To the Graduate Council:

I am submitting herewith a thesis written by Robert Nichols Sims Crownover entitled "Forest Communities of House Mountain, Knox County, Tennessee and Their Relationship to Site and Soil Factors." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Ecology.

H. R. DeSelm

Hal R. DeSelm, Major Professor

We have read this thesis and recommend its acceptance:

James R. Carter

D. A. Lietzke

Accepted for the Council:

L. Evans Roth

Vice Chancellor
Graduate Studies and Research

FOREST COMMUNITIES OF HOUSE MOUNTAIN, KNOX COUNTY, TENNESSEE AND THEIR RELATIONSHIP TO SITE AND SOIL FACTORS

A Thesis

Presented for the

Master of Science

Degree

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Robert Nichols Sims Crownover

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ABSTRACT

A study of the vegetation of House Mountain in Knox County, Tennessee was carried out in the field from June to October, 1980. The objectives were to classify vegetation types and relate them ecologically to their environments.

Ninety-seven circular 0.04 hectare plots were placed in the second growth forests covering House Mountain. Trees greater than ten cm. dbh were counted by taxon and placed into two cm. dbh classes. Saplings between one and ten cm. dbh were only counted by taxon. Seedlings and the shrub layer were noted and recorded.

Environmental factors were determined in the field from direct measurement and from maps. These factors include slope angle, aspect, slope position, slope shape, and the soil characteristics, depth to rock, coarse fragment content and horizon thickness. Soil pH and texture were determined in the laboratory.

Statistical analysis consisted of correlation among soil and site factors and species importance values (IV). Linear stepwise regression with maximum r-square improvement was performed using species importance value (IV), absolute density (AD), absolute basal area (ABA), relative density (RD), and relative basal area (RB) as the dependent variables and site and soil factors as the independent variables.

Slope position affects more soil variables than any

other site factor. Aspect and slope position are the site factors most often correlated with species importance values. Of the soil variables, sand content of both the A and B horizons correlate with the most site factors. However, both sand and silt in the A and B horizons most often correlate significantly with importance values.

In the regression equations, the xerophytes are predicted mainly by site and soil variables which are correlated with top slope positions (shallow soils, steeper slope angles and increased sand in the soil). Mesophytes characteristically are predicted by those variables correlated with bottom slope positions such as increased coarse fragments, higher pH, and lesser slope angles.

Seven community types were defined on House Mountain. Three of them were dominated by chestnut oak (one with much pine), and one by black oak. On top was the pine-oak community while on the lower slopes was the white oak dominated community and in the draws the tulip poplar types.

Future trends indicate the stability of the chestnut oak dominated communities on House Mountain. The pine-oak community likewise appears to be unchanging. However, the white oak-northern red oak and tulip cove communities are not reproducing as well, leaving their futures uncertain.

Precipitation data was correlated with soil moisture, which in turn was related to mean radial tree growth. Measured soil moisture correlated highest with four day precipitation periods terminating two days before each soil collection date. Both aspect and slope position demonstrated an influence on available soil moisture. Attempts to relate moisture data to mean radial tree growth resulted in a coefficient of determination of 0.35.

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CHAPTER I

INTRODUCTION

House Mountain, near Knoxville, Tennessee, is one of the high, steep-sloped sandstone-capped ridges in the Ridge and Valley of East Tennessee.

This project was devised to study the vegetation of this mountain. Previous local studies in the Great Valley have given only a cursory overview of the high ridges due chiefly to their inaccessibility. The project was undertaken to classify the vegetation types and relate them statistically and thus ecologically to the site and soil factors with which they occur. It is intended that the results show present vegetation types and their future trends if left undisturbed.

It is hoped that this project will aid and eventually culminate in public ownership of House Mountain as a natural area for future generations of Tennesseeans.

CHAPTER II

THE STUDY AREA

Introduction

This details a study of the vegetation of House Mountain (Figure 1), one of the ridges in the Ridge and Valley of Tennessee. Because of their inaccessability, the vegetation of this and similar high ridges of the Tennessee Ridge and Valley have not been examined. The project was designed to determine the vegetation types and relate them and their component species to their site and soil characteristics. These results describe the present vegetation types and the future successional trends were the vegetation to be left undisturbed.

The mountain, which is currently in private ownership, has been considered as a Tennessee Department of Conservation Natural Area; however when a hearing was held, local opposition surfaced and no further action has been taken. As demonstrated in this study, House Mountain's diverse young communities and unique geologic features make it worthy of consideration in the future.

House Mountain is in the extreme northeast corner of Knox County, Tennessee, approximately 24 km. northeast of Knoxville. The area is accessible from Knoxville by way of U.S. Highway 11W and Roberts Road. The site is mapped on the John Sevier 7.5 minute quadrangle map of the U.S.

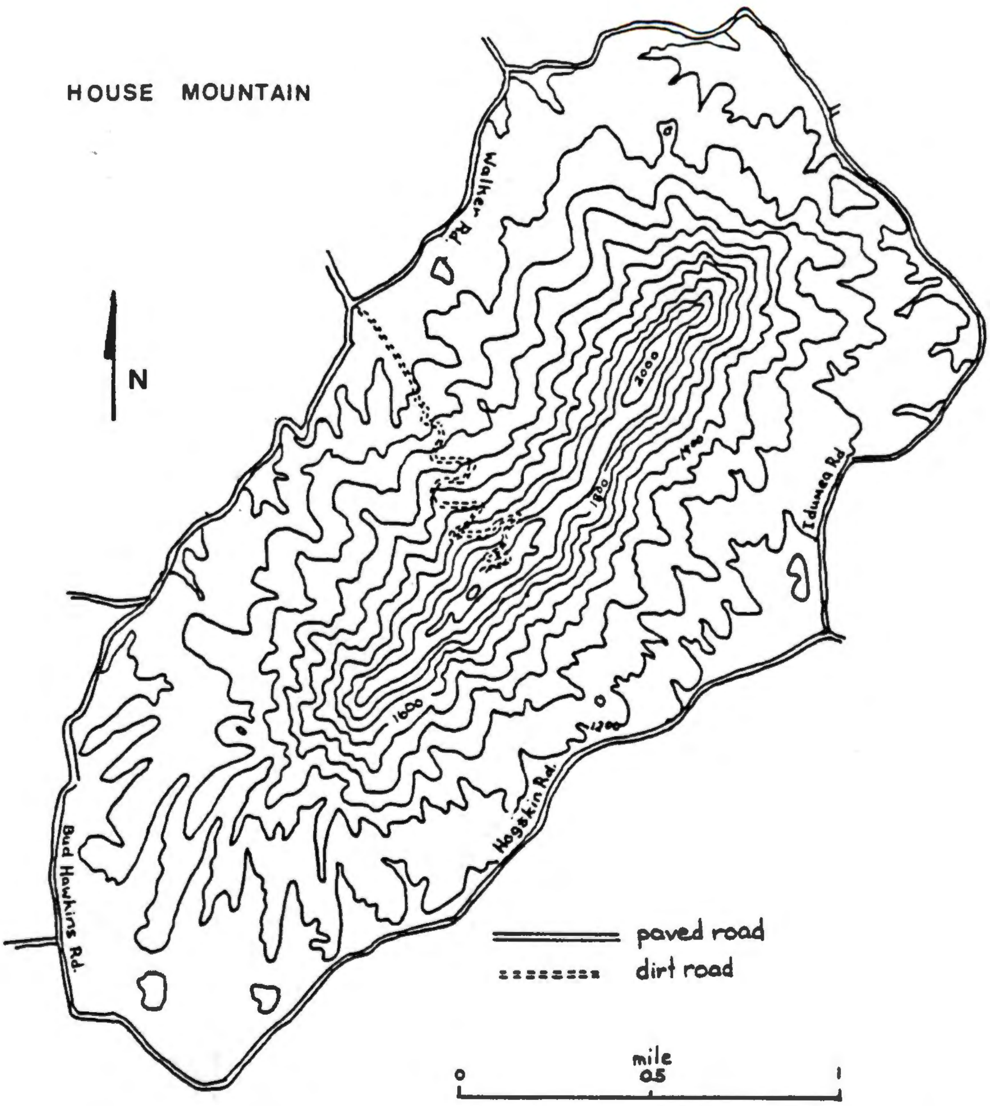

Figure 1. Contour Map of House Mountain.

Geological Survey. It lies on 83° 46′ west longitude and 36° 07′ north latitude. It is an outlier of Clinch Mountain which extends south about 150 km. through Tennessee from Virginia. It is now separated from Clinch Mountain by Big Flat Creek Gap, which is nearly 5 km. wide.

Climate

The climate of an area is considered to be one of the most influential factors determining the distribution of tree taxa. However, it cannot be considered alone. The effects of climate on a particular area are modified by exposure, slope angle and relief as well as local conditions such as humidity and wind variation (Martin, 1971).

According to Thornthwaite (1948), the climate of the area is temperate and continental. The area is classified as humid, second mesothermal, with little or no water deficiency during any season.

Climate is influenced here by the Cumberland Plateau and mountains to the west and the Smoky Mountains to the east. The Cumberlands weaken the force of cold winter air masses moving from the north and together with the Smokies reduce the intensity of summer heat (U.S. Department of Commerce, 1969). At the Knox County weather station, mean maximum temperature (degrees C) is 20.4 and mean minimum is 9.4; the average is 14.9 degrees. Mean monthly temperature is 4.1 for January and 25.4 for July. Mean annual precipitation is 121.3 cm. (U.S. Dept. of Commerce, 1972)

As suggested by Shanks and Norris (1950), variation in microclimate may account for large differences in the distribution of vegetation. They found a 1.67 C mean temperature difference between north and south facing slopes in a small valley near Knoxville, Tennessee. Although these differences seem small, it was noted that they become critical to plants when temperature extremes are approached.

Physiography and Geology

House Mountain is in the central portion of the Ridge and Valley Physiographic Province in Tennessee. Here, the Ridge and Valley Province is bordered on the west by the Cumberland Plateau and on the east by the Blue Ridge Province and is commonly called the Great Valley of East Tennessee (Amick and Rollins, 1937). It is an assortment of valley floors and long narrow, even topped ridges oriented in a northeast to southwest direction (Fenneman, 1938; Hardeman, 1966).

The Great Valley of Tennessee is about 320 km. long with a width of 88 km. in the north and 54 km. to the south (Case, 1925). The ridges are usually about 1.25 to 6.5 km. wide while valleys range from 1.5 to 13.5 km. wide (Martin,1971). The difference in elevation between the valleys and ridges range approximately from 55 to 122 meters, except for the high ridges such as House Mountain which, at 649 meters, is 275 meters above the adjacent upland (Roberts et al., 1955).

According to Fenneman (1938), the formation of the Ridge and Valley Province was preceeded by deposition of Paleozoic sediments into a geosyncline. This was followed by the folding and faulting that occurred during the Appalachian Revolution near the close of the Paleozoic era. The differential subsequent erosion of the various strata has left the present landscape. The valleys are evident where the less resistant strata such as pure limestones and shales are exposed while the resistant sandstones and some cherty dolomites have remained as ridges.

The rock strata which underlie House Mountain are Martinsburg Shale and Sequatchie Formation topped by the Clinch Sandstone. The Martinsburg Shale, which is composed of rock of the Upper Ordovician, crops out around the mountain's base below elevations of 450 meters (Millici, 1973). It consists of shale, sandy calcareous siltstone and thin interbedded limestone lenses. Exposed on the upper slopes at elevations from 450 to 610 meters is the Sequatchie Formation which consists of about 135 meters of calcareous siltstone, shale and silty limestone. The mountain is capped by Lower Silurian deposits of Clinch Sandstone which is made up of about 60 meters of quartzose sandstone in beds up to a meter thick (Cattermole, 1966).

Soils

The soils of House Mountain are derived from the residuum of Paleozoic sedimentary strata and the colluvium and alluvium derived from them. Differences in parent material and relief have resulted in the various soil series, types and phases present. Nine soil series occurred on House Mountain. Descriptions below of these soils are based on the reports of The Knox County Soil Survey (Roberts et al., 1955).

The dominant soil mapped on House Mountain is of the Muskingum series. Muskingum soils developed in residuum and surficial colluvium from interbedded sandstone, siltstone and shale. They are droughty, low in natural fertility and strongly to extremely acid. Most are shallow, being less than 36 inches to weathered bedrock.

House Mountain is topped by soils in the Muskingum series, stony, very steep phase. The slopes on the north and east aspects of the mountain consist of the Muskingum, stony, fine sandy loam steep phase; southern and western slopes are chiefly the Muskingum-Lehew complex, eroded, steep and hilly phases. Lehew soils are developed from reddish sandstone and siltstone parent materials similar to the Muskingum series, but they differ mostly in color and depth.

In the draws of House Mountain several other soil series occur. In addition to Muskingum, are the Dandridge (calcareous shale) and Leadvale series which formed in alluvium and non-stony colluvium derived from soils higher in the landscape and occurs in coves and on foot slopes. The most common sideslope colluvial soil occurring around House Mountain is that of the Jefferson series. At the base are Hamblen, Prader and Melvin series, floodplain soils which are forming in recent alluvial deposits of sandstone, shale or limestone. The Waynesboro series is a terrace soil, derived from pre-Pleistocene alluvium, found on the lower gentle slopes.

Since publication of the Knox County Soil Survey, there have been many advances in the knowledge of soils. Present knowledge of House Mountain soils (Springer and Elder, 1980) and present soil series concepts (Soil Survey Staff, 1975) have changed from those in the 1955 report. The soils of House Mountain are now classified as Dystrochrepts, Hapludalfs and Hapludults.

