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I am submitting herewith a thesis written by William Robert Knight entitled "Relationship of Soils and Vegetation to Topography and Elevation in the Cumberland Mountains of Campbell County, Tennessee." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Plant and Soil Science.

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Thesis

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RELATIONSHIP OF SOILS AND VEGETATION TO TOPOGRAPHY
AND ELEVATION IN THE CUMBERLAND MOUNTAINS
OF CAMPBELL COUNTY, TENNESSEE

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

William Robert Knight

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ABSTRACT

A transect study and a pedon sampling study were conducted in the Cumberland Mountains in Campbell County, Tennessee. Soil formation and forest productivity were considered in relation to soil-site-vegetation variables.

In the study area, the mean annual soil temperature was 14°C, and the mean annual precipitation was between 120 cm and 145 cm. Soil parent material was shale, siltstone and sandstone.

Soil morphological, site and vegetational data were collected on 141 sites on 28 randomly selected north-south transects.

A definite pattern of soils was evident. Fifty-seven percent were Hapludults, and 43% were Dystrochrepts. On south aspects, 76% of the soils were Hapludults; 24%, Dystrochrepts. On north aspects, 59% of the soils were Dystrochrepts; 41%, Hapludults.

Correlation analysis indicated soils from colluvium in lower and concave positions. An increase in slope gradient indicated less water-holding capacity. Depth to bedrock, thickness of argillic horizon and surface stoniness decreased with increasing elevation. Al horizons were thicker and darker, and B horizon development was less on north aspects and high elevations.

Morphological differences between horizons were generally weak. Transition zones were thicker on north than on south aspects.

North aspects were more mesic than south aspects. Trees also segregated according to moisture conditions of the soil. Petros had more drought-resistant trees than Berks and Muskingum. Muskingum,

Gilpin (tax) and Shelocta (tax) had less variety and more drought-resistant trees than Muskingum (tax), Gilpin and Shelocta. Depth to bedrock and coarse fragment content were major factors affecting distribution of taxa.

In a separate study, eight soils on north and south aspects at elevations ranging from 520 m to 920 m were selected for morphological, chemical, physical and mineralogical analysis.

Morphological differentiation between A and B horizons was stronger on south than on north aspects. A horizons were darker on north aspects. Redder hues were in B horizons on south aspects.

On north aspects, pH values were higher in upper horizons than in lower horizons. Values were more uniform throughout the solum on south than on north aspects.

Organic carbon was greatest in the soils on north aspects and at higher elevations than at other positions.

Soils on south aspects had argillic horizons; those on north aspects did not.

Coarse fragment content greatly reduced the soils' capacity to hold water. Available water also was reduced by coarse fragments and nearness of bedrock. Soils 3S and 4N contained $>1/4$ by volume coarse fragments and were <100 cm thick. They held less available water (8 to 9 cm) than thicker soils with fewer coarse fragments, such as soils 1N and 4S with 17 to 18 cm of available water.

Texture, structure and organic matter content were also important soil physical properties which determine available water. A clay content

of >35% in soil 2S limited available water to 12 cm. Soil 1N with a whole soil average of 2.5% organic carbon has 18 cm of available water.

Thus, available water as influenced by coarse fragment content and depth to bedrock among other soil physical properties was a prime factor determining differences in plant growth.

Site factors (aspect, slope gradient, slope shape, position, elevation and parent material) influenced the distribution of water and the amount of evapotranspiration. The amount of soil water recharge and rate of water loss were results of an interaction among soil-site factors. The soil's physical properties were responsible for interception and storage of this water which was then available for plant utilization.

In both the transect study and the pedon sampling study, difference in soil development was related chiefly to topography and elevation which caused differences in microenvironments on similar parent material. On north aspects and upper elevations, A1 horizons were thicker and darker than those of other positions, and on south aspects clay translocation and B horizon development were greater than on north aspects. Thus, both direction and intensity of soil formation were determined by differences in the microenvironments developed from varied topography and elevation.

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CHAPTER I

INTRODUCTION

On the northeastern portion of the Cumberland Plateau in Tennessee, the highly dissected topography has been considered the reason for much of the variation in the soils and vegetation. Topography and elevation have a modifying effect on climate, producing numerous microenvironments which complicate the analysis of vegetation patterns and soil formation.

In order to make a comprehensive study of soil formation and soil-vegetation relationships, all facets of the environment need examination. Of concern to soil scientists and foresters are the characteristics of the environment which influence growing conditions for vegetation.

The objective of this report is to infer and interpret some soil-vegetation-topography-elevation relationships as they relate to soil formation and forest productivity.

Figure 1 is a block diagram depicting a generalization of the soil, geologic and topographic relationships as they exist in the Cumberland Mountains of Tennessee.

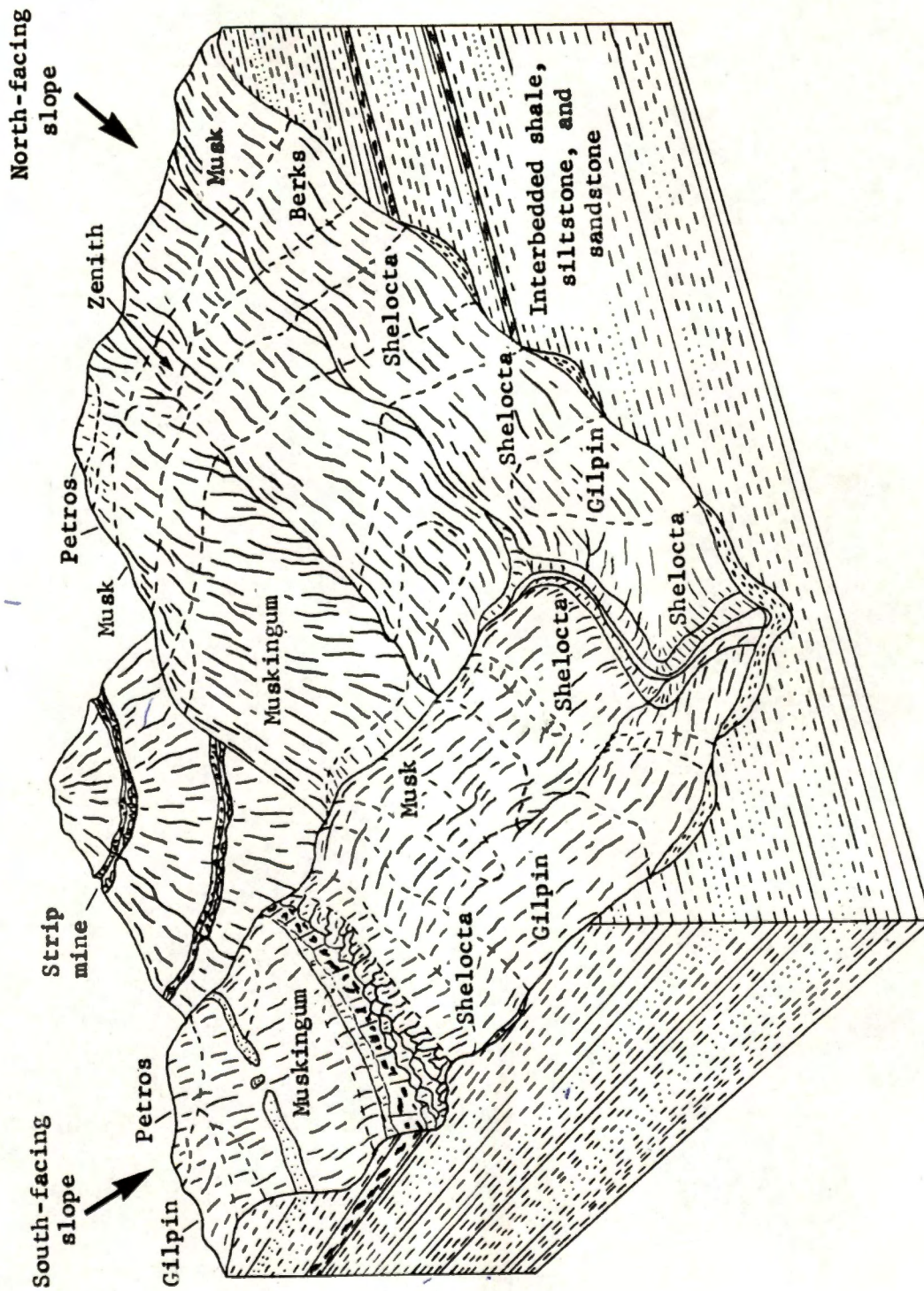


Fig. 1. Soils, geology and topography; Block quadrangle, Campbell County, Tennessee.

CHAPTER II

THE STUDY AREA AND REVIEW OF LITERATURE

Location and Extent

The Cumberland Plateau is the southern portion of the Appalachian Plateau's Physiographic Province extending from New York to Alabama. In Tennessee, the western margin of the Cumberland Plateau is separated from the Interior Lowland's Physiographic Province by a wide fringe. The eastern edge is defined by the Cumberland escarpment.

In Tennessee, the northern part of the plateau, the Cumberland Mountains, is more maturely dissected than the southern portion (Fenneman, 1938). The study area is an eastern section of the Cumberland Mountains contained within the boundaries of Campbell County, Tennessee (Wilson et al., 1956).

Physiography and Structure

The Cumberland Mountains in Campbell County are represented by the Cumberland Block and the Wartburg Basin. Wilson (1958) states that the Cumberland Block is a large overthrust sheet involving Pennsylvanian rocks. Pine Mountain, on the northwest border of the Cumberland Block, was caused by upper Ordovician beds being thrust over Pennsylvanian beds.

Pine Mountain separates the Cumberland Block from the Wartburg Basin. There is a subsidiary fault slice occurring northwest of Pine Mountain. Hells Point Ridge, an outlying klippe, reflects the dip of this fault.

At its southwestern extent, the Pine Mountain fault zone meets the Jacksboro fault. This fault continues the boundary between the Cumberland Block and the Wartburg Basin. A tight anticline along the northeastern side of the Jacksboro fault was a result of lateral movement. Southeast of the Cumberland Block, the Jacksboro fault extends along the plateau edge separating the Cumberland Mountains from the Valley and Ridge Physiographic Province (Wilson, 1958). Figure 2 depicts some geologic structures of the Cumberland Mountains.

From the Cincinnati arch there is a southeast regional dipping of rocks. This decline ends just northwest of the Pine Mountain fault zone. The strata in this area dip steeply to the northwest and reflect the result of drag phenomena associated with the movement of the Cumberland Block. There is an area of rock deformation variable in character and intensity just west of the fault zone. Localized discordance in the interval between coal beds can also be linked to the drag phenomena. The beds are flatter to the north of these deformed rocks but continue to dip northwest about 1° into the Woolridge syncline. From this structure, the beds begin to rise reflecting the gentle dip off the Cincinnati arch to the southeast (Englund, 1968).

There is some local crumpling and faulting along the Jacksboro fault, but there is no indication of overthrusting. Structural contour lines show that beds are horizontal southwest of the Jacksboro and Terry Creek faults (Stateler, 1970; Englund, 1968).

Thus, the present stratigraphy reflects the regional Appalachian geosyncline as well as structural deformation associated with thrust faulting during the Appalachian orogeny (Luther, 1967).

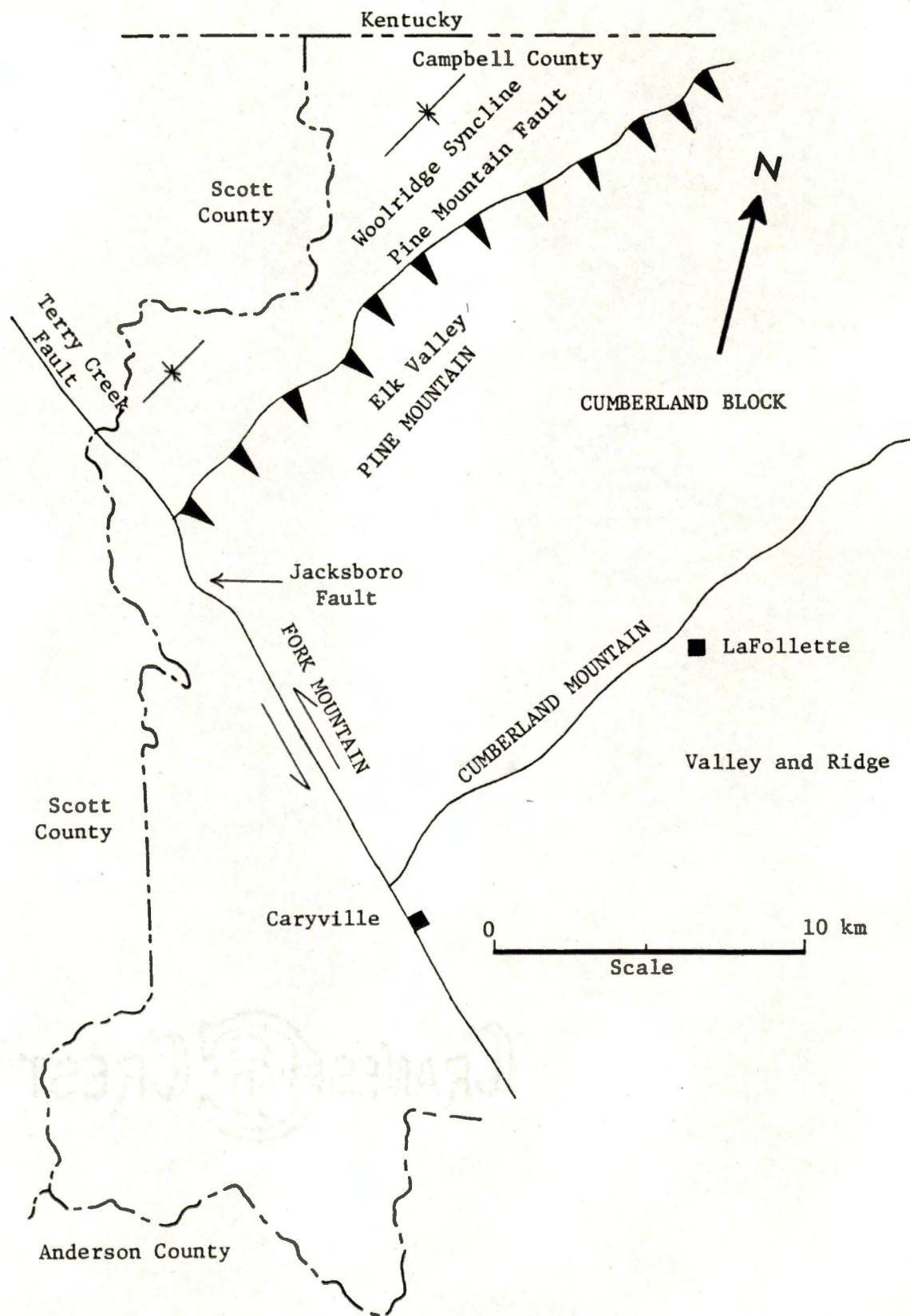


Fig. 2. Physiography and structure of the Cumberland Mountains in Campbell County, Tennessee.

Topography

The sharp relief of the area lying northwest and southwest of the Cumberland Block is attributed to the erosion resistant sandstones and conglomerates. The extensive stream dissection has caused relief ranging from 300 to 400 m. The highest elevation is approximately 1,075 m on Cross Mountain (Luther, 1959).

The area is characterized by dendritic drainage patterns and deep, V-shaped valleys. There is limited flatland along benches and on hillslopes formed by differential erosion of weak shale beds and resistant sandstone beds and in narrow flood plains along larger streams (Cathey, 1950; Englund, 1968).

Stratigraphy and Geology

The Pennsylvanian rocks of the northern Cumberland Plateau consist chiefly of sandstone, conglomerate, siltstone, shale, coal and ironstone. These lithologies are divided into a lower division of thick, continuous sandstone and shale and an upper division of mostly shale with numerous coal beds and discontinuous sandstones (Luther, 1959; Tisdale, 1974). According to Barlow (1969), the folio by Wilson et al. (1956) is a source of proper lithostratigraphic terminology for the Cumberland Plateau. Figure 3 is an adaption after Tisdale.

The northern Cumberland Plateau has for many years been a major coal-producing region in Tennessee. The middle and lower Pennsylvania formations have interbedded coal deposits of varying thickness, ranging from thin rider coals to economically important coal horizons (Luther, 1967).

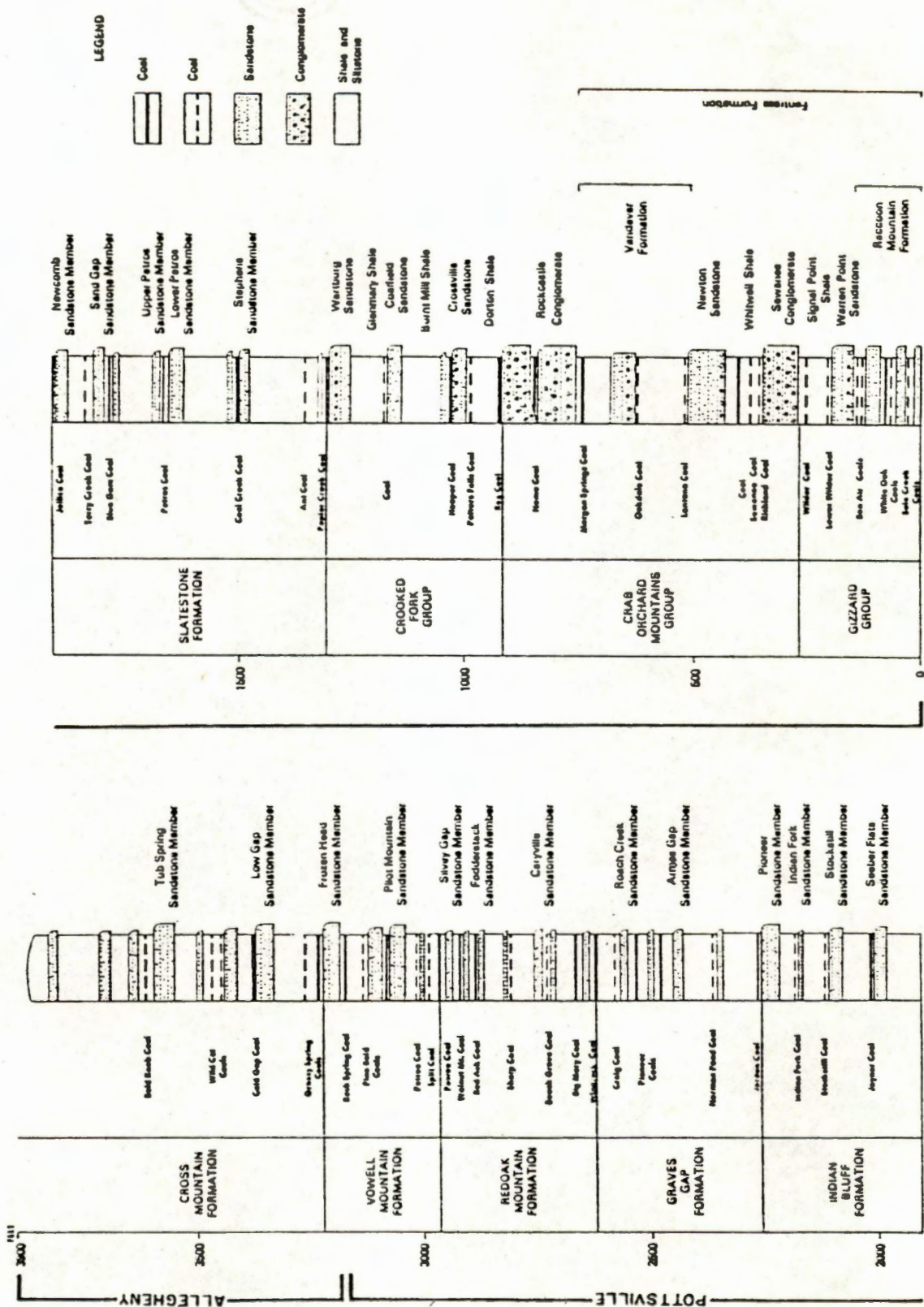


Fig. 3. Generalized stratigraphic sequence of Pennsylvanian rocks in Tennessee (after Tisdale, 1974).

Climate

The macroclimate in the study area is considered to be temperate and continental (Dickson, 1960). Thornwaite's classification (1948) for this region is humid, second mesothermal with no season of water deficiency and a potential evapotranspiration of 52 to 56% ($B_3B'_2rb'_3$). Precipitation arrives mainly from the western Gulf region (Dickson, 1960). The mean annual precipitation for the study area is between 120 cm and 145 cm. The mean maximum and minimum air temperatures for January are 9°C and -2°C. The mean maximum and minimum air temperatures for July are 32°C and 18°C. The mean dates of the first fall temperature of 0°C or lower are October 15 to October 25 (U.S. Department of Commerce, Weather Bureau, 1955, 1965).

The amount of solar radiation and moisture reaching a surface on the earth is greatly modified by topography in mountainous areas. If adequate rainfall is assumed, solar radiation is the main factor determining plant growth (Hutchins, 1975). According to Barfield (1973), the solar energy striking a surface is influenced by slope, aspect and time of year. The actual evapotranspiration is a result of the interaction of all the components in a topography. Thus, topography ultimately influences both moisture and temperature regimes of the soil. For classification purposes, this area was considered mesic (Soil Survey Staff, 1975).

A readily available measurement of soil temperature is not always possible during investigations. The mean annual air temperature plus 1°C has been considered a good estimator of the mean annual soil temperature

on level or gently sloping soils (Soil Survey Staff, 1964). Data collected from a topographically similar area in Anderson County by Springer and Longwell (personal communication) suggest that there was less than 1°C difference between the mean annual soil and the mean annual air temperatures.

Generally, soil temperatures, evaporation rates, transpiration rates, maximum air temperatures and light intensities are relatively higher on south-facing slopes (Cooper, 1960; Hutchins, 1976). Also, cycles of freezing and thawing in the winter and cycles of wetting and drying in the spring and summer are seen to be most prevalent on south-facing slopes (Cooper, 1960).

The mean annual soil temperature differences between north-facing and south-facing slopes was found by Franzmeier et al. (1969) to be 1.5°C in Kentucky and 1.9°C in Tennessee. Data by Springer and Longwell (personal communication) suggest a difference of 1.4°C between north-facing and south-facing slopes in Anderson County.

Variation in the gradient of slope is a result of topography which influences the amount of solar radiation reaching a surface. Barfield (1973) stated that the ratio of daily or monthly total energy reaching a sloping surface as compared with a horizontal surface is determined only after the daily variation in angles between the surface and the sun has been accounted for.

An increase in elevation adds to the complexity of the climatic relationships. The intensity of radiation increases, air temperatures decrease and precipitation varies erratically. Generally, the mean annual air temperature tends to decrease about 1.5°C for every 900 m increase.

Soil temperatures, however, may not decrease as much as air temperatures (Soil Survey Staff, 1964).

Soils

Numerous studies have been conducted which infer relationships about topography's effect on microclimate and soil genesis. North-facing and south-facing slopes (hereinafter referred to as north and south slopes) are generally considered to exhibit topographic and microclimatic extremes. Various works, qualitatively and quantitatively document relationships between and among microclimates, vegetation and soils.

Jenny (1941) recognized that soil temperature and moisture conditions had primary importance in the role of soil formation on slopes. He cited greater leaching on gentler slopes as the reason for more pronounced soil development.

Cooper (1960) studied the role of microclimates of north and south slopes in southwestern Michigan. He contended that local differences in topography offer "controlled experiments" in which the processes and factors of soil formation can be studied. Three of the factors-- regional climate, parent material and time--could be considered constant, allowing the study of topography and its effect on microclimate and organisms. He concluded that greater chemical and biotic weathering on south slopes caused by higher soil temperatures and cycles of freezing and thawing and of wetting and drying were major factors accounting for greater B horizon clay content.

Finney et al. (1962) studied topography's influence on climate and its relation to soil morphology of the northeast and southwest slopes of

the Allegheny plateau in southeastern Ohio. Microclimate and the associated differences in vegetation were cited as the major factors contributing to the variation in soil formation. These elements and others are interrelated, and separation in order to single out one as the prime reason for soil differences was suggested to be incorrect.

Franzmeier et al. (1969) studied soils and site factors in the southern Cumberland Mountains. The influence of aspect on soil temperature affected the soil's organic matter content, color and water-holding capacity. Argillic horizons were common on south slopes, while cambic horizons prevailed on north slopes.

Steeply sloping landscapes in Virginia and North Carolina were studied by Losche et al. (1970). Little variation was observed between opposing north and south slopes for the Virginia study. A lack of variety of precursor minerals in the acid sandstone and shale parent material was the explanation given. The North Carolina study showed south slopes had soils with stronger development. Granitic biotite gneiss was the parent material in this area and contributed a greater variety of precursor minerals. This in conjunction with higher annual precipitation and aspect-related soil temperature differences was suggested as the factors for the observed differences in soil properties.

Bailey and Avers (1971) cited the need for more emphasis on the deep colluvial soils on mountain slopes in eastern Kentucky. The soil chemical and physical properties were studied in an effort to support earlier mapping observations that the Shelocta soil (an Ultisol) was not the only soil in deep colluvium. An addition was suggested to include the Cranston series (an Alfisol). This soil with its coarser texture,

higher base saturation and aspect variability could provide better forest growth conditions than the Shelocta soil.

Hutchins et al. (1976) found soils on southwest slopes in Kentucky's Robinson Forest to be sandier with less water-holding capacity than northeast slopes. Again, topography's effect on microclimate was the most probable influence which caused differences in soil formation.

The USDA Soil Conservation Service at the time of this writing was conducting a progressive soil survey of Campbell County as part of the National Cooperative Soil Survey. The portion of the county involved in this study had been partially mapped. Table 1 contains ranges of some selected morphological properties of the major soils in the study area. These ranges were adapted from the National Cooperative Soil Survey established soil series descriptions. These standards were considered modal and were useful in placement of soils described during the study into soil series.

Vegetation

The Cumberland Mountain study area is part of the Mixed Mesophytic Forest Region (Braun, 1950). The plant communities generally fall into mixed mesophytic, mixed oak, oak-pine and swamp forest categories; however, local microclimatic and edaphic conditions produce a large number of stable component communities (Braun, 1935). Variants of the mixed mesophytic are called association-segregates. Cabrera (1969) states that they are characteristic of the forests of the central Cumberlands.

