TP--tulip poplar; SG--sweet gum; BG--black gum; SPH--sweet pignut hickory; MH--mockernut hickory; BH--bitternut hickory; Be--beech; PH--pignut hickory; Bu--buckeye; Ba--basswood.

TABLE XXV

SIGNIFICANT CORRELATIONS BETWEEN VEGETATION VARIABLES AND BASAL AREA BY TAXON (1/5-ACRE)^a

Vegetation Variables	Correlations by Taxon ^b																	
	SLP	WP	NRO	SO	WO	BO	CO	RM	TP	SG	BG	SPH	MH	BH	Be	PH	Bu	Ba
Canopy closure	-0.21		0.19					-0.22	0.19			0.20						
Shrub cover			0.22									0.26						
Total density, 1/100-acre	-0.28		0.35	-0.21		-0.23	-0.20	0.24	0.19			0.36						
Total density, 1/5-acre	0.35			0.22		0.25	0.23											
Total basal area			0.32				0.36		0.38			0.19						
Total numbers of taxa, 1/100-acre	-0.22							0.30		0.20								
Total numbers of taxa, 1/5-acre			0.22				0.27	0.21				0.33					0.19	

^aOnly correlations $>.18$ are included; p of $r >.18 <.01$.^bSLP--shortleaf pine; WP--white pine; NRO--northern red oak; SO--scarlet oak; WO--white oak; BO--black oak; CO--chestnut oak; RM--red maple; TP--tulip poplar; SG--sweet gum; BG--black gum; SPH--sweet pignut hickory; MH--mockernut hickory; BH--bitternut hickory; Be--beech; PH--pignut hickory; Bu--buckeye; Ba--basswood.

The positive correlations between red maple density and basal area with increasing values of overstory density and numbers of taxa implies that a significant contribution of red maple to overstory is an indicator of both sites taxonomically diverse and dense.

Canopy closure, understory density, numbers of taxa in overstory and understory are negatively correlated with shortleaf pine density. Shortleaf pine predominates on south ridges where coarse texture soils, thinner O layers, and thinner A horizons probably restrict numbers of taxa and understory density due to lower available moisture. The negative correlation with canopy closure is probably due to its shade intolerance. The positive correlation between total overstory density and basal area (Table XXV) of a taxon (shortleaf pine, scarlet oak, black oak, and chestnut oak) is probably due to their increased contribution to total density and basal area on south slopes.

The negative correlation between density and basal area of these taxa and understory density is probably affected by several factors. On sites dominated by shortleaf pine, less moisture or minerals may be limiting, while on oak sites, decreased light intensity as well as available water and minerals may become limiting factors.

Correlations of basal area of sweet pignut hickory, tulip poplar, and northern red oak and total basal area are positive because they are in large measure responsible for it. These taxa reach their greatest size and contribute significantly to total basal area on upper north slopes.

Correlations between density (Table XXVI) and basal area (Table XXVII) of certain tree taxa and their associated soil-site variables are more meaningful. Slope direction, slope position, and soil pH are most frequently related to density and basal area of taxa. In general, density of oak increases from north to south slopes. Preponderance of oak on south slopes in the Cumberland Mountains was documented by Braun (1950) and on the Cumberland Plateau by Caplenor (1965). Conversely, density and basal area of red maple, tulip poplar, sweet pignut hickory, and density of bitternut hickory and beech are negatively correlated with southerly aspect. These correlations concur with observations by others concerning these taxa (Fowells, 1965). Moist, fine-textured soils of the north slopes enhance their chance establishment, growth, and contribution to the overstory.

The inverse relationship of beech and sweet gum to increase in slope and slope position indicates an increase in density and basal area of the taxa with lower slopes. Braun (1950) observed that distribution of beech and sweet gum in the Cumberland Mountains was restricted to lower mountain slopes and river bottoms, respectively. The restriction of these taxa is probably due to increased soil moisture; the flattened slopes at the base of the mountain are the exceptionally moist sites of the study area.

Correlations between shortleaf pine density and basal area and soil texture documents the prominence of this taxon to sandier soils of the south slopes.

TABLE XXVI
SIGNIFICANT CORRELATIONS BETWEEN SOIL-SITE VARIABLES AND DENSITY BY TAXON (1/5-ACRE)^a

Soil-Site Variables	Correlations by Taxon ^b																	
	SLP	WP	NRO	SO	WO	BO	CO	RM	TP	SG	BG	SPH	MH	BH	Be	PH	Bu	Ba
Thickness of A	0.26				0.23		0.25		-0.52			-0.25		-0.25				-0.24
Slope direction					0.26	0.35	0.30	-0.36	-0.42			-0.28		-0.21	-0.21			
Percent slope			0.21		-0.22					-0.26					-0.30			
Slope position			-0.22	0.20		-0.22				0.31		-0.22		-0.24	0.27			
pH	-0.39			-0.22	-0.28	-0.35	-0.28		0.49			-0.29						0.23
Thickness of O		0.19										0.19						
Texture of A	-0.33																	
Texture of B	-0.45		0.18										-0.23					
Depth to rock																		
Percent stone	-0.15																	0.32

^aOnly correlations $>.18$ are included; p of $r >.18 <.01$.

^bSLP--shortleaf pine; WP--white pine; NRO--northern red oak; SO--scarlet oak; WO--white oak; BO--black oak; CO--chestnut oak; RM--red maple; TP--tulip poplar; SG--sweet gum; BG--black gum; SPH--sweet pignut hickory; MH--mockernut hickory; BH--bitternut hickory; Be--beech; PH--pignut hickory; Bu--buckeye; Ba--basswood.