Vegetation

Shantz and Zon (1924) included the Ridge and Valley of Tennessee in the chestnut-chestnut oak-yellow poplar forests, a division of their oak forest of North America. Weaver and Clements (1938) classified the area as part of their oak-chestnut association of the Deciduous Forest, and later, Küchler (1964) considered it as part of the Appalachian oak forest.

Few vegetation studies have been carried out in the

Great Valley of Tennessee. Hall (1910) recognized a ridge type with chestnut oak, chestnut, black oak and what he called spanish oak (scarlet oak), and Williams (1928) reported from Dr. Thomas Walker's 1750 journal that there were pines on the ridge tops in the Great Valley.

The Tennessee Valley Authority Principal Forests Type Map (1941) recognized in the region an upland hardwood forest type of oak and hickory on moist, mountainous sites. Drier sites were occupied by an oak-chestnut, blackjack oak-hardwood, or yellow pine types.

Braun (1950) reported that the forests of the ridges in the Great Valley were dominated by the oak-chestnut type except in the ravines where mixed mesophytic occurred. Remnants of the white oak-beech community occurred on the lower south-facing slopes of nearby Clinch Mountain.

Other studies of the vegetation (Martin, 1971; Hedge, 1979; Hardaway, 1962), have excluded the high ridges. On Rome ridges with soils somewhat similar to those on House Mountain, Martin and Hedge reported white oak, white oak-shagbark hickory and various chestnut oak communities on northwest facing slopes. On the southeast aspects they observed white oak-mockernut hickory, tulip poplar-southern red oak, and shortleaf pine-oak communities. In the draws of both aspects mixed mesophytic communities occurred. Martin and DeSelm (1976) reported communities dominated by chestnut oak on dry upland sites of the prominent ridges of the Ridge and Valley of Tennessee.

Human Impact

Evidence of prehistoric cultures in Tennessee indicates that the first people to enter Tennessee were the Paleo-Indians, nomadic hunters and gatherers of the Ice Age, who arrived some 15,000 years ago. About 6,000 years later, another group of nomads, the Archaic (Mesolithic) people arrived. Although both groups may have set fires as an aid to hunting, their impact on the area is mostly unknown (Lewis and Kneberg, 1958).

The Moundbuilders (Woodland Indians) or Neolithic man appeared in Tennessee about 3,000 years ago only to be supplanted by the Mississippi culture some 2,000 years later. Though both groups hunted and raised corn, their impact on the landscape is also unknown (Lewis and Kneberg, 1958). From this last culture arose the Cherokees (Folmsbee et al., 1969) who placed their settlements along streams where soils were moist and naturally fertile.

The arrival of the Europeans in the 18th century ended the domination of the area by these Indians and thus began a new era of extensive logging for homes, industry and agriculture. What remained of the forests was grossly mismanaged and by the turn of this century it was a common practice to use forests (especially the ridge forests) for pasture (Rothrock, 1946). The removal of timber from this area, like that throughout the entire country, was so intense that in 1908 Gifford Pinchot was prompted to exclaim that there was only enough timber left in the United States to last 20 or 30 years (Horn, 1943). Although this proved false, the population of the Ridge and Valley in Tennessee has continued to rise (U.S. Bureau of the Census, 1960), and the total forest acreage of Knox County has decreased accordingly (Inventory Committee, 1971).

CHAPTER III

THE VEGETATION

Introduction

During the summer of 1980, plot sampling was carried out on House Mountain to classify the overstory into communities and relate them to the measurable soil and site factors.

Field Methods

Reconnaissance of House Mountain predeeded formulation of a viable strategy for sampling. It was decided that transects at regular intervals perpendicular to the main ridge would be most efficient. Effort was made to sample all aspects and slope positions from the top to the bottom of the mountain in order to gain a proper cross section of the vegetation. Slopes steeper than 40 degrees were not sampled.

Ninety-seven circular, 0.04 hectare plots were placed throughout the study area. Plot centers were established and marked with a stake. The radius was corrected for slope angle according to Bryan (1956) and measured with a tape to establish plot boundaries. Overstory trees greater than 10 cm. dbh (diameter at breast height) were counted by taxon and placed in two cm. dbh classes. Saplings between 1 and 10 cm. dbh were counted by taxon. Seedlings under 1 cm. and the shrub layer were noted and recorded as present.

A soil pit was dug near the center of each plot. The thickness of the organic layer and the A and B horizons were measured. The percentage of stone was estimated and the depth to the least permeable layer was recorded. Samples from the A and B horizons were taken and bagged for later analysis. Where possible, parent material depth and rock lithology was noted.

All field data were recorded on prepared data sheets. Site factors including aspect, slope angle, slope shape and position were recorded. Aspect was measured using a Silva Ranger compass and slope angle was determined using a Suunto clinometer. Shape of both vertical and horzontal slopes was designated convex (1) to flat (3) to concave (5). Slope position was estimated as percent distance from the top using the USGS-TVA 7.5 quadrangle map. Evidence of disturbance by fire was noted but no attempt was made to date it. Keys and references used to identify plants were those of Shanks and Sharp (1963) and Radford et al. (1968). In addition, the University of Tennessee Herbarium was used to verify determinations. Nomenclature follows Radford et al. (1968). The reference collection of tree and shrub specimens from House Mountain was unfortunately discarded from the writer's university desk by persons unknown.

<u>Laboratory Methods</u>

Soil samples were air dried. The soil was put through a 2 mm. seive so that percent coarse fragments could be determined. The pH of each sample was measured using a Leeds and Northrup pH meter, using a 1:1 soil to water ratio (Jackson, 1958). Textures of soil samples from 12 representative plots (A and B-horizons) was determined using the Bouyoucous (1936) method modified by Day (1956) and provided by M.E. Springer, Professor Emeritus of the University of Tennessee Plant and Soil Science Department. These known textures were used as standards and textures of all other samples were determined using the "feel method" (Soil Survey Staff, 1951). Water holding capacity of each horizon and of the top 12 inches was determined by application of the relationship of coarse fragment percentage and texture class to available water holding capacity (Longwell et al., 1963).

The aspect of each plot has been transformed (Beers et al., 1966) for use in statistical analysis; southwest aspects were assigned a value of 0, and the northeast a value of 2. Potential solar insolation per year for each plot was ascertained using the tables of Frank and Lee (1966), using latitude, slope angle, and aspect.

Absolute and relative density (AD and RD) and absolute and relative basal area (ABA and RB) were calculated for each overstory taxon by plot. Sapling absolute and relative densities were computed by taxon. The importance value of each taxon (IV), which has a maximum value of 200, was calculated by combining relative density and relative basal area. Canopy taxa with an average importance value of at least two are referred to as common canopy species. These computations were carried out using the author's programs on a Radio Shack TRS-80 personal computer.

Other statistical analysis was performed using the Statistical Analysis System (SAS) package (Helwig and Council, 1979) on the IBM 370 computer located at the University of Tennessee Computing Center.

Results and Discussion

Introduction. Plots were grouped into community types using the SAS cluster procedure (Helwig and Council, 1979). The results of the clustering are shown in a dendrograph (Figure 2). Because of the presence of sassafras in recently disturbed cove sites, the sassafras (2) and tulip cove (3) communities have been combined as the tulip cove community. Plot locations and types are shown in Figure 3.

The pine-oak community. Of the fourteen common canopy species present in this study, eleven occur in this community type (Table 1). Table mountain pine (*Pinus pungens*), Virginia pine (*P. virginiana*) and chestnut oak (*Quercus prinus*) are the principle canopy species, but pitch pine (*P. rigida*), black oak (*Q. velutina*) and northern red oak (*Q. rubra*) are also important constituents. Of the potential canopy species mentioned above Virginia pine saplings are most numerous; table

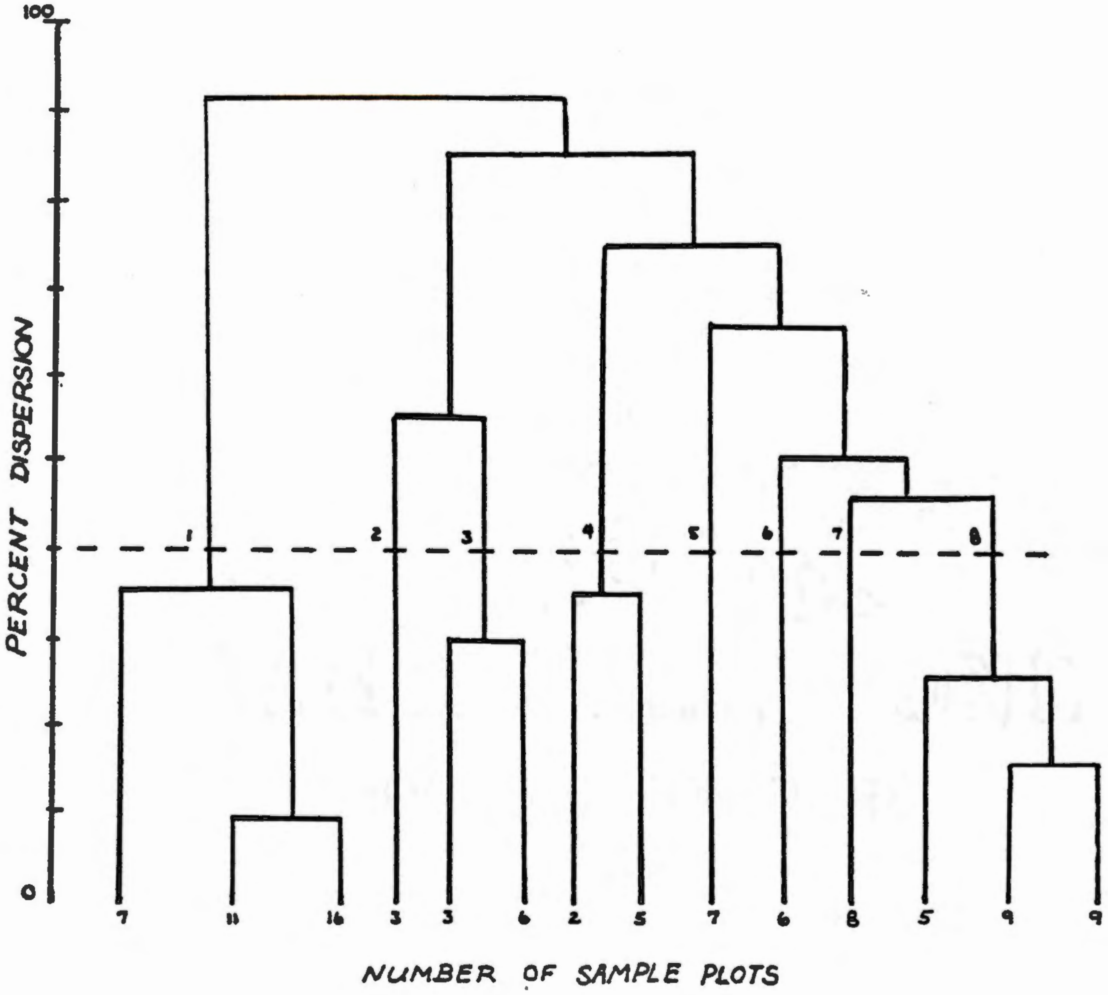

Figure 2. Dendrograph of the Communities on House Mountain. The horizontal line is drawn along the 40 percent level of dispersion where community types were derived. The numbers along the line represent the community types as follows: (1) Chestnut Oak, (2) Sassafras, (3) Tulip Cove, (4) White Oak-Red Oak, (5) Pine-Oak, (6) Black Oak, (7) Chestnut Oak-Black Oak-Mockernut Hickory, (8) Chestnut Oak-Hickory.

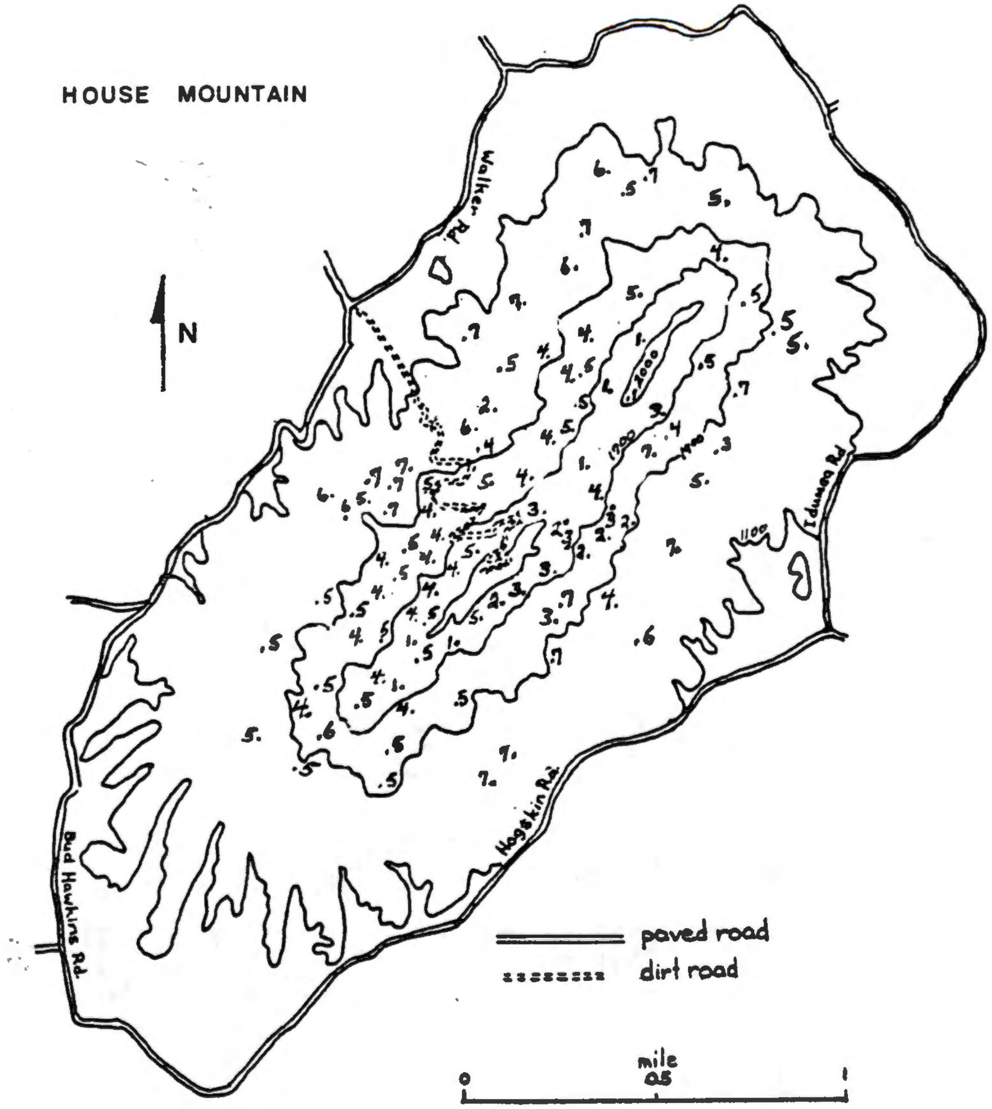

Figure 3. Communities on House Mountain by Plot. The numbers by each plot represent the community types as follows: (1) Pine-Oak, (2) Black Oak, (3) Chestnut Oak-Black Oak-Mockernut Hickory (4) Chestnut Oak-Hickory, (5) Chestnut Oak, (6) White Oak-Northern Red Oak, (7) Tulip Cove.

