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CLASSIFICATION AND DESCRIPTION OF FOREST COMMUNITY TYPES AND SOILS OF BIRD MOUNTAIN, FROZEN HEAD STATE NATURAL AREA, MORGAN COUNTY, TENNESSEE

A Thesis

Presented for the

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ABSTRACT

Overstory vegetation of Bird Mountain, a part of Frozen Head State Natural Area, was sampled using ninety-five 0.04 ha circular plots to determine community types, stability and species distribution. Site factors and soil samples were obtained from each plot. Cluster analysis, using canopy species importance values, classified seven community types: chestnut oak, white oak-northern red oak, beech, northern red oak-sugar maple, yellow poplar, sugar maple-white basswood-yellow poplar-yellow buckeye and black cherry-sugar maple. Community types were segregated by aspect, slope position, elevation and geomorphic form. All community types have been disturbed by logging or fire in the past. The chestnut oak, white oak-northern red oak, beech, northern red oak-sugar maple and sugar maple-white basswood-yellow poplar-yellow buckeye types were reproductively stable. Yellow poplar reproduction was low in the yellow poplar type. The black cherry-sugar maple type was successional toward a mixed mesophytic type.

Regression analysis was employed to predict canopy species importance value, relative density and relative basal area using site and soil factors. The site factors of aspect, elevation, slope angle, slope shape and insolation were the most important predictors of species importance, relative density and relative basal area. Soil factors contributed a small percent to explained variation and total R^2 in the regression equations.

Soils on Bird Mountain were mapped at a 1:24000 scale. Soil formation was closely related to geomorphic position, aspect, elevation, vegetation, parent material and lithology. Six mapping units were segregated primarily by aspect, elevation, geomorphic position and form. The ridgetop and cove map units consisted of exclusively residual and colluvial soils, respectively. The south-facing map unit consisted of a complex of residual and colluvial soils intermingled with rock outcrops. The upper north-facing map unit consisted of a complex of two unnamed soils, a colluvial Humic Hapludult and a residual Typic Haplumbrept. The lower north-facing map unit was similar to the south-facing complex, but contained an unnamed, colluvial Humic Hapludult. An unnamed alluvial Typic Hapludult was mapped on narrow, continuous floodplains of 2nd order streams.

Ten soil series were mapped on Bird Mountain including five established series and five unnamed soils. Three of the established series were Typic Hapludults (Jefferson, Grimsley, Gilpin); the remaining two included a Lithic Dystrochrept (Ramsey) and a Typic Dystrochrept (Petros). Of the five unnamed soils, two were colluvial Humic Hapludults; the remaining three included a Typic Hapludult, an Ochreptic Hapludult and a Typic Haplumbrept. These unnamed soils were widely distributed on Bird Mountain and may occur elsewhere in the Cumberland Mountains.

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CHAPTER I

INTRODUCTION

The Cumberland Mountains in Tennessee are distinguished from the adjacent Plateau and Ridge and Valley by higher elevation, steeper relief, younger age of rocks and greater degree of dissection. Frozen Head State Natural Area lies within the Wartburg Basin at the southernmost end of the Cumberland Mountains in Morgan County, Tennessee. This area was selectively logged in the early part of this century and most forest growth is secondary. Human impact since the establishment of the area as a State Forest in the 1930's has been minimal. Frozen Head State Natural Area and the surrounding mountains contain many economically important coal seams. Preservation of the Natural Area, by the exclusion of strip mining operations, is of paramount importance to present and future Tennesseans.

The primary objective of this study was the description and classification of forest communities occurring on Bird Mountain, a part of Frozen Head State Natural Area. Ecological relationships between forest community composition and site and soil characteristics were investigated. Regression analysis was used to predict species relation to soil and site factors. Analysis of variance was used to test the null hypothesis that no differences existed for mean site and soil variables between community types. The stability, disturbance history and successional trends were described by analysis of the diameter distribution curves.

Detailed vegetation studies of the Cumberland Mountains in Tennessee are limited. Martin (1966) described forest communities on Wilson Mountain, Morgan County and related their distribution to site and soil properties. Cabrera (1969) working on Ash Log Mountain in Campbell County described several mesic segregate communities and tested the hypothesis of homogeneity of the mixed mesophytic forest community as proposed by Braun. He related topographic form and aspect to forest community distribution. Hinkle (1975) described fifteen secondary community types in Cumberland Gap National Historical Park. Topography, elevation and aspect were important determinants of community distribution.

Numerous vegetation studies on the Cumberland Plateau and gorges (Caplenor 1965; Safley 1970; Quarterman et al. 1972; Hinkle 1978; Schmalzer 1978, 1982; Smith 1977; Wade 1977) related forest community distribution to site and soil variables.

A secondary objective of this study was the development of a soil map, complete with map unit and pedon descriptions. Soil distribution was closely related to topography, parent material, macro and microclimate and vegetation. Morgan County has not been mapped by the Soil Conservation Service; thus, the information gained in this study should be useful when the mapping is initiated.

CHAPTER II

THE STUDY AREA

Location

Frozen Head State Natural Area, formerly Morgan State Forest, is approximately 70 km northwest of Knoxville in southeastern Morgan County, Tennessee. State highway 62 runs seven km south of the park and state highway 116 passes through the southeast portion of the Natural Area. Wartburg, the county seat of Morgan county, is five air km from the Natural Area. Frozen Head State Natural Area is mapped on the Fork Mountain and Petros 7.5 minute quadrangle maps of the U.S. Geological Survey, and lies 84° 30′ west longitude and 36° 08′ north latitude. Bird Mountain is in the northwest corner of the Natural Area and has a maximum elevation of 990 m which rises from a base at 410 m.

Climate

The climate of a region affects the distribution of vegetation and soils. Interactions of climate with site and soil properties define community composition. Local variations in air temperature, wind velocity, precipitation, evapotranspiration, soil moisture, relative humidity and solar radiation are due to differences in exposure, slope angle, topography, relief, elevation and aspect. Microclimate may differ greatly from the regional macroclimate, especially in mountainous terrain. Several studies have documented microclimatic variations within a small area (Wolfe et al. 1949; Shanks and Norris 1950; Cantlon 1953; Mowbray and Oosting 1968).

The climate of the Cumberland Mountains is classified by Thornthwaite (1948) as humid, mesothermal with little or no water deficit in any season (BB′b′). Cold, dry continental air masses from Canada alternate with warm, moist Gulf air masses controlling seasonal and daily macroclimate. Southerly winds prevail from May to September and northerly ones from November to March (Anthes et al. 1981). Rainfall station 167 at Petros, Tennessee, 6 km southeast of the study site, reported a 34 year mean annual precipitation of 152 cm, including 50 cm of snow (Holtzclaw 1977). Mean annual precipitation at Crossville, Tennessee, which is 50 km southwest of the study area on the Cumberland Plateau, 550 m elevation, is 136 cm. Maximum precipitation occurs from December through April and again in midsummer (Dickson 1960). Precipitation minimums occur from September through November; October is the driest month. Drought is less severe and frequent (Vaiksnoras and Palmer 1973), and evapotranspiration lower (Safley and Parks 1974) on the Cumberland Plateau than on the Highland Rim or the Ridge and Valley. Orographic precipitation increases sharply with elevation. Shanks (1954) reported a 25% increase in precipitation between 445 and 760 m levels in the Great Smoky Mountain National Park from 1946-1950. It is not known if comparable increases occur in the Cumberland Mountains, but a strong orographic effect is probable.

Mean annual temperature at Crossville, Tennessee is 12.8°C; mean monthly temperatures for January and July are 3.2°C and 23.2°C respectively. Temperatures decrease from west to east and south to north across the Cumberland Plateau (Dickson 1960). Frost-free period averages 180 days, increasing toward the south and decreasing at higher elevations.

Severe storms are infrequent; Tennessee is too far inland to be directly affected by hurricanes, too far south for blizzard and glaze storms, and east of the center of tornado activity (Dickson 1960). Summer thunderstorms are frequent, with severe storms producing high velocity winds and floods.

Physiography

The Appalachian Plateau Province is an upland area which extends from the Coastal Plain in northwest Alabama to western New York, and varies in width from 320 km in Ohio, West Virginia and Pennsylvania to 50 km in Tennessee. Thornbury (1965) states that the Appalachian Plateau province differs from adjacent physiographic provinces in six ways: (1) elevations are higher than surrounding provinces, (2) rocks are younger; Mississippian and Pennsylvanian strata predominate, (3) limestones are uncommon; clastic rocks such as sandstone, shale, siltstone, conglomerates and coal are common, (4) degree of deformation of rock units; the Appalachian Plateau province was mildly affected by the Appalachian Orogeny, this is evident on the eastern edge and diminishes westward (5) outfacing escarpments characterize the eastern and western sides (the latter being very highly dissected in Tennessee) (6) high degree of fluvial dissection relative to adjacent provinces.

Frozen Head State Natural Area lies within the Wartburg Basin at the southern end of the Cumberland Mountain section of the Appalachian Plateau province (Fenneman 1938). The Cumberland Plateau borders this area on the south and west and the highly folded and faulted Cambrian and Ordovician rocks of the Ridge and Valley province border it to the east. The Cumberland Plateau province is the southern extension of the unglaciated Allegheny Plateau. The Kentucky River serves as an arbitrary boundary between these two provinces; the percentage of resistant rocks and the degree of dissection is higher in the south than the north (Thornbury 1965).

The Cumberland Mountain section of the Appalachian Plateau province lies between 36° 05′ and 37° 20′ north latitude and 81° 55′ and 84° 40′ west longitude and covers approximately 7,500 square km in Tennessee, Kentucky and Virginia. Five counties in Tennessee--Anderson, Campbell, Claiborne, Morgan and Scott--lie partly within the Cumberland Mountain region. The high degree of dissection, greater relief and greater elevations are the basis for separating the Cumberland Mountains from the Cumberland Plateau (Thornbury 1965).

The Cumberland Mountain section is divided into the Cumberland overthrust block and the Wartburg Basin. The Cumberland overthrust block is outlined geologically by four faults: the Pine Mountain thrust fault on the northwest, the Hunter Valley-Wallen Valley thrust fault on the southeast, the Russell Fork transverse fault on the northeast and the Jacksboro transverse fault on the southwest (Thornbury 1965). The Cumberland overthrust block is bounded by Pine Mountain to the northwest, Cumberland, Stone and Powell Mountains on the southeast, Russell Fork River on the northeast and Cove Creek on the southwest (Rutherford 1985).

The Wartburg Basin is south and west of the Cumberland overthrust block and is geologically similar to the Middlesboro syncline. This basin is bounded on the northeast by the Jacksboro transverse fault and Cumberland overthrust block, on the southeast by the Chattanooga fault (Walden Ridge), on the southwest by the Emory River and Whetstone Mountain faults and merges with the Cumberland Plateau on the northwest (Rutherford 1985). Braun (1950) considered the Wartburg Basin to be an "outlying area" of the Cumberland Mountain overthrust block, which she considered to be the true Cumberland Mountains.

Geology and Lithology

Rock strata that underlie the Cumberland Mountains are clastic sedimentary rocks of the Pennsylvanian period. The regional strike of these rocks is northeast and the dip is 0.5° southeast and reflects the regional dip of the Cincinnati Arch (Wilson and Stearns 1958; Bergenback and Wilson 1961). The nearly horizontal, relatively undisturbed rocks of the Wartburg Basin consist of alternating beds of shale, siltstone, sandstone and coal. Lower Pennsylvanian formations (Crooked Fork, Crab Orchard and Gizzard groups) contain more or less equal amounts of sandstone and shale and dominate the adjacent Cumberland Plateau. Upper Pennsylvanian formations have more shale than sandstone. Six geological formations define the upper Pennsylvanian strata in Tennessee and delineate the Cumberland Mountains from the adjacent Cumberland Plateau (Wilson et al. 1956). The top of the Wartburg sandstone (Crooked Fork group) divides the lower Pennsylvanian strata of the Plateau from the upper shaly rocks of the Cumberland Mountains. The Wartburg sandstone forms a topographic bench that surrounds the Cumberland Mountains on the northwest, west and south. All six geologic formations occur on Bird Mountain, within Frozen Head State Natural Area (Hershey 1975). A generalized stratigraphic sequence of the Pennsylvanian rocks in Tennessee is given in Figure 1 (adapted after Wilson and Stearns 1958).

The oldest upper Pennsylvanian stratum is the Slatestone formation, which underlies the foot and toeslopes of Bird Mountain. This formation consists of interbedded shale, clayey to sandy siltstone, sandstone and several coal seams. The Jellico coal seam lies at the top of this formation at 510 m.

The Indian Bluff formation consists of shale, clayey to sandy siltstone and fine to medium grained sandstone. This formation underlies the upper footslopes of Bird Mountain and contains no coal seams. Elevations range from 510 to 620 m.

The Graves Gap formation contains numerous coal seams which are interbedded with shale, clayey to sandy siltstone and a more resistant sandstone. The sandstone will locally form small cliffs and ledges; this formation occurs between 620 and 705 m on Bird Mountain.

The Red Oak formation contains several important coal seams (Big Mary, Walnut Mountain, Pewee) which are interbedded with shale, siltstone and sandstone. The sandstones are fine to medium grained and are lenticular. This formation occurs on upper sideslopes and spur ridges between 705 and 800 m.

The Vowell Mountain formation occurs on upper slopes and in topographic saddles between the higher summits. Elevations range from 800 to 885 m. This unit contains one coal seam interbedded with shale,

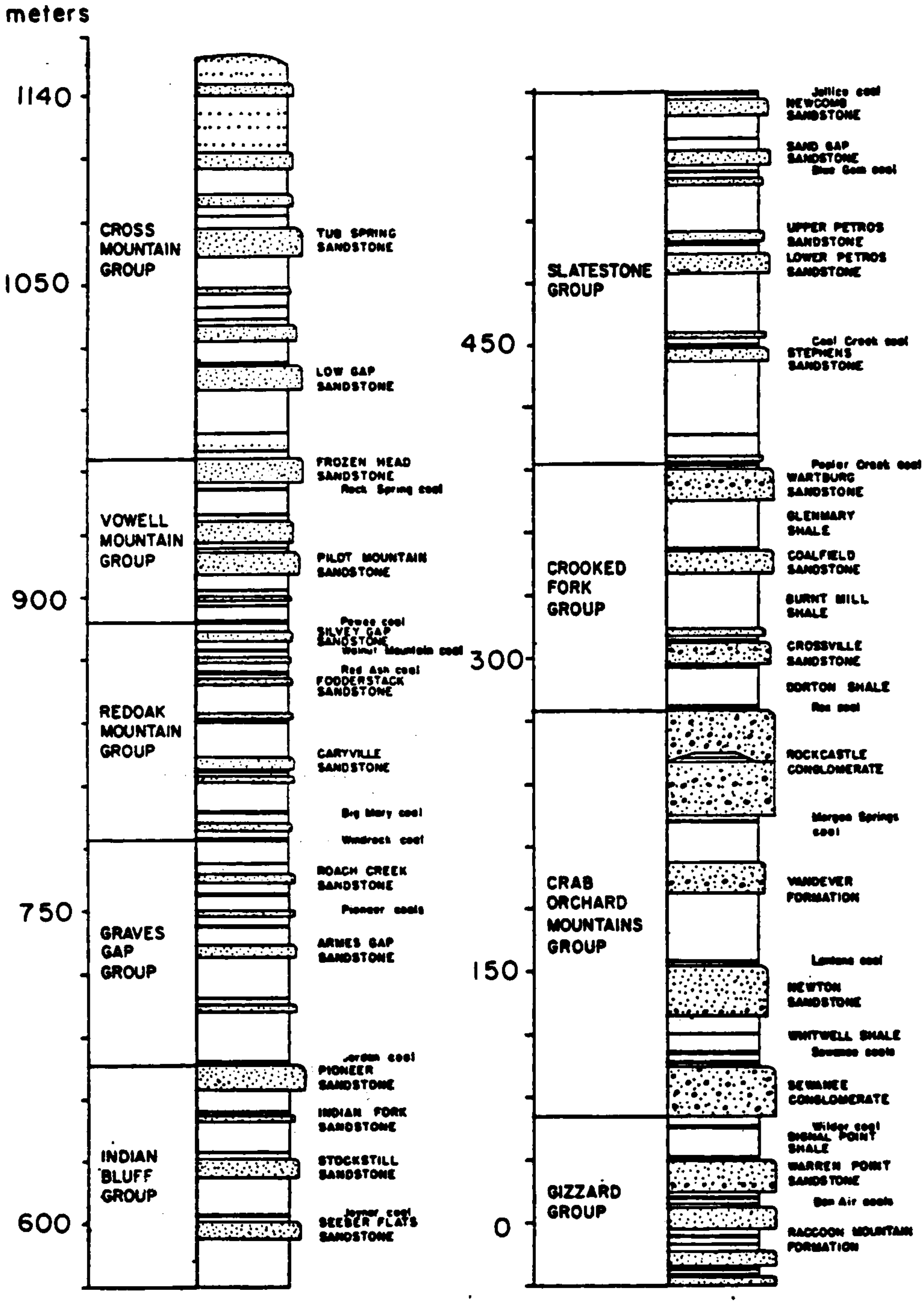

Figure 1. Generalized Pennsylvanian stratigraphic sequence for the Cumberland Plateau and Mountains, Tennessee. (Adapted after Wilson and Stearns 1958)

clayey to sandy siltstone and sandstone. Frozen Head sandstone is the uppermost member of this unit and forms conspicuous cliffs up to 15 m high.

The youngest Pennsylvanian stratum in Tennessee is the Cross Mountain formation which caps the higher summits and knobs in the area. Tub Springs sandstone caps Frozen Head Mountain (1013 m) and knobs on Bird Mountain; Low Gap sandstone caps Bird Mountain which is 25 m lower. Several coal seams are interbedded with the shale, siltstone and sandstone strata.

The lithology of upper Pennsylvanian sediments is complex and varies across geologic formations. Generalizations concerning grain size, structure and color can be made for the sandstones, siltstones and shales (Wilson et al. 1956). Sandstones are placed into two categories: a coarse grained, well sorted, massive type which is high in silica and a finer grained, poorly sorted, less massive type which contains more silt and clay sized particles. Quartz dominates the silt sized particles. Shales are divided into two groups: silty or sandy shales and clay shales. Silty shales are more common and contain large quantities of sand and silt size particles, are nonfissile and are gray or brown in color. Clay shales are dominated by clay size particles, are fissile and are white, light to dark gray and black. Clay shales are often associated with coal seams as underclays. The siltstones are poorly bedded and grade from sandy or silty shales to fine-grained, shaly sandstones. The silt-sized particles consist mainly of quartz (Wilson et al. 1956).

Geologic History

The Cumberland Plateau and Mountains are underlain by rocks of the Paleozoic era. Rock strata from the late Precambrian through Pennsylvanian periods are 12,000 m thick and represent an accumulation of sediments into an ancient geosyncline (Luther 1977). The current location of the Appalachian Mountains represents the trough of the geosyncline, which started to downwarp some 600 million years ago and continued for almost 350 million years (Byrne 1974). Sediments were continually supplied from an unknown source east (Pangea) of the geosyncline. An ancient landmass, Pangea, lying off the east coast of North America may have been the sediment source. During the early Paleozoic (Cambrian and Ordovician) shallow marine seas spread across the geosyncline depositing carbonates. Shorelines were widely fluctuating and created many depositional environments. Carbonates are thought to form in quiet, shallow marine environments at or below low tide (Miller 1974). During the early Ordovician period, emergence of the land in Tennessee exposed these carbonates to subaerial weathering. An unconformity between the Knox and Chickamauga Groups provides evidence of an erosional surface. Downwarping occurred during the middle Ordovician with subsequent invasion by the sea. Deposition of carbonates as well as clastic sediments continued into the shallow Silurian aged sea. Renewed uplift and erosion characterized the late Silurian and Devonian periods. Downwarping and invasion of shallow seas occurred in the late Devonian and continued into the Mississippian. Deposition of carbonates characterized the Mississippian period, with much of the land at or near sea level by the close of this period. During the Pennsylvanian period, marshes, lagoons and swamps existed which supported a variety of plant life. Many depositional environments existed which is evident in the gradational lithogies of the shales, siltstones and sandstones (Ferm et al. 1972). The Pennsylvanian period was tropical and supported a luxurious swamp forest which ultimately formed the coal beds characteristic of this period (Miller 1974).

At the end of the Paleozoic seas were retreating from the North American continent and a new era characterized by mountain building was initiated. During the Permian period a massive collision of North America with Africa (Gondwanaland) sheared off and overthrust large areas of land northwestward. This thrusting and faulting produced the new Appalachian mountains, the complex folding and faulting of the Ridge and Valley and was responsible for the movement of the Cumberland overthrust block.

Development of fault planes in formations above the basement complex are common in the Ridge and Valley and Cumberland Plateau provinces. Harris (1970) considered this type of movement thin-skinned tectonics and may have been responsible for some of the geological features of the Plateau and adjacent Ridge and Valley. Fault planes on the northwest and southeast sides of the Cumberland overthrust block lie in the lower incompetent Cambrian Rome and Conasauga shale formations and cut through overlying competent beds into the incompetent Devonian-Mississippian Chattanooga shale (Chorley et al. 1984).

Geomorphic History

Early theories of topographic development assumed cycles of rapid uplift followed by quiescence, with peneplanation, presumably during the Cretaceous and Tertiary (Johnson 1931; Meyergoff and Olmsted 1936; Thompson 1939; Wright 1942). The Cumberland Plateau is thought to represent the Schooley peneplane, which was formed during the Miocene. Fenneman (1938) considered the Cumberland Mountains to be the result of imperfect peneplanation. Later theories (Hack 1960, 1966; Hatcher 1972) of topographic evolution do not rely on peneplanation. Hack's (1960) dynamic equilibrium theory states that all hillslopes and channels in an erosional system are adjusted to each other. If the topography is in equilibrium, all parts of the landscape are downwasted at the same rate. Differences in relief and topographic form are explained in terms of resistance and spatial arrangement of underlying rocks. Diversity of form is the result of differential weathering. Hack (1979) states that a differential erosion rate rather than geologic uplift is responsible for the present topography.

Hatcher (1972) presents a developmental model for the southern Appalachians which integrates structural concepts, sedimentology, metamorphism, igneous activity and plate tectonics. He relates four phases of tectonic movement along the east coast to mountain building. Intermittent uplift followed by periods of quiescence probably characterized the Mesozoic. Present topography is the result of early Tertiary uplift and subsequent intervals of fluctuating sea levels, concomitant river entrenchment and land denudation during the Pleistocene.

Soils

Soils of the Cumberland Mountains are classified as Ultisols (mostly Hapludults) and Inceptisols (primarily Dystrochrepts) (Springer and Elder 1980). Frozen Head State Natural Area contains a wide variety of soils which are distributed in a complex, yet predictable pattern. Soils on ridgetops are thin, poorly developed, well drained and are formed in residuum from acid sandstone and shale. These soils are classified as Lithic Dystrochrepts (Ramsey series), Typic Dystrochrepts (Petros series), Ochreptic Hapludults (no series designation) and Typic Hapludults (Gilpin series).

Soils on sideslopes are derived from a mixture of residuum or colluvium from acid shales, siltstones and sandstones. It is not uncommon to find a colluvial surface capping over a residual subsurface soil. The colluvial cap usually has a lower clay content and a higher fragment content than the underlying soil that formed in residuum. Colluvial soils are deep, well drained and contain many coarse fragments. These soils are classified as Typic Hapludults and form in shale, siltstone and sandstone material moving downslope by mass wasting. Common colluvial soils on Bird Mountain are classified into the Jefferson, Grimsley and Shelocta series.

Cove soils are exclusively colluvial and contain a high percentage of stones and boulders. Coarse fragment content of soils increases toward drainageways; bedrock may be exposed in smaller 1st order drains. Most cove soils are mapped as a Grimsley-Jefferson complex. Grimsley soils are skeletal and are located closer to drainageways than Jefferson soils.

Above elevations of 825 m, upper north-facing slopes contain soils with an umbric epipedon. These soils have a dark, silt loam surface that is high in organic carbon. Depending on subsoil morphology, they are classified Typic Haplohumults, Humic Hapludults, Typic Haplumbrepts and Umbric Dystrochrepts. Lower north-facing sideslope soils have thicker and darker epipedons than their south-facing counterparts.

Alluvial soils occur along the current floodplains of higher order streams and on low terraces. These soils are cobbly, well drained and are classified as loamy-skeletal, siliceous, mesic Typic Hapludults.

Vegetation

There are few detailed vegetation studies of the Cumberland Mountains in Tennessee are few; but numerous studies have been conducted on the adjacent Cumberland Plateau and its gorges. Early timber surveys of the Cumberland Plateau by Killebrew and Safford (1874) reported chestnut (Castanea dentata), buckeye (Aesculus octandra), poplar (Liriodendron tulipifera), sugar maple (Acer saccharum), white oak (Quercus alba), ash (Fraxinus spp.), shell bark hickory (Carya laciniosa), black walnut (Juglans nigra) and elm (Ulmus spp.) on the surface and in gorges. Hall (1910) described Plateau coves dominated by yellow poplar, chestnut oak (Quercus prinus), and white oak; with important associates of beech (Fagus grandifolia), sugar maple, basswood (Tilia americana), red oak (Quercus rubra), hickories (Carya spp.) and ash. Braun (1942,1950) included the Wartburg Basin in her discussion of the Cumberland Mountains. She considered the interior of the Cumberland overthrust block to represent the true Cumberland Mountains and reported on the vegetation of Pine

Mountain (1935b), Black Mountain (1940) and the Cumberland Mountains (1942) in southeastern Kentucky. This area, part of the Mixed Mesophytic Forest Region, included the Cumberland and Allegheny plateaus and the southern Allegheny Mountains. The mixed mesophytic forest of the Cumberland Mountains was the oldest and most complex of all deciduous forests and occupied a central position from which "sub" or "physiographic" climaxes (association segregates) have arisen (Braun 1950). From the central, best developed mixed mesophytic forest, complexity and diversity decreased outward, as the forest was restricted to fewer mesic sites. On the Cumberland Plateau deep gorges and lower north-facing slopes provided mesic habitats. In mixed mesophytic forests, dominance is shared by many species; importance may vary locally due to changing environmental conditions. Dominant overstory trees include: sugar maple, white basswood (Tilia heterophylla), yellow poplar, beech, buckeye, northern red oak, white oak, hemlock (Tsuga canadensis), black cherry (Prunus serotina), cucumber magnolia (Magnolia acuminata), white ash (Fraxinus americana), red maple (Acer rubrum), yellow birch (Betula lutea), sweet birch (Betula lenta), blackgum (Nyssa sylvatica) and, formerly, chestnut.

Braun (1935a) considered the local development of distinct climax communities, association-segregates, as part of one great climatic climax. The sugar maple-white basswood-yellow buckeye-yellow poplar community of the outlying area was an association segregate of the all deciduous, mixed mesophytic forest. This segregate occurred on north-facing slopes, extending from 450 to 1070 m. Beech may be entirely absent from this segregate, and did not occur between 600 and 1200 m in the Cumberland Mountains (Braun 1950).

Braun (1950) described several communities in which beech was dominant or codominant. These communities occurred on footslopes and ravines below elevations of 600 m. White oak was an important associate on low, southerly slopes and yellow poplar may be codominant in coves.

A hemlock-mixed mesophytic community was recognized and occurred on mesic slopes at low elevations. Community composition varies with topographic position, aspect and protection. Ravine communities resembled the all deciduous mixed mesophytic forest; hemlock, beech and yellow poplar were codominant but sugar maple, white basswood and buckeye were poorly represented. On drier slopes, hemlock shared dominance with white oak and red maple.

A chestnut-sugar maple-yellow poplar community was described by Braun (1950) on upper west and southwest slopes of the Cumberland Mountains. She considered this community a variant of the mixed mesophytic forest, with most mesic species present as associates.

Sub- or physiographic climaxes were recognized by Braun (1950) and occupied the upper southwest slopes, dry ridgetops and areas with rocky or shallow soils of the Cumberland Mountains. The oak-chestnut and oak-pine communities represented the most xeric conditions described by Braun.

Studies have been made within the Wartburg Basin of Tennessee by Martin (1966) and Cabrera (1969). Martin (1966) described five forest communities on Wilson Mountain, elevation 670 m, 10 km south of Bird

Mountain in Morgan County. He reported a chestnut oak type on middle to low north-facing ridges and draws and middle to upper south-facing draws; a yellow poplar type on upper north-facing slopes and draws; a northern red oak type on upper north-facing slopes; a white oak type occupied lower slopes of ridges and draws on north and south exposures and a shortleaf pine (Pinus echinata) type occurred on south-facing spur ridges.

Cabrera (1969) working in virgin deciduous stands on Ash Log Mountain, Campbell County, described four community types. A chestnut oak-black locust (Robinia pseudoacacia) type occurred on west and southwest ridges and draws and was considered a variant of the Appalachian chestnut oak forest; northern red oak-sugar maple-black locust type on west to north-facing leads and draws; sugar maple-northern red oak-yellow poplar-white basswood type on flat sideslopes with a northern aspect and a sugar maple-yellow poplar-white basswood-buckeye type in north-facing draws. All association segregates of the mixed mesophytic forest contained sugar maple and segregation was related to topography and aspect.

Hinkle (1975) described the vegetation and flora of Cumberland Mountain, Cumberland Gap National Historical Park at Middlesboro Kentucky. Cumberland Mountain is a homoclinal ridge forming the eastern flank of the Middlesboro syncline. Fifteen secondary community types were recognized, dominated by pitch pine (Pinus rigida), Virginia pine (Pinus virginiana), scarlet oak (Quercus coccinia), black oak (Quercus velutina), chestnut oak, northern red oak, white oak, yellow poplar, red maple, blackgum and hemlock. Topographic position and form, elevation, aspect and depth to bedrock were important factors affecting community distribution.

Detailed vegetation studies of the Cumberland Plateau and gorges in Tennessee and southeast Kentucky are numerous. Sherman (1958) described the vegetation of five gorges of the Cumberland Plateau in Tennessee, Georgia and Alabama. Mixed mesophytic, oak-hickory and chestnut oak communities were segregated by aspect and topographic position. MacDonald (1964), in a forest inventory study of University of Tennessee land in Morgan and Scott counties, reported yellow poplar, white oak and northern red oak on a variety of sites.

Caplenor (1965) described the vegetation in the gorges of Fall Creek Falls State Park in Bledsoe and Van Buren counties, Tennessee. Six stable community types were described: mixed mesophytic, hemlock, hemlock-basswood, hemlock-birch, oak-hickory and chestnut oak; two successional stands occupied lower slope positions. Mixed mesophytic stands occurred on north and east slopes of the gorges; pignut hickory (Carya glabra), white basswood, hemlock, beech, yellow poplar, sugar maple and yellow birch were codominants. Hemlock stands occurred on protected gorge bottoms. The chestnut oak community occurred on upper southwest-facing slopes and the oak-hickory type occupied middle southwest and west-facing slopes of Cane Creek Gulf. The habitat of the hemlock-yellow birch type was similar to the hemlock type; the hemlock-basswood community was intermediate in composition to the mixed mesophytic and hemlock-yellow birch types.

Safley (1970) described 14 communities in the gorge and upland area of the Big South Fork of the Cumberland River in Scott, Pickett and Fentress counties in Tennessee and McCreary County, Kentucky. Gorge vegetation types were: river birch (Betula nigra), yellow poplar-sweet gum (Liquidambar styraciflua), red cedar (Juniperus virginiana), white oak-chinquapin oak (Quercus muehlenbergii), yellow poplar-hemlock, white oak-Virginia pine, northern red oak-chestnut oak-white oak, white oak-beech and white oak-hemlock-chestnut oak. Cumberland Plateau communities were dominated by white oak or Virginia pine-white oak types.

Cumberland Mountain types were: beech-white oak-sugar maple in north-facing draws; white oak-beech on low north-facing ridges and leads; chestnut oak-white oak-beech on upper north-facing ridges and draws; chestnut oak-northern red oak on south-facing ridges. Slope shape, topographic position and aspect were important factors in community distribution.

Quarterman and Turner (1972) in a transect study of virgin vegetation in Savage Gulf State Natural Area in Grundy County, Tennessee, reported a mixed mesophytic community on north-facing slopes and an oak-hickory-yellow poplar community on south-facing slopes. Codominants in the mixed mesophytic forest included white basswood, hemlock, sugar maple and yellow poplar. Chestnut oak, mockernut hickory (Carya tomentosa), northern red oak and yellow poplar were the most important taxa on southern exposures.

Sherman (1978) described 8 virgin and 6 secondary community types in Savage Gulf Natural Area, Grundy County, Tennessee. Virgin types on the north-facing slope included: mixed mesophytic forest on low to middle sideslopes dominated by basswood, yellow poplar and sugar maple; yellow poplar-hemlock and hemlock types at low slope positions; and a hemlock-chestnut oak type on middle to upper slopes. Virgin forests on the south-facing slope included: white oak-hemlock on low slopes, mockernut hickory-northern red oak on middle sideslopes and chestnut oak on upper slopes. A beech-shagbark hickory type occurred on low south-facing draws and middle north-facing sideslopes.

Secondary communities were segregated by aspect and slope position. South slopes were dominated by white oak, yellow poplar, white ash, northern red oak and hickories; north slope dominants included sugar maple, basswood, beech and to a lesser extent oaks and hickories.

Herman and See (1973) described successional trends in Tight Holler, Wolfe County, Kentucky, 47 years after a fire in a mature hemlock-mixed mesophytic forest. Even-aged stands of yellow poplar accounted for 70% of the basal area; red maple, sweet birch, hemlock, umbrella magnolia (Magnolia tripetala) and big leaf magnolia (Magnolia macrophylla) were associated overstory taxa.

McCarthy (1976) described 12 forest communities in Fentress County, Tennessee. These included types dominated by sugar maple, red maple, blackgum, yellow poplar, chestnut oak, hemlock, shortleaf pine, scarlet oak, white oak, hickory and Virginia pine.

Martin (1975) studied the vegetation in the Lilley Cornett Woods, on the Cumberland Plateau, in Letcher County Kentucky. Nine communities were recognized: a mixed mesophytic type dominated by sugar maple, white basswood and yellow poplar; four beech types which included buckeye, sugar maple and white oak as codominants; three oak types: white, chestnut and mixed, and a hemlock type. Community composition and species distribution were related to aspect, slope shape and position.

Winstead and Nicely (1976) described the vegetation of Rock Creek Natural Area, Laurel County, Kentucky. This area lies within Daniel Boone National Forest and is part of Braun's "cliff" section of the Cumberland Plateau. Hemlock, yellow poplar, sweet birch and red maple accounted for 80% of the relative basal area.

Carpenter (1976) studied stand structure of a 50 year old secondary forest in the Cumberland Plateau of eastern Kentucky. Upland stream bottoms and north-facing slopes were dominated by even-aged stands of yellow poplar and south slopes by white oak and hickories.

Wade (1977) described dry phase vegetation on the uplands of the Cumberland Plateau in Tennessee. He distinguished 9 secondary community types. White oak, chestnut oak and blackjack oak (Quercus marilandica) types were found to be stable; shortleaf pine, black oak, post oak (Quercus stellata) and scarlet oak types were considered successional to a white oak type.

Smith (1977) studied swamp and mesic community types on the Cumberland Plateau surface in Tennessee. He described 8 secondary community types in which white oak, yellow poplar, blackgum, white pine (Pinus strobus), red maple and river birch were dominant. Slope shape and position were important site factors affecting community distribution.

Schmalzer (1978) classified the vegetation in 5 coves of the Cumberland Plateau. Fourteen community types were recognized: chestnut oak, chestnut oak-white oak, hemlock-yellow poplar, white pine-chestnut oak, white basswood-sugar maple-buckeye, and beech types were considered stable. Other community types appear to be reproductively unstable with respect to dominant taxa. Northern red oak was not reproducing in the northern red oak or white oak-northern red oak types. Yellow poplar reproduction was poor in the yellow poplar and beech-yellow poplar types. Sugar maple appears to be increasing in importance in several types. Available soil moisture, slope position, soil texture and pH were important factors segregating community types.

Hinkle (1978) classified Cumberland Plateau vegetation of Tennessee into 24 communities. On uplands he reported 12 types: Virginia pine, blackjack oak, post oak-scarlet oak, shortleaf pine-white oak, scarlet oak, mixed oak, chestnut oak, white oak, red maple-white oak, blackgum, red maple, hemlock and red maple-river birch-holly (<u>Ilex opaca</u>). Important factors affecting community distribution were slope position, total available soil water, soil depth, surface stone content and slope angle. In Plateau ravines he distinguished 12 types: chestnut oak, mixed oak, sugar maple-white oak, sugar maple-white basswood-ash-buckeye, northern red oak-sugar maple, beech, yellow poplar-shagbark hickory-northern red oak, beech-yellow poplar, white oak-northern red oak, white pine, hemlock and river birch. Community distribution was affected by topographic position, soil pH, phosphorous, potassium, and the ratio of gorge depth to width.

Schmalzer (1982) studied the vegetation in the Obed Wild and Scenic River in Cumberland and Morgan counties, Tennessee. Ten community types were recognized: river birch, beech-yellow poplar, yellow poplar, white oak, hemlock, sweet birch-hemlock-chestnut oak, chestnut oak, chestnut oak-white oak, white pine-white oak-chestnut oak, white oak-scarlet oak and Virginia pine. Slope position, soil moisture, gorge width and protection were important variables separating community types.

Human Impact

Human influence on the forests of the Cumberland Plateau and Mountain region of Tennessee by prehistoric Indians is unknown (Lewis and Kneberg 1958). Nomadic hunters entered Tennessee more than 10,000 years ago and were displaced by a later group, the Archaic (Mesolithic), 9,000 years BP. The Woodland (Neolithic) Indians replaced earlier tribes 3,000 years BP and were displaced or absorbed by the Mississippian culture 1,500 years BP. These latter tribes were farmers and led a more settled existence. Historic Indians in East Tennessee were the Creek Confederacy and the Cherokee. The Cherokees are thought to be derived from the Mississippian culture (Folmsbee et al. 1969). These tribes used the Cumberland Plateau as a hunting ground and few, if any, permanent settlements existed.

Historically, white settlers entered the area and gradually replaced these Indians after a series of treaties in the late 1700's and early 1800's. Morgan County was established in 1817; Wartburg was settled by Swiss and German colonists in 1845 and the county seat moved there in 1870 (Freytag and Ott 1971).

In 1902, the state of Tennessee purchased approximately 8,000 acres of forested land in Morgan County as a site for Brushy Mountain State Prison. Between 1911 and 1915, the area was heavily cut in a stream skidder operation; during the 1920's portable sawmills cut all of the remaining timber over 35 cm in diameter (Peterson 1957). Forest fires were frequently reported during these years. In 1933, Governor McAllister transferred part of the area to the Division of Forestry, to be administered as a State Forest. A Civilian Conservation Corps camp was established during the mid 1930's and trails, fire control roads and a fire tower were constructed.

A management plan published in 1941 recommended no timber sales before 1950. In 1952, most of this forest was subjected to a major forest fire. In 1957 a forest inventory was made and recommended no timber sales before 1967. This management plan reported the average acre of land was less than 50% stocked with trees greater than 10 cm in diameter.

In the late 1970's, this area was placed under control of the Division of State Parks to facilitate the development of a State Natural Area. An additional 4,000 acres of forested land associated with Brushy Mountain State Prison and 1,800 acres of farm land associated with the State Honor Farm came under the control of the Tennessee Department of Conservation in 1972. The area is currently managed as a State Natural Area and a State Environmental Education Area.

CHAPTER III

CLASSIFICATION AND DESCRIPTION OF COMMUNITY TYPES

Introduction

During the summers of 1982 and 1983 overstory vegetation was sampled for the purpose of classifying community types. Relationships between community types and site and soil variables were investigated to help explain community distribution.

Field Methods

Stratified random sampling, in the form of transects perpendicular to the ridge line, was thought to be the most efficient sampling method. All aspects, slope positions and geomorphic landforms were sampled to ensure adequate representation of the vegetation.

Ninety-five circular, 0.04 ha plots were established throughout the study area. Plots were located and recorded on USGS-TVA 7.5 minute topographic quadrangle maps. Plot centers were randomly chosen and marked by tying nylon flagging to the closest overstory tree and recording distance and direction to plot center. Radius of all plots was corrected for slope angle as described by Bryan (1956) and boundaries measured with a tape. Overstory species greater than 10 cm diameter breast height (dbh) were measured and placed into 2 cm diameter classes. Saplings more than 1 m tall and 1 to 10 cm dbh were counted and recorded by taxon. Shrubs and vines less than 10 cm in diameter and over 1 m tall were identified and recorded. Tree species were identified using the <u>Summer Key to Tennessee Trees</u> (Shanks and Sharp 1963). Shrubs and vines were identified using the keys of Core and Ammons (1958) and Duncan (1975). Scientific nomenclature follows Radford et al. (1968) and common names of trees follow Shanks and Sharp (1963).

Site factors measured included: aspect, slope angle, elevation, slope position, slope shape parallel (horizontal) and perpendicular (vertical) to the contour and fire occurrence. Aspect was measured with a Silva Ranger compass; slope angle with a Suunto clinometer and elevation with a hand held altimeter accurate to 20 m. Slope position was estimated as percent distance from ridgetop to valley floor. Slope shape was designated convex (1), planar (2) and concave (3). Evidence of past disturbance such as fire scars and logging activities was noted.

Soil characteristics were determined for each plot. A small soil pit was dug at plot center and morphologic properties determined. Profile characteristics measured in the field included O, A and B horizon thickness. Soil samples of the A and B horizons were collected to determine pH, percent coarse fragment, texture, color and available water holding capacity. Geomorphic position on the landscape, nature and lithology of the parent material (colluvium or residuum) and depth to bedrock were recorded when possible. Identification of epipedons and subsurface horizons for taxonomic classification were determined by thickness, texture, structure and color changes within the soil profile. The soil in the center of each plot was classified down to the subgroup level using Soil Taxonomy (Soil Survey Staff 1975).