TABLE XXVII

SIGNIFICANT CORRELATIONS BETWEEN SOIL-SITE VARIABLES AND BASAL AREA BY TAXON (1/5-ACRE)^a

Soil-Site Variables	Correlations by Taxon ^b																	
	SLP	WP	NRO	SO	WO	BO	CO	RM	TP	SG	BG	SPH	MH	BH	Be	PH	Bu	Ba
Thickness of A	0.24		-0.23						-0.45			-0.23		-0.23				
Slope direction	0.30		-0.19			0.34		-0.33	-0.37		0.23	-0.31						
Percent slope			0.21		-0.26					-0.22					-0.27			
Slope position		0.21	-0.30	0.20		-0.20				-0.26		-0.22		-0.20	0.20			
pH	-0.35			-0.20	-0.21	-0.35			0.48		-0.22	0.28						0.21
Thickness of O		0.24		0.15														
Texture of A	-0.38																	
Texture of B	-0.43																	
Depth to rock																		
Percent stone																		0.30

^aOnly correlations $>.18$ are included; p of $r >.18 <.01$.^bSLP--shortleaf pine; WP--white pine; NRO--northern red oak; SO--scarlet oak; WO--white oak; BO--black oak; CO--chestnut oak; RM--red maple; TP--tulip poplar; SG--sweet gum; BG--black gum; SPH--sweet pignut hickory; MH--mockernut hickory; BH--bitternut hickory; Be--beech; PH--pignut hickory; Bu--buckeye; Ba--basswood.

The positive correlation of tulip poplar density and basal area with thicker A horizons and north exposure agrees with Auten's (1945) conclusions from studies of tulip poplar stands. He noted that it grew best on soils with a thicker A horizon on moist sites on north exposures. Coile (1952) points out that thicker A horizons exhibit a higher water-holding capacity with more available minerals. Since the greatest amount of root absorbing surface is located in this horizon, optimum water and mineral uptake may occur.

Sweet pignut hickory and bitternut hickory apparently have similar requirements as indicated by the positive correlation of their density and basal area to thickness of A and slope position.

White oak and black oak form a higher percentage of density and basal area on south slopes than on north slopes. White oak is codominant with other taxa on lower north slopes but is not a major constituent of the overstory throughout the area. Predominance of white oak on lower and upper slopes suggests that this taxon occupies moist sites. The negative correlation between white oak and percent slope is indirect evidence that the growth of the taxon is enhanced on the lower or upper slopes with good internal drainage where lost water is replaced by higher precipitation above and seepage below.

Highly significant negative and positive correlations with pH have been observed previously. The correlation indicating pH as an effect may not be real because H-ion concentration is affected in part by the vegetation. Coile (1937) indicated that an inverse relationship

existed between replaceable calcium and H-ion concentration; tulip poplar litter was higher in calcium than shortleaf pine, white oak or black oak litter. Further, Coile (1933) found that litter of pines and oak in the Duke Forest was relatively acid. It follows that a low pH could develop on sites with a high pine and (or) oak basal area because of an accumulation of acid litter; in that case, pH would be considered a result of vegetation activity.

Generally speaking, the simple correlations imply that taxa forming the overstory community are influenced by factors associated with percent slope, slope direction and slope position rather than soil characteristics per se. This is not to say that site (versus soil) factors are most important; the effect of site factors on soil moisture, texture, thickness of soil horizons, depth of soil profile, accumulation of organic matter are recognized as interacting relationships affecting vegetation.

The predictive equations, formulated by multiple regression, express these relationships with individual taxa (Appendix B, equations 6-30). Equations with a total R^2 value less than .10 are omitted. Although canopy closure and shrub cover are present in the equations, these variables are not considered causes.

Soil texture contributes less than 5 percent to R^2 in all equations except in predicting density (6) and basal area (19) of shortleaf pine. Apparently, coarse-textured soils enhance its distribution and growth in this area. Coile and Shumacher (1953) reported that site

index of shortleaf pine decreased if sub-soils were fine-textured; they contended that root development was inhibited by fine-textured horizons. This suggests that fine-textured soils on Wilson Mountain restricted shortleaf pine to sandier soils. Since coarse textured soils are found primarily on south exposures, the coarse-texture soils permit increased water movement but apparently pine has the ability to withstand the moisture stress through control of transpiration or increased root surface.

Slope position is the variable most frequently occurring in the predictive equations accounting for as little as 2 percent of the variation in basal area of red maple (26) to as much as 10 percent of the variation in sweet gum density (15). Density and basal area of white pine (7,20), scarlet oak (9,22), red maple (13,26), sweet gum (15,28), and beech (18,30) decrease toward upper slope position; density and basal area of northern red oak (8,21), black oak (11,24) sweet pignut hickory (16,29), and density of bitternut hickory (17) decrease at lower slope positions; northern red oak and black oak occupy upper ridge positions and the hickories occupy upper draw positions.

Slope direction accounted for 2 percent of the variation in density and basal area of tulip poplar (14,27), density of white pine (7), basal area of beech (30), and accounted for 10 percent of the basal area of sweet pignut hickory (29) and 12 percent of black oak basal area (24). Density and basal area of white oak (10,23) and chestnut oak density (12) is greatest on south slopes.

Generally, the same factors accounting for variation in density effect basal area. However, basal area of northern red oak (21) is influenced by thickness of the A horizon, whereas this variable does not account for variation in density (8). Apparently, ability to ecize is enhanced on fine-textured soils, but once established, a thicker A horizon enhances growth through effects on available water and nutrients. Chestnut oak density (12) is positively influenced by a thicker A horizon, south exposure, and a thicker O layer; basal area (25) is influenced by position on slope rather than exposure. When the two equations are considered concurrently, chestnut oak distribution and growth is best developed on upper south slopes. Density of sweet pignut hickory (16) is effected by slope position, but in addition to slope position, basal area is influenced by slope direction and depth to bedrock. The contribution of this taxon to total density and basal area is greatest in north draws. The contribution of pH to R^2 may have removed the effects of slope direction on density. The negative relationship with a shallow profile and lower slope position indicates that sweet pignut hickory develops best on deep soils on upper, north slopes.