Table 1. Composition of the Pine-Oak Community Type. N=7

Taxa	Canopy RD%	Canopy RBA%	Canopy IV	Saplings RD%
Acer rubrum				8.0
Carya glabra	1.6	0.5	2.0	2.7
C. ovalis				0.5
C. tomentosa	1.2	0.5	1.6	7.3
Cornus florida				3.6
Diospyros virginiana				0.6
Nyssa sylvatica	0.8	0.1	0.9	15.3
Oxydendrum arboreum	7.3	1.9	9.2	5.0
Pinus pungens	22.5	29.6	52.0	6.3
P. rigida	9.1	5.5	13.5	0.3
P. virginiana	17.1	16.9	35.0	19.9
Quercus marilandica	0.7	0.1	0.8	1.3
Q. prinus	23.6	39.2	63.7	5.3
Q. rubra	5.0	1.9	6.9	8.9
Q. velutina	6.3	2.6	8.9	7.5
Sassafras albidum				6.6
BA/ha (m^2)		39.7		
D/ha	765.5			1911.8

mountain pine, chestnut oak, northern red oak and black oak maintain a lower reproductive density. Although virtually non-existent as a portion of the canopy, black gum (*Nyssa sylvatica*) and mockernut hickory (*Carya tomentosa*) are highly conspicuous in the sapling layer. Pitch pine is not reproducing.

Based on this data, it appears this community type is maintaining itself with the exception of pitch pine. In the future however, it will have a higher importance of black gum, northern red oak, and black oak.

The pine-oak community occurs for the most part on the drier west and south-west facing slopes near and on the top of House Mountain (Appendix). The soils are shallow and extremely acid; their texture is primarily sandy loam or cobble sandy loam throughout the profile. Evidence of fire was found on 43% of the plots of this type.

The Society of American Foresters (Eyre,1980) describes a Virginia pine-oak Type 78 which is much like this community type. Martin (1971) recognizes a chestnut oak-Virginia pine complex on middle and upper, dry, nutrient depleted southwest slopes. Table mountain pine and pitch pine are absent however. Hinkle (1975) reports a pitch pine-Virginia pine community on the upper slopes and ridge tops in Cumberland Gap National Historic Park with a higher representation of black oak and an absence of table mountain pine. Hedge (1979) has designated a similar chestnut oak-pine community on dry slopes in Roane County but with a high density of shortleaf pine.

The black oak community. Eleven of the fourteen common canopy species occur in the black oak community type (Table 2). Although black oak is the main constituent here, blackjack oak (*Q. marilandica*) and chestnut oak are well represented. Hickories present in quantity are sand hickory (*Carya pallida*) and mockernut hickory; yellow poplar (*Liriodendron tulipifera*), black gum, table mountain pine and Virginia pine are less dense. Black gum and chestnut oak are reproducing best, with mockernut hickory and black oak reproducing less well. The understory is otherwise dominated by dogwood (*Cornus florida*), sourwood (*Oxydendrum arboreum*), red maple (*Acer rubrum*), and sassafras (*Sassafras albidum*). This community type grades into one dominated by chestnut oak.

The black oak community occurs mostly on steep, southeast facing slopes near the top of House Mountain (Appendix). Dry, extremely acid, shallow soils low in stoniness are the rule; textures are predominantly loamy sand and sandy loam throughout the profile. Presence of fire was observed only at 17 percent of the plots.

Wade (1979) describes a black oak type on the Cumberland Plateau with a slight hickory presence but without the codominance of chestnut oak and blackjack oak. Hinkle (1975) recognizes a black oak-sand hickory community

Table 2. Composition of the Black Oak Community Type. N=6

Taxa	Canopy RD%	Canopy RBA%	Canopy IV	Saplings RD%
Acer rubrum	2.8	2.0	4.8	3.7
A. saccharum	1.3	0.2	1.5	3.2
Carya glabra	0.8	0.5	1.3	0.3
C. ovalis	1.3	1.7	3.0	1.5
C. ovata	1.3	0.3	1.6	1.0
C. pallida	4.7	5.8	10.5	2.8
C. tomentosa	7.2	7.3	14.5	5.7
Cercis canadensis	0.8	0.2	1.0	1.0
Cornus florida	2.3	0.3	2.8	12.7
Diospyros virginiana	0.5	0.2	0.7	1.0
Juniperus virginiana				0.5
Liriodendron tulipifera	3.0	5.5	8.5	0.3
Nyssa sylvatica	5.7	3.2	8.9	19.3
Oxydendrum arboreum	8.0	5.5	13.5	9.3
Pinus pungens	2.2	3.7	5.9	0.5
P. virginiana	2.7	3.3	6.0	0.2
Quercus marilandica	12.9	10.5	23.4	4.2
Q. prinus	14.2	15.5	29.7	10.7
Q. rubra	0.5	0.5	1.0	3.2
Q. velutina	24.2	32.2	56.4	5.0
Sassafras albidum	4.5	1.7	6.2	11.2
BA/ha (m^2)		36.3		
D/ha	971.2			1621.3

in Cumberland Gap. It too has a black oak dominant with a low density sapling layer . Hedge (1979) also describes a black oak type on middle and upper south-facing slopes in Roane County. The Society of American Foresters' Type 110 (Eyre, 1980) describes a similar black oak type. They believe it to be intermediate in succession, replacing shortleaf pine on heavily cutover areas.

The chestnut oak-black oak-mockernut hickory community. Of the 14 major canopy species in this study, ten appear in this community (Table 3). This type is dominated by chestnut oak, black oak and mockernut hickory; black gum is the only other canopy species with an importance value greater than five. Black gum is reproducing best, but chestnut oak and mockernut hickory also contribute substantially to the understory. Although black oak is not reproducing as well, it appears that this community will remain basically unchanged in the near future. Other understory trees present in order of importance are sassafras, dogwood, sourwood and persimmon (*Diospyros virginiana*).

The chestnut oak-black oak-mockernut hickory community occurs on steep south and southeasterly facing slopes just below the top of House Mountain (Appendix). The soils here are dry, extremely acid, low in coarse fragments and somewhat deeper than other soils near the top. Their textures are predominantly loamy sand and sandy loam.

Table 3. Composition of the Chestnut Oak-Black Oak-Mockernut Hickory Community Type. N=8

	Canopy			Saplings
Taxa	RD%	RBA%	IV	RD%
Acer rubrum				1.8
Carya glabra	0.5	0.3	0.8	1.0
C. ovalis	1.3	1.1	2.5	0.6
C. pallida	0.3	0.1	0.5	0.1
C. tomentosa	22.8	20.8	43.6	16.8
Cercis canadensis				0.1
Cornus florida	0.8	0.5	1.2	9.6
Diospyros virginiana	0.8	0.3	1.1	3.0
Liriodendron tulipifera	2.0	1.1	3.1	0.6
Nyssa sylvatica	8.5	10.9	19.3	21.8
Oxydendrum arboreum	6.0	2.5	8.3	4.5
Pinus pungens				0.1
P. virginiana	2.3	1.6	3.9	1.1
Quercus marilandica	0.3	0.1	0.5	
Q. prinus	30.1	37.1	67.2	13.5
Q. rubra	0.8	0.3	1.0	0.3
Q. velutina	19.8	23.0	42.8	8.8
Sassafras albidum	3.8	1.1	4.6	15.1
BA/ha (m^2)		38.2		
D/ha	950.6			1916.7

Evidence of fire was observed in half the plots of this type.

Hinkle (1975) describes a chestnut oak-black oak community on the middle to upper convex slopes in Cumberland Gap. It, however, has a high pignut hickory (*Carya glabra*) constituency as opposed to mockernut. Hedge (1979) has also recognized a chestnut oak-black oak community in Roane County but mockernut again is missing. Martin (1971) reported chestnut oak and mockernut hickory with some black oak on south facing slopes in non-cherty dolomite limestone areas of the Great Valley. This community is likely a variant of the Society of American Foresters' (Eyre, 1980) chestnut oak Type 44.

The chestnut oak-hickory community. The chestnut oak-hickory community is dominated chiefly by chestnut oak, red hickory (*Carya ovalis*) and pignut hickory (Table 4). Tulip poplar and black gum are also well represented in the canopy. Twelve of the 14 major canopy species occur here, but none of them has a high sapling density. As is often the case, the understory is dominated by dogwood, redbud (*Cercis canadensis*) and red maple. Based on this data, this community seems to be stable with no canopy species replacements in progress. It seems likely though that red maple and northern red oak will increase in importance in the future.

The chestnut oak-hickory community occurs on all slope

Table 4. Composition of the Chestnut Oak-Hickory Community Type. N=23

Taxa	Canopy RD%	Canopy RBA%	Canopy IV	Saplings RD%
Acer rubrum	4.3	1.9	6.2	8.6
A. saccharum	0.5	0.2	0.7	1.2
Aesculus octandra				0.2
Carya cordiformis	0.1	0.1	0.2	0.1
C. glabra	8.0	10.3	18.3	5.5
C. ovalis	8.3	12.5	20.7	0.8
C. ovata	1.2	0.7	1.9	0.3
C. tomentosa	1.8	1.0	2.8	0.5
Cercis canadensis	6.0	1.3	7.5	10.6
Cornus florida	9.0	2.0	11.0	36.6
Diospyros virginiana	0.2	0.3	0.5	0.5
Fraxinus americana	1.8	1.0	2.8	1.5
Liriodendron tulipifera	9.2	5.5	14.7	2.7
Nyssa sylvatica	5.1	5.5	10.6	6.7
Oxydendrum arboreum	3.5	1.0	4.5	2.3
Pinus pungens	1.6	2.0	3.6	0.7
P. virginiana	2.1	2.3	4.4	
Quercus alba	0.2	0.3	0.5	0.2
Q. prinus	23.0	45.5	68.5	4.3
Q. rubra	3.1	2.1	5.2	4.5
Q. velutina	1.3	1.5	2.8	1.6
Sassafras albidum	7.0	2.9	9.9	6.9
BA/ha (m^2)		57.0		
D/ha	951.5			2036.2

positions except the top of House Mountain; most occur in the middle positions (Appendix). Slopes are generally steep, and most aspects are north to west. Most soils are very strongly acid to extremely acid, but 13 percent of the plots are in the medium range. More than half of the plots in this group have soils greater than 48 inches in depth; all but one have fewer than 50% coarse fragments. Textures range from sand to silty clay, most being either sandy loam, loam or silt loam. Fire has occurred in 39% of the plots.

Martin (1971) reports communities in which chestnut oak shares dominance with hickories on northeast middle and upper ,convex slopes of prominent Rome ridges. Hedge's (1979) chestnut oak-hickory-northern red oak type is similar but contains a higher northern red oak importance and no red hickory. This community type is probably a variant of the Society of American Foresters' chestnut oak Type 44 (Eyre, 1980).

<u>The chestnut oak community</u>. The most distinct community on House Mountain is the chestnut oak type (Table 5), which clearly dominates the canopy. Twelve of the 14 common canopy species in this study occur in this community type. Chestnut oak dominates these plots, but other associated canopy species include red maple, pignut hickory, Virginia pine and northern red oak and to a lesser degree black oak and mockernut hickory.