DeSelm et al. (1978) describes five forest types in the southern

Table 1. Range of morphological properties for selected soil series.

Soil series	Moist color of B		Texture of Ba	Coarse fragments in B		Coarse fragments in C	Solum thickness	Depth to bedrock	Characteristic horizons
	Hue	Value chroma		in B	in C				
-----cm-----									
% by wt									
----- (whole soil) -----									
Muskingum	7.5YR to 10YR	4/ to 5/ 4 to 6	sil (ch)	10-30	>35		40-90	50-100	
Petros	7.5YR to 10YR	5/ 3 to 6	sil, sil (vsh)	35-80			25-50	>50	Cr
Berks	7.5YR to 10YR	5/ to 6/ 6 to 8	1, sil (sh, sh)	25-75	60-80		60-80	50-100	
Zenith	7.5YR to 10YR	4/ to 5/ 4 to 8	1, cl, sil (gr)	15-35	1-35			100-175	thick, dark surface
Gilpin	7.5YR to 2.5YR	5/	1, sil, sil	5-40	30-90		45-90	50-100	argillic
Shelocta	7.5YR to 2.5YR	4/ to 5/ 4 to 8	sil, sil (ch)	<35	30-70		100-150	>300	argillic
Jefferson	7.5YR to 10YR	5/ 4 to 8	1, sil, cl (gr)	5-35	20-80		100-150	>150	argillic
Grimsley	7.5YR to 10YR	4/ to 5/ 4 to 8	1, cl, sil, 1 (cob)	35-65	35-65		100-150	100-150	argillic

^aCh = channery, sh = shaly, vsh = very shaly, gr = gravelly, cob = cobbly.

Source: Unpublished National Cooperative Soil Survey descriptions.

Cumberlands, including a tulip poplar type which had the greatest diversity and closely approximated the mixed mesophytic of Braun (1950). Site parameters were useful in making inferences about water-holding capacity which was the best indicator of forest segregates. A chestnut oak type was seen on middle and upper south slopes. A white oak type occupied lower slopes on both exposures, while the tulip poplar type occupied upper north slopes and draws (DeSelm et al., 1978).

Cabrera (1969) describes a mixed mesophytic forest community with a vegetation pattern following a gradient determined primarily by availability of moisture. He considers the four segregates as part of a vegetational continuum with no rigid limits on community boundaries. This type of gradation is also recognized by Whittaker (1967), who makes the assumption that a gradually changing community composition reflects a gradually changing environmental gradient. Safley (1970) found mixed mesophytic forests restricted to protected sites in the Southern Cumberland Plateau and Mountains. His vegetation patterns conformed to the association-segregation pattern on which forest taxa segregating on the basis of soil and site factors related to availability of water. A study of the Cumberland Gap area in Kentucky by Hinkle (1975) revealed communities totaling 15 on sites ranging from mesic to xeric.

CHAPTER III

METHODS AND PROCEDURES

Preliminary field studies were conducted to determine the problem extent, the methods that should be employed for problem analysis and the limits of the study area.

Transect Methods

Random sampling was used to determining transect locations on USGS-TVA 7.5' quadrangle maps. From 75 points previously located by grid overlay of the study area, 35 points were randomly selected for the study. The nearest north-northeast-facing and south-southwest-facing slopes from each point were found. A transect was located on these slopes from stream line to ridge top. In the Wartburg Basin, 22 transects were located, and all were studied. In the Cumberland Block region, 13 transects were located, but owing to lack of time, only 6 were studied. On each transect, 6-10 stops were made; these were separated by distances which allowed 30 to 90 m rise in elevation. One hundred forty-one recorded stops were made.

At each stop a hole was dug to 1 or 2 m depth, this depending upon coarse fragment and bedrock conditions. Soil morphological data were collected according to the Soil Survey Staff guidelines (1951). Canopy and sapling size trees (>7.5 cm and <7.5 cm diameter) were identified on approximately 0.04 ha plots using Shanks and Sharp (1963). Also estimated and recorded were percent canopy closure, percent shrub cover and evidence of burn. Moist soil colors were described according to the

Munsell color charts. Slope gradient was measured in percent with an Abney level. Aspect was measured with a Silva Ranger compass. All aspects were transformed according to a method by Beers et al. (1966). A direction of 25° is given a value of 2 while a direction of 205° is given a value of 0. Elevation was recorded from USGS-TVA 7.5' quadrangle maps.

A sample form used to record data is in Appendix A.

Strip mining has been done in parts of this region; thus, at certain elevations the examination of soils and vegetation was hampered.

All transect and site locations were marked on USGS-TVA 7.5' quadrangle maps. In the course of walking the transects, limited soil mapping was done to aid in the selection of soil sampling sites.

Sampling Methods

Eight sites from three transects were selected for complete physical and chemical characterization. These transects were selected from the transect study after a thorough examination of the area including review of geology, soil mapping from adjacent areas, discussions with Soil Conservation Soil Scientists, observations during preliminary field soil studies and examination of the transect study data.

An excavation approximately 1 m² was dug to bedrock. Each soil was described according to Soil Survey Staff guidelines (1951). Moist colors were described using the Munsell soil color charts. Three clods were taken from selected horizons. Each clod was placed in a hair net and immersed for a few seconds in Dow Saran dissolved in methyl isobutyl ketone. The clods were allowed to dry at the site, placed in plastic

bags and suitably stored to prevent disruption. A representative bulk sample was taken from each horizon by working up from the bottom of the pit. Coarse fragments >2 cm were sieved at the site, and volume estimates were recorded for coarse fragments from 2 to 8 cm and coarse fragments >8 cm. The <2 cm fraction was quartered, and a representative portion was bagged for lab analyses. Vegetation and other site analyses were conducted as described under "transect methods."

Laboratory Procedures

Bulk samples collected for laboratory analyses were air dried at room temperature and humidity. Air dry samples were rubbed with a rubber-tipped pestle. Coarse fragments not passing 4-mesh (per 2.5 cm) and 10-mesh sieves were weighed and considered the 1.9 to 4.7 mm and 4.7 to 2.0 mm fractions, respectively. Coarse fragments were retained for particle density analysis. The fraction passing the 10-mesh sieve was mixed well, and about 600 g were stored in pint cartons. Another 300 g were labeled and sent to The University of Tennessee testing laboratory in Nashville for P, K and pH determinations.

Clods collected for physical analysis were stored in air-tight plastic bags. Determinations for water at field state were made as soon as possible after collection to reduce evaporation. In the laboratory an additional coating of Saran resin was applied just prior to analysis (Brasher et al., 1966).

Physical Determinations

Mass and volume were measured for all clods according to the method described by the U.S. Department of Agriculture (1967). After oven

drying, clods were crushed and washed through a 2 mm sieve. The oven dry weight of the coarse fragments was determined. Samples of these coarse fragments and those coarse fragments taken at sampling were used to determine density by weighing the suspended fragment in air and again in water as described for the clod method by the U.S. Department of Agriculture (1967). Moisture retained at 15 bars tension was determined according to a method by Richards (1954).

The pipette method of Kilmer and Alexander (1949) along with nomographs for sedimentation by Tanner and Jackson (1947) were used on all samples to determine particle size distribution; however, sodium pyrophosphate was substituted for sodium hexametaphosphate as the dispersing agent (Yaalon, 1976).

The appropriate calculations for the physical measurements were performed with computer programs written and executed by the author. }

Chemical Determinations

Soil pH was determined in 1:1 soil-water suspension and in 1:1 soil-1N KCl suspension with a Fisher Accumet model 210 pH meter.

Organic matter content was determined by the chromate oxidation method of Walkley and Black (1934) with modifications by Jackson (1970).

Exchangeable bases (Ca, Mg, Na and K) were extracted by leaching with 1N NH_4OAc buffered at pH 7 as described by the U.S. Department of Agriculture (1967). The Perkin-Elmer 372 Atomic Absorption Spectrophotometer was used to determine solution concentrations. Standards were prepared in appropriate concentrations of 1N NH_4OAc .

Exchangeable acidity was determined by the BaCl_2 -triethanolamine method as described by Peech et al. (1947).

The sum of the cation extracts plus the exchangeable acidity was assumed to be the cation exchange capacity.

Extractable K and P were determined by The University of Tennessee soil testing laboratory using 1% $(\text{NH}_4)_2\text{SO}_4$ in 0.05 N H_2SO_4 (Sabbe and Breland, 1974).

Mineralogical Determinations

Glass slides of clay were prepared prior to X-ray analyses from air dried samples by a method of Jackson (1975). Hydrogen peroxide was used to destroy organic matter, and sodium pyrophosphate was used as a dispersing agent. Clay particles (<0.002 mm) were separated with a centrifuge. Magnesium ions were used to saturate one clay portion, and potassium ions were used to saturate another portion. The clay was transferred to glass slides. Diffraction traces were obtained from the potassium-saturated slide at room temperature and after heating to 300° and 550°C , successively. Traces were also obtained from the magnesium-saturated slide after treatment with ethylene glycol. Copper radiation, Geiger counter and chart recorder were used in X-ray analysis.

CHAPTER IV

TRANSECT STUDY

Soil of the Study Area

All soils were given a series name according to the morphological criteria in Table 1, page 13. Distribution and tentative classification of all soils examined in a transect study are in Table 2.

Hapludults were 57% and Dystrochrepts were 43% of the soils. Gilpin and Shelocta were common Hapludults; Muskingum, Berks and Petros were common Dystrochrepts (Table 2). Grimsley soils were described, but no percentages are available because this soil was included with the Shelocta series for distribution and correlation analyses.

Observed and recorded during the transect study were soils with some characteristics not within the ranges of soil series expected within the study area. These soils were important enough to warrant separate recognition with a taxadjunct modifier.

Zenith (1% of all soils) and Zenith taxadjuncts having bedrock within 100 cm depth (1% of all soils) were described (Table 2). Soils of limited extent in coves and other protected positions on north slopes had deeper, darker surface horizons than Zenith and were classified as Umbrepts.

Soils meeting other requirements for Muskingum but thicker than 100 cm represented 6% of the sample population (Table 2). Eleven percent of the soils similar to Shelocta and 7% similar to Gilpin (Table 2) had more coarse fragments than allowed by standard descriptions (Table 1, page 13).

Table 2. Distribution and tentative classification of soils examined in a transect study in Campbell County, Tennessee.

Great group ^a soil series	Classification	Composi- tion ---%---
Dystrochrepts		
Petros	Loamy-skeletal, mixed, mesic, shallow Typic Dystrochrepts	7
Berks	Loamy-skeletal, mixed, mesic, Typic Dystrochrepts	10
Zenith (tax)	Fine-loamy, siliceous, mesic, Umbric Dystrochrepts	1
Muskingum	Fine-loamy, mixed, mesic, Typic Dystrochrepts	18
Muskingum (tax)	Same as Muskingum	6
Zenith	Same as Zenith (tax)	1
Hapludults		
Gilpin (tax)	Loamy-skeletal, mixed, mesic, Typic Hapludults	7
Gilpin	Fine-loamy, mixed, mesic, Typic Hapludults	19
Shelocta (tax)	Loamy-skeletal, mixed, mesic, Typic Hapludults	11
Jefferson	Fine-loamy, siliceous, mesic, Typic Hapludults	2
Shelocta	Fine-loamy, mixed, mesic, Typic Hapludults	18

^atax = taxadjunct.

Hapludults were more common on south-facing slopes, while Dystrochrepts were more frequent on north-facing slopes (Table 3).

Petros was most common on south aspects and upper positions (Table 3). Berks was most common on north-facing slopes and lower positions. Muskingum and Muskingum taxadjuncts had high frequencies on north-facing slopes and middle and upper positions. Gilpin and Gilpin taxadjuncts were common on south aspects and middle and upper positions. Shelocta taxadjuncts were most common on south aspects. Shelocta was on both aspects but was most common on lower positions. Jefferson was found only on south aspects and upper positions (Table 3).

Also, Shelocta was on all positions on south aspects but limited to lower and middle north aspects. Shelocta taxadjuncts were most common on lower and middle south aspects and upper north aspects (Table 3).

The distribution of soils by elevation is in Table 4. Berks, Muskingum taxadjuncts, Shelocta taxadjuncts and Shelocta were common below 600 m. Gilpin was common at mid-elevations. Hapludults were 53% of the soils above 730 m; Dystrochrepts were the remainder.

Correlation Analysis

Introduction. The relationship between soil, site and vegetation variables was estimated by simple linear correlation techniques as was done by Martin (1966) in Morgan County, Tennessee. Observations made during the study were strengthened, and relationships not so easily recognized were clarified by correlation analyses. Some relationships between variables may not be linear and, therefore, could not be verified or detected by the technique used.

Table 3. Distribution of soils by aspect and position in a transect study in Campbell County, Tennessee

Great group soil series ^a	Aspect		Position		
	S	N	Lower	Middle	Upper
	-----%	----	-----	-----%	-----
Dystrochrepts					
Petros	5	2	1	2	4
Berks	2	8	5	3	3
Zenith	0	2	1	0	1
Muskingum	4	14	1	7	11
Muskingum (tax)	2	4	1	2	3
Hapludults					
Gilpin (tax)	5	2	2	1	4
Gilpin	12	7	4	8	7
Shelocta (tax)	8	3	5	3	4
Jefferson	2	0	0	1	1
Shelocta	9	9	8	7	4

^atax = taxadjunct.

Table 4. Distribution of soils by elevation in a transect study in Campbell County, Tennessee.

Great group soil series ^a	Elevation (m)		
	<600	600- 730	>730
		----- %	
Dystrochrepts			
Petros	3	1	2
Berks	8	1	1
Zenith	1	0	1
Muskingum	10	2	9
Muskingum (tax)	4	1	1
Hapludults			
Gilpin	1	1	3
Gilpin	7	10	5
Shelocta (tax)	6	2	2
Jefferson	1	0	1
Shelocta	11	3	5

^atax = taxadjunct.

Variables used in the analysis originated from data collected in the transect study. The variables were transformed, scaled or recorded directly as depicted in Table 5.

Correlation matrices were developed using all 141 plots as a unit and after stratification by aspect. Alpha = 0.05 was chosen at the beginning of the study. For some correlation matrices, the 0.01 alpha level was used if only a few more correlations were significant at 0.05 compared with 0.01. Data manipulation and correlations were performed using SAS (1976) available on The University of Tennessee IBM 360/65 computer.

Results. Correlations between site variables are in Table 6. Compared to residuum, colluvium was more prevalent in concave positions and at greater distances from ridgetops. The negative correlation between elevation and position was due to the assignment of lower values to upper-slope positions.

No significant soil-site correlations were seen for the soil variables: thickness of the O1, O2, B and C horizons; presence of Cr horizon; grade of structure of the B horizon; hue of the A1 horizon; chroma of the A2 horizon and hue of the B horizon. Therefore, these variables are not included in Table 6.

Thicker solum, greater depth to bedrock, silt loam textures and stronger grade were associated with soils from colluvium (Table 6).

An increase in slope gradient resulted in thinner soils, thinner argillic horizons and less clay in the A and B horizons (Table 6). Size of structure in the A and B horizons and grade of structure in the B

Table 7. Correlation matrix between soil variables on north aspects in Campbell County, Tennessee.^a

	TKA1	TKA2	TKB1	TKB	TKC	TKSOL	BEDRX	TKANG	TEKA	TEXB	TEXC	CLAYA	CLAYB	CLAYFN	STGA	STSA	STGB	STSB	CFA	CFB	CFC	STONE	VALA1	MUEA2	VALA2	CBA2	MUEB	VALB	CRB
TKA1	1.0																												
TKA2		1.0																											
TKB1			1.0																										
TKB				1.0																									
TKC					1.0																								
TKSOL						1.0																							
BEDRX							1.0																						
TKANG								1.0																					
TEKA									1.0																				
TEXB										1.0																			
TEXC											1.0																		
CLAYA												1.0																	
CLAYB													1.0																
CLAYFN														1.0															
STGA															1.0														
STSA																1.0													
STGB																	1.0												
STSB																		1.0											
CFA																			1.0										
CFB																				1.0									
CFC																					1.0								
STONE																						1.0							
VALA1																							1.0						
MUEA2																								1.0					
VALA2																									1.0				
CBA2																										1.0			
MUEB																											1.0		
VALB																												1.0	
CRB																													1.0

^aAll correlations are significant at $p = .01$.

Table 8. Correlation matrix between soil variables on south aspects in Campbell County, Tennessee.^a

	TKA1	TKA2	TKB1	TKB	TKC	TKSOL	BEDRX	TKARG	TEXA	TEXB	TEXC	CLAYA	CLAYB	CLAYPM	STGA	STSA	STGB	STSB	CFA	CFB	CFC	STONE	VALA1	HUEA2	VALA2	CRA2	HUEB	VALB	CBB
TKA1	1.0																												
TKA2		1.0																											
TKB1			1.0																										
TKB				1.0																									
TKC					1.0	.76																							
TKSOL						1.0	.67	.61																					
BEDRX							1.0	.45																					
TKARG								1.0																					
TEXA									1.0	.79	.77																		
TEXB										1.0	.77																		
TEXC											1.0																		
CLAYA												1.0																	
CLAYB													1.0																
CLAYPM														1.0															
STGA															1.0														
STSA																1.0													
STGB																	1.0												
STSB																		1.0											
CFA																			1.0										
CFB																				1.0									
CFC																					1.0								
STONE																						1.0							
VALA1																							1.0						
HUEA2																								1.0					
VALA2																									1.0				
CRA2																										1.0			
HUEB																											1.0		
VALB																												1.0	
CBB																													1.0

^a All correlations are significant at $p = .01$.

Correlations among the soil variables were performed separately for north-facing and south-facing slopes (see also Hinkle, 1975), however, many results were similar for both aspects (Tables 7 and 8).

Thickness of C horizon and solum increased as the depth to bedrock increased. Thickness of the argillic horizon, when present, also increased as the solum thickness and depth to bedrock increased (Tables 7 and 8).

Homogeneity among horizons was indicated by positive correlations among textures of the A, B and C horizons. Discontinuities in texture were seldom encountered (Tables 7 and 8). Amount of clay and strength of structure in the B horizon increased with solum thickness. As coarse fragment content in the A horizon declined, the textures of the A and B horizons were more likely to be silt loam. Increasing percentages of clay in the B horizon usually indicated silty clay loam textures. Also, structure in the A horizon became stronger as the clay content of the B horizon increased (Tables 7 and 8).

Generally, an increase in coarse fragment content of one horizon was related to an increase in coarse fragments of an adjacent horizon (Tables 7 and 8). That is, an increase in coarse fragments in an A or B horizon indicated an increase in coarse fragments in the B or C horizon.

Similarities in texture and coarse fragment content among horizons are indications that horizon differentiation is not great.

On southern aspects (Table 8), the thickness of the A1 horizon increased as the solum thickness increased. The thickness of the A2

horizon tended to increase with increasing percentages of clay in the B horizon. This may indicate clay translocation.

Also, on south aspects (Table 8), strength of structure in the B horizon increased with thickness of the solum. The clay in the B horizon increased with increasing argillic thickness. Strength of structure in the B horizon increased with depth to bedrock. The strength of structure for the A horizons increased as clay percentages in the B horizon increased. The grade of structure in the A horizon increased with decreasing surface stoniness (Table 8).

Color value of the A2 horizon on south aspects (Table 8) became darker as the thickness of the A1 horizon increased.

On northern aspects (Table 7), the A1 horizon thickness, depth to bedrock and, in soils having them, argillic horizon thickness increased as the B1 horizon increased.

On south aspects, narrower transition zones and argillic horizons, when present, were observed nearer the surface. Soils on north aspects had wider transitions with argillic horizons farther from the surface.

On north aspects (Table 7), the strength of structure in the A horizon increased with the thickness of the A1 horizon. High clay content in the A horizons on north aspects was associated with high clay content in the B horizons. Thus, on north aspects there was less indication of clay translocation than on south aspects.

On northern aspects (Table 7), the thickness of the A2 horizon was inversely related to the coarse fragment content of the A and B horizons and surface stoniness. The grade of structure in the B horizon decreased when the coarse fragment content in the B horizon increased. Hence, an

increase in the percentage of coarse fragments is associated with weak horizon differentiation. Coarse fragment contents in the A and B horizons were usually positively correlated and were correlated with increases in surface stoniness.

On northern aspects (Table 7), redder colors in the B horizon were associated with increases in clay content of the B and A horizons. Redder hues in the A2 horizon were associated with redder hues in the B horizon. Weaker chromas in the B horizon accompanied darker B horizon values. Strength of structure and strength of color chroma in the B horizon increased together.

Various pairs of soil variables in Tables 7 and 8, pages 35 and 38, respectively, which had significant correlations but could not be explained adequately nor fully understood are underlined.

In the correlation matrix prepared for canopy trees and site parameters (Table 9), only those variables having significant correlations with other variables appear. Scarlet oak, white oak, black oak, post oak, chestnut oak and black gum were negatively correlated with aspect, strengthening the observation that these trees occur most frequently on southern aspects. Trees with higher relative densities (RD) on north aspects were sugar maple, tulip poplar, American beech, pignut hickory, mockernut hickory, yellow buckeye and basswood. Red maple was common at all sites and showed no significant correlations with any site or soil variables.

Sugar maple and black gum were positively correlated with elevation, indicating greater RD's at higher elevations (Table 9).

Table 9. Correlation matrix between canopy trees and site parameters in
Campbell County, Tennessee.^a

	SO	WO	BO	PO	CO	SM	TP	BG	AB	PH	MH	MB	YB	BW
ASP	-.25	-.29	-.22	-.21	-.30	.28	.23	-.57	.37			.27	.23	.24
ELEV						.30		.19	-.40					
FORM					-.24									
POS									.35		.23			
SLOPE														
PM			-.22		-.22		.22		.30	.21	.26			

^a All correlations are significant at $p = .05$.

Chestnut oak's RD was high on convex slope forms and on soils from residuum. Black oak was also frequent on soils from residuum (Table 9).

American beech and mockernut hickory had positive correlations with position, indicating greater RD's at lower positions (Table 9). Cabrera (1969) and Safley (1970) did not find American beech above 610 m in elevation. In Table 9, American beech and elevation were negatively correlated, indicating less beech at high elevations.

Tulip poplar, American beech, pignut hickory and mockernut hickory had greater RD's on soils from colluvium (Table 9).

Table 10 shows that canopy cover was greater on north than on south aspects. Fire damage was greater on south aspects and at higher elevations. Wind direction and moisture content may be two reasons.

On south aspects (Table 11), northern red oak's RD had positive correlations with thickness of the A1 horizon and percentage of clay in the B horizon. In Table 11, RD of northern red oak and coarse fragment content in the B horizon were negatively correlated. Thus, on south aspects, the greater RD of northern red oak was associated with the soil conditions: thick A1 horizons, high percentages of clay and few coarse fragments in the B horizon.

Correlation analysis suggests that on south-facing slopes higher RD's of scarlet oak were related to clay percentage decreases (Table 11).

On southern aspects (Table 11), black oak's RD was higher on soils which had fewer coarse fragments in the B horizon. On north-facing slopes (Table 12), the RD for black oak was greatest on shallow soils.

On southern aspects (Table 11), chestnut oak's RD was most prevalent on soils with thin A1 horizons, thin sola, thin argillic horizons, shallow

Table 10. Correlation matrix between site parameters^a
in Campbell County, Tennessee.

	PM	SLOPE	POS	FORM	ELEV	ASP
% canopy cover						.37
% shrub cover						
Fire damage					.28	.34

^aAll correlations are significant at $p = .01$.

Table 11. Correlation matrix between canopy species and soil variables on south aspects in Campbell County, Tennessee.^a

	NRO	SO	BO	CO	SM	TP	AB	PH	MH	YB
TKA1	.39			-.40				.33		
TKSOL				-.41						
BEDRX				-.48	.38		.35			.29
TKARG				-.46						
CLAYA		-.58						.37		
CLAYB	.29					-.33		.44		
CFB	-.24		-.28	.39						

^aAll correlations are significant at $p = .01$.

Table 12. Correlation matrix between canopy species and soil variables on north aspects in Campbell County, Tennessee.^a

	NRO	SO	BO	CO	SM	TP	AB	PH	MH	YB
TKA1				-.29	.34					.30
TKSOL			-.43							
BEDRX										
TKARG										
CLAYA										
CLAYB						.33			-.29	
CFB										

^aAll correlations are significant at $p = .01$.

bedrock and greater coarse fragment content. On northern aspects (Table 12), chestnut oak's RD and thickness of the A1 horizon were negatively correlated.

On south-facing slopes (Table 11), sugar maple and yellow buckeye had greatest RD's when bedrock was deep and on north-facing slopes (Table 12) when the A1 horizon was thick.

The correlation between tulip poplar's RD and percentage of clay in the B horizon was negative on south-facing slopes (Table 11) and positive on north-facing slopes (Table 12).

On southern aspects (Table 11), American beech had a higher RD when bedrock was deep. Also on south-facing slopes, pignut hickory was prevalent on soils with thicker A1 horizons and high clay percentages in the A and B horizons.

Canopy Trees of the Study Area

Relative densities of canopy trees appear in Table B-1, Appendix B. This composition is similar to the deciduous mixed mesophytic forest community described in the Cumberland Mountains by Braun (1950). Similar communities were described by Martin (1966), Cabrera (1969), Safley (1970) and Hinkle (1975) in the Cumberland Mountains and Plateau. Thomas (1966) noted similar communities on Chilhowee Mountain. Powells (1965) listed the community occurrence of certain economically important trees. Rodriguez (1973) used local soil and site data to obtain site index values for white oak, tulip poplar and chestnut oak.

Table B-2, Appendix B, presents the relative densities of the canopy trees by aspect. As in correlation analysis, probable oak forests occupy

south-facing slopes, while probable mixed mesophytic forests occupy north-facing slopes.

Relative densities of the canopy trees by soil series without stratification by aspect are in Table B-3, Appendix B. Petros, a shallow skeletal soil frequently on points and crests of mountain ridges, has a high relative density for chestnut oak. Tulip poplar and sugar maple do occur in the canopy, but from observation made during field studies, they probably were not equilibrium species and will be replaced by more drought-resistant trees.