Characteristics of understory taxa. The nested analysis of variance indicated significant differences between exposures in total density of tree taxa in the overstory (Table XVII, page 69). Correlation between plot or total overstory density and understory density indicated that as overstory density decreased, understory density decreased (Table XVIII,

page 70). Understory density is highest on north slopes and is positively correlated with thicker A horizons (Table XIX, page 72). Increased availability of water and minerals associated with thicker A horizons in spite of lower light intensity reaching the forest floor appear to be the factors enhancing the establishment and survival of taxa forming this lower stratum.

Understory density is inversely related to density and basal area of certain overstory taxa, viz., shortleaf pine, scarlet oak, and black oak (Tables XXIV and XXV, pages 84 and 85). These taxa are primarily constituents of south exposure forests. Thinner A and O layers are characteristic of these south exposures. Although a thinner O layer is not correlated with understory density, there is an inverse relationship between thin O layers and estimated shrub cover. Kortsian (1927) and Wood (1938) indicated that increased litter favored establishment and survival of oak. The thinner A horizons and O layers associated with south exposures indicate less available water effecting establishment and survival of few seedlings. Conversely, understory density is directly related to density and basal area of northern red oak, tulip poplar, red maple, and sweet pignut hickory (Tables XXIV and XXV). These taxa are indicative of vegetation on north slopes. These positive correlations indicate that understory density increases on upper, north slopes, particularly in the draws.

Separate nested analyses indicated that exposure significantly effected understory density of 50 percent of the taxa selected (Table XX, page 76); effects due to ridge and draw were significant for only two taxa (Table XXI, page 78).

On the average, there are twenty-five trees 3 feet-4.9 inches d.b.h. per 1/100-acre sample. Density ranges from an average of thirty-two trees in north draws to twenty trees on south ridges on 1/100-acre plots (Table XXVIII). Chestnut oak and red maple contribute a higher percentage to density than any other selected taxa and are not restricted to exposures or ridges or draws. Black gum contributes significantly to understory on south slopes. Shortleaf pine and mockernut hickory appear restricted to south slopes; reproduction of scarlet, black, and northern red oaks contribute higher percentages to the understory on south slopes. Reproduction of white pine, sweet pignut hickory, bitternut hickory, beech, buckeye, and basswood appear restricted to north slopes.

Tabulation of the absolute density of each taxon and expressing the percentage of its density relative to exposure and topography indicates that although contribution to understory density may appear restricted, such is not always the case (Table XXIX). A significant percent of total density of shortleaf pine and mockernut hickory is developing on north slopes. Sweet pignut hickory is actually a minor component of the understory on south slopes. Bitternut hickory, beech, buckeye, and basswood are minor components of the understory vegetation. Their restriction to north slopes, particularly to north draws, suggests very specific site requirements.

Separating density by height classes indicates that average density of the understory is composed primarily of taxa 3-10 feet

TABLE XXVIII

MEAN DENSITY AND RELATIVE DENSITY OF SELECTED UNDERSTORY TAXA
RELATED TO EXPOSURE AND TOPOGRAPHY (1/100-ACRE)

Taxon	Position						Total Area
	North Ridge	North Draw	North Total	South Ridge	South Draw	South Total	
	Mean Density ^a						
	26.0	32.0	28.0	20.0	21.0	20.0	
Relative Density ^b							
Shortleaf Pine	0.0	<1.0	<1.0	2.8	<1.0	1.5	<1.0
White Pine	4.0	<1.0	2.2	<1.0	<1.0	<1.0	1.2
Northern Red Oak	1.7	2.9	2.2	2.1	2.5	2.4	2.3
Scarlet Oak	2.3	<1.0	1.3	2.5	<1.0	1.6	1.5
White Oak	2.4	<1.0	1.5	3.9	6.5	5.5	3.5
Black Oak	1.7	<1.0	<1.0	3.8	1.6	2.8	1.9
Chestnut Oak	10.6	9.5	10.3	11.0	12.0	12.1	11.1
Red Maple	14.3	10.4	12.8	11.8	9.4	11.2	11.9
Tulip Poplar	2.6	1.9	2.3	<1.0	1.6	<1.0	1.7
Sweet Gum	<1.0	3.9	2.1	1.2	3.6	2.6	2.3

TABLE XXVIII (Continued)

Taxon	Position						
	North Ridge	North Draw	North Total	South Ridge	South Draw	South Total	Total Area
	Mean Density ^a						
	26.0	32.0	28.0	20.0	21.0	20.0	25.0
Relative Density ^b							
Black Gum	7.1	2.3	4.9	27.4	14.8	22.2	13.3
White Ash	2.2	12.1	6.7	<1.0	3.1	1.7	4.2
Sweet Pignut Hickory	1.9	1.9	1.9	<1.0	<1.0	<1.0	1.3
Mockernut Hickory	<1.0	<1.0	<1.0	1.4	1.1	1.3	<1.0
Bitternut Hickory	<1.0	1.2	<1.0	0.0	0.0	0.0	<1.0
Beech	1.8	3.5	2.6	<1.0	0.0	<1.0	1.4
Pignut Hickory	0.0	2.7	1.5	4.9	2.6	4.0	3.3
Buckeye	0.0	1.2	<1.0	0.0	0.0	0.0	<1.0
Basswood	0.0	<1.0	<1.0	0.0	0.0	0.0	<1.0

^aData as mean total density per 1/100-acre on north ridges, north draws, north exposure, south ridges, south draws, south exposure, total area.

^bData as percent of total density per 1/100-acre on north ridges, north draws, north exposure, south ridges, south draws, south exposure, total area.