Table 5. Composition of the Chestnut Oak Community Type. N=34

	Canopy			Saplings
Taxa	RD%	RBA%	IV	RD%
Acer rubrum	9.1	2.2	11.3	17.0
A. saccharum	1.8	0.5	2.3	2.5
Carya cordiformis	0.2	0.1	0.3	
C. glabra	5.2	2.1	7.3	7.2
C. ovalis	1.1	0.8	1.9	0.6
C. ovata	0.1	0.1	0.2	0.3
C. tomentosa	2.5	1.3	3.8	2.8
Cercis canadensis	0.6	0.5	1.1	2.1
Cornus florida	4.0	0.8	4.8	28.3
Diospyros virginiana	0.1		0.1	0.3
Fraxinus americana	0.1		0.1	0.6
Juniperus virginiana	0.7	0.1	0.8	1.3
Liriodendron tulipifera	1.9	0.8	2.7	1.9
Nyssa sylvatica	1.7	0.6	2.3	3.5
Oxydendrum arboreum	3.5	0.9	4.3	
Pinus pungens	0.1	0.1	0.2	0.1
P. rigida	1.8	1.0	2.8	0.2
P. virginiana	5.7	5.0	10.7	4.7
Quercus alba	1.3	1.2	2.5	0.1
Q. muehlenbergii	0.9	0.6	1.5	
Q. prinus	46.6	76.2	122.8	6.2
Q. rubra	5.1	3.9	9.0	4.2
Q. velutina	2.9	2.1	5.0	2.5
Sassafras albidum	1.9	0.6	2.5	6.0
BA/ha (m^2)		60.5		
D/ha	870.7			1755.3

Red maple and dogwood are the most evident understory species present. Chestnut oak is the fourth ranked in sapling relative density and although intermediate in shade tolerance it is quite a prolific and persistent sprouter (Fowells,1975). The frequency with which chestnut oak forests have been described in the eastern United States and its present sapling density here suggests it permanence on House Mountain.

The chestnut oak community occurs on a wide range of aspects as well as slope positions, angles and soils (Appendix). For the most part the soil pH is extremely acid, and the textures vary from loamy sand to clay loams. The soils are generally deep and well drained. Fire is evident at 32% of the plots of this type.

Braun (1950) observed that chestnut oak was important in chestnut communities before the chestnut blight. Since then, it has become recognized as a major replacement of the chestnut (Woods and Shanks, 1959). Similar chestnut oak communities have been described by Wade (1979) on the Cumberland Plateau, Hinkle (1975) at Cumberland Gap, and by Martin (1971) and Hedge (1979) in the Great Valley. The chestnut oak type, Society of American Foresters (Eyre, 1980) Number 44, aptly describes this community.

<u>The white oak-northern red oak community</u>. Ten of the common canopy taxa occur in the white oak-northern red oak community type (Table 6). The predominant species here is

Table 6. Composition of the White Oak-Northern Red Oak Community Type. N=7

Taxa	Canopy RD%	Canopy RBA%	Canopy IV	Saplings RD%
Acer rubrum				3.7
A. saccharum	1.5	0.5	2.0	3.5
Aesculus octandra	6.3	3.3	9.6	2.3
Carya glabra	1.1	0.6	1.7	0.9
C. ovalis	3.0	6.0	9.0	
C. ovata	3.2	4.4	7.6	1.3
C. tomentosa	1.0	1.1	2.1	0.7
Cercis canadensis	5.3	1.5	6.8	14.6
Cornus florida	10.0	1.5	11.5	31.0
Diospyros virginiana	0.5	0.3	0.8	0.3
Fraxinus americana	4.9	4.0	8.9	5.2
Juniperus virginiana				2.9
Liriodendron tulipifera	2.3	3.3	5.6	0.2
Nyssa sylvatica	5.7	2.8	8.5	7.7
Oxydendrum arboreum	0.3	0.2	0.5	1.3
Quercus alba	21.0	35.8	56.9	1.8
Q. muehlenbergii	1.1	0.7	1.8	
Q. prinus	6.9	8.0	14.9	1.5
Q. rubra	10.8	15.5	26.3	1.8
Q. velutina	1.9	2.3	4.2	0.2
Sassafras albidum	2.8	0.7	3.5	3.6
BA/ha (m^2)		59.5		
D/ha	751.3			1651.3

white oak (Quercus alba); northern red oak is a prominent associate. Chestnut oak is present, although less dense, as are buckeye (Aesculus octandra), red hickory, white ash (Fraxinus americana) and black gum. No pines occur in this community type. Although white oak is not reproducing, the community appears to be stable as there are younger white oaks nearby. As is true of most communities on House Mountain, the understory is dominated by such species as dogwood, redbud, black gum, and red maple. Sugar maple (Acer saccharum), buckeye, tulip tree and ash occur in both under and overstory. It would be of interest to see if these mesophytes increased were fire suppression imposed on the mountain.

The white oak-northern red oak community occurs on various aspects (mostly westerly) on the moderate slopes from the bottom to midslope positions of House Mountain (Appendix). The soils range from dry to moist, extremely to medium acid and from shallow to depths greater than 48 inches. Soil textures range from sandy loam to silt loam in the A-horizon and to clay loam in the B horizon. Fire was observed on 57% of the plots.

The white oak-northern red oak community on House Mountain closely resembles the white oak-northern red oak types described by Hedge (1979) on north facing slopes in Roane County and by Hinkle on southeast mid slopes at Cumberland Gap. Martin (1971) has observed a similar community, but with more yellow poplar, on sites extending to middle slope positions, characterized by cherty dolomitic limestone. The Society of American Foresters' (Eyre, 1980) white oak-black oak-northern red oak Type 52 when found on moist, lower and middle slopes, is similar to this community.

The tulip cove community. Twelve of the 14 common canopy species in this study appear in the tulip cove community (Table 7). The principle canopy species here is overwhelmingly yellow poplar, accompanied by buckeye and on recently disturbed sites by sassafras. On these plots a variety of secondary dominants occur. Most notable of these taxa are chestnut oak, northern red oak, black oak, pignut hickory and red hickory; all of these exhibit low percentages among the saplings.

As in several community types, red maple, black gum, redbud and dogwood are important sapling species, but are too small or short lived to appear or last in the canopy. Although low in sapling relative density, poplar is believed to overcome much competition simply because it grows so rapidly into openings (Fowells, 1965). It seems likely that the mature community here of the future will be dominated by the mesophytes, the maples, buckeye, ash, and tulip tree, with a considerable mixture of oaks and hickories. Sassafras may persist into the mature canopy.

The tulip cove community occurs in the north to

Table 7. Composition of the Tulip Cove Community Type. N=12

	Canopy			Saplings
Taxa	RD%	RBA%	IV	RD%
Acer rubrum	1.5	0.6	2.1	13.9
A. saccharum	0.2	0.1	0.3	3.5
Aesculus octandra	6.1	7.5	13.6	4.2
Carya cordiformis	1.6	1.2	2.8	0.1
C. ovalis	4.3	5.6	9.9	1.1
C. ovata	1.2	0.5	1.7	1.2
C. tomentosa	5.1	3.8	8.9	5.3
Cercis canadensis	2.1	0.2	2.3	10.8
Cornus florida	2.3	0.9	3.2	14.1
Diospyros virginiana	2.2	1.3	3.5	0.6
Fraxinus americana	1.3	1.0	2.3	2.1
Liriodendron tulipifera	28.0	43.2	71.2	6.5
Nyssa sylvatica	1.1	0.8	1.9	4.2
Oxydendrum arboreum	0.2	0.1	0.3	1.0
Pinus pungens	0.3	0.2	0.5	0.3
P. virginiana	0.8	0.7	1.5	
Quercus alba	2.6	1.9	4.3	1.3
Q. marilandica	0.8	0.5	1.3	
Q. muehlenbergii	0.5	0.5	1.0	0.3
Q. prinus	5.1	6.0	11.1	3.8
Q. rubra	2.0	5.0	7.0	1.0
Q. velutina	4.6	3.3	7.9	2.7
Sassafras albidum	18.0	10.8	28.8	9.8
BA/ha (m^2)		53.3		
D/ha	1111.1			1695.5

southeast, gentle moist draws from the middle to the bottom of House Mountain. The soils are generally deep with about 50% coarse fragments and a pH that ranges from slightly to extremely acid. The soil textures also vary widely from sandy to silt loams. 25 percent of the plots had clayey, argillic B-horizons. Evidence of fire was observed on half the plots studied.

This community type resembles some of the tupip poplar-oak types reported by Martin (1971) in the Great Valley--beech (*Fagus grandifolia*) however is absent on House Mountain. Hedge(1979) reports a similar type on the lower and middle slopes and ravines in Roane County with a higher constituency of black oak and sourwood. The mixed mesophytic described by Braun (1950) is also similar but the absence on House Mountain of beech and basswood (*Tilia heterophylla*) is quite notable. Except for the lack of buckeye in Hinkle's (1975) tulip-mixed oak community, it closely resembles this type. The Society of American Foresters (Eyre 1980) recognizes a yellow poplar Type 57 in which tulip poplar clearly is important just as it is here.

The occurrence of chestnut. The previous classification of the area with chestnut (*Castanea dentata*) as a widespread dominant (Shantz and Zon, 1923) and the reports of chestnut in preblight forests (summarized by Braun, 1950) and the widespread occurrence of stumps, snags and sprouts reported by Martin (1971) and Hedge (1979), made the writer aware of the possibility of seeing chestnut or chestnut evidence in the field. Although chestnut saplings were encountered on four occasions on House Mountain, none occurred in any of the plots.

CHAPTER IV

CORRELATION AND REGRESSION ANALYSIS

Introduction

Simple linear correlation (Pearson Product-Moment Correlation) was used to determine the extent of relationship between site, soil and vegetation variables (Table 8).

Stepwise multiple regression was used to develop predictive models for dominant species' importance values, relative densities and relative basal areas. Regression is useful because of its ability to screen large numbers of independent variables and determine which are most significantly related (Fritts, 1962). From these models, relationships between vegetation and environmental variables can be examined so that the patterns of plant commmunities can be better understood.

There have been several previous studies similar to this carried out in the Appalachian area. Of these, Martin (1966) related basal area and density to soil and site factors on Wilson Mountain. Safley (1970) and Hinkle (1975) related importance values, relative density and basal area. Hedge (1979) made a similar study in Roane County. However, the most extensive study of this type was performed by Martin (1971) in the Great Valley of Tennessee, where 684 plots were examined.

Table 8. Variables Used in Correlation and Regression Analysis.

Abbreviation	Variable Name	Units
Vegetation		
AR	Acer rubrum	IV
AS	A. saccharum	IV
AO	Aesculus octandra	IV
CC	Carya cordiformis	IV
CG	C. glabra	IV
COL	C. ovalis	IV
COT	C. ovata	IV
CP	C. pallida	IV
CT	C. tomentosa	IV
CCN	Cercis canadensis	IV
CF	Cornus florida	IV
DV	Diospyros virginiana	IV
FA	Fraxinus americana	IV
JV	Juniperus virginiana	IV
LT	Liriodendron tulipifera	IV
NS	Nyssa sylvatica	IV
OA	Oxydendrum arboreum	IV
PP	Pinus pungens	IV
PR	P. ridgida	IV
PV	P. virginiana	IV
PS	P. species	IV
QA	Quercus alba	IV
QM	Q. marilandica	IV
QMX	Q. muehlenbergii	IV
QP	Q. prinus	IV
QR	Q. rubra	IV
QV	Q. velutina	IV
SAL	Sassafras albidum	IV
Site		
AN	Slope Angle	Degrees
AB	Aspect (Beers)	SW=0,NE=2
SP	Slope Position	% from top
VS	Vertical Shape	1=Convex,5=Concave
HS	Horizontal Shape	1=Convex,5=Concave
FI	Evidence of Fire	+ or -
SR	Potential Radiation	Langleys

Table 8. (Continued)

Abbreviation	Variable Name	Units
Soil		
SA	A-horizon sand	%
LA	A-horizon silt	%
CA	A-horizon clay	%
SB	B-horizon sand	%
LB	B-horizon silt	%
CB	B-horizon clay	%
PA	A-horizon pH	pH
PB	B-horizon pH	pH
LP	Depth to least permeable	inches
CFA	A coarse fragments	%
CFB	B coarse fragments	%
WA	A available water capacity	inches
WB	B available water capacity	inches
WT	Top 12 inches water capacity	inches
Communities		
PO	Pine-Oak	
BO	Black Oak	
OMH	Chestnut Oak-Black Oak-Mockernut Hickory	
COH	Chestnut Oak-Hickory	
CO	Chestnut Oak	
WRO	White Oak-Northern Red Oak	
TC	Tulip Cove	

<u>Statistical Procedures</u>

Data from the 97 plots was entered by the author into the TRS-80 computer to calculate relative density (RD) and relative basal area (RB) and importance value (IV) of the canopy vegetation. These results with the site and soil factors from the plot sheets were recorded on University of Tennessee Computing Center (UTCC) data sheets. From the sheets, the data was entered into the IBM Model 370 using the DECsystem-10.

The Statistical Analysis System (SAS) (Helwig et al, 1979) deleted observations with missing values from the regression analysis. For this study, mean values were inserted for missing values to avoid deletion of an observation.

The forward stepwise multiple regression technique gave the best one variable model, then the best two variable model and so on as it replaced variables from the previous step in order to insure the highest r square for the model. Models were chosen based on the following criteria:

1. Reliability of the overall model was checked at P=0.01 as determined by an F-test (ratio of regression mean square to error mean square).

2. Reliability of each partial regression coeficient was checked using an F-test at P=0.10.

3. The model chosen should have the highest r square

at a point where there were no more than six independent variables and the r square improvement was less than 5%.

The amount of relative contribution of each independent variable (Xi) to explained variation in the dependent variable was obtained by dividing Type II sum of squares calculated for each Xi by the sum of all Type II sum of squares of all Xi's.

The coefficient of determination (r square), mean dependent variable value ($\bar{Y}$) and the standard error of the estimate (SEE) for Yi's in each model are given. In the regression equation for importance value, any independent variable that is also significant in the correlation analysis is underlined.