Laboratory Methods

Soil samples collected at the plots were air dried and passed through a number 10 sieve to determine percent coarse fragment by weight. Texture of the A and B horizons was estimated by the "feel" method (Soil Survey Staff 1972). Color (moist) of the soil matrix and mottling were determined using Munsell color charts. Available water holding capacity was calculated in the upper solum to a depth of 50 cm. Texture, percent coarse fragment, thickness and depth of the horizon were used to make the available water determination using the method of Peterson et al. (1968). Total available water holding capacity, to a depth of 50 cm, was calculated and expressed in cm of H_2O/50 cm soil. For statistical analysis, textures of the A and B horizons were coded based upon available water holding capacity (1=sandy clay loam to 8=silt loam). The pH of each soil sample was determined using a Leeds and Northrup pH meter in a 1:1 soil-water suspension and 1:1 soil-1N KCl suspension as specified in Soil Survey Investigations Report No. 1 (Soil Survey Staff 1972).

Potential insolation, per year, was determined from the tables of Frank and Lee (1966) using slope angle, aspect and latitude. Insolation was expressed in thousands of langleys/year. The aspect of each plot was transformed according to Beers et al. (1966). A value of 0.00 represents a southwest aspect, while 2.00 is northeast.

Relative and absolute density (RD and AD) and relative and absolute basal area (RBA and ABA) were determined for overstory trees in each plot. Importance value (IV) of each tree species was calculated as the sum of the relative density and relative basal area

(IV=RD+RBA), and had a maximum value of 200. Common canopy species were defined as overstory taxa with an average importance value of two or more. Sapling relative and absolute density were determined for each taxon recorded. Also calculated, on a per plot basis, were: total overstory canopy tree density expressed as stems/hectare, total basal area (m^2/hectare) and total sapling density (stems/hectare). All calculations of vegetation parameters were made using a Radio Shack TRS-80 microcomputer, with programs written by Mr. Sims Crownover. Most statistical analysis was performed on the IBM 370 computer, located at the University of Tennessee Computing Center, using Statistical Analysis Systems (SAS) programs. Results are presented in a later chapter.

Structural analysis may reveal the detailed history and reproductive trends of a community or stand (Johnson and Bell 1975). Diameter distribution curves were constructed for select overstory trees and all trees combined in each community type. Taxa were grouped into 8 cm diameter classes and their density was plotted. The 1 to 10 cm class included all stems considered sapling, and resulted in an artificially steep slope for this diameter class.

Schmelz and Lindsey (1965) summarized four general patterns discernable from a diameter curve of all species in a community type:

1) straight line (negative slope), indicates little or no community disturbance,
2) sharp break in line, indicates severe disturbance at that diameter class,

3) widely deviating negative slope, indicates a late stage of recovery after disturbance, and

4) a curve with a plateau, indicates recovery after a disturbance.

No attempt was made to core trees and relate tree ages to past disturbances such as fire or logging.

Sample plots were placed into community types using SAS cluster analysis (centroid option) of overstory species importance values. This agglomerative hierarchical clustering procedure computes the squared (Euclidian) distance between centroids or means of plots and minimizes the within group variation (SAS Institute, Inc. 1985). The cluster procedure begins by combining a pair of plots with the minimal within group variation (dispersion) and continues until all plots are combined into one group. Results are presented as a dendrogram; a 45% level of dispersion was chosen to separate community types (Figure 2). The 45% level of dispersion indicates that 45% of the total variance in the data was within group and 55% was between group. Seven community types were segregated at this level. Plot locations by community type are shown in Figure 3. Composition of the overstory and sapling layers, in the form of tables, follows the discussion on each type. Means, standard errors and ranges of environmental variables accompany the discussion for each community type. Site and soil properties, expressed as percentage of plots and frequency of shrubs, vines and common canopy species are summarized in Appendix A, Tables 22-24.

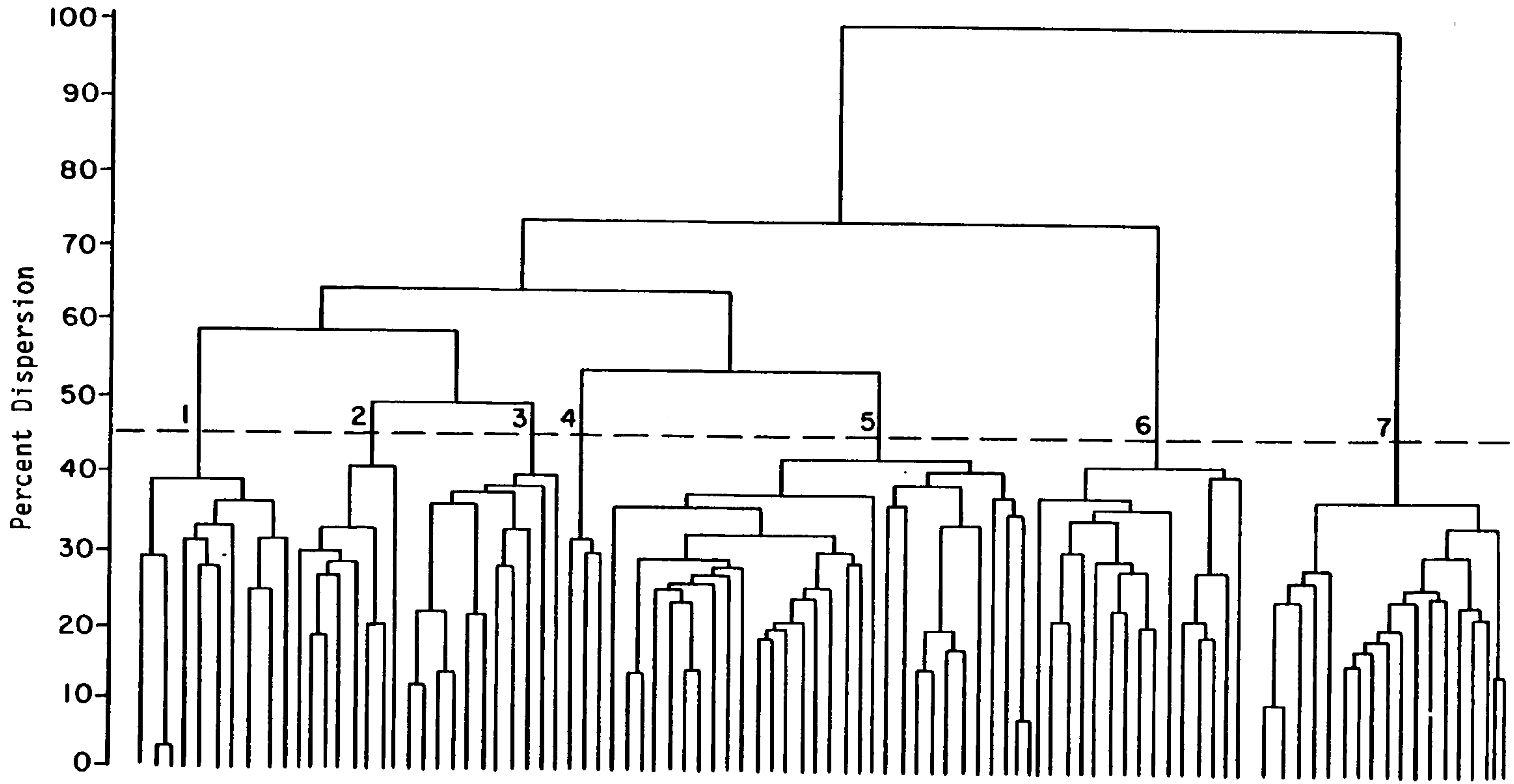

Figure 2. Dendrogram of cluster analysis of Bird Mountain vegetation plots, Frozen Head State Natural Area. Community Types are defined at the 45% dispersion level, 1 = Yellow Poplar, 2 = White Oak-Northern Red Oak, 3 = Northern Red Oak-Sugar Maple, 4 = Black Cherry-Sugar Maple, 5 = Sugar Maple-White Basswood-Yellow Poplar-Yellow Buckeye, 6 = Beech, 7 = Chestnut Oak.

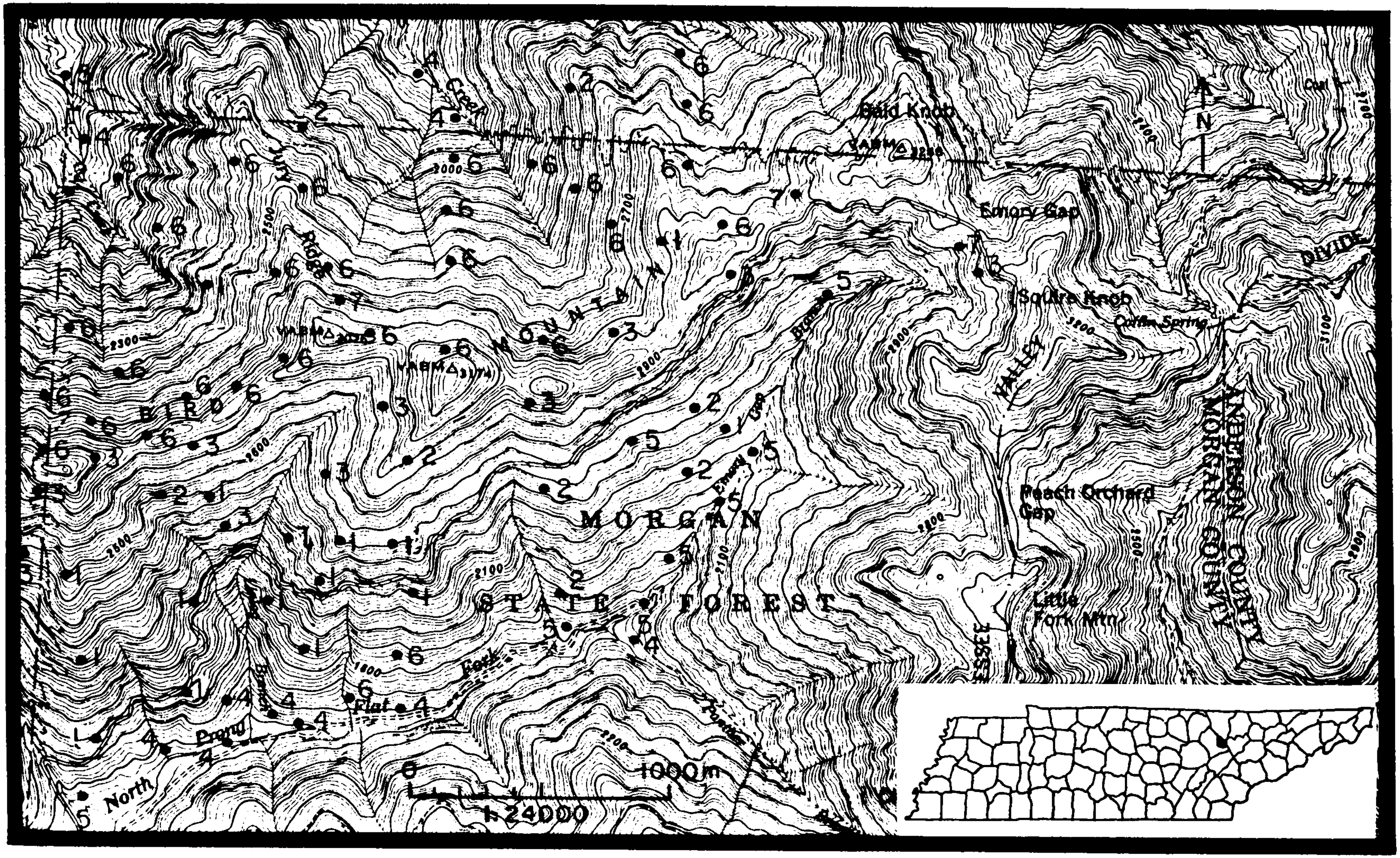

Figure 3. Location and classification of vegetation plots occurring on Bird Mountain, Frozen Head State Natural Area. The numbers by each plot represent the Community Types as follows: 1 = Chestnut Oak, 2 = White Oak-Northern Red Oak, 3 = Northern Red Oak-Sugar Maple, 4 = Beech, 5 = Yellow Poplar, 6 = Sugar Maple-White Basswood-Yellow Poplar-Yellow Buckeye, 7 = Black Cherry-Sugar Maple.

The SAS discriminant analysis procedure was used to check the effectiveness of the cluster analysis. Classification functions were derived using species importance values to predict the probability of membership of a vegetation plot into a community type. A high success rate of classification indicated good discrimination by original variables and reflected the vegetationally distinct character of each community type; a low success rate was indicative of poor discrimination by the original variables. Several workers (Schmalzer 1978; Arends 1981; Callaway et al. 1987) have used discriminant analysis to check the success of cluster analysis. In these studies community types were vegetationally distinct as indicated by a low rate of misclassification using vegetation parameters; environmental variables were often poor discriminators of community types with much misclassification, presumably due to environmental overlap between community types.

In this study classification success was very high (98.9%) for the discriminant analysis, reflecting the vegetationally distinct character of each community type defined by cluster analysis. Only one vegetation plot was misclassified by the cluster analysis; it was originally classified into the white oak-northern red oak type and subsequently reclassified, by the discriminate procedure, into the northern red oak-sugar maple type. Cluster analysis grouped plots that were most similar vegetationally with a high degree of success.

The distinct character of these community types did not necessarily indicate the existence of discrete communities on the landscape; rather they may represent clusters of stands along a vegetation continuum whose structure is controlled by gradually changing environmental conditions (i.e. elevation, soil water, aspect, precipitation). This analysis in particular and the study in general did not determine the discrete or continuous nature of the vegetation on Bird Mountain. The community types were vegetationally distinct enough to warrant a discussion of their compositions and a characterization of their sites.

Chestnut Oak Community Type (n=18)

The chestnut oak type was well represented and occurred on middle to upper south, southwest and west-facing sideslopes and ridges. Thirteen of eighteen common canopy species occurred in this type; chestnut oak was the most dominant species with an average importance value of 104. Associated canopy species included red maple, northern red oak, sugar maple, pignut hickory, blackgum, yellow poplar, white oak, and to a lesser extent red hickory, black cherry, cucumber magnolia, black locust and yellow buckeye (Table 1).

In the sapling layer red maple, dogwood (*Cornus florida*), sugar maple, blackgum, chestnut oak, sourwood (*Oxydendrum arboreum*) and northern red oak were most important. Shrubs and vines present in this community type included mountain laurel (*Kalmia latifolia*), maple-leaved viburnum (*Viburnum acerifolium*), blueberry (*Vaccinium vacillans*), greenbrier (*Smilax* spp.), blackberry (*Rubus* spp.) and grapes (*Vitis* spp.) (Table 23, Appendix A).

All of the canopy species except white oak and yellow buckeye were reproducing. Red and sugar maple were the most abundant canopy

Table 1. Species composition of canopy trees and saplings of the Chestnut Oak Community Type (n=18).

Taxa	Canopy RD*	Canopy RBA**	Canopy IV***	Sapling RD
Acer rubrum	23.4	9.2	32.6	27.5
A. saccharum	7.9	2.1	10.0	18.8
Aesculus octandra	0.2	0.1	0.3	
Betula lenta				0.3
B. lutea	0.2		0.2	0.6
Carya glabra	3.3	4.0	7.3	1.5
C. ovalis	1.0	1.1	2.1	0.1
C. ovata	0.2	0.3	0.5	
C. tomentosa	0.2	0.1	0.3	
Cornus florida	0.7	0.1	0.8	20.0
Fagus grandifolia				1.1
Fraxinus americana				1.2
Liquidambar styraciflua	0.7	0.1	0.8	
Liriodendron tulipifera	2.5	3.1	5.6	0.9
Magnolia acuminata	0.6	0.4	1.0	1.7
Nyssa sylvatica	4.1	1.6	5.7	8.4
Oxydendrum arboreum	5.3	1.7	7.0	3.4
Prunus serotina	0.7	0.4	1.1	1.8
Pyrularia pubera				0.8
Quercus alba	1.4	1.7	3.1	
Q. prinus	37.9	66.7	104.6	6.4
Q. rubra	6.8	6.3	13.1	3.4
Q. velutina	0.5	0.4	0.9	
Robinia pseudoacacia	0.7	0.3	1.0	0.8
Sassafras albidum	1.7	0.5	2.2	1.1
Tilia heterophylla				0.2
Tsuga canadensis				0.2
BA/ha(m^2)(ft^2/ac.)		47.8(208.1)		
D/ha(D/ac)	601.7(243.6)			1069.2(432.9)

*RD = Relative density

**RBA = Relative basal area

***IV = Importance value

species in the sapling layer followed by chestnut oak. Chestnut oak was well represented not only in the sapling layer but in all diameter classes and shows a steady decline in the number of stems per hectare as diameter increases (Figure 4). This implies that the chestnut oak type is a stable, self-sustaining climax community.

The chestnut oak community occurred on middle to upper sideslopes and spur ridges with a southerly aspect. Seventy-two percent of the plots had an aspect of south or southwest. Slopes were steep to very steep, with 56% of the plots having a gradient of 50% or more. Vertical and horizontal slope shapes were dominantly convex with some planar shapes and no concave shapes (Table 2; Table 22, Appendix A).

The soils within the Chestnut Oak community were extremely to very strongly acid, high in coarse fragment content, had a low available water holding capacity and were well to excessively well drained. Textures in the A horizon were dominantly loams and silt loams with B horizon textures mainly silty clay loams, silty clays, clay loams and silt loams. Three-fourths of these soils were classified into fine-loamy, mixed or siliceous, mesic families of Typic Hapludults and fit into the Jefferson or Grimsley (taxadjunct) soil series. These deep, well drained soils formed in colluvial material. Parent material, in most cases, was sandstone and shale colluvium with lesser amounts of sandstone, shale and siltstone residuum beneath the colluvium. Residual soils have thinner sola, hold less water and are excessively well drained. Ramsey (Lithic Dystrochrepts) and Petros (Typic Dystrochrepts) soil series have been mapped in this community

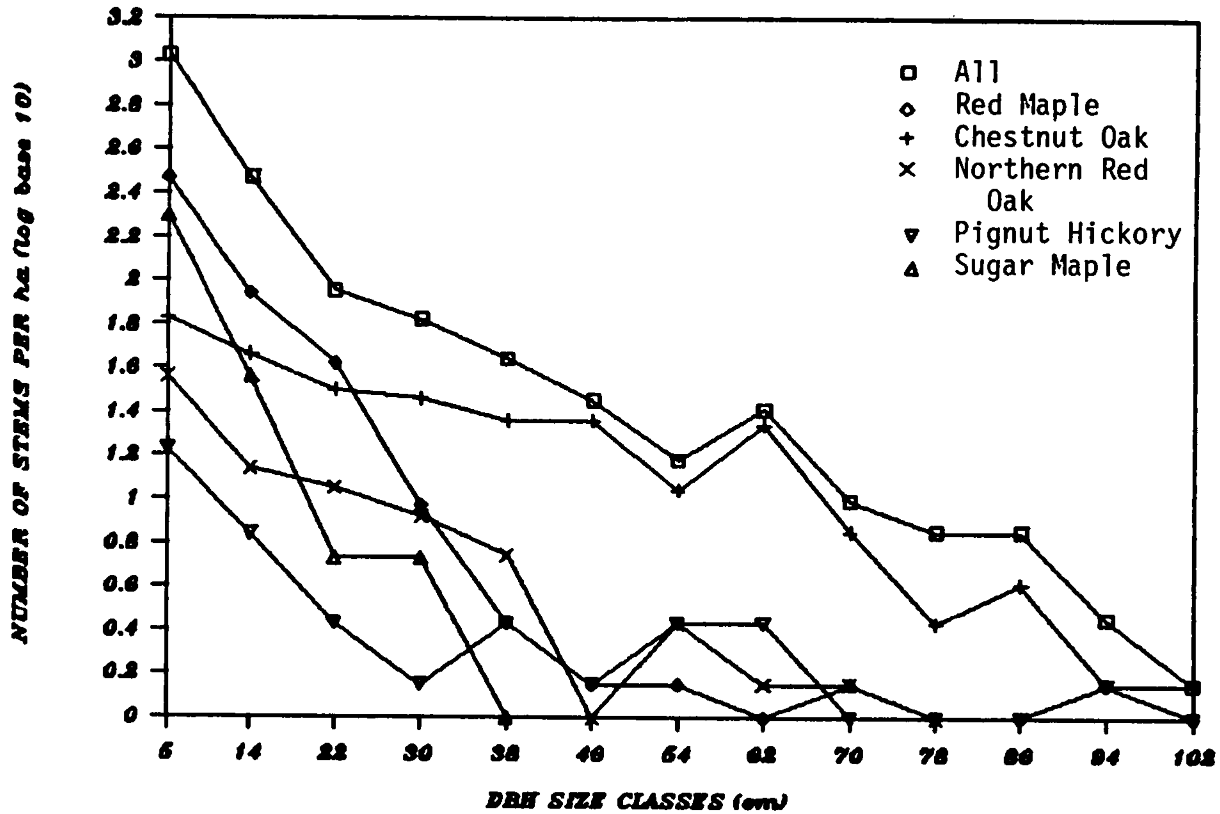

Figure 4. Diameter distribution curves of Chestnut Oak, Red Maple, Northern Red Oak, Sugar Maple, Pignut Hickory, and all taxa in the Chestnut Oak Community Type (n=18).

Table 2. Site and soil characteristics of the Chestnut Oak Community Type (n=18).

Environmental Variables	Mean ± S.E.	Range
Slope angle (percent)	51.7 ± 2.1	35.0 - 65.0
Aspect*	0.35 ± 0.13	0.00 - 1.71
Slope position (percent from ridgetop)	59.4 ± 5.6	10.0 - 100.0
Elevation (m)	651.8 ± 24.5	457.0 - 853.0
Vertical slope shape*	1.3 ± 0.1	1.0 - 2.0
Horizontal slope shape*	1.1 ± 0.1	1.0 - 2.0
Potential insolation (Kly/yr)	290.3 ± 7.2	198.0 - 317.0
pH (water) of A horizon	4.1 ± 0.07	3.7 - 5.0
pH (water) of B horizon	4.4 ± 0.04	4.1 - 4.6
pH (1N KCl) of A horizon	3.4 ± 0.09	2.9 - 4.5
pH (1N KCl) of B horizon	3.4 ± 0.04	2.9 - 3.7
A horizon texture*	7.1 ± 0.2	4.0 - 8.0
B horizon texture*	5.3 ± 0.4	2.0 - 8.0
Available water holding capacity of A horizon (cm)	1.35 ± 0.20	0.60 - 3.90
Available water holding capacity of B horizon (cm), down to 50 cm	2.96 ± 0.24	1.90 - 6.00
Total available water holding capacity (cm), top 50 cm	4.31 ± 0.28	2.80 - 6.90
O horizon thickness (cm)	2.5 ± 0.5	1.0 - 7.0
A horizon thickness (cm)	14.1 ± 1.8	6.0 - 36.0
A horizon coarse fragment content (percent wt.)	46.4 ± 2.4	27.0 - 61.0
B horizon coarse fragment content (percent wt.)	47.3 ± 3.2	24.0 - 71.0
A horizon hue*	2.0 ± 0.0	2.0 - 2.0
A horizon value	3.9 ± 0.2	3.0 - 5.0
A horizon chroma	3.7 ± 0.3	2.0 - 6.0
B horizon hue*	1.9 ± 0.1	1.0 - 2.0
B horizon value	4.8 ± 0.1	3.0 - 5.0
B horizon chroma	5.4 ± 0.5	1.0 - 8.0

*Coding of variables as in Table 16.

type. Thicknesses of the O and A horizons was the least of any community type. Evidence of fire occurred in 78% of this type.

Chestnut oak communities have been seen from New England to Alabama and Georgia; Society of American Foresters type 44 occurred on dry upland sites within rock soils (Eyre 1980). Chestnut oak types have been reported in the Cumberland Mountains of Tennessee. Martin (1966), working on Wilson Mountain in Morgan County reported a chestnut oak type on low to middle north-facing ridges and draws and middle to upper south-facing draws. Cabrera (1969) described a chestnut oak-black locust type on southwest and west-facing leads and draws on Ash Log Mountain in Campbell County. Hinkle (1975) reported a chestnut oak type on convex slopes with a variety of aspects in Cumberland Gap National Historical Park. Chestnut oak and chestnut oak-chestnut communities have been described by Braun (1950) in the Cumberland Mountains of Tennessee and Kentucky. She considers this type a physiographic or subclimax in the mixed mesophytic forest region.

Chestnut oak types have also been reported from the Cumberland Plateau (Sherman 1958; Caplenor 1965; Safley 1970; McCarthy 1970; Wade 1977; Sherman 1978; Schmalzer 1978, 1982; Hinkle 1978) and the Ridge and Valley province of Tennessee (Martin 1971; Hedge 1979; Crownover 1983; Condley 1984). Southerly, steep upper convex slopes and thin, rocky acid soils were common site and soil characteristics of these studies.

White Oak-Northern Red Oak Community Type (n=8)

The white oak-northern red oak type occurred on lower, middle and upper south-facing sideslopes of Bird Mountain from 550 to 850 m elevation. Thirteen of the eighteen common canopy species occurred in this type; white oak was the most important and northern red oak, red maple and red hickory were codominants. Sugar maple, blackgum, yellow poplar, and pignut hickory were important associated species. Other common canopy species occurring included cucumber magnolia, black locust, black cherry, yellow buckeye and sweet birch (Table 3).

In the sapling layer sugar maple, dogwood, red maple, blackgum, white ash and northern red oak were most important. All canopy species except sweet birch and black locust were reproducing. White oak was poorly represented in the sapling layer, but was well represented in larger diameter classes (Figure 5). White oak seems to have an adequate number of trees in the larger dbh classes to ensure its persistence in this community type. Northern red oak was well represented in the sapling layer and all dbh classes. Shrubs and vines present included blueberry, greenbrier, grapes and blackberry (Table 23, Appendix A).

Twenty-five percent of the vegetation plots had a northerly aspect and a low slope position. Slopes were steep and convex to planar; no slope shapes were concave (Table 4; Table 22, Appendix A). Soils were extremely to very strongly acid, high in coarse fragment content, had a low to moderate available water holding capacity and were well drained. Soil textures in the A horizon were loams, silt loams or sandy loams; textures of the B were predominately silty clay loams, silt loams or

Table 3. Species composition of canopy trees and saplings of the White Oak-Northern Red Oak Community Type (n=8).

Taxa	Canopy RD	Canopy RBA	Canopy IV	Sapling RD
Acer rubrum	14.9	10.0	24.9	11.4
A. saccharum	7.8	1.8	9.6	39.6
Aesculus octandra	0.8	0.4	1.2	0.9
Betula lenta	0.8	0.1	0.9	
Carya glabra	2.4	1.0	3.4	0.9
C. ovalis	7.5	7.1	14.6	0.6
C. tomentosa	1.3	2.1	3.4	2.0
Cercis canadensis				0.8
Cornus florida				22.0
Fagus grandifolia				1.4
Fraxinus americana				2.8
Juglans nigra	0.8	0.3	1.1	0.4
Liquidambar styraciflua	3.8	0.8	4.6	1.2
Liriodendron tulipifera	4.8	0.8	5.6	1.3
Magnolia acuminata	2.0	1.1	3.1	0.9
Nyssa sylvatica	4.1	2.3	6.4	4.8
Oxydendrum arboreum	2.8	0.8	3.6	1.4
Populus grandidentata				1.9
Prunus serotina	0.4	1.4	1.8	1.2
Quercus alba	26.0	48.5	74.5	0.4
Q. rubra	14.5	18.9	33.4	2.5
Q. velutina	2.0	1.4	3.4	
Robinia pseudoacacia	1.9	0.9	2.8	
Sassafras albidum	2.5	1.3	3.8	1.6
Tilia heterophylla				0.9
BA/ha(m^2)(ft^2/ac)		33.6(146.3)		
D/ha(D/ac)	423.1(171.3)			1288.0(521.5)

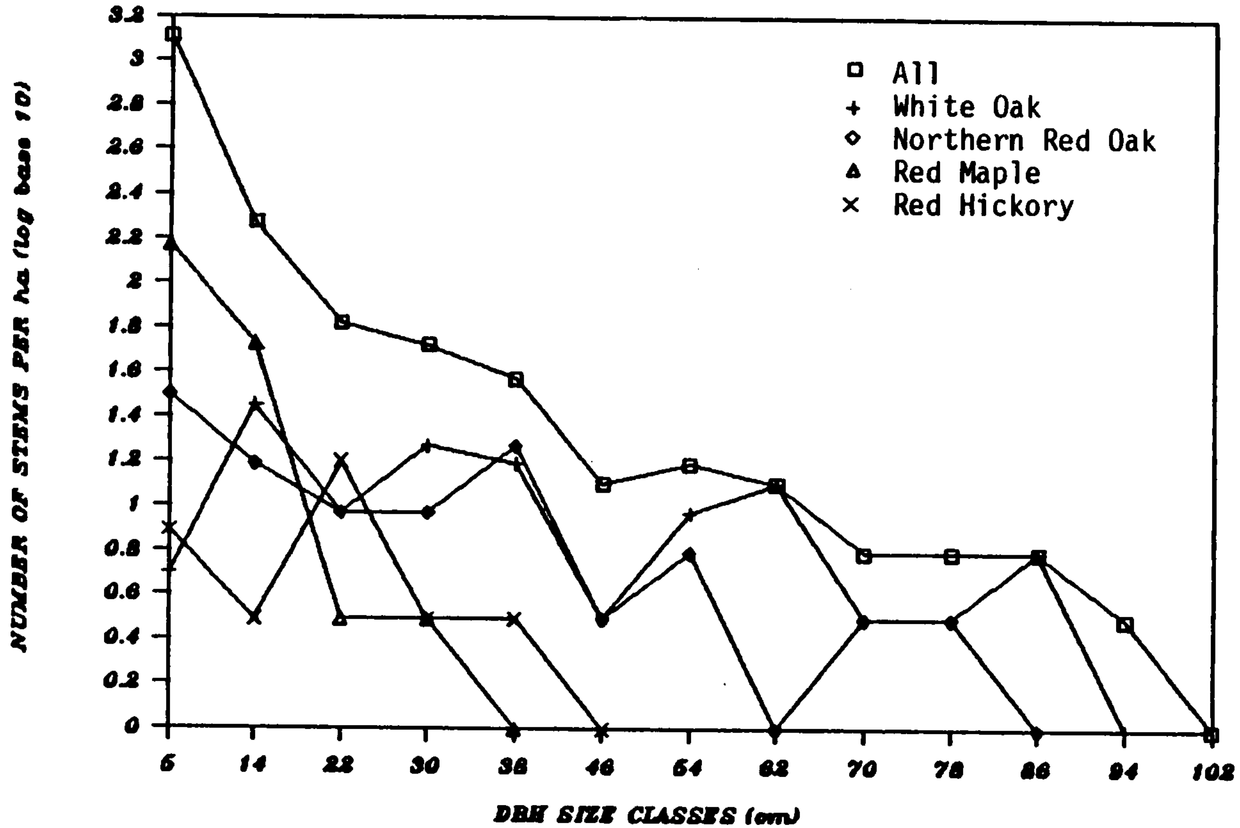

Figure 5. Diameter distribution curves of White Oak, Northern Red Oak, Red Maple, Red Hickory and all taxa in the White Oak-Northern Red Oak Community Type (n=8).

Table 4. Site and soil characteristics of the White Oak-Northern Red Oak Community Type (n=8).

Environmental Variables	Mean ± S.E.	Range
Slope angle (percent)	40.3 ± 5.4	20.0 - 65.0
Aspect*	0.51 ± 0.19	0.00 - 1.71
Slope position (percent from ridgetop)	43.8 ± 8.2	10.0 - 80.0
Elevation (m)	729.3 ± 38.1	564.0 - 884.0
Vertical slope shape*	1.3 ± 0.2	1.0 - 2.0
Horizontal slope shape*	1.4 ± 0.2	1.0 - 2.0
Potential insolation (Kly/yr)	285.5 ± 14.4	213.0 - 316.0
pH (water) of A horizon	4.2 ± 0.2	3.6 - 5.2
pH (water) of B horizon	4.3 ± 0.1	3.7 - 4.7
pH (1N KCl) of A horizon	3.5 ± 0.2	2.8 - 4.3
pH (1N KCl) of B horizon	3.4 ± 0.1	3.2 - 3.6
A horizon texture*	7.1 ± 0.4	5.0 - 8.0
B horizon texture*	5.6 ± 0.7	1.0 - 8.0
Available water holding capacity of A horizon (cm)	1.48 ± 0.22	0.80 - 2.30
Available water holding capacity of B horizon (cm), down to 50 cm	3.25 ± 0.35	1.70 - 5.00
Total available water holding capacity (cm), top 50 cm	4.73 ± 0.50	2.60 - 7.10
O horizon thickness (cm)	4.0 ± 0.6	1.0 - 7.0
A horizon thickness (cm)	15.0 ± 2.1	10.0 - 28.0
A horizon coarse fragment content (percent wt.)	43.5 ± 4.8	24.0 - 64.0
B horizon coarse fragment content (percent wt.)	39.5 ± 6.2	19.0 - 71.0
A horizon hue*	2.0 ± 0.0	2.0 - 2.0
A horizon value	3.6 ± 0.2	3.0 - 4.0
A horizon chroma	3.0 ± 0.2	2.0 - 4.0
B horizon hue*	2.0 ± 0.0	2.0 - 2.0
B horizon value	5.0 ± 0.0	5.0 - 5.0
B horizon chroma	5.0 ± 0.5	4.0 - 8.0

*Coding of variables as in Table 16.

sandy clay loams. Sixty-three percent of the soils were classified as Typic Hapludults (Grimsley, Jefferson or Shelocta). These are deep, well drained colluvial soils. The remainder of the soils formed in residuum from sandstone or shale and were classified as fine-loamy, mixed or siliceous, mesic Typic or Lithic Dystrochrepts. These soils are thinner and hold less water than colluvial soils. Evidence of fire was observed on 63% of the plots.

White oak forests are common in the Cumberland Mountains, Cumberland Plateau and Ridge and Valley provinces of Tennessee. Martin (1966) described a white oak type on lower ridge slopes and draws and upper south-facing slopes of Wilson Mountain. Chestnut oak was codominant with white oak on lower south-facing ridges in his study. Hinkle (1975) described a white oak-northern red oak type on middle southeast-facing slopes and a white oak-hickory type on southerly aspects on Cumberland Mountain. These communities were considered young and unstable due to inadequate white oak reproduction. Braun (1950) considered white oak a component of her beech-white oak mixed mesophytic segregate, in which either species may dominate. This type occurred on slopes with a southerly aspect at low elevations in the Cumberland Mountains.

Sherman (1958) described an oak-hickory type on south-facing slopes, but northern red oak was virtually absent. Caplenor (1965) reported an oak-hickory type on middle west and southwest-facing slopes of Cane Creek Gulf in Fall Creek Falls State Park, which was dominated by white oak, pignut hickory, northern red oak and yellow poplar. Safley (1970) described several white oak types in the gorge of the Big South Fork River. White oak dominated these types with associated taxa segregated along aspect and topographic form. Schmalzer (1978; 1982) described a white oak-northern red oak type on middle to low slopes along the Obed River and a white oak type on middle to upper northeast to northwest-facing slopes at Dick Cove. Yellow poplar was considered a codominant in his types. Wade (1977) described a more xeric white oak type on the plateau surface and Smith (1977) reported a white oak-red maple type on poorly drained uplands. Hinkle (1978) reported a white oak-northern red oak type on many aspects in low slope positions. Sherman (1978) described a virgin white oak-hemlock type on low south-facing slopes in Savage Gulf; northern red oak was a minor constituent.

The white oak-northern red oak type has been described in the Ridge and Valley province (Martin 1971; Hedge 1979; Crownover 1983). The SAF (Eyre 1980) recognized a white oak-black oak-northern red oak type (52) which occurred on a variety of sites. A white oak-northern red oak variant was recognized on low to middle, north and east-facing sideslopes, coves and benches.

Northern Red Oak-Sugar Maple Community Type (n=11)

The northern red oak-sugar maple type occurred on middle to upper south-facing sideslopes of Bird Mountain, predominantly above 700 m elevation. Fourteen of the eighteen common canopy species occurred in this type; northern red oak and sugar maple were the most important and pignut hickory and white oak were codominant. Important associated species included black cherry, chestnut oak, white basswood and cucumber magnolia. Other common canopy species present included blackgum, red maple, black locust, yellow poplar, white ash and sweet birch (Table 5).

The most important understory species were sugar maple, dogwood, pignut hickory, blackgum and northern red oak. All canopy species except chestnut oak and yellow poplar were reproducing. Sugar maple was well represented in the sapling layer with a relative sapling density of 55. Sugar maple was also represented in larger dbh classes (Figure 6). White oak reproduction was low in the sapling layer, but was well represented in the smaller tree dbh classes. Sugar maple, northern red oak, pignut hickory and white oak reproduction, especially in the smaller classes, was adequate to sustain these species. Shrubs and vines present include mountain laurel, blueberry, greenbrier and grapes (Table 23, Appendix A).

This type occurred at upper, south, southwest and southeast-facing sideslope positions. Seventy-three percent of the plots within this community type had a southerly aspect. Slopes were steep and convex to planar; no slope shapes were concave (Table 6; Table 22, Appendix A). Soils were extremely acid, high in coarse fragment content, had low available water holding capacity and were well to excessively well drained. Textures in the A horizon were mainly loams and silty clay loams; some were sandy loams, silt loams and silty clays. Textures in B horizons were dominantly clays, silty clay loams and silty clays. Soils were classified as fine-loamy (some skeletal), mixed or siliceous, mesic, Typic and Humic Hapludults. The Typic Hapludults occurred on the southerly aspects; Humic Hapludults occurred on cooler, more northerly aspects. The Typic Hapludults belong to the Jefferson,

Table 5. Species composition of canopy trees and saplings of the Northern Red Oak-Sugar Maple Community Type (n=11).

Taxa	Canopy RD	Canopy RBA	Canopy IV	Sapling RD
Acer rubrum	2.6	0.7	3.3	3.5
A. saccharum	28.7	11.0	39.7	54.8
Aesculus octandra				0.8
Betula lenta	0.4	0.4	0.8	0.1
Carya cordiformis	0.4	0.1	0.5	0.1
C. glabra	11.9	11.9	23.8	4.6
C. ovata	0.3	0.1	0.4	
Castanea dentata				0.4
Cornus florida				15.4
Fraxinus americana	0.7	0.1	0.8	2.3
Liriodendrum tulipifera	0.6	0.6	1.2	
Magnolia acuminata	1.9	3.4	5.3	0.6
Nyssa sylvatica	3.0	1.1	4.1	4.6
Oxydendrum arboreum	0.5	0.1	0.6	
Populus grandidentata				0.4
Prunus serotina	4.9	4.4	9.3	1.9
Quercus alba	7.2	6.3	13.5	1.6
Q. prinus	3.0	3.8	6.8	
Q. rubra	24.6	51.3	75.9	3.5
Q. velutina	1.4	2.2	3.6	
Robinia pseudoacacia	1.1	0.6	1.7	0.4
Sassafras albidum	2.4	0.4	2.8	1.9
Tilia heterophylla	4.6	1.6	6.2	2.5
Ulmus americana				0.6
BA/ha(m^2)(ft^2/ac)		53.6(233.4)		
D/ha(D/ac)	624.4(252.8)			1370.4(554.8)

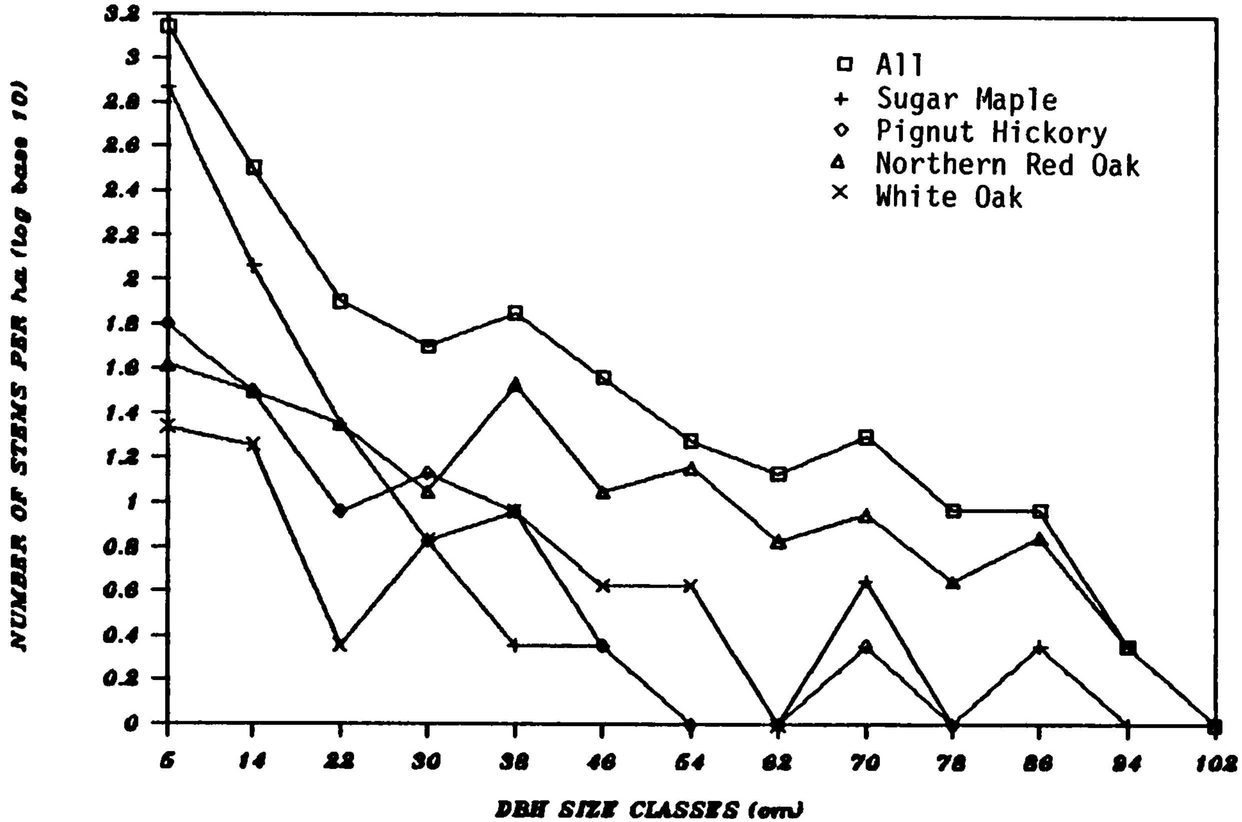

Figure 6. Diameter distribution curves of Northern Red Oak, Sugar Maple, Pignut Hickory, White Oak and all taxa in the Northern Red Oak-Sugar Maple Community Type (n=11).