TABLE XXIX
DISTRIBUTION OF REPRODUCTION OF SELECTED TAXA
RELATED TO EXPOSURE AND TOPOGRAPHY

Taxon	Absolute Density ^a	Position			
		North	North	South	South
		Ridge	Draw	Ridge	Draw
Percent Reproduction ^b					
Shortleaf Pine	62	0.0	50.0	46.8	3.2
White Pine	51	88.2	3.9	7.8	0.0
Northern Red Oak	120	32.5	32.5	14.2	20.8
Scarlet Oak	49	46.9	2.0	38.8	12.2
White Oak	139	21.6	5.0	27.3	46.0
Black Oak	81	28.4	1.2	48.2	22.2
Chestnut Oak	509	24.8	32.4	19.8	23.0
Red Maple	507	33.5	26.8	21.3	18.6
Tulip Poplar	110	50.9	27.3	1.8	20.0
Sweet Gum	136	3.7	46.0	19.7	29.9

TABLE XXIX (Continued)

Taxon	Absolute Density ^a	Position			
		North Ridge	North Draw	South Ridge	South Draw
		Percent Reproduction ^b			
Black Gum	584	17.3	6.0	53.1	23.5
White Ash	237	16.5	67.5	0.04	15.6
Sweet Pignut Hickory	80	51.3	32.3	12.5	5.0
Mockernut Hickory	35	25.7	5.7	40.0	28.6
Bitternut Hickory	18	16.6	83.3	0.0	0.0
Beech	81	25.9	71.6	2.5	0.0
Pignut Hickory	183	32.2	22.4	29.0	16.4
Buckeye	15	0.0	100.0	0.0	0.0
Basswood	1	0.0	100.0	0.0	0.0

^aTotal density of taxon in study area.

^bData as percent of total density.

in height (Table XXX). The taxa in this height class compose 61 to 72 percent of density in the understory (south ridges and north draws, respectively). Taxa in the 10-20 foot class compose 15-20 percent of density; the 20-30 foot class, 7-12 percent; the 30-40 foot class, 5-8 percent. The low density in the 30-40 foot class indicates that mortality rate is high during early years of growth and development.

Highly significant correlations of several taxa with total density of understory and total numbers of taxa on 1/100-acre plots indicate that a high percentage of these taxa are components of the understory on north slopes (Table XXXI). Reproduction of shortleaf pine on north exposures is probably a function of light intensity. Correlation with canopy closure is statistically non-significant. However, Kramer and Decker (1944) contend that establishment of pine seedlings in the Piedmont of North Carolina was reduced in shaded areas. Field observations support this viewpoint. The number of shortleaf pine seedlings and saplings may have been too few to establish any significant trend.

Distribution of tulip poplar is probably dependent on the same environmental gradient. Boyce and Parry (1958) state that reproduction of tulip poplar increased in open areas. On north slopes of Wilson Mountain, thickets of tulip poplar develop in areas where there are relatively large openings in the overstory.

Highly significant correlations with soil-site variables pinpoint the location and distribution in the understory of some taxa (Table XXXII). Correlation of northern red oak, tulip poplar, sweet pignut

TABLE XXX

MEAN DENSITY OF UNDERSTORY BY HEIGHT CLASS RELATED
TO EXPOSURE AND TOPOGRAPHY (1/100-ACRE)

Exposure	Height Classes ^a				Total ^b
	3-10	10-20	20-30	30-40	
North ridge	18	4	2	2	26
North draw	23	5	2	2	32
North total	20	4	2	2	28
South ridge	12	4	2	2	20
South draw	14	4	2	1	21
South total	13	4	2	1	20
Total area	17	4	2	2	25

^aIn feet.

^bMean density per 1/100-acre on north ridges, north draws, north exposure, south ridges, south draws, south exposure, total area.

TABLE XXXI

SIGNIFICANT CORRELATIONS BETWEEN VEGETATION VARIABLES AND UNDERSTORY DENSITY BY TAXON (1/100-ACRE)^a

Vegetation Variables	Correlations by Taxon ^b																	
	SLP	WP	NRO	SO	WO	BO	CO	RM	TP	SG	BG	SPH	MH	BH	Be	PH	Bu	Ba
Canopy closure																		
Shrub cover													-0.19					
Total density, 1/100-acre	0.25		0.28			0.22			0.38	0.19		0.31					0.28	
Total density, 1/5-acre															-0.21			
Total basal area																		
Total numbers of taxa, 1/100-acre			0.40			0.18			0.31	0.23		0.28	0.24				0.31	
Total numbers of taxa, 1/5-acre																		

^aOnly correlations $>.18$ are included; p of $r >.18 <.01$.^bSLP--shortleaf pine; WP--white pine; NRO--northern red oak; SO--scarlet oak; WO--white oak; BO--black oak; CO--chestnut oak; RM--red maple; TP--tulip poplar; SG--sweet gum; BG--black gum; SPH--sweet pignut hickory; MH--mockernut hickory; BH--bitternut hickory; Be--beech; PH--pignut hickory; Bu--buckeye; Ba--basswood.

TABLE XXXII

SIGNIFICANT CORRELATIONS BETWEEN SOIL-SITE VARIABLES AND TAXON DENSITY (1/100-ACRE)^a

Soil-Site Variables	Correlations by Taxon ^b																	
	SLP	WP	NRO	SO	WC	BO	CO	RM	TP	SG	BG	SPH	MH	BH	Be	PH	Bu	Ba
Thickness of A				0.20		0.21					0.27			-0.22				
Slope direction		-0.19	-0.16			0.20			-0.19		0.37	-0.19			-0.21			
Percent slope		-0.19					0.20			-0.29					-0.36			
Slope position					-0.25					0.33					0.29			
pH				-0.19		-0.25					-0.29			0.20				
Thickness of O																		
Texture of A																		
Texture of B																		
Depth to rock																		
Percent stone																		

^aOnly correlations $>.18$ are included; p of r $>.18 <.01$.^bSLP--shortleaf pine; WP--white pine; NRO--northern red oak; SO--scarlet oak; WO--white oak; BO--black oak; CO--chestnut oak; RM--red maple; TP--tulip poplar; SG--sweet gum; BG--black gum; SPH--sweet pignut hickory; MH--mockernut hickory; BH--bitternut hickory; Be--beech; PH--pignut hickory; Bu--buckeye; Ba--basswood.

hickory, and beech with slope direction is further evidence that distribution of these taxa is related to north slopes.