Correlation Results and Discussion

Simple linear correlations between site, soil and vegetation variables were produced to examine the association between these factors. Although the association may be strong, discretion need be exercised in attributing causality.

On House Mountain slope angle steepness increases upslope, also, as is often the case, vertical and horizortal shapes are correlated (Table 9). The Frank and Lee (1966) radiation tables are set up so that on each aspect certain angles receive maximum radiation, greater or lesser angles receive less. The radiation correlations here indicate that slope angles are steep enough to reduce

Table 9. Simple Linear Correlations Between Site Variables.

	AN	AB	SP	VS	HS	SR
AN	1.00		-.43*			-.34*
AB		1.00				-.63*
SP			1.00			
VS				1.00	.53*	
HS					1.00	
SR						1.00

*Significant at P=0.01
All others are significant at P=0.05

radiation from the maximum at that aspect and further, as is to be expected, radiation decreases toward the northeast.

As these soils are primarily a product of parent material, weathered and eroded, through time, it is not unexpected that the parent material shows its influence throughout the profile (Table 10). Sand in the A-horizon is strongly positively correlated with B sand while both are negatively correlated with silt and clay content in each horizon. Likewise both A silt and A clay associate positively with silt and clay in the B.

Coarse fragment content of both the A and B-horizons is negatively related to increased A and B sand, and likewise positively correlated with silt and clay in both horizons. The soils derived from siltstones and shale had loose fragments scattered throughout the profile, but the sandy soils encountered on the upper slopes of House Mountain are derived from sandstone which apparently weathers completely to fines leaving few coarse fragments. These upper slope, steep, sandy soils were also shallow as evidenced by the negative relationship of A and B sand with the depth to the least permeable layer and with the positive correlation of A and B silt and clay with soil depth. Since House Mountain is a steep sandtone capped ridge, slope position is a major contributing factor here.

Since clay surfaces are the primary cation absorption

Table 10. Simple Linear Correlations Between Soil Variables.

	SA	LA	CA	SB	LB	CB	PA	PB	LP	CFA	CFB	WA	WB	WT
SA	1.00	-.93*	-.72*	.87*	-.85*	-.52	-.21		-.31*	-.60*	-.48*	-.35*	-.21	-.47*
LA		1.00	.45*	-.80*	.83*	.38	.28*		.25	.50*	.41*	.37*	.22	.56*
CA			1.00	-.69*	.53*	.62*			.32*	.56*	.45*			
SB				1.00	-.90*	-.70*			-.39*	-.58*	-.58*	-.35*	-.23	-.45*
LB					1.00	.32*			.27*	.45*	.50*	.37*		.51*
CB						1.00		-.28*	.42*	.52*	.45*		.23	
PA							1.00	.85*				.26*	.33*	.30*
PB								1.00						
LP									1.00			.52*	.65*	.25
CFA										1.00	.79*	-.20		
CFB											1.00			
WA												1.00	.56*	.72*
WB													1.00	.49*
WT														1.00

*Significant at P=0.01
All others are significant at P=0.05

sites for exchange with H+ ions, it is surprising that the pH of the B-horizon is negatively correlated with B-horizon clay content. PH in the A however is, as expected, negatively correlated with A sand and positively with A silt. The pH of the A-horizon is strongly positively correlated with B-horizon pH.

The available water holding capacity of the A-horizon as well as that of the top 12 inches is negatively correlated with increased A and B sand but related positively with A and B silt. Likewise, water holding capacity of the A is negatively correlated with increased A coarse fragments. Surprisingly, no significant relationship is evident between water and clay in the A, but B water holding capacity does demonstrate a positive correlation with B-horizon clay content. All available water holding categories show a positive correlation with pH in the A-horizon and the depth to the least permeable layer. This reiterates that the sandy soils at the top of House Mountain are shallow, are low in water holding capacity and have a low pH.

Steep slopes are negatively correlated with clay in the B-horizon, pH of the A, depth to the least permeable layer and water holding capacity of the B (Table 11). This confirms that the soils on the steep slopes of House Mountain are, as one would expect, acid, coarse textured, shallow and dry. Both Hedge (1979) and Martin (1971)

Table 11. Simple Linear Correlations Between Site and Soil Variables.

	AN	AB	SP	VS	HS	SR
SA			-.42*	.25	.21	.37*
LA			.37*	-.31*		-.43*
CA			.36*			
SB			-.38*	.25	.21	.31*
LB			.24	-.30*	-.23	-.40*
CB	-.47*		.44*			
PA	-.21		.39*			
PB		.26	.32*			
LP	-.25		.20			-.26
CFA			.39*			
CFB		-.20				
WA					-.28*	-.32*
WB	-.37*					
WT				-.27*	-.35*	-.45*

*Significant at P=0.01
All others are significant at P=0.05

report negative relationships between slope angle and B clay, soil depth and available water.

Aspect (northeast 2, southwest 0) is positively associated with pH in the B-horizon and negatively with B-horizon coarse fragments indicating that the B-horizon is less acid and less stony as the northeast aspect is approached. Both Martin (1971) and Wade (1979) report similar pH correlations and Hedge (1979) observed both, a positive correlation with B-horizon pH and a negative association with B coarse fragments.

Since House Mountain is a sandstone capped ridge, it was expected that the distance from the top would be negatively correlated with increased sand in the A and B-horizons and distance be positively related to the silt and clay content of both horizons. Likewise, the pH of the A and B-horizons also increases downslope. The soils are also deeper and coarse fragments of the A-horizon increase downslope, indicating presence of colluvial deposits.

The positive corelation of vertical and horizontal shape (concave) with the A and B-horizon sand content, along with the negative correlations for silt, attests to sand in the concavities (derived from the sandy colluvium). The negative correlation between vertical and horizontal shape and water holding capacity of the A and top 12 inches is doubtless related to the sandy texture.

Solar radiation is related positively to sand in the A and B-horizons and negatively to silt in the A and B, soil depth and water holding capacity of the A-horizon and of the top 12 inches. Solar radiation has greater impact on southerly aspects where soils are sandy and shallow and subsequently dry.

Correlations between canopy IV's and site variables reveal the importance of slope position, angle and aspect in the distribution of canopy species on House Mountain (Table 12).

Those species more important on steep slopes are pignut hickory and black gum while tulip poplar and white oak have greater importance on less steep slopes. Hedge (1979) reports observing pignut on steep angles and tulip poplar and white oak on the gentle slopes in the Great Valley. Martin (1966) also reports white oak on the lower slopes on Wilson Mountain.

As the aspect approaches the northeast, there are positive correlations with tulip poplar, buckeye, pignut and red hickory. Those correlated with the southwest are table mountain pine and Virginia pine and chestnut oak. According to Fowells (1965), tulip poplar is a species of northern slopes and a member of the mixed mesophytic forests of the Appalachians. Both Martin (1966) and Hedge (1979) observed that tulip poplar is positively correlated to northeast aspects. Conversely, Hedge (1979) reports pignut on southerly slopes.

Table 12. Simple Linear Correlations Between Canopy Species IV and Site Variables.

	AN	AB	SP	VS	HS	SR
AO		.23	.33*			-.21
CG	.37*	.28*		-.22		-.53*
COL		.25				-.29*
CT			-.25	.20	.28	.42
LT	-.21	.39*	.34*			
NS	.20			.48*	.48*	
PP		-.31*	-.35*			
PR			-.23			
PV		-.24	-.43*			
QA	-.33*		.37*			
QM						.21
QP		-.32*		-.20		
QR						
QV			-.26	.23		.44

*Significant at P=0.01
All others are significant at P=0.05

The importance values of buckeye, tulip poplar and white oak are positively correlated with increased distance from the top of the ridge, but the pines along with mockernut hickory and black oak are negatively related. Buckeye, tulip poplar and white oak are all main constituents of Braun's (1950) Mixed Mesophytic forest and both Hedge (1979) and Hinkle (1975) associate bottom slope positions with tulip poplar and white oak. Fowells (1965) states that mockernut hickory grows best on dry ridges and that pitch pine is related to shallow, infertile, sandy soils, like those on the top of House Mountain. Wade (1979) reports Virginia pine to be positively correlated with top positions on the Cumberland Plateau underlain by sandstone.

Only mockernut hickory and black gum are correlated positively to both vertical and horizontal shapes indicating higher presence of both on concave slopes. Pignut hickory and chestnut oak are both negatively correlated with vertical shape to which black oak is positively related. Hinkle (1975) reports chestnut oak on convex northern slopes.

Mockernut hickory, blackjack oak and black oak are positively correlated with increased potential solar radiation, indicating shade intolerance. On the other hand, shade tolerance is demonstrated by the negative correlations found with buckeye, pignut and red hickory.

Based on results from previous tables and field observations, I expect the mesophytes buckeye and tulip poplar to be negative on sand (occur on lower slopes), positive on clay or silt, positive on coarse fragments (which accumulate in the draws), positive on pH and on water. Many of these correlations appear in Table 13.

Similarly, I expect xerophytes such as the pines, blackjack oak, black oak, mockernut hickory and black gum to be positive on sand, negative on silt or clay, negative on ph, positive on coarse fragments and negative on water. Their often negative correlation with coarse fragments suggests that they were sampled mainly on lateral spurs where soils contain few coarse fragments. Many other correlations occur in Table 13.

An hypothesis for behavior of understory species is more difficult as many of the taxa are widespread. Persimmon, cedar and sassafras are early old field invaders. The mesophytes and submesophytes sugar and red maples, redbud, and dogwood are positive on clay or silt and negative on sand, positive on coarse fragments (draw positions) and positive on water. The xerophyte or subxeric sourwood behaves oppositely, positive on sand, negative on silt and clay, negative on pH, negative on depth (shallow soil), negative on coarse fragments (ridges) and negative on water. While these taxa's behavior is more or less clear, other taxa is less so.

Table 13. Simple Linear Correlations Between Canopy Species IV and Soil Variables.

	SA	LA	CA	SB	LB	CB	PA	PB	LP	CFA	CFB	WA	WB	WT
AO	-.25	.31					.52*	.52*	.23	.23			.32*	
CG	-.35*	.41*		-.45*	.50*							.27*		.44*
COL								.25				.27*		.30*
CT	.57*	-.53*	-.42*	.52*	-.52*	-.27*				-.50*	-.52*	-.25		-.27*
LT							.63*	.67*					.30*	
NS	.31*	-.31*		.28*	-.25	-.21				-.42*	-.41*			
PP	.25	-.26*		.29*	-.26	-.22	-.22		-.26			-.25	-.23	-.25
PR														
PV	.28*	-.25	-.26	.33*	-.25	-.30*	-.25		-.38*			-.22	-.23	
QA														
QM	.27*	-.23	-.22	.26	-.26				-.25	-.25	-.37*			
QP			.38*	-.33*	.39*		-.41*	-.43		.23	.37*			
QR		.22			.25		.23							.25
QV	.46*	-.48*	-.25	.43*	-.52*		-.20		-.23	-.37*	-.35*	-.31		-.27*

*Significant at P=0.01
All others are significant at P=0.05

Several species' importance values are correlated significantly (Table 14). Tulip poplar and buckeye, both dominants of the Mixed Mesophytic forest (Braun, 1950), are positively related. Both occur on northeasterly aspects, and in lower draws where the soil pH and available water holding capacity are higher. According to Fowells (1965), the soils and topography where buckeye occurs are also excellent for tulip poplar. Table mountain pine and Virginia pine are found together on the more southwest aspects near the top of House Mountain where the soils are sandy, shallow and low in both pH and available water holding capacity. Although it often occurs in pure stands, table mountain pine commonly grows with Virginia pine (Fowells, 1965).

Black oak, blackjack oak and mockernut hickory also occur together. All are significantly related to increased potential solar radiation (south aspect); only black oak and mockernut are correlated with upslope positions. All three are positively correltated with increased sand in the A and B and negatively so with A and B coarse fragments and A-horizon available water holding capacity. Both oaks are more important on shallow soils. Black gum is positively related to mockernut.

Although occurring together, pignut hickory and red oak share no site characteristics. However soil characteristics such as higher A and B-horizon silt

Table 14. Simple Linear Correlations Between Canopy Species Importance Values.

	AO	CG	COL	CT	LT	NS	PP	PR	PV	QA	QM	QP	QR	QV
AO	1.00				.51*							-.39*		
CG		1.00		-.23									.22*	-.24
COL			1.00									-.26		
CT				1.00		.49*								.45*
LT					1.00				-.22			-.51*		
NS						1.00								
PP							1.00		.22					
PR								1.00						
PV									1.00					
QA										1.00		-.29*		
QM											1.00	-.22		.33*
QP												1.00		
QR													1.00	
QV														1.00

*Significant at P=0.01; all others are significant at P=0.05

content, along with available water holding capacity in the top 12 inches are correlated with those taxa.

Several species were exclusive of each other (disassociated) by evidence of their negative correlations. Chestnut oak, although dominant throughout the mountain, is negative on buckeye, red hickory, tulip poplar, white oak and blackjack oak. Pignut hickory and mockernut hickory, Virginia pine and tulip poplar, and black oak and pignut hickory are all examples of exclusive pairs which seldom occur together. No site or soil variable is correlated to both members of these pairs.

Of the understory, red maple is found most with chestnut oak (Table 15). Redbud is present with both pignut and red oak. Dogwood is the major understory species present with white oak and red hickory. Persimmon is in the draws with tulip poplar and buckeye. Sourwood is on the mountain top with mockernut hickory, black gum, table mountain pine, black oak and blackjack oak.