Table 6. Site and soil characteristics of the Northern Red Oak-Sugar Maple Community Type (n=11).

Environmental Variables	Mean ± S.E.	Range
Slope angle (percent)	39.1 ± 4.5	10.0 - 60.0
Aspect*	0.63 ± 0.18	0.00 - 2.00
Slope position (percent from ridgetop)	14.5 ± 4.5	0.0 - 40.0
Elevation (m)	839.5 ± 23.7	655.0 - 914.0
Vertical slope shape*	1.4 ± 0.1	1.0 - 2.0
Horizontal slope shape*	1.5 ± 0.1	1.0 - 2.0
Potential insolation (Kly/yr)	283.3 ± 11.8	206.0 - 314.0
pH (water) of A horizon	4.0 ± 0.1	3.5 - 5.0
pH (water) of B horizon	4.3 ± 0.1	3.8 - 5.4
pH (1N KCl) of A horizon	3.4 ± 0.1	3.2 - 3.8
pH (1N KCl) of B horizon	3.7 ± 0.1	3.4 - 5.1
A horizon texture*	6.3 ± 0.4	3.0 - 8.0
B horizon texture*	3.9 ± 0.5	2.0 - 6.0
Available water holding capacity of A horizon (cm)	1.47 ± 0.23	0.50 - 2.80
Available water holding capacity of B horizon (cm), down to 50 cm	2.43 ± 0.28	1.40 - 4.80
Total available water holding capacity (cm), top 50 cm	3.90 ± 0.29	2.80 - 5.90
O horizon thickness (cm)	3.4 ± 0.5	1.0 - 6.0
A horizon thickness (cm)	16.9 ± 2.1	9.0 - 29.0
A horizon coarse fragment content (percent wt.)	48.7 ± 3.0	26.0 - 63.0
B horizon coarse fragment content (percent wt.)	50.5 ± 3.8	18.0 - 61.0
A horizon hue*	2.1 ± 0.1	2.0 - 3.0
A horizon value	4.0 ± 0.3	3.0 - 6.0
A horizon chroma	3.2 ± 0.2	2.0 - 4.0
B horizon hue*	2.0 ± 0.0	2.0 - 2.0
B horizon value	5.2 ± 0.1	5.0 - 6.0
B horizon chroma	5.8 ± 0.4	4.0 - 8.0

*Coding of variables as in Table 16.

Shelocta or Grimsley soil series. These are soils that formed in colluvial material derived from acid sandstones and shales. The Humic Hapludults have no current series designation. These soils occurred at higher elevations with a northerly aspect and are deep and well drained. Other soils formed in residuum weathered from acid sandstone and shale occurred within this vegetation type and were classified as Typic or Lithic Dystrochrepts (Petros and Ramsey). Rock outcrops were intermingled with the residual soils at upper slope positions. Evidence of fire was found in 55% of the plots of this type.

Martin (1966) described a northern red oak type on upper north-facing slopes on Wilson Mountain. Pignut hickory, red hickory, scarlet oak and chestnut oak were codominant; sugar maple was unimportant. Cabrera (1969) described a sugar maple-northern red oak-yellow poplar-basswood segregate on Ash Log Mountain. His classification included stands on north-northeast leads in which sugar maple, northern red oak and to a lesser extent shagbark hickory were codominant. Schmalzer (1978) described a sugar maple-northern red oak type on middle to low northerly slopes in Dick Cove and Doe Creek on the western escarpment of the Cumberland Plateau. Yellow poplar was codominant; white ash, blackgum and shagbark hickory were important associates.

McCarthy (1976) described a cove hardwood type in Fentress County in which sugar maple, ash, northern red oak and hickories were the major overstory taxa. Hinkle (1975) reported a northern red oak-hickory type, with white oak an important associate. Sugar maple was absent from this type. Hinkle (1978) described a northern red oak-sugar maple type on steep upper, middle and lower slopes, and middle draws of northerly aspects. Shagbark hickory was an important taxon in the canopy. This community type was not similar to any SAF (Eyre 1980) forest type.

Beech Community Type (n=15)

The Beech type occurred on a variety of aspects on low footslopes and along the major drainageways of Bird and Old Mac Mountains. Fifteen of the eighteen common canopy species occurred in this type; beech and hemlock were most important. Associated canopy species included yellow poplar, red maple, white oak, sweet birch, northern red oak, white basswood and to a lesser extent sugar maple, blackgum, white ash, black locust, chestnut oak, cucumber magnolia and pignut hickory (Table 7). Beech, hemlock, sugar maple, red maple, dogwood and American hornbeam (*Carpinus caroliniana*) were the most important species in the sapling layer. Shrubs and vines present included mountain laurel, maple-leaved viburnum, blueberry, buffalo nut (*Pyrularia pubera*), greenbrier and strawberry bush (*Euonymous americanus*) (Table 23, Appendix A).

All of the canopy species present except black locust and chestnut oak were reproducing. Beech and hemlock were the most important canopy species reproducing in the sapling layer and were well represented in the smaller diameter classes. Beech was present and hemlock absent in the larger diameter classes (Figure 7). Red maple, the fourth most important canopy species, was reproducing in the sapling layer and the smaller diameter classes. Yellow poplar, the third most important canopy species, was poorly represented in the sapling layer but showed

Table 7. Species composition of canopy trees and saplings of the Beech Community Type (n=15).

Taxa	Canopy RD	Canopy RBA	Canopy IV	Sapling RD
Acer rubrum	9.5	5.1	14.6	8.9
A. saccharum	1.9	1.0	2.9	10.8
Aesculus octandra				0.1
Asimina triloba				1.9
Betula lenta	5.5	2.5	8.0	2.5
Carpinus caroliniana	0.5	0.1	0.6	5.2
Carya cordiformis	0.6	2.5	3.1	0.2
C. glabra	0.6	0.3	0.9	0.1
C. tomentosa	0.8	1.1	1.9	0.3
Castanea dentata				0.4
Cornus florida				7.4
Fagus grandifolia	24.4	51.4	75.8	21.5
Fraxinus americana	1.2	0.7	1.9	1.4
Ilex opaca				0.3
Liquidambar styraciflua	2.9	1.4	4.3	2.6
Liriodendron tulipifera	9.1	8.7	17.8	0.7
Magnolia acuminata	0.9	0.3	1.2	1.7
M. macrophylla				1.6
Nyssa sylvatica	1.2	0.9	2.1	1.9
Ostrya virginiana				1.1
Oxydendrum arboreum	8.9	3.3	12.2	1.9
Populus grandidentata				0.9
Prunus serotina				0.1
Pyrularia pubera				5.5
Quercus alba	5.7	3.9	9.6	0.3
Q. prinus	0.7	0.6	1.3	
Q. rubra	2.6	2.3	4.9	0.1
Q. velutina	0.2	0.5	0.7	
Robinia pseudoacacia	0.6	1.0	1.6	
Tilia heterophylla	2.8	1.7	4.5	3.2
Tsuga canadensis	19.7	10.9	30.6	17.0
Ulmus americana				0.5
U. rubra				0.1
BA/ha(m^2)(ft^2/ac)		44.7(194.7)		
D/ha(D/ac)	484.3(196.0)			1530.4(619.6)

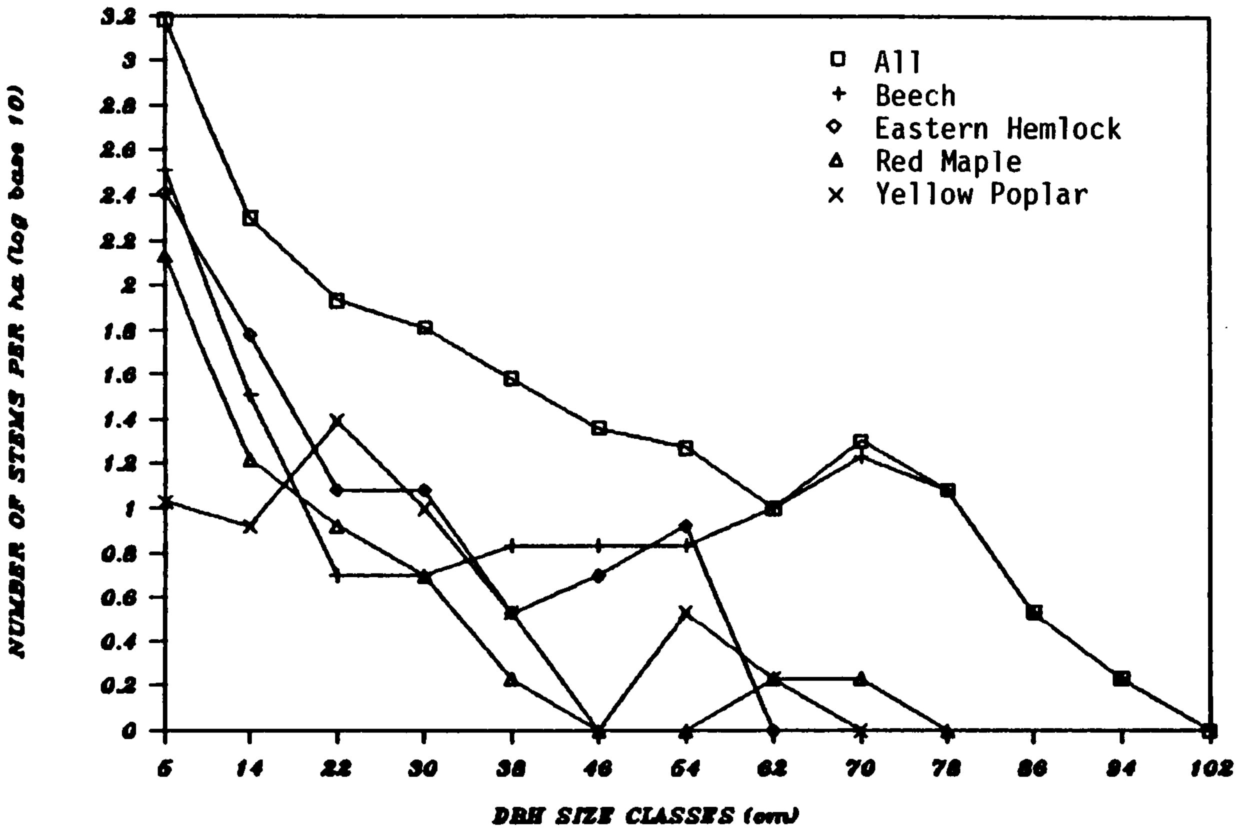

Figure 7. Diameter distribution curves of Beech, Eastern Hemlock, Yellow Poplar, Red Maple and all taxa in the Beech Community Type (n=15).

an increase in density in the smaller tree diameter classes. Beech, hemlock, red maple and to a lesser extent yellow poplar reproduction was adequate to ensure the persistence of these species in this community type.

The beech type occurred on toeslopes, footslopes and along drainageways at elevations less than 600 m. Seventy-three percent of the plots had an elevation less than 500 m. Aspect was variable; plots occurred on both north and south-facing slopes.

Vertical slope shape was planar to convex; horizontal slope shape was dominantly planar (Table 8; Table 22, Appendix A). Slopes range from 10 to 55%, with a distinct bimodal character in the 11-20% and 41-50% slope gradient classes. Plots closer to major drainageways were less sloping and more often planar than those on upland sites which were steeper and more convex. The soils were extremely to very strongly acid, moderate to high in coarse fragment content, had moderate available water holding capacity and were deep and well drained. Mean available water holding capacity, for the top 50 cm, was the highest of all the community types. The A horizon textures were silt loams or loams with B horizon textures of silty clay loams, silt loams, loams and some clays. The relatively high silt content of these horizons had a positive effect on total available water holding capacity.

Soils were classified as Typic Hapludults in the Grimsley, Jefferson and Shelocta series and occurred in footslope and toeslope positions. These soils formed in colluvial materials derived from acid shales, siltstones and sandstones. The argillic horizon texture was

Table 8. Site and soil characteristics of the Beech Community Type (n=15).

Environmental Variables	Mean ± S.E.	Range
Slope angle (percent)	32.0 ± 3.9	10.0 - 55.0
Aspect*	0.99 ± 0.20	0.00 - 1.98
Slope position (percent from ridgetop)	92.5 ± 2.7	60.0 - 100.0
Elevation (m)	482.5 ± 12.5	426.0 - 610.0
Vertical slope shape*	1.7 ± 0.1	1.0 - 2.0
Horizontal slope shape*	2.0 ± 0.1	1.0 - 3.0
Potential insolation (Kly/yr)	258.9 ± 12.5	168.0 - 316.0
pH (water) of A horizon	4.4 ± 0.1	3.9 - 5.2
pH (water) of B horizon	4.5 ± 0.1	4.1 - 4.9
pH (1N KCl) of A horizon	3.5 ± 0.1	2.9 - 4.0
pH (1N KCl) of B horizon	3.6 ± 0.1	3.3 - 3.7
A horizon texture*	7.5 ± 0.2	6.0 - 8.0
B horizon texture*	6.1 ± 0.5	2.0 - 8.0
Available water holding capacity of A horizon (cm)	2.17 ± 0.30	1.21 - 5.60
Available water holding capacity of B horizon (cm), down to 50 cm	3.46 ± 0.25	1.53 - 5.02
Total available water holding capacity (cm), top 50 cm	5.63 ± 0.33	3.72 - 8.21
O horizon thickness (cm)	4.5 ± 0.6	1.0 - 9.0
A horizon thickness (cm)	18.1 ± 1.9	10.0 - 35.0
A horizon coarse fragment content (percent wt.)	36.0 ± 3.2	14.0 - 57.0
B horizon coarse fragment content (percent wt.)	33.7 ± 3.5	13.0 - 60.0
A horizon hue*	2.0 ± 0.0	2.0 - 2.0
A horizon value	4.0 ± 0.1	3.0 - 5.0
A horizon chroma	3.4 ± 0.1	3.0 - 4.0
B horizon hue*	2.0 ± 0.0	2.0 - 2.0
B horizon value	4.8 ± 0.1	4.0 - 5.0
B horizon chroma	5.6 ± 0.4	4.0 - 8.0

*Coding of variables as in Table 16.

silty clay loam or silt loam for the Shelocta series, while the argillic horizon in the Jefferson series contained more sand and less silt. Humic Hapludults, Typic and Umbric Dystrochrepts and Typic Haplumbrepts also occurred in this type but their distribution was localized and small in extent. No series designation currently exists for these soils. Fire was evident in 73% of the plots.

This community differed from previously reported beech types in Cumberland Mountains and Plateau. Hemlock and yellow poplar were important codominants; red maple and white oak were important associates. Recent studies (Safley 1970; McCarthy 1976; Sherman 1978; Hinkle 1975, 1978; Schmalzer 1978, 1982) have described a variety of beech and hemlock communities.

Martin (1966) stated that beech was a codominant in his white oak type on low north-facing slopes. Cabrera (1969) reported beech as a minor component in his forest types. Braun (1950) stated that beech may become dominant in ravines and at the foot of mountain slopes, below 600 m. She considered beech a characteristic taxa of her mixed mesophytic forest and recognized a beech-white oak segregate occurring on southerly slopes at low elevations. Hemlock-mixed mesophytic communities were recognized by Braun (1950) in which hemlock was codominant with beech, yellow poplar and red maple. The species composition of Braun's (1950) hemlock-mixed mesophytic forest (Clover Fork of Leatherwood Creek, Kentucky) and this beech type yielded a Jaccard similarity index (Muller-Dombois and Ellenberg 1974) of 57%. Sherman (1958) considered beech an important taxon in the mixed mesophytic forests of his study area. Caplenor (1965) described a mixed mesophytic forest type in the gorges of Fall Creek Falls State Park; it contained ten codominants, in which beech and hemlock were important canopy taxa in the narrow gorge bottoms along streams. Safley (1970) described a beech-white oak-sugar maple type, in which hemlock, the fourth most important species, occurred in north-facing draws below 500 m along the Big South Fork River. He also described a white oak-beech type and a chestnut oak-white oak-beech type on low north-facing ridges and leads, and steep upper north-facing ridges and draws, respectively. Hinkle (1978) described a beech type on low to middle north-facing ravine slopes, in which yellow poplar and northern red oak were important associates; hemlock was virtually absent. Sherman (1978) described a virgin beech-shagbark hickory type in Savage Gulf; hemlock, the third most important taxon in this type, occurred on low south-facing draws and middle north-facing flats. Schmalzer (1978) described a beech type on middle and low positions along the Obed River and at Flint Fork; beech was clearly the dominant taxon accounting for 46% of the canopy importance; yellow poplar, white oak, northern red oak and hemlock were associates. Martin (1971) reported beech a dominant taxon and hemlock unimportant in his mixed mesophytic forest of the Ridge and Valley province. The SAF (Eyre 1980) recognized a beech-sugar maple type (60) which occurred with many other taxa in rough topography and was a regional climax in part of the middle west (Braun 1950).

Yellow Poplar Community Type (n=10)

The yellow poplar community type occurred in coves at middle to low slope positions. Seventeen of the eighteen common canopy species occurred in this type; yellow poplar was the dominant species. Associated canopy species included red maple, white oak, northern red oak, chestnut oak, hemlock and to a lesser extent black locust, sugar maple, hickories, sweet birch, yellow buckeye, blackgum, white basswood, beech, cucumber magnolia and white ash (Table 9).

The most important understory species were dogwood, red and sugar maple, hemlock, blackgum, beech and white ash. Shrubs and vines present included blueberry, maple-leaved viburnum, greenbrier, grapes and strawberry bush (Table 23, Appendix A).

All the common canopy species, except white basswood, were reproducing. Red and sugar maple, hemlock and blackgum were the most abundant canopy species in the sapling layer. Canopy species with high importance values and low relative sapling density included yellow poplar, white oak and northern red oak. Although poorly represented in the sapling layer, yellow poplar was well represented in the larger diameter classes (Figure 8). Fowells (1965) considered yellow poplar a shade intolerant species which will grow rapidly into canopy openings, but is unable to reproduce except in gaps. Gap phase dynamics and growth habits of yellow poplar regeneration by stump sprouting may ensure reproduction in climax communities (Buckner and McCracken 1978). Runkle (1981) in a study of gap regeneration in old growth forests in Pennsylvania, Ohio and the southern Appalachians concluded that small canopy gaps were sufficient to ensure reproduction of shade intolerant canopy dominants.

The yellow poplar type occurred primarily on middle to low slope positions in coves below 750 m elevation; some plots were in upper

Table 9. Species composition of canopy trees and saplings of the Yellow Poplar Community Type (n=10).

Taxa	Canopy RD	Canopy RBA	Canopy IV	Sapling RD
Acer rubrum	16.0	5.2	21.2	19.3
A. saccharum	3.4	1.3	4.7	11.3
Aesculus octandra	0.8	1.6	2.4	0.6
Asimina triloba			0.8	
Betula lenta	1.8	1.4	3.2	0.2
Carpinus caroliniana			0.5	
Carya glabra	2.2	0.7	2.9	0.8
C. ovalis	0.3	0.3	0.6	0.4
C. ovata	0.7	0.4	1.1	0.5
C. tomentosa	3.8	1.7	5.5	2.3
Cladrastis lutea			0.2	
Cornus florida	2.0	0.3	2.3	23.7
Fagus grandifolia	0.9	0.5	1.4	4.0
Fraxinus americana	0.3	0.5	0.8	3.6
Liquidambar styraciflua	2.0	0.8	2.8	0.2
Liriodendron tulipifera	26.9	49.4	76.3	0.2
Magnolia acuminata	0.7	1.0	1.7	0.8
M. macrophylla			1.0	
Nyssa sylvatica	1.8	0.9	2.7	6.9
Ostrya virginiana	0.3	0.1	0.4	
Oxydendrum arboreum	4.1	1.5	5.6	2.0
Prunus serotina			2.8	
Pyrularia pubera			1.6	
Quercus alba	6.7	12.4	19.1	0.2
Q. prinus	7.4	4.8	12.2	1.4
Q. rubra	7.4	6.9	14.3	1.4
Q. velutina	0.3	0.2	0.5	
Robinia pseudoacacia	3.6	2.0	5.6	1.0
Sassafras albidum			0.3	
Tilia americana			0.8	
T. heterophylla	0.3	1.2	1.5	
Tsuga canadensis	5.6	4.6	10.2	10.9
Ulmus americana			0.2	
U. rubra	0.6	0.7	1.3	0.4
BA/ha(m^2)(ft^2/ac)		51.2(223.0)		
D/ha(D/ac)	570.7(231.1)			1485.1(601.3)

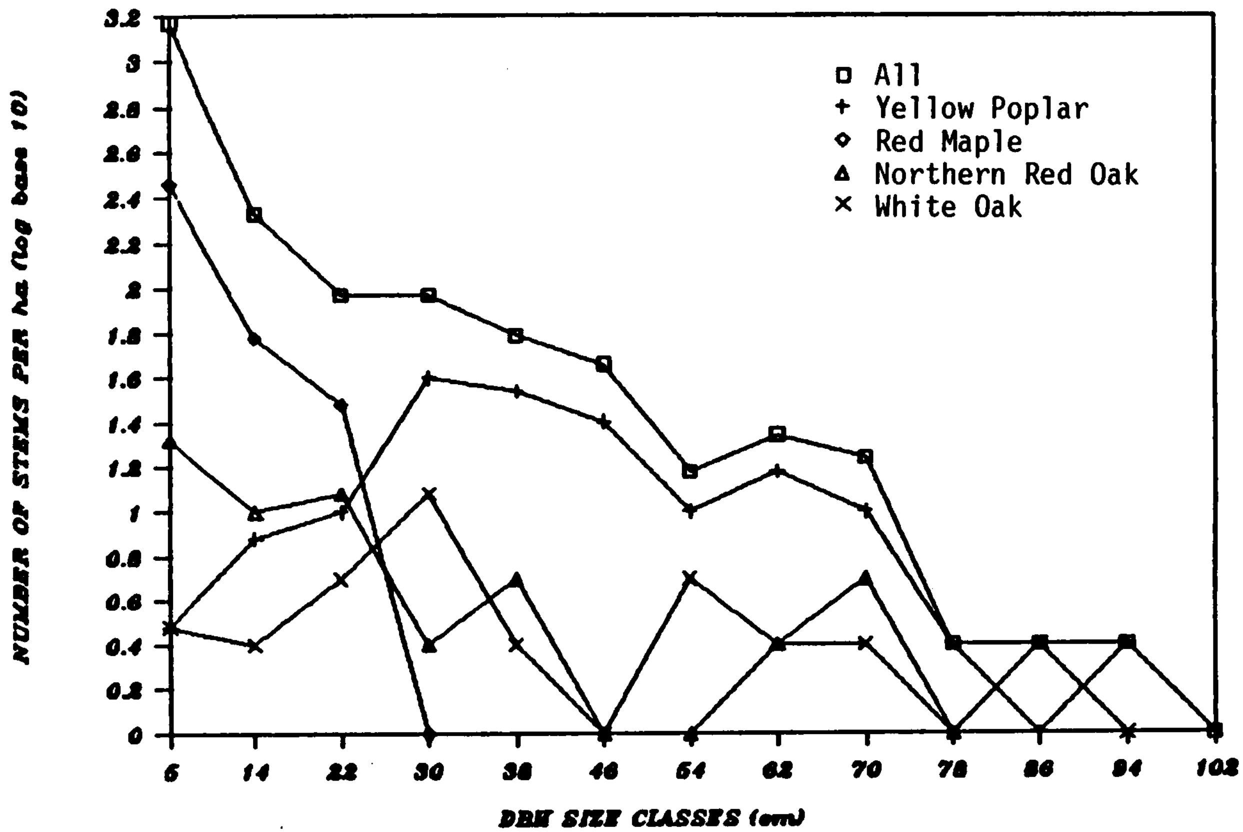

Figure 8. Diameter distribution curves of Yellow Poplar, Red Maple, White Oak, Northern Red Oak and all taxa in the Yellow Poplar Community Type (n=10).

reaches of these coves. Aspect was dominantly south or southeast. Slope gradient ranged from 10-65%; a wide variety of slope classes were equally represented. Vertical and horizontal slope shape ranged from convex to concave--the planar shape dominated (Table 10; Table 22, Appendix A).

The soils were extremely, very strongly or strongly acid, had a moderate to high coarse fragment content, had moderate available water holding capacity and were deep and well drained. Textures of the A horizon were loams and silt loams; B horizon textures were predominantly silty clay loams, silt loams and loams. The soils in 60% of the plots were classified as Typic Hapludults and belonged to the Grimsley, Jefferson or Shelocta series. Small areas of well drained, deep soils with thick dark surfaces occurred on north aspects at high elevations. Small areas of residual soils also occurred. These soils were classified as Typic Dystrochrepts or Typic Haplumbrepts. No series designation exists for these soils. Fire was evident in 80% of the plots of this type.

In the Cumberland Mountains, Martin (1966) described a yellow poplar type on the upper slopes of ridges which extended into protected north-facing draws. Northern red oak, white oak and chestnut oak were important associates in his type. Cabrera (1969) reported yellow poplar an important codominant in his sugar maple-yellow poplar-basswood segregate. Yellow poplar was most dominant in draws with a northerly aspect. Hinkle (1975) described a yellow poplar-mixed oak-hickory community; it occurred on south-facing, middle to upper draw positions below 750 m on Cumberland Mountain. Chestnut oak and

Table 10. Site and soil characteristics of the Yellow Poplar Community Type (n=10).

Environmental Variables	Mean ± S.E.	Range
Slope angle (percent)	35.0 ± 6.2	10.0 - 65.0
Aspect*	0.81 ± 0.15	0.29 - 1.64
Slope position (percent from ridgetop)	76.4 ± 6.6	40.0 - 100.0
Elevation (m)	592.9 ± 35.7	442.0 - 762.0
Vertical slope shape*	2.0 ± 0.2	1.0 - 3.0
Horizontal slope shape*	2.1 ± 0.2	1.0 - 3.0
Potential insolation (Kly/yr)	287.6 ± 7.4	238.0 - 315.0
pH (water) of A horizon	4.5 ± 0.1	4.1 - 5.3
pH (water) of B horizon	4.5 ± 0.1	4.2 - 4.9
pH (1N KCl) of A horizon	3.8 ± 0.1	3.0 - 4.6
pH (1N KCl) of B horizon	3.6 ± 0.1	3.4 - 3.8
A horizon texture*	7.3 ± 0.2	7.0 - 8.0
B horizon texture*	6.0 ± 0.5	3.0 - 8.0
Available water holding capacity of A horizon (cm)	1.89 ± 0.56	0.60 - 6.40
Available water holding capacity of B horizon (cm), down to 50 cm	3.31 ± 0.42	1.30 - 5.80
Total available water holding capacity (cm), top 50 cm	5.20 ± 0.52	2.80 - 7.70
O horizon thickness (cm)	3.0 ± 0.9	1.0 - 8.0
A horizon thickness (cm)	16.4 ± 3.1	8.0 - 40.0
A horizon coarse fragment content (percent wt.)	40.6 ± 6.6	3.0 - 71.0
B horizon coarse fragment content (percent wt.)	40.2 ± 5.7	14.0 - 64.0
A horizon hue*	2.0 ± 0.0	2.0 - 2.0
A horizon value	3.7 ± 0.2	3.0 - 4.0
A horizon chroma	3.2 ± 0.1	3.0 - 4.0
B horizon hue*	2.0 ± 0.0	2.0 - 2.0
B horizon value	5.0 ± 0.1	4.0 - 6.0
B horizon chroma	6.0 ± 0.4	4.0 - 8.0

*Coding of variables as in Table 16.

white oak were important canopy taxa in his study. Safley (1970) described a yellow poplar-hemlock type on north-facing ridges and draws and a young yellow poplar-sweetgum type on low terraces along the Big South Fork River.

McCarthy (1970) reported a yellow poplar type confined to coves in Fentress County. Sherman (1978) described a virgin yellow poplar-hemlock type associated with mesic taxa on low north-facing draws and ridges in Savage Gulf. Yellow poplar was an important component of his virgin basswood-tulip poplar-sugar maple type and a secondary white oak-tulip poplar type. Quarterman et al. (1972) listed yellow poplar as the fourth most important codominant taxa in virgin mixed mesophytic and oak-hickory-tuliptree types in Savage Gulf; yellow poplar was absent from the understory. Hinkle (1978) described a yellow poplar-northern red oak type on low north-facing slopes of the Cumberland Plateau. Schmalzer (1978) described a yellow poplar type along the Obed River at Dick Cove and Doe Creek on a variety of slope positions. He considered this type successional despite the lack of recent disturbance. Schmalzer (1982) described a tulip poplar type on terraces and low slopes of the Obed river and its tributaries. Yellow poplar dominated the canopy; red maple, white pine and Virginia pine were important associates. Several workers (Braun 1950; Caplenor 1965; Carpenter 1970) have recognized the importance of yellow poplar on disturbed sites. Braun (1950) considered yellow poplar an important associate in the all deciduous mixed mesophytic forest, rarely achieving dominant status in virgin stands. Smith (1977) reported a successional yellow poplar type on some lower draws on the Plateau surface. Yellow poplar types have been described in the Ridge and Valley province of Tennessee (Martin 1971; Hedge 1979; Crownover 1983). This type was similar to the SAF type 57 (Eyre 1980) in which yellow poplar, the dominant taxon, was associated with a wide variety of species.

Sugar Maple-White Basswood-Yellow Poplar-Yellow Buckeye Community Type (n=30)

The sugar maple-white basswood-yellow poplar-yellow buckeye community was the most widely distributed type in this study. It occurred on a variety of slope positions and shapes on the north-facing slope of Bird Mountain. Sixteen of the eighteen common canopy species occurred in this type; sugar maple, white basswood, yellow poplar and yellow buckeye were codominant. Black cherry, white ash, northern red oak and cucumber magnolia were important associated species. Common canopy species with less importance were chestnut oak, black locust, sweet birch, beech, white oak, red hickory, pignut hickory and blackgum. Bitternut hickory (Carya cordiformis), yellowwood (Cladrastis lutea) and yellow birch occurred in the canopy (Table 11).

Pignut and red hickories and white and chestnut oaks were canopy species not reproducing. Sugar maple and white basswood were the most important species in the sapling layer, accounting for 67% of the total sapling relative density. Sugar maple and white basswood were well represented in all tree diameter classes and may be considered stable, self-sustaining codominants. Yellow buckeye and yellow poplar were well represented in the sapling layer and in smaller diameter

Table 11. Species composition of canopy trees and saplings of the Sugar Maple-White Basswood-Yellow Poplar-Yellow Buckeye Community Type (n=30).

Taxa	Canopy RD	Canopy RBA	Canopy IV	Sapling RD
Acer rubrum				0.5
A. saccharum	27.9	35.0	62.9	54.1
Aesculus octandra	5.2	9.1	14.3	2.8
Betula lenta	0.6	1.0	1.6	1.0
B. lutea	0.9	0.3	1.2	0.4
B. nigra				0.1
Carya cordiformis	1.7	1.5	3.2	1.3
C. glabra	0.3	0.2	0.5	
C. ovalis	0.4	0.7	1.1	
C. ovata	0.6	1.0	1.6	0.1
C. tomentosa	0.1	0.1	0.2	0.2
Castanea dentata				0.2
Cladrastis lutea	1.0	0.3	1.3	4.1
Cornus florida	0.1	0.1	0.2	9.3
Fagus grandifolia	0.6	0.8	1.4	0.7
Fraxinus americana	4.9	5.2	10.1	3.9
Juglans nigra	0.1	0.4	0.5	
Liriodendrum tulipifera	9.8	9.1	18.9	1.2
Magnolia acuminata	2.5	2.0	4.5	1.7
M. macrophylla				0.1
Nyssa sylvatica	0.3	0.2	0.5	0.3
Ostrya virginiana				0.4
Oxydendrum arboreum	0.1	0.1	0.2	
Populus grandidentata				2.4
Prunus serotina	6.2	5.1	11.3	0.5
Quercus alba	0.4	0.9	1.3	
Q. prinus	1.5	2.9	4.4	
Q. rubra	3.8	3.3	7.1	0.5
Q. velutina	0.1	0.1	0.2	
Robinia pseudoacacia	2.4	1.7	4.1	0.1
Sassafras albidum				0.1
Tilia americana				0.3
T. heterophylla	28.6	19.1	47.7	13.4
Ulmus americana				0.4
U. rubra	0.2	0.1	0.3	0.4
BA/ha(m^2)(ft^2/ac)		50.6(220.4)		
D/ha(D/ac)	518.1(209.8)			1592.0(644.5)

classes (Figure 9). These species populations were apparently stable. Dogwood, yellowwood and white ash were important understory species. Red maple, sweet birch, American chestnut, big leaf magnolia, big toothed aspen (Populus grandidentata), sassafras (Sassafras albidum), basswood and American elm were present in the sapling layer but absent from the canopy. Shrubs and vines present in this type included maple-leaved viburnum, greenbriar, grapes and dutchmans pipe (Aristolochia durior) (Table 23, Appendix A).

This type occurred on lower middle to upper sideslopes, ridgetops and draws on the north-facing slopes of Bird Mountain. Eighty percent of the plots had a north or northwest aspect. Slopes were steep to very steep with 57% of the plots having a gradient of 50% or more. Vertical and horizontal slope shapes were predominantly convex; roughly 25% of the shapes were planar and 20% were concave (Table 22, Appendix A).

The soils were extremely, very strongly or strongly acid. The mean pH of the A and B horizons was 4.7, the highest of all community types (Table 12). Coarse fragment content of the soil was moderate to high and available water holding capacity was moderate to low. Textures of the A horizon were loams or silt loams with B horizon textures more variable but primarily silty clay loams, silt loams, clay loams and silty clays. The O horizons were the thickest of any community type; A horizons were thicker and darker than all community types except for the black cherry type.

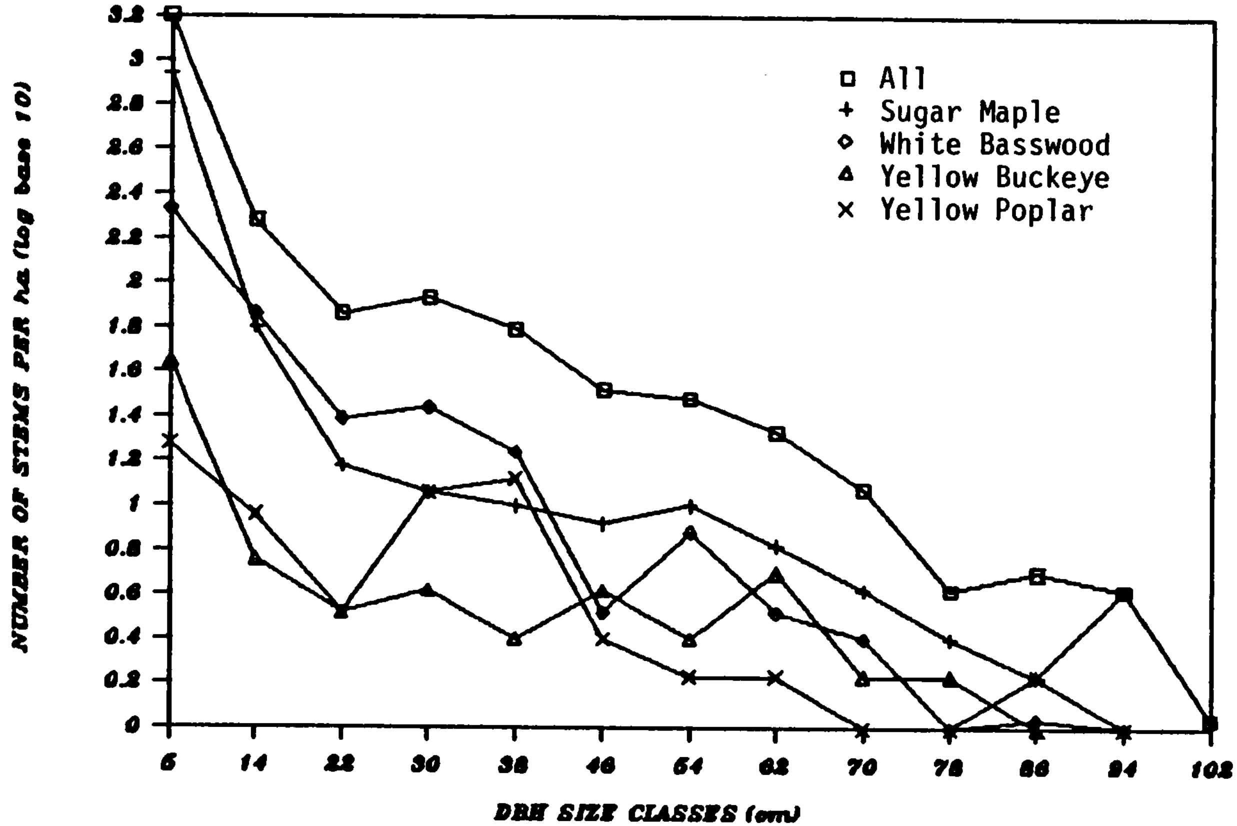

Figure 9. Diameter distribution curves of Sugar Maple, White Basswood, Yellow Poplar, Yellow Buckeye and all taxa in the Sugar Maple-White Basswood-Yellow Poplar-Yellow Buckeye Community Type (n=30).

Table 12. Site and soil characteristics of the Sugar Maple-White Basswood-Yellow Poplar-Yellow Buckeye Community Type (n=3).

Environmental Variables	Mean ± S.E.	Range
Slope angle (percent)	52.2 ± 2.2	35.0 - 75.0
Aspect*	1.59 ± 0.09	0.18 - 2.00
Slope position (percent from ridgetop)	34.5 ± 4.9	0.0 - 90.0
Elevation (m)	756.8 ± 22.3	487.0 - 930.0
Vertical slope shape*	1.6 ± 0.1	1.0 - 3.0
Horizontal slope shape*	1.7 ± 0.1	1.0 - 3.0
Potential insolation (Kly/yr)	194.5 ± 7.7	136.0 - 316.0
pH (water) of A horizon	4.7 ± 0.1	3.7 - 5.5
pH (water) of B horizon	4.7 ± 0.1	3.7 - 5.4
pH (1N KCl) of A horizon	4.0 ± 0.1	3.3 - 4.9
pH (1N KCl) of B horizon	3.7 ± 0.1	3.3 - 4.4
A horizon texture*	7.2 ± 0.1	5.0 - 8.0
B horizon texture*	5.7 ± 0.3	1.0 - 8.0
Available water holding capacity of A horizon (cm)	2.21 ± 0.13	1.21 - 3.93
Available water holding capacity of B horizon (cm), down to 50 cm	2.55 ± 0.17	0.63 - 4.30
Total available water holding capacity (cm), top 50 cm	4.76 ± 0.20	1.80 - 6.74
O horizon thickness (cm)	4.7 ± 0.3	2.0 - 9.0
A horizon thickness (cm)	23.8 ± 1.1	14.0 - 33.0
A horizon coarse fragment content (percent wt.)	44.9 ± 2.8	18.0 - 77.0
B horizon coarse fragment content (percent wt.)	42.7 ± 2.5	11.0 - 81.0
A horizon hue*	2.0 ± 0.0	2.0 - 2.0
A horizon value	3.6 ± 0.1	3.0 - 5.0
A horizon chroma	3.2 ± 0.1	2.0 - 4.0
B horizon hue*	2.0 ± 0.0	2.0 - 2.0
B horizon value	4.7 ± 0.1	4.0 - 5.0
B horizon chroma	4.6 ± 0.2	3.0 - 8.0

*Coding of variables as in Table 16.

A wide variety of soils occur within this type due to differences in elevation, parent material, slope shapes and aspect. Soils on upper north-facing slopes were classified Humic Hapludults, Typic Haplumbrepts and Umbric Dystrochrepts. Soils on middle and lower slope positions were Typic Hapludults (Jefferson and Grimsley), Typic Dystrochrepts (Petros) and Lithic Dystrochrepts (Ramsey). Series designation was variable and depended on coarse fragment content in the control section, mineralogy, depth to bedrock and nature of the parent material (i.e. colluvium or residuum). Soils on ridgetops were classified as Typic or Lithic Dystrochrepts and Ochreptic Hapludults. These soils formed in acid sandstone residuum and were excessively well drained. Evidence of fire was observed on 80% of the plots.