All other soil series in Table B-3, Appendix B, have a greater variety of trees common to them. Soils of Muskingum (tax) were deeper than Muskingum, but this difference was not reflected to a significant degree by the RD of trees. Shelocta (tax) and Gilpin (tax) had higher percentages of coarse fragments than Shelocta and Gilpin, respectively. Regardless of coarse fragment content, Shelocta soils generally occupy concave and lower positions. This may be the reason for similarity in kinds and amounts of trees on Shelocta and Shelocta (tax). The relative diluting effect of coarse fragments in decreasing available water-holding capacity was not reflected by composition or RD among Shelocta tax-adjuncts, Shelocta and Gilpin. The Gilpin (tax) had lower tree diversity than Gilpin, Shelocta and Shelocta (tax).

Comparison of the relative densities of canopy species by soil series on adjacent south and north aspects (Tables B-4 and B-5, Appendix B), shows north aspects with higher diversity and more mesophytes.

Petros supported more mesophytic taxa on north aspects (Table B-5, Appendix B) than on south aspects (Table B-4, Appendix B). Chestnut oak

on Petros had a relative density of 45 on south aspects and 17 on north aspects. Relative densities on Berks and Muskingum indicated more mesophytic taxa on north than south aspects. On south aspects (Table B-4, Appendix B), the effect of greater soil depth of Muskingum (tax) was indicated by presence of fewer drought-resistant taxa (i.e., blackgum, chestnut oak) than on Muskingum.

The diluting effect of coarse fragments on the availability of water in the Gilpin (tax) is not evident from RD data on south aspects (Table B-4, Appendix B). However, on north aspects (Table B-5, Appendix B) a greater variety in kinds of trees and fewer drought-resistant trees were on Gilpin than on Gilpin (tax). Gilpin (tax) had >35% by volume coarse fragments.

The trees' diversity was greater on Shelocta than on Shelocta (tax) on north aspects (Table B-5, Appendix B). On south aspects (Table B-4, Appendix B), more drought-resistant trees were on Shelocta (tax) than on Shelocta.

The reliability of the comparative diversity statements may be weakened since tree sample size was unequal throughout.

Discussion of Soil Formation

In the Cumberland Mountains of Campbell County, relationships between soil-site variables suggest that relief is a dominant soil-forming factor affecting climate and organisms acting on similar parent material. Relief affects the distribution of solar radiation accompanied by modifications in the rates of evapotranspiration. Also, water movement above and below ground is determined by relief. Variation in organism populations is induced by resultant microenvironments. The

action of organisms tends to slow down natural erosion and leaching, thus influencing soil formation. In the Cumberland Mountains, there is a constant interaction among the soil-forming factors under the cominant control of relief.

In this study, the components of relief (slope gradient, slope direction and elevation) among other site variables were individually analyzed in relation to soil properties. It was then possible to postulate and infer about the direction and intensity of soil formation.

Soils within the study area were deeper and more highly developed than might have been expected in steep mountain areas. The rate of runoff and leaching was influenced by topography, but it is evident that other factors modified this rate to allow a stabilizing effect and an enhancement of soil formation. Both Franzmeier (1969) and Losche (1970) challenged the concept that soils of the Cumberland Mountains are "thin and immature." They described in their respective works a complex array of soils involving numerous soil orders. Finney et al. (1962) reasoned that the soil in mountainous areas was a result of many factors of soil formation. To single out any one element as the main cause for a soil property would be in error.

During the transect study, it was observed on north aspects that the upper boundary of argillic horizons (when present) was farther from the surface than argillic horizons on south aspects. Correlation analysis showed B1 horizons significantly thicker on north aspects. The greater degree of soil mixing on north aspects may be a contributing factor. Since this was not recognized on south aspects, inference suggests that soils on south aspects have narrower transitions between A and B horizons.

Finney et al. (1962) observed that the mantle of colluvium on north aspects was thicker and more extensive than on the south aspects.

Cooper (1960) found the solum shallowest at the top of south aspects and deepest on north aspects. Correlation analysis in Campbell County shows no significant indication of a solum thickness difference between aspects. However, observations during the transect study indicated that colluvium may reach farther from the stream line on north aspects.

The thickness of A1 horizons was greater on north aspects. Finney et al. (1962) found similar results and attributed them to moister, more mesophytic conditions, higher base status and more understory associated with north aspects. Such factors increase activity of microflora and microfauna. Mixing of the organic matter with mineral material lessens the chance of loss by erosion. Loss of organic matter by oxidation is also reduced. On south aspects, the decomposition products of oak litter had a greater mobilizing effect on ions than leaves of mixed mesophytic taxa. According to Reichle (1970), leaves of mesophytic taxa are able to break down more readily and more completely. Thus, decomposition products are able to be readily mixed but not easily oxidized, leached or eroded.

Generally, soils with thick, dark A1 horizons also supported a high percentage of canopy, shrub and often herbaceous covers. These covers in conjunction with mesic conditions on north aspects suggest high productivity and low decay rate. Perhaps in the Cumberland Mountains a thick, dark A1 horizon is associated with a thin B horizon.

Fire damage was greater on south aspects than on north aspects. Similar findings were presented by Finney et al. (1962). Not only was

organic matter lost directly by burning, but also many combustion by-products remaining in the soil were mobile and more readily leached.

Discussion of Vegetation and Environmental Relationships

Since an understanding of soil properties was the main objective in this study, a comprehensive vegetation analysis was limited by time.

The index used in the analysis of vegetation was relative density (RD) of overstory trees which does not reflect pole size trees nor wood quality. Some of the trees, red maple, black gum, dogwood and tulip poplar, for example, had high indexes because they were numerous, while other trees in a stand may have been important because of large size, although they had low RD's.

The environmental factors that affect water relationships and tree growth were quite complex in the study area since geologic, topographic, vegetation and soil factors have to be considered together. The arrangement of land masses and geologic features was not measured, but it probably does influence the availability of soil water. Rodriquez (1973) measured the effects of surrounding land masses as a variable influencing plant growth. Hinkle (1975) found significant similarities and differences when evaluating between factors on dip and scarp slopes. The modifying effects of geologic and protection factors in Campbell County were probably slight when compared to the site factors aspect and slope gradient.

Even though correlations between some soil-site factors and vegetation were highly significant in this study, multiple regression equations by Martin (1966), Hinkle (1975) and Safley (1970) show soil-site variables

to account for little of the variation in vegetation. Martin (1966) cites several factors to account for these low values:

- (1) wide range of values within independent variables,
- (2) variables other than those selected may account for more variation within communities, (3) environmental gradients affecting overstory characteristics may not affect establishment and early survival of taxa, (4) variable effects may not be linear and (or) additive.

In this Campbell County study, northern aspects and other moist sites had a composition of trees resembling a mixed mesophytic forest, while southern aspects had oak as a dominant. Correlation analysis indicated chestnut oak and black oak to be associated with drier sites, while tulip poplar, American beech, yellow buckeye and sugar maple had correlations with factors connoting mesophytic conditions.

Shreve (1924) cited insolation and soil temperature as controlling factors for the difference between vegetation on north and south aspects. Cabrera (1969) in Campbell County found aspect to be the most important factor controlling species segregation in more xeric sites, while in mesic sites, form was the most important. He also found a greater variety of taxa on the mesophytic north aspects but found the interaction between form and aspect such that neither could be designated as the controlling factor. Rodriquez (1973) found aximuth and slope useful in predicting site productivity. Similar findings concerning water, temperature and light intensity as controlling factors in species segregation were described by Finney (1962), Fowells (1965), Martin (1966), Safley (1970, Hutchins et al. (1975), Hinkle (1975) and Wade (1977).

Relief affects climate by modifying soil temperature, light intensity and soil water. In the Campbell County study, the components of relief

(slope gradient, slope position, slope shape, aspect and elevation) did not influence vegetation equally. For example, when gradient was steep, the effect of aspect on the plant's environment was greater.

Soils and relief are controlling factors of species segregation. However, part of the influence on resultant vegetation is due to their effect on microclimate. Effectiveness of soil water is influenced by both relief and soil. The effects of relief, elevation and topography determine the total amount and frequency of water a soil will receive. Soils affect infiltration, percolation and available water-holding capacity. In areas of Petros, a shallow soil, and Muskingum (tax), a soil with many coarse fragments, soil has an important role because of limited water available for plant growth.

Geologic features also may affect ground water. Soils may be drier on scarp slopes than on dip slopes (Hinkle, 1975).

Thus, an appropriate equation for the Cumberland Mountains in Tennessee is:

$$\text{vegetation} = f(\text{soil, relief}, o, p, t, cl)$$

The independent variables soil and relief are main determinants of variation in frequency and yield of vegetation. P (parent material) may be included within parenthesis of the equation if the effect of geologic bedding planes is evident. O (organisms), cl (climate) and t (time) are considered constant.

CHAPTER V

A STUDY OF EIGHT SOIL PEDONS

Location

Eight sites were selected on north and south aspects at various slope positions. The ranges of slope gradient and elevation were 25% to 60% and 520 m to 920 m, respectively. The sampling locations were located on the Pioneer and Block quadrangles.¹ The exact location of each site is included with the soil descriptions. Cross sectional sketches through the Straight Fork, Massengale Mountain and Hatmaker Knob area are depicted.² The slope gradient, aspect and elevation are shown for each site.

Results and Discussion

Soil descriptions and physical and chemical properties are shown in Tables 13 through 28. Soil descriptions are in Tables 13, 15, 17, 19, 21, 23 and 25; physical and chemical properties are in Tables 14, 16, 18, 20, 22, 24, 26 and 28.

Morphological properties. A graphical presentation of the pedological development for each soil is shown.³ A quantitative method (Bilzi and Ciolkosz, 1977) was used to aid in the evaluation of the relative distinctness of horizons by comparisons of adjacent horizons. The surface horizons of south-facing slopes have ratings of 7 to 9, connoting strong differences between these and underlying horizons. Only slight differences in development are shown for other horizons; all values being less than 7.

¹Figure 4 shows sampling locations in Campbell County, Tennessee.

²Figure 5 depicts cross sectional sketches through the Straight Fork, Massengale Mountain and Hatmaker Knob areas.

³Figure 6 is a graphical presentation of the pedological development for each soil.

Table 13. Soil 1N, Zenith (tax).

		Description
O1	4-1 cm	Deciduous leaf litter and twigs; medium acid.
O2	1-0 cm	Very dark brown (10YR 2/2) decomposed organic residue; slightly acid.
A1	0-12 cm	Very dark grayish brown (10YR 3/2) channery loam; moderate medium granular structure; friable, slightly sticky, slightly plastic; many fine roots; 19% by volume shale, siltstone and sandstone coarse fragments; strongly acid; clear wavy boundary.
A3	12-32 cm	Dark brown (10YR 3/3) channery clay loam; moderate medium granular structure; friable, slightly sticky, slightly plastic; common fine and medium roots; 29% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; clear wavy boundary.
B21	32-61 cm	Dark yellowish brown (10YR 4/4) clay loam; moderate medium subangular blocky structure; friable, slightly sticky, slightly plastic; common fine and medium roots; 14% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; gradual wavy boundary.
B22	61-94 cm	Strong brown (7.5YR 5/6) channery clay loam; moderate medium subangular blocky structure; slightly sticky, slightly plastic, friable; few medium and coarse roots; 17% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; gradual wavy boundary.
B3	94-116 cm	Yellowish brown (10YR 5/6) channery silt loam; moderate medium subangular blocky structure; slightly sticky, slightly plastic, friable; few medium and coarse roots; 46% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; abrupt wavy boundary.
IIR	116+ cm	Massive fine-grained sandstone.

Topography--Lower slope position with 60% gradient. Relief concave.
Aspect 5°. Elevation 520 m.

Table 13, continued

Description
Parent material--Colluvium with 15% stone cover (sandstone).
Vegetation--Forest cut over or burned approximately 30 years ago. Beech, tulip poplar and red maple most common canopy trees. Other canopy trees include basswood. Sapling trees include red maple, dogwood, beech and basswood. Canopy closure, 85%. Shrub cover, 20%.
Location--Block quadrangle, 128-SE; 3.0 km, 275° from Turley; 100 m, 180° above Stright Fork.

Table 15. Soil 2N, Muskingum.

		Description
01	2-0.5 cm	Deciduous leaf litter and twigs; slightly acid.
02	0.5-0 cm	Black (10YR 2/1) decomposed organic residue; medium acid.
A1	0-5 cm	Brown to dark brown (10YR 4/3) silt loam; moderate fine granular structure; friable, slightly sticky, nonplastic; many fine roots; 10% by volume siltstone and shale coarse fragments; medium acid; clear wavy boundary.
A2	5-10 cm	Yellowish brown (10YR 5/4) silt loam; moderate medium subangular blocky structure; friable, slightly sticky, slightly plastic; many fine roots; 3% by volume siltstone and shale coarse fragments; very strongly acid; gradual wavy boundary.
B1	10-28 cm	Yellowish brown (10YR 5/6) silt loam; moderate medium subangular blocky structure; friable, slightly sticky, slightly plastic; common fine and medium roots; 9% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; clear wavy boundary.
IIB2	28-53 cm	Brownish yellow (10YR 6/6) channery silt loam; moderate medium subangular blocky structure; firm, slightly sticky, slightly plastic; few thin clay films on some ped faces; few medium and thick roots; 23% by volume siltstone, sandstone and shale coarse fragments; very strongly acid; gradual wavy boundary.
IIB3	53-87 cm	Yellowish brown (10YR 5/6) channery silt loam; moderate medium subangular blocky structure; firm, slightly sticky, slightly plastic; few thin clay films on coarse fragments; few medium and thick roots; 41% by volume siltstone, sandstone and shale coarse fragments; very strongly acid; abrupt wavy boundary.
IIIR	87+ cm	Massive fine-grained sandstone.

Table 15, continued

Description
Topography--Upper slope position ranging from 55 to 65% gradient. Relief straight, breaking below a narrow bench. Aspect 5°. Elevation 640 m. Approximately 150 m up slope from abandoned strip mine.
Parent material--Colluvium in top 28 cm over shale and siltstone residuum. Two percent stone (sandstone) cover in immediate area. Adjacent areas very stony (sandstone).
Vegetation--Forest cut over or burned approximately 30 years ago. Red maple and hickories most common trees. Other canopy trees include tulip poplar, chestnut oak, blackgum and basswood. Sapling size trees include red maple, dogwood, blackgum and sourwood. Canopy closure, 80%. Shrub cover, 35%.
Location--Block quadrangle, 128-SE; 3.0 km 275° from Turley; 400 m, 180° above Straight Fork.

Table 16. Physical and chemical properties--Soil 2N, Muskingum

Horizon	Depth --cm--	Diameter (mm)					Text. class	Diameter (mm)					Total		Entire Clod D _b																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
		2.0-	1.0-	0.5-	0.25-	0.1-		0.02-	0.005-	0.002-	D _b																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
		1.0	0.5	0.25	0.1	0.05		0.005	0.002	<2 mm	76-	19-	4.7	Total																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
		--% by wt. of <2 mm--														--% by wt. (whole soil)--		vol.%																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					

Table 17. Soil 3N, Muskingum (tax).

		Description
01	2-0.5 cm	Deciduous leaf litter and twigs; slightly acid.
02	0.5-0 cm	Very dark brown (10YR 2/2) decomposed organic residue; slightly acid.
A1	0-5 cm	Dark grayish brown (10YR 4/2) silty clay loam; moderate medium granular structure; very friable, slightly sticky, slightly plastic; many fine roots; 8% by volume shale, siltstone and sandstone coarse fragments; medium acid; abrupt wavy boundary.
A2	5-9 cm	Brown (10YR 5/3) silty clay loam; moderate medium granular structure; very friable, slightly sticky, slightly plastic; common fine roots; 6% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; gradual wavy boundary.
B1	9-20 cm	Yellowish brown (10YR 5/4) silty clay loam; moderate medium subangular blocky structure; friable, slightly sticky, slightly plastic; 9% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; gradual wavy boundary.
B21	20-44 cm	Yellowish brown (10YR 5/4) silty clay loam; moderate medium subangular blocky structure; friable, slightly sticky, slightly plastic; common fine and medium roots; 7% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; clear wavy boundary.
B22	44-72 cm	Yellowish brown (10YR 5/4) silty clay loam; moderate medium subangular block structure; firm, slightly sticky, slightly plastic; few medium and coarse roots; 23% by volume shale siltstone and sandstone coarse fragments; very strongly acid; clear wavy boundary.
B3	72-90 cm	Yellowish brown (10YR 5/4) silty clay loam; moderate medium subangular blocky structure; firm, slightly sticky, slightly plastic; few medium and coarse roots; 40% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; clear wavy boundary.

Table 17, continued

Description		
II	90+ cm	Massive fine-grained sandstone.
Topography--Middle slope position with 50% gradient. Relief straight, breaking below 35% slope. Aspect 4°. Elevation 820 m.		
Parent material--Shale and siltstone residuum with colluvium on lesser slope above. Three percent stone cover (sandstone).		
Vegetation--Some evidence of recent fire damage. Forest cut over or burned approximately 30 years ago. Mockernut hickory, shagbark hickory, pignut hickory and tulip poplar most common canopy trees. Other canopy trees include northern red oak and yellow buckeye. Sapling size trees include sugar maple, tulip poplar, dogwood, black cherry and basswood. Canopy closure, 85%. Shrub closure, 35%.		
Location--Block quadrangle, 128-SE; Massengale Mountain; 0.9 km, 210° above confluence of North and South Forks; 0.6 km, 55° from Roasting Ear Spring.		

Table 19. Soil 4N, Zenith (tax).

		Description
01	3-1 cm	Deciduous leaf litter and twigs; slightly acid.
02	1-0 cm	Very dark brown (10YR 2/2) decomposed organic residue; very strongly acid.
A11	0-16 cm	Very dark grayish brown (10YR 3/2) channery loam; moderate medium granular structure; friable, nonsticky, nonplastic; many fine and medium roots; 18% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; gradual wavy boundary.
A12	16-32 cm	Very dark grayish brown (10YR 3/2) channery loam; weak moderate subangular blocky and moderate medium granular structures; friable, nonsticky, nonplastic; many fine and medium roots; 31% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; clear wavy boundary.
A3	32-50 cm	Very dark grayish brown (10YR 3/2) channery loam; moderate medium subangular blocky and moderate medium granular structures; friable, nonsticky, nonplastic; many fine, medium and coarse roots; 27% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; clear wavy boundary.
B	50-69 cm	Brown to dark brown (10YR 4/3) channery loam; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic; common medium roots; 42% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; abrupt wavy boundary.
IIR	69-80+ cm	Massive fine-grained sandstone.

Topography--Upper slope position with 60% gradient. Relief concave.
Aspect 8°. Elevation 910 m.

Parent material--Shale and siltstone residuum with 5% 3-6 cm, flat stones (sandstone) under 02 layer.

Table 19, continued

Description
Vegetation--Forest cut over or burned approximately 30 years ago. Sugar maple, northern red maple, black oak and pignut hickory most common canopy trees. Other canopy trees include white oak, black walnut, yellow buckeye, mockernut hickory and black cherry. Sapling size trees include sugar maple, basswood, black locust, pignut hickory and mockernut hickory. Canopy closure, 90%. Shrub cover, 50%.
Location--Block quadrangle, 128-SE; 0.8 km, 270° from Grissel Knob; 0.7 km, 10° from Hatmaker Knob.

Table 21. Soil 1S, Grimsley

		Description
01	2-0.5 cm	Deciduous leaf litter and twigs; strongly acid.
02	0.5-0 cm	Very dark brown (10YR 2/2) decomposed organic residue; very strongly acid.
A1	0-5 cm	Dark grayish brown (10YR 4/2) silt loam; weak fine granular structure; friable, nonsticky, nonplastic; many fine roots; 9% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; clear wavy boundary.
A2	5-14 cm	Brownish yellow (10YR 6/6) silt loam; weak medium granular structure; friable, slightly sticky, nonplastic; common fine and medium roots; 10% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; clear wavy boundary.
B1	14-40 cm	Yellowish brown (10YR 5/6) channery loam; moderate medium subangular blocky structure; firm, slightly sticky, slightly plastic; common fine and medium roots; 38% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; clear wavy boundary.
B2t	40-62 cm	Strong brown (7.5YR 5/6) channery loam; moderate medium subangular blocky structure; firm, slightly sticky, slightly plastic; few thin discontinuous clay films on ped faces; few medium roots; 38% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; gradual wavy boundary.
C1	62-100 cm	Strong brown (7.5YR 5/6) and yellowish red (5YR 5/6) channery clay loam; massive; very firm, slightly sticky, slightly plastic; few fine and medium roots, 53% by volume shale, siltstone and sandstone coarse fragments; strongly acid; gradual wavy boundary.
IIC2r	100-155 cm	Laminated siltstone and shale; can be removed with hand tools; yellowish red (10YR 5/6) and brownish yellow (10YR 6/6) silt loam soil material found within occasional discontinuous cracks; 81% by volume siltstone and shale; strongly acid; abrupt irregular boundary.

Table 21, continued

Description		
IIR	155+ cm	Siltstone bedrock.
Topography--Middle to lower slope position with 60% gradient. Relief straight. Aspect 185°. Elevation 560 m.		
Parent material--Colluvium with 15% stone cover (sandstone). Some rock outcrops nearby.		
Vegetation--Forest cut over or burned approximately 30 years ago. Chestnut oak and scarlet oak most common canopy trees. Other canopy trees include white oak, black oak and red maple. Sapling size trees include red maple, sourwood, chestnut oak, black gum, scarlet oak and beech. Canopy closure, 60%. Shrub cover, 30%.		
Location--Pioneer quadrangle, 128-NE; 3.0 km, 275° from Turley; 120 m, 5° above Straight Fork.		

Table 22. Physical and chemical properties--Soil IS, Grimsley.

Horizon	Depth --cm--	Diameter (mm)					Sand	Clay	Silt	Diameter (mm)		Text. class	Diameter (mm)					Total		Entire Clod		
		2.0-	1.0-	0.5-	0.25-	0.1-				0.02-	0.005-		76-	19-	4.7	Total						
		1.0	0.5	0.25	0.1	0.05				0.005	0.002		>76	19	4.7	2	>2					
-----% by wt. of <2 mm-----																			vol.%			
A1	0-5	1.7	0.9	1.2	8.5	25.4	37.7	10.6	51.7	20.8	6.6	sll	0	0	6	12	18	9	1.30	--		
A2	5-14	3.0	1.0	1.2	8.2	23.7	37.1	12.3	50.6	21.5	8.4	sll	0	0	8	12	20	10	1.54	--		
B1	14-40	2.6	1.7	1.5	7.6	21.5	34.9	17.0	48.1	20.8	10.2	1	0	5	20	26	51	38	1.92	1.67		
B2t	40-62	3.9	2.5	1.1	4.8	13.1	25.4	25.8	48.8	22.2	11.2	1	0	11	19	21	51	38	1.91	1.76		
C1	62-100	5.0	3.4	1.3	3.5	9.6	22.8	27.2	50.0	22.2	11.4	cl	0	24	20	21	65	53	2.08	1.84		
IIC2r	100-155	6.1	5.2	1.5	1.9	7.4	22.1	23.0	54.9	25.9	13.5	sll	--54--	--	22	11	87	81	2.36	--		

Horizon	Depth --cm--	D _b		Entire clod		<2 mm		1/3 bar		15 bar		1/3 to 15 bar		Ca		Mg		K		Na		Acidity		CEC		Base sat.		pHs		Extractable	
		1/3	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar
		bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar
O1	2-0.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5.1	4.4	--	--
O2	0.5-0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.4	3.7	--	--
A1	0-5	1.20	--	--	--	--	--	--	--	33	16	--	--	--	0.15	0.26	0.04	0.04	0.03	0.03	9.6	3.4	10.4	8	4.4	3.5	4.7	1.0	75	55	
A2	5-14	1.40	--	--	--	--	--	--	--	29	14	--	--	--	0.06	0.11	0.04	0.02	0.02	0.02	2.0	2.0	2.6	23	11	4.7	3.7	1.6	1.5	75	
B1	14-40	1.53	1.56	0.006	0.004	14	17	6	13.6	0.21	0.06	0.11	0.04	0.02	0.06	0.27	0.04	0.04	0.02	0.02	4.2	2.4	3.2	25	5.0	5.1	5.0	3.9	0.7	1.0	55
B2t	40-62	1.50	1.52	0.004	0.003	14	21	9	5.8	0.11	0.04	0.33	0.06	0.03	0.04	0.33	0.06	0.03	0.03	4.2	2.4	3.2	25	5.0	5.1	5.0	3.9	0.1	1.0	95	
C1	62-100	1.54	1.56	0.004	0.002	14	25	11	4.8	0.10	0.04	0.33	0.05	0.04	0.04	0.33	0.05	0.05	0.04	2.4	2.4	3.2	25	5.1	5.1	5.1	3.8	--	1.0	140	
IIC2r	100-155	1.55	--	--	--	25	11	--	1.8	0.04	0.05	0.34	0.06	0.05	0.05	0.34	0.06	0.06	0.05	4.2	4.2	5.1	18	5.2	3.8	3.8	--	2.0	2.0	145	

Table 23. Soil 2S, Gilpin.

		Description
01	3-0.5 cm	Deciduous leaf litter and twigs; very strongly acid.
02	0.5-0 cm	Very dark grayish brown (10YR 3/2) decomposed organic residue; very strongly acid.
A1	0-5 cm	Dark grayish brown (10YR 4/2) loam; medium fine granular structure; friable, slightly sticky, nonplastic; many fine roots; 14% by volume shale, siltstone and sandstone coarse fragments; extremely acid; abrupt smooth boundary.
A2	5-18 cm	Light yellowish brown (10YR 6/4) silt loam; medium moderate granular structure; friable, slightly sticky, nonplastic; many fine roots; 9% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; abrupt wavy boundary.
B1	18-29 cm	Yellowish brown (10YR 5/6) silt loam; moderate medium subangular blocky structure; friable, slightly sticky, slightly plastic; few thin clay films on some ped faces; common fine and medium roots; 12% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; clear wavy boundary.
B21t	29-44 cm	Strong brown (7.5YR 5/6) silty clay loam; moderate medium subangular blocky structure; firm, slightly sticky, slightly plastic; few thin clay films on some ped faces; common fine and medium roots, few coarse roots; 11% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; clear wavy boundary.
B22t	44-72 cm	Strong brown (7.5YR 5/6) silty clay loam; moderate medium subangular blocky structure; firm, sticky, slightly plastic; few thin clay films on some ped faces; common fine and medium roots, few coarse roots; 7% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; clear wavy boundary.