Regression Results and Discussion

Multiple regression techniques were applied to relate soil and site variables to importance value (maximum IV=200),absolute density (AD), relative density (RD), absolute basal area (ABA), and relative basal area (RB). Absolute values given are expressed in square centimeters per each 0.04 ha. plot.

Table 15. Simple Linear Correlations Between Canopy Species IV and Understory Species IV.

	CANOPY					SPECIES								
	AO	CG	COL	CT	LT	NS	PP	PR	PV	QA	QM	QP	QR	QV
AR												.32*	-.27*	
AS														
CCN		.35*											.35*	
CF			.36*	-.23*			-.23			.24				-.23
DV	.36*				.38*							-.44*		
JV												.35*		
OA				.20	-.30*	.21	.46*			-.21	.32*		-.22	.32*
SAL					.29*							-.34*		

*Significant at P=0.01
All others are significant at P=0.05

<u>Pines</u>. The pines often occur on the steep slopes where the soils are infertile, shallow and excessively well drained. Table mountain pine is usually restricted to the higher elevations but pitch and Virginia pines may occur at various other locations. Virginia pine thrives only on well drained soils and is distinctly less tolerant of moisture than pitch (Fowells, 1965). Olson and Della Bianca (1959) report that in the Piedmont, Virginia pine often occurs in pure stands and is mostly on shallow, dry soils. Pines occured in 57% of the plots used in this study.

The pine (N=55) prediction equations derived are:

$$IV=64.12 - 0.54\ \underline{LP} - 10.32\ \underline{AB} - 0.47\ \underline{SP}$$

$R^2=0.43$ $\bar{Y}=15.22$ SEE=22.48

$$AD=4.74 - 0.08\ LP + 0.02\ SR - 0.99\ SP$$

$R^2=0.43$ $\bar{Y}=0.91$ SEE=3.98

$$RD=46.11 - .34\ LP - 0.50\ AN - 0.30\ SP$$

$R^2=0.44$ $\bar{Y}=2.57$ SEE=11.11

$$ABA=54.98 - 0.45\ LP - 10.15\ AB - 0.39\ SP$$

$R^2=0.43$ $\bar{Y}=429.89$ SEE=1935.74

$$RB=32.77 - 0.27\ LP - 6.38\ AB - 0.22\ SP$$

$R^2=0.43$ $\bar{Y}=2.49$ SEE=11.61

In the IV equation, slope position (SP) accounts for 68% of the explained variation, depth to the least permeable layer (LP) and aspect (AB) account for 17% and 15% respectively. All three variables are correlated significantly with pine IV in the simple correlation matrices. The negative association with slope position (SP), that is, distance from the top, indicates the greater importance of the pines near the top of House Mountain. In addition, the negative relation with soil depth (LP) shows pine's importance on the shallow soils at the top of the mountain. The negative association with aspect (AB) demonstrates pine's importance on southwesterly slopes.

Both absolute basal area (ABA) and relative basal area (RB) are similarly related to the three independent variables in the IV equation furthur verifying the maximum growth rate of pines on shallow soils on south to west facing positions near the crest. However the density equations differ slightly. The previous aspect relationship has been replaced by a positive one with solar radiation (SR) in the absolute density (AD) equation and with a negative association with slope angle (AN) in the relative density (RD) equation. This is not unexpected as solar radiation (SR) is negatively correlated with both slope angle (AN) and aspect (AB) in the simple correlation matrices.

Mockernut hickory. According to Fowells (1965), mockernut hickory grows well on dry south and west facing slopes and on dry ridges but reaches its best development on deep fertile soils. Similarly, Martin (1966) reported that mockernut hickory was more widespread on drier south facing slopes than on north facing ones. It was observed in 32% of the plots on House Mountain.

The predictive equations for mockernut hickory (N=31) are:

$$IV=-11.64 + 0.21\ \underline{SA} - 0.27\ \underline{CFB} + 0.08\ \underline{SR}$$

$$R^2=0.46 \quad \bar{Y}=7.75 \quad SEE=11.88$$

$$AD=-11.81 + 0.11\ AN - 0.05\ CFA + 0.04\ SR + 2.29\ AB$$

$$R^2=0.44 \quad \bar{Y}=1.73 \quad SEE=2.72$$

$$RD=-30.83 + 0.30\ AN - 0.14\ CFA + 0.11\ SR + 5.92\ AB$$

$$R^2=0.49 \quad \bar{Y}=4.38 \quad SEE=6.28$$

$$ABA=-1.34 - 0.26\ CFA + 0.07\ SR$$

$$R^2=0.30 \quad \bar{Y}=560.82 \quad SEE=1072.60$$

$$RB=-3.13 + 1.04\ HS - 0.17\ CFA + 0.04\ SR$$

$$R^2=0.41 \quad \bar{Y}=3.41 \quad SEE=5.94$$

In the IV equation, 41% of the variation is explained by B-horizon coarse fragments (CFB), 31% by solar radiation (SR) and 28% by A-horizon sand (SA) content. The postitive relation of mockernut IV with increased A-horizon sand (SA) and the negative one with B-horizon coarse fragments (CFB) suggests the increased presence of mockernut on sites with sandy soils from well weathered colluvium. It is also more important on those sites receiving increased solar radiation (southerly aspect).

All predictive equations computed for mockernut hickory have a negative relation with either coarse fragments in the A or B (CFA or CFB) and a positive one with potential solar radiation (SR). Densities are greatest where the slope angles (AN) are steep and the aspect (AB) is northeast. Basal area equations do not include either of these conditions. Relative basal area (RB) is positively related to more concave slope shapes (HS), a condition conducive to increased soil moisture.

Pignut hickory. Pignut hickory generally occurs on dry ridges and slopes with well drained upland soils. However in the Southern Appalachian region, it is also common on mesic sites (Fowells, 1965). Martin (1971) found pignut hickory on steep slopes with shallow soils, and determined that it had the the lowest water requirements of the hickories in his study area. Pignut hickory occurs in 44% of the plots on House Mountain.

The prediction equations for pignut hickory (N=43) are:

$$IV=23.16 + 0.24\ \underline{LB} - 0.12\ SP - 0.08\ \underline{SR}$$

$$R^2=0.46 \qquad \bar{Y}=7.28 \qquad SEE=8.71$$

$$AD=5.60 - 0.06\ SA - 0.04\ SP + 1.24\ AB$$

$$R^2=0.41 \qquad \bar{Y}=1.51 \qquad SEE=1.83$$

$$RD=23.45 - 0.10\ SA - 0.09\ SP - 0.04\ SR$$

R^2=0.50 $\bar{Y}$=4.00 SEE=4.02

ABA=3.05 + 0.47 AN + 11.82 WT - 0.08 SR

R^2=0.32 $\bar{Y}$=745.36 SEE=1355.63

RB=0.69 + 0.20 AN + 5.21 WT - 0.03 SR

R^2=0.31 $\bar{Y}$=3.29 SEE=5.76

B-horizon silt (LB) accounts for 39% of the explained variation, solar radiation (SR) for 36% and slope position (SP) 25%. The negative relationship of pignut hickory to slope position (SP) and the positive relation with silt in the B-horizon (LB) demonstrates that although pignut hickory occurs near the top of House Mountain, it is not important in the sandy soils prevalent there. The negative association of IV to solar radiation (SR) indicated that pignut is more important on those areas not saturated with solar radiation.

In both absolute and relative density equations B-horizon silt (LB) has been replaced, understandably, by a negative association with A-horizon sand (SA). Absolute density is related positively to aspect (AB) (northerly) instead of negatively with solar radiation (SR) (northerly). These two are negatively correlated in the simple correlation matrices. Both absolute and relative basal area are related positively to slope angle (AN) and available water content of the top twelve inches of soil (WT) while maintaining the negative relation with solar radiation (SR). This suggests that maximum density and growth of pignut hickory is reached on moist, steep northerly slopes. However, note that both basal area equations posess an r square much lower than all other equations.

Chestnut oak. Fowells (1965) states that chestnut oak grows better than most other oaks on dry, sandy or gravelly soils but achieved its best size on well drained coves and bottom sites. Martin (1971) reports increased importance values of chestnut oak on dry, steep, upper slope positions with low A-horizon pH. Safley (1970) and Ike and Huppach (1968) also relate chestnut oak to upper steep slope positions. It occurs in 91% of the plots examined on House Mountain.

The prediction equations derived for chestnut oak (N=88) are:

$$IV=143.16 - 1.52\ LA + 2.45\ \underline{LB} - 18.14\ \underline{PA} - 31.17\ WT$$

$$R^2=0.54 \qquad \bar{Y}=73.66 \qquad SEE=31.79$$

$$AD=53.53 - 0.25\ SA - 3.45\ PA - 10.48\ WT - 0.13\ CFA$$

$$R^2=0.35 \qquad \bar{Y}=10.06 \qquad SEE=6.06$$

$$RD=113.7 - 14.77\ AB - 10.01\ PA - 0.11\ SR$$

$$R^2=0.31 \qquad \bar{Y}=27.99 \qquad SEE=15.55$$

$$ABA=405.49 - 1.73\ SA - 28.06\ AB - 39.58\ PA$$

$$R^2=0.35 \qquad \bar{Y}=10468.04 \qquad SEE=6768.44$$

$$RB=199.39 - 23.39\ AB - 16.33\ PA - 0.24SR$$

R^2=0.34 $\bar{Y}$=45.73 SEE=23.59

In the importance value equation, silt content of the B-horizon (LB) accounts for 62% of the explained variation, silt in the A (LA) 17%, pH of the A (PA) 12% and available moisture of the top twelve inches of soil (WT) 9%. This model indicates that on House Mountain chestnut oak is more important also on dry sites with low A-horizon pH but where silt occurs in the B-horizon.

A-horizon pH (PA) is related negatively in all equations, but silt is only predictive in the importance value equation. Sand content of the A (SA) is negatively related in both absolute density and basal area equations but does not appear in the relative equations. This is unusual since almost all plots were sandy. Relative density and absolute and relative basal area all reach greater values on aspects (AB) toward the southwest. Absolute density is negatively associated with A-horizon coarse fragments (CFA) typical of these sandy low coarse fragmented soils. Increased relative density and basal area are negative on solar radiation (SR). Though all r squares but that for IV are low, it appears that chestnut oak is densest on any aspect where the soils are acid and dry but reaches its greatest growth potential on southwest aspects.

<u>Black gum</u>. Fowells (1965) states that in the uplands,

black gum grows best on the loams and clay loams of the lower slopes and coves. Martin (1971) reports that although black gum rarely dominates forest communities, it occurs on a wide range of sites. Likewise, Braun (1950) has observed it in many different deciduous forest communities. In this study black gum occurs in 54% of the plots.

The predictive equations derived for black gum (N=52) are:

$$IV=-10.67+0.16\ LP-0.17\ \underline{CFB}+0.32\ \underline{AN}+1.47\ \underline{VS}+2.11\ \underline{HS}$$

$R^2=0.55$ $\bar{Y}=6.36$ SEE=5.89

$$AD=-1.42 + 0.02\ SP - 0.03\ CFA + 0.07\ AN + 0.48\ HS$$

$R^2=0.43$ $\bar{Y}=1.34$ SEE=1.25

$$RD=-3.18 + 0.05\ SP - 0.09\ CFA + 0.19\ AN + 1.18\ HS$$

$R^2=0.42$ $\bar{Y}=3.44$ SEE=3.36

$$ABA=-.055 + 0.07\ SP - 0.16\ CFA + 1.72vs+ 1.75\ HS$$

$R^2=0.35$ $\bar{Y}=570.10$ SEE=790.64

$$RB=-1.35 + 0.08\ LP - 0.10\ CFA + 0.98vs+ 0.96\ HS$$

$R^2=0.47$ $\bar{Y}=2.92$ SEE=3.72

In the importance value equation, B-horizon coarse fragments (CFB) accounts for 33% of the explained variation, horizontal shape (HS) 25%, slope angle (AN) 18%, depth to the least permeable layer (LP) 14%, and vertical shape (VS) 10%. The equation suggests that on House

Mountain, black gum reaches its greatest importance on steep, concave slopes where the soil is deep but the B-horizon has few coarse fragments.

All of the equations include a positive relation to horizontal shape (HS); the vertical shape (VS) factor also appears. Both density and basal area equations show negative relationships with coarse fragments (CFA) but here it is significant in the A-horizon. Steep slopes (AN) and low slope positions (SP) are related to the densities indicating where reproduction is greatest.

Tulip tree. Tulip tree grows on a wide variety of sites including stream bottoms, coves and moist slopes on loamy and friable soils. However, it rarely grows very well in either very wet or very xeric situations (Fowells, 1965). Hebb (1962) suggests that cool, moist sites with well drained soils are quite favorable for tulip tree growth. Tryon et al. (1960) report that 97% of the variation in tulip tree height is explained by A1 horizon thickness, but Della-Bianca and Olson (1961) state that only a weak correlation exists between soil thickness variables and height. Braun (1950) recoginized tulip tree's contribution to forest communties of the oak chestnut forest and of the mixed mesophytic forest. According to Whittaker (1956), tulip tree reaches it greatest size and is a major constituent of the mesic cove-hardwood forests in the Great Smoky Mountains. In this study, tulip tree occurs in 49% of the plots on House Mountain.