This community was similar to Braun's (1950) sugar maple-white basswood-yellow buckeye-yellow poplar segregate of the all deciduous mixed mesophytic forest of the Cumberland Mountains. In outlying areas (Wartburg Basin) this segregate occurred locally on north-facing slopes and had no relation to elevation (Braun 1950). Comparison of this type with Braun's (1950) sugar maple-white basswood-yellow buckeye-yellow poplar segregate and the all deciduous mixed mesophytic forest of the Cumberland Mountains yielded a Jaccard similarity index (Mueller-Dombois and Ellenberg 1974) of 64% and 65% respectively. Braun (1950) states that beech may be absent at higher elevations within this type; beech is not very important (IV=1.4) in the present type and is restricted to low elevations (below 600 m). Martin (1966) reported a yellow poplar type which contained a few stands of white basswood, buckeye and bitternut hickory. Cabrera (1969) described a sugar maple-yellow poplar-basswood-buckeye segregate in north-facing draws on Ash Log Mountain; it differed from the present type in the importance of white basswood.

Caplenor (1965) described a mixed mesophytic type on a variety of sites in the gorges of Fall Creek Falls State Park which differed from the present type in the importance of pignut hickory, buckeye and hemlock. Sherman (1978) described a virgin white basswood-yellow poplar-sugar maple type on low to middle north-facing slopes and a secondary sugar maple-white basswood type on middle to upper north-facing slopes in Savage Gulf. Quarterman et al. (1972) reported a virgin mixed mesophytic type on north-facing slopes in Savage Gulf dominated by nine species; white basswood, hemlock, sugar maple and yellow poplar were most important. McCarthy (1976) described a cove hardwood forest in Fentress County; basswood and buckeye were absent.

Schmalzer (1978) reported a white basswood-sugar maple-buckeye type on northerly middle and low slopes and draws at Dick Cove and Doe Creek. The SAF recognized a sugar maple-basswood type (26) which occurred primarily in central Minnesota and western Wisconsin but extends south into the southern Appalachians (Eyre 1980).

<u>Black Cherry-Sugar Maple Community Type (n=3)</u>

On Bird Mountain, the black cherry-sugar maple type occurred on upper north-facing slopes, above elevations of 825 m. Ten of the eighteen common canopy species occurred in this type; black cherry and sugar maple were codominant. Associated canopy species included white basswood, white ash, cucumber magnolia and to a lesser extent northern red oak, yellow poplar, black locust and red maple (Table 13). Six of

Table 13. Species composition of canopy trees and saplings of the Black Cherry-Sugar Maple Community Type (n=3).

Taxa	Canopy RD	Canopy RBA	Canopy IV	Sapling RD
Acer rubrum	3.3	0.7	4.0	5.0
A. saccharum	34.3	24.0	57.3	63.7
Aesculus octandra				1.3
Carya cordiformis	1.0	0.3	1.3	
C. ovata	1.7	6.0	7.7	
Castanea dentata				0.3
Cladrastis lutea				1.3
Cornus florida				2.0
Fagus grandifolia				0.3
Fraxinus americana	2.7	5.0	7.7	3.3
Liriodendron tulipifera	1.7	2.7	4.4	
Magnolia acuminata	4.7	2.0	6.7	5.0
Nyssa sylvatica				2.3
Prunus serotina	31.3	44.7	76.0	3.3
Quercus alba	0.7	0.3	1.0	
Q. rubra	3.6	1.3	4.9	
Q. velutina	1.7	6.3	8.0	
Robinia pseudoacacia	2.3	2.0	4.3	
Tilia heterophylla	11.3	6.7	18.0	11.4
BA/ha(m^2)(ft^2/ac)		56.3(245.2)		
D/ha(D/ac)	794.3(321.6)			1194.3(483.5)

the ten canopy species were reproducing; sugar maple and white basswood accounted for 75% of the total sapling relative density; cucumber magnolia, red maple, black cherry and white ash were less important. Black cherry, sugar maple and white basswood were well represented in the smaller dbh classes. Sugar maple was sporadically present and white basswood and black cherry were absent from the larger dbh classes (Figure 10). The high level of sugar maple and basswood reproduction relative to black cherry suggests an increasing importance of these species in the future. Black cherry reproduction was adequate to maintain its status within this type.

Species present in the sapling layer but absent from the canopy included yellow buckeye, American chestnut, yellowwood, dogwood, beech and blackgum. Species present in the canopy but absent from the understory included bitternut and pignut hickories, yellow poplar, white, northern red and black oaks and black locust.

This type occurred on upper north and east-facing spur ridge shoulders and sideslopes above elevations of 825 m. Slopes were steep and dominantly convex (Table 14; Table 22, Appendix A). The soils were extremely acid, moderate to very high in coarse fragment content, low in available water holding capacity and well drained. The A horizon textures were exclusively loams; B horizon textures were loams, silty clay loams or clay loams. The A horizons were thicker and darker and B horizons darker than any other community type. These soils were classified as fine-loamy, mixed or siliceous, mesic Humic Hapludults and loamy, mixed or siliceous, mesic shallow Typic Haplumbrepts; small areas of Typic Haplohumults and Umbric Dystrochrepts also occurred as

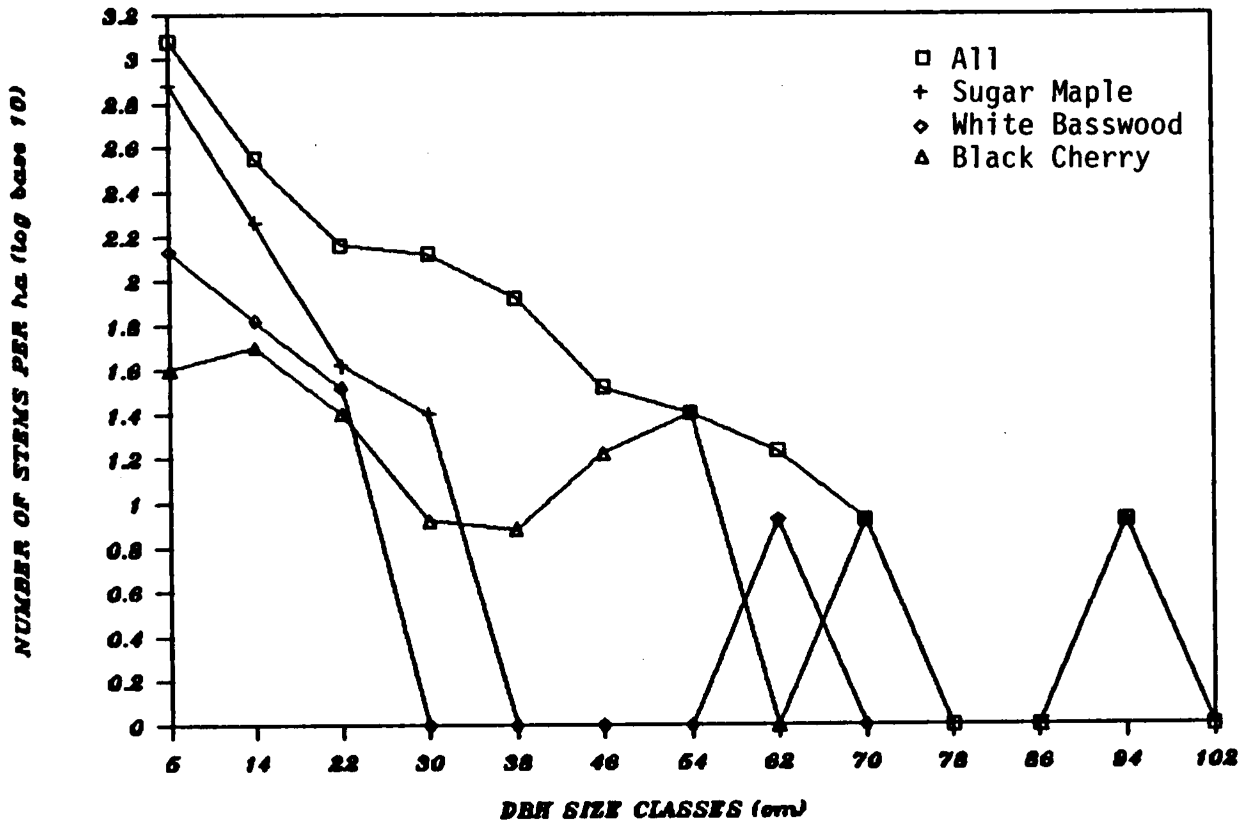

Figure 10. Diameter distribution curves of Black Cherry, Sugar Maple, White Basswood and all taxa in the Black Cherry-Sugar Maple Community Type (n=3).

Table 14. Site and soil characteristics of the Black Cherry-Sugar Maple Community Type (n=3).

Environmental Variables	Mean ± S.E.	Range
Slope angle (percent)	50.0 ± 10.0	40.0 - 70.0
Aspect*	1.55 ± 0.26	1.09 - 2.00
Slope position (percent from ridgetop)	6.7 ± 3.3	0.0 - 10.0
Elevation (m)	883.7 ± 34.9	823.0 - 944.0
Vertical slope shape*	1.3 ± 0.3	1.0 - 2.0
Horizontal slope shape*	1.6 ± 0.7	1.0 - 3.0
Potential insolation (Kly/yr)	216.7 ± 24.0	177.0 - 260.0
pH (water) of A horizon	4.2 ± 0.1	4.0 - 4.4
pH (water) of B horizon	4.5 ± 0.1	4.4 - 4.6
pH (1N KCl) of A horizon	3.7 ± 0.1	3.7 - 3.8
pH (1N KCl) of B horizon	3.7 ± 0.1	3.6 - 3.7
A horizon texture*	7.0 ± 0.0	7.0 - 7.0
B horizon texture*	5.7 ± 0.9	4.0 - 7.0
Available water holding capacity of A horizon (cm)	2.00 ± 0.0	2.00 - 2.00
Available water holding capacity of B horizon (cm), down to 50 cm	2.03 ± 0.8	0.51 - 2.93
Total available water holding capacity (cm), top 50 cm	4.03 ± 0.8	2.53 - 4.94
O horizon thickness (cm)	4.0 ± 0.6	3.0 - 5.0
A horizon thickness (cm)	26.3 ± 7.4	18.0 - 41.0
A horizon coarse fragment content (percent wt.)	48.3 ± 11.1	33.0 - 70.0
B horizon coarse fragment content (percent wt.)	49.4 ± 10.3	34.0 - 69.0
A horizon hue*	2.0 ± 0.0	2.0 - 2.0
A horizon value	3.0 ± 0.0	3.0 - 3.0
A horizon chroma	2.7 ± 0.3	2.0 - 3.0
B horizon hue*	2.0 ± 0.0	2.0 - 2.0
B horizon value	4.3 ± 0.3	4.0 - 5.0
B horizon chroma	4.6 ± 0.7	4.0 - 6.0

*Coding of variables as in Table 16.

inclusions. Soils classified as Humic Hapludults formed in colluvium, while soils classified as Typic Haplumbrepts formed in residuum. Both were well drained and had a thick, dark surface high in organic carbon. The Typic Haplohumults have more than 0.9% organic carbon in the upper 15 cm of the argillic horizon; this was the major difference between the Typic Haplohumults and the Humic Hapludults. No series were assigned to these soils with umbric epipedons.

No black cherry-sugar maple type has been reported on the Cumberland Plateau and Mountains. The SAF type 28, black cherry-sugar maple, occurred widely below 670 m on the Allegheny Plateau of northern Pennsylvania and southern New York, in scattered stands of the Allegheny Mountains in Maryland, West Virginia and Pennsylvania, and up to 1,200 m in the southern Appalachians (Eyre 1980). The present type has resulted from disturbance of some previous type and represents an intermediate stage of succession. The high level of sugar maple and white basswood reproduction relative to black cherry, has been noted and suggests increased importance of these shade tolerant species. Black cherry, a shade intolerant species, will gradually be replaced by these more shade tolerant species; community composition will shift toward a mixed mesophytic type.

CHAPTER IV

SOIL SURVEY OF BIRD MOUNTAIN

Introduction

Jenny (1941) stated that soils were the product of five interacting factors: climate, organisms, topography, parent material and time. These factors influence or define the pedogenic process which give rise to soil formation. Pedogenic processes include: additions to and removals from the soil, along with translocations and transformations within the soil body. Differential expression of one or more of the soil forming factors will be reflected in the morphology and properties of the soil. Each soil forming factor interacts with and influences the other factors such that the net effect of one particular factor can be difficult to discern. Energy used in soil formation is supplied by the climate and organisms. Topography affects the distribution of solar radiation with resultant modifications in microclimate. The movement of water, above and below ground, is directly related to slope angle, shape and length. Parent material is affected by energy inputs which influence the direction and intensity of the weathering process. Time is considered a neutral soil forming factor; each process acts at a given rate in soil genesis. Young soils have properties inherited from the parent material and are as yet only slightly developed. Older soils have more developed profiles that are produced by a particular soil forming process, which exert more influence as time passes.

A detailed soil survey does not exist for Morgan County, but a general soil association map has been published (USDA Soil Conservation Service 1978). The upland soils of the Cumberland Mountains were mapped as Ramsey-Grimsley association; soils along major drainageways of the mountains were grouped into the Philo, Pope and Sequatchie association. A soil survey of Anderson County (Moneymaker 1981) included a section of the Cumberland Mountains. Grimsley and Jefferson soils were mapped in coves and on footslopes; Muskingum and Gilpin were mapped on sideslopes above Jefferson soils; Ramsey and Petros were mapped on upper sideslopes underlain by residual sandstone and shale, respectively; Zenith soils were mapped on upper north and east-facing slopes. Alluvial soils included a Sewanee-Ealy complex along the current floodplain of the New River. These soils differ from Pope and Philo only in the mineralogy of the control section. Welchland soils were mapped on low terraces.

A progressive soil survey of Campbell County is near completion (personal communication with Clarence Connor, Soil Conservation Service soil scientist). Soils of the Cumberland Mountains have been mapped as complexes. A Muskingum-Sequoia-Petros complex was mapped on ridge crests and middle sideslopes; a Muskingum-Petros complex on upper sideslopes; a Jefferson-Grimsley complex on footslopes and in coves; a Ramsey-Rock outcrop complex on upper slopes; soils in the Lily series have been mapped on ridgetops underlain by acid sandstone; soils in the Cutshin series were mapped on north and east-facing slopes above 900 m.

Smalley (1984) classified forest sites in the Cumberland Mountains. He recognized three subregions, eight landtype associations and thirty landtypes. Within the Wartburg Basin he distinguished forest sites based upon topography, geology and soils. Landtypes included: shallow soils and sandstone outcrops, mountain footslopes, fans, terraces and streambottoms with poor and good drainage, upper mountain and colluvial slopes with north and south-facing aspects, narrow shale ridges and convex upper shale slopes. Landtype descriptions included dominant soils, geographic setting, vegetation, soil drainage characteristics and bedrock type.

Field Methods

Soils were examined along transects which extended across all geomorphic landforms to determine the nature and extent of soils on Bird Mountain. Vegetation transects in conjunction with soil transects were used to define each map unit. Soils were mapped on a 7.5 minute USGS topographic map at 1:24000 scale (Figure 11). Once map units were defined and delineated on the topographic map, areas were examined on random transects to ascertain the distribution of each major soil. A small soil pit or auger hole, to a depth of 1.5 m, was used to collect transect data which included: slope angle, geomorphic position, nature of parent material, aspect, elevation, slope shape, morphology including horizonation, thickness, color, texture, % coarse fragment and pH. Using this information, each soil observation was classified and a series name assigned, when possible, to each soil at a particular location.

Typifying pedons, representative of soils identified during the transect study, were dug and described using the methodology of Chapter 4 of the Soil Survey Manual (Soil Survey Staff 1984). Soils

Figure 11. Soil map of Bird Mountain, Frozen Head State Natural Area.

Symbol	Legend
Gj	Grimsley (taxadjunct)-Jefferson complex, 25 to 60 percent slopes.
Jr	Jefferson-Grimsley-Ramsey (taxadjunct)-Rock outcrop complex, 30 to 70 percent slopes.
Rr	Ramsey (taxadjunct)-Petros (taxadjunct)-Ochreptic Hapludult-Gilpin-Rock outcrop complex, 10-35 percent slopes.
Jh	Jefferson-Grimsley (taxadjunct)-Humic Hapludult-Ramsey (taxadjunct) complex, 25 to 65 percent slopes.
Hh	Humic Hapludult-Typic Haplumbrept complex, 35 to 60 percent slopes.
Th	Typic Hapludult, 0 to 5 slopes.

were classified to the family level using Soil Taxonomy (Soil Survey Staff 1975) and a series name was used when possible. All soils were considered to have a mesic temperature regime. Mineralogy of the control section was not determined and precluded the absolute classification of a soil at the family level. However, most soils were assumed to have either mixed or siliceous mineralogy based on previous mineralogical studies (Franzmeir et al. 1969). Typifying pedon descriptions are in Appendix B, along with descriptions of soils considered inclusions in some mapping units.

Ranges of select morphological properties of established soil series occurring in or near Frozen Head State Natural Area is given in Table 15; classification is given in Appendix C. Properties considered most valuable to field identification and classification were obtained from soils official series sheets published by the Soil Conservation Service.

Laboratory Methods

Soil samples from typifying pedons were collected and air dried to determine pH and percent organic carbon for each horizon. The pH was determined using a Leeds and Northrup pH meter in a 1:1 soil-water suspension as specified in Soil Survey Investigations Report No. 1 (Soil Survey Staff 1972). Percent organic carbon was determined with a Leco Model CR-12 carbon analyzer. Available water holding capacity using fine earth texture and coarse fragment content of the entire pedon was calculated and is expressed as cm H_2O/cm soil. These data are included with each pedon description. No other chemical or physical soil characterization were performed.

Table 15. Range of select morphological properties for established soil series occurring in or near Frozen Head State Natural Area.

Soil Series	Moist Color of A: Hue	Moist Color of A: Value/Chroma	Texture of A*	% Coarse Fragments in A	Moist Color of B: Hue	Moist Color of B: Value/Chroma	Texture of B*	% Coarse Fragments in B	% Coarse Fragments in C	Solum Thickness (cm)	Depth to Bedrock (cm)	Diagnostic Horizons
Berks	10YR	3/ to 5/ /3	l, sil (sh, ch)	10-30	7.5YR, 10YR	5/ to 6/ /6 to /8	l, sil (sh, vsh, ch, vch)	25-75	60-80	45-90	50-100	ochric cambic
Cutshin	10YR	2/ to 3/ /2 to /3	l, cl, scl, sl (ch, fl, gr)	10-35	7.5YR, 10YR	4/ to 6/ /3 to /6	l, cl, scl, sl (ch, fl, gr)	10-35		100->200	100->200	umbric cambic
Ealy	10YR	3/ to 4/ /2 to /4	l, fsl	<15	10YR	3/ to 4/ /2 to /4	l, fsl	<15	<15	75-150	>150	ochric cambic
Gilpin	10YR	3/ to 5/ /2 to /4	l, sil (sh, ch)	5-40	7.5YR, 10YR, 2.5Y	5/ /4 to /8	l, sil, sicl (sh, ch)	5-40	30-90	45-90	50-100	ochric argillic
Grimsley	10YR	3/ to 5/ /3 to /4	l, sl (cb, vcb, st, vst)	15-50	7.5YR, 10YR	4/ to 5/ /4 to /8	l, cl, scl, sl (cb, vcb, st, vst)	35-65	35-65	100-150	100-150	ochric argillic
Jefferson	10YR	3/ to 5/ /1 to /3	l, fsl, sl (cb, st)	5-35	7.5YR, 10YR	4/ to 6/ /4 to /8	l, cl, scl (cb, st)	5-35	20-80	100-150	>150	ochric argillic
Lily	7.5YR, 10YR	4/ to 6/ /2 to /4	l, fsl, sl (gr, st)	0-30	5YR, 7.5YR, 10YR	4/ to 6/ /4 to /8	l, cl, scl (gr, st)	0-35	0-35	50-100	50-100	ochric argillic
Muskingum	7.5YR, 10YR	3/ to 5/ /3 to /6	l, sil, fsl (ch)	<30	7.5YR, 10YR	4/ to 5/ /4 to /6	sil (ch)	10-30	>35	40-90	50-100	ochric cambic
Petros	10YR	3/ to 5/ /1 to /4	l, sil (sh)	15-35	7.5YR, 10YR	5/ /3 to /6	sil, sicl (sh, vsh)	35-80		25-50	>50	ochric cambic
Pineville	7.5 YR, 10YR	2/ to 4/ /1 to /3	l, sil, sl (ch, vch)	10-60	7.5YR, 10YR	4/ to 6/ /4 to /8	l, cl, sl (ch, vch)	10-60	10-60	100-150	>180	ochric argillic
Ramsey	10YR	3/ to 5/ /2 to /4	l, fsl, sl (gr)	<35	7.5YR, 10YR	4/ to 6/ /4 to /8	l, fsl, sl (gr)	<35		18-50	18-50	ochric cambic

Table 15 (continued)

Soil Series	Moist Color of A: Hue	Moist Color of A: Value/Chroma	Texture of A*	% Coarse Fragments in A	Moist Color of B: Hue	Moist Color of B: Value/Chroma	Texture of B*	% Coarse Fragments in B	% Coarse Fragments in C	Solum Thickness (cm)	Depth to Bedrock (cm)	Diagnostic Horizons
Sewanee	10YR	4/ to 6/ /2 to /3	l, sil, fsl	0-15	7.5YR, 10YR	4/ to 6/ /3 to /4	l, sil, fsl	0-15	0-30	65-100	100-150	ochric cambic
Shelocta	7.5YR, 10YR, 2.5Y	4/ to 5/ /2 to /4	l, sil (ch, sh, gr)	<35	7.5YR, 10YR, 2.5Y	4/ to 6/ /4 to /8	sil, sicl (ch, sh, gr)	5-45	5-70	100->150	120->300	ochric argillic
Wallen	10YR	4/ to 6/ /3 to /6	l, sil, sl, fsl (gr, ch, cb)	15-35	7.5YR, 10YR	5/ to 6/ /4 to /6	l, sil, sl, fsl (gr, ch, cb)	35-70	35-70	50-100	50-100	ochric cambic
Welchland	7.5YR, 10YR	3/ /2 to /4	l, sl (gr, cb, st)	15-35	5YR, 7.5YR, 10YR	4/ to 5/ /3 to /6	l, cl, scl, sl	20-60	20-60	75-150	>180	umbric-like or umbric argillic
Zenith	7.5YR, 10YR	2/ to 3/ /1 to /3	l, sil (ch)	10-30	7.5YR, 10YR	4/ to 5/ /4 to /8	l, cl, sicl (ch)	15-35	1-35		100-175	umbric-like cambic

*l = loam, sil = silt loam, sicl = silty clay loam, sl = sandy loam, fsl = fine sandy loam, scl = sandy clay loam, cl = clay loam, sh = shaly, vsh = very shaly, ch = channery, vch = very channery, gr = gravelly, cb = cobbly, vcb = very cobbly, st = stony, vst = very stony, fl = flaggy.

Source: Official soil series descriptions published by USDA - Soil Conservation Service.

Vegetation plots were randomly located without regard for soils. After soil mapping was completed, each vegetation plot was relocated on the soil map. The soil identified in the center of each plot was compared with the dominant soils identified in the map unit. Mean values for site and soil characteristics are given in Chapter V.

Local Geomorphology

Topography of Frozen Head State Natural Area is characterized by narrow ridge crests, steep, flat to convex upper sideslopes, flat to concave footslopes, lower toeslopes and nearly level discontinuous floodplains. Slope gradient ranges from greater than 100% on upper sideslopes to nearly level on toeslopes and floodplains. Elevation ranges from 410 m at park headquarters, along the North Prong Flat Fork River to 1013 m at the top of Frozen Head Mountain. Other prominent peaks include Bald Knob, 990 m, Squire knob, 1,000 m, and Old Mac Mountain, 933 m. Maximum relief of the area is 600 m with local relief ranging from 300 to 450 m.

Ridge crests are typically very narrow, less than 50 m wide, nearly level and capped with resistant sandstone. Higher knobs of the area are doubly convex and occupy a small percent of the landscape. Soils are usually thin, less than 50 cm, well to excessively well drained, poorly developed and are classified as Lithic Dystrochrepts and Ochreptic Hapludults.

Upper mountain sideslopes are very steep with planar to convex shapes and are geomorphically very active. Slopes are long, irregular and form a series of flat narrow benches, underlain by sandstone, and convex backslopes underlain by shale and siltstone. This stairstep pattern is evident throughout the Natural Area. Sandstone escarpments, up to 15 m high, occur above the 800 m level and are a major source of colluvium. Sandstone and shale colluvium occur on flat to concave slopes and may extend to the ridge crest. Residual soils are shallow, less than 1 m deep and well drained. A thin layer of soil creep material mantles most residual soils. Colluvial soils are deep, well drained and contain more coarse fragments than residual soils.

Lower mountain slopes are generally planar to concave and are an active site of colluvium deposition and soil creep. Slopes gradients are less steep, colluvium is more extensive and soils are more developed than on upper convex slope positions. On toeslopes with lower slope gradients soil drainage problems are evident by the presence of low chroma mottles in the upper 60 cm of the soil. Most soils formed in colluvium; residual soils are restricted to narrow convex spur ridges and the shale backslopes of the "stairstep" landform.

Drainage of the area is dendritic - most streams are of 1st or 2nd order. In the upper reaches of 1st order streams, the gradient is steep, floodplains are narrow and discontinuous, and there is little or no soil development on very steep sideslopes. In the lower reaches of 2nd order streams, gradients are lower, floodplains are wider and continuous with deep, well developed soils on terraces, and colluvial toeslopes. Colluvium is actively funneled into narrow 1st order drainageways.

The Tennessee Valley Basin Divide is within the Natural Area. Most of the Natural Area drains into the Emory River, a tributary of the Tennessee River. Headwaters of the Emory River are on the north side of Bird Mountain and flow southwest to the Obed River; from this point it follows a southeast course to the Tennessee River. Headwaters of the New River are on the east side of the Natural Area park; it is a trunk tributary of the Big South Fork of the Cumberland River. The New River drains much of the northern Cumberland Plateau and Wartburg Basin in Tennessee. The Big South Fork River flows north and is a major tributary of the Cumberland River.

Topography and Microclimate

The effects of topography and microclimate on soil genesis have been inferred from many studies. In the Cumberland Mountains, topography has a major influence upon microclimate, which in turn affects soil formation and vegetation distribution. Slope orientation, especially to the north and south results in both vegetational and microclimatic extremes. The pedogenic processes are modified by microclimate such that the direction and intensity of soil formation differs on opposing slopes. Qualitative studies of microclimate, soils and vegetation will be reviewed, with emphasis on differential soil formation.

Cooper (1960) studied soil genesis in relation to microclimates on north and south-facing slopes on the George Reserve in southwestern Michigan. He stated that differences in microclimates produced by topography offer "controlled experiments" in which three factors of soil formation (regional climate, parent material and time) could be in a steady state for certain periods of time. Soil and air temperatures, evaporation rates and light intensities were higher on south slopes.

Cycles of freezing and thawing, wetting and drying and biotic weathering were major factors accounting for redder hues and greater clay content in the B horizon on south slopes. North slopes had higher soil moisture and lower minimum air temperatures (more water was available for leaching and deep weathering).

Finney et al. (1962) studied the influence of microclimate on soil morphology of the Allegheny Plateau in Ohio. Soils on the southwest slopes had thinner A horizons, more developed E and B horizons, and higher leaf litter temperature. They also had lower available water holding capacity, pH, percent base saturation, total organic carbon and C/N ratio relative to northeast slopes. The vegetation on southwest slopes was mixed oak and the northeast slopes was mixed mesophytic. Differences in soil morphology and chemistry were related to microclimatic regimes and vegetation. Other factors interacting to influence microclimate included slope configuration and distribution of colluvial material. Soils on northeast-facing slopes were Ochrepts; southwest slopes were dominated by Udalfs (Birkeland 1984).

Franzmeier et al. (1969) reported soil properties related to slope aspect, postion and shading in Frozen Head State Natural Area, Morgan County, Tennessee. Particle size distribution, percent base saturation and soil temperature were dependent upon slope position. Soils on low slope positions were cooler and had higher base saturation than upper slope soils; soils on middle slopes had the highest coarse fragment content. Most horizons had base saturations less than 50% and pH values less than 5.0. Soils on south-facing non-shaded slopes were:

hotter, lighter in color, and lower in organic matter content and total available soil water. Argillic horizons were more prevalent on south slopes; Hapludults were common. Cambic horizons occurred on north slopes; Dystrochrepts were dominant. Soils were deeper to paralithic on north-facing slopes. Clay mineralogy was similar on both slopes. The dominant weathering process was the conversion of mica to vermiculite; kaolinite weathering occurred in the upper horizons. No Al-chlorite was recorded by X-ray analysis. The coarse silt fraction was dominated by quartz, but there was an ample supply of weatherable feldspars and mica. The clay fraction of the acid shale bedrock was composed primarily of mica and kaolinite with small amounts of vermiculite and interstratified vermiculite-mica.

Losche et al. (1970) studied the affect of slope orientation on steeply sloping mountain landscapes in Virginia and North Carolina. The Virginia soils, which formed in acid sandstone and shale in the Ridge and Valley province, showed little variation in morphological, physical, chemical and mineralogical properties with respect to aspect and slope position. The highly siliceous parent material, devoid of precursor minerals, precluded significant morphological soil differentiation on opposite slopes with different soil tempertures. The North Carolina soils, developed in granitic biotite gneiss, showed profile differentiation on opposing slopes. South slope soils were: warmer, deeper, redder, had stronger structure and contained more clay in the B horizon than north slope soils. Gibbsite dominated the clay mineral fraction and indicated a more advanced stage of weathering. Kaolin and pedogenic 2:1-2:2 intergrade minerals occurred in north slope soils. Differentiation of soil properties on opposing slopes was due to a large amount of weatherable minerals in the gneiss, higher annual precipitation and aspect related soil temperature differences. No differences were measured in the amount of exchangable cations, KCl displaced Al, and organic matter with respect to aspect and slope position at the two sites.

Bailey and Avers (1971) studied soils from deep mountain colluvium on the western edge of the Cumberland Plateau and the Eastern Highland Rim in Kentucky. Soils developed in colluvium from Pennsylvanian age bedrock (sandstone, shale) were dominantly Shelocta (Typic Hapludults) while Cranston (Typic Hapludalfs) developed in colluvium from Mississippian age bedrocks (limestones). The Cranston soil with its high base status and aspect variability provided better growth conditions than Shelocta.

Hutchins et al. (1976) related the effects of microclimate on soils and vegetation on northeast and southwest-facing slopes of Robinson Forest, located on the Cumberland Plateau in eastern Kentucky. Soils on southwest-facing slopes had higher temperatures, lower available water holding capacity and lower pH relative to northeast slopes. A mixed oak-hickory forest occurred on southwest slopes; northeast slopes supported a more diverse mesophytic forest dominated by yellow poplar, cucumber magnolia and white basswood. Soils on both slopes were Typic Hapludults, differing in particle size class; the control section of the southwest-facing soils were coarse-loamy (Rigley) and northeast slopes fine-loamy (Shelocta).

Knight (1979) studied the relationship of soils and vegetation to topography in the Cumberland Mountains of Campbell County, Tennessee. Morphological, physical and chemical differences were related to aspect induced microclimates. Soils on north-facing slopes had thicker sola, darker and thinner surface layers and contained more organic carbon and available water than soils on south slopes. Morphological differentiation between A and B horizons was less pronounced on north aspects. North and south aspects were dominated by Dystrochrepts and Hapludults, respectively. Vegetation differences were related to moisture conditions of the soil; shallow, rocky soils supported more xeric taxa due to a lower available water holding capacity.

Map Unit Descriptions

Ridgetop Map Unit: Ramsey (taxadjunct)-Petros (taxadjunct)-Ochreptic Hapludults-Gilpin-Rock Outcrop Complex, 10 to 35% Slopes. This unit consists of soils that formed in residuum weathered from acid sandstone, siltstone and shale, which occur on ridgetops, knobs and upper shoulder slopes of Bird Mountain (Figure 12). Rock outcrops and soils are so intermingled that it is impractical to map them separately. Each soil occupies 15 to 30% of the map unit.

Ramsey (taxadjunct) channery silt loam occurs on ridgetops underlain by acid sandstone. It is shallow (less than 50 cm to hard bedrock), loamy, excessively well drained, strongly acid and exhibits little profile development. Available water holding capacity is very low due to solum thickness and high coarse fragment content. This soil

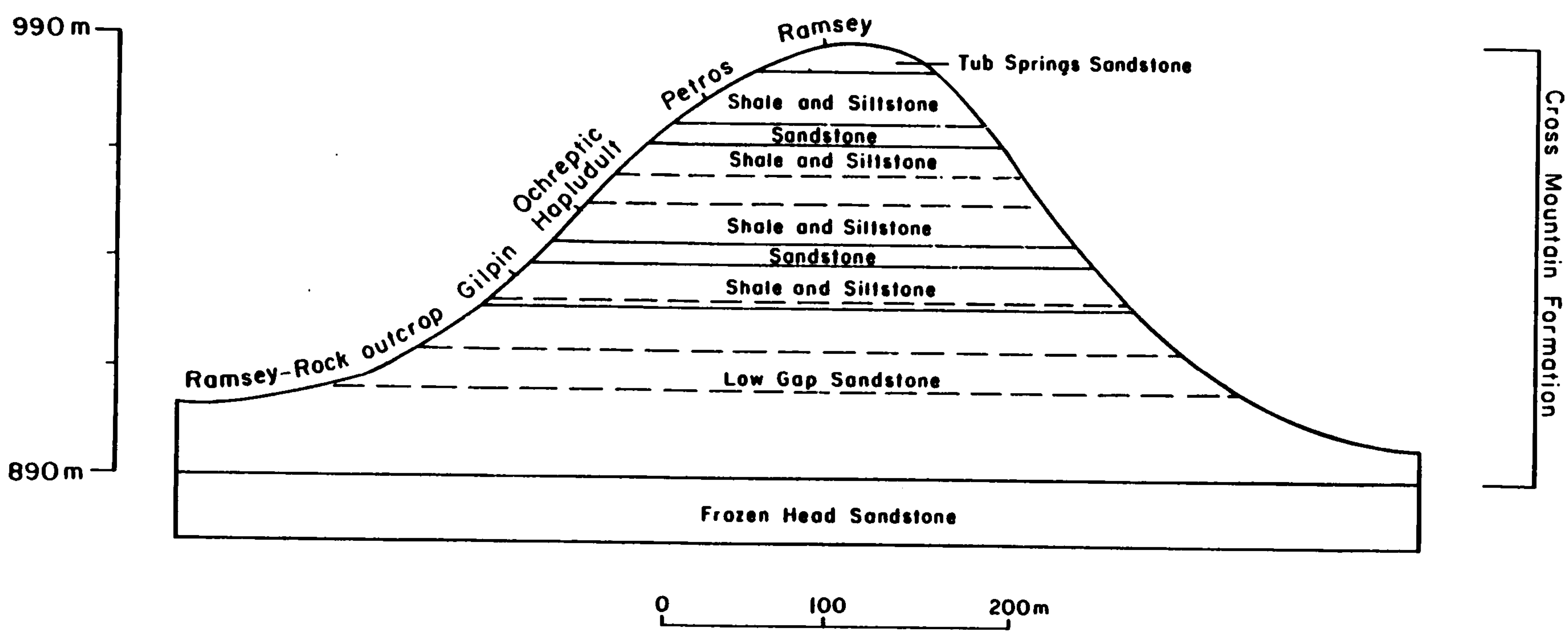

Figure 12. Cross sectional diagram of soils and geology of Bald Knob and the ridgetop of Bird Mountain, Frozen Head State Natural Area.

is geographically associated with Jefferson and Grimsley soils. Ramsey (taxadjunct) is a member of the loamy, siliceous, mesic family of Lithic Dystrochrepts. It differs from the Ramsey series in texture of the A horizon.

Petros (taxadjunct) gravelly loam occurs on steep, convex sideslopes of spur ridges and knobs of Bird Mountain underlain by residual acid siltstone and shale. It is shallow (less than 50 cm to paralithic soft shale), skeletal, very strongly acid, excessively well drained, and has a very low available water holding capacity. Profile development is weak due to steep, convex slopes. Depth to soft shale bedrock (Cr horizon) decreases as slope angle increases. Petros is a member of the loamy-skeletal, mixed, mesic shallow family of Typic Dystrochrepts. The Petros typifying pedon (Figure 15, Appendix B) is slightly deeper to the Cr horizon than the range allows, and is considered a taxadjunct. Berks, a soil in the same subgroup, has a solum 50 to 100 cm deep and formed in acid shale and siltstone residuum. It is an inclusion in this map unit.

The Ochreptic Hapludult loam is a shallow, very strongly acid, excessively well drained soil that is transitional between the Petros and Gilpin series. Available water holding capacity is very low. It occupies slopes less steep than Petros and is underlain by siltstone, shale and interbedded sandstone residuum. On the high knobs of Bird Mountain, this soil occurs at a middle slope position, below the Petros soil and above the Gilpin soil. An argillic horizon, less than 25 cm thick, is indicative of a more developed soil. Textures of the A horizon are loam or silt loam; colors are dark brown, brown and dark yellowish brown. The Bt horizon textures are silty clay loam or clay loam and generally contain less than 30% clay; colors are dark yellowish brown or yellowish brown. Soft, highly weathered and fractured saprolite occurs at less than 50 cm and contains pockets of soil material and roots. The typifying pedon (Figure 16, Appendix B) is classified in the loamy, mixed, mesic shallow family of Ochreptic Hapludults. Small areas of a skeletal variant are inclusions in this map unit (Figure 17, Appendix B). No series designation currently exists for these soils.

Gilpin silt loam occupies a position below the Ochreptic Hapludult on high knobs and lower gradient slopes of spur ridges on Bird Mountain. Residual acid siltstone, shale and rarely interbedded sandstone are the parent material. Solum thickness and depth to soft saprolite range from 50 to 100 cm. This soil is well drained, very strongly acid, and has moderate available water holding capacity. Gilpin is a member of the fine-loamy, mixed, mesic family of Typic Hapludults. The Gilpin typifying pedon (Figure 18, Appendix B) is on a doubly convex spur ridge, at an elevation of 790 m.

Sandstone rock outcrops occur throughout this unit and occupy up to 25% of the area. Ridgetops, upper sideslopes and upper slopes of knobs are frequent sites of outcrops. Ramsey and Ochreptic Hapludult are geographically associated soils which formed in acid sandstone residuum.

An analysis of vegetation plots occurring in the map unit reflects the xeric nature of these sites. Total basal area, canopy tree density and sapling density are lowest of all map units. Eight of the eighteen common canopy trees occur in this unit, with chestnut oak and northern red oak accounting for 53% of the overstory importance (Table 25, Appendix C). The understory is dominated by sugar maple, red maple and dogwood. Sugar maple, chestnut oak and northern red oak are reproducing (Table 26, Appendix C).

Site and soil characteristics for vegetation plots are given in Appendix C, Table 27. Slopes are nearly level on ridgetops and range to 60% on knobs and spur ridges; slope shape is convex to planar. Available soil water holding capacity for the upper 50 cm is very low to low and soil pH of the A and B horizons is very strongly acid, the lowest of any map unit.

South-Facing Map Unit: Jefferson-Grimsley-Ramsey (taxadjunct)-Rock Outcrop Complex, 30 to 70% Slopes. This unit consists of soils that formed in acid sandstone residuum and colluvial material moved downslope by mass wasting. Colluvial soils form in material moving downslope from soils that formed in saprolite from acid sandstone, shale and siltstone. Jefferson, Grimsley and Ramsey soils occupy up to 75% of the map unit. Sandstone rock outcrops occur at upper and middle sideslope positions and are associated with Ramsey. This unit occurs on the south-facing spurs and sideslopes of Bird Mountain at all elevations (Figure 13).

Ramsey (taxadjunct) silt loam soils are geographically associated with rock outcrops at upper shoulder and middle sideslope positions. Sandstone bluffs, up to 15 m high, occur at 790 and 885 m levels. Ramsey soils occur on low gradient sideslopes and benches underlain by acid sandstone residuum. The typifying pedon (Figure 19, Appendix B)

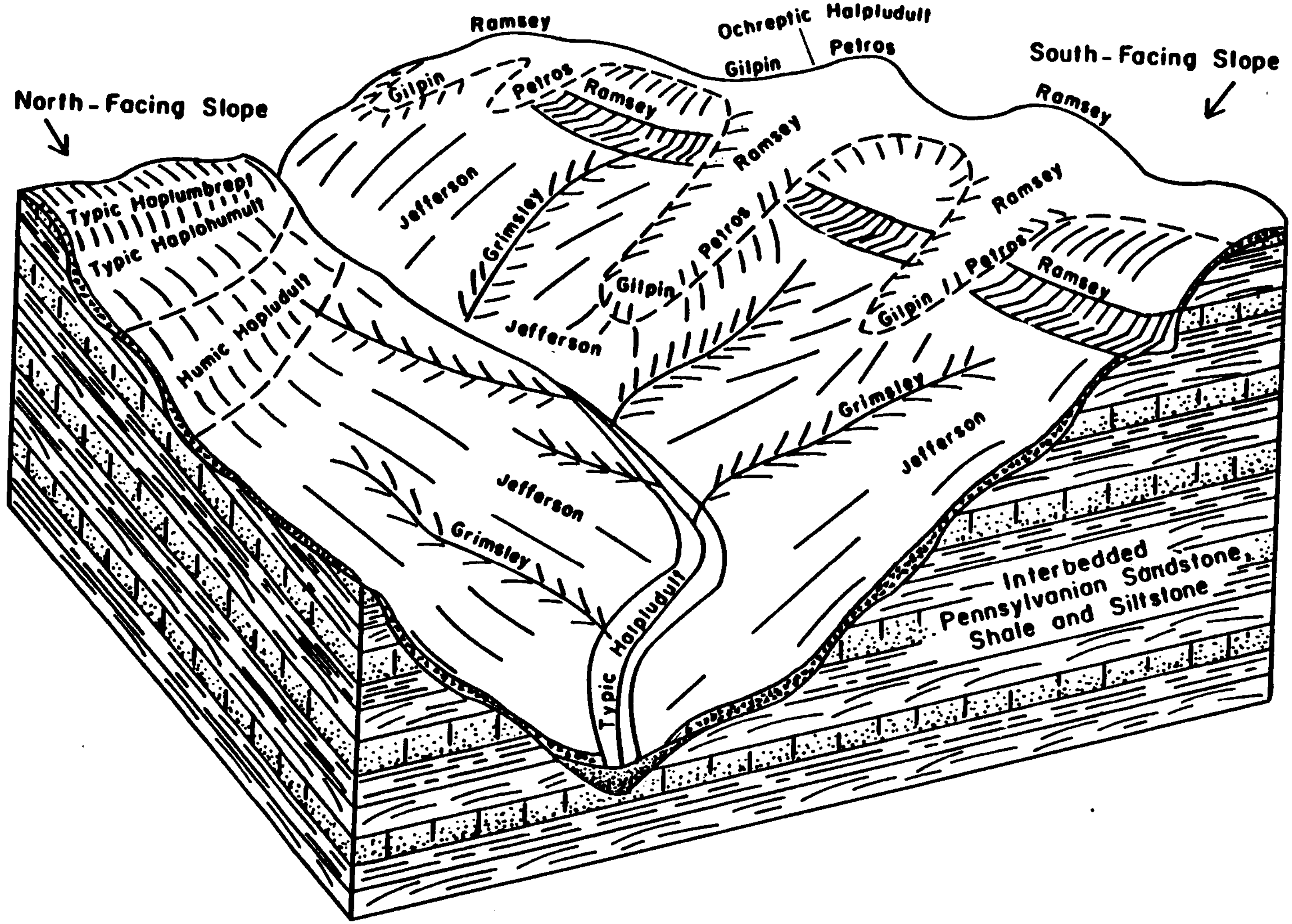

Figure 13. Block diagram of soils, geology and topography emphasizing the south-facing slope of Bird Mountain, Frozen Head State Natural Area.

is located at an upper sideslope position above a small sandstone escarpment. It is a taxadjunct to the Ramsey series due to silt loam texture of the A horizon; only loam and sandy loam textures are allowed in this series.