Table 23, continued

		Description
B23t	72-96 cm	Strong brown (7.5YR 5/6) silty clay loam; moderate medium subangular blocky structure; very firm sticky, slightly plastic; few thin clay films on ped faces; common medium roots; 10% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; abrupt wavy boundary.
Cr	96-135 cm	Laminated shale and siltstone; can be removed by hand tools; yellowish brown (10YR 5/6) silty clay loam soil material found within occasional discontinuous cracks; 98% by volume shale and siltstone; very strongly acid; abrupt wavy boundary.
R	135+ cm	Moderately hard shale bedrock.

Topography--Upper slope position with 55% gradient. Relief slightly concave, breaking below narrow bench. Aspect 185°. Elevation 640 m.

Parent material--Shale residuum with 2% stone cover. Rock outcrop nearby.

Vegetation--Forest cut over or burned approximately 30 years ago. Red maple and chestnut oak most common canopy trees. Other canopy trees include northern red oak, scarlet oak and white oak. Sapling size trees include red maple, chestnut oak, yellow poplar, sourwood and dogwood. Canopy closure, 75%. Shrub cover, 20%.

Location--Pioneer quadrangle, 128-NE; 3.0 km, 275° from Turley; 400 m, 5° above Straight Fork.

Table 24. Physical and chemical properties--Soil 25, Gilpin.

Horizon	Depth --cm--	Diameter (mm)					Sand	Clay	Silt	Diameter (mm)		Text. class	Diameter (mm)					Total		Entire Clod D _b		
		2.0-	1.0-	0.5-	0.25-	0.1-				0.02-	0.005-		76-	19-	4.7	Total	C	P	K			
		1.0	0.5	0.25	0.1	0.05				0.005	0.002		>76	19	4.7	2					>2	
--% by wt. of <2 mm-----																			--% by wt. (whole soil)--		vol.%	
																			--% by wt. (whole soil)--		vol.%	
A1	0-5	3.6	2.0	2.0	10.0	18.1	35.7	15.4	48.9	21.7	9.8	1	0	0	13	14	27	14	1.38	--		
A2	5-18	1.9	1.4	2.1	8.4	16.3	30.1	19.4	50.5	21.8	11.4	s11	0	0	10	8	18	9	1.48	--		
B1	18-29	1.0	1.5	1.5	5.5	12.1	21.6	25.7	52.7	22.8	12.2	s11	5	3	3	7	18	12	1.50	--		
B21c	29-44	0.7	1.3	0.7	2.2	7.0	11.9	34.9	53.2	24.7	11.5	s1c1	3	3	4	6	16	11	1.70	--		
B23c	44-72	0.4	0.7	0.4	1.3	6.7	9.5	37.1	53.4	24.4	11.4	s1c1	0	6	2	3	11	7	1.68	1.63		
B23c	72-96	0.3	0.8	0.6	1.7	4.6	8.0	36.1	55.9	25.6	11.7	s1c1	0	2	4	9	15	10	1.66	1.58		
Cr	96-135	1.7	1.3	0.5	1.2	4.5	9.2	36.3	54.5	28.2	11.5	s1c1	---	96---	2	1	99	98	2.54	--		

Horizon	Depth --cm--	<2 mm		Entire clod	<2 mm		1/3 bar	15 bar	15		Ca	Exchangeable		Acidity	CEC	Base		pHw	pHs	Extractable			
		D _b	D _b		1/3 bar	15			bar	bar		Mg	K			Na	sat.			z	C	P	K
		bar	Dry		----	----			----	----		meq/100g	meq/100g			----	z			z	z	z	
O1	3-5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.8	4.0	--	--		
O2	5-0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.7	3.6	--	--		
A1	0-5	1.20	--	--	--	33	16	12.3	0.17	0.18	0.21	0.05	0.03	19.6	20.4	4	4.1	3.3	9.2	2.0	75		
A2	5-18	1.40	--	--	--	29	14	12.3	0.18	0.04	0.19	0.04	0.02	6.0	6.5	7	4.5	3.7	1.9	2.0	55		
B1	18-29	1.40	--	--	--	23	10	10.7	0.16	0.02	0.28	0.05	0.02	4.2	4.8	12	4.7	4.0	1.2	1.0	60		
B21c	29-44	1.60	--	--	--	23	15	6.9	0.12	0.03	0.31	0.05	0.03	7.0	7.7	9	4.8	4.0	1.0	1.0	80		
B22c	44-72	1.61	1.63	0.004	0.003	21	22	5.8	0.10	0.03	0.32	0.05	0.03	6.8	7.5	9	4.9	3.9	0.5	1.0	80		
B23c	72-96	1.56	1.59	0.007	0.006	22	23	5.6	0.09	0.03	0.32	0.05	0.03	6.8	7.5	9	4.9	3.9	--	1.0	70		
Cr	96-135	1.56	--	--	--	23	16	0.1	0.00	0.03	0.32	0.06	0.02	6.8	7.4	8	5.0	4.0	--	1.0	60		

Table 25. Soil 3S, Gilpin (tax).

		Description
01	3-1 cm	Deciduous leaf litter and twigs; medium acid.
02	1-0 cm	Very dark brown (10YR 2/2) decomposed organic residue; very strongly acid.
A1	0-5 cm	Very dark grayish brown (10YR 3/2) silt loam; moderate medium granular structure; friable, slightly sticky, nonplastic; many fine roots; 11% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; abrupt wavy boundary.
A2	5-16 cm	Brown (10YR 5/3) channery silt loam; moderate medium granular structure; friable, slightly sticky, nonplastic; common fine and medium roots; 16% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; clear wavy boundary.
B1	16-22 cm	Yellowish brown (10YR 5/6) channery silt loam; moderate medium subangular blocky structure; friable, slightly sticky, slightly plastic; common fine and medium roots; 25% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; gradual wavy boundary.
IIB21t	22-45 cm	Yellowish brown (10YR 5/6) channery silty clay loam; moderate medium subangular blocky structure; friable, slightly sticky, slightly plastic; few thin discontinuous clay films on ped faces; common medium roots; 48% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; clear wavy boundary.
IIB22t	45-54 cm	Yellowish brown (10YR 5/6) channery silty clay loam; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic; few thin discontinuous clay films on ped faces; common medium roots; 61% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; clear wavy boundary.

Table 25, continued

		Description
IIB3	54-88 cm	Yellowish brown (10YR 5/6) channery silty clay loam; weak medium subangular blocky structure; friable, slightly plastic; few medium and coarse roots; 77% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; clear irregular boundary.
IICr	88-96 cm	Laminated shale, siltstone and sandstone; can be removed with hand tools; brownish yellow (10YR 6/6) silty clay loam soil material found within discontinuous cracks; 89% by volume shale, siltstone and sandstone; very strongly acid; abrupt irregular boundary.
IIR	96+ cm	Massive siltstone and fine-grained sandstone bedrock.

Topography--Middle slopes position with 45% gradient. Relief straight, breaking below a 25% concave slope. Aspect 192°. Elevation 820 m. Approximately 90 m up slope from strip mine area.

Parent material--Shale and siltstone residuum with evidence of soil creep in top 22 cm. Two percent stone cover (sandstone).

Vegetation--Evidence of recent fire damage to the understory and sapling trees. Chestnut oak, white oak and pignut hickory most common canopy trees. Other canopy trees include black oak, red maple, black gum and bitternut hickory. Sapling size trees include red maple, black gum, chestnut oak, pignut hickory, dogwood and black oak. Canopy closure, 75%. Shrub cover, 40%.

Location--Block quadrangle, 128-SE; Massengale Mountain; 1.0 km, 270° from Nig Field; 0.9 km, 165° from Roasting Ear Spring.

Table 26. Physical and chemical properties--Soil JS, Gilpin (tax).

Horizon	Depth --cm--	Diameter (mm)					Silt	Clay	Sand	by wt. of <2 mm					Text. class	Diameter (mm)					Total Entire Clod										
		2.0-	1.0-	0.5-	0.25-	0.1-				1/3 bar	15 bar	<2 mm	Entire clod	D _b		Dry	1/3 bar	15 bar	<2 mm	Diameter (mm)					Total Entire Clod						
		1.0	0.5	0.25	0.1	0.05														76-	19-	4.7	2	Total	76-	19-	4.7	2	Total		
		--% by wt. (whole soil)---															--% by wt. (whole soil)---														
		vol. %																													
A1	0-5	3.3	2.2	0.7	3.1	15.3	24.6	18.3	57.1	26.5	10.6	sil	0	0	7	15	22	11	1.31	--	--	--									
A2	5-16	1.9	1.8	0.6	2.1	12.4	18.8	23.4	57.8	30.6	13.5	sil	0	8	11	7	26	16	1.52	1.44	--	--									
B1	16-22	1.9	1.8	0.8	2.4	11.4	18.3	25.3	56.4	22.8	12.6	sil	0	9	15	14	38	25	1.69	--	--	--									
IIB21c	22-45	0.4	2.1	0.5	1.4	9.2	13.6	31.2	55.2	19.4	11.7	sic1	32	13	10	7	62	48	1.95	--	--	--									
IIB22t	45-54	1.2	1.5	0.7	2.0	12.6	18.0	29.7	53.3	22.1	10.5	sic1	0	51	14	9	74	61	2.10	1.64	--	--									
IIB3	54-88	1.6	1.2	0.5	1.2	12.7	17.2	28.8	53.0	26.8	3.7	sic1	55	24	3	4	86	77	2.29	--	--	--									
IICr	88-96	0.9	0.7	0.5	3.5	22.4	28.0	11.5	60.5	28.9	4.1	sil	--	84	6	3	93	89	2.43	--	--	--									

Horizon	Depth --cm--	D _b		Dry	Entire clod		1/3 bar	15 bar	<2 mm	1/3 to 15 bar	Exchangeable					Base		Extractable																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
		1/3 bar	15 bar		Ca	Mg					K	Na	Acidity	CEC	sat.	pHs	pHw	C	P	K																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
		--%	--%		--	--					--	--	--	--	--	--	--	--	--	--	--																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
O1	3-1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 27. Soil 4S, Jefferson.

		Description
01	3-1 cm	Deciduous leaf litter and twigs; very strongly acid.
02	1-0 cm	Very dark grayish brown (10YR 3/2) decomposed organic residue; very strongly acid.
A1	0-10 cm	Dark grayish brown (10YR 4/2) channery loam; moderate fine and medium granular structure; friable, slightly sticky, nonplastic; many fine roots; 17% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; abrupt irregular boundary.
A2	10-18 cm	Yellowish brown (10YR 5/6) loam; weak medium granular structure; friable, slightly sticky, nonplastic; common fine and medium roots; 12% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; abrupt wavy boundary.
B21	18-45 cm	Yellowish brown (10YR 5/6) and strong brown (7.5YR 5/6) channery clay loam; weak and moderate medium subangular blocky structure; friable, slightly sticky, slightly plastic; common medium roots; 23% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; gradual wavy boundary.
IIB22	45-83 cm	Strong brown (7.5YR 5/6) channery loam; moderate medium subangular blocky structure; friable, slightly sticky, slightly plastic; few medium and coarse roots; 28% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; clear wavy boundary.
IIB23	83-103 cm	Brownish yellow (10YR 6/6) channery loam; moderate medium subangular blocky structure; firm, slightly sticky, slightly plastic; few thin discontinuous clay films on ped faces; few medium and coarse roots; 28% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; clear wavy boundary.

Table 27, continued

		Description
IIC1	103-120 cm	Brownish yellow (10YR 6/6) and light yellowish brown (10YR 6/4) channery silt loam; massive; very firm, slightly sticky, slightly plastic; 44% by volume shale, siltstone and sandstone coarse fragments; very strongly acid; gradual wavy boundary.
IIC2r	120-140 cm	Laminated shale and siltstone; can be removed with hand tools; yellowish brown (10YR 5/6) and brownish yellow (10YR 6/6) silt loam soil material found within occasional discontinuous cracks; 73% by volume siltstone and shale; very strongly acid; abrupt wavy boundary.
IIR	140+ cm	Thin-bedded shale and siltstone.
Topography--Upper slope position with 50% gradient. Relief convex to straight. Aspect 180°. Elevation 920 m.		
Parent material--Colluvium in top 45 cm over shale and siltstone residuum. Three percent stone cover (sandstone). Some rock outcrops nearby.		
Vegetation--Forest cut over approximately 20 years ago. Black oak, black gum, pignut hickory and mockernut hickory most common canopy trees. Sapling size trees include white oak, black oak, post oak, chestnut oak, red maple, black gum, sassafrass and black locust. Canopy closure, 60%. Shrub cover, 40%.		
Location--Block quadrangle; 128-SE; 0.3 km, 230° from Hatmaker Knob; 0.5 km, 25° from Nig Field.		

Table 28. Physical and chemical properties--Soil 4S, Jefferson.

Horizon	Depth --cm--	Diameter (mm)					Sand of <2 mm	Clay	Silt	Diameter (mm)		Text. class	Diameter (mm)			Total		Total		Entire Clod				
		2.0-	1.0-	0.5-	0.25-	0.1-				0.02-	0.005-		76-	19-	4.7-	Total	76-	19-	4.7-	Total	D _h	C	P	K
		1.0	0.5	0.25	0.1	0.05				0.005	0.002		>76	19	4.7	>2	>76	19	4.7	>2	>2	1/3 bar	--	--
-----% by wt. of <2 mm-----																								
A1	0-10	2.8	2.5	1.1	4.9	21.2	32.5	18.8	48.7	18.9	10.8	1	0	4	13	14	31	17	1.42	--	--			
A2	10-18	3.7	1.9	0.7	3.6	20.2	30.1	23.9	46.0	18.4	8.6	1	0	5	5	12	22	12	1.55	--	--			
B21	18-45	3.2	1.8	0.8	4.1	19.7	29.6	27.0	43.4	19.3	6.5	c1	9	12	6	8	35	23	1.71	--	--			
B22	45-83	3.3	2.2	0.8	3.3	18.6	28.2	23.4	48.4	20.3	9.2	1	3	14	11	12	40	28	1.77	1.61	--			
B23	83-103	1.9	2.0	1.1	4.1	24.5	33.6	19.7	46.7	19.4	8.2	1	0	14	13	13	40	28	1.84	1.67	--			
IIC1	103-120	1.5	1.8	0.9	3.5	19.4	27.1	20.3	52.6	22.6	9.5	sil	0	25	15	16	56	44	2.03	--	--			
IIC2r	120-140	1.2	1.7	0.8	4.4	19.6	27.7	20.2	52.1	22.5	9.6	sil	--55--	--	16	10	81	73	2.30	--	--			

Horizon	Depth --cm--	<2 mm		Entire clod		1/3 bar		15 bar		1/3 to 15 bar		Exchangeable		Acidity		Base		Extractable					
		D _b	D _h	D _b	D _h	1/3 bar	15 bar	1/3 bar	15 bar	1/3 to 15 bar	cm/cm	Ca	Mg	K	Na	CEC	sat.	pHw	pHs	C	P	K	
		bar	Dry	bar	Dry	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar	bar
O1	3-1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5.0	4.2	--	--	--	
O2	1-0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.4	3.5	--	--	--	
A1	0-10	1.20	--	--	--	33	16	11.7	0.17	1.22	0.29	0.05	0.05	0.04	0.02	29.2	31.1	6	4.6	3.7	11.3	3.0	65
A2	10-18	1.40	--	--	--	29	14	11.8	0.18	0.11	0.12	0.05	0.02	0.02	0.02	15.2	15.7	3	4.9	4.1	4.3	2.0	30
B21	18-45	1.45	--	--	--	23	10	8.4	0.14	0.08	0.07	0.04	0.03	0.01	0.01	9.8	10.1	2	4.7	4.1	2.1	1.0	30
B22	45-83	1.47	1.52	0.011	0.008	16	19	6.5	0.12	0.07	0.06	0.03	0.01	0.01	0.01	6.4	6.7	4	4.8	4.1	0.8	2.0	30
B23	83-103	1.56	1.62	0.013	0.009	14	17	7.3	0.13	0.06	0.07	0.04	0.01	0.01	0.01	4.0	4.3	7	4.8	3.9	0.5	1.0	25
IIC1	103-120	1.60	--	--	--	17	5	5.3	0.11	0.05	0.08	0.04	0.01	0.01	0.01	4.3	4.3	7	4.7	4.0	--	1.0	30
IIC2r	120-140	1.60	--	--	--	17	5	2.3	0.05	0.04	0.11	0.04	0.01	0.01	0.01	5.2	5.5	5	4.6	4.0	--	1.0	30

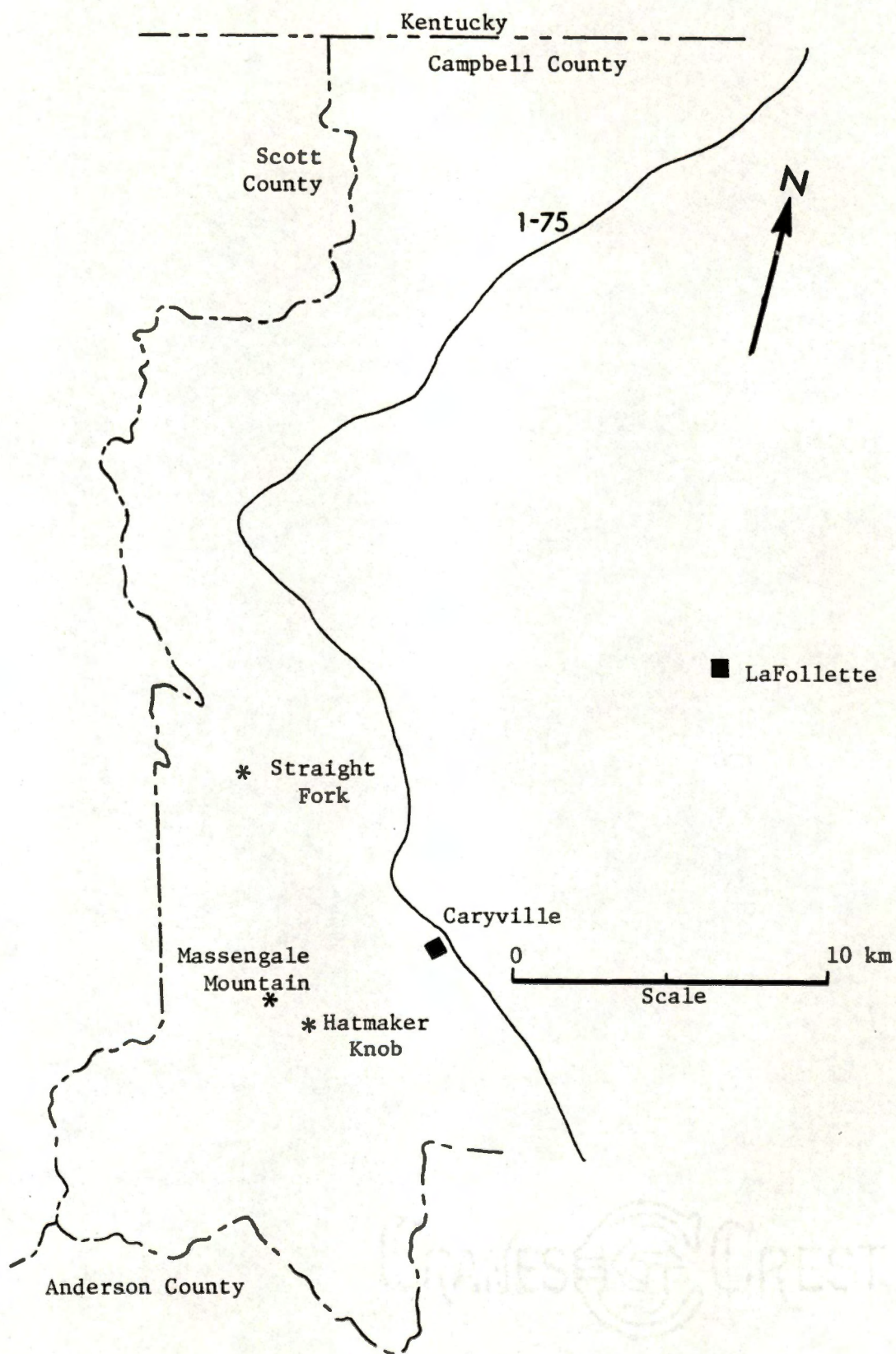


Fig. 4. Sampling locations in a soil morphological study in Campbell County, Tennessee.

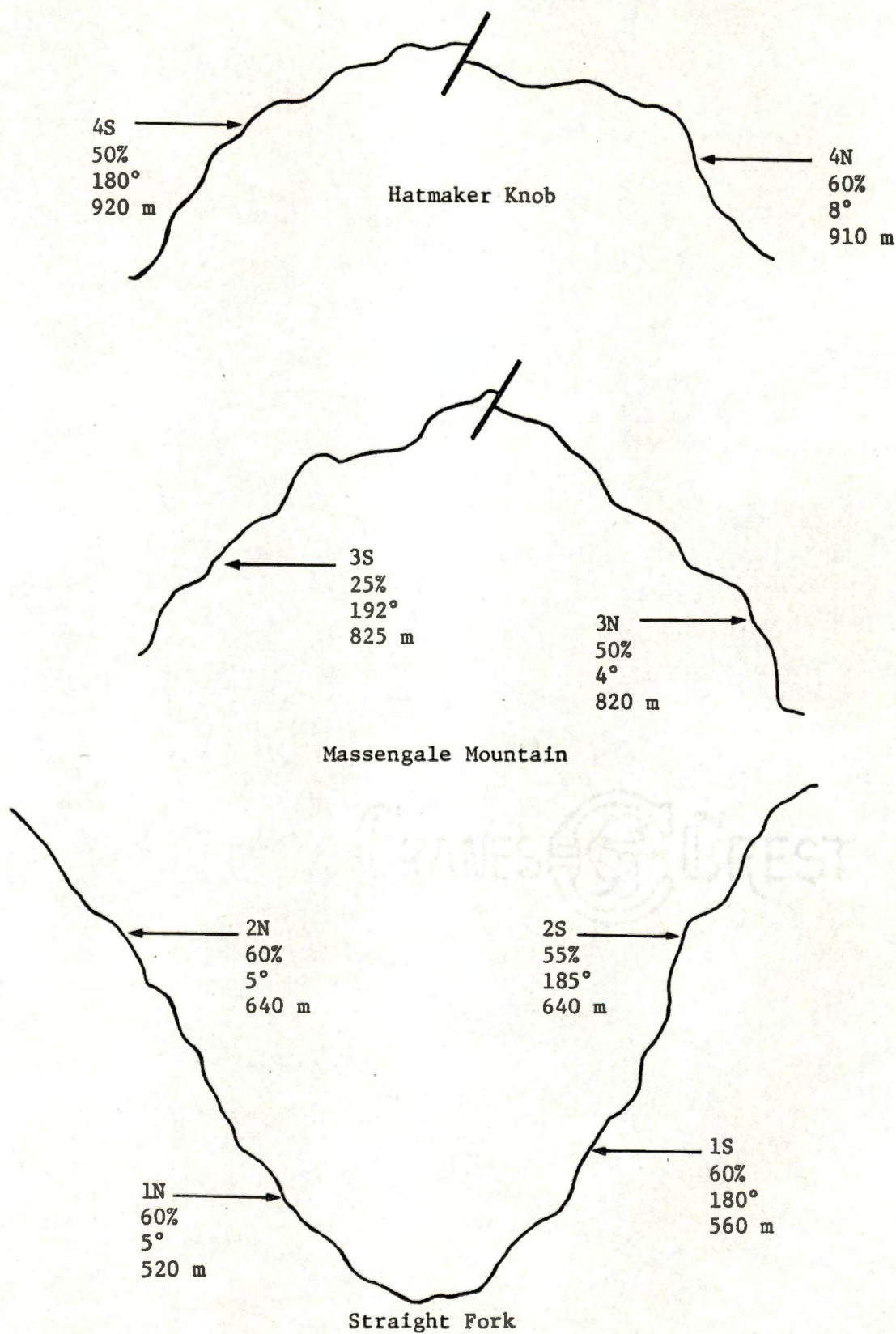


Fig. 5. Cross sections with sampling locations in Campbell County, Tennessee.

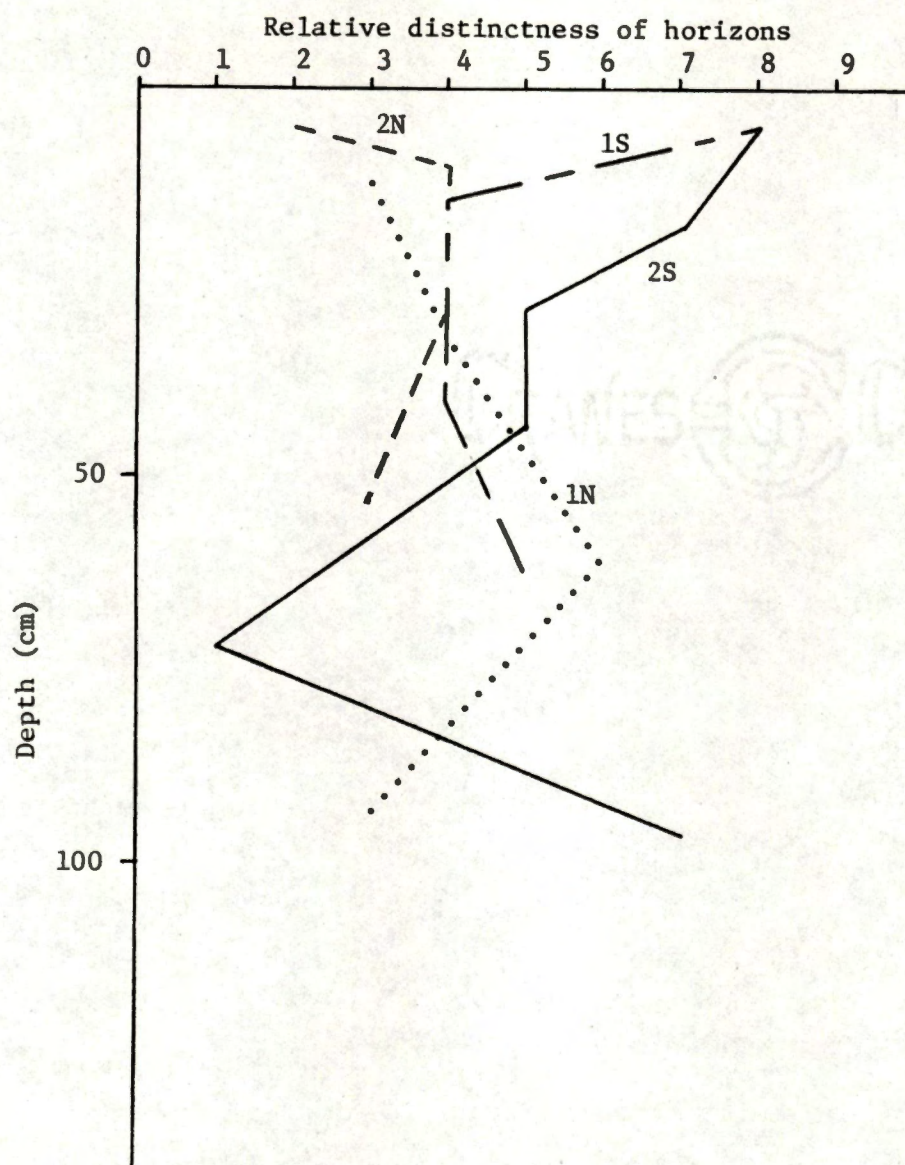


Fig. 6. Relative distinctness of horizons for eight soils in Campbell County, Tennessee.