The prediction equations for tulip tree (N=48) are:

$$IV=-110.13-0.33\ LB+23.88\ \underline{PB}+0.35\ CFA+5.42\ \underline{WB}+8.64\ \underline{AB}$$

$$R^2=0.63 \qquad \bar{Y}=14.34 \qquad SEE=16.02$$

$$AD=-17.60 + 4.07\ PA + 2.20\ AB$$

$$R^2=0.46 \qquad \bar{Y}=2.84 \qquad SEE=3.65$$

$$RD=-43.42 + 10.16\ PA + 4.68\ AB$$

$$R^2=0.49 \qquad \bar{Y}=6.81 \qquad SEE=8.20$$

$$ABA=-11.81 + 29.68\ PA - 23.79\ WT + 18.21\ AB$$

$$R^2=0.44 \qquad \bar{Y}=1767.01 \qquad SEE=2717.73$$

$$RB=-85.87 + 11.73\ PA + 0.17\ CFA + 0.09\ SR + 12.45\ AB$$

$$R^2=0.51 \qquad \bar{Y}=7.57 \qquad SEE=10.67$$

In the IV equation, 57% of the explained variation is attributed to pH in the B-horizon (PB), 15% to available water in the B (WB), 10% to A-horizon coarse fragments (CFA), 9% to silt in the B (LB), and 8% to aspect (AB). The positive relationships that exist between tulip tree IV and B-horizon pH (PB), available water in the B (WB) and aspect (AB) suggests the importance in the less acid, mesic, northeasterly draws where tulip tree occurs. The negative association of silt in the B (LB) and the positive of that of A coarse fragments (CFA) are probably not causal but a result of the sandstone rock colluvium which is deposited in the coves where tulip tree is so prominant.

It is the positive relationship with increased pH (PA) and more northeasterly aspects (AB) that appears in each of the five equations. Increased coarse fragments (CFA) appear again in the relative basal area equation. In the basal area or relative basal area equations negative water (WT) and increased radiation (SR) also appear. These represent discrepancies from mesic northeast aspects.

Yellow buckeye. Yellow buckeye attains it largest size in the coves and on northern slopes in the mesophytic forests of the Appalachians (Fowells, 1965). It usually occurs on deep dark soils and is one of the main constituents of the mixed mesophytic forest (Braun, 1950). It is seen in only 11% of the plots in this study.

The prediction equations derived for buckeye (N=9) are:

$$IV=-38.04 + 7.40\ \underline{PB} + 0.11\ \underline{CFA} + 2.02\ \underline{WB}$$

$$R^2=0.40 \quad \bar{Y}=2.36 \quad SEE=7.43$$

$$AD=-6.46 + 1.35\ PA + .0.2\ CFA$$

$$R^2=0.24 \quad \bar{Y}=0.54 \quad SEE=1.87$$

$$RD=-14.16 + 3.41\ PA$$

$$R^2=0.23 \quad \bar{Y}=1.21 \quad SEE=4.19$$

$$ABA=-29.33 + 5.54\ PA + 0.10\ CFA + 1.55\ WB$$

$$R^2=0.35 \quad \bar{Y}=223.71 \quad SEE=739.51$$

$$RB=-16.82 + 3.16\ PA + 0.06\ CFA + 0.93\ WB$$

$R^2=0.37$ $\bar{Y}=1.16$ SEE=4.03

In the importance value equation, B-horizon pH (PB) accounts for 62% of the explained variation, available water holding capacity of the B-horizon (WB) 24%, and A-horizon coarse fragment content (CFA) 14%.

In all of these equations, increased pH (PA) and increased water (WB) appear emphasizing the less acid, mesic nature of the sites (mostly north aspect draws) where buckeye occurs. These draw soils are colluvial in origin as suggested by the A-horizon coarse fragments (CFA).

CHAPTER V

SOIL MOISTURE STUDY

Introduction

The factors affecting soil moisture and its subsequent effect on radial tree growth have been the subject of much discussion and study. Carlson et al. (1956) suggested that wetting in the surface foot of soil is determined by the amount of rainfall and the space available for water storage in the soil. Marquis (1967) related soil moisture to soil temperature in sandy loam soils like those on House Mountain. Nash (1963) and Lee (1964) both examined the relationship between solar radiation and potential evaporation. Similarly, Stearns and Carlson (1960() found moisture loss to be strongly related to solar radiation. Helvey et al. (1972) examined the direct relation of slope position on available soil moisture in the Southern Appalachians and found it to be an important factor only on the lower 25% of the slope. Hewlett and Hibbert (1963) stated that on steep slopes, soil within and below the zone of tree roots but above bedrock, when regularly recharged by rain, is probably the main source for stored water .

As early as 1941 (Locke), the Soil Conservation Service attempted to predict timber yields from site factors. Hebb (1962), Stage (1972) and Fritts (1958) have since conducted similar studies associating environmental factors to tree growth. Bassett (1964) related radial tree growth to soil moisture availability, but Fritts (1960) found that soil moisture was limiting when present in excessive amounts because of poor aeration.

It is the intent here to examine the relationships between precipitation and available soil moisture through time and then, to examine the effects of slope position and aspect. These and to a slight extent slope angle and soil texture were examined for their effect on soil moisture and tree growth.

Field Methods

Six soil pits were dug, one each on northeast and southwest aspects at top, middle and bottom slope positions of House Mountain. At two week intervals for ten weeks (from July 25 to October 11), samples were collected from the pits at similar depths and bagged for gravimetric determination of soil moisture content. Slope angle, aspect and slope position were measured and recorded as previously described. At the end of the growing season, trees near these pits were cored and the 10-year average radial increment determined. Trees were cored at breast height from the upslope position.

Slope angle and aspect were combined as radiation data using the tables of Frank and Lee (1966). This potential solar radiation is thought to be closely related to evapotranspiration (Fowler, 1964; Van Bavel, 1960) and thereby to available soil moisture.

Laboratory Methods

In the laboratory, the samples were immediately weighed using an electronic balance, and two weeks later after air drying, they were reweighed. From these readings, soil moisture percentage (SM) on an air dry basis was calculated.

Precipitation data was obtained for the nearby Strawberry Plains station (courtesy of the Climate Section of the Tennessee Valley Authority). Strawberry Plains is approximately 10 km. southeast of House Mountain, thereby probably giving better data on precipitation at House Mountain than the next nearest but much more distant Knoxville stations.

Tree growth was quantified by measuring the last ten years growth of each tree core. In all, 23 trees were cored and the ten-year radial increment measured. However, since chestnut oak (N=10) was the sole taxon found near all pit locations, only it was used in this analysis.

Quantitative Methods, Results, and Discussion

Most statistical analysis was carried out using programs written by the author on a Radio Shack TRS-80 computer. However, stepwise multiple regression required use of the Statistical Analysis System on the IBM Model 370 computer at the University of Tennessee Computing Center.

Stoeckeler and Curtis (1960) report that in a valley near La Crosse, Wisconsin, soil moisture in the top two feet of soil on a north facing slope is twice that of the south facing slope. Percent soil moisture (SM) varies considerably on the different locations and aspects of House Mountain. Using a 0.05 level of significance, T-tests were made between data from the various positions. The averages for the two opposing aspects (NE=5.16, SW=3.22) do differ (p=0.05) significantly (see below and see Table 16).

Hewlett (1961) reports that on steep slopes following rainfall, a gradual decrease in moisture content occurs into the upslope position. On the northeast side of House Mountain, the top slope position (4.00) is significantly different (p=0.05) from the mid slope position (5.38), but the middle does not differ significantly from the bottom (6.10). Not only is the same true for the southwest but its top (2.77) and bottom (3.37) slope position differences are not significant either. Even though the contrasting top positions differ significantly, the top northeast does not differ from the middle and bottom positions on the southwest side, demonstratiing a rough equivilancy in soil moisture content between northeast top position and dry middle and bottom sites and the real difference in the whole set of the northeast middle and bottom sites from all other pits.

Table 16. Percent Soil Moisture Per Slope Position and Aspect.

Position	Collection Date					
	Northeast Aspect					
	7/25	8/11	8/28	9/13	9/31	Mean
Top	3.42	4.08	3.35	4.39	4.78	4.00
Middle	4.25	4.35	4.07	7.77	6.44	5.38
Bottom	5.65	5.52	5.03	8.22	6.10	6.10
Mean	4.44	4.65	4.15	6.79	5.77	5.16
	Southwest Aspect					
Top	2.81	2.60	1.86	3.17	3.39	2.77
Middle	3.19	2.98	2.86	3.94	4.70	3.53
Bottom	3.56	3.34	3.00	2.35	4.63	3.37
Mean	3.19	2.97	2.57	3.15	4.24	3.22
Total Mean	3.82	3.81	3.36	4.97	5.01	4.19

An attempt was made to relate periods of precipitation to measured soil moisture. The TRS-80 was programmed to group days of precipitation data for use as an independent variable with the dependent variable average soil moisture per collection date. The length of the precipitation groups progressed from one day to 14 as each was tested for the best r square. Likewise, the length of time from the last day of the precipitation period to the collection day was incremented by one day (up to 14 days) for each test so that the proper seepage delay could be established. To determine the precipitation effect on the individual aspects and slope positions, soil moisture per location per collection date was also employed as a dependent variable and r square also determined.

The highest r square obtained for the soil moisture average of all pit positions for each collection date was 0.8996. The precipitation events were those on the four day period which terminated two days before each soil collection date. Although Beasley (1976) reports that subsurface flow often begins shortly after rainfall, one or two day periods immediately preceeding the collection date surprisingly yielded such inauspicious r squares as 0.0013 and 0.0283 respectively, indicating that seepage delay is a major factor.

When the same four day grouping as above is used as an independent variable with each pit position , more of the picture emerges (Table 17). The dominant precipitation period however remained four days with a two day delay. The r squares for the northeast aspects are all quite high with an average of 0.87. However, the southwest differs considerably. Although the top and middle slope positions have strong positive relationships, the bottom slope position has an r square of only 0.01. It was discovered that this position attains its highest r square two days before the other five - that is a four day period terminating four days before each collection date (four day lag). Using this condition the r square rises to 0.42. This extended delay could be due to the particular site factors at this location such as slope angle or soil texture. Here the slope angles are 25 degrees which is slightly less steep than the other sites, and textures were more clayey. It is likely that the lessened slope angle in addition to the clayey nature of the soil has slowed the water movement in the soil thus increasing the delay.

When examined alone, the slope position effect on average soil moisture at each position was determined. On the northeast an r square of 0.96 was obtained while that for the southwest side was 0.60. Again, the southwest bottom position seems to present a problem - position alone is not an answer. When stepwise multiple regression is applied with slope angle, slope position, solar radiation, several textural variables and percent coarse fragments as

Table 17. R Squares for Strawberry Plains Precipitation and Soil Moisture (Four Day Periods).

Position	6	5	4	3	2	1
	Northeast Aspect Number of days until collection date					
Top	.09-	.01-	.38	.81	.52	.15
Middle	.35-	.20-	.01-	.48	.90	.69
Bottom	.46-	.44-	.05-	.36	.74	.88
Mean	.36-	.23-	.01	.55	.87	.70
	Southwest Aspect					
Top	.58-	.29-	.12	.43	.72	.43
Middle	.27-	.05-	.12	.34	.75	.26
Bottom	.01	.09	.42	.01	.01	.13-
Mean	.21-	.02-	.30	.22	.42	.07
Total Mean	.40-	.17-	.06	.54	.90	.52

R-squares followed by (-) indicates a negative R.

independent variables a better total model is constructed. The regression equation is:

$$\text{percent soil moisture (SM)} = 7.18 + .02\ SP - .01\ SR - .02\ SA$$

$$\bar{Y}=4.19 \qquad R=0.92 \qquad SEE=0.57$$

Solar radiation (SR) accounts for 74% of the explained variation, slope position (SP) 23% and sand in the A-horizon (SA) only 3%. As expected slope position is positively related, the drier sites being near the top. Solar radiation's strong negative association substantiates its suspected relationship to evapotranspiration (Van Bavel, 1966; Fowler, 1964). A-horizon sand's negative relation to moisture again suggests sandy soil's inablity to hold water.

Soil moisture's influence on growth was somewhat difficult to ascertain because of the absence of numerous like species at each pit location. When simple linear regression techniques are applied to ten year growth measurements and soil moisture, the following prediction equation emerges.

$$\text{Radial Growth} = +\ 0.47 + 0.18\ SM$$

$$R=0.35 \qquad \bar{Y}=1.21 \qquad SEE=0.31$$

With an r square of 0.35, the least squares line appears to be a poor fit. Because of the few similar trees and the use of an extremely dry growing season in attempting to predict 10 years of growth, the validity of this figure is questionable. This leaves this phenomenon open for further investigation.

CHAPTER V

SUMMARY AND CONCLUSIONS

More than one-half of this study area is in chestnut oak dominated forests. It is dominant in three distinct community types: the chestnut oak-black oak-mockernut hickory community, the chestnut oak-hickory community and in the chestnut oak community.

The chestnut oak-black oak-mockernut hickory vegetation type occurs on steep south and southeasterly facing slopes near the top of House Mountain. The soils of this community are sandy, dry, extremely acid but some what deeper than other soils near the top.

The chestnut oak-hickory forest occurs on all slope positions except the top of House Mountain. Most of the plots however are near the middle third of the slope. The soils here are deep, strongly acid, but have few coarse fragments.

The chestnut oak community is the most distinct and widespread type identified on House Mountain. It occurs on a wide array of slope positions and aspects. Much of the soil is loamy, extremely acid and well drained. These chestnut oak dominated communities are reproducing well and will probably remain basically unchanged in the future.

The rest of the forest cover of House Mountain is of four community types. The pine-oak type occurs on the drier west and southwest facing slopes near the top of the mountain. Here the soils are sandy, shallow and extremely acid, conditions which surely reduce the level of competition for light, enabling pines to survive, reproduce and prosper in the future.