The correlation of white pine with slope direction is obvious when distribution of the taxon is considered. The negative correlation with steepness of slope indicates that white pine in the understory is restricted to lower slopes. Correlations of sweet gum and beech with slope position and percent slope point out that these taxa are components of understory on the lowest slopes in flattened areas. Apparently, samples were too few to establish a significant direction effect, but observations in the field indicate restriction of beech to north exposures. Sweet gum is not so restricted. Moist sites evidently enhance the development of these taxa.

Scarlet oak, black oak, and black gum are positively correlated with thin A horizons and lower pH. Apparently, these taxa can establish and survive on soils that probably have less available water and a lower base-exchange capacity.

Although white oak is a codominant in the overstory on lower and upper slopes its distribution in the understory is predominantly associated with upper slope positions. Carvell and Tryon (1961) stated that reproduction of white oak and northern red oak was most abundant on middle slopes on south exposures in West Virginia. They suggested that limited moisture conditions on upper slopes may affect growth of the taxa although establishment is not necessarily affected. It has been mentioned that available moisture is not likely as limiting

on upper slopes as might be expected from the ridge position thus enhancing development of white oak in this area.

Highly significant correlations exist between understory and overstory taxa (Table XXXIII). The high number of intraspecific correlations suggests a close relation of understory taxa to seed source. However, Fowells (1965) asserts that sprouting from stumps or roots has been reported for all these taxa except white pine and buckeye. Highly significant intraspecific correlation of white oak, sweet gum, beech, and bitternut hickory as well as other taxa may be a result of root sprouting; it is unlikely that sprouting is primarily from stumps because of limited evidence of recent disturbance. Since it is generally recognized that oaks, hickories, and sweet gum are immediately to shade intolerant (Baker, 1949), it seems likely that their presence under a canopy is increased to a degree by sprouting; although beech is shade tolerant, seedling sprouts of root origin are known to be produced in abundance (Fowells, 1965).

Northern red oak and black oak do not appear directly related to oak overstory. This may be due to environmental conditions, e.g., low light intensity and (or) moisture stress. Carvell and Tryon (1961) noted that oak regeneration in West Virginia was positively correlated with increased light intensity and dry exposures; seedling density was high on moist sites provided light intensity was not limiting. Rodent activity, inability to produce seed, non-viable seed, and a low sprouting ability combine making a low seedling density.

TABLE XXXIII

SIGNIFICANT CORRELATIONS BETWEEN ABSOLUTE DENSITIES OF OVERSTORY AND UNDERSTORY TAXA^a

Code	Taxa in Understory	Taxa in Overstory ^b																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1.	Shortleaf Pine			0.18	d														
2.	White Pine		0.28						0.32										
3.	Northern Red Oak								0.19										
4.	Scarlet Oak	c			0.20														
5.	White Oak					0.48													
6.	Black Oak									-0.20									
7.	Chestnut Oak							0.26											
8.	Red Maple																		
9.	Tulip Poplar								0.29										
10.	Sweet Gum							-0.20			0.61								
11.	Black Gum	0.26					0.23			-0.20		0.20	-0.25						
12.	Sweet Pignut Hickory												0.27						
13.	Mockernut Hickory													0.29					
14.	Bitternut Hickory														0.50				
15.	Beech							-0.19								0.57			
16.	Pignut Hickory																		
17.	Buckeye															0.26		0.25	0.22
18.	Basswood																		

^aOnly correlations $> .18$ are included; p of $r > .18 < .01$.^bCode number in first column on left; selected taxa on 1/100-acre.^cLower left half; e.g., scarlet oak understory density on shortleaf pine overstory density.^dUpper right half; e.g., scarlet oak overstory density on shortleaf pine understory density.

When compared to overstory, fewer predictive equations account for more than 10 percent of the variation by taxon (Appendix B, equations (31-37)). Only two equations account for more than 20 percent of the variation.

Position on slope and slope percent contribute more to variation than any other variables. White oak and chestnut oak densities (31 and 33, respectively) are influenced by a thinner A horizon (such as those of south slopes).

Density of white oak (31) and black oak (32) increases significantly toward upper slopes but is not reached on the steepest slopes. The distribution of these taxa may be inversely related to rapid internal drainage and surface run-off of water.

Although the equation for chestnut oak density (33) accounts for less than 12 percent of the variation, it appears that chestnut oak is directly related to drier sites. It is inversely related to thickness of the A horizon and depth of soil profile. A direct relationship to steep slopes accounted for 4 percent of the variation; this relationship indicates that chestnut oak will establish and survive on sites with less available water.

Fourteen percent of variation in black gum (35) is accounted for by exposure. This taxon occupies the drier sites since over 50 percent of density is on south ridges (Table XXIX, page 98).

Since only eighteen individuals of bitternut hickory (36) were recorded, the estimating equation may be questionable. A direct

relationship to steep, upper slopes indicates that rapid internal drainage may be necessary for establishment and growth; thicker A horizons, containing more available water and minerals are also related to density.

Only a few beech (37) understory plants were seen. However, their density is as seen before, i.e., on north exposures at lower slope positions.

In general, physical effects were more important to understory density than characteristics of the soil profile. Low R^2 values could be a result of small sample size and (or) selection of variables; the same variables effecting growth and distribution of present overstory taxa are not necessarily the same variable effecting developing strata.