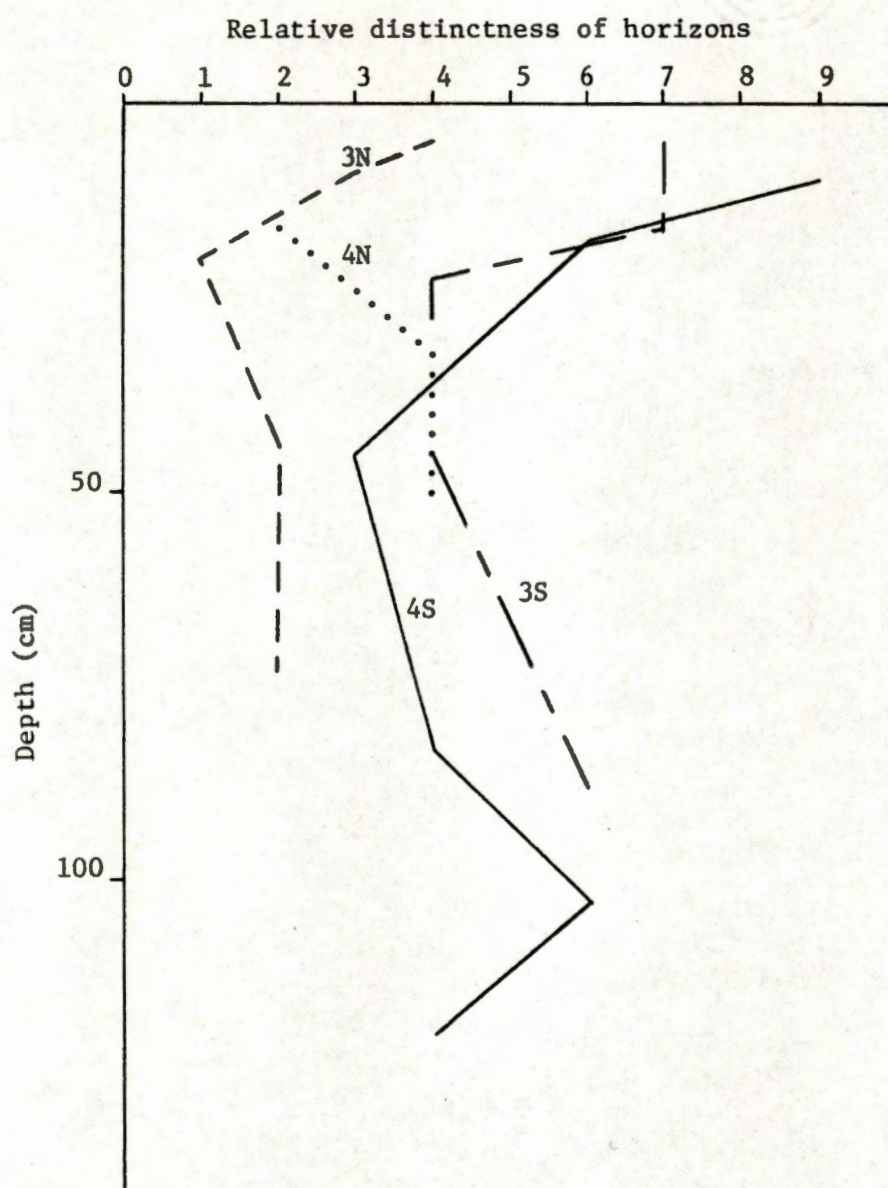


Fig. 6, continued

Table 29 is a summary of some of the morphologic properties for the soils.

Thick, dark surface horizons for soils 1N (Table 13, page 54) and 4N (Table 19, page 63) are strong criteria for placement into the Umbrepts. Most soils on north aspects were darker (lower values and chromas). Soils on south aspects had redder hues (Table 29).

There were only slight differences in grade and size of structure; however, few thin, clay films were described in some B horizons on south aspects (Table 29).

Cr horizons were evident in soils on south aspects only (Table 29). This may be a result of the greater frequency and intensity of wetting and drying and of freezing and thawing on south-facing slopes.

Observations during soil description concerning the arrangement of coarse fragments suggested discontinuities in soils 2N (Table 15, page 57), 3S (Table 25, page 72) and 4S (Table 27, page 75). The soil descriptions also indicated soil creep (colluvium) in the upper soil horizons.

For each soil, parent material was described as either residuum or colluvium. The arrangement of coarse fragments in situ was the main distinguishing criteria.

Chemical properties. With few exceptions, horizons of all soils had pHw values in the strongly acid (5.1-5.5) to very strongly acid (4.5-5.0) range. Few free salts were originally present in the eight soils as indicated by a constant difference of 0.6 to 0.9 of a pH unit between pHw and pHs. On north-facing slopes, soils were less acid in

Table 29. Summary of some morphological features of eight pedons in the Cumberland Mountains in Campbell County, Tennessee.

Soil	Color (M)										Structure ^a								Clay films
	A1	A2	A3	B1	B21	B22	B23	B3	C	A1	A2	A3	B1	B21	B22	B23	B3	Cr	
	-----hue----- -----value/chroma-----																		
1N	10YR 3/2		10YR 3/3		10YR 4/4	7.5YR 5/6		10YR 5/6			2m		2m		2m		2m		
2N	10YR 4/3	10YR 5/4		10YR 5/6	10YR 6/6			10YR 5/6			2f	2m		2m	2m		2m		few thin
3N	10YR 4/2	10YR 5/3		10YR 5/4	10YR 5/4	10YR 5/4		10YR 5/4			2m	2m		2m	2m		2m		
4N	10YR 3/2		10YR 3/2		10YR 4/3						2m		2m		1m				
1S	10YR 4/2	10YR 6/6		10YR 5/6	7.5YR 5/6				7.5YR 5/6		1f	1m		2m	2m			*	few thin
2S	10YR 4/2	10YR 6/4		10YR 5/6	7.5YR 5/6	7.5YR 5/6	7.5YR 5/6				2f	2m		2m	2m		2m	*	few thin
3S	10YR 3/2	10YR 5/3		10YR 5/6	10YR 5/6	10YR 5/6		10YR 5/6			2m	2m		2m	2m		1m	*	few thin disc
4S	10YR 4/2	10YR 5/6		10YR 5/6	7.5YR 5/6	10YR 6/6			10YR 6/6		2m	1m		2m	2m		2m	*	few thin

^a1 = weak, 2 = moderate; f = fine, m = medium.

upper horizons than in lower horizons. On south aspects pH values were uniform throughout the solum.

Except for A horizons, all pedons had low base saturation. Soil 1S (Table 22, page 68) was the only pedon with base saturation as high as 20% in lower horizons. In a similar study area, Franzmeier et al. (1969) found lower positions to be highest in bases. This was not evident in the Campbell County study.

Higher percentages of organic carbon at greater depths (Figure 7) were seen in the soils on north aspects. Warmer temperatures and faster oxidation on south aspects (Finney, 1962) and greater leaf accumulation on north aspects (Franzmeier et al., 1969) were reasons given in similar studies. Also, the organic carbon percentage was greatest in soils at high elevations (Figure 7). The organic carbon distribution decreased with depth, indicating no buried horizons. The higher organic carbon content in surface horizons is in agreement with higher CEC and base saturation. Hutchins et al. (1976) found higher base saturation and pH on north aspects.

K values were found to be uniform within a soil and also varied little between soils. All soils were deficient in phosphorus (less than 3.0 ppm).

On north aspects, Na is highest in A1 horizons and decreases with depth. Na values are uniform within a profile, with the exception of 4S in which Na decreases with depth.

In all eight soils, Ca + Mg was higher in the A1 horizons than in lower horizons. The generally low Ca/Mg ratios of deeper horizons of all soils indicate much weathering and leaching. The upper horizons of

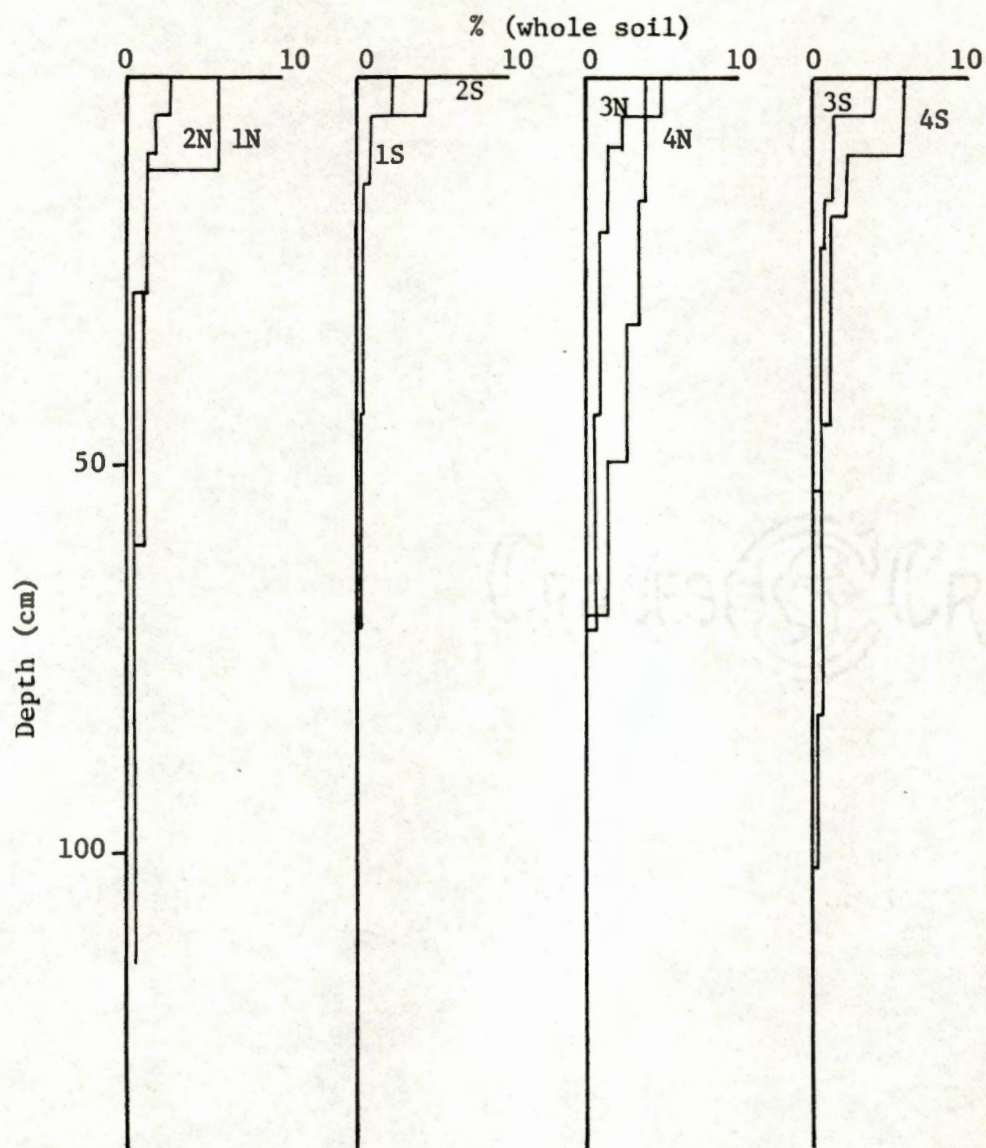


Fig. 7. Organic carbon content of eight soils in Campbell County, Tennessee.

soils on north aspects had much higher Ca/Mg ratios (Table 30) than those on south aspects. This concurs with Bailey and Avers (1971), who attribute this to recycling of elements before removal by leaching.

Soil 4S had a high Ca/Mg ratio (Table 30) in the A1 horizon. Again, recycling of elements may be the cause. At higher elevations (~900 m) on south aspects, low temperatures and less evapotranspiration approach microclimatic conditions of north aspects.

Physical properties. Table 31 contains the average densities of the coarse fragments for five of the soils. The average density was 2.60 g/cm^3 . Buckman and Brady (1971) state that most mineral soils have particle densities within the range of 2.60 to 2.75 g/cm^3 . The density determined was not true particle density since pore space within the coarse fragments was included as a portion of the denomination. Considering the low densities (Table 31), it can be inferred that quartz and other light minerals were major components of the coarse fragments. Particle density of the fine earth was not measured, but 2.65 g/cm^3 was assumed.

The coarse fragment distribution for each horizon (Tables 13, page 54, to 28, page 77) aids in determining the type of parent material. Soils 2N (Table 16, page 59), 3S (Table 26, page 74) and 4S (Table 28, page 77) show some variation in size distribution of coarse fragments between upper and lower horizons. This reinforces field observations of "soil creep" and the arrangement of coarse fragments in the upper horizons.

Table 30. Ca/Mg ratios for eight soils in Campbell County, Tennessee.

Soil	Depth --cm--	Ca/Mg	Soil	Depth --cm--	Ca/Mg
1N	0-12	9.0	1S	0-5	1.0
	12-32	2.3		5-14	0.5
	32-61	1.2		14-40	0.2
	61-94	1.3		62-100	0.1
	94-116	1.1		100-155	0.1
2N	0-5	6.4	2S	0-5	0.9
	5-10	1.9		5-18	0.1
	10-28	1.0		18-29	0.1
	28-53	0.7		29-44	0.1
	53-87	0.4		44-72	0.1
3N	0-5	6.5		72-96	0.1
	5-9	2.4		96-135	0.1
	9-20	1.4	3S	0-5	1.7
	20-44	1.5		5-16	0.9
	44-72	1.0		16-22	0.6
	72-90	1.0		45-54	0.3
4N	0-16	3.5		54-88	0.2
	16-32	1.6		88-96	0.1
	32-50	1.2	4S	0-10	4.2
	50-69	1.1		10-18	0.9
				18-45	1.0
				45-83	1.2
				83-103	0.9
				103-120	0.6
				120-140	0.4

Table 31. Average density of coarse fragments for five soils
in Campbell County, Tennessee.

Soil	Density g/cm ³
1S	2.86
2N	2.48
3S	2.40
3N	2.60
4N	2.50

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High silt content of all soils reflects the shale content of the Pennsylvanian geology. Bailey and Avers (1971) also state that high CEC and clay content are a result of weathering from Pennsylvanian age rock. Clay contents of all B2 horizons were between 22 and 37% (Tables 13, page 54, to 28, page 77).

Silt loam, silty clay loam and loam were the most prevalent <2 mm textural classes (Tables 13 to 28). Sand content of surface horizons was less on north aspects (Figures 8 to 11) than on south aspects (Figures 12 to 15). Possibly this could be attributed to more intense eluviation. Total clay content of 1S (Figure 12), 2S (Figure 13), 3S (Figure 14) and 4S (Figure 15) is greater than for soils on north aspects. None of the north-aspect soils have enough clay increase in the particle size control section for an argillic horizon. Bailey and Avers (1971) also found an increase in clay with depth. This indicated a loss from the profile rather than a translocation within the profile.

The summation percentages (Figures 16 to 23) graphically represent the sand and silt particles. Similar shapes and closeness of lines for different horizons indicate uniform parent material. The shapes are similar for all soils; large amounts of silt with small percentages of sand. Figure 20, page 102, for 1S and Figure 21, page 103, for 2S indicate more silt in the lower horizons, possibly discontinuities.

Total bulk densities for all soils and all horizons were higher than the bulk densities for the <2 mm fraction. This was due to coarse fragment influence and reflects the soil's reduced capacity to hold water. Figures 24 to 31 show the solid, liquid and gaseous phases of

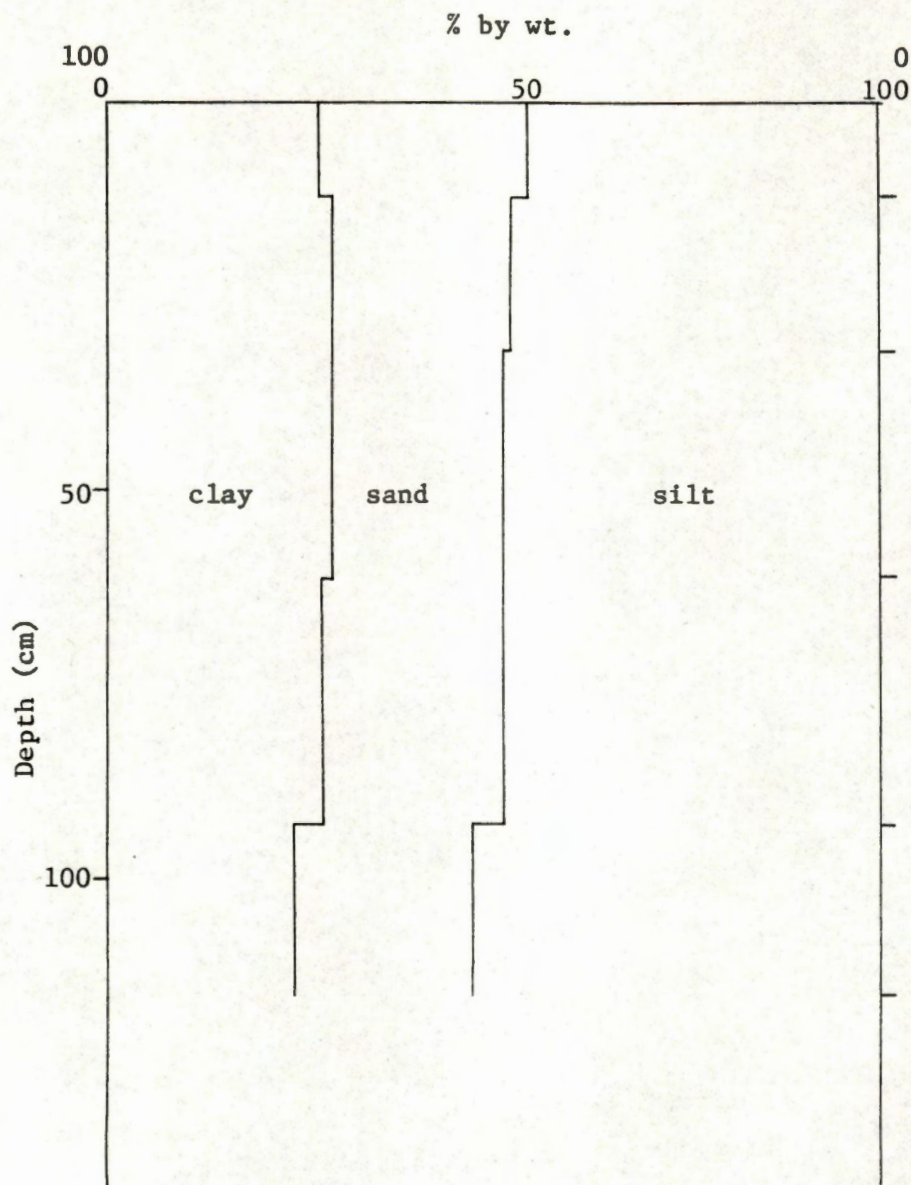


Fig. 8. Particle size distribution for soil 1N, Zenith (tax).

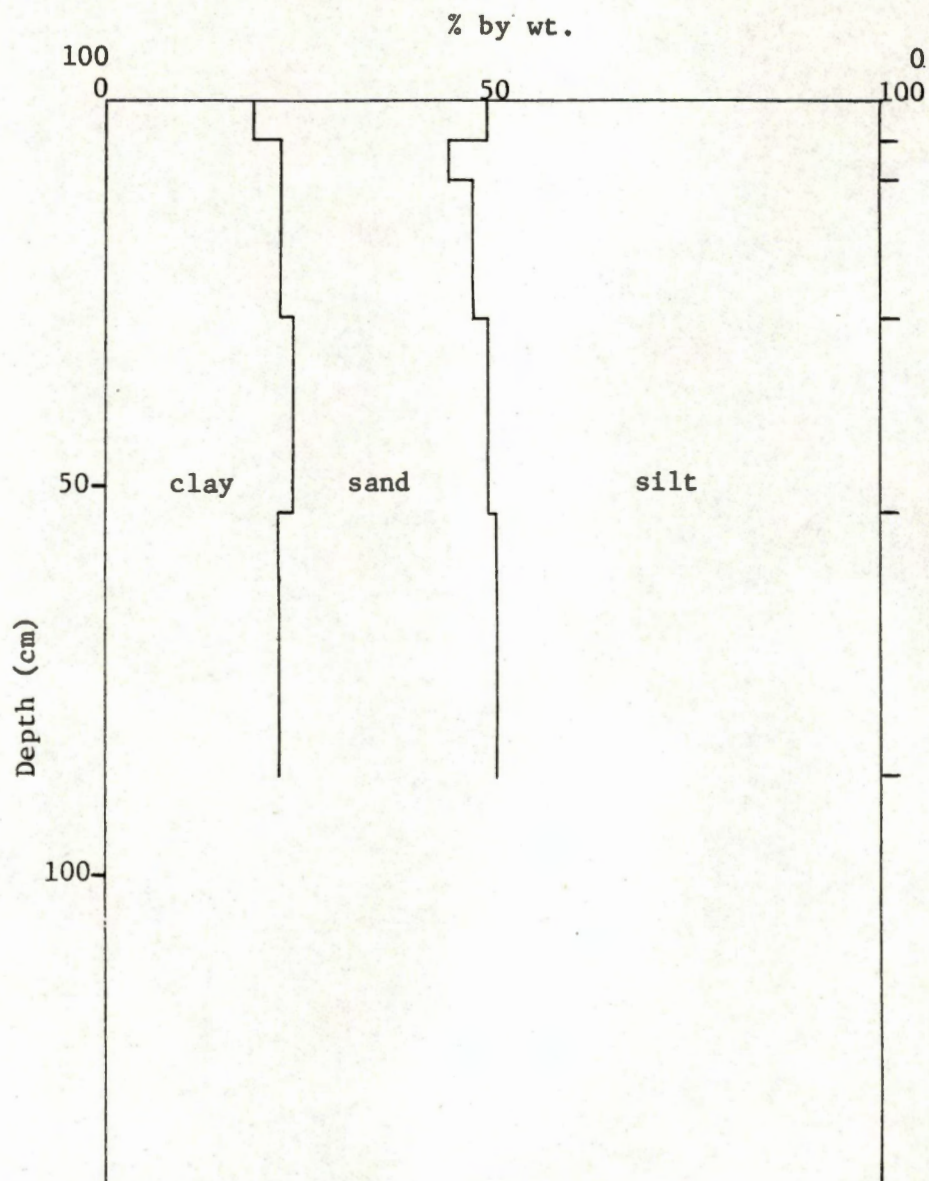


Fig. 9. Particle size distribution for soil 2N, Muskingum.

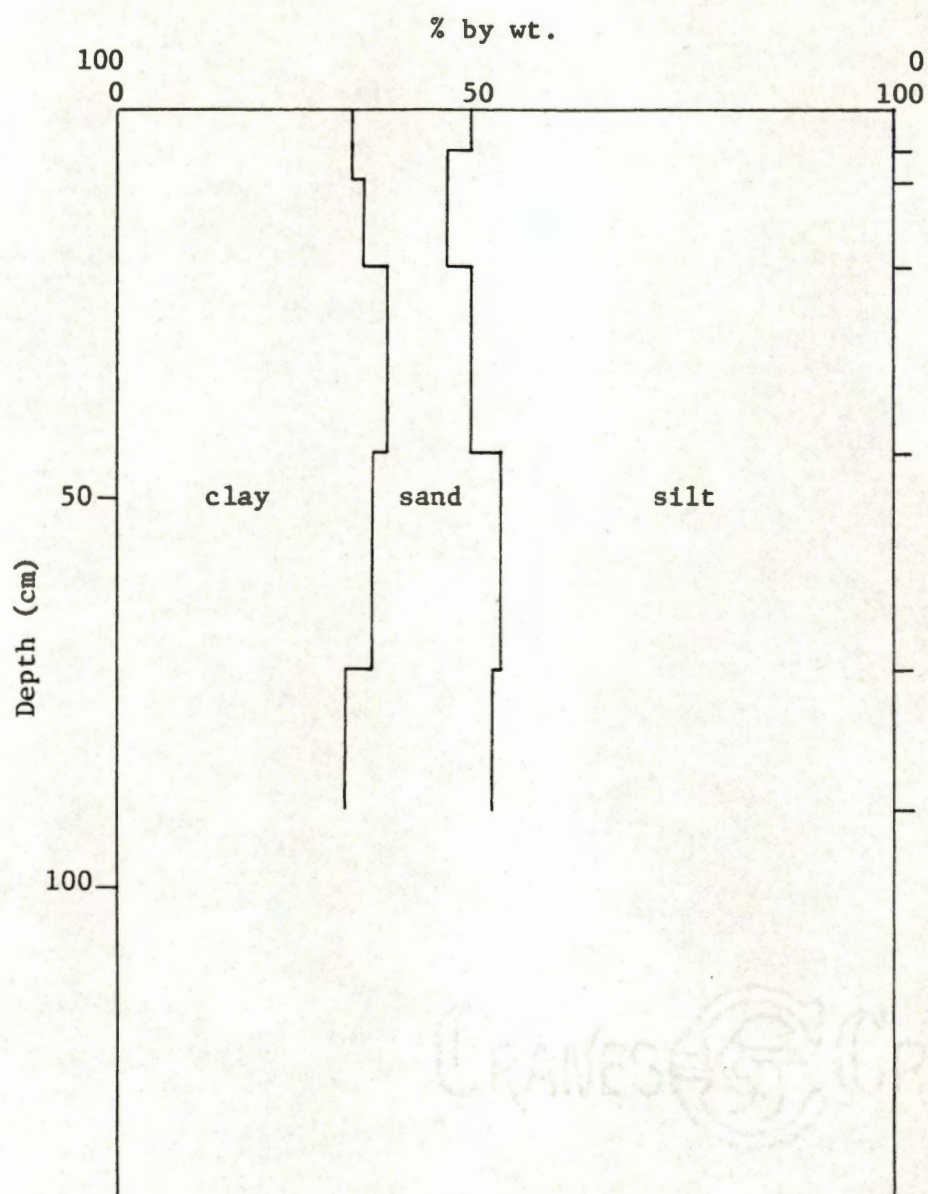


Fig. 10. Particle size distribution for soil 3N, Muskingum (tax).