Soils in the Jefferson series are deep, well drained and formed in colluvial material occurring at upper to middle sideslopes, footslopes and toeslopes of Bird Mountain. Solum thickness ranges from 1 to 1.5 m; depth to bedrock is greater than 1.5 m. Parent material is colluvium from upslope residual soils that formed in acid sandstone, shale and siltstone. Rock fragment content is less than 35% in the control section but may range up to 80% below a depth of 1 m. A wide range of rock fragment contents and sizes is characteristic of soils in this series. Cobbly loam, gravelly loam and loam surface texture phases occur in this unit. These soils are very strongly acid or strongly acid, and natural fertility is low. Available water holding capacity is low in cobbly soils and moderate in noncobbly analogues. Soils in the Jefferson series are members of the fine-loamy, siliceous, mesic family of Typic Hapludults.

Grimsley cobbly and stony loam soils occur on landforms similar to Jefferson. These soils are skeletal, deep, well drained and formed in acid sandstone, shale and siltstone colluvium. Solum thickness and bedrock depth are less than 1.5 m. Coarse fragement content is greater than 35% in the control section and ranges up to 65% in the B horizon. These soils contain sandstone cobbles, stones and boulders. Surface cobble and stone content ranges from 10 to 50%. These soils are very strongly acid, strongly acid, have low available water holding capacity and a low natural fertility. Soils in the Grimsley series are members of the loamy-skeletal, siliceous, mesic family of Typic Hapludults.

Included in mapping are small areas of Petros and Gilpin soils. These soils occur on spur or nose slopes too small to be mapped with the ridgetop unit. Soils in the Shelocta series, an inclusion in this map unit, occur on topographic positions similar to Jefferson but differ in primary texture of the B horizon. Shelocta soils have a silt loam or silty clay loam B horizon; soils in the Jefferson series have more sand in the B horizon and textures are loam, clay loam and sandy clay loam. Soils in the Shelocta series are members of the fine-loamy, mixed, mesic family of Typic Hapludults; a pedon description is given in Appendix B, Figure 20.

Lily and Muskingum soils, inclusions in this map unit, are moderately deep (50 to 100 cm) and geographically associated with occurrences of Ramsey soils. These areas are small and form on more stable landforms than those landforms on which Ramsey soils occur. Soils in the Lily series classify as Typic Hapludults; Muskingum soils classify as Typic Dystrochrepts and have been widely mapped in the Cumberland Mountains (Moneymaker 1981). Most soils initially classified as Muskingum were found to contain an argillic horizon and were reclassified as Typic or Ochreptic Hapludults. True Muskingum soils are limited to very small areas. Soils that classify into the Wallen series occur with Ramsey. Wallen series are members of the loamy-skeletal, siliceous, mesic family of Typic Dystrochrepts and formed in acid sandstone residuum.

Vegetation plots occurring within this map unit contain seventeen of the eighteen common canopy species. Chestnut oak, northern red oak red maple, white oak, sugar maple and beech account for 74% of the overstory importance (Table 25, Appendix C). The understory is dominated by sugar maple, red maple, dogwood, blackgum and beech. Total canopy tree density, basal area and sapling density is second lowest of all the map units.

Site and soil characteristics indicate that most plots are steep, convex to planar, located at all elevations and have a southern exposure (Table 27, Appendix C). Soils of this unit have the lowest available water holding capacity, thinnest O and A horizons and highest coarse fragment content. Approximately 89% of these plots have an argillic horizon, and 84% were classified Typic Hapludults.

Cove Map Unit: Grimsley (taxadjunct)-Jefferson Complex, 25 to 60% Slopes. This unit consists of two colluvial soils that classify into the Grimsley (taxadjunct) and Jefferson series. They are located in coves at all elevations and aspects on Bird Mountain. These soils are intermingled; separate mapping at a 1:24000 scale is impractical. Grimsley cobbly and stony silt loam soils make up approximately 40% of the mapping area and occur next to drainageways. These deep, well drained soils have a high rock fragment content in the solum. Surface rock fragment content ranges from 30 to 75%; stones and boulders are most limiting for use in management. These soils are very strongly acid or strongly acid and have low natural fertility. Available water holding capacity is low due to the high stone content. Soils in the Grimsley series are members of the loamy-skeletal, siliceous, mesic family of Typic Hapludults. The Grimsley typifying pedon (Figure 21, Appendix B) is in a cove (Linlog Branch) at 610 m elevation. This pedon is a taxadjunct to the Grimsley series due to A horizon texture and solum thickness.

Jefferson cobbly loam, gravelly loam and loam soils make up 30 to 50% of each mapped area. These soils occur in drainageways above Grimsley cobbly loam soils and are very strongly acid, deep, well drained and low in natural fertility. Rock fragment content is dominated by cobbles and stones; few boulders are present. Rock fragment content of the surface and solum increases toward drainageways. Available water holding capacity, as influenced by rock fragment content, is low to moderate. Soils in the Jefferson series are members of the fine-loamy, siliceous, mesic family of Typic Hapludults. The Jefferson typifying pedon (Figure 22, Appendix B) is on a flat sideslope of a draw at 700 m elevation.

Included in mapping are areas of soils that classify as fine-loamy, siliceous, mesic Humic Hapludults. They occur at higher elevations and in protected or shaded sites at all elevations. These soils have a very dark grayish brown (10YR 3/2) or dark brown (10YR 3/3), loam or gravelly loam A horizon, 15 to 22 cm thick. The Bt horizon is a dark yellowish brown (10YR 4/4), yellowish brown (10YR 5/4, 10YR 5/6) or strong brown (7.5YR 5/6) gravelly clay loam. Coarse fragment content ranges to 20% in the A horizon and 35% in the B horizon. Solum thickness and depth to bedrock are greater than 2 m. A pedon description of this soil, located on Emory Gap Branch at 625 m elevation, is given in Appendix B, Figure 23. These soils are strongly to moderately acid, deep, well drained and has moderate available water holding capacity. Parent material is colluvium from residual soils forming in acid sandstone, shale and siltstone.

Small areas of Ramsey and Petros soils occur on steep sideslopes adjacent to drainageways. These areas are discontinuous and are considered nonlimiting inclusions.

Vegetation plots in this map unit are dominated by mesophytic species. All eighteen common canopy trees occur in this unit with yellow poplar, hemlock, white basswood and beech accounting for 54% of the overstory importance (Table 25, Appendix C). The sapling layer is dominated by dogwood, sugar maple, hemlock, red maple and beech (Table 26, Appendix C). Total basal area and total canopy tree density is second highest of all map units.

Site and soil characteristics from plot data indicate a planar to concave slope shape; no plots are convex. Mean available water holding capacity for the top 50 cm is 5.5 cm, second only to the lower north-facing map unit. The A horizon pH is the highest and B horizon pH second highest of all mapping units.

Lower North-Facing Map Unit: Jefferson-Grimsley (taxadjunct)-Humic Hapludults-Ramsey (taxadjunct) Complex, 25 to 65% Slopes. This unit consists of residual and colluvial soils that occur on the north-facing slopes of Bird Mountain, below an elevation of 825 m (Figure 14). Jefferson and Grimsley (taxadjunct) soils make up 40 to 60% of the map unit; Ramsey (taxadjunct) and a Humic Hapludult make up 25 to 40% of each unit.

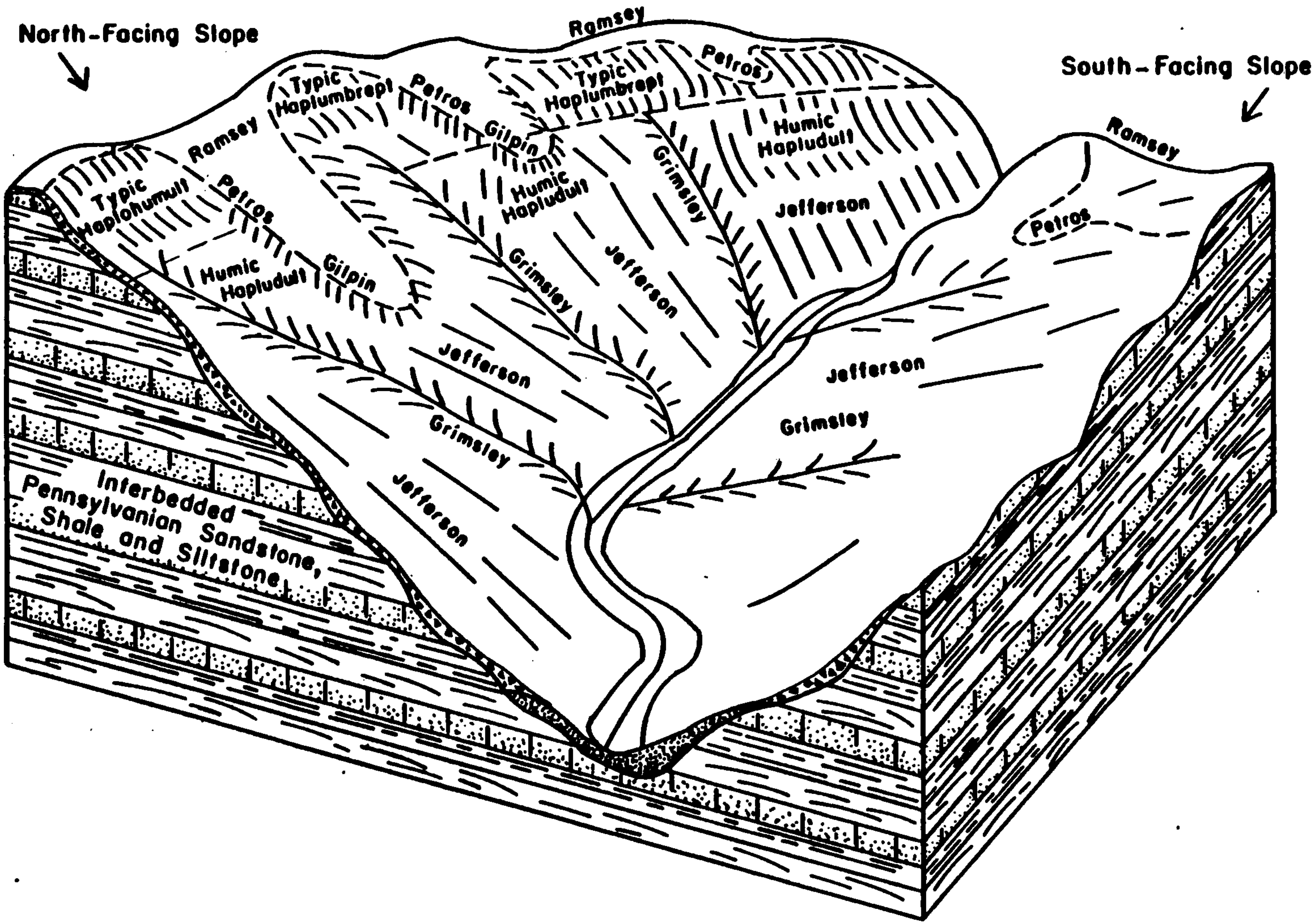

Figure 14. Block diagram of soils, geology and topography emphasizing the north-facing slope of Bird Mountain, Frozen Head State Natural Area.

Jefferson is a deep, well drained soil occuring on middle to low, flat to convex, sideslope positions, below 750 m. It forms in colluvium derived from higher soils that formed in residuum of acid sandstone, siltstone and shale. Depth to bedrock is greater than 1.5 m and solum thickness ranges from 1 to 1.5 m. Rock fragment content varies widely, but is less than 35% in the control section. Jefferson cobbly loam, gravelly loam and loam soils occur in this unit. The relative amount of each phase is not known. These soils are strongly acid and have low natural fertility. Available water holding capacity is low to moderate and reflects the coarse fragment content of the solum.

Grimsley cobbly and stony loam soils occur on planar to concave sideslopes at elevations similar to Jefferson. These are deep, well drained colluvial soils, with a high cobble and stone content throughout the solum. Depth to bedrock and solum thickness is usually less than 1.5 m; in many places hard bedrock is greater than 1.5 m depth. Cobbles, stones and boulders litter the surface (15 to 40%) but solum stone content depends upon slope shape. These soils are strongly acid, low in natural fertility and have low available water holding capacity.

Soils that classify as Humic Hapludults occur on cool, north or east-facing slopes between 825 and 750 m elevation. They are transitional between soils of the upper north-facing map unit and the Jefferson/Grimsley soils of the lower north-facing unit. Morphologically, these soils are similar to Jefferson soils except for a dark A horizon. No series designation currently exists. The A horizon hue is 10YR, value 2 or 3, and chroma of 1 through 3. Texture is loam or silt loam; rock fragments range from 10 to 30%. Transitional (AB or BA) and B horizons have a lower value and chroma, contain more silt and are thicker than Jefferson soils. Solum thickness and depth to bedrock is greater than 1.5 m. Diagnostic horizons include an umbric or umbric-like epipedon and an argillic subsurface horizon. Texture of the B horizon is silt loam, clay loam, silty clay loam or loam. These soils may be locally more similar to Shelocta soils due to high silt content in the B horizon. These soils form in acid sandstone and shale colluvium moving downslope by mass wastage or creep. This soil is similar to the Humic Hapludult inclusion of the cove map unit except for landform position (Figure 23, Appendix B).

Ramsey (taxadjunct) silt loam soils occur on middle to upper, low gradient sideslopes above 700 m elevation. These soils are strongly acid, shallow, well to excessively well drained and formed in acid sandstone residuum. These soils occur on small sandstone escarpments and topographic benches. Rock outcrops are not continuous or extensive as in the south-facing unit and are treated as inclusions rather than part of the map complex.

Included in mapping are moderately deep (50 to 100 cm) areas of residual, Lily and Muskingum soils. They are geographically associated with Ramsey soils and occupy a small percent of the map unit. Small areas of Petros and Gilpin soils occur on nose slopes at middle to low slope positions. These steep, doubly convex landforms are distinct but nonmappable, and are characteristic of the ridgetop map unit. At the upper elevational limit, Petros and Gilpin soils have a darker surface layer.

Shelocta soils are associated and included with Jefferson soils and may locally become important. In areas more influenced by shale colluvium, B horizon textures contain more silt and less sand. Texture of the B horizon is one criterion used to separate Shelocta from Jefferson.

Vegetation plots located within this map unit are dominated by sugar maple, white basswood, yellow poplar and beech which account for 58% of the overstory importance (Table 25, Appendix C). All eighteen common canopy trees occur here, with mesophytic taxa assuming dominance. The sapling layer is dominated by sugar maple, dogwood, basswood and hemlock. All trees are reproducing with the exception of red hickory, white, chestnut and black oaks.

Total sapling density and available water holding capacity are highest and thickness of the O horizon second highest of all map units. Mean pH of the A and B horizons is 4.5--comparable to the cove and upper north slope units. Average coarse fragment content of the B horizon is lowest of any map unit and may reflect a more rigorous weathering environment on the north slope. These soils are moist most of the time and weathering continues for 12 months.

Floodplain Map Unit: Typic Hapludults, 0 to 5% Slopes. This map unit consists of alluvial soils along the North Prong of the Flat Fork River, which drains the south slopes of Bird Mountain and the north and south slopes of Old Mac Mountain. Dominant soils are members of the loamy-skeletal, siliceous, mesic family of Typic Hapludults. These soils are deep and well drained. No series designation currently exists. Level or nearly level, narrow, continuous floodplains of 2nd and 3rd order streams characterize the area. This soil has been mapped from park headquarters, elevation 410 m, southwest to a point just outside the park where the floodplain widens significantly. The Soil Conservation Service has partially mapped this larger floodplain and it consists of two well drained terrace soils, Sequatchie and Welchland (USDA Soil Conservation Service 1978); younger soils along this larger floodplain include Pope (Ealy) and Philo (Sewanee). Sequatchie and Welchland soils are Humic Hapludluts; Pope soils are Fluventic Dystrochrepts and Philo soils are Fluvaquentic Dystrochrepts.

The typifying pedon (Figure 24, Appendix B) is outside the park boundary, at an elevation of 400 m. Solum thickness ranges from 1 to 1.5 m and depth to bedrock is greater than 2 m. Diagnostic horizons include an ochric epipedon and an argillic subsurface horizon. The A horizon hue is 10YR, value 4 through 6 and chroma of 4 or 6. Texture is loam or sandy loam. Rock fragment content ranges from 5 to 25%. The B horizon hue is 10YR or 7.5YR, value 4 through 6 and chroma of 4 through 8. Texture is loam, sandy loam or light clay loam and cobbly analogues. Rock fragment content ranges from 15% in the upper B to 65% in the lower B horizon. Structure is moderate, medium subangular blocky in the upper B, and weak, fine to medium subangular blocky in the lower B. The C horizon hue is 10YR, value 5 or 6 and chroma 6 or 8. It is massive and has loam, sandy loam or fine sandy loam textures. Rock fragments, dominated by stones and boulders, range from 50 to 90% in the C horizon. The pH of all horizons is strongly to very strongly acid. Available water holding capacity is low due to the high coarse fragment content of the solum. Parent material is alluvium washed from upland soils that formed in residuum or colluvium from acid sandstone, shale and siltstone.

Included in mapping are small areas of a non-skeletal variant and soils with a dark brown (10YR 3/3) surface. The non-skeletal soils are away from the main drainageway, and distribution is limited and discontinuous. These soils are nonlimiting inclusions and make up less than 15% of the map unit.

Upper North-Facing Map Unit: Humic Hapludults-Typic Haplumbrepts Complex, 35 to 60 % Slopes. This unit consists of soils with thick dark surfaces that formed in acid sandstone, shale and siltstone residuum or colluvium. These soils occur on upper north and east-facing shoulders and sideslopes of Bird Mountain, above elevations of 825 m. Neither of the two soils that compose this unit has a series designation. The soils dominant classify as members of the fine-loamy, mixed mesic family of Humic Hapludults and occur on planar to concave landscapes, making up 60% of the map unit. These soils formed in colluvial material washed from upper slope soils underlain by sandstone, shale and siltstone. The soils are deep, well drained, strongly to very strongly acid and have a moderate available water holding capacity. Solum thickness and depth to bedrock are greater than 1.5 m. Diagnostic horizons include an umbric or umbric-like epipedon and an argillic subsurface horizon. The A horizon hue is 10YR, value of 2 or 3 and chroma of 1 through 3. Texture is silt loam,

loam or channery analogues. Coarse fragment content ranges from 5 to 35% and depth from 15 to 50 cm.

The B horizon hue is 10YR or 7.5YR, value of 3 through 5, and chroma of 4 or 6. Texture is silt loam, silty clay loam or clay loam. Coarse fragment content ranges from 5 to 15%; rarely up to 25%. The typifying pedon (Figure 25, Appendix B) is on a northeast, concave sideslope of Bird Mountain at 870 m. High organic carbon levels occur in the upper part of the argillic horizon. Based on these data, reclassification of this pedon from a Humic Hapludult to a fine-loamy, mixed, mesic Typic Haplohumult is appropriate. An organic content of 0.9% in the upper 15 cm of the argillic horizon is the criterion used for this separation (Soil Survey Staff 1975). Organic carbon is 1.28% in the Bt1, 1.15% in the Bt2 and 1.53% in the BC horizon at a depth of 1.6 m. It is not known if these high organic carbon levels characterize all Humic Hapludults in this map unit.

Soils that classify into the loamy, mixed, mesic shallow family of Typic Haplumbrepts make up 20 to 30% of the map unit. These soils occur on north or east-facing, convex spur ridges and shoulder slopes above 825 m. They are shallow, strongly acid, well drained and have low available water holding capacity. Solum thickness and depth to soft, weathered bedrock are less than 50 cm. Diagnostic horizons include an umbric epipedon and a cambic subsurface horizon. The A horizon hue is 10YR, value of 2 or 3 and chroma of 1 through 3. Texture is channery silt loam and coarse fragment content ranges from 15 to 35%. The B horizon hue is 10YR or 7.5YR, value and chroma are 3 or 4. Texture is loam, silt loam or channery analogues and coarse fragment content ranges from 10 to 35%. Parent material is interbedded acid shale, siltstone and sandstone residuum. The typifying pedon (Figure 26, Appendix B) is on a doubly convex, northeast-facing spur ridge at 890 m elevation. Clay content of all horizons is less than 18%.

Included in this map unit are areas of moderately deep (1 to 1.5 m.) soils that classify as Humic Hapludults. These soils are formed in residuum and occur in the transition zone between the deeper, colluvial Humic Hapludults and the shallow residual Typic Haplumbrepts. Small, limited areas of deep (greater than 1.5 m) soils with a dark surface that classify as Umbric Dystrochrepts (Cutshin or Zenith) are intermingled with the Humic Hapludult soils. Cutshin and Zenith soils have been mapped in Campbell and Anderson counties on high, north-facing slopes. On Bird Mountain, deep soils on similar landforms usually contain an argillic rather than a cambic subsurface horizon. Most soils that classify as Typic Haplumbrepts and Umbric Dystrochrepts are shallow and are associated with convex landscapes; as slopes become concave, a concomitant increase in solum thickness and argillic formation implies increased slope stability. It is rare to find deep soils that show no evidence of clay translocation or incipient argillation.

Jefferson and Grimsley soils occur as inclusions at the lower elevational limit (825 m) of this map unit, and are transitional to the lower north-facing map unit. Discontinuous rock outcrops occupy less than 10% of the map unit and occur below the ridge crest. Large, recently detatched floaters up to 10 m across are geographically associated with these rock outcrop areas.

Vegetation plots of this map unit contain fifteen of the eighteen common canopy species. Overstory taxa are dominated by sugar maple, white basswood, black cherry, northern red oak and yellow buckeye (Table 25, Appendix C). Sugar maple and white basswood account for nearly half of the overstory importance and three-fourths of the sapling density (Table 26, Appendix C). Total canopy tree density and basal area are highest and total sapling density second highest of all map units. The O and A horizons are thicker and A horizons darker than other map units.

CHAPTER V

CORRELATION, MULTIPLE REGRESSION AND ANALYSIS OF VARIANCE OF SITE, SOIL AND VEGETATION FACTORS

Introduction

Simple linear correlation analysis (Pearson product-moment) is used to identify interactions between site, soil and vegetation variables. Correlation is useful in the quantification of observed relationships between variables. A linear relationship between two variables is assumed, but if untrue, precludes the usefulness of this technique. Correlation analysis has been used in studies of the Cumberland Mountains (Martin 1966; Hinkle 1975; Knight 1979), Cumberland Plateau (Safley 1970; Smith 1977; Wade 1977; Schmalzer 1978; Sherman 1978) and the Ridge and Valley (Martin 1971; Crownover 1983). All correlations reported in this study are significant at the p=0.01 level unless otherwise noted.

Multiple regression analysis is used to derive predictive linear models for overstory importance values, relative densities and relative basal areas using site and soil variables. Multiple regression is useful in ecological studies because relationships of many environmental variables to vegetation may be examined and patterns of species distribution understood. The ability to screen a large number of independent variables, measure the overall variation of the model and produce a best fit equation for the data makes regression analysis a useful tool in plant ecology.

Several studies in the Cumberland Mountains and Plateau have used multiple regression analysis to explore relationships of overstory taxa to site and soil variables. Martin (1966) used twelve site and soil variables to predict absolute density and absolute basal area for select taxa on Wilson Mountain. Safley (1970) and Hinkle (1975) predicted species importance, relative basal area and relative density using site and soil variables. Hinkle (1975) sorted his data by aspect, developing predictive equations for north and south-facing slopes. Similar vegetation studies in the Ridge and Valley province have used multiple regression analysis to predict species importance (Martin 1971; Hedge 1979; Crownover 1983; Condley 1984).

Statistical Procedures

The SAS stepwise, maximum R^2 improvement technique, is used in regression analysis to develop predictive linear models for select overstory vegetation importance value, relative density and relative basal area. This technique produces the best one variable model with the highest R^2, then a two variable model that yields the largest R^2 increase and so forth; it replaces variables from a previous model if they did not maximize the R^2 value (SAS Institute, Inc. 1985). Independent variables used in regression analysis are given in Table 16. Regression models selected met the following requirements:

1. The significance of the overall model is determined using an F-test at a p=0.01 level. This tests the null hypothesis that all independent variables do not predict the dependent variable (i.e. the linear functions of the indeqendent variables equal zero). F-values

Table 16. Independent variables used in regression analysis.

Variable Symbol	Variable Name	Units
SITE		
SA	slope angle	percent
AB	aspect	SW = 0.00, NE = 2.00
SP	slope position	percent from ridgetop
EL	elevation	m
VS	vertical slope shape	1 = convex, 3 = concave
HS	horizontal slope shape	1 = convex, 3 = concave
SR	potential insolation	kilolangleys/year
SOIL		
pA	pH (water) of the A horizon	pH
pB	pH (water) of the B horizon	pH
pKA	pH (1N KCl) of the A horizon	pH
pKB	pH (1N KCl) of the B horizon	pH
Text A	A horizon texture	1 = sandy clay loam 2 = clay 3 = silty clay 4 = clay loam 5 = sandy loam 6 = silty clay loam 7 = loam 8 = silt loam
Text B	B horizon texture	code same as A horizon
WA	available water holding capacity of the A horizon	cm H_2O/cm soil

Table 16 (continued)

Variable Symbol	Variable Name	Units
WB	available water holding capacity of the B horizon, down to 50 cm	cm H_2O/cm soil
WT	total available water holding capacity of the top 50 cm	cm H_2O/50 cm soil
THO	O horizon thickness	cm
THA	A horizon thickness	cm
CFA	coarse fragment content of the A horizon	percent weight
CFB	coarse fragment content of the B horizon	percent weight
HUA	hue of the A horizon	1=7.5YR, 2=10YR, 3=2.5Y
HUB	hue of the B horizon	code same as A horizon
VA	value of the A horizon	
VB	value of the B horizon	
CA	chroma of the A horizon	
CB	chroma of the B horizon	

represent the ratio of the regression mean square to the error mean square.

2. Each partial regression coefficient is checked at a p=0.10 level of significance as determined by a partial F-test. This tests whether the addition of a variable to the model improves the predictive power of that model. Partial F-values, the ratio of the type II sums of squares to the mean square error, are equivalent to a test of significance for the partial correlation coefficient (Kleinbaum and Kupper 1978).

3. The model has the highest R^2 with no more than five independent variables. Addition of a variable to the model must result in a 5% increase in the R^2 value.

The independent variables of each model are arranged in order of relative contribution to the dependent variable. The relative contribution of a particular X_i to a specific model is determined by dividing the type II sums of squares for that X_i by the sum of all type II sums of squares of that model. The type II sums of squares for a variable are the sums of squares added to the error sums of squares if that one variable is removed from the model; it is invariant to the ordering of the independent variables (SAS Institute, Inc. 1985). In each regression the coefficient of determination (R^2), mean value of the dependent variable (Y) and the standard error of the estimate (SEE) are given.

One way analysis of variance (ANOVA) is used to test the null hypothesis that no differences exist for mean site, soil and vegetation variables between community types. The ANOVA technique assesses, with the F-test statistic, how several nominal independent variables (community types) affect a continuous dependent variable (site, soil, vegetation factors). Tukey's studentized range test is performed, if the F-test is significant at the p=0.05 level, to determine which community types are significantly different with respect to site or soil variables. The Tukey method tests for differences at the p=0.05 level and is considered appropriate for unequal cell designs (SAS Institute, Inc. 1985).

Regression Results and Discussion

Chestnut Oak. Fowells (1965) states that chestnut oak reaches maximum size in well drained coves and bottoms; on dry, sandy or gravelly soils it competes better than most other oaks and is widely distributed in the Appalachians, up to 1350 m elevation. On Bird Mountain, chestnut oak is dominant in the chestnut oak type, an associate in the yellow poplar type and a minor constituent of the northern red oak-sugar maple, mixed mesophytic and beech types.

Chestnut oak has a frequency of 28% and an average importance value of 23.4, the second highest of all taxa. The predictive equations for chestnut oak (n=27) are:

IV=60.89 - 18.92AB + 0.69SA - 0.05EL - 3.69 THO

R^2=0.27 $\bar{Y}$=23.43 SEE=±38.41

RD=22.39 + 0.09SR + 0.37SA - 0.03EL - 7.55 PA

R^2=0.28 $\bar{Y}$=8.93 SEE=±15.19

$$RB=12.46 - 15.48AB + 0.38SA$$

$$R^2=0.21 \quad \bar{Y}=14.50 \quad SEE=\pm 24.78$$

In the importance value equation, aspect (AB) accounts for 45% of the explained variation, slope angle (SA) 27%, elevation (EL) 15% and O horizon thickness (THO) 13%. Aspect and O horizon thickness are negatively correlated with chestnut oak importance values (r=-0.41 and -0.35, respectively). In the relative density equation increased insolation (SR) replaces aspect and decreased A horizon pH (PA) replaces O horizon thickness. In the relative basal area equation, aspect and slope angle are the only predictors.

These models indicate that on Bird Mountain, chestnut oak is more important on steep, low to middle, southwest-facing slopes with thin O horizons and acid soils with low available water and high evapotranspiration. Convex slope shapes are common in the chestnut oak community and should be included in the site characterization of chestnut oak.

In the Cumberland Mountains, Braun (1950) recognizes the importance of chestnut oak on steep, upper slopes. Whittaker (1956) reports chestnut oak communities on open, south and southwest slopes, below 1200 m, in the Great Smoky Mountains. Martin (1966) reports chestnut oak density greatest on south aspects with thicker O horizons; basal area is related to upper slope position, thinner A horizons and thicker O horizons in his regression equations. Safley (1970) reports that chestnut oak is best developed on upper south-facing slopes with thin soils; convex slope shapes and thinner A horizons contribute to importance value prediction. Hinkle (1975) reports chestnut oak importance values increase on south slopes with clayey B horizons, steep slopes and acid soils; on north slopes, chestnut oak reaches its best development and is related to convex, upper slopes with shallow soils. Wade (1977) states that chestnut oak is more important on less acid, coarse, well drained soils of the Cumberland Plateau.

Martin (1971) reports increased importance values of chestnut oak on upper, steep slopes of large topographic units and lower A horizon pH. Site variables associated with topographic variation are more important than soil variables predicting species importance, relative density and basal area. Crownover (1983) reports chestnut oak importance negatively related to percent silt in the A horizon, pH of the A horizon, available water holding capacity of the top 30 cm and positively related to percent silt in the B horizon. Dry, acid soils and southerly aspects characterize chestnut oak sites on House Mountain. Ike and Huppuch (1968) report greater site index on low, steep slopes with silty subsoils and thinner O horizons.

Red Maple. On Bird Mountain red maple generally occurs on southerly aspects at middle to low slope positions. It is the second most important species in the chestnut oak and yellow poplar types and third most important in the white oak-northern red oak type; it is absent from the mixed mesophytic community and occurs sparingly in the cherry and northern red oak-sugar maple types. Red maple has a frequency of 48% and an average importance value of 13.5. The predictive equations for red maple (n=46) are:

$IV=-18.87 + 0.16SR + 1.82TEXTB + 8.58VS - 10.89HS - 0.02EL$

$R^2=0.38 \quad \bar{Y}=13.49 \quad SEE=\pm 15.28$

$RD=-26.56 + 0.13SR + 1.43TEXTB + 5.93VS - 7.35HS$

$R^2=0.37 \quad \bar{Y}=9.44 \quad SEE=\pm 10.29$

$RB=16.58 - 3.30AB - 0.01EL$

$R^2=0.18 \quad \bar{Y}=4.05 \quad SEE=\pm 7.64$

In the importance value equation, increased solar radiation (SR) accounts for 69% of explained variation based on the percentage of the total Type II sum of squares; finer B horizon texture (TEXTB), concave vertical slope shape (VS), convex horizontal slope shape (HS) and low elevation (EL) account for 10%, 9%, 7% and 6% of the explained variation, respectively. Increased solar radiation, finer B horizon texture and concave vertical slope shape are important predictors of relative density; convex horizontal slope shape is negatively associated. In the relative basal area equation, southerly aspect and lower elevation are important. These models indicate that on Bird Mountain, red maple is most important on south aspects at low slope positions; slope shapes are variable. Concave vertical slope shapes are common on sideslopes and footslopes at low elevations. Slope shape varies locally across the landscape where underlying geology is the controlling factor. Solar radiation (r=0.51), elevation (r=-0.30) and aspect (r=-0.48) are significant red maple site correlations.

Fowells (1965) states that red maple reaches its best development on moderately well drained sites at low to intermediate elevation, on south and west-facing upper slopes and ridgetops in mountainous areas.

Martin (1966) reports red maple absolute density and basal area positively related to A horizon thickness, canopy closure, low slope position and mesic aspects in the Cumberland Mountains. Red maple is distributed over a wide variety of soil and topographic conditions; this is reflected in his low R^2 values for absolute density (0.23) and basal area (0.19). Martin (1971) reports red maple on mesic sites in the Ridge and Valley province; soil depth and slope shape are important predictors in his regression equations. In the Smoky Mountains, Whittaker (1956) reports red maple in mesic cove hardwood forests and xeric pine communities on dry ridgetops. Schmelz and Lindsay (1970) considered red maple an important constituent on poorly drained sites in Indiana.

Pignut Hickory. Fowells (1965) states that pignut hickory occurs on dry ridges and hillsides with well drained soils and is common on mesic sites in the southern Appalachians. In the Cumberland Mountains, pignut hickory occurs on drier sites and is associated with chestnut oak, scarlet oak and shagbark hickory (Braun 1950). Whittaker (1956) reports a northern red oak-pignut hickory community at low elevations (750 to 900 m) which occupy submesic sites in the Great Smoky Mountains. On Bird Mountain, pignut hickory is codominant in the northern red oak-sugar maple community, an associate in the chestnut oak and white oak-northern red oak types, but unimportant in other communities. Pignut hickory has a frequency of 24% and an average importance value of 4.9. The predictive equations for pignut hickory (n=24) are:

$IV=-10.27 + 0.08SR + 0.02EL - 2.97TEXTA$

$R^2=0.27$ $\bar{Y}=4.93$ $SEE=\pm10.29$

$RD=-3.81 + 0.04SR + 0.01EL - 1.57TEXTA$

$R^2=0.30$ $\bar{Y}=2.58$ $SEE=\pm4.80$

$RB=-19.27 + 0.05SR + 0.01EL$

$R^2=0.17$ $\bar{Y}=2.35$ $SEE=\pm6.47$

Insolation (SR) accounts for 63%, elevation (EL) 36% and A horizon texture (TEXTA) 20% of the explained variation in the importance value equation. Increased insolation and elevation appear in all equations and are (positively) related to the dependent variables. Texture of the A horizon is negatively associated with species importance and relative density, and reflects a decreasing available water holding capacity. A lower texture value is related to a higher sand content of the horizon and reflects a lower available water holding capacity than a finer textured soil (Peterson 1968). Importance value is positively correlated with insolation (r=0.33) and elevation (r=0.24 at the 5% level); a negative correlation exists for A horizon texture (r=-0.34). Middle to upper south-facing sideslopes with coarse textures charcterize pignut hickory sites. The occurrence of pignut hickory as a codominant in the northern red oak-sugar maple community indicates that pignut hickory is submesophytic. Martin (1966) reports pignut hickory a codominant in his northern red oak type and an associate in his chestnut oak type on Wilson Mountain. Safley (1970) reports pignut hickory a minor constituent of several mesic communities and Cabrera (1969) states pignut hickory occurs on sites intermediate between mesic north slopes and more xeric southwest slopes. Martin (1971) reports steep slopes, decreasing solum thickness and B horizon clay important predictors in his regression equations for pignut hickory; he considers it the most drought tolerant hickory in his study. Crownover (1983) reports increasing B horizon silt, decreasing insolation and upper slope positions important predictors of species importance on House Mountain.

White Oak. Fowells (1965) reports white oak is most important on lower north and east-facing slopes and coves with deep well drained loamy soils; white oak occurs on a variety of sites within its range except extremely dry ridgetops and poorly drained bottoms. On Bird Mountain, white oak is dominant or codominant in the white oak-northern red oak, yellow poplar, northern red oak-sugar maple and beech communities; it is unimportant in the chestnut oak, mixed mesophytic and cherry types.

White oak has a frequency of 36% and an average importance value of 12.3. The predictive equations for white oak (n=34) are:

$$IV=-46.22 + 0.20SR - 0.51CFB + 0.04EL$$

R^2=0.22 $\bar{Y}$=12.28 SEE=$\pm$21.36

$$RD=-10.13 + 0.07SR - 0.18CFB + 0.11EL$$

R^2=0.25 $\bar{Y}$=4.99 SEE=$\pm$8.13

$$RB=-33.12 + 0.13SR - 0.30CFB + 0.03EL$$

R^2=0.20 $\bar{Y}$=7.29 SEE=$\pm$14.40

In the importance value equation, insolation (SR), percent coarse fragment of the B horizon (CFB) and elevation (EL) account for 55%, 26% and 19% of the explained variation, respectively. Insolation and elevation appear in all equations and are positively related to the dependent variables; percent coarse fragment content of the B horizon is negatively related. Insolation is positively correlated with white oak importance value (r=0.32) and indicates the importance of this taxon on sites with a southerly aspect. Middle to upper, south-facing sideslopes and coves with soils low in percent coarse fragment content characterize the most favorable white oak sites on Bird Mountain.

In the Cumberland Mountain and Plateau regions of Tennessee white oak is one of the least site restricted taxa, as indicated by low R^2 values (Hebb 1962; Martin 1966; Safley 1970; Hinkle 1975; Wade 1977). Martin (1966) reports southerly aspects, acid soil and decreasing slope angle predictors in his absolute density and basal area equations. Safley (1970) reports a ubiquitous distribution of white oak; southerly aspects, thick O horizons, lower slope position and deep soils are important variables in all equations; R^2 of the importance value is only 0.06. Hinkle (1975) suggests white oak grows best in residual, clayey soils on middle to upper south-facing slopes at Cumberland Gap; low R^2 values in his study are attributed to lack of site restriction or factors not measured which influence white oak distribution. Wade (1977) reports white oak importance greater on steeper, north-facing slopes with high B horizon pH. On uplands of the Cumberland Plateau, white oak occurs more often on the less xeric northern slopes, with deep, well drained soils.

Martin (1971), working in the Ridge and Valley province of Tennessee, reports available water holding capacity (positive) and slope angle (negative) important variables predicting white oak distribution. Low R^2 values characterize all equations.

Site index studies report white oak grows on many sites (Einspahr and McComb 1951; Trimble and Weitzman 1956; Della-Bianca and Olson 1961; Hebb 1962; Smalley 1967; Hannah 1968; Yawney and Trimble 1968; Ike and Huppuch 1968). These studies indicate that white oak grows best on lower north and east-facing slopes with deep, well drained soils high in organic matter; it grows most poorly on upper south-facing slopes with thin soils. Topographic position, slope shape and aspect are common variables in these studies which directly affect moisture supply and tree growth. In the Cumberland Mountains, Smalley (1984) reports a 50 year site index of 75 for white oak on footslopes, terraces, well drained bottoms, upper north-facing slopes, colluvial toeslopes and in coves. The lowest site indices (<60) occur on soils with poor internal drainage, narrow ridgetops and upper south-facing slopes with thin, excessively well drained residual soils.

Northern Red Oak. Northern red oak is widely distributed in the eastern United States and occurs frequently on low to middle, north and east-facing slopes, and in coves and ravines. Optimal sites are characterized by fine textured soil and topography that favors increased available water (Fowells 1965). On Bird Mountain, northern red oak is codominant in the northern red oak-sugar maple and white oak-northern red oak communities; it occurs as an associate in the chestnut oak and yellow poplar types and is unimportant in the beech, mixed mesophytic and cherry types.