VI. CONCLUSIONS

Five forest types are recognized on Wilson Mountain. The pre-dominating Chestnut Oak Type occupies middle and lower slopes on the north slopes and middle and upper slopes, particularly in draws on south slopes. The Tulip Poplar Type occupies upper north slopes and extends into north draws within this type is the greatest diversity of taxa. The Northern Red Oak Type occupies the least area and is located on uppermost north slopes. A White Oak Type occupies lower slopes on both exposures and the uppermost south slopes where it merges with the Northern Red Oak and Tulip Poplar Type. The Short-leaf Pine-Oak Type occupying the south ridges and isolated areas on top of the mountain is considered a temporary type because hardwoods presently occupy the understory.

Soils are more diverse in texture on south slopes; sandy soils apparently develop because of removal of silts and clay on steeper slopes. Soils high in clay develop on flattened, exposed lower and middle slopes where rate of weathering is apparently accelerated and fine particles are deposited from upslope. In general, thinner O layers develop on south slopes; decomposition is probably accelerated on south slopes. Thinner A horizons develop on south slopes due to erosion.

Lower pH values are recorded from south slopes, particularly on ridge positions. Accumulation of litter low in exchangeable bases

are indicative of soils with higher H-ion concentration. Further, pH values are lowest on sandier soils where percolation of water through the profile leaches bases.

The percentage of stone in the soil profile is lower on south slopes and highest in north draws; weathering speeds up breakdown of rock on south slopes.

Deeper soil profiles occur on south slopes; it appears that weathering is occurring faster than erosion.

Overstory densities between the two exposures are not significantly different. Understory density and overstory basal area is highest on north slopes but differences between ridges and draws are non-significant. North slopes have significantly greater numbers of taxa in the overstory and understory.

An increase in overstory density effects a decrease in understory density. Understory density appears to increase as light intensity increases; shade tolerant taxa have become established in areas of dense overstory. This relation is modified by root sprouting.

Understory density increases on soils with a thicker A horizon and finer-textured B horizon. More available water and nutrients commonly associated with these two variables probably enhance establishment and survival of seedlings.

Total basal area is greatest on upper, north slopes on fine-textured soils with a thick A horizon; values for basal area are

inversely related to high stone content. Apparently an orographic influence produces more precipitation at higher elevations. This increase in precipitation accompanied by a greater soil water-holding capacity and lowered evapotranspiration may result in an increase in diameter.

Density and basal area of overstory taxa appears to be affected by characteristics associated with physical site factors such as slope direction, slope position and percent slope which in turn affect soil characteristics. Shortleaf pine density and basal area is greatest on coarse-textured soils on south ridges. Apparently it develops a root system with more absorbing surface in coarse-textured soils compensating for a reduced water supply, and (or) transpiration is controlled.

Density and basal area of oaks, with the exception of northern red oak, increases on south slopes. White oak density and basal area increases on lower south slopes and on uppermost south slopes. Chestnut oak density and basal area increases on upper south slopes on soils with a thicker A horizon and O layer. These taxa are major constituents of the overstory on the moist sites on south slopes. Northern red oak density increases on slopes with fine-textured soils and basal area increases on soils with a thicker A horizon.

Beech and sweet gum contribute to density and basal area at lower slope positions where available soil moisture is highest. Beech is restricted to lower north slopes. Distribution and growth of white pine, red maple and scarlet oak is greatest on lower slopes.

Tulip poplar, sweet pignut hickory, and bitternut hickory apparently have similar site requirements. These taxa contribute to the overstory on north slopes particularly on sites with a thicker A horizon. Increased available water and nutrients may enhance their development.

Understory density ranges from an average of thirty-two trees in north draws to twenty trees on south ridges on 1/100-acre plots. When density by height class is considered, 61 to 72 percent of density is in the 3-10 foot height class.

The contribution of northern red oak, tulip poplar, sweet pignut hickory to understory is greatest on north slopes; beech and sweet gum contribute to the understory at the lowest slopes.

Although bitternut hickory, basswood, and buckeye are minor constituents of the understory, restriction to north draws indicates very specific requirements for these taxa.

Oak reproduction is greatest on south slopes. Chestnut oak in the understory is greatest on steeper south slopes where increased internal drainage and evapotranspiration results in drier soils. White oak and black oak density increases upslope but these taxa do not occupy the steepest slopes. Chestnut oak apparently becomes established and survives on drier sites than other oaks.

Intraspecific correlations of overstory and understory taxa indicate that understory development under a canopy is probably increased by root sprouting since many of the taxa are of intermediate

or low tolerance with respect to shade. Taxa such as shortleaf pine and tulip poplar are shade intolerant and make greater contributions to understory if there are openings in the canopy. The large number of intraspecific correlations indicate that the communities are relatively stable at present; correlations between shortleaf pine in the overstory and hardwood in the understory indicate that pine stands are temporary and will be replaced eventually by hardwoods.

Although correlations between soil and (or) physical factors and vegetation are highly significant, the amount of variation in vegetation accounted for by the soil-site variables is low; the multiple regression equations account for a rather low percent of the variation in taxa. Several factors could account for these low values: (1) wide range of values within independent variables, (2) variables other than those selected may account for more variation within communities, (3) environmental gradients affecting overstory characteristics may not affect establishment and early survival of taxa, (4) variable effects may not be linear and (or) additive.

VII. SUMMARY

The vegetation, soil and site characteristics of Wilson Mountain, Morgan County, Tennessee were studied during the summer of 1965 in an attempt to establish relationships between vegetation and site character.

Twenty transects were traversed from the base to the top of the mountain on northeast and southwest exposures; an average of ten samples with circular plots were established within each transect. Within the plots, all tree taxa in the overstory (greater than 5 inches d.b.h.) and understory (greater than 3 feet and less than 5 inches d.b.h.), as well as several soil and site characteristics were recorded.