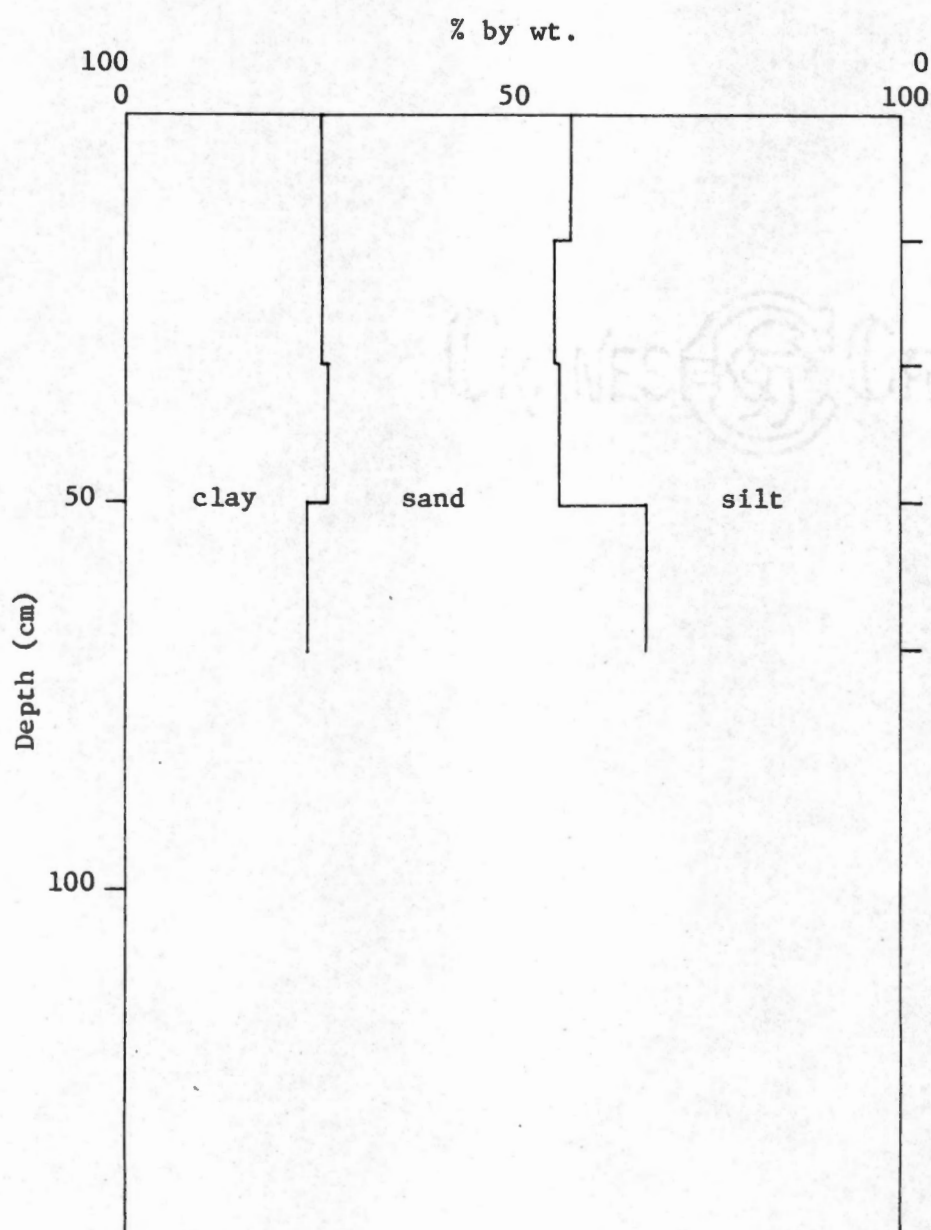


Fig. 11. Particle size distribution for soil 4N, Zenith (tax).

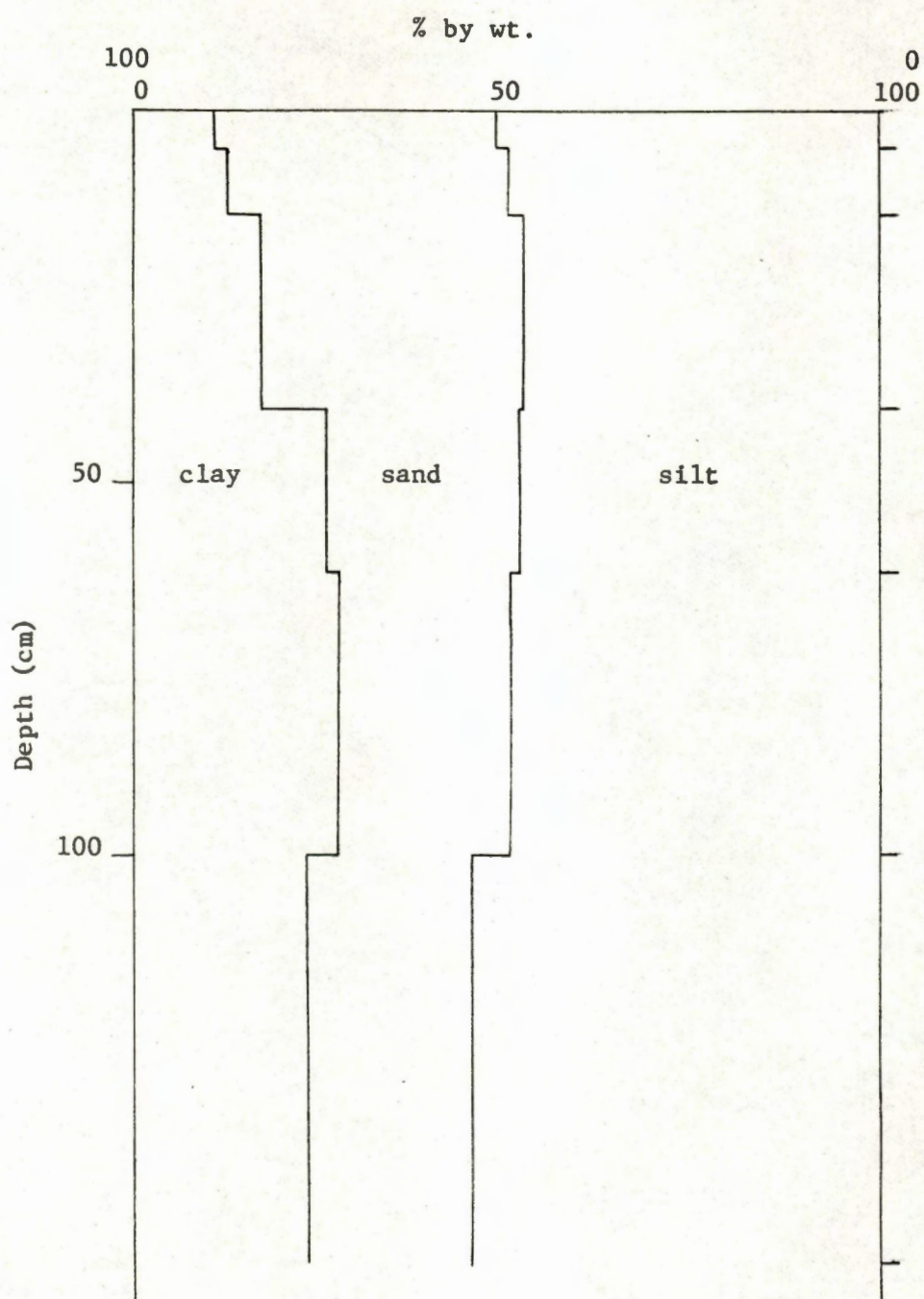


Fig. 12. Particle size distribution for soil 1S, Grimsley.

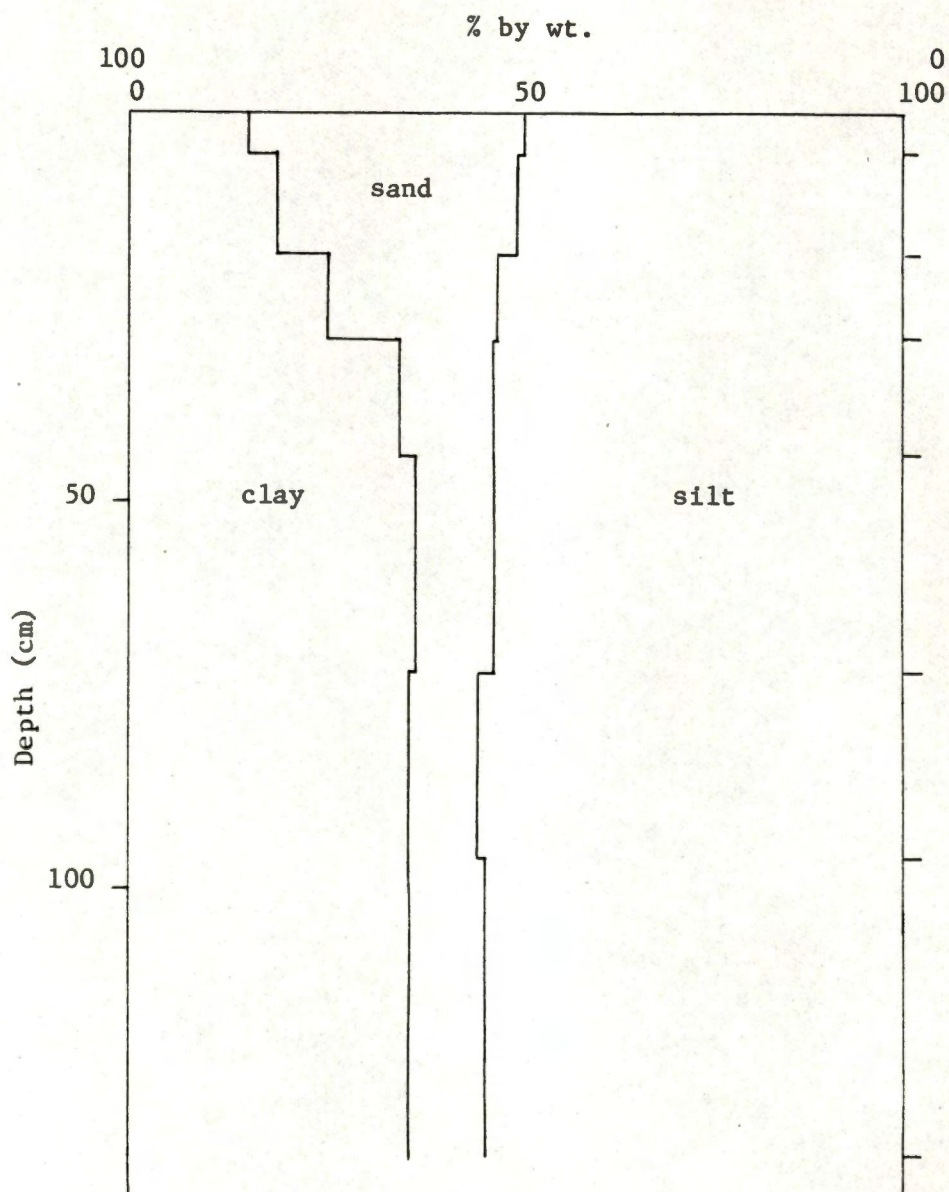


Fig. 13. Particle size distribution for soil 2S, Gilpin.

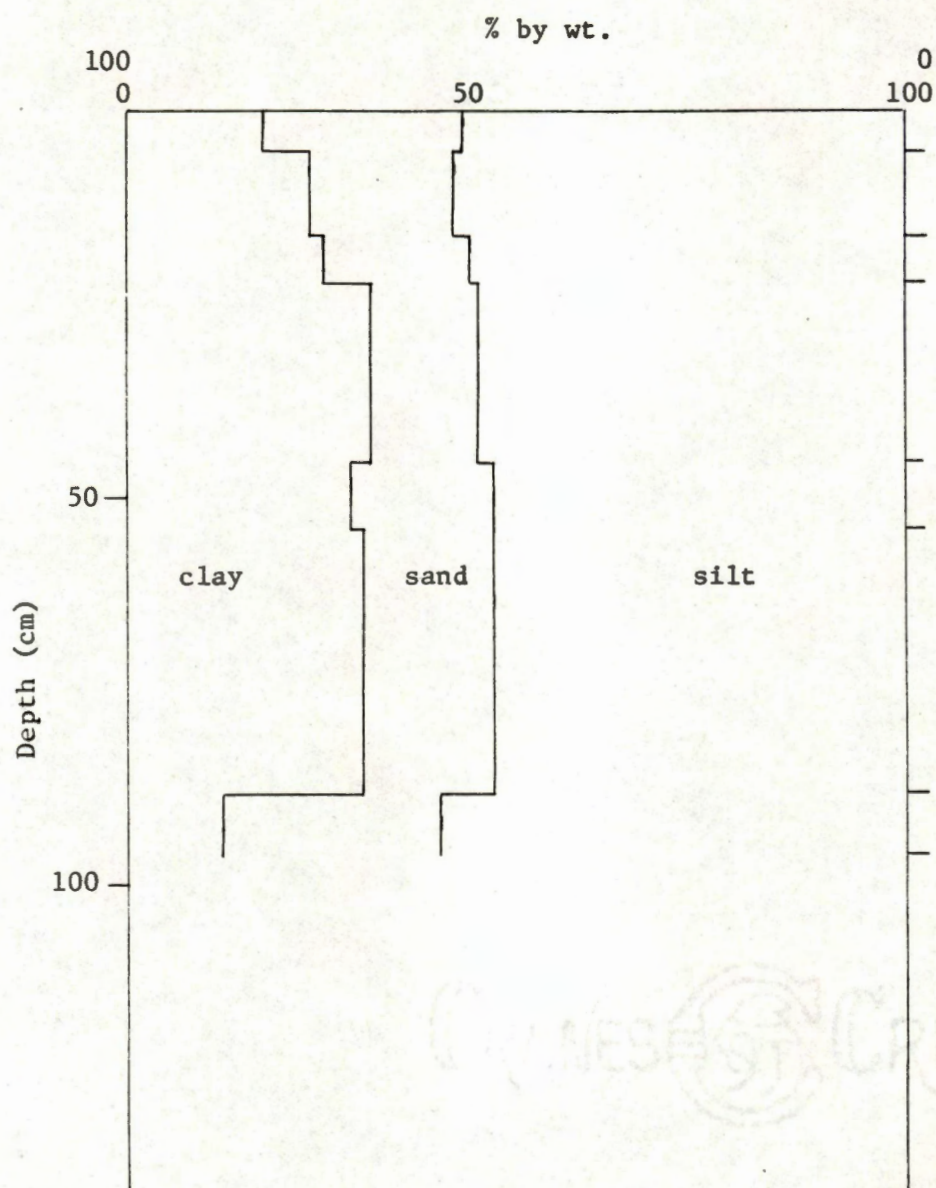


Fig. 14. Particle size distribution for soil 3S, Gilpin (tax).

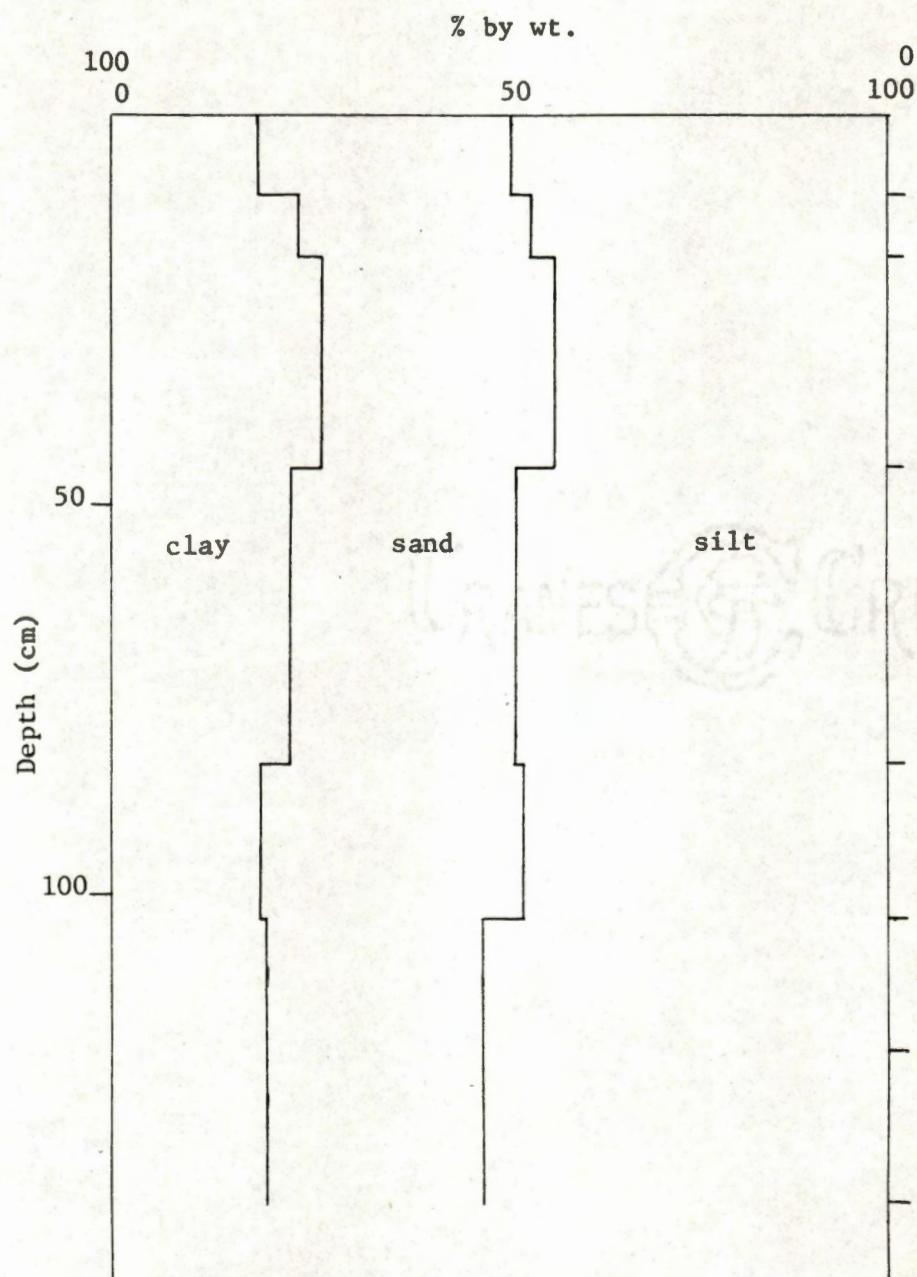


Fig. 15. Particle size distribution for soil 4S, Jefferson.

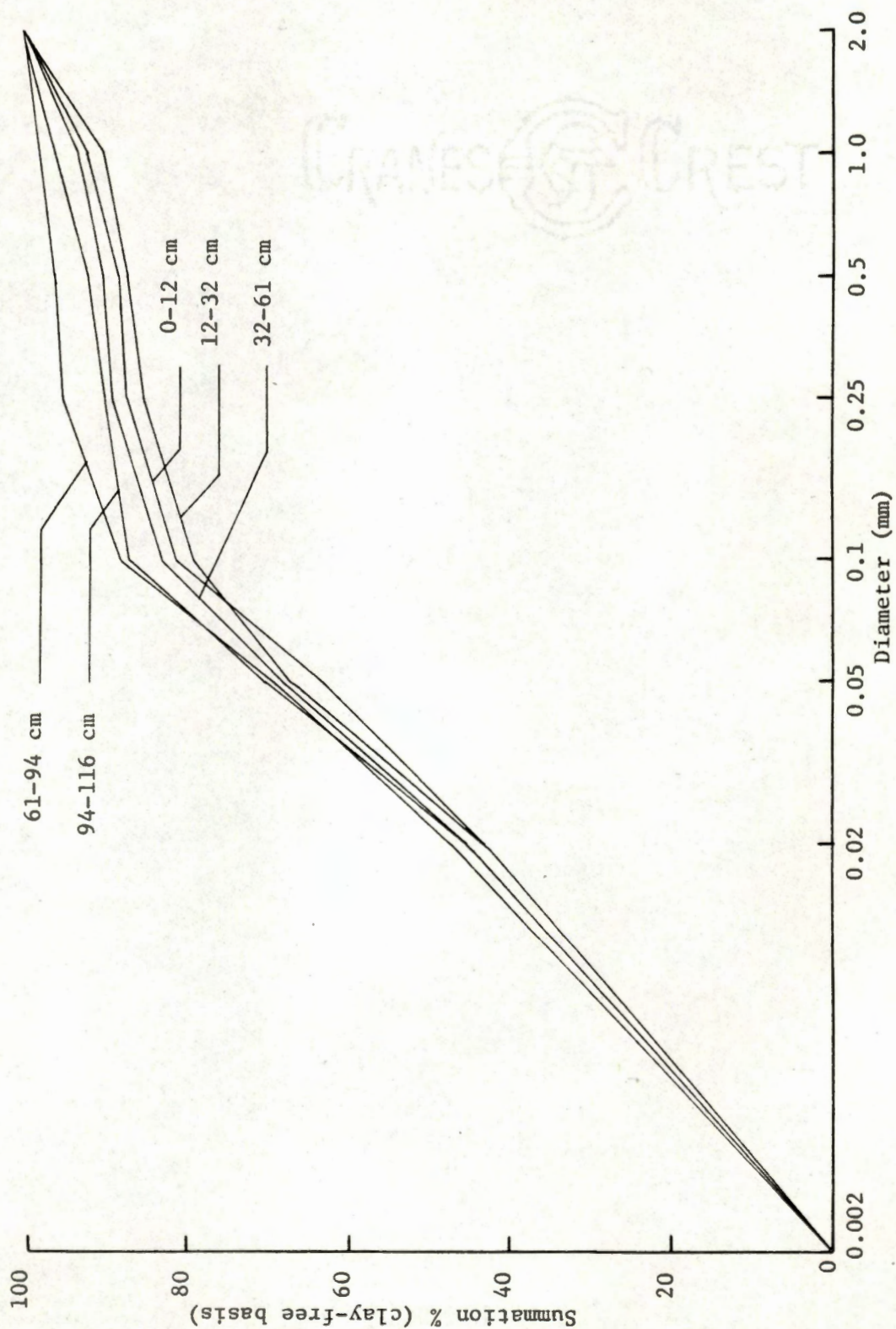


Fig. 16. Summation percentages of silt and sand-sized particles in horizons of soil 1N, Zenith (tax).

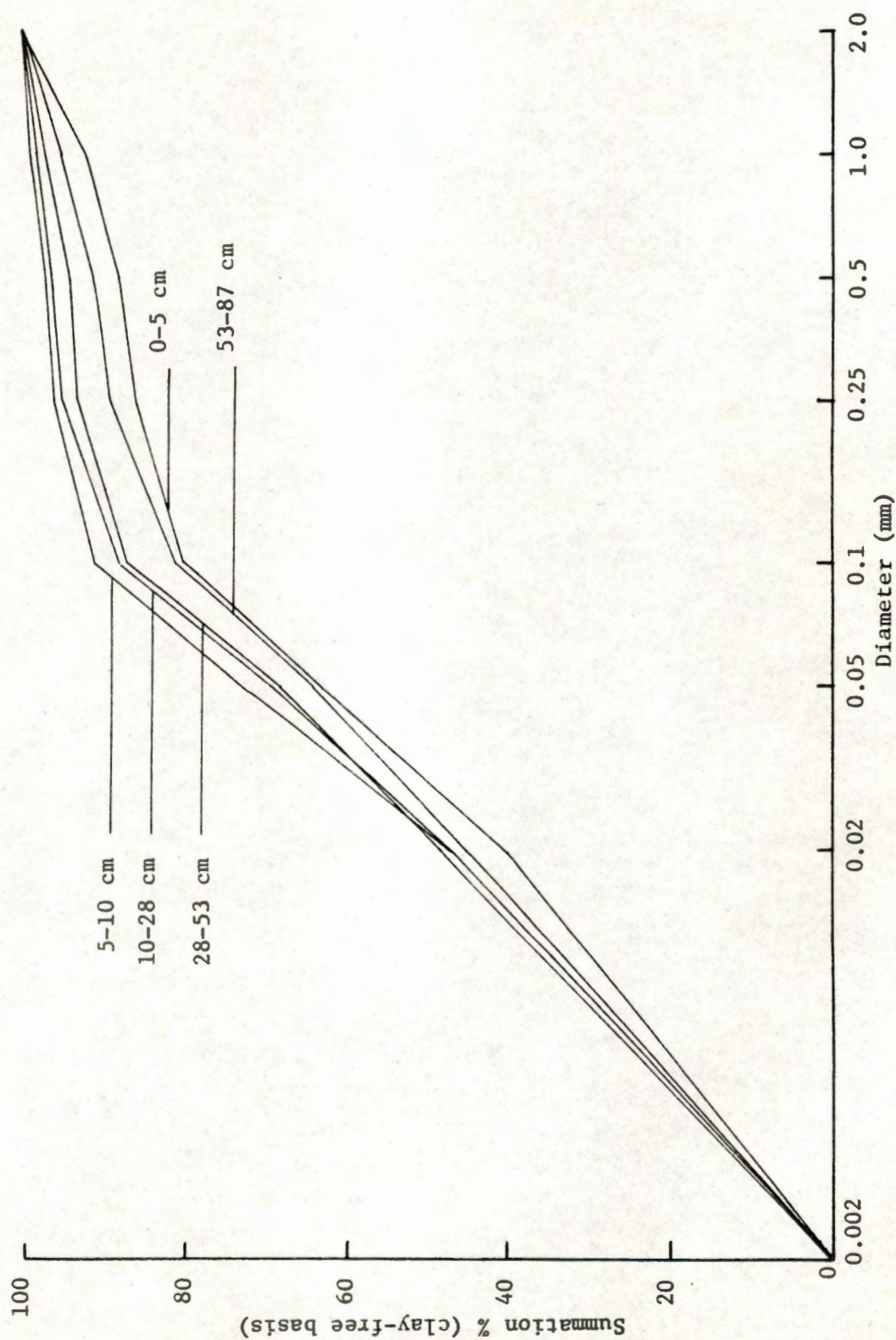


Fig. 17. Summation percentages of silt and sand-sized particles in horizons of soil 2N, Muskingum.