Also near the top on steep, southeast aspects is the black oak community. These soils are similar to other soils near the top of House Mountain (shallow, extremely acid and dry), but are more loamy than the other types. This community grades into a chestnut oak dominated one.

The white oak-northern red oak vegetation type occupies various aspects but is restricted to the lower, gentler slopes on the mountain. The soils have a wide textural range, are deeper and moister than most other soils present and are but medium acid. Although no white oak occurred in the sapling layer, several were noted nearby.

The tulip cove community occurs in moist, northeasterly draws located on the gentler slopes from the middle to the bottom of House Mountain. These soils are deep, vary widely in texture and range from slightly to extremely acid. In the future, this community will likely be dominated by the mesophytes, buckeye and tulip tree with a mixture of oaks and hickories.

Without further disturbance, most of this young second growth forest will remain dominated by chestnut oak.

Although fire is evident at almost half the plots in this study, there are several large trees that have somehow escaped recent logging and fires. The largest tree in this study is a 108 cm. dbh black oak located near the bottom on the southeast aspect. Also nearby are two chestnut oaks over 100 cm. dbh. The largest white oak observed is an 83 cm. dbh tree which is in an isolated stand of large white oaks on a lower northwesterly slope near the bottom of House Mountain. Other than oaks, the largest tree in the study is an 81 cm. dbh tulip poplar in a northeast upper draw.

Mountain laurel (Kalmia latifolia) dominates the shrub layer near the top on the north side of House Mountain. On top, much huckleberry (Gaylussacia baccata) and blueberry (Vaccinium spp.) is present. There is a moderate to very diverse herb layer present.

Simple linear correlations between site and soil variables reveal that on House Mountain slope position affects more soil variables than any other site factor. Potential solar radiation, a function of slope angle and aspect, also correlates with many of the soil factors. Of the soil variables, sand content of both the A and B horizons correlated with the most site factors.

Correlations between site and soil variables and species importance values reveal that slope position and aspect are the site factors most often correlated with species importance values. Of the soil variables, sand and silt in both the A and B horizons most frequently correlates significantly with importance values.

In the regression equations, the xerophytes such as the pines and mockernut hickory are predicted mainly by those site and soil variables which are correlated with top slope positions (shallow soils, steeper slopes and sandier soils). Pignut hickory, black gum and chestnut oak are found on various sites therefore the prediction equations contain a variety of independent variables. The mesophytes tulip tree and yellow buckeye characteristically are predicted by those variables correlated with bottom slope positions such as increased coarse fragments, higher pH and less steep slope angles.

Assuming equal precipitation everywhere on the mountain, percent soil moisture is best correlated with the precipitation of the preceeding four days allowing an additional two day lag period before the collection date. The two day lag period is believed to be the period of seepage movement of the water downslope to the pits. Generally, there is greater moisture downslope due to the cumulative effect of slope position (increased cumulative size of the drainage field downslope). On south aspects, soil moisture increased from top to mid slope but the lowest had moisture percentages equal to the mid slope pit. The lack of increase in moisture of the lowest pit here compared to the northeast aspect is likely due to topographical differences and a more clayey soil.

The differences in aspect result in a 60% average difference in soil moisture, that is moisture level on the northeast is 60% greater than on the southwest aspect. Increased soil moisture is predicted (in multiple regression) by reduced radiation (largely a function of aspect), lower slope position and less sand.

This area is in private ownership; several families own most of the mountain. The easily accessible road on the morthwest side is now used by off-road vehicular traffic, which is resulting in severe erosion on and adjacent to the road. The diversity of communities, the diverse flora, the youth of most communities showing development (but with some big trees to 108 cm.), the geologic uniqueness (Silurian caprock sandstone) and easy accessibility to population centers argue for public ownership of at least part of this unique mountain.

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APPENDIX

Table 18. Means Within Communities of Site and Soil Variables and Importance Values (IV) by Species[a]

	COMMUNITY TYPE							
	PO	BO	OMH	COH	CO	WRO	TC	MEAN
N =	7	6	8	23	34	7	12	97
AN	25.7	29.2	28.3	30.2	27.2	19.1	20.8	26.7
AB	0.2	0.9	0.8	1.1	0.8	1.1	1.6	0.9
SP	6.4	29.2	22.5	43.0	43.2	76.4	71.2	43.9
VS	2.6	3.7	4.1	2.7	2.3	3.0	3.0	2.8
HS	2.1	2.2	4.9	2.5	2.1	3.5	2.8	2.6
SR	286.4	287.0	306.9	198.9	238.5	247.0	238.4	241.8
SA	72.9	80.0	82.5	46.7	49.0	44.3	56.7	55.5
LA	15.0	12.5	10.6	39.6	32.5	40.0	30.8	30.2
CA	12.1	7.5	6.9	13.7	18.5	15.7	12.5	14.3
SB	60.0	68.3	73.8	33.9	31.0	37.8	49.2	42.4
LB	22.9	13.3	12.5	43.3	45.3	37.9	22.9	35.2
CB	17.1	18.3	13.8	22.8	23.8	24.3	27.9	22.4
PA	4.0	4.1	4.0	4.6	4.3	5.4	5.3	4.5
PB	3.9	4.1	4.2	4.6	4.2	4.8	5.2	4.4
LP	21.7	23.3	30.4	37.1	36.4	34.4	38.5	34.4
CFA	41.7	19.7	13.3	33.9	46.1	36.9	46.9	37.9
CFB	50.3	15.2	15.8	35.9	49.1	37.6	38.8	39.0
WA	0.4	0.5	0.6	0.9	0.8	1.0	0.9	0.7
WB	0.8	1.7	1.6	1.6	1.7	2.1	2.5	1.7
WT	0.6	0.9	0.6	1.2	0.8	1.2	0.9	0.9
AOIV						9.7	13.4	2.4
CGIV	1.9	1.5	0.8	18.2	7.3	1.7		7.3
COLIV		2.8	2.5	20.6	1.9	9.0	9.9	7.8
CTIV	1.4	14.2	43.4	2.7	3.7	2.1	8.9	7.8
LTIV		8.5	3.1	14.5	2.6	14.3	71.2	14.3
NSIV	0.9	8.8	19.6	10.6	2.2	8.4	2.0	6.4
PPIV	52.1	5.8		3.6	0.2		0.4	5.1
PRIV	14.6				2.8			2.0
PVIV	34.0	6.2	3.8	4.5	10.6		1.3	8.1
QAIV				0.4	2.4	56.9	4.3	5.6
QMIV	0.9	23.3	0.3				1.3	1.7
QPIV	63.4	29.2	67.1	68.5	122.8	14.9	11.1	73.7
QRIV	6.6	1.0	1.0	5.2	8.9	26.3	7.0	7.7
QVIV	8.4	56.3	42.5	3.0	4.9	4.2	8.0	11.3

[a]Abbreviations follow those in Table 8.

Table 19. Site Properties Expressed as Percentages of Plots.

	COMMUNITY TYPE							
	PO	BO	OMH	COH	CO	WRO	TC	Total
N =	7	6	8	23	34	7	12	97
Aspect (± 22.5°)								
Northwest		17		43	12	43		19
North				35	15	14	25	18
Northeast					6		25	5
East					9		25	6
Southeast	14	83	75	4	3	14	25	19
South			25		3			3
Southwest	14			9	24	14		12
West	71			9	29	14		19
Slope Angle (°)								
0-5		17						1
6-10							8	1
11-15	14				6	43	17	8
16-20	14		13	9	18	14	25	14
21-25			13	17	15	14	25	14
26-30	43	17	38	17	24	29	25	25
31-35	29	33	25	39	32			26
36-40		33	13	17	6			9
Slope Position (%)								
Top	14	17	13		3			4
1-20	86	17	63	22	26		8	28
21-40		50	13	26	26			20
41-60				30	9	14	8	12
61-80		17	13	13	26	43	42	23
81-100				9	9	43	42	13
Vertical Shape								
Convex	14			39	38	14	25	28
Convex-Flat	14		13	4	21	14	17	13
Flat	71	67	25	22	29	43	8	31
Flat-Concave				13		14	33	8
Concave		33	63	22	12	14	17	20
Horizontal Shape								
Convex	29	50		48	50	14	33	40
Convex-Flat	29	17		9	15	14	25	13
Flat	43	17		13	21	29	8	18
Flat-Concave			13	4	9			5
Concave		17	88	26	6	43	33	24

Table 19. (Continued)

	COMMUNITY TYPES							
	PO	BO	OMH	COH	CO	WRO	TC	Total
N=	7	6	8	23	34	7	12	97
A-horizon pH								
3.6 and less			13					1
3.6-4.0	71	67	38	9	18			21
4.1-4.5	29	33	38	57	74	14	33	52
4.6-5.0				22	6	14	17	11
5.1-5.5							8	1
5.6-6.0				13	3	71	8	10
6.1 and more							25	3
B-horizon pH								
3.6 and less								
3.6-4.0	43	33	38	4	24	14	25	22
4.1-4.5	57	50	38	61	74	14	8	53
4.6-5.0		17	25	17	3	43	8	12
5.1-5.5				4		14	25	5
5.6-6.0				13		14	8	5
6.1 and more							25	3
Depth to Rock (inches)								
0-12					3			1
13-24	71	67	38	30	21	29	25	32
25-36	29	17	13	17	18	14	8	16
37-48			38		12	14	8	9
More Than 48		17	13	52	47	43	58	41
Coarse Fragments (%,ave)								
0-25	14	83	100	22	3	14	25	24
26-50	57	17		74	53	71	42	52
51-75	29			4	38	14	17	20
76-100					6	17		5
Available Water (inches)								
0-1.0	57	33	38	4	29	14	17	24
1.1-2.0	14	50	25	39	21	14	33	28
2.1-3.0	29			35	15	29		18
3.1-4.0			38	13	15	14	17	14
4.1-5.0				4	18	14		8
5.1 or more		17		4	3	14	33	8
Evidence of Fire								
Not Present	57	83	50	61	68	57	50	62
Present	43	17	50	39	32	43	50	38

Table 19. (Continued)

	COMMUNITY TYPES							
	PO	BO	OMH	COH	CO	WRO	TC	Total
N =	7	6	8	23	34	7	12	97
A-horizon Texture								
Sand			13	4			8	3
Loamy Sand	14	67	75	9	12		8	19
Sandy Loam	86	33	13	26	26	29	33	31
Sandy Clay Loam								
Loam				22	35	43	25	24
Silt								
Silt Loam				35		29	25	13
Silty Clay Loam					6			2
Clay Loam					21			7
Silty Clay				4				1
Clay								
B-horizon Texture								
Sand								
Loamy Sand			38	13			17	8
Sandy Loam	86	83	50	4	18	14	17	26
Sandy Clay Loam			13	9		14		4
Loam				22	24	29	25	19
Silt								
Silt Loam				30	21	14		15
Silty Clay Loam	14			17	32	14		18
Clay Loam						14		1
Silty Clay					6			2
Sandy Clay		17					17	3
Clay				4			25	4

Table 20. Canopy Species Co-occurence (numbers of plots).

	AO	CG	COL	CT	LT	NS	PP	PR	PV	QA	QM	QP	QR	QV
AO	9		1		8	4			1	4		3	3	
CG		43	16	10	23	23	6	3	16	1		42	27	21
COL			30	11	23	20	2		12	7	2	27	14	11
CT				31	14	21	4	1	16	4	5	31	17	25
LT					48	31	4		12	11	1	40	25	15
NS						52	7	1	13	11	5	50	24	27
PP							14		11		2	14	7	11
PR								5	3			5	3	4
PV									36	3	5	33	20	22
QA										19	1	14	10	7
QM											7	6	2	6
QP												88	43	48
QR													48	23
QV														49

Table 21. Simple Linear Correlations Between Canopy Species IV and Sapling Species Relative Density

	AO	CG	COL	CT	LT	NS	PP	PR	PV	QA	QM	QP	QR	QV
AR				-.28		-.21						.25	-.26*	-.28
AS	.30*													
AO	.96*				.54*							-.39*		
CC	.49*				.46*							-.32*		
CG		.52		-.26*	-.22	-.20		.23		-.20		.44*		
COL			.30*											
COT	.41*				.20					.32*				
CP											.66*			.36*
CT	-.22			.73*				.30*						.46*
CCN		.22	.25	-.25	.28*							-.22	.37*	-.26
CF		.24	.40*	-.33*			-.33*		-.35*		-.27*			-.21
DV				.20										
FA					.21									
JV										.59*				
LT	.41*				.62*				-.21					
NS		-.21		.46*		.59*	.31*				.24	-.22		.44*
OA			-.20	.24	-.27		.25		.33*	-.20	.42*			.35*
PP							.86*							
PR								.43*						
PV							.36*		.78*					
QA			.33*							.36*		-.31*	.31*	
QM									.40*		.84*			.27*
QP	-.21			.54*						-.21	.22			.42*
QR		.28*				-.22	.26		.36*				.29*	-.21
QV		-.23		.53*	-.22		.24		.20*		.33*			.35*
SAL			-.28*	.35*		.32*								.34*

*Significant at P=0.01
All others are significant at P=0.05

VITA

Robert Nichols Sims Crownover was born October 24, 1946, in Nashville, Tennessee. He received his elementary education from Woodmont School and graduated from Hillsboro High School in Nashville in 1965.

In December 1974, he received a Bachelor of Science degree in psychology from The University of Tennessee, Nashville. He received an associates degree in Conservation and Environmental Technology from Volunteer State Community College in August of 1975.

He entered The University of Tennessee, Knoxville Graduate School Program in Ecology in September 1979 and began study toward a masters degree from The Graduate Program in Ecology. He received a Master of Science in Ecology in June 1983.