Statistical analysis included nested analysis of variance, simple correlation and multiple regression.

Five forest (cover) types were recognized relative to exposure and topography.

Slope direction accounted for the most variation in soils; thin and sandy A horizons, thin O layers and deeper profiles were indicative of south slopes.

Total overstory density was not significantly different between exposures, but total basal area was higher on north slopes; density and basal area of certain taxa contributing to the overstory were significantly different between exposures, e.g., density and basal area of shortleaf pine and white oak was greatest on south slopes, while

northern red oak and tulip poplar density and basal area was greatest on north slopes. Ridge and (or) draw affected fewer taxa, but differences were noted, e.g., chestnut oak density was greatest in south draws, scarlet oak density greatest on ridges.

Significant differences in density and basal area of overstory taxa were related to slope position. Beech and sweet gum density and basal area was greatest on lower slopes, sweet pignut hickory and bitternut hickory on upper slopes. Significant differences were found in relation to percent slope, e.g., northern red oak density and basal area was greatest on steeper slopes.

Total understory density was significantly greater on north slopes. Density of specific understory taxa was also related to slope direction, e.g., greater density of tulip poplar was found on north slopes while black gum density was greatest on south slopes. Slope position, percent slope, and density of overstory were other factors influencing density of understory taxa, e.g., sweet gum density was greatest on lower slopes, chestnut oak density greatest on steepest south slopes, and density of shortleaf pine and tulip poplar was greatest in open areas.

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APPENDICES

APPENDIX A

PLOT DATA CODING

Column	Item	Coding
1-2	Transect	1-20
3-9	Date	Day, Month, Year
10-12	Plot number	1-199
13-15	Thickness of A-horizon (inches)	
	16 plus	1
	14-16	2
	12-14	3
	10-12	4
	8-10	5
	6-8	6
	4-6	7
	2-4	8
	0-2	9
16	Slope Direction	
	Flat	1
	NE	2
	N	3
	E	4
	NW	5
	SE	6
	W	7
	S	8
	SW	9
17	Steepness (percent)	
	0-1	1
	1-5	2
	5-12	3
	12-20	4
	20-30	5
	30-45	6
	45-65	7
	65 -	8

Column	Item	Coding
18	Position on Slope (percent from bottom)	
	100-90	1
	90-80	2
	80-70	3
	70-60	4
	60-50	5
	50-40	6
	40-30	7
	30-20	8
	20-0	9
19	Form of Slope	
	Concave	1
	Straight	2
	Convex	3
20-21	pH of Top Six Inches	Actual reading to tenth unit
22	Thickness of Humus Layer (inches)	
	0- $\frac{1}{2}$	1
	$\frac{1}{2}$ -1	2
	1-1 $\frac{1}{2}$	3
	1 $\frac{1}{2}$ -2	4
	2-2 $\frac{1}{2}$	5
	2 $\frac{1}{2}$ -3	6
	3-3 $\frac{1}{2}$	7
	3 $\frac{1}{2}$ -4	8
	4	9
23	Type of Humus Layer	
	Mull	1
	Mor	2
	Intermediate	3
24	Texture of A-horizon	
	Sandy Clay	1
	Silty Clay	2
	Clay	3
	Loam	4
	Silt Loam	5
	Silt	6
	Sandy Clay Loam	7
	Clay Loam	8
	Silty Clay Loam	9

Column	Item	Coding
25	Texture of B horizon	Code as 24 above
26	Depth to Rock (inches)	
	42 plus	1
	36-42	2
	30-36	3
	24-30	4
	18-24	5
	12-18	6
	6-12	7
	0-6	8
27	Stone in percent of total soil volume	
	0-20	1
	20-40	2
	40-60	3
	60-80	4
	80-100	5
28	Canopy closure on 1/5-acre plot (percent)	
	0-15	1
	15-25	2
	25-35	3
	35-45	4
	45-55	5
	55-65	6
	65-75	7
	75-85	8
	85-95	9
29	Shrub cover on 1/10-acre plot (percent)	Code as 28 above
30	Fire Damage	
	No ground cover. Repro- duction dead or principally of sprout origin. Trees show definite fire damage.	1
	Some ground cover. Some reproduction. Trees show signs of past fires by blackened bark or slight butt damage.	2
	No apparent fire damage.	3

APPENDIX B

MULTIPLE REGRESSION EQUATIONS

Independent Variables

X_1	Thickness of A Horizon
X_2	Slope Direction
X_3	Percent Slope
X_4	Position on Slope
X_5	pH
X_6	Thickness of O
X_7	Texture of A Horizon
X_8	Texture of B Horizon
X_9	Depth to Rock
X_{10}	Percent Stone in Soil Volume
X_{11}	Canopy Closure
X_{12}	Shrub Cover

$\hat{Y}$ = General Characteristics R^2

(1) Total Density, 1/100-acre

$$\hat{Y} = -2.73 - .848x_2 + 1.24x_8 + 2.83x_{12} \quad .30$$

(2) Total Density, 1/5-acre

$$\hat{Y} = 52.40 - .531x_5 + 2.34x_{11} - 1.93x_{12} \quad .33$$

(3) Total Basal Area, 1/5-acre

$$\begin{aligned} \hat{Y} = 19.38 - .377x_2 - .397x_4 - 1.318x_{10} \\ + 1.740x_{11} - 1.073x_{12} \quad .43 \end{aligned}$$