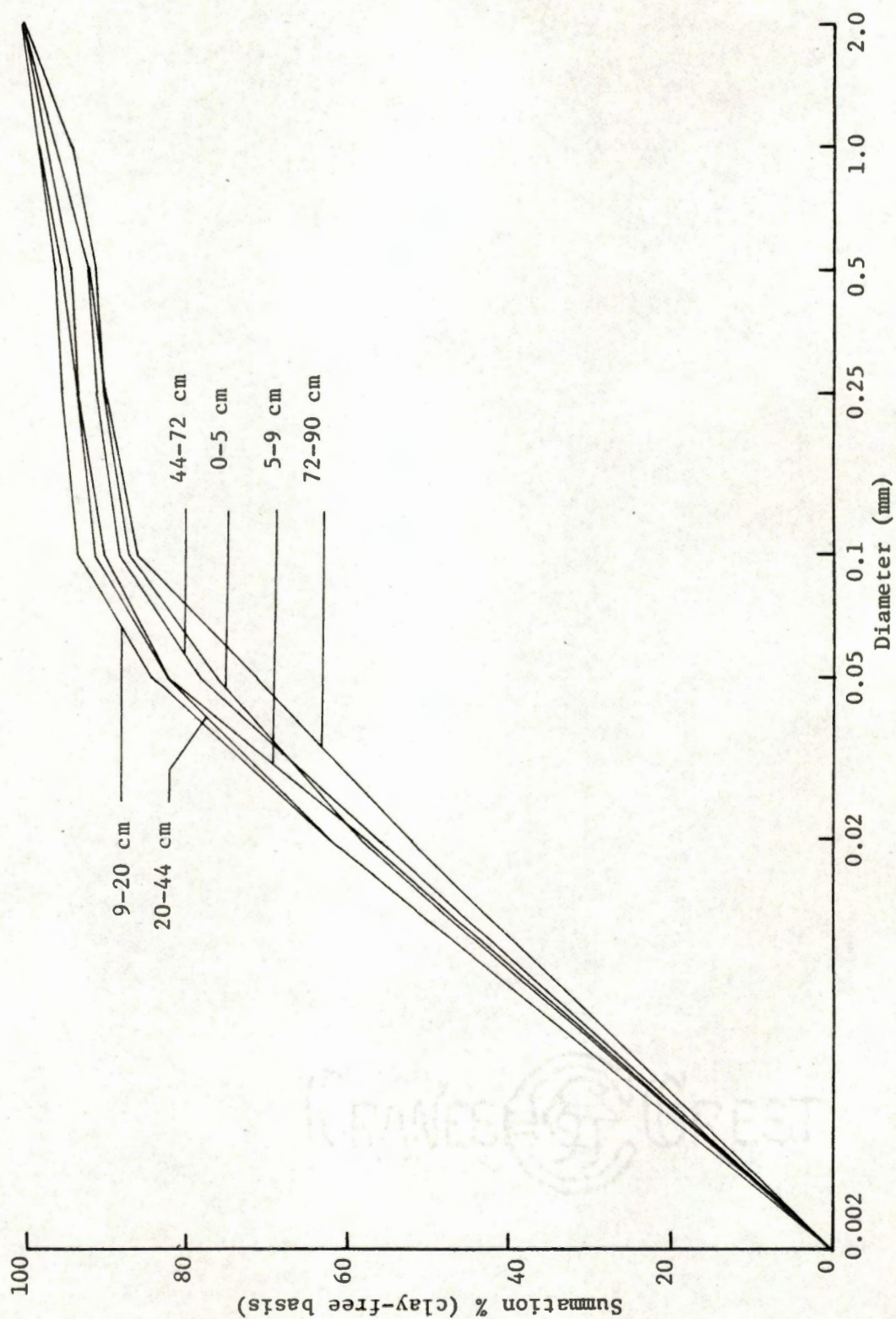


Fig. 18. Summation percentages of silt and sand-sized particles in horizons of soil 3N, Muskingum (tax).

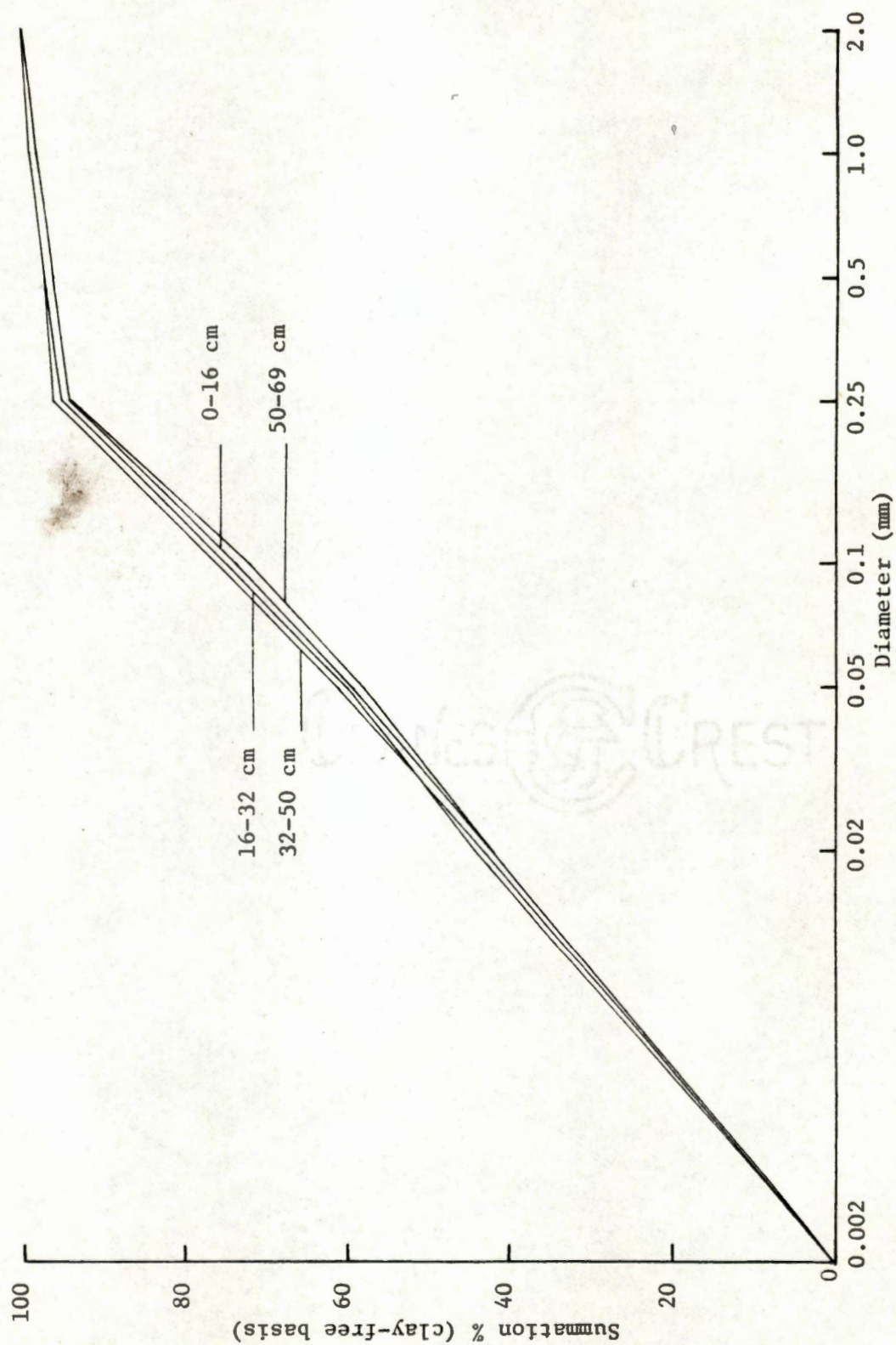


Fig. 19. Summation percentages of silt and sand-sized particles in horizons of soil 4N, Zenith (tax).

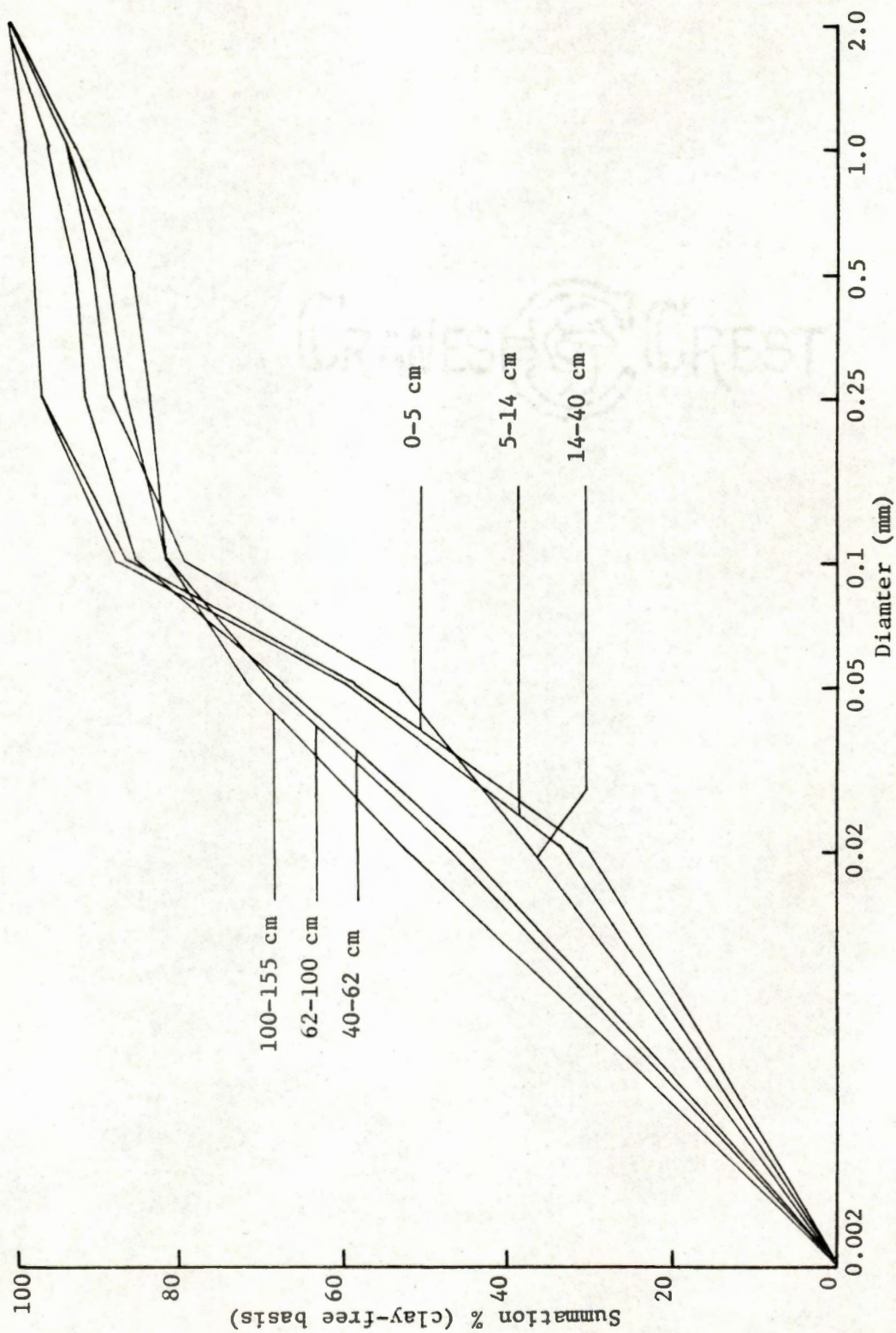


Fig. 20. Summation percentages of silt and sand-sized particles in horizons of soil 1S, Grimsley.

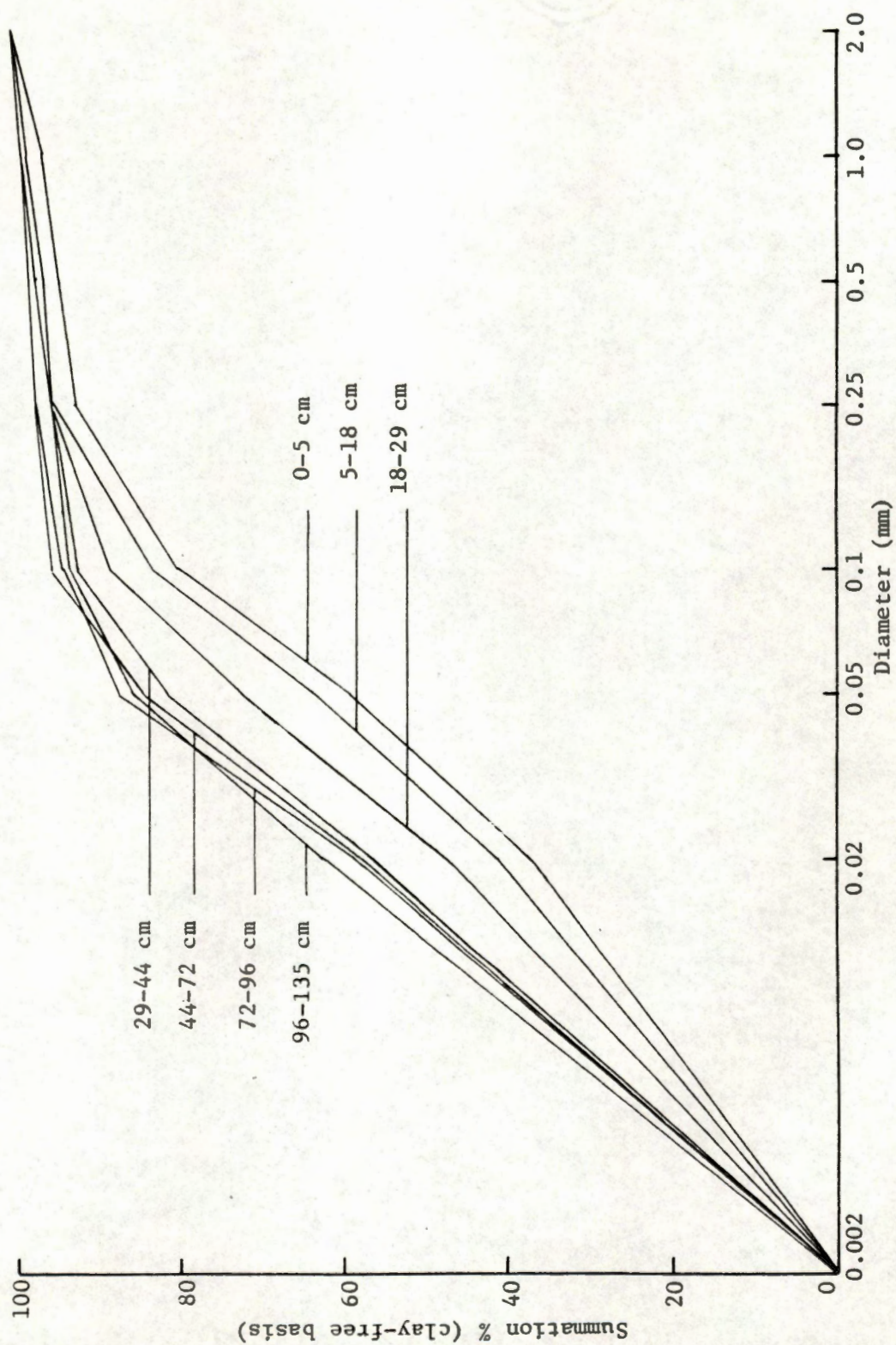


Fig. 21. Summation percentages of silt and sand-sized particles in horizons of soil 2S, Gilpin.

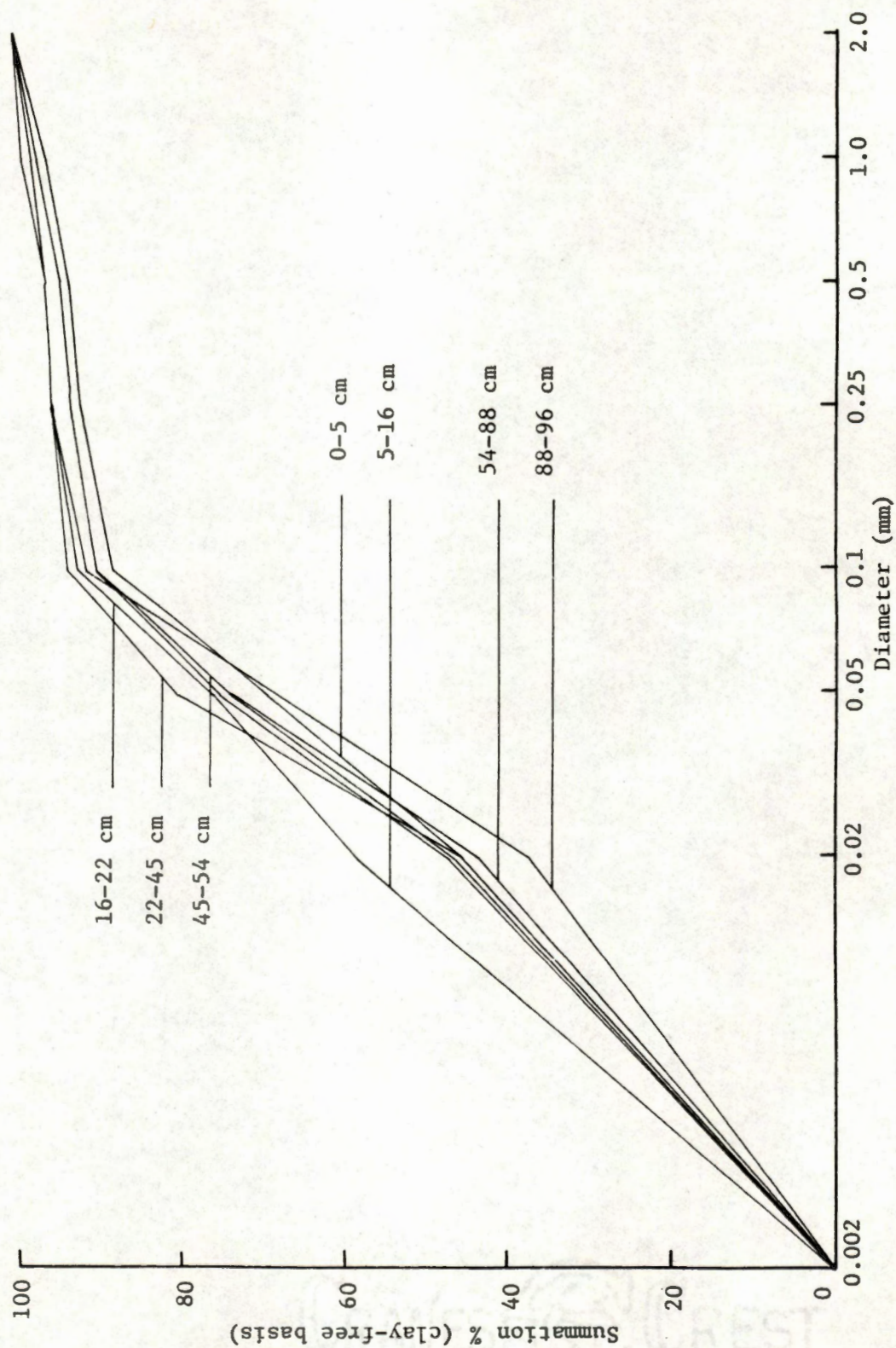


Fig. 22. Summation percentages of silt and sand-sized particles in horizons of soil 3S, Gilpin (tax).

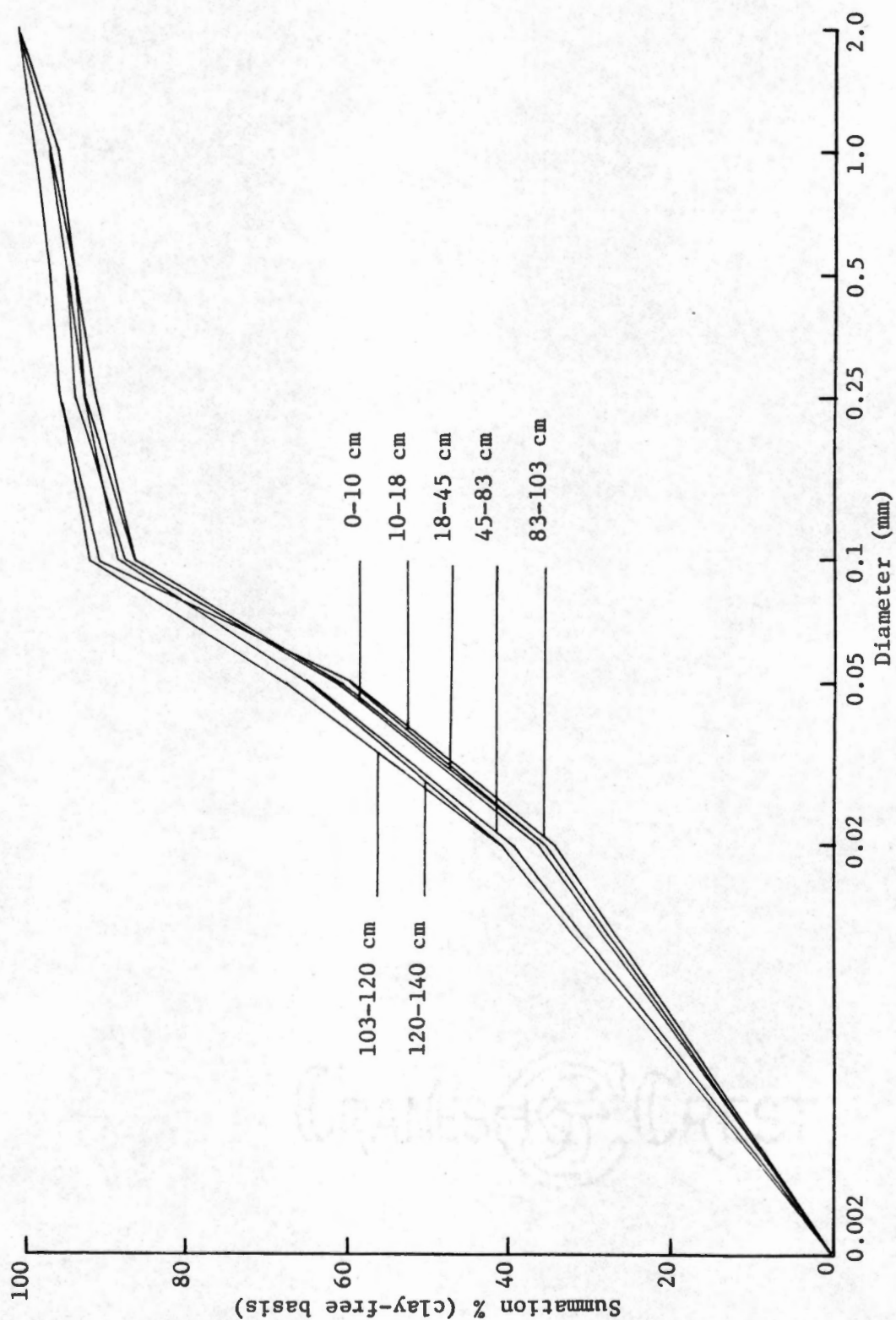


Fig. 23. Summation percentages of silt and sand-sized particles in horizons of soil 4S, Jefferson.

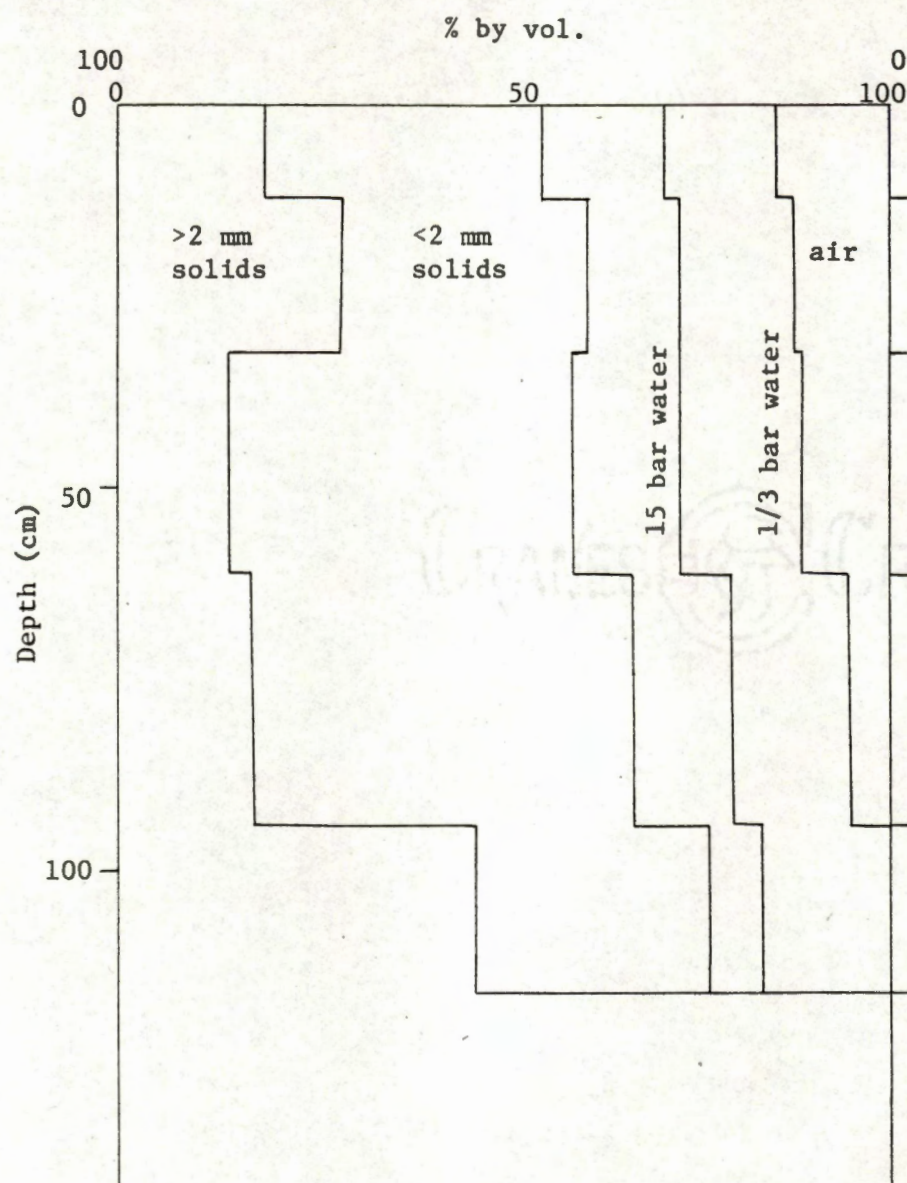


Fig. 24. Volume composition for soil 1N, Zenith (tax).