Northern red oak has the highest frequency, 62%, and third highest average importance value, 18.7, of all taxa. The predictive equations for northern red oak (n=59) are:

$$IV=-33.29 + 0.08EL + 0.16SR - 0.50SA - 7.22\ VS - 2.42TEXTB$$

$$R^2=0.38 \quad \bar{Y}=18.72 \quad SEE=\pm 21.65$$

$$RD=-15.31 + 0.03EL + 0.06SR - 0.17SA - 3.66VS$$

$$R^2=0.34 \quad \bar{Y}=7.89 \quad SEE=\pm 7.84$$

$$RB=-31.57 + 0.05EL + 0.11SR - 0.29SA - 1.80TEXTB$$

$$R^2=0.32 \quad \bar{Y}=10.83 \quad SEE=\pm 15.78$$

In the importance value equation, elevation (EL) accounts for 46% of the explained variation, insolation (SR) 24%, slope angle (SA) 17%, vertical slope shape (VS) 7% and B horizon texture (TEXTB) 6%. Elevation, insolation and slope angle appear in all equations and account for most of the explained variation; increased elevation (r=0.31) and insolation (r=0.30) are significant northern red oak site correlations. Convex vertical slope shapes and coarse B horizon textures are the least important predictors of species importance.

These models indicate that northern red oak importance increases on middle to upper, southerly slopes with a less steep, convex slope configuration; B horizon textures are negatively related to importance and reflect an increasing sand content and a concomittant decrease in available water holding capacity. On Bird Mountain the northern red oak-sugar maple community occurs on middle to upper south-facing sideslopes, above 700 m. This community occurs on steep slopes; the negative relationship of slope angle to northern red oak importance is not understood.

Martin (1966) reports steep, upper slopes with thick A horizons and clayey B horizons most favorable sites for northern red oak. Safley (1970) reports southerly aspect, thick O horizons and clayey B horizons important predictors in his models for northern red oak importance, relative density and relative basal area. Martin (1971) reports site variables account for most variation in his regression equations. However, steep slopes, low slope position and thick A horizons are important predictors. Low R^2 values in his equations imply little site restriction. Hinkle (1975) reports increasing clay content of the B horizon and higher pH as important predictors on south slopes; clayey B horizons and increased slope angle are important variables in the north slope equations. He states increased clay content of the B horizon increases available water holding capacity of that horizon. However, this relationship is influenced and modified by the sand and silt percentages of the soil separates; clay content alone gives an incomplete picture of available water holding capacity, which is a curvilinear function of soil texture (Brady 1974).

Several studies report high site indices on gentle, low, east-facing slopes (Yawney 1964; Smalley 1967; Ike and Huppuch 1968). Smalley (1984) reports a 50 year site index of 80 for northern red oak on footslopes, bottoms and terraces with good drainage. He also reports that upper north-facing slopes, colluvial toeslopes and coves are also favorable sites. All sites are mesic and are characterized by deep, well drained soils.

American Beech. Beech is commonly associated with cool, moist sites and it occurs on low, protected footslopes, coves and north-facing slopes of the Cumberland Mountains (Braun 1950) and Great Smoky Mountains (Whittaker 1956). In Frozen Head State Natural Area American beech occurs on all aspects in coves and lower slopes below 600 m. Braun (1950) states that beech does not occur above 600 m in the Cumberland Mountains and is a major component of the beech-mixed mesophytic forest. In the present study beech is a minor component in the mixed mesophytic and yellow poplar types. Beech has a frequency of 19% and has an average importance value of 12.4. The predictive equations calculated for beech (n=18) are:

$$IV=67.04 - 0.10EL + 3.19WT$$

$$R^2=0.34 \quad \bar{Y}=12.41 \quad SEE=\pm 24.30$$

$$RD=28.47 - 0.04EL$$

$$R^2=0.28 \quad \bar{Y}=4.09 \quad SEE=\pm 8.82$$

$$RB=43.50 - 0.07EL + 2.41WT$$

$$R^2=0.35 \quad \bar{Y}=8.32 \quad SEE=\pm 16.07$$

In the equation for importance value, elevation (EL) and available water holding capacity of the top 50 cm of the soil (WT) account for 93% and 7% of the explained variation, respectively. Negative elevation occurs in all equations. Increased available water holding capacity occurs in the importance value and relative basal area equations. Beech importance values are significantly correlated with elevation (r=0.57) and available water (r=0.28).

On Bird Mountain low elevation coves with deep, well drained soils, high in available water holding capacity characterize beech habitats. Martin (1966) reports an increase of beech absolute density and absolute basal area on planar, upper north-facing slopes. R^2 values for his regression equations are less than 0.16. Safley (1970) reports high elevation, shallow solum and low slope angle important predictors in his regression equations for importance value, relative density and relative basal area. Both Martin (1966) and Safley (1970) worked at elevations much lower than the present study. Martin (1971) reports beech importance higher at low slope positions, low relief, steep slope angles and shallow soils with low clay content of the B horizon. He suggests protection may create a more mesic site than would be expected from these variables. A genetic variant of the beech population, capable of surviving on sub-xeric sites, is a possible explaination for these anomalies (Martin 1971).

Eastern Hemlock. Near the southern limit of its range, hemlock is restricted to north and east-facing slopes, coves, benches, sides of ravines and moist cool valleys (Fowells 1965). Several studies report the importance of topography and slope position to site restriction of hemlock (Daubenmire 1931; Friesner and Potzger 1932, 1934; Bormann and Platt 1958). In the Cumberland Mountains, hemlock is confined to low elevations and occupies mesic to dry slopes (Braun 1950). On Bird Mountain, hemlock is codominant in the beech community, an associate in the yellow poplar type but absent elsewhere. Hemlock has a frequency of 11% and average importance of 5.9. The predictive equations for hemlock (n=10) are:

$$IV=58.57 - 0.04EL - 0.35SA - 0.35CFA + 1.74THO$$

$$R^2=0.45 \quad \bar{Y}=5.85 \quad SEE=\pm14.70$$

$$RD=42.78 - 0.02EL - 0.25SA - 0.24CFA$$

$$R^2=0.38 \quad \bar{Y}=3.66 \quad SEE=\pm9.99$$

$$RB=21.73 - 0.02EL - 0.13SA - 0.14CFA + 0.73THO$$

$$R^2=0.48 \quad \bar{Y}=2.19 \quad SEE=\pm5.29$$

In the importance value equation, elevation (EL) accounts for 37% of the explained variation, slope angle (SA) 27%, A horizon coarse fragment content (CFA) 24% and O horizon thickness (THO) 13%. Low elevation, shallow slope angle and low A horizon coarse fragment content appear in all equations. All of these factors are related to increased available water holding capacity of the soil. Flatter slopes at low elevations enhance infiltration and subsurface flow relative to upper slopes. Importance value is also negatively correlated with elevation (r=-0.46), slope angle (r=-0.47), A horizon coarse fragment content (r=-0.37) and positively correlated with O horizon thickness (r=0.32). Gentle slopes at low elevations, thicker O horizons and low coarse fragment content of the A horizon characterize hemlock sites on Bird Mountain. Increased O horizon thickness may be caused by high productivity or low decay rates or both (Birkeland 1984). Helvey et al. (1972) states the lower quarter of a slope is an important predictor of soil moisture in the southern Appalachians. In sloping topography, downslope subsurface flow of water has been demonstrated in the southern Appalachians (Hewlett and Hibbert 1963), in Mississippi (Beasley 1976) and in the Cascade Mountains of Oregon (Harr 1977). This additional soil water may be available to tree roots, enhancing growth and effecting distribution of mesophytic taxa. Decreasing coarse fragment content directly affects available soil moisture. Available water holding capacity of the A horizon is negatively correlated with A horizon coarse fragment content (r=-0.51). Thick O horizons retain water and also help reduce evaporation of soil water by insulating the soil surface and reducing soil temperature fluctuations.

Hinkle (1975) reports low slope position the most important factor affecting hemlock distribution on south slopes, but it only accounts for a small percentage of explained variation on north slopes. Where this taxon is less site position restricted, increasing B horizon clay content and concave slope shapes were important predictors on north slopes.

Braun (1950) states that hemlock is an important constituent of the hemlock-mixed mesophytic forest which occurs on mesic ravine slopes in the Cumberland Mountains. On drier slopes below 600 m, hemlock occurs with white oak and red maple. Whittaker (1956) reports hemlock a codominant in mesic cove hardwood forests and a dominant in the less mesic eastern hemlock forests at higher elevations of the Great Smoky Mountains.

Sugar Maple. On Bird Mountain sugar maple occurs primarily on north-facing, middle and upper slopes. It has the highest importance value in the mixed mesophytic type, the second highest in the cherry and northern red oak-sugar maple types and occurs as an associate in the chestnut oak and white oak-northern red oak types. It is relatively unimportant in the yellow poplar and beech types. Sugar maple has frequency of 61% and an average importance value of 29.6, the highest of all taxa. The predictive equations for sugar maple (n=58) are:

$IV=29.34 + 0.09EL - 0.25SR$

$R^2=0.45 \quad \bar{Y}=29.61 \quad SEE=\pm 25.57$

$RD=-73.55 + 0.06EL + 8.79PB + 0.16CFB$

$R^2=0.39 \quad \bar{Y}=15.85 \quad SEE=\pm 13.19$

$RB=51.40 + 0.36SA - 0.21SR$

$R^2=0.48 \quad \bar{Y}=13.76 \quad SEE=\pm 14.79$

In the equation for importance value, elevation (EL) and solar radiation (SR) account for 52% and 48% of the explained variation, respectively, based upon Type II sums of squares. Elevation has a positive and solar radiation a negative association with sugar maple importance; sites are characterized by higher elevations and more northerly aspects. Elevation is positively correlated (r=0.58) and solar radiation negatively correlated (r=-0.54) with sugar maple importance values. Sugar maple grows best in cool, moist, well drained sites.

The relative density equation includes the variables pH (pB) and coarse fragment content of the B horizon (CFB); the relative basal area equation includes slope angle (SA). Slope angle increases at upper slope positions and is positively correlated with elevation (r=0.35). Sugar maple importance is also positively correlated with aspect (r=0.44), slope angle (r=0.34) and B horizon pH (r=0.26).

On Bird Mountain, sugar maple grows best on steep, middle to upper north-facing slopes which have a high coarse fragment content and high pH.

Braun (1950) considered sugar maple to be a dominant taxon in the undifferentiated mixed mesophytic forest of the Cumberland Mountains. The sugar maple-basswood-buckeye association segregate occupies mesic sites within the Cumberland Mountains. Whittaker (1956) considers sugar maple to be an important component of the cove hardwood forest in the Great Smoky Mountains, which is similar to the mixed mesophytic forest of the Cumberlands. Sugar maple approaches its southern limit of distribution in the Cumberland Mountains of Tennessee where it is restricted to more mesic sites than in the north (Fowells 1965).

Martin (1971) reports low slope position and concave slope shapes important variables in regression equations predicting species relative density and species importance. Low R^2 values characterize this study.

<u>White Basswood</u>. Fowells (1965) states that white basswood grows best on moist, deep, well drained soils and could tolerate neither wet nor very dry sites. It attains its largest size in the Appalachian Mountains and is a common overstory constituent in the mixed mesophytic forests of the Cumberland Mountains. On Bird Mountain, white basswood is codominant in the mixed mesophytic and cherry types; it is unimportant in all other communities.

White basswood has a frequency of 38%, and an average importance value of 17.0, the fifth highest of all taxa. The predictive equations for white basswood (n=36) are:

$$IV=35.14 - 0.32SR + 17.87PB - 3.90WT$$

$R^2=0.50$ $\bar{Y}=17.03$ $SEE=\pm20.28$

$$RD=21.06 - 0.19SR + 10.60PB - 2.14WT$$

$R^2=0.54$ $\bar{Y}=10.28$ $SEE=\pm11.36$

$$RB=14.58 - 0.13SR + 7.22PB - 2.14WT$$

$R^2=0.39$ $\bar{Y}=6.75$ $SEE=\pm9.98$

In the importance value equation, insolation (SR) accounts for 83% of the explained variation, B horizon pH (PB) 10%, and total available water holding capacity (WT) 7%. These variables appear in all equations. Importance value is also negatively correlated with insolation (r=-0.65) and positively correlated with B horizon pH (r=0.41). Insolation is negatively related to all dependent variables and indicates increasing importance of basswood on north and northeast aspects. The B horizon pH increases on northeast aspects. A positive correlation (r=0.31) exists between aspect and B horizon pH. Higher soil pH's characterize the north slope of Bird Mountain and the entire mixed mesophytic community. The negative relationship of total available water holding capacity (WT) in all equations is poorly understood. Total available water holding capacity is weakly correlated with aspect (r=0.26 at the 5% level) and insolation (r=-0.29). The negative relationship of total water to basswood importance may be due to the occurance of basswood at upper slope positions, where soils contain more coarse fragments and are generally thinner. These models indicate that white basswood importance increases on north slopes with higher soil pH's and low to moderate total available water holding capacity. These soils are moist most of the year so available soil water is not very important. The importance of basswood in mesic forests is reviewed by Braun (1950) and Whittaker (1956).

Yellow Poplar. Yellow poplar is widely distributed in the eastern United States and grows on moderately moist, deep, well drained, medium textured soils and seldom occurs on hydric or xeric sites (Fowells 1965). Yellow poplar reaches its maximum size in the mesic cove hardwood forests of the Great Smoky Mountains (Whittaker 1956). Braun (1950) recognized this dominant taxon in many community types within the mixed mesophytic, western mesophytic and oak-chestnut forest regions.

On Bird Mountain, yellow poplar growth is optimal in coves at middle to low slope positions and on north-facing sideslopes, at all elevations. Yellow poplar is dominant or codominant in the yellow poplar, mixed mesophytic and beech communities; it is a minor constituent in the chestnut oak, white oak-northern red oak, northern red oak-sugar maple and cherry types. Yellow poplar has a frequency of 49% and an average importance value of 18.4, the fourth highest of all taxa. The predictive equations for yellow poplar (n=47) are:

$$IV=-73.33 + 13.38HS + 20.62PA - 1.07THA$$

$R^2=0.23$ $\bar{Y}=18.42$ $SEE=\pm 26.35$

$$RD=-37.25 + 3.91HS + 9.20PA + 1.37\ TEXTA - 0.45THA$$

$R^2=0.24$ $\bar{Y}=8.26$ $SEE=\pm 11.36$

$$RB=-37.86 + 9.40HS + 10.78PA - 0.62THA$$

$R^2=0.22$ $\bar{Y}=10.16$ $SEE=\pm 16.07$

In the equation for importance value, horizontal slope shape (HS), pH of the A horizon (PA) and thickness of the A horizon (THA) account for 38%, 35% and 28% of the explained variation, respectively; these variables appear in all equations. A horizon texture occurs in the relative density equation. Horizontal slope shape ($r=0.34$) and pH of the A horizon ($r=0.31$) are positively correlated with yellow poplar importance values. Concave slope shapes, increasing pH of the A horizon and thinner A horizons characterize yellow poplar sites on Bird Mountain. Several studies suggest increasing depth of the A horizon is a good indicator of site quality (Auten 1945; Tyron 1960; Della-Bianca and Olson 1961; Martin 1966); depth to tight subsoil and mottling are important factors contributing to the prediction of site index (Auten 1945; Tyron 1960; Hebb 1962; Phillips 1966; Gilmore et al. 1968). High clay content in the B horizon may inhibit root penetration, and mottling, if gray, is an indication of wetness; these are poor yellow poplar sites.

Few studies relate slope shape to yellow poplar distribution. However, position on the slope is commonly used in site index studies to predict tree height. Concave slope shapes occur in coves and at low slope positions and are associated with increased soil moisture downslope. Low slope position is an important predictor of site quality in many studies (Della-Bianca and Olson 1961; Hebb 1962; Phillips 1966; Ike and Huppuch 1968; Smalley 1969). Hinkle (1975) reports concave slope shapes the most important variable predicting yellow poplar relative density, relative basal area and importance.

In the Cumberland Mountains, Martin (1966) reports pH of the A horizon positively related to yellow poplar absolute density and absolute basal area; Gilmore et al. (1968) reports yellow poplar height positively correlated with A horizon pH in southern Illinois. Hinkle (1975) reports increasing pH levels of the B horizon an important predictor of relative density, relative basal area and importance value on north-facing slopes, but not south slopes. Crownover (1983) reports B horizon pH positively related to importance value; A horizon pH occurs in his relative density and relative basal area equations. Smalley (1984) classified forest sites in the Cumberland Mountains. He reports yellow poplar growth optimal on mountain footslopes, terraces, well drained streambottoms, upper north-facing slopes, colluvial slopes and in coves; all sites are very productive and have a 50 year site index of 100. He characterizes the soils as deep, loamy and well drained.

<u>Yellow Buckeye</u>. In the Cumberland and Appalachian Mountains, yellow buckeye attains its largest size in coves and north-facing slopes of mixed mesophytic forests and occurs on deep, dark well drained soils (Fowells 1965). In the Cumberland Mountains, yellow buckeye extends from 450 to 900 m elevation and is codominant with

sugar maple, basswood, yellow poplar, beech, white oak and northern red oak (Braun 1950). In the Great Smoky Mountains, yellow buckeye is most important in the cove hardwood forest between 1200 and 1500 m elevation and occurs to 1800 m (Whittaker 1956).

On Bird Mountain, buckeye is codominant in the mixed mesophytic community and is unimportant or absent in all other types. Yellow buckeye has a frequency of 22% and an average importance value of 4.9. The predictive equations for yellow buckeye (n=22) are:

$$IV=-40.13 + 4.56AB + 6.65PA + 0.02EL$$

$R^2=0.26$ $\bar{Y}=4.86$ $SEE=\pm3.53$

$$RD=-8.81 - 0.02SR + 2.66PA + 0.006EL$$

$R^2=0.30$ $\bar{Y}=1.80$ $SEE=\pm3.53$

$$RB=-24.62 + 3.05AB + 4.11PA + 0.01EL$$

$R^2=0.22$ $\bar{Y}=3.06$ $SEE=\pm7.35$

In the importance value equation, aspect (AB) accounts for 41% of the explained variation, A horizon pH (PA) 34% and elevation (EL) 26%. Aspect is positively related in the importance value and relative basal area equations, but it is replaced by insolation (SR) in the relative density equation. The A horizon pH and elevation occur in all equations and are positively related to the dependent variables. Importance value is positively correlated with aspect (r=0.43), A horizon pH (r=0.33) and elevation (r=0.22 at the 5% level). Lower middle to upper, north-facing sideslopes and draws with increasing A horizon pH characterize yellow buckeye sites on Bird Mountain. Yellow buckeye is confined to moist mesic sites and generally does not occur on convex ridgetops or spur ridges, regardless of aspect. Deep, dark, well drained soils with thick O and A horizons occur at higher elevations on north-facing sideslopes and in coves on Bird Mountain; these sites are favorable for yellow buckeye growth. Crownover (1983) reports that increasing A and B horizon pH and higher available water holding capacity are important predictors of species importance, relative density and relative basal area on House Mountain where buckeye occurs in north-facing draws, which reflects the mesic, less acid nature of the sites.

Black Cherry. Black cherry is widely distributed in the eastern United States, and grows under a wide range of climatic conditions. Optimal growth occurs in cool, moist temperate climates with adequate rainfall year round; deep, well drained soils, low slope positions and north and east aspects are the most favorable sites (Fowells 1965).

On Bird Mountain, black cherry occurs in scattered stands on north-facing slopes, predominantly above 700 m. It is dominant in the black cherry-sugar maple community and is an associated taxon in the mixed mesophytic and northern red oak-sugar maple types; it is minor to absent in other types. Black cherry has a frequency of 29% and an average importance value of 7.3. The predictive equations for black cherry (n=28) are:

$IV=-27.05 + 0.04EL + 5.68AB$

$R^2=0.26 \quad \bar{Y}=7.34 \quad SEE=\pm 14.50$

$RD=-12.74 + 0.02EL + 2.80AB$

$R^2=0.28 \quad \bar{Y}=3.66 \quad SEE=\pm 6.47$

$RB=-14.40 + 0.02EL + 2.85AB$

$R^2=0.21 \quad \bar{Y}=3.68 \quad SEE=\pm 8.62$

In the importance value equation, elevation (EL) accounts for 69% of the explained variation and aspect (AB) 31%. Both variables are positively related to the dependent variables and occur in all equations. On Bird Mountain, black cherry reaches its greatest importance on northeast-facing slopes at high elevations. Importance values are correlated with elevation (r=0.44) and aspect (r=0.33).

Braun (1950) considers black cherry a minor constituent in the mixed mesophytic forests of the Cumberland Mountains. Whittaker (1956) reports black cherry locally important between 1070 and 1675 m in cove hardwood forests of the Great Smoky Mountains.

The future of black cherry on Bird Mountain is uncertain; high levels of sugar maple reproduction may preclude the regeneration of black cherry.

Analysis of Variance Results and Discussion

Analysis of variance was used to test the null hypothesis that no differences existed for mean site, soil and vegetation variables between community types. The site variables of slope angle, aspect, elevation, potential insolation and horizontal slope shape were significantly different between community types (Table 17). Slope

Table 17. Tukey's studentized range test of mean site and soil variables calculated for Community Types on Bird Mountain, Frozen Head State Natural Area.

Environmental Variables		Community Types						
		Chestnut Oak	White Oak-Northern Red Oak	Northern Red Oak-Sugar Maple	Yellow Poplar	Beech	Black Cherry-Sugar Maple	Sugar Maple-White Basswood
	N=	18	8	11	10	15	3	30
SITE VARIABLES								
Slope Angle (Percent)		51.7^{a*}	$40.3^{a,b}$	$39.1^{a,b}$	35.0^{b}	33.4^{b}	$50.0^{a,b}$	52.1^{a}
Aspect**		0.35^{b}	0.51^{b}	0.63^{b}	0.81^{b}	0.94^{b}	1.55^{a}	1.59^{a}
Slope Position (Percent from Ridgetop)		$59.4^{b,c}$	$43.8^{c,d}$	$14.6^{d,e}$	$76.4^{a,b}$	92.6^{a}	6.7^{e}	$34.5^{c,d,e}$
Elevation (m)		$651.8^{c,d}$	$729.4^{b,c,d}$	$839.5^{a,b}$	$592.9^{d,e}$	481.8^{e}	883.7^{a}	$756.8^{a,b,c}$
Vertical Slope Shape**		1.3^{a}	1.3^{a}	1.4^{a}	2.0^{a}	1.6^{a}	1.3^{a}	1.6^{a}
Horizontal Slope Shape**		1.1^{b}	$1.4^{a,b}$	$1.5^{a,b}$	2.1^{a}	1.9^{a}	$1.7^{a,b}$	$1.7^{a,b}$
Potential Insolation (Kly/YR)		290.3^{a}	285.5^{a}	283.3^{a}	287.6^{a}	$262.5^{a,b}$	$216.7^{b,c}$	194.5^{c}
SOIL VARIABLES								
pH (water) of A horizon		4.1^{b}	$4.2^{a,b}$	4.0^{b}	$4.5^{a,b}$	$4.4^{a,b}$	$4.2^{a,b}$	4.7^{a}
pH (water) of B horizon		4.4^{a}	4.3^{a}	4.3^{a}	4.5^{a}	4.4^{a}	4.5^{a}	4.7^{a}
pH (1N KCl) of A horizon		3.4^{b}	$3.5^{a,b}$	3.4^{b}	$3.8^{a,b}$	$3.5^{a,b}$	$3.7^{a,b}$	4.0^{a}

Table 17 (continued)

Environmental Variables N=	Community Types: Chestnut Oak 18	White Oak-Northern Red Oak 8	Northern Red Oak-Sugar Maple 11	Yellow Poplar 10	Beech 15	Black Cherry-Sugar Maple 3	Sugar Maple-White Basswood 30
pH (1N KCl) of B horizon	3.4[b]	3.4[b]	3.6[a,b]	3.6[a,b]	3.5[a,b]	3.7[a]	3.7[a]
A horizon texture**	7.1[a,b]	7.1[a,b]	6.3[b]	7.3[a,b]	7.4[a]	7.0[a,b]	7.2[a,b]
B horizon texture**	5.3[a]	5.6[a]	3.9[a]	6.0[a]	5.8[a]	5.7[a]	5.7[a]
Available water holding capacity of A horizon (cm)	1.35[a]	1.48[a]	1.47[a]	1.89[a]	2.13[a]	2.00[a]	2.22[a]
Available water holding capacity of B horizon (cm), down to 50 cm	2.96[a]	3.25[a]	2.43[a]	3.31[a]	3.34[a]	2.03[a]	2.55[a]
Total available water holding capacity (cm) top 50 cm	4.31[a,b]	4.73[a,b]	3.90[b]	5.21[a,b]	5.47[a]	4.03[a,b]	4.77[a,b]
O horizon thickness (cm)	2.5[b]	4.0[a,b]	3.4[a,b]	3.0[a,b]	4.8[a]	4.0[a,b]	4.7[a]
A horizon thickness (cm)	14.1[b]	15.0[b]	16.9[a,b]	16.4[a,b]	17.9[a,b]	26.3[a]	23.8[a]
A horizon hue**	2.0[a]	2.0[a]	2.1[a]	2.0[a]	2.0[a]	2.0[a]	2.0[a]
A horizon value	3.9[a]	3.6[a]	4.0[a]	3.7[a]	4.0[a]	3.0[a]	3.6[a]
A horizon chroma	3.7[a]	3.0[a]	3.2[a]	3.2[a]	3.4[a]	2.7[a]	3.2[a]

Table 17 (continued)

Environmental Variables N=	Community Types Chestnut Oak 18	White Oak-Northern Red Oak 8	Northern Red Oak-Sugar Maple 11	Yellow Poplar 10	Beech 15	Black Cherry-Sugar Maple 3	Sugar Maple-White Basswood 30
B horizon hue **	1.9^{a}	2.0^{a}	2.0^{a}	2.0^{a}	2.0^{a}	2.0^{a}	2.0^{a}
B horizon value	$4.8^{a,b}$	5.0^{a}	5.2^{a}	5.0^{a}	$4.8^{a,b}$	4.3^{b}	$4.7^{a,b}$
B horizon chroma	5.4^{a}	5.0^{a}	5.8^{a}	6.0^{a}	5.8^{a}	4.7^{a}	4.6^{a}
A horizon coarse fragment content (percent wt.)	46.4^{a}	43.5^{a}	48.7^{a}	40.6^{a}	36.4^{a}	48.3^{a}	45.0^{a}
B horizon coarse fragment content (percent wt.)	47.3^{a}	39.5^{a}	50.5^{a}	40.2^{a}	36.0^{a}	49.3^{a}	42.7^{a}

*Means followed by the same letter are not significantly different at $P < 0.05$; df = 88.

**Coding of variables as in Table 16.

angle decreased at low elevations and reached its lowest values on footslopes and coves where the beech and yellow poplar communities were restricted. The chestnut oak and sugar maple-white basswood-yellow poplar-yellow buckeye communites occurred predominantly on middle to upper sideslopes and had the highest mean slope angles of all community types. Aspect was significantly different for community types occurring on opposing (north versus south) slopes. The black cherry-sugar maple and sugar maple-white basswood-yellow poplar-yellow buckeye types were restricted to the north-facing slope of Bird Mountain; the remaining communities had predominantly a southern aspect.

Mean elevations and slope positions were different between many community types. Community types occurring high on the landscape (northern red oak-sugar maple, black cherry-sugar maple, sugar maple-white basswood-yellow poplar-yellow buckeye) were different from communities at lower slope positions (beech, yellow poplar). The chestnut oak and white oak-northern red oak types occupied intermediate positions on the landscape and were rarely different from other community types. Community types were segregated by elevation, which was one of many factors controlling their distribution.

Horizontal slope shape was significantly more convex for the chestnut oak type compared to that in the beech and yellow poplar types. The former community occurred on middle to upper convex sideslopes and spur ridges; the latter types occurred in coves and on lower sideslopes with flat to concave slope shapes. Slope shape is one determinant predicting water movement above and below ground. Flatter slope shapes enhanced infiltration and subsurface flow, especially at low elevations, which may have favored the mesophytic taxa characteristic of the beech and yellow poplar types.

Vertical slope shapes were not different between community types. Slope shape in complex topography may not vary predictably with slope position (i.e. convex shoulder and upper sideslopes, concave foot and toeslopes). Geomorphic form of the landscape was controlled more by the underlying geology rather than slope position. Sandstone benches and shale backslopes defined the stairstep topography characteristic on the sideslopes of Bird Mountain. Vertical and horizontal slope shapes were not correlated with slope position, but were highly correlated with each other (r=0.79).

The lack of significant differences in vertical slope shapes between community types suggested that the factors of aspect and elevation controlled community distribution to a greater extent than vertical slope shape or its interaction with topographic position.

Potential insolation, from the tables of Frank and Lee (1966), was determined by the interaction of slope angle, aspect and latitude. Steep, northerly slopes recieved less insolation than south-facing counterparts. This influenced the microclimate on opposing slopes and favored more mesophytic taxa on north-facing slopes. Increased available soil water and reduced soil and air temperatures, evaporation rates and light intensities have been reported on north-facing slopes relative to south-facing slopes on the Cumberland Plateau in Kentucky (Hutchins et al. 1976), where a mixed mesophytic forest characterized north slope vegetation and a mixed oak-hickory type occurred on south slopes. On Bird Mountain, mesophytic taxa occurred more frequently on north slopes while a variety of oaks and hickories dominated south slopes.

The soil variables that were significantly different between community types were: A and B horizon pH's, as measured in water and 1N KCl, O and A horizon thicknesses, A horizon textures and total available water holding capacities of the top 50 cm. Communities occurring on the north-facing slope of Bird Mountain had higher A horizon pH's compared to communities on the south-facing slope; B horizon pH's were rarely different between community types. Higher pH values of the A horizons on north-facing slopes compared to those on south-facing slopes may be due to vegetation differences. Finney et al. (1962) reported a higher base content in the leaves of mesophytic taxa on north slopes, which were returned to the surface as litterfall, responsible for higher pH values there compared to those on south-facing slopes. Hutchins et al. (1976) also reported similar trends in pH on opposing slopes and attributed it to vegetation differences.

Texture of the A and B horizons were rarely different between community types. Silt loams and loams were common A horizon textures; B horizons were predominantly silty clay loams, clay loams and heavy loams. The majority of soils on Bird Mountain formed in sandstone and shale colluvium. Similar parent material, regardless of landscape position or aspect produced similar solum textures observed between community types.

Available water holding capacities of the A and B horizons were not different between community types; total available water holding capacity, down to 50 cm, was different between just two community types. These results were poorly understood, and may have been caused by inaccurate sampling of coarse fragments in the A and B horizons. Coarse fragment content in conjunction with horizon texture and thickness affected available water holding capacity. The consistent and accurate sampling of coarse fragments would be necessary for the correct calculation of available water holding capacity. Coarse fragments in the A and B horizons were not significantly different between community types. Since texture and coarse fragment content were not different between community types, but horizon thickness was, the lack of significance for total available water holding capacity between types was questionable.

Horizon thicknesses were different between community types occurring on opposing (north versus south) sideslopes. The thickest O and A horizons occurred in the predominant north-facing black cherry-sugar maple and sugar maple-white basswood-yellow poplar-yellow buckeye types; the thinnest horizons occurred in the chestnut oak type. The hotter, less protected middle to upper south-facing slope of Bird Mountain probably enhanced organic matter decomposition as compared to the cooler north-facing slope and the more protected footslopes and coves.

Average data for hues, values and chromas were not significantly different between community types. Solum color was similar in all community types and reflected the widespread distribution of the sandstone and shale colluvium, which served as parent material. Residual soils often had colors similar to colluvial ones; soil series did not segregate by community types.

In most community types, dominant taxa had significantly higher mean importance values compared to that in other types (Table 18). Sugar maple, a codominant taxon in three commuinity types, and northern red oak, a codominant in two communities, had significantly higher importance values between community types in which they were unimportant. Importance values of associated taxa were not as frequently significantly different between community types as dominant taxa. Unimportant taxa, with chronically low importance values, rarely were significantly different between community types. Mean importance values were not significantly different between community types among the following taxa: yellow birch, sweet birch, American hornbeam, bitternut hickory, black walnut, sweetgum, bigleaf magnolia, cucumber magnolia, blackgum, eastern hop hornbeam, big-toothed aspen, black locust, sassafras, slippery elm, yellowwood, shagbark hickory and mockernut hickory.

Mean total canopy tree densities, basal areas and sapling densities were rarely different between community types (Table 19). The successional black cherry-sugar maple type had the highest mean canopy tree density and basal area of all community types. The sugar maple-white basswood-yellow poplar-yellow buckeye type, dominant on the north-facing slope of Bird Mountain, had the highest total sapling density. The north slope of Bird Mountain supported a mixed mesophytic forest which was more diverse and contained larger trees as compared to

Table 18. Tukey's studentized range test of mean common canopy tree importance values calculated for Community Types on Bird Mountain, Frozen Head State Natural Area.

Common Canopy Tree Species	Community Types: Chestnut Oak	White Oak-Northern Red Oak	Northern Red Oak-Sugar Maple	Yellow Poplar	Beech	Black Cherry-Sugar Maple	Sugar Maple-White Basswood
N=	18	8	11	10	15	3	30
Acer rubrum	32.6^{a*}	24.9^{a}	$3.3^{b,c}$	$21.2^{a,b}$	$15.6^{a,b,c}$	$3.7^{b,c}$	0.0^{c}
A. saccharum	$9.8^{b,c}$	$9.6^{b,c}$	$39.7^{a,b}$	4.8^{c}	2.8^{c}	57.0^{a}	62.9^{a}
Aesculus octandra	0.2^{b}	1.1^{b}	0.0^{b}	2.3^{b}	0.0^{b}	0.0^{b}	14.4^{a}
Betula lenta	0.0^{a}	0.9^{a}	0.8^{a}	3.2^{a}	8.0^{a}	0.0^{a}	1.6^{a}
Carya glabra	7.3^{b}	3.4^{b}	23.7^{a}	2.7^{b}	0.8^{b}	0.0^{b}	0.4^{b}
C. ovalis	2.2^{b}	14.5^{a}	0.0^{b}	0.7^{b}	0.0^{b}	0.0^{b}	1.1^{b}
Fagus grandifolia	0.0^{b}	0.0^{b}	0.0^{b}	1.4^{b}	71.0^{a}	0.0^{b}	1.4^{b}
Fraxinus americana	0.0^{b}	0.0^{b}	0.9^{b}	0.8^{b}	$1.8^{a,b}$	$7.3^{a,b}$	10.1^{a}
Liriodendron tulipifera	5.6^{b}	5.5^{b}	1.4^{b}	76.4^{a}	16.3^{b}	4.3^{b}	18.9^{b}
Magnolia acuminata	1.0^{a}	3.1^{a}	5.3^{a}	1.7^{a}	1.2^{a}	6.7^{a}	4.5^{a}
Nyssa sylvatica	5.7^{a}	6.4^{a}	4.1^{a}	2.7^{a}	2.1^{a}	0.0^{a}	0.5^{a}
Prunus serotina	1.2^{c}	$1.8^{b,c}$	$9.0^{b,c}$	0.0^{c}	0.0^{c}	76.0^{a}	11.4^{b}
Quercus alba	$3.2^{b,c}$	74.5^{a}	$13.5^{b,c}$	19.0^{b}	$9.0^{b,c}$	1.3^{c}	1.3^{c}
Q. prinus	104.5^{a}	0.0^{b}	6.8^{b}	12.1^{b}	2.4^{b}	0.0^{b}	4.4^{b}

Table 18 (continued)

Common Canopy Tree Species		Community Types						
		Chestnut Oak	White Oak-Northern Red Oak	Northern Red Oak-Sugar Maple	Yellow Poplar	Beech	Black Cherry-Sugar Maple	Sugar Maple-White Basswood
	N=	18	8	11	10	15	3	30
Q. rubra		$13.1^{b,c}$	33.4^{b}	75.8^{a}	$14.6^{b,c}$	5.6^{c}	4.3^{c}	7.1^{c}
Robinia pseudoacacia		1.0^{a}	2.8^{a}	1.7^{a}	5.6^{a}	1.6^{a}	4.3^{a}	4.1^{a}
Tilia heterophylla		0.0^{b}	0.0^{b}	6.3^{b}	1.5^{b}	4.2^{b}	17.7^{b}	47.7^{a}
Tsuga canadensis		0.0^{b}	0.0^{b}	0.0^{b}	$10.2^{a,b}$	28.8^{a}	0.0^{b}	0.0^{b}

*Means followed by the same letter are not significantly different at $P < 0.05$; df = 88.

Table 19. Tukey's studentized range test of mean total canopy tree densities, basal areas and sapling densities calculated for Community Types on Bird Mountain, Frozen Head State Natural Area.

	Community Types						
Vegetation Variables N=	Chestnut Oak 18	White Oak-Northern Red Oak 8	Northern Red Oak-Sugar Maple 11	Yellow Poplar 10	Beech 15	Black Cherry-Sugar Maple 3	Sugar Maple-White Basswood 30
Total canopy tree density (stems/ha)	$601.7^{a,b}$*	423.1^{b}	$624.4^{a,b}$	$570.7^{a,b}$	486.5^{b}	794.3^{a}	$518.1^{a,b}$
Total basal area (m^2/ha)	$47.8^{a,b}$	33.6^{b}	53.6^{a}	$51.2^{a,b}$	$44.5^{a,b}$	56.3^{a}	$50.6^{a,b}$
Total sapling density (stems/ha)	1069.2^{b}	$1288.0^{a,b}$	$1370.5^{a,b}$	$1485.1^{a,b}$	$1470.3^{a,b}$	$1194.3^{a,b}$	1592.0^{a}

*Means followed by the same letter are not significantly different at $P < 0.05$; df = 88.

those of the south slope. Fewer, but larger trees on the north slope may partially explain the lack of significant differences in mean canopy tree densities. A more favorable microenvironment, cooler and moister, on the north slopes compared to south slopes probably enhanced the establishment and growth of mesophytic taxa. Information regarding disturbance history (fire, logging) was sketchy and incomplete. Selective logging, the loss of chestnut and fire occurrence may have had a major impact upon forest structure, reproduction of canopy taxa and successional status of the community types. The lack of data regarding disturbance history precluded the accurate interpretation of community structure data and prevented the historical reconstruction of successional trends.

Analysis of variance was used to test the null hypotheses that no differences existed for mean site and soil variables between map units. Vegetation plots were subjectively placed into map units based upon aspect, elevation and topographic position. No vegetation plots occurred in the floodplain map unit.

Since soil map units were defined by aspect, elevation and slope position, these variables were often significantly different between units (Table 20). Slope angles and slope shapes were frequently different between map units at extreme slope positions (ridgetop versus cove).

The soil factors of pH, coarse fragment content, horizon thickness and available water holding capacity were significantly different between map units. Differences in soil horizon pH's were related to aspect. The A horizon pH was lowest in the ridgetop and south-facing

Table 20. Tukey's studentized range test of mean site and soil variables calculated for map units on Bird Mountain, Frozen Head State Natural Area.

	Map Unit				
Environmental Variables N=	Upper North-Facing 18	Lower North-Facing 21	Cove 14	South-Facing 37	Ridgetop 6
SITE VARIABLES					
Slope angle (percent)	51.4^{a*}	$44.3^{a,b}$	34.6^{b}	$45.5^{a,b}$	$43.3^{a,b}$
Aspect**	1.56^{a}	1.65^{a}	1.15^{a}	0.36^{b}	0.10^{b}
Slope position (percent from ridgetop)	6.9^{a}	57.9^{a}	77.9^{a}	61.6^{a}	28.3^{b}
Elevation (m)	880.6^{a}	655.1^{b}	569.3^{b}	636.2^{b}	779.5^{a}
Vertical slope shape**	$1.7^{a,b}$	$1.4^{b,c}$	2.2^{a}	$1.4^{b,c}$	1.0^{c}
Horizontal slope shape**	1.7^{b}	1.4^{b}	2.6^{a}	1.4^{b}	1.2^{b}
Potential insolation (Kly/YR)	198.6^{c}	195.3^{c}	254.8^{b}	303.6^{a}	$285.3^{a,b}$
SOIL VARIABLES					
pH (water) of A horizon	$4.4^{a,b}$	4.5^{a}	4.7^{a}	4.2^{b}	3.9^{b}
pH (water) of B horizon	4.6^{a}	4.6^{a}	4.5^{a}	4.4^{a}	4.4^{a}
pH (1N KCl) of A horizon	$3.8^{a,b}$	$3.8^{a,b}$	3.9^{a}	3.4^{c}	3.3^{c}
pH (1N KCl) of B horizon	$3.7^{a,b}$	$3.6^{a,b}$	$3.7^{a,b}$	3.4^{b}	3.8^{a}
A horizon texture**	7.0^{a}	7.3^{a}	7.4^{a}	7.1^{a}	6.5^{a}

Table 20 (continued)

Environmental Variables	Map Unit				
N=	Upper North-Facing 18	Lower North-Facing 21	Cove 14	South-Facing 37	Ridgetop 6
B horizon texture**	5.7[a]	5.9[a]	6.4[a]	5.1[a]	3.2[b]
Available water holding capacity of A horizon (cm)	2.30[a,b]	2.25[a,b]	2.56[a]	1.19[c]	1.53[b,c]
Available water holding of B horizon (cm), down to 50 cm	2.17[b]	3.16[a]	2.91[a,b]	3.01[a]	2.93[a,b]
Total available water holding capacity (cm), top 50 cm	4.47[a,b]	5.41[a]	5.47[a]	4.20[b]	4.46[a,b]
O horizon thickness (cm)	4.9[a]	4.7[a]	4.6[a]	2.7[b]	3.7[b]
A horizon thickness (cm)	26.2[a]	20.8[a]	21.6[a]	13.5[b]	15.2[b]
A horizon hue**	2.0[a]	2.0[a]	2.0[a]	2.1[a]	2.0[a]
A horizon value	3.1[b]	3.8[a]	3.8[a]	3.9[a]	4.3[a]
A horizon chroma	2.8[b]	3.3[a,b]	3.2[a,b]	3.5[a]	3.5[a]
B horizon hue**	2.0[a]	2.0[a]	2.0[a]	1.9[a]	2.0[a]
B horizon value	4.6[b]	4.7[a,b]	4.9[a,b]	5.0[a]	5.0[a]
B horizon chroma	4.6[b]	4.8[a,b]	5.1[a,b]	5.9[a]	5.0[a,b]

Table 20 (continued)

		Map Unit				
Environmental Variables	N=	Upper North-Facing 18	Lower North-Facing 21	Cove 14	South-Facing 37	Ridgetop 6
A horizon coarse fragment content (percent wt.)		47.2[a,b]	38.0[b]	36.4[b]	48.9[a]	39.3[a,b]
B horizon coarse fragment content (percent wt.)		47.2[a,b]	35.8[b]	37.5[a,b]	48.4[a]	36.2[b]

*Means followed by the same letter are not significantly different at $P < 0.05$; df = 90.