(4) Total Numbers of Taxa, 1/100-acre

$$\hat{Y} = 1.89 + .173x_4 + .256x_8 + .216x_{12} \quad .09$$

(5) Total Numbers of Taxa, 1/5-acre

$$\hat{Y} = 3.09 - .091x_2 + .508x_7 + .295x_{11} \quad .13$$

$\hat{Y}$ = Absolute Density, 1/5-acre

R^2

(6) Shortleaf Pine

$$\hat{Y} = 32.44 - .354x_5 - 1.20x_8 - 1.54x_{10} \quad .29$$

(7) White Pine

$$\hat{Y} = 3.07 - .084x_2 + .118x_4 + .171x_6 \quad .13$$

(8) Northern Red Oak

$$\hat{Y} = -.67 + .164x_3 - .094x_4 + .149x_8 \quad .11$$

(9) Scarlet Oak

$$\hat{Y} = 5.12 + .146x_4 - .115x_5 + .483x_6 \quad .13$$

(10) White Oak

$$\hat{Y} = 5.43 + .267x_2 - .578x_3 - .116x_5 + .675x_{11} \quad .21$$

(11) Black Oak

$$\hat{Y} = 6.42 + .129x_2 - .168x_3 - .106x_5 \quad .21$$

(12) Chestnut Oak

$$\begin{aligned} \hat{Y} = & .302 + .918x_1 + .563x_2 + 1.78x_6 + .852x_{11} \\ & - 1.44x_{12} \end{aligned} \quad .22$$

(13) Red Maple

$$\hat{Y} = -2.75 + .476x_1 - .380x_2 + .199x_4 + .459x \quad .23$$

(14) Tulip Poplar

$$\begin{aligned} \hat{Y} = & 6.37 - .832x_1 - .330x_2 + .175x_5 - .936x_6 \\ & - .510x_9 - .454x_{12} \end{aligned} \quad .41$$

$\hat{Y}$ = Absolute Density, 1/5-acre (Continued) R^2

(15) Sweet Gum

$$\hat{Y} = -.134 - .182x_3 + .163x_4 - .243x_6 + .171x_{11} \quad .17$$

Black Gum Less than .10

(16) Sweet Pignut Hickory

$$\hat{Y} = -4.12 - .098x_4 + .074x_5 + .191x_{12} \quad .16$$

Mockernut Hickory Less than .10

(17) Bitternut Hickory

$$\hat{Y} = .896 - .080x_1 - .042x_4 \quad .10$$

(18) Beech

$$\hat{Y} = .596 - .039x_2 - .100x_3 + .055x_4 \quad .16$$

Pignut Hickory Less than .10

Buckeye Less than .10

Basswood Less than .10

$\hat{Y}$ = Absolute Basal Area, 1/5-acre R^2

(19) Shortleaf Pine

$$\hat{Y} = 17.01 - .159x_5 - .993x_7 - .369x_8 \quad .27$$

(20) White Pine

$$\hat{Y} = -.648 + .084x_4 + .283x_6 \quad .11$$

(21) Northern Red Oak

$$\hat{Y} = -.111 - .256x_1 + .214x_3 - .192x_4 + .358x_{12} \quad .17$$

(22) Scarlet Oak

$$\hat{Y} = 2.88 + .091x_4 - .064x_5 + .251x_6 \quad .12$$

(23) White Oak

$$\hat{Y} = .259 + .166x_2 - .479x_3 + .445x_{11} \quad .16$$

(24) Black Oak

$$\hat{Y} = 3.56 + .081x_2 - .106x_3 - .099x_4 - .049x_5 \quad .21$$

(25) Chestnut Oak

$$\hat{Y} = 5.97 + .681x_1 - .267x_4 + 1.11x_6 - .859x_{12} \quad .11$$

(26) Red Maple

$$\hat{Y} = -1.33 + .220x_1 - .183x_2 + .082x_4 + .236x_{11} \quad .19$$

(27) Tulip Poplar

$$\hat{Y} = -5.67 - .607x_1 - .189x_4 + .341x_5 - .647x_{12} \quad .34$$

(28) Sweet Gum

$$\hat{Y} = -.378 - .113x_3 + .094x_4 + .115x_{11} \quad .11$$

$\hat{Y}$ = Absolute Basal Area, 1/5-acre

R^2

Black Gum

Less than .10

(29) Sweet Pignut Hickory

$$\hat{Y} = .384 - .088x_2 - .070x_4 - .139x_9 + .150x_{12} \quad .19$$

Mockernut Hickory

Less than .10

Bitternut Hickory

Less than .10

(30) Beech

$$\hat{Y} = .763 - .040x_2 - .127x_3 + .049x_4 \quad .11$$

Pignut Hickory

Less than .10

Buckeye

Less than .10

Basswood

Less than .10

$\hat{Y}$ = Absolute Density, 1/100-acre R^2

Shortleaf Pine	Less than .10
White Pine	Less than .10
Northern Red Oak	Less than .10
Scarlet Oak	Less than .10
(31) White Oak	
$\hat{Y} = .967 + .266x_1 - .179x_3 - .239x_4$	.11
(32) Black Oak	
$\hat{Y} = 4.73 - .116x_3 - .726x_4 - .049x_5 - .132x_{11}$	.15
(33) Chestnut Oak	
$\hat{Y} = -4.35 + .604x_1 - .222x_2 + .600x_3 + .511x_9$	.11
Red Maple	Less than .10
Tulip Poplar	Less than .10
(34) Sweet Gum	
$\hat{Y} = .905 - .360x_3 + .246x_4 + .297x_9$	.15
(35) Black Gum	
$\hat{Y} = -6.35 + .602x_2 + .602x_9 - 1.09x_{10} + .850x_{12}$	.21
Sweet Pignut Hickory	Less than .10
Mockernut Hickory	Less than .10
(36) Bitternut Hickory	
$\hat{Y} = .842 - .069x_1 - .032x_2 + .055x_3 - .027x_4$ $- .135x_6$	.13

$\hat{Y}$ = Absolute Density, 1/100-acre (Continued)

R^2

(37) Beech

$$\hat{Y} = .246 - .081x_2 - .343x_3 + .144x_4 + .216x_{12} \quad .23$$

Pignut Hickory

Less than .10

Buckeye

Less than .10

Basswood

Less than .10