**Coding of variables as in Table 16.

map unit and highest in the cove and lower north-facing unit. No significant differences existed between map unit B horizon pH's.

Map unit available water holding capacities were related to aspect and topographic position. Soils in map units high on the landscape with a southern exposure held significantly less total water than north-facing soils low on the landscape. The cove and lower north-facing map units were dominated by deep, colluvial soils, which had high available water holding capacities. The south-facing map unit contained a large proportion of shallow, residual soils, with low available water holding capacities. Differences in total soil water was directly related to differences in coarse fragments and horizon thicknesses between map units.

Soil profile values and chromas were significantly different between map units although hue was not different. Brown (the hue of 10 YR) was the dominant hue in the A and B horizons. Value and chroma were lower (darker) on the north slope compared to the south slope of Bird Mountain. Upper north-facing soils (pedons) were thicker, darker and contained more organic carbon than south-facing counterparts. The microclimate of north aspects and high elevations may favor higher levels of organic matter production and lower rates of mineralization and may be responsible for the higher organic carbon percentages, darker soil colors and thicker O and A horizons compared to those on similar south slopes.

Analysis of variance was used to examine differences in mean site, soil and vegetation variables between community types and map units. The site factors of aspect, elevation, insolation and slope shape were significantly different between most community types and map units. These site factors were the most important variables controlling community and species distribution. Mean importance values of canopy taxa were significantly different between community types; importance values of associated and unimportant taxa were less frequently different between community types, compared to those of dominant taxa. The soil variables of pH, O and A horizon thickness were commonly significantly different between community types and map units. Total available water holding capacity was significantly different between only two community types; unfortunately, this variable did not help characterize the edaphic environment of community types and only contributed a small amount to explained variation in some regression equations of species importance. Quantitatively this variable was unimportant to site characterization; qualitatively, it may be the most important soil variable influencing community and species distribution.

CHAPTER VI

DISCUSSION

Seven community types, classified by cluster analysis using canopy species importance values, were segregated along environmental gradients. Aspect, slope position, elevation, geomorphic form and soil type were important determinants of community distribution. Soil types were distributed in a complex, yet predictable pattern, and were loosely associated with community types. The yellow poplar community type, dominant in coves below 750 m, occurred primarily on colluvial soils characteristic of the cove map unit. The black cherry-sugar maple type occurred on upper, north-facing slopes and contained the soils of the upper north-facing map unit. The sugar maple-white basswood-yellow poplar-yellow buckeye community type occurred at all elevations on the north-facing slope of Bird Mountain and was associated with the upper and lower north-facing map units. The south-facing map unit occurred on southerly sideslopes and was associated with the white oak-northern red oak type, below 700 m, and with the northern red oak-sugar maple type above this elevation. The chestnut oak community type occurred on middle to upper, southerly sideslopes and spur ridges; it was distributed in the ridgetop and south-facing map units. The beech type occurred on footslopes and coves, below 600 m; it was associated with the lower north-facing, south-facing and cove map units below this elevation. Congruency of community types and map units was revealed by cluster analysis. Map units would have been more closely related to community types if a 50% dispersion level was chosen to define the community types. At this level of dispersion, the white oak-northern red oak and the northern red oak-sugar maple types would be combined and correspond to the south-facing map unit; the cove, upper north-facing, lower north-facing and ridgetop map units would still be roughly correlated to the yellow poplar, black cherry-sugar maple, sugar maple-white basswood-yellow poplar-yellow buckeye and chestnut oak types, respectively. The beech type occurred across several map units and did not correspond to a specific unit.

Soil series on Bird Mountain were mapped as complexes due to their high spatial variability. They varied locally across the landscape with parent material, elevation, aspect, geomorphic form and slope position controlling distribution. Map scale precluded the separation of soil series into consociations and slightly reduced their interpretive value regarding community types. A more detailed soil map, delineating each soil type, slope class, and phase, would have aided community type site characterization. However, most established soil series may have too wide a range in characteristics to have much predictability.

Community types and map units varied across large landscape units while soil series varied across small ones. Environmental factors controlled the distribution of vegetation and soils, but operated on different spatial scales. An individual community type may have occurred on many soil types (series), map units, and slope positions; soil types occurred on specific landforms which varied locally due to the complex geology of the area. The interaction of site factors with geologic variability produced a complex array of soils, which influenced community distribution.

Regression analysis was used to predict overstory importance values, relative densities and relative basal areas, using site and soil factors. No attempt was made to predict community type distribution using multiple regression. Although the dominant canopy trees were not exclusively confined to a single community type, they had significantly different mean importance values between communities and were considered indicator species of a particular community. In the regression equations, site factors contributed a large percent to explained variation and total R^2. They were more important predictors of species importance, relative density and relative basal area than soil variables.

Aspect, elevation, slope angle, slope shape and insolation were the most frequent site factors occurring in the equations. Soil factors contributed a small but significant amount to explained variation; soil texture, available water holding capacity, percent coarse fragment content, pH and O horizon thickness were the most important soil variables occurring in the regression equations.

Elevation was an important predictor of species importance for beech, eastern hemlock, northern red oak, sugar maple and black cherry. Beech and eastern hemlock were dominant taxa in the beech type, which was restricted to low elevations (below 600 m). Total available water holding capacity contributed a small amount to explained variation in the equation for beech importance. Northern red oak, sugar maple and black cherry were dominant taxa in community types segregated by elevation and aspect. Insolation, as influenced by aspect, was the second most important predictor of northern red oak and sugar maple importance; these taxa were dominant in community types occurring on the south-facing and north-facing slopes of Bird Mountain, respectively. Aspect, important to black cherry prediction, helped control the distribution of the black cherry-sugar maple type, which occurred on the upper north-facing slope of Bird Mountain, above 825 m.

Aspect and slope angle contributed 82% to explained variation in the importance value equation for chestnut oak, the overwhelming dominant taxon in the chestnut oak type. This community type was restricted to steep, convex southwest slopes of Bird Mountain. Decreased elevation and O horizon thickness were less important predictors of species importance. Thin O horizons, characteristic of the ridgetop and south-facing map units, were common in this community type.

Decreased insolation and increased B horizon pH predicted the importance of white basswood, a codominant in the sugar maple-white basswood-yellow poplar-yellow buckeye type; this community type occurred on the north slope of Bird Mountain and had significantly lower mean insolation relative to most community types. Decreased aspect (northerly) and increased A horizon pH contributed 75% to explained variation in the equation for yellow buckeye importance, the fourth most important taxon in this community. Higher soil pH's were characteristic of the map units occurring on the north slope relative to the south slope of Bird Mountain. Increased insolation helped predict white oak importance; white oak occurred in many community types on the south slope of Bird Mountain. The low level of site restriction of white oak was reflected in the low R^2 values for all predictive equations.

Increased horizontal slope shape (concave) and A horizon pH contributed 73% to explained variation for yellow poplar importance. This taxon was dominant in the yellow poplar type (coves) and codominant in the sugar maple-white basswood-yellow poplar-yellow buckeye type at low slope positions. Yellow poplar distribution was coextensive with the cove map unit and the lower one-third of the lower north-facing map unit. Concave slope shapes were characteristic of these sites. A significantly higher mean A horizon pH existed for these map units relative to the south-facing and ridgetop units.

In all regression equations for species importance, site factors contributed more to explained variation and total R^2 than soil factors. For most taxa, elevation, insolation and aspect were major predictors of species importance; soil variables were the least important predictors on upper north-facing and south-facing slopes. In only one regression equation for importance (yellow poplar) did soil factors contribute more to total R^2 and explained variation than site factors and in only three equations did these same variables appear more than once. Soil factors were rarely the second most important predictors of species importance.

Total available water holding capacity was an unimportant predictor of species importance and occurred in only two regression equations - beech and white basswood; in both equations they were the least important predictor of species importance. Total available water holding capacity, down to 50 cm, was expected to be a more powerful predictor of species importance. It was observed, during the soil survey, that rooting depth of canopy trees was much greater than 50 cm. Colluvial soils in coves and on the north-facing slope had roots occurring at depths greater than 2 m; south-facing colluvial soils had much shallower solums and rooting depths (at least 1 m). Residual soils were the most shallow rooted of all soils, regardless of aspect; virtually impermeable R horizons were characteristic of these soils, but some were fractured and contained small pockets of soil material which supported roots. Roots may occur at much greater depths in paralithic and lithic materials than previously thought. Colluvial soils on north-facing slopes had thicker, more friable solums, and a higher root density at greater depths than their south-facing counterparts. Upper north-facing colluvial soils were most extreme in this respect. Available water holding capacity of the whole soil was higher in north-facing colluvial soils versus south-facing colluvial soils and residual soils, regardless of aspect. Viewed in this light, total available water holding capacity of the top 50 cm, was a poor indicator of the actual amount of water available to tree roots. The moisture dynamics of the soils on different aspects and elevations were probably more important than available soil water in explaining community distribution.

Pritchett (1979) stated that soil moisture influenced root development and distribution more than other soil factors and that most tree roots occurred in the upper 1m; the majority of fine roots occurred in the upper 20 cm. He reported root density a function of available soil moisture, nutrient concentrations, aeration and temperature of the soil; genetic form and habit of rooting were equally important determinants of rooting density. If most rooting occurred in the upper 1 m, available water holding capacity of the top 50 cm should accurately reflect water availability to roots, assuming adequate aeration, temperature, nutrient levels and similar rooting habits for most taxa. In this study mean total available water holding capacity rarely differed between community types and was a poor predictor of species importance.

The inconsistent and inaccurate sampling of coarse fragment content of the A and B horizons precluded the accurate calculation of total available water holding capacity; this may have contributed to the nonsignificant differences in mean available water holding capacities between community types and the virtual exclusion of this soil variable in the regression equations for species importance, relative density and relative basal area. However, soil factors not measured such as the seasonal distribution of moisture on opposing slopes probably affects tree growth more than any other soil variable.

Generally, the north-facing slope of Bird Mountain contained deep, friable soils which supported a mixed mesophytic forest type; the south-facing slope supported a more drought tolerant, mixed oak forest type. Quantitatively, soil moisture explained little in terms of community and species distribution. A qualitative assessment, based upon map unit interpretation, pedon data and patterns of vegetation, indicated the importance of available water in site characterization for community types. Distinct morphological differences were observed for soil map units on opposing slopes. Soils on the south-facing slope were rockier, shallower, droughtier and supported less mesic taxa than north-facing soils. Cove vegetation was mesophytic, characterized by deep, stony, colluvial soils. Moisture supply and replenishment were probably enhanced by the concave slope shape in coves which concentrated surface runoff and subsurface flow. Rooting depths, as observed during the soil survey study, often exceeded 2 m in these soils.

Patterns of community distribution were not adequately explained in terms of soil moisture availability. It would be naive to conclude that soil water did not influence tree growth and distribution; sampling errors and subsequent soil water calculations did not reflect the soil water differences which probably existed on the landscape. The typifying pedon data supported these differences; residual soils, more common on the south-facing slope, had low to very low available water holding capacity. Colluvial soils, more common in coves and on the north-facing slope of Bird Mountain, had 3 to 5 times higher available water holding capacities relative to the residual soils. The upper north-facing colluvial Humic Hapludult (Figure 25, Appendix B) had the highest available water holding capacity of all typifying pedons. These qualitative interpretations relating available soil water to community types needed to be supported or refuted quantitatively. Inaccurate coarse fragment data precluded this quantification and rendered this important soil variable virtually useless to the site characterization of community types.

CHAPTER VII

SUMMARY AND CONCLUSIONS

Vegetation, environmental and soils data from ninety-five .04 ha circular plots on Bird Mountain were analyzed for the purpose of classifying vegetation types and to predict species distribution. All vegetation was secondary. Seven community types were recognized using cluster analysis at a 45% dispersion level. Discriminant analysis was used to test the effectiveness of the cluster analysis; a high rate of classification success reflected the vegetatively distinct character of the community types defined by the cluster procedure. Regression analysis was used to predict species relation to soil and site factors. Analysis of variance was used to detect differences in mean soil, site and vegetation variables between community types and map units. The stability, successional trends and disturbance history of each community type were described by the analysis of diameter distribution curves. Another objective of the study was to describe and map soils. Soils were distributed in a complex manner; topography, parent material, vegetation and microclimate affected soil morphology and genesis.

The chestnut oak community occurred on middle to upper south, southwest and west-facing slopes and spur ridges. Soils were loamy, strongly acid, had a high coarse fragment content, had a low available water holding capacity and were well drained. Deep, well drained colluvial soils (Jefferson, Grimsley, Shelocta) occurred on sideslopes and thinner residual soils (Ramsey, Petros) occurred on spur ridges and upper, convex slopes. Chestnut oak was overwhelmingly dominant and was associated with red maple, northern red oak, sugar maple and pignut hickory. Chestnut oak and associated taxa were well represented in all tree diameter classes; this implied community stability.

The white oak-northern red oak type occurred primarily on lower, middle and upper south-facing sideslopes from 550 to 850 m elevation. White oak was the most important taxon; northern red oak, red maple and red hickory were codominants. Soils were strongly to extremely acid, loamy, had a high coarse fragment content, had low total available soil water holding capacity and were well drained. Colluvial soils (Jefferson, Shelocta and Grimsley) occurred on planar and concave sideslopes; residual soils (Ramsey, Petros) were restricted to upper, convex slopes. White oak and northern red oak sapling total averaged 38 stems per hectare.

The northern red oak-sugar maple type occurred on steep, middle to upper south, southwest and southeast sideslopes above 700 m elevation; some plots had a northerly aspect. Northern red oak and sugar maple were the most important taxa; they were codominant with pignut hickory and white oak. Soils were loamy, extremely acid, had a low available water holding capacity, had a high coarse fragment content, and were well to excessively well drained. Colluvial soils were dominant; Typic Hapludults (Jefferson, Grimsley) occurred on southerly slopes and a Humic Hapludult (no series designation) on upper, northerly slopes. The residual Ramsey and Petros soils occurred with rock outcrops on convex, upper southerly slopes. This community type was stable;

northern red oak, sugar maple, pignut hickory and white oak sapling total averaged 883 stems per ha.

A beech dominated type occurred on lower foot and toeslopes along the major drainageways of Bird and Old Mac Mountains below 600 m elevation; aspect was variable. Beech and hemlock were most important; they were associated with yellow poplar, red maple, white oak, sweet birch, northern red oak and white basswood. Soils were very strongly acid, had moderate available water holding capacity and were deep and well drained; silty textures were dominant in these soils. Colluvial soils (Jefferson, Shelocta, Grimsley) were dominant. Small, localized areas of Humic Hapludults, Typic Haplumbrepts, Umbric Dystrochrepts and Typic Dystrochrepts occurred in this type. Beech and hemlock were reproducing taxa in this community type.

A yellow poplar type occurred in coves at middle to low slope positions, below 750 m elevation; aspect was predominantly south or southeast. Soils were extremely to strongly acid, had moderate available water holding capacity and were deep and well drained. All soils were colluvial; Jefferson, Shelocta and Grimsley were dominant. A deep, well drained Humic Hapludult occurred on cooler, more protected sites; its area was small and distribution was localized. Yellow poplar reproduction was present in several diameter classes to suggest that this type may be self sustaining. Gap phase regeneration of yellow poplar enhances its persistence in this type, despite a low sapling density.

A sugar maple-white basswood-yellow poplar-yellow buckeye type occurred on a variety of landforms and at all elevations on the north-facing slope of Bird Mountain; it was the most widespread type identified in this study and was similar to the mixed mesophytic forest described by Braun (1950) in the Cumberland Mountains. Sugar maple, white basswood, yellow poplar and yellow buckeye were codominant; important associated species included black cherry, white ash, northern red oak and cucumber magnolia. Many soils occurred in this type due to differences in elevation, topography, parent material and aspect. Soils on the north-facing slopes were less acid, deeper, darker, held more water and contained less coarse fragments than south-facing counterparts. Colluvial soils (Grimsley, Jefferson, Shelocta) occurred on toeslopes, footslopes, in coves and on low to middle sideslopes, up to 750 m elevation; a colluvial Humic Hapludult (no series designation) occurred on upper north-facing slopes. Residual soils were less common and restricted to spur ridges, upper convex shoulder slopes and ridgetops; at elevations greater than 825 m, umbric or umbric like epipedons were common. Sugar maple and white basswood were well represented in all tree diameter classes; yellow buckeye and yellow poplar reproduction was low in larger diameter classes but high in the sapling class. All codominants were reproducing and this type was considered stable.

A successional black cherry-sugar maple type occurred on upper north-facing slopes of Bird Mountain, above 825 m elevation. Black cherry and sugar maple were codominant; white basswood, white ash and cucumber magnolia were important associated taxa. Vegetation was coextensive with the upper north-facing map unit. Areas of deep, well drained, colluvial Humic Hapludults and a shallow, residual Typic

Haplumbrepts occurred in this type. Moderately deep, residual Humic Hapludults occurred in the transitional zone between the deep Humic Hapludults and the shallow Typic Haplumbrepts. No series designation exists for these soils. Sugar maple and white basswood reproduction was high relative to black cherry, suggesting a future shift in overstory composition toward a mixed mesophytic type.

In the regression equations, site factors were more important predictors of overstory importance, relative density and relative basal area, than soil variables. In all equations, site factors explained more variation and contributed more to the total R^2 than soil variables. The site factors of aspect, elevation, insolation, slope angle and slope shape appeared most frequently in the regression equations; pH of the A and B horizons, O horizon thickness, total available water holding capacity, texture and percent coarse fragment content were the most important soil variables used in regression analysis.

Elevation was the most important predictor of species importance for northern red oak, beech, hemlock, sugar maple and black cherry; insolation was the most important predictor for red maple, pignut hickory, white oak and basswood importance values; aspect was the most important predictor of chestnut oak and yellow buckeye; horizontal slope shape was the most important predictor of yellow poplar importance.

Chestnut oak importance value was highest on steep, convex, low to middle southwest-facing slopes. Acid soils with thinner O horizon were characteristic soil variables. Aspect, slope angle and elevation accounted for most of the variation in the predictive equations. Thickness of the O horizon and A horizon pH were less important predictors of species importance and relative density, respectively.

Red maple importance increased on low, southerly slopes with variable shapes and coarse soil textures. Insolation was the most important predictor of species importance and relative density. Coarse B horizon textures, vertical (concave) and horizontal (convex) slope shapes and lower elevations contributed a small but significant amount to explained variation for species importance and relative density. Southerly aspects and low elevations were the only predictors of relative basal area.

Pignut hickory importance was greatest on middle to upper, south-facing slopes with coarse soil textures. Insolation and elevation were important predictors in all equations. Coarse textured A horizon was an important predictor of species importance. The submesic nature of this taxon was suggested by the occurrence on upper, southerly slopes. Soils with less clay content and low total available water holding capacity were characteristic.

White oak importance increased on middle to upper, southerly sideslopes and in coves. Increasing insolation, low B horizon coarse fragment content and higher elevations were important predictors in all equations. Low R^2 values suggest variables other than those measured were important to species distribution. White oak is widely distributed on south slopes and in coves; the ubiquitous nature of white oak due to a low level of site restriction, may contribute to low R^2 values.

Northern red oak, the most widely distributed taxon in this study, occurred on middle to upper, planar or convex southerly sideslopes. Increasing elevation and insolation and decreasing slope angle were important predictors in all equations. Convex slope shapes and coarse B horizon textures were less important predictors of species importance. Site variables accounted for most of the variation in the equation for species importance.

Beech importance increased at low elevations (<600 m) along major drainageways; deep, well drained soils high in available water holding capacity were characteristic sites. Elevation accounted for most of the explained variation in all equations. Available water holding capacity of the upper 50 cm was an important predictor of species importance and relative basal area. Braun (1950) reported beech absent above 600 m in the Cumberland Mountains.

Hemlock importance increased on gentle slopes at low elevations. Deep, well drained soils with low coarse fragment content and thick O horizons were characteristic and suggested increasing available water holding capacity. Elevation, slope angle and A horizon coarse fragment content were important predictors in all equations; O horizon thickness appeared in the equation for species importance and contributed a small amount to explained variation.

Sugar maple, the most important and second most widely distributed taxon in this study, occurred on steep, middle to upper, predominantly north-facing slopes. Increasing elevation and decreasing insolation were the only, and equally important, predictors of species importance; increasing pH and coarse fragment of the B horizon were important predictors of relative density. Increasing slope angle was a predictor of relative basal area. Steep, middle to upper north-facing sideslopes with higher soil pH's were optimal sugar maple sites. A sugar maple, with a 136 cm dbh, occurred on a steep, northeast convex sideslope at a middle slope position (730 m). It was the largest tree seen in the study.

White basswood importance increased on north-facing slopes at all elevations. Decreasing insolation, higher B horizon pH and decreased total available water holding capacity were important predictors and occurred in all equations. Insolation accounted for most of the explained variation in all equations and was highly correlated with species importance. The negative relationship of species importance with total available soil water in all equations is poorly understood.

Yellow poplar importance increased in southerly coves and north-facing sideslopes at low to middle elevations. Concave slope shapes, increased A horizon thickness and pH appeared in all equations and were equally important predictors. The A horizon texture was positively related to relative density and reflected an increase in available soil water.

Yellow buckeye occurred on middle to upper north-facing coves and sideslopes. Northerly aspects, increased A horizon pH and high elevations were important predictors of species importance and relative basal area. Insolation was the most important predictor of relative density.

Black cherry importance increased on upper, north-facing slopes. Elevation and aspect were the only predictors of species importance, relative density and relative basal area. Elevation accounted for 69% of the explained variation in the importance value equation. All regression equations had low R^2 values (0.21 to 0.28).

Analysis of variance detected differences between community types and map units. The site factors of aspect, elevation, insolation and slope shape were significantly different between map units and community types; these variables appeared most frequently in the regression equations for species importance and were important determinants of community type distribution. Mean importance values for dominant canopy taxa were significantly different between most community types and reflected their vegetationally distinct character. Mean importance values for associated taxa were less frequently different, and unimportant taxa rarely different between community types.

The soil variables of pH, O and A horizon thickness, texture and total available water holding capacity were significantly different between community types and map units. These variables were less important to community distribution than site factors, but equally important to site characterization. Total available water holding capacity, down to 50 cm, was significantly different between the beech and northern red oak-sugar maple types. Available soil water did not help discriminate between community types or map units. Coarse fragment sampling anomalies precluded its accurate calculation and rendered it useless to quantitative analysis. Qualitatively, soil water was an important soil variable affecting community distribution. The time of >1500 kPa (15 bar) moisture tension in soils may be more important to tree growth, based upon recent work on the Cumberland Platueau by TVA soil scientists.

Soils on Bird Mountain and along major drainageways were mapped as complexes on a topographic map at a 1:24000 scale. Differences in soil development were related to geomorphic position, elevation, aspect, vegetation, nature of the parent material and lithology of the Pennsylvanian aged sandstones, shales and siltstones. Topography and elevation influenced local microclimate and affected the direction and intensity of the soil forming process. Generally, soils on south-facing slopes were thinner, more acid, droughtier, had a higher coarse fragment content, had redder subsoils, had lighter colored epipedons and exhibited stronger structure than north-facing counterparts. However, most colluvial soil series were mapped in most map units.

A more rigorous weathering environment on south slopes enhanced the soil forming process. Generally, soils on south slopes experienced more cycles of freezing and thawing, wetting and drying, and had greater diurnal and annual temperature fluctuations (Cooper 1960); these soils were developmentally older than north slope soils. Soils on south slopes of Bird Mountain had an ochric epipedon and an argillic or cambic subsurface horizon. North slope soils at high elevations had an umbric or umbric-like epipedon. Lower to middle north slope soils were similar morphologically to south-facing counterparts. Organic carbon content of the surface and subsurface horizons was greatest on north aspects at high elevations. Six mapping units were distinguished; geomorphic position, aspect and elevation were the most important factors segregating mapping units.

Map units were associated with community types at the 1:24000 scale. The cove, upper north-facing, lower north-facing and ridgetop map units corresponded to the yellow poplar, black cherry-sugar maple, sugar maple-white basswood-yellow poplar-yellow buckeye and chestnut oak community types, respectively. The white oak-northern red oak and northern red oak-sugar maple community types were associated with the south-facing map unit. The beech community type occurred in the cove, lower north-facing and south-facing map units, below 600 m elevation.

The ridgetop map unit consisted of a complex of residual soils and rock outcrops; soils formed in acid sandstone, siltstone and shale and occurred on ridgetops, knobs, spur ridges and upper shoulder slopes of Bird Mountain. Ramsey, Petros, Gilpin and an Ochreptic Hapludult (no series designation) were common soils.

The south-facing map unit consisted of a complex of residual and colluvial soils intermingled with rock outcrops; it occurred on south-facing sideslopes at all elevations. The residual soil Ramsey and the colluvial soils Jefferson and Grimsley were common. Rock outcrops occurred at middle to upper slope positions and were associated with Ramsey.

The cove map unit consisted of a complex of two colluvial soils, Grimsley and Jefferson; it occurred in coves at all elevations and aspects on Bird Mountain. High stone and boulder content in the solum and on the surface were characteristic of this unit. Grimsley soils occurred closer to drainageways than Jefferson soils. Included in this unit were colluvial soils classified as Humic Hapludults (no series). They occurred at higher elevations and in protected sites at all elevations.

The lower north-facing map unit consisted of a complex of residual (Ramsey) and colluvial (Jefferson, Grimsley, Humic Hapludults-unnamed) soils; it occurred on the north-facing slope, below 825 m elevation. Ramsey soils occurred on middle to upper sideslopes, above 700 m; Jefferson and Grimsley soils occurred on middle to low sideslopes and footslopes, below 750 m elevation. The Humic Hapludult soils (no series) occurred between 825 and 750 m elevation. It was considered transitional between the soils of the upper north-facing map unit and the Jefferson/Grimsley soils of the lower north-facing map unit.

The upper north-facing map unit occurred on side and shoulder slopes of Bird Mountain, above 825 m; it contained soils with an umbric or umbric-like epipedon. Deep, well drained colluvial soils classified as Humic Hapludults (no series) and shallow residual soils classified as Typic Haplumbrepts (no series) were mapped as a complex. Colluvial soils occurred on flat to concave sideslopes, while residual soils occurred on convex spur ridges and shoulder slopes. Small areas of moderately deep (1 to 1.5 m), well drained, residual soils classified as Humic Hapludults (no series) occurred in the transition zone between the deep colluvial and shallow residual soils.

The floodplain map unit consisted of alluvial soils along the North Prong of the Flat Fork River. Soils classified in the family of loamy-skeletal, siliceous mesic Typic Hapludults (no series) characterized this small, level to nearly level, continuous floodplain.

Small areas of a non-skeletal soils and soils with dark surfaces occurred as inclusions in this unit.

Ten distinct soil series were mapped on Bird Mountain; five were established series and five unnamed. Two of the five established series were colluvial Typic Hapludults (Grimsley, Jefferson); these deep, well drained soils occurred on south-facing slopes at all elevations and on middle to lower north-facing slopes. Three (Gilpin, Petros, Ramsey) of the five established series were residual, shallow to moderately deep and restricted to ridgetops, knobs or spur ridges. Two of these were Dystrochrepts (Petros, Ramsey) and one a Hapludult (Gilpin). Four unnamed Hapludults and one Haplumbrept were mapped. An Ochreptic Hapludult occurred on ridgetops and spur ridges; it was shallow, excessively well drained and formed in residuum. A Typic Hapludult was restricted to level, narrow floodplains, at low elevations and formed in alluvium. It was cobbly (skeletal), deep and well drained. Two Humic Hapludults were mapped. One formed in colluvium and was deep and well drained. It had a high organic carbon level throughout the solum and was restricted to upper north and east-facing slopes. Another Humic Hapludult occurred in the transitional zone between the upper and lower north-facing map units. It was similar to the Jefferson series except it contained a dark A horizon. This soil was an inclusion in the cove map unit. A Typic Haplumbrept was mapped on upper north-facing slopes. It was residual, shallow and excessively well drained. Numerous inclusions occurred in each map unit. Established series considered inclusions were Berks, Cutshin, Lily, Muskingum, Shelocta, Wallen and Zenith. Unnamed inclusions were a Humic Hapludult in coves, a skeletal Ochreptic Hapludult on ridgetops and a non-skeletal variant of the floodplain Typic Hapludult.

The factors of soil formation, climate, organisms, topography, parent material and time (Jenny 1941) influenced the pedogenic processes which gave rise to soil formation. Differences in soil properties were related to differential expression of all soil forming factors except time; the effect of any single factor was difficult to discern due to this synergism. Topography and aspect affected the amount of insolation reaching the ground, which modified the microclimate. These factors, coupled with elevational changes, created a more mesic environment on the north-facing slope relative to the south slope. Parent material was highly variable and had a major influence upon soil properties. Colluvial and residual soils had distinctly different morphologies and supported different canopy taxa. The topography and underlying geology of the area, coupled with microclimatic variation and vegetation differences created a large number of soil series which were distributed in a complex pattern on the landscape. Chemical and physical characterization of the unnamed soil types occurring on Bird Mountain would aid in the establishment of several new soil series, lead to a better understanding of their formation and would provide a more complete site assessment for vegetation types. Further examination of these soils would contribute to the fund of knowledge for better management, use and protection of these natural resources.

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APPENDICES

APPENDIX A

SUMMARY STATISTICS BY COMMUNITY TYPE

Table 21. Abbreviations of Community Types Used in Tables 22-24.

Abbreviation	Community Type
CO	chestnut oak
WORO	white oak-northern red oak
ROSM	northern red oak-sugar maple
BE	beech
YP	yellow poplar
SMBA	sugar maple-white basswood-yellow poplar-yellow buckeye
BCSM	black cherry-sugar maple

Table 22. Site and soil properties of Community Types expressed as percentages of vegetation plots.

	Community Type*							
	CO	WORO	ROSM	BE	YP	SMBA	BCSM	Total
N=	18	8	11	15	10	30	3	95
Aspect (±22.5°)								
Northwest		12.5	18.2	6.6		6.7	33.3	7.4
North	5.5	12.5		26.6	10.0	46.7		22.1
Northeast			9.1	13.3		33.3	33.3	14.7
East	5.5						33.3	2.1
Southeast	5.5		9.1	13.3	40.0	3.3		9.5
South	27.7	62.5	45.4	26.6	40.0	3.3		25.2
Southwest	44.4	12.5	18.2	13.3				13.7
West	11.1				10.0	6.7		5.3
Slope Angle (Percent)								
0-10			9.1	6.7	20.0			4.2
11-20		12.5	9.1	26.7	10.0			7.3
21-30		12.5		13.3	10.0			5.1
31-40	16.7	37.5	45.5	13.3	10.0	33.3	66.7	27.2
41-50	27.7	12.5	9.1	33.3	20.0	10.0		17.7
51-60	50.0	12.5	27.3	6.7	20.0	30.0		26.1
61-70	5.6	12.5			10.0	23.3	33.3	11.4
71-80						3.3		1.0
Slope Position (Percent from Ridgetop)								
Top						16.7	33.3	9.3
1-20	5.6	25.0	72.7			23.3	66.7	17.7
21-40	22.2	37.5	27.3		20.0	26.6		20.9
41-60	38.9	12.5		6.7		16.7		14.6
61-80	22.2	25.0		6.7	40.0	13.3		13.6
81-100				86.6	40.0	3.3		23.9
Vertical Slope Shape								
Convex	72.2	75.0	63.6	33.3	20.0	56.7	66.7	55.2
Planar	27.8	25.0	36.4	66.7	60.0	23.3	33.3	36.5
Concave					20.0	20.0		8.3
Horizontal Slope Shape								
Convex	94.4	62.5	54.5	13.3	20.0	50.0	66.7	52.1
Planar	5.6	37.5	45.5	73.4	50.0	26.7		34.4
Concave				13.3	30.0	23.3	33.3	13.5

Table 22 (continued)

	Community Type*							
	CO	WORO	ROSM	BE	YP	SMBA	BCSM	Total
N=	18	8	11	15	10	30	3	95
pH (Water) A Horizon								
≤ 3.5 (extremely acid)			9.1					1.0
3.6-4.0 (extremely acid)	38.9	50.0	45.5	13.3		10.0	33.3	24.0
4.1-4.5 (extremely acid)	50.0	12.5	36.4	53.3	60.0	30.0	66.7	40.6
4.6-5.0 (very strongly acid)	11.1	25.0	9.1	26.6	30.0	33.3		22.9
5.1-5.5 (strongly acid)		12.5		6.7	10.0	26.7		11.5
pH (Water) B Horizon								
3.6-4.0		12.5	18.2			6.7		5.2
4.1-4.5	83.3	50.0	72.7	66.7	70.0	26.7	66.7	57.3
4.6-5.0	16.7	37.5		33.3	30.0	50.0	33.3	31.2
5.1-5.5			9.1			16.6		6.3
pH (1N KCl) A Horizon								
≤ 3.5	66.7	62.5	72.7	66.7	20.0	20.0	66.7	45.8
3.6-4.0	27.7	25.0	27.3	33.3	60.0	50.0	27.7	40.7
4.1-4.5	5.6	12.5			20.0	23.3	5.6	10.4
4.6-5.0						6.7		3.1
pH (1N KCl) B Horizon								
≤ 3.5	88.9	87.5	54.5	53.3	50.0	33.3		55.2
3.6-4.0	11.1	12.5	36.4	46.7	50.0	56.7	100.0	40.6
4.1-4.5						10.0		3.2
4.6-5.0								
5.1-5.5			9.1					1.0
Elevation (m)								
400-500	5.6			73.3	30.0	3.3		17.7
501-600	27.7	12.5		20.0	20.0	13.3		15.6
601-700	33.3	25.0	9.1	6.7	30.0	13.3		17.7
701-800	27.7	37.5	18.2		20.0	33.3		22.8
801-900	5.6	25.0	54.5			23.3	66.7	18.9
> 900			18.2			13.3	33.3	7.3

Table 22 (continued)

	Community Type*							
	CO	WORO	ROSM	BE	YP	SMBA	BCSM	Total
N=	18	8	11	15	10	30	3	95
Epipedon								
Ochric	88.9	100.0	72.7	93.3	90.0	56.7	33.3	77.1
Umbric	11.1		27.3	6.7	10.0	43.3	66.7	22.9
Subsurface Horizon								
Argillic	83.3	87.5	90.9	60.0	70.0	80.0	66.7	78.1
Cambic	16.7	12.5	9.1	40.0	30.0	20.0	33.3	21.9
Subgroup								
Typic Dystrochrept		12.5	9.1	26.7	20.0	3.3		9.4
Umbric Dystrochrept	11.1			6.7		3.3		4.2
Typic Haplumbrept	5.6			6.7	10.0	13.3	33.3	8.3
Typic Hapludult	72.2	62.5	54.5	60.0	60.0	46.7		56.3
Ochreptic Hapludult	5.6	12.5				3.3		3.1
Humic Hapludult	5.6	12.5	36.4		10.0	30.0	66.7	18.8
Coarse Fragments (Percent Wt.) A Horizon								
0-20 (low)	5.6			13.3	20.0	6.7		6.2
21-40 (moderate)	16.7	37.5	9.1	46.7	20.0	36.7	66.7	30.3
41-60 (high)	72.1	50.0	81.8	40.0	40.0	43.3		53.1
61-80 (very high)	5.6	12.5	9.1		20.0	13.3	33.3	10.4
Coarse Fragments (Percent Wt.) B Horizon								
0-20	11.2	12.5	9.1	20.0	10.0	3.3		7.3
21-40	27.7	37.5		46.7	50.0	43.3	33.3	37.5
41-60	44.4	37.5	81.8	33.3	20.0	46.7	33.3	43.7
61-80	16.7	12.5	9.1		20.0	6.7	33.3	11.5
Available Water Holding Capacity (top 50 cm)								
1.1-2.0 (very low)						3.3		1.0
2.1-3.0 (very low)	11.2	12.5	18.2		10.0		33.3	8.4
3.1-4.0 (low)	33.3	25.0	45.4	13.3	10.0	26.7		25.0
4.1-5.0 (low)	38.7	12.5	27.3	20.0	30.0	30.0	66.7	29.1
5.1-6.0 (moderate)	5.6	37.5	9.1	26.7	20.0	26.7		19.8
6.1-7.0 (moderate)	11.2			33.3	10.0	13.3		12.5
7.1-8.0 (high)					10.0			3.2
> 8.0 (high)				6.7				1.0

Table 22 (continued)

		Community Type*							
		CO	WORO	ROSM	BE	YP	SMBA	BCSM	Total
	N=	18	8	11	15	10	30	3	95
Texture A Horizon									
Silty Clay				9.1					1.0
Clay Loam		5.6							1.0
Sandy Loam			12.5	9.1			3.3		3.1
Silty Clay Loam		5.6		27.3	6.7		3.3		6.3
Loam		55.6	50.0	45.4	40.0	70.0	60.0	100.0	56.3
Silt Loam		33.3	37.5	9.1	53.3	30.0	33.3		32.3
Texture B Horizon									
Sandy Clay Loam			12.5				3.3		2.1
Clay		5.6		36.4	13.3		3.3		9.4
Silty Clay		16.7		18.2		10.0	6.7		8.3
Clay Loam		11.1				10.0	6.7	33.3	6.3
Sandy Loam				9.1					1.0
Silty Clay Loam		50.0	75.0	36.4	46.7	50.0	60.0	33.3	52.1
Loam		5.6			20.0	10.0	10.0	33.3	9.4
Silt Loam		11.1	12.5		20.0	20.0	10.0		11.5
Fire									
Absent		22.2	37.5	45.4	26.7	20.0	20.0	33.3	27.1
Present		77.8	62.5	54.5	73.3	80.0	80.0	66.7	72.9

*Coding of Community Types as in Table 21.

Table 23. Frequency of shrubs and vines by Community Type.

Taxa	N=	CO 18	WORO 8	ROSM 11	BE 15	YP 10	SMBA 30	BCSM 3	Total 95
		Community Type*							
Aristolochia durior							13.3		4.2
Euonymous americana					6.7	10.0			2.1
Kalmia latifolia		22.2		9.1	26.7				9.5
Rubus sp.		5.6	12.5						2.1
Smilax sp.		72.2	62.5	54.5	60.0	70.0	13.3		46.3
Vaccinium vacillans		50.0	12.5	18.2	6.7	10.0			14.7
Viburnum acerfolium		22.2			26.7	10.0	6.7		11.6
Vitis sp.		38.9	50.0	45.5	6.7	20.0	33.3		30.5

*Coding of Community Types as in Table 21.

Table 24. Frequency of common canopy tree species by Community Type.

Taxa		Community Type*							
		CO	WORO	ROSM	BE	YP	SMBA	BCSM	Total
	N=	18	8	11	15	10	30	3	95
Acer rubrum		77.8	75.0	36.4	73.3	90.0		33.3	48.4
A. saccharum		38.9	50.0	81.8	13.3	40.0	96.7	100.0	61.1
Aesculus octandra		5.6	12.5			20.0	56.7		22.1
Betula lenta			12.5	9.1	40.0	20.0	10.0		13.7
Carya glabra		27.8	25.0	72.7	13.3	40.0	6.7		24.2
C. ovalis		5.6	62.5			10.0	3.3		8.4
Fagus grandifolia					100.0	20.0	3.3		18.9
Fraxinus americana				9.1	13.3	10.0	46.7	66.7	21.1
Liriodendron tulipifera		27.8	37.5	9.1	73.3	100.0	53.3	33.3	49.5
Magnolia acuminata		11.1	25.0	9.1	13.3	20.0	33.3	33.3	21.1
Nyssa sylvatica		33.3	50.0	36.4	26.7	20.0	6.7		23.2
Prunus serotina		16.7	12.5	36.4			56.7	100.0	29.5
Quercus alba		22.8	100.0	63.6	46.7	50.0	6.7	33.3	35.8
Q. prinus		100.0		18.2	13.3	30.0	6.7		28.4
Q. rubra		72.2	87.5	100.0	33.3	90.0	40.0	66.7	62.1
Robinia pseudoacacia		11.1	25.0	9.1	6.7	30.0	10.0	33.3	13.5
Tilia heterophylla				18.2	26.7	100.0	90.0	66.7	37.9
Tsuga canadensis					53.3	20.0			10.5

*Coding of Community Types as in Table 21.

APPENDIX B

PEDON DESCRIPTIONS

Oi--5 to 1 cm; hardwood leaf litter.

Oe--1 to 0 cm; partially decomposed hardwood leaves.

A--0 to 6 cm; dark brown (10YR 3/3) gravelly loam; moderate fine granular structure; very friable; many fine and medium roots; 20% by volume coarse fragments of sandstone; extremely acid; abrupt smooth boundary; 3.24% organic carbon.

Bw--6 to 23 cm; yellowish brown (10YR 5/4) very channery loam; weak medium subangular blocky structure; friable; many fine and medium roots; 40% by volume coarse fragments of sandstone most which are channers; very strongly acid; abrupt smooth boundary; 1.29% organic carbon.

C--23 to 55 cm; yellowish brown (10YR 5/6); extremely channery sandy loam; massive; friable; few fine and medium roots; 75% by volume coarse fragments of sandstone; very strongly acid; abrupt smooth boundary; 0.49% organic carbon.

2Cr--55+ cm; acid siltstone.

Classification: loamy-skeletal, mixed, mesic Typic Dystrochrept (Petros taxadjunct).
Geomorphic Position: middle nose slope.
Slope Gradient: 60%. Aspect: 190°.
Slope Shape: convex perpendicular to the contour, convex parallel to the contour.
Elevation: 670 m.
Parent Material: fine grained sandstone colluvium over acid siltstone residuum.
Geologic Formation: Graves Gap.
Drainage: excessively well drained.
Available Water Holding Capacity: very low (2.83 cm/55 cm).
Diagnostic Horizons: ochric epipedon, cambic subsurface.
Location: UTM zone 16, 725980 m E, 4002460 m N.

Figure 15. Petros (taxadjunct) typifying pedon.

Oi--3 to 1 cm; hardwood leaf litter.

Oe--1 to 0 cm; partially decomposed hardwood leaves.

A--0 to 9 cm; dark brown (10YR 3/3) loam; moderate fine granular structure; very friable; many fine and medium roots; 10% by volume coarse fragments of sandstone; extremely acid; abrupt smooth boundary; 4.10% organic carbon.

BE--9 to 16 cm; dark yellowish brown (10YR 4/4) loam; weak medium subangular blocky structure; very friable; many fine and common medium roots; 15% by volume coarse fragments of sandstone; very strongly acid; abrupt smooth boundary; 3.10% organic carbon.

Bt--16 to 29 cm; dark yellowish brown (10YR 4/6) light gravelly clay loam; moderate medium subangular blocky structure; friable; common fine and medium roots; 20% by volume coarse fragments of sandstone; very strongly acid; abrupt smooth boundary; 1.58% organic carbon.

Cr--29 to 60+ cm; fractured fine grained acid sandstone bedrock interbedded with siltstone; few fine roots.

Classification: loamy, mixed, mesic shallow Ochreptic Hapludult (no series designation).
Geomorphic Position: ridgetop.
Slope gradient: 15%. Aspect: 260°.
Slope Shape: convex perpendicular to the contour, convex parallel to the contour.
Elevation: 885 m.
Parent Material: interbedded acid sandstone and siltstone residuum.
Geologic Formation: Cross Mountain.
Drainage: excessively well drained.
Available Water Holding Capacity: very low (3.30 cm/29 cm).
Diagnostic Horizons: ochric epipedon, argillic subsurface.
Location: UTM zone 16, 725010 m E, 4002820 m N.

Figure 16. Ochreptic Hapludult typifying pedon.

Oi--4 to 1 cm; hardwood leaf litter.

Oe--1 to 0 cm; partially decomposed hardwood leaves.

A--0 to 5 cm; dark brown (10YR 3/3) silt loam; moderate fine granular structure; very friable; very fine and medium roots; 10% by volume coarse fragments of sandstone; extremely acid; abrupt smooth boundary; 3.42% organic carbon.

AB--5 to 16 cm; brown (10YR 4/3) gravelly silt loam; weak medium subangular blocky structure; very friable; many fine and medium roots; 35% by volume coarse fragments of sandstone; very strongly acid; clear smooth boundary; 1.18% organic carbon.

Bt--16 to 40 cm; yellowish brown (10YR 5/6) very gravelly silty clay loam; weak medium subangular blocky structure; friable; common fine and few medium roots; 60% by volume coarse fragments of sandstone; very strongly acid; clear wavy boundary; 0.70% organic carbon.

Cr--40 to 95+ cm; massive fine grained acid sandstone.

Classification: loamy-skeletal, siliceous, mesic shallow Ochreptic Hapludult (no series designation).
Geomorphic Position: ridgetop at the base of a knob.
Slope Gradient: 37%. Aspect: 240°.
Slope Shape: convex perpendicular to the contour, convex parallel to the contour.
Elevation: 915 m.
Parent Material: acid sandstone residuum.
Geologic Formation: Cross Mountain.
Drainage: excessively well drained.
Available Water Holding Capacity: very low (2.86 cm/40 cm).
Diagnostic Horizons: ochric epipedon, argillic subsurface.
Location: UTM zone 16, 726010 m E, 4003320 m N.

Figure 17. Ochreptic Hapludult--skeletal inclusion.

Oi--4 to 2 cm; hardwood leaf litter.

Oe--2 to 0 cm; decomposed hardwood leaves.

A--0 to 8 cm; dark browwn (10YR 3/3) silt loam; moderate medium granular structure; very friable; many fine, medium and common coarse roots; common fine continuous tubular pores; 5% by volume coarse fragments of sandstone; strongly acid; abrupt smooth boundary.

BA--8 to 18 cm; dark yellowish brown (10YR 4/6) silt loam; weak fine subangular blocky structure; very friable; common fine medium and coarse roots; common fine continuous tubular pores; 5% by volume coarse fragments of sandstone; strongly acid; clear smooth boundary.

Bt1--18 to 33 cm; yellowish brown (10YR 5/6) silt loam; few medium faint yellowish brown (10YR 5/8) mottles; weak medium subangular blocky structure; friable; common fine, medium and coarse roots; common fine continuous tubular pores; few thin clay films on ped faces; 10% by volume coarse fragments of sandstone; strongly acid; clear smooth boundary.

Bt2--33 to 65 cm; yellowish brown (10YR 5/6) silty clay loam; weak medium subangular blocky structure; friable; common fine and few medium roots; common fine continuous tubular pores; common thin clay films on ped faces; 10% by volume coarse fragments of sandstone; strongly acid; gradual smooth boundary.

Bt3--65 to 86 cm; strong brown (7.5YR 5/6) silty clay loam; few medium distinct yellowish brown (10YR 5/6) mottles; weak medium subangular blocky structure; friable; few fine roots; common fine continuous tubular pores; common thin clay films on ped faces; 15% by volume coarse fragments of sandstone; strongly acid; gradual smooth boundary.

Bt4--86 to 102 cm; yellowish brown (10YR 5/6) silty clay loam; common medium distinct strong brown (7.5YR 5/6) mottles; weak fine subangular blocky structure; friable; few fine roots; common fine continuous tubular pores; few thin clay films on ped faces; 15% by volume coarse fragments of sandstone; strongly acid; gradual smooth boundary.

Cr--102 to 135 cm +; strong brown (7.5YR 5/8) interbedded weathered acid shale and sandstone.

Classification: fine-loamy, mixed, mesic Typic Hapludult (Gilpin).
Geomorphic Position: middle to upper spur ridge.
Slope Gradient: 42%. Aspect: 170°.
Slope Shape: convex perpendicular to the contour, convex parallel to the contour.
Elevation: 790 m.
Parent Material: interbedded siltstone and sandstone residuum.
Geologic Formation: Redoak Mountain.
Drainage: well drained.
Available Water Holding Capacity: moderate (15.10 cm/102 cm).
Diagnostic Horizons: ochric epipedon, argillic subsurface.
Location: UTM zone 16, 726960 m E, 4002900 m N.

Figure 18. Gilpin typifying pedon.

Oi--3 to 1 cm; hardwood leaf litter.

Oe--1 to 0 cm; decomposed hardwood leaves.

A--0 to 5 cm; dark yellowish brown (10YR 4/4) channery silt loam; moderate medium granular structure; very friable; many fine, medium and coarse roots; common fine continuous tubular pores; 25% by volume sandstone channers up to 15 cm; strongly acid; abrupt smooth boundary.

BA--5 to 15 cm; dark yellowish brown (10YR 4/6) channery silt loam; weak medium subangular blocky structure; very friable; common fine and medium roots; common fine continuous tubular pores; 30% by volume coarse fragments of sandstone; strongly acid; clear smooth boundary.

Bw--15 to 30 cm; yellowish brown (10YR 5/6) channery silt loam; weak medium subangular blocky structure; very friable; few fine and medium roots; common fine continuous tubular pores; 35% by volume coarse fragments of sandstone; few thin clay films on ped faces; strongly acid; clear smooth boundary.

R--30 cm; fine to medium grained acid sandstone bedrock of the Vowell Mountain formation.

Classification: loamy, siliceous, mesic Lithic Dystrochrept (Ramsey taxadjunct).
Geomorphic Position: upper sideslope.
Slope Gradient: 50%. Aspect: 150°.
Slope Shape: convex perpendicular to the contour, flat parallel to the contour.
Elevation: 840 m.
Parent Material: sandstone residuum.
Geologic Formation: Vowell Mountain.
Drainage: excessively well drained.
Available Water Holding Capacity: very low (3.20 cm/30 cm).
Diagnostic Horizons: ochric epipedon, cambic subsurface.
Location: UTM zone 16, 727280 m E, 4003210 m N.

Figure 19. Ramsey (taxadjunct) typifying pedon.

Oi--5 to 4 cm; hardwood leaf litter.
Oe--4 to 2 cm; partially decomposed hardwood leaves.
Oa--2 to 0 cm; decomposed hardwood leaves.
Overwash--0 to 9 cm; yellowish brown (10YR 5/6) gravelly sandy loam; weak fine granular structure; friable; many fine roots; 15% by volume coarse fragments of sandstone most of which are less than 7 cm across; very strongly acid; abrupt smooth boundary.
A--9 to 13 cm; dark yellowish brown (10YR 4/4) silt loam; weak fine granular structure; very friable; few fine roots; 5% by volume coarse fragments of sandstone; very strongly acid; abrupt smooth boundary; 2.47% organic carbon.
BE--13 to 28 cm; yellowish brown (10YR 5/6) silt loam; weak medium subangular blocky structure; friable; common fine roots; 5% by volume coarse fragments of sandstone; very strongly acid; clear smooth boundary; 0.64% organic carbon.
Bt1--28 to 60 cm; strong brown (7.5YR 5/8) silty clay loam; moderate medium subangular blocky structure; friable; common fine roots; 10% by volume coarse fragments of sandstone; few medium Mn nodules; very strongly acid; gradual smooth boundary; 0.39% organic carbon.
Bt2--60 to 95 cm; strong brown (7.5YR 5/6) silty clay loam; many medium distinct mottles of yellowish brown (10YR 5/4 and 10YR 5/6); strong medium subangular blocky structure; firm; common fine roots; 10% by volume coarse fragments of sandstone; few medium Mn nodules; very strongly acid; gradual smooth boundary; 0.24% organic carbon.
2Bt3--95 to 110 cm; yellowish red (5 YR 5/8) silty clay; many medium distinct mottles of yellowish brown (10YR 5/6); strong medium angular blocky structure; firm; few medium Mn nodules; extremely acid; gradual smooth boundary; 0.25% organic carbon.
2CB--110+ cm; light gray (10YR 7/1) silty clay; many medium prominent mottles of gray (10YR 5/1) and reddish brown (5YR 5/4); massive; platey rock structure; firm; siltstone; very strongly acid; 0.14% organic carbon.

Classification: fine-loamy, mixed, mesic Typic Hapludult (Shelocta).
Geomorphic Position: lower toeslope.
Slope Gradient: 38%. Aspect: 130°.
Slope Shape: concave to planar perpendicular to the contour, planar to slightly convex parallel to the contour.
Elevation: 490 m.
Parent Material: siltstone and sandstone colluvium over siltstone residuum.
Geologic Formation: Slatestone.
Drainage: well drained.
Available Water Holding Capacity: moderate (15.30 cm/95 cm).
Diagnostic Horizons: ochric epipedon, argillic subsurface.
Location: UTM zone 16, 725710 m E, 4001740 m N.

Figure 20. Shelocta typifying pedon.

Oi--6 to 2 cm; hardwood leaf litter.

Oa--2 to 0 cm; decomposed hardwood leaves.

A--0 to 10 cm; dark brown (10YR 3/3) cobbly silt loam; moderate medium granular structure; very friable; many fine and medium, and common coarse roots; many very fine and fine continuous tubular pores; 15% by volume sandstone cobbles; strongly acid; abrupt smooth boundary.

BA--10 to 20 cm; dark yellowish brown (10YR 4/4) cobbly silt loam; weak fine and medium subangular blocky structure; friable; many fine, common medium, and few coarse roots; many fine continuous tubular pores; 15% by volume sandstone cobbles up to 20 cm; strongly acid; clear smooth boundary.

Bt1--20 to 50 cm; dark yellowish brown (10YR 4/4) cobbly silt loam; moderate medium subangular blocky structure; friable; common fine and medium roots; many fine continuous tubular pores; few thin patchy clay films on ped faces; 35% by volume shale channers and sandstone cobbles and stones up to 60 cm; strongly acid; clear smooth boundary.

Bt2--50 to 69 cm; strong brown (7.5 YR 5/6) very cobbly clay loam; few fine faint mottles of brownish yellow (10YR 6/6); moderate medium subangular blocky structure; firm; few fine and medium roots; common fine and few coarse continuous tubular pores; common thin patchy clay films on ped faces; 60% by volume shale flagstones and sandstone cobbles, stones and boulders up to 75 cm; very strongly acid; gradual smooth boundary.

Bt3--69 to 99 cm; strong brown (7.5YR 5/6) extremely stony clay loam; few fine faint mottles of brownish yellow (10YR 6/6); moderate medium subangular blocky structure; firm; few fine and medium roots; common fine and few medium continuous tubular pores; common thin patchy clay films on ped faces; 70% by volume sandstone cobbles, stones and boulders up to 1 m; very strongly acid; gradual smooth boundary.

Bt4--99 to 140 cm; yellowish brown (10YR 5/6) extremely stony clay loam; few fine faint mottles of brownish yellow (10YR 6/8) and yellowish brown (10YR 5/4); weak coarse and moderate medium subangular blocky structure; firm; few fine, medium and coarse roots; few fine and medium continuous tubular pores; common thin patchy clay films on ped faces; 70% by volume rock fragments up to 1 m; few coal fragments less than 3 cm across; very strongly acid; gradual smooth boundary.

Bt5--140 to 160 cm; yellowish brown (10YR 5/6) extremely stony light clay loam; few fine faint mottles of brownish yellow (10YR 6/8); weak medium subangular blocky structure; firm; few fine, medium and coarse roots; common fine and few medium continuous tubular pores; few thin patchy clay films on ped faces; 70% by volume rock fragments of sandstone up to 1 m; few coal fragments less than 5 cm across; very strongly acid; gradual smooth boundary.

C--160 to 200+ cm; yellowish brown (10YR 5/8) extremely stony loam; common medium distinct mottles of pale brown (10YR 6/3) and few medium faint mottles of yellow brown (10YR 5/6); massive; very firm; few fine and medium roots; common fine, few medium and coarse continuous tubular pores; 80% by volume rock fragments of sandstone up to 1.25 m; few coal fragments less than 5 cm across; strongly acid.

Figure 21. Grimsley (taxadjunct) typifying pedon.

Classification: loamy-skeletal, siliceous, mesic Typic Hapludult (Grimsley taxadjunct).
Geomorphic Position: cove, middle slope.
Slope Gradient: 30%. Aspect: 230°.
Slope Shape: concave perpendicular to the contour, concave parallel to the contour.
Elevation: 620 m.
Parent Material: sandstone and shale colluvium.
Geologic Formation: Indian Bluff.
Drainage: well drained.
Available Water Holding Capacity: low (9.10 cm/150 cm).
Diagnostic Horizons: ochric epipedon, argillic subsurface.
Location: UTM zone 16, 725820 m E, 4002540 m N.

Figure 21 (continued).

Oi--2 to 0.5 cm; hardwood leaf litter.

Oa--0.5 to 0 cm; decomposed hardwood leaves.

A--0 to 3 cm; brown (10YR 4/3) loam; moderate fine granular structure; friable; many fine roots; 10% by volume coarse fragments of sandstone; strongly acid; clear smooth boundary; 2.98% organic carbon.

AB--3 to 15 cm; dark yellowish brown (10YR 4/4) loam; weak medium subangular blocky structure; friable; common fine roots; 10% by volume coarse fragments of sandstone; very strongly acid; clear wavy boundary; 1.26% organic carbon.

Bt1--15 to 50 cm; yellowish brown (10YR 4/4) loam; friable; thin patchy clay films of dark yellowish brown (10YR 4/4) on ped faces; common fine roots; 15% by volume coarse fragments of sandstone; few skeletans present; extremely acid; gradual wavy boundary; 0.90% organic carbon.

Bt2--50 to 90 cm; yellowish brown (10YR 5/6) light clay loam; friable; thin continuous clay films of dark yellowish brown (10YR 4/4) on ped faces; few fine roots; 15% by volume coarse fragments of sandstone and few coal chips; very strongly acid; gradual wavy boundary; 0.43% organic carbon.

Bt3--90 to 115+ cm; yellowish brown (10YR 5/8) clay loam; moderate medium subangular blocky structure; common medium distinct mottles of pale brown (10YR 6/3); thin continuous clay films on ped faces; firm; 10% by volume sandstone channers and flagstones; common medium Mn nodules; very strongly acid; 0.46% organic carbon.

Classification: fine-loamy, siliceous, mesic Typic Hapludult (Jefferson).
Geomorphic Position: cove middle slope.
Slope Gradient: 70%. Aspect: 180°.
Slope Shape: convex perpendicular to the contour; planar parallel to the contour.
Elevation: 700 m.
Parent Material: sandstone colluvium.
Geologic Formation: Graves Gap.
Drainage: well drained.
Available Water Holding Capacity: low (10.40 cm/90cm).
Location: UTM zone 16, 725850 m E, 4002740 m N.

Figure 22. Jefferson typifying pedon.

Oi--3 to 1 cm; hardwood leaf litter.

Oa--1 to 0 cm; decomposed hardwood leaves.

A--0 to 22 cm; very dark grayish brown (10YR 3/2) loam; moderate fine granular structure; friable; many fine and medium roots; 10% by volume coarse fragments of sandstone; moderately acid; clear smooth boundary; 3.82% organic carbon.

BA--22 to 42 cm; brown (10YR 4/3) light clay loam; weak medium subangular blocky structure; friable; common fine and medium roots; 15% by volume coarse fragments of sandstone; strongly acid; gradual wavy boundary; 1.30% organic carbon.

Bt1--42 to 76 cm; dark yellowish brown (10YR 4/4) clay loam; moderate medium subangular blocky structure; friable; few fine roots; thin patchy clay films of yellowish brown (10YR 5/4) on ped faces; 15% by volume coarse fragments of sandstone; strongly acid; diffuse wavy boundary; 0.55% organic carbon.

Bt2--76 to 135 cm; yellowish brown (10YR 5/4) gravelly clay loam; moderate medium subangular blocky structure; friable; few fine roots; thin continuous clay films of brown (10YR 5/3) on ped faces; 20% by volume coarse fragments of sandstone; strongly acid; diffuse wavy boundary; 0.57% organic carbon.

Bt3--135 to 200+ cm; dark yellowish brown (10YR 4/4) gravelly clay loam; moderate medium subangular blocky structure; friable; few fine roots; thick continuous clay films of yellowish brown (10YR 5/4) in pores; 25% by volume coarse fragments of sandstone; strongly acid; 0.40% organic carbon.

Classification: fine-loamy, siliceous mesic Humic Hapludult (no series designation).
Geomorphic Position: cove middle slope.
Slope Gradient: 30%. Aspect: 140°.
Slope Shape: concave to planar perpendicular to the contour, concave parallel to the contour.
Elevation: 625 m.
Parent Material: sandstone colluvium.
Geologic Formation: Indian Bluff.
Drainage: well drained.
Available Water Holding Capacity: moderate (15.50 cm/150 cm).
Diagnostic Horizons: umbric-like epipedon, argillic subsurface.
Location: UTM zone 16, 727560 m E, 4002820 m N.

Figure 23. Humic Hapludult--inclusion.

Oi--5 to 2 cm; hardwood leaf litter.

Oa--2 to 0 cm; decomposed hardwood leaves.

A1--0 to 5 cm; dark yellowish brown (10YR 4/4) loam; moderate fine and medium granular structure; very friable; many fine and medium and common coarse roots; many very fine and fine continuous tubular pores; 5% by volume coarse fragments of sandstone up to 5 cm; very strongly acid; abrupt smooth boundary.

A2--5 to 13 cm; yellowish brown (10YR 5/6) loam; weak fine subangular blocky structure parting to moderate medium granular structure; many fine and medium and common coarse roots; many very fine and fine continuous tubular pores; 10% by volume coarse fragments of sandstone up to 7 cm; strongly acid; clear smooth boundary.

BA--13 to 33 cm; yellowish brown (10YR 5/6) cobbly loam; moderate medium subangular blocky structure; very friable; many fine and medium and few coarse roots; many very fine and fine continuous tubular pores; 25% by volume sandstone cobbles and channers up to 10 cm; strongly acid; clear smooth boundary.

Bw--33 to 51 cm; dark yellowish brown (10YR 4/6) cobbly loam; moderate medium subangular blocky structure; friable; common very fine and fine, and few medium and coarse roots; many fine and common medium continuous tubular pores; 15% by volume sandstone cobbles and channers up to 12 cm; strongly acid; clear smooth boundary.

2Bt1--51 to 74 cm; strong brown (7.5YR 4/6) cobbly loam; moderate medium subangular blocky structure; friable; common fine, and few medium and coarse roots; common fine, and few medium continuous tubular pores; common thin patchy clay films on ped faces; 20% by volume sandstone cobbles up to 25 cm; very strongly acid; clear smooth boundary.

2Bt2--74 to 101 cm; strong brown (7.5YR 4/6) very cobbly loam; moderate medium subangular blocky structure; friable; common fine and few medium roots; many fine and common medium continuous tubular pores; common thin patchy clay films on ped faces; 50% by volume sandstone cobbles up to 25 cm and channers up to 15 cm; very strongly acid; gradual smooth boundary.

2Bt3--101 to 127 cm; strong brown (7.5YR 5/6) extremely cobbly loam; weak medium subangular blocky structure; friable; few fine roots; few fine and common medium continuous tubular pores; few thin patchy clay films on ped faces; 65% by volume cobbles, stones, channers and flagstones; very strongly acid; clear smooth boundary.

2BC--127 to 170+ cm; yellowish brown (10YR 5/6) extremely stony loam; few medium distinct strong brown (7.5YR 5/8) mottles; weak fine and medium subangular blocky structure; friable; many, fine and common medium continuous tubular pores; 90% by volume cobbles, stones and boulders up to 1.2 m; very strongly acid.

Figure 24. Typic Hapludult typifying pedon.

Classification: loamy-skeletal, siliceous, mesic Typic Hapludult (no series designation).
Geomorphic Position: floodplain.
Slope Gradient: 3%. Aspect: 180°.
Slope Shape: planar perpendicular to the contour, planar parallel to the contour.
Elevation: 410 m.
Parent Material: acid sandstone and shale alluvium.
Geologic Formation: Slatestone.
Drainage: well drained.
Available Water Holding Capacity: low (11.10 cm/127cm).
Diagnostic Horizons: ochric epipedon, argillic subsurface.
Location: UTM zone 16, 723830 m E, 4000310 m N.

Figure 24 (continued).

Oi--7 to 2 cm; hardwood leaf litter.

Oe--2 to 0 cm; decomposed hardwood leaves.

A1--0 to 25 cm; very dark gray (10YR 3/1) loam; strong fine granular structure; very friable; many fine and medium roots; 5% by volume coarse fragments of sandstone; many fine and medium roots and pores; very strongly acid; clear smooth boundary; 6.67% organic carbon.

A2--25 to 45 cm; very dark grayish brown (10YR 3/2) loam; strong fine granular structure; very friable; many fine and medium roots; many fine pores; 5% by volume coarse fragments of sandstone; very strongly acid; clear wavy boundary; 3.64% organic carbon.

AB--45 to 55 cm; dark reddish brown (5YR 3/3) loam; strong fine granular structure; very friable; many fine and medium roots; 5% by volume coarse fragments of sandstone; very strongly acid; gradual wavy boundary; 1.86% organic carbon.

Bt1--55 to 75 cm; dark brown (7.5YR 4/4) clay loam; moderate medium subangular blocky structure; very friable; common fine and medium roots; common distinct clay films on ped faces; 10% by volume coarse fragments of sandstone; very strongly acid; diffuse wavy boundary; 1.28% organic carbon.

Bt2--75 to 135 cm; dark brown (7.5YR 4/4) clay loam; strong medium subangular blocky structure; friable; few fine and medium roots; common distinct clay films on ped faces; 15% by volume coarse fragments of sandstone; very strongly acid; diffuse wavy boundary; 1.15% organic carbon.

BC--135 to 200+ cm; dark yellowish brown (10YR 4/4) channery loam; moderate medium subangular blocky structure; friable; few fine roots; 20% by volume coarse fragments of sandstone which include channers, flagstones and cobbles; very strongly acid; 1.53% organic carbon.

Classification: fine-loamy, mixed mesic Humic Hapludult (no series designation).
Geomorphic Position: upper concave sideslope.
Slope Gradient: 60%. Aspect: 20°.
Elevation: 870 m.
Parent Material: sandstone colluvium.
Geologic Formation: Vowell Mountain.
Drainage: well drained.
Available Water Holding Capacity: moderate (18.40 cm/150 cm).
Diagnostic Horizons: umbric epipedon, argillic subsurface.
Location: UTM zone 16, 725040 m E, 4003010 m N.

Figure 25. Humic Hapludult typifying pedon.

Oi--6 to 3 cm; hardwood leaf litter.
Oe--3 to 0 ccm; decomposed hardwood leaves.
A--0 to 8 cm; very dark grayish brown (10YR 3/2) channery silt loam; moderate medium granular structure; very friable; many fine and medium roots; common fine continuous tubular pores; 15% by volume sandstone channers up to 10 cm; strongly acid; abrupt smooth boundary.
BA--8 to 26 cm; dark brown (10YR 3/3) channery silt loam; weak fine subangular blocky structure; very friable; many fine and medium roots; common fine continuous tubular pores; 20% by volume sandstone channers up to 12 cm; strongly acid; clear smooth boundary.
Bw--26 to 48 cm; dark yellowish brown (10YR 3/4) channery silt loam; weak fine subangular blocky structure; very friable; many fine and common medium roots; common fine continuous tubular pores; 30% by volume sandstone channers up to 12 cm; strongly acid; clear smooth boundary.
Cr--48 to 60+ cm; light brownish gray (10YR 6/2) siltstone interbedded with fine grained sandstone.

Classification: loamy, mixed, mesic shallow Typic Haplumbrept (no series designation).
Geomorphic Position: upper spur ridge.
Slope Gradient: 45%. Aspect: 30°.
Elevation: 890 m.
Parent Material: interbedded siltstone and sandstone residuum.
Geologic Formation: Cross Mountain.
Drainage: well drained.
Available Water Holding Capacity: low (5.80cm/48cm).
Diagnostic Horizons: umbric epipedon, cambic subsurface.
Location: UTM zone 16, 727510 m E, 4003900 m N.

Figure 26. Typic Haplumbrept typifying pedon.

APPENDIX C

SUMMARY STATISTICS BY MAP UNIT

Table 25. Means of canopy tree species importance values by map unit.

Taxa	N=	Upper North Facing 18	Lower North Facing 21	Cove 14	South Facing 37	Ridgetop 6	Total 95
Acer rubrum		3.6	5.1	11.1	24.8	9.2	13.5
A. saccharum		56.2	45.1	7.4	17.5	22.2	29.6
Aesculus octandra		12.4	6.8	6.6	0.3		4.9
Betula lenta		2.4	4.9	5.2			2.3
B. lutea			1.9				0.4
Carpinus caroliniana			0.3	0.4			0.1
Carya cordiformis		3.7	1.2	4.3			1.6
C. glabra		3.3	0.4	2.1	8.0	14.0	4.9
C. ovalis			2.5	0.4	2.2	9.4	2.0
C. ovata		3.5	0.9	0.8	0.2		1.0
C. tomentosa			0.3	3.4	1.8		1.3
Cladrastis lutea			0.7	1.7			0.4
Cornus florida		0.3	0.2	1.1	0.5		0.4
Fagus grandifolia			20.5	14.4	15.2		12.4
Fraxinus americana		7.6	4.8	2.6	2.7		3.9
Juglans nigra			1.1				0.2
Liquidambar styraciflua			0.7	2.5	2.7		1.5
Liriodendron tulipifera		7.5	22.0	52.3	11.9		18.4
Magnolia acuminata		5.9	5.4	1.1	1.5		3.0
Nyssa sylvatica		0.6	3.1	1.4	4.8		2.8
Ostrya virginiana				0.3			0.1
Oxydendrum arboreum		0.3	2.9	5.2	7.0	2.7	4.3
Prunus serotina		25.8	6.4	2.8	1.8		7.3
Quercus alba		3.0	8.0	7.0	20.1	19.0	12.3
Q. prinus		3.5	3.6	7.7	44.8	57.5	23.4
Q. rubra		17.9	7.2	12.1	23.3	48.7	18.2
Q. velutina		1.4	0.2	0.3	1.4	6.8	1.3
Robinia pseudoacacia		1.0	5.4	3.8	1.2	8.3	2.8
Sassafras albidum		0.3	2.6		0.7	3.2	1.1
Tilia heterophylla		40.4	28.2	19.3	1.2		17.0
Tsuga canadensis			8.4	22.6	1.9		5.9
Ulmus rubra		0.4		0.9			0.2
Total Canopy Tree Density/ha		604.6	533.0	575.3	531.8	448.8	546.9
Basal Area (m^2)/ha		51.9	49.9	50.0	46.4	38.1	48.2
Sapling Density/ha		1487.9	1583.8	1387.2	1296.2	1153.2	1399.4

Table 26. Means of sapling relative densities by map unit.

	Map Unit					
Taxa	Upper North Facing	Lower North Facing	Cove	South Facing	Ridgetop	Total
N=	18	21	14	37	6	95
Acer rubrum	1.7	3.0	10.9	18.7	15.3	10.7
A. saccharum	59.7	41.2	16.4	25.4	40.2	34.9
Aesculus octandra	2.9	1.9	0.8	0.3		1.2
Asimina triloba		1.4		0.2		0.4
Betula lenta	0.5	1.8	1.4	0.2	0.8	0.8
B. lutea		1.0		0.1		0.2
B. nigra				0.1		0.02
Carpinus caroliniana		0.7	2.3	1.0		0.9
Carya cordiformis	0.2	0.5	0.6	0.5		0.5
C. glabra	0.9	0.1	0.5	1.4	3.0	1.0
C. ovalis			0.3		1.2	0.1
C. ovata		0.1	0.4			0.1
C. tomentosa		0.2	1.1	0.7		0.5
Castanea dentata	0.7	0.1	0.3			0.2
Cercis canadensis				0.2		0.06
Cladrastis lutea	0.9	3.6	2.4	0.1		1.3
Cornus florida	4.3	12.2	20.1	17.4	13.5	13.9
Fagus grandifolia	0.1	3.1	7.6	6.5		4.3
Fraxinus americana	3.9	2.8	3.1	2.1	0.2	2.6
Ilex opaca		0.1		0.1		0.04
Juglans nigra		0.1				0.03
Liquidambar styraciflua		0.4		1.1		0.5
Liriodendron tulipifera	0.2	1.2	0.5	1.0		0.8
Magnolia acuminata	2.4	1.7	0.9	1.4	0.7	1.5
M. macrophylla		1.1	0.7	0.1		0.4
Nyssa sylvatica	1.8	1.0	3.0	6.7	2.0	3.7
Ostrya virginiana		0.6	0.6	0.1		0.3
Oxydendrum arboreum		0.4	0.8	4.0	0.8	1.8
Populus grandidentata	1.4	2.4	0.5	0.2	2.8	1.1
Prunus serotina	1.7	0.2	1.5	1.1	3.0	1.2
Pyrularia pubera		1.6	2.7	1.1		1.2
Quercus alba			0.2	0.4	1.8	0.3
Q. prinus	0.1		1.0	2.5	3.5	1.4
Q. rubra	1.4	0.4	1.1	1.8	6.8	1.6
Robinia pseudoacacia	0.6	0.1	0.1	0.4		0.3
Sassafras albidum	0.2	0.1	0.2	0.6	4.7	0.6
Tilia heterophylla	13.9	8.9	3.8	0.9		5.4
Tsuga canadensis		5.3	13.3	1.9		3.8
Ulmus americana	0.4	0.9	0.3			0.3
U. rubra			0.4	0.4		0.2

Table 27. Site and soil properties of map units expressed as percentages of vegetation plots.

	Map Unit					
N=	Upper North Facing 18	Lower North Facing 21	Cove 14	South Facing 37	Ridgetop 6	Total 95
Aspect (± 22.5°)						
Northwest	27.7	9.5				7.3
North	22.0	57.1	35.7			21.9
Northeast	38.9	28.6	7.1			14.6
East	5.5			2.7		2.1
Southeast			28.6	13.5		9.4
South			14.3	62.2		26.0
Southwest			14.3	18.9	66.7	13.5
West		4.8		2.7	33.3	5.2
Slope Angle (Percent)						
0-10	5.6		14.3	2.7		4.2
11-20		9.5	21.4	5.4		7.3
21-30		9.5	7.1	5.4		5.1
31-40	27.8	28.6	21.4	24.3	50.0	27.2
41-50	16.7	14.3	14.3	18.9	33.3	17.7
51-60	16.7	23.8	7.1	40.5	16.7	26.1
61-70	27.8	14.3	14.3	2.7		11.4
71-80	5.6					
Slope Position (Percent from Ridgetop)						
Top	38.9			5.4		9.3
1-20	61.1			8.1	50.0	17.7
21-40		43.0	7.1	21.6	33.3	20.9
41-60		19.0	21.4	16.2	16.7	14.6
61-80		19.0	28.6	13.5		13.6
81-100		19.0	42.9	35.1		23.9
Elevation (m)						
400-500		9.5	35.7	27.0		17.7
501-600		28.6	14.3	18.9		15.6
601-700		14.3	42.9	18.9	16.7	17.7
701-800	5.6	42.9	7.1	21.6	50.0	22.9
801-900	61.1	4.8		10.8	33.3	18.8
> 900	33.3			2.7		7.3

Table 27 (continued)

	Map Unit					
	Upper North Facing	Lower North Facing	Cove	South Facing	Ridgetop	Total
N=	18	21	14	37	6	95
Vertical Slope Shape						
Convex	55.6	61.9		64.9	100.0	55.2
Planar	22.2	38.1	78.6	32.4		36.5
Concave	22.2		21.4	2.7		8.3
Horizontal Slope Shape						
Convex	50.0	57.1		64.9	83.3	52.1
Planar	27.8	42.9	42.9	32.4	16.7	34.4
Concave	22.2		57.1	2.7		13.4
pH (Water) A Horizon						
≤ 3.5				2.7		1.0
3.6-4.0	16.7	19.0		32.4	66.7	24.0
4.1-4.5	50.0	28.6	42.9	43.2	33.3	40.6
4.6-5.0	33.3	33.3	28.6	10.8		22.9
5.1-5.5		19.0	28.6	8.1		11.5
pH (Water) B Horizon						
3.6-4.0		4.8		8.1	16.7	5.2
4.1-4.5	50.0	47.6	64.3	62.2	66.7	57.3
4.6-5.0	50.0	33.3	28.6	27.0		31.2
5.1-5.5		14.3	7.1	2.7	16.7	6.3
pH (1N KCl) A Horizon						
≤ 3.5	22.2	28.6	28.6	67.6	83.3	45.8
3.6-4.0	66.7	47.6	42.9	27.0	16.7	40.7
4.1-4.5	11.1	19.0	14.3	5.4		10.4
4.6-5.0		4.8	14.3			
5.1-5.5						
pH (1N KCl) B Horizon						
≤ 3.5	22.2	52.4	28.6	86.5	33.3	55.2
3.6-4.0	77.8	38.1	64.3	13.5	50.0	40.6
4.1-4.5		9.5	7.1			3.2
4.6-5.0						
5.1-5.5					16.7	1.0

Table 27 (continued)

	Map Unit					
	Upper North Facing	Lower North Facing	Cove	South Facing	Ridgetop	Total
N=	18	21	14	37	6	95
Coarse Fragments (Percent Wt.) A Horizon						
0-20		9.5	28.6			6.2
21-40	22.2	61.9	28.6	13.5	50.0	30.3
41-60	72.2	14.3	21.4	78.4	50.0	53.1
61-80	5.6	14.3	21.4	8.1		10.4
> 50	38.9	19.0	28.4	48.7	16.7	33.6
Coarse Fragments (Percent Wt.) B Horizon						
0-20	5.6	9.5	7.1	5.4	16.7	7.3
21-40	14.8	52.4	57.3	27.0	50.0	37.5
41-60	40.7	38.1	21.4	48.7	33.3	43.7
61-80	11.1		14.3	18.9		11.5
> 50	50.0	9.5	28.4	45.9	16.7	32.6
Epipedon						
Ochric	11.1	81.0	85.7	100.0	100.0	77.1
Umbric	88.9	19.0	14.3			22.9
Subsurface Horizon						
Argillic	77.8	66.7	64.3	89.2	83.3	78.1
Cambic	22.2	33.3	35.7	10.8	16.7	21.9
Subgroup						
Typic Dystrochrept		14.3	28.6	2.7	16.7	11.4
Umbric Dystrochrept		4.8		8.1		2.1
Typic Haplumbrept	22.2	14.3	7.1			8.3
Typic Hapludult	5.6	61.9	50.0	83.8	33.3	56.3
Ochreptic Hapludult					50.0	3.2
Humic Hapludult	72.2	4.8	14.3	5.4		18.7
Hue A Horizon						
10YR	100.0	100.0	100.0	97.3	100.0	99.0
2.5Y				2.7		1.0

Table 27 (continued)

	Map Unit					
	Upper North Facing	Lower North Facing	Cove	South Facing	Ridgetop	Total
N=	18	21	14	37	6	95
Value A Horizon						
3	94.4	28.6	21.4	29.7		38.5
4		66.7	78.6	48.6	66.7	49.0
5	5.6	4.8		18.9	33.3	11.5
6				2.7		1.0
Chroma A Horizon						
2	22.2			8.1		7.3
3	72.2	66.7	78.6	45.9	50.0	60.4
4	5.6	33.3	21.4	37.8	50.0	29.2
6				8.1		3.1
Hue B Horizon						
7.5YR				5.4		2.1
10YR	100.0	100.0	100.0	94.6	100.0	97.9
Value B Horizon						
3		4.8				1.0
4	44.4	23.8	14.3	5.4		17.7
5	55.6	71.4	85.7	86.5	100.0	78.2
6				8.1		3.1
Chroma B Horizon						
1		4.8				1.0
3	5.6					1.0
4	61.1	57.1	42.9	35.1	66.7	47.9
6	33.3	28.6	57.1	35.1	16.7	35.4
7						
8		9.5		29.7	16.7	14.6
Available Water Holding Capacity (Top 50 cm)						
1.1-2.0				2.7		1.0
2.1-3.0	5.6		7.1	16.2		8.4
3.1-4.0	33.3	4.8	7.1	35.1	50.0	25.0
4.1-5.0	50.0	19.0	28.6	27.0	16.7	29.1

Table 27 (continued)

	Map Unit					
	Upper North Facing	Lower North Facing	Cove	South Facing	Ridgetop	Total
N=	18	21	14	37	6	95
5.1-6.0		57.2	14.3	8.1	33.3	19.8
6.1-7.0		19.0	21.4	8.1		12.5
7.1-8.0			14.3	2.7		3.2
> 8.0			7.1			1.0
Texture A Horizon						
Silty Clay				2.7		1.0
Clay Loam				2.7		1.0
Sandy Loam	5.6				33.3	3.1
Silty Clay Loam		9.5		8.1	16.7	6.3
Loam	83.3	47.6	57.1	54.1	16.7	56.3
Silt Loam	11.1	42.9	42.9	32.4	33.3	32.3
Texture B Horizon						
Sandy Clay Loam	5.6				16.7	2.1
Clay		4.8		16.2	33.3	9.4
Silty Clay	5.6	9.5		10.8		8.3
Clay Loam	11.1	4.8	7.1	5.4	16.7	6.3
Sandy Loam					16.7	1.0
Silty Clay Loam	55.6	47.6	57.1	56.8	16.7	52.1
Loam	11.1	19.0	14.3	2.7		9.4
Silt Loam	11.1	14.3	21.4	8.1		11.5

Table 28. Classification of established soil series occurring in or near Frozen Head State Natural Area.

Order Soil Series	Taxonomic Classification
INCEPTISOLS	
Berks	loamy-skeletal, mixed, mesic Typic Dystrochrepts
Cutshin	fine-loamy, mixed, mesic Typic Haplumbrepts
Ealy	coarse-loamy, siliceous mesic Fluventic Dystrochrepts
Muskingum	fine-loamy, mixed, mesic Typic Dystrochrepts
Petros	loamy-skeletal, mixed, mesic, shallow Typic Dystrochrepts
Ramsey	loamy, siliceous, mesic Lithic Dystrochrepts
Sewanee	coarse-loamy, siliceous, mesic Fluvaquentic Dystrochrepts
Wallen	loamy-skeletal, siliceous, mesic Typic Dystrochrepts
Zenith	fine-loamy, siliceous, mesic Umbric Dystrochrepts
ULTISOLS	
Gilpin	fine-loamy, mixed, mesic Typic Hapludults
Grimsley	loamy-skeletal, siliceous, mesic Typic Hapludults
Jefferson	fine-loamy, siliceous, mesic Typic Hapludults
Lily	fine-loamy, siliceous, mesic Typic Hapludults
Pineville	fine-loamy, mixed, mesic Typic Hapludults
Shelocta	fine-loamy, mixed, mesic Typic Hapludults
Welchland	coarse-loamy, siliceous, mesic Humic Hapludults

VITA

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