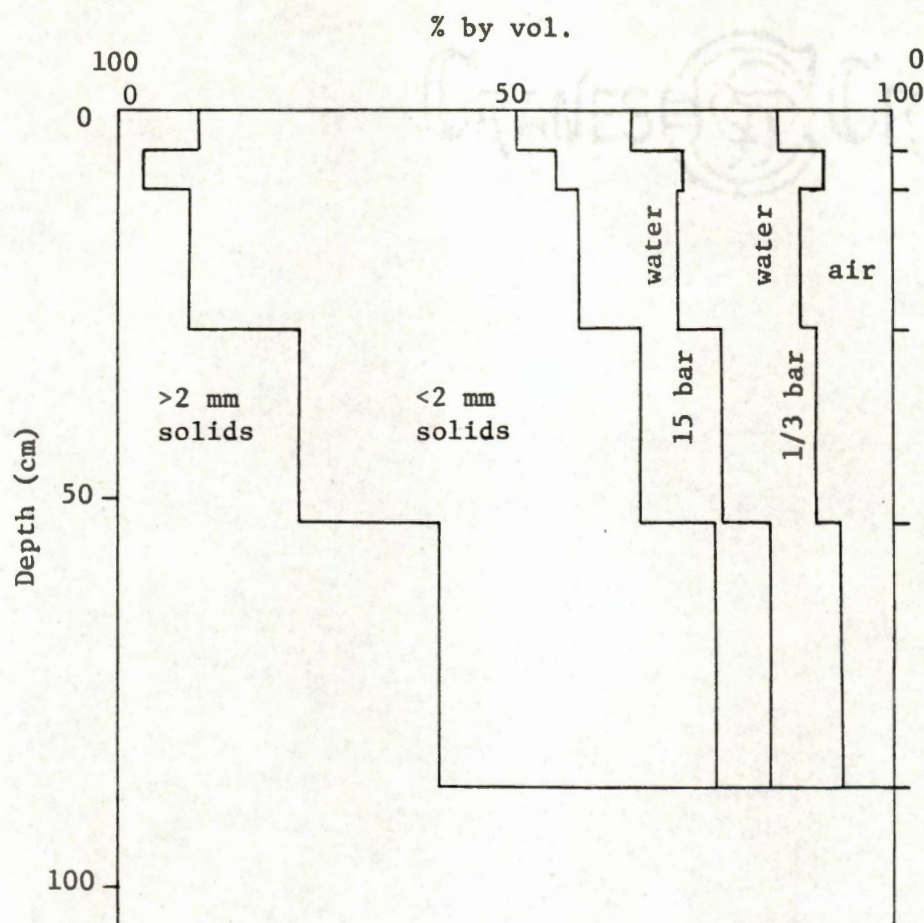


Fig. 25. Volume composition for soil 2N, Muskingum.

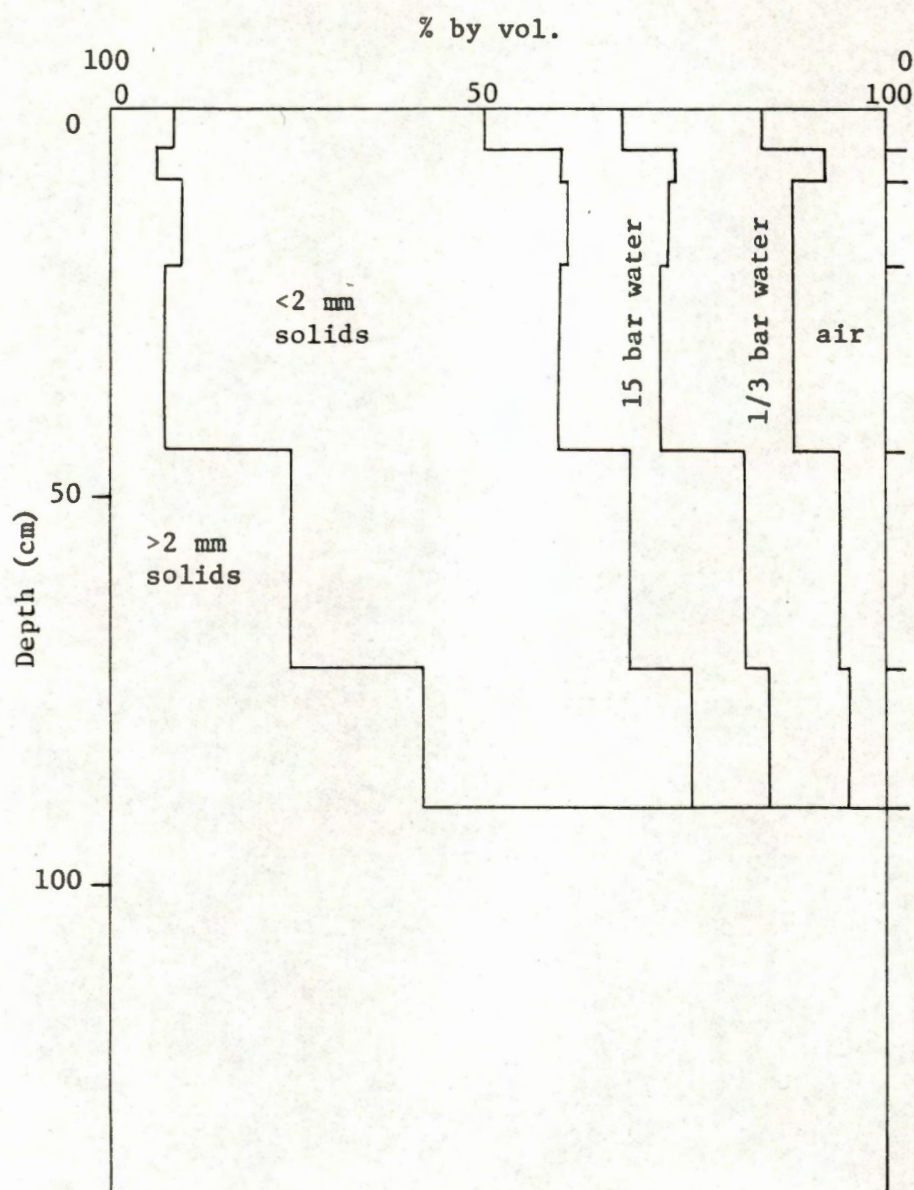


Fig. 26. Volume composition for soil 3N, Muskingum (tax.)

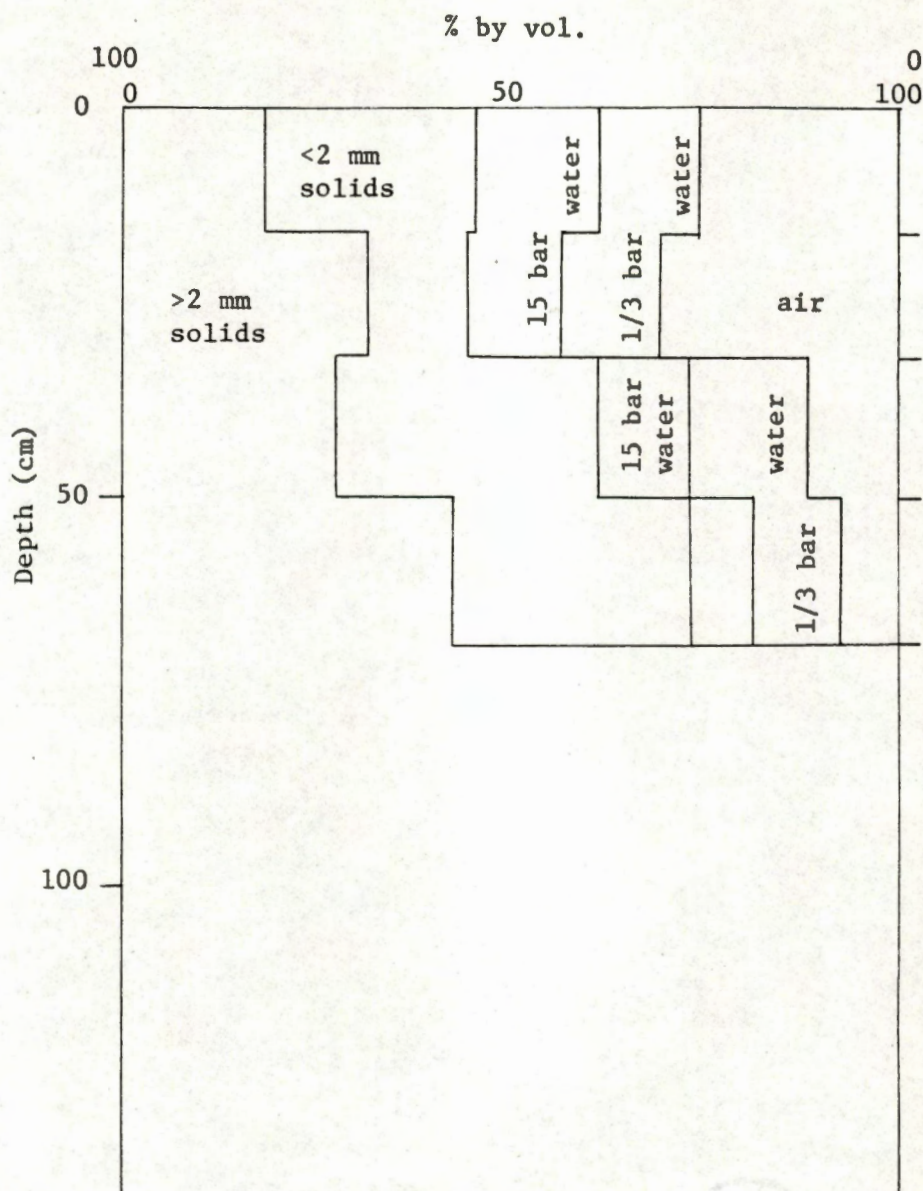


Fig. 27. Volume composition for soil 4N, Zenith (tax).

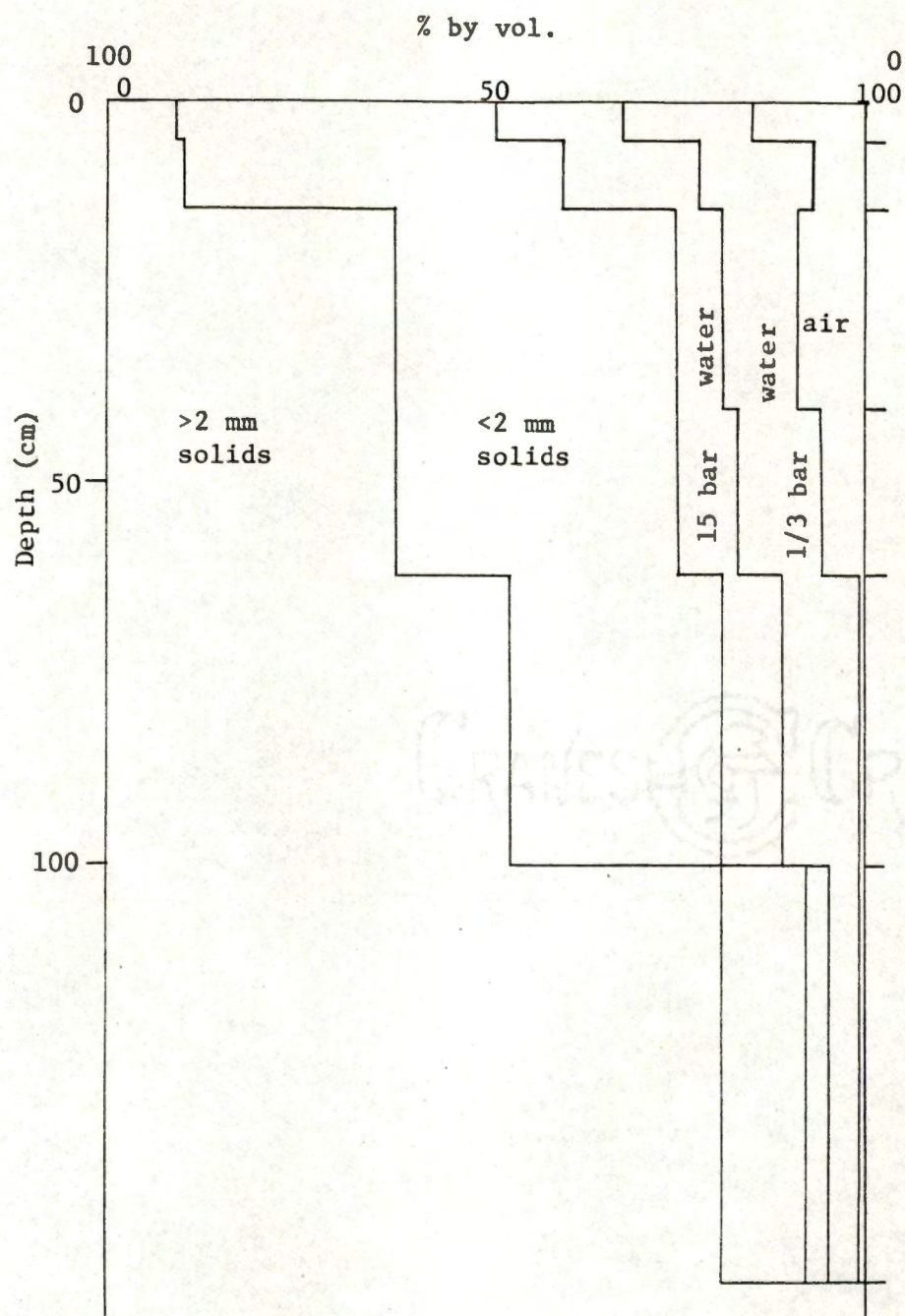


Fig. 28. Volume composition for soil 1S, Grimsley

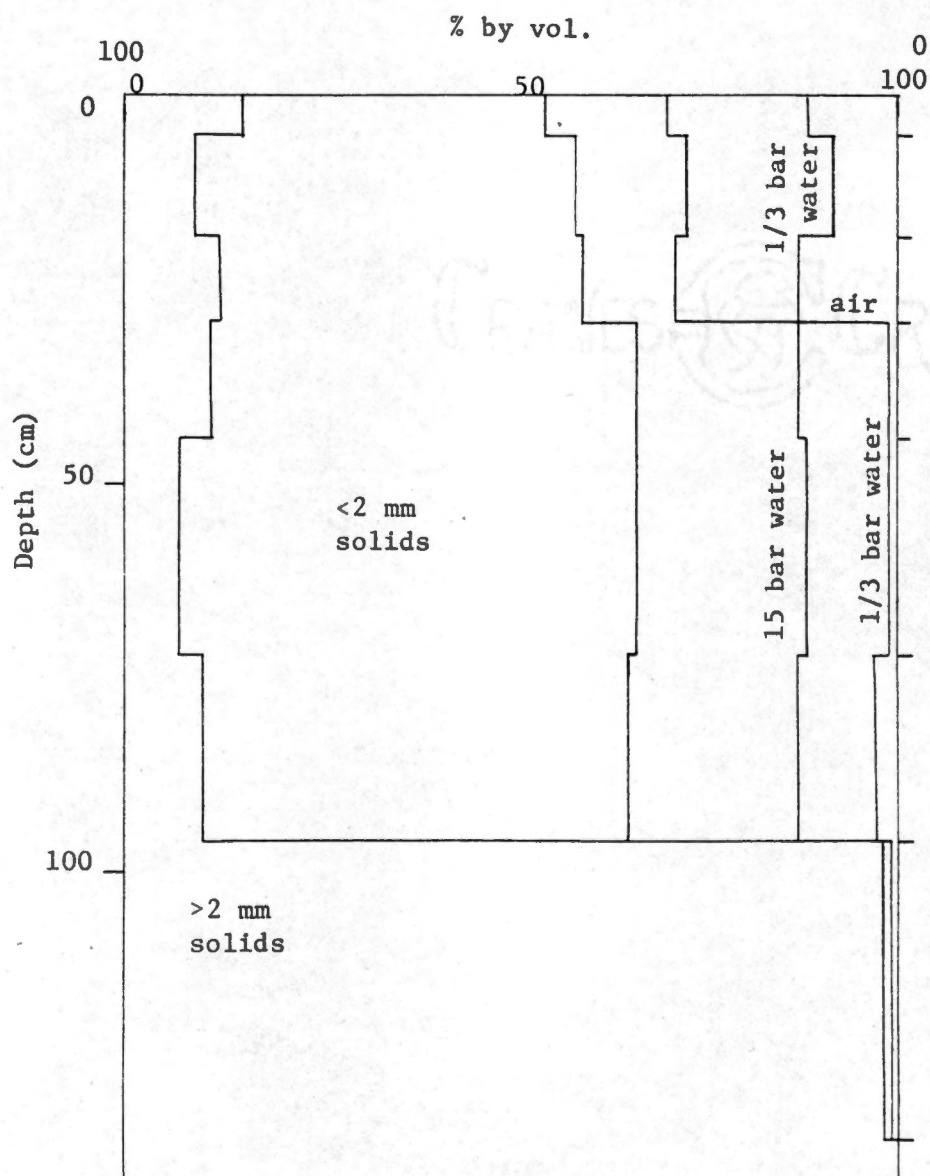


Fig. 29. Volume composition for soil 2S, Gilpin.

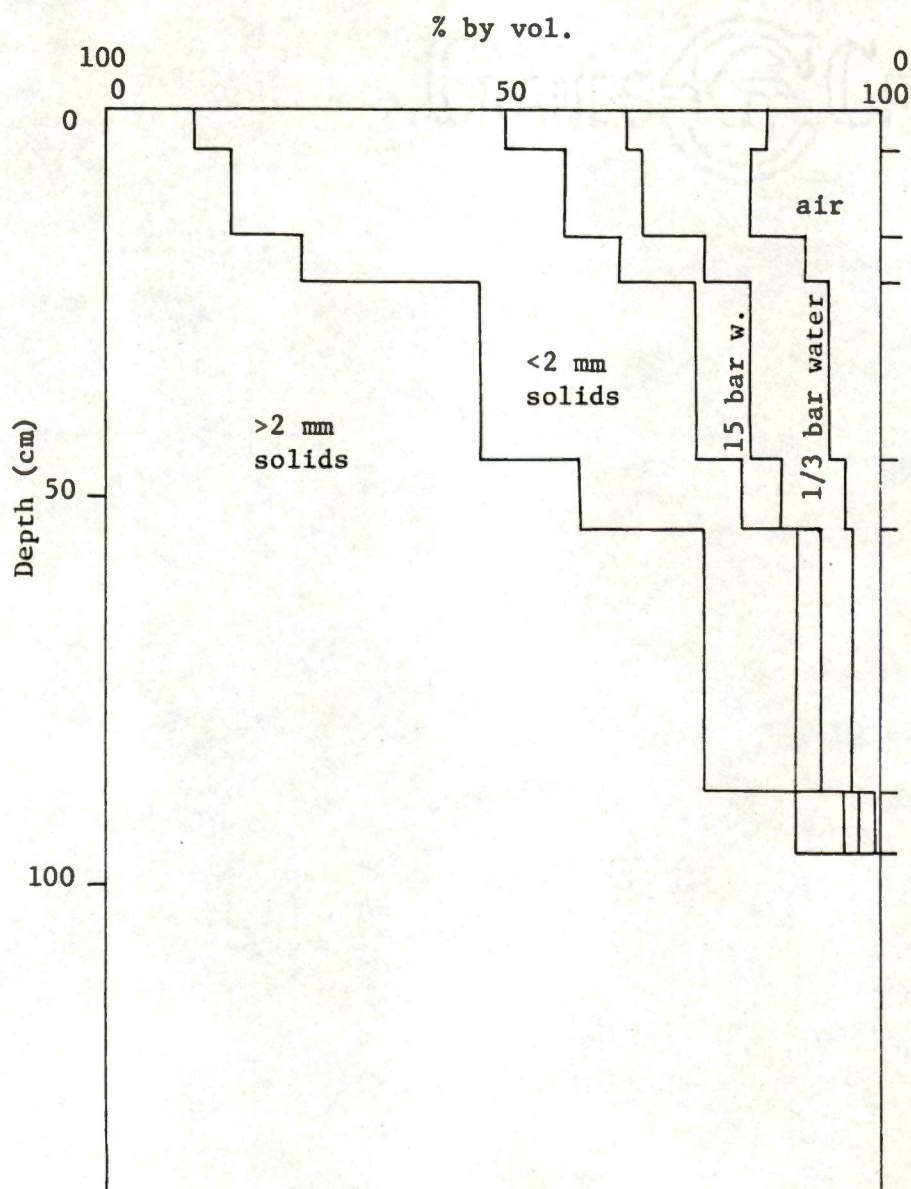


Fig. 30. Volume composition for soil 3S, Gilpin (tax).

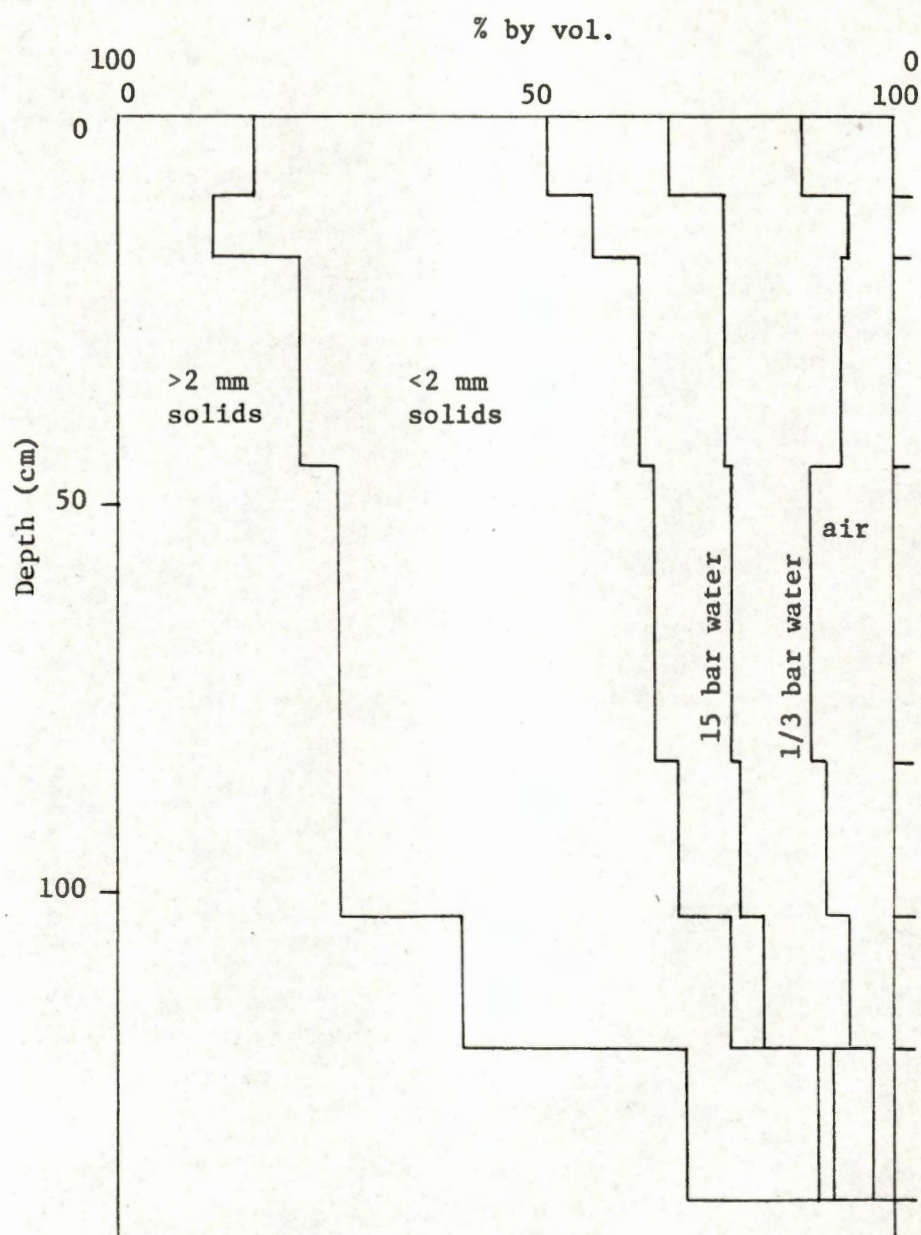


Fig. 31. Volume composition for soil 4S, Jefferson.

the soil. Pore space and available water-holding capacity are reduced when coarse fragment content is high.

Soil 1N (Figure 24, page 106) had 18 cm of available water to 116 cm. Coarse fragment content was 25% by volume, but high organic matter content and loam to clay loam textures were responsible for high water-holding capacity.

Soils 2N (Figure 25, page 107) and 3N (Figure 26, page 108) had between 11 and 13 cm of available water to 90 cm. Thus, water-holding capacity is limited, but evapotranspiration is less on north aspects.

Soil 4N (Figure 27, page 109) had 9 cm of available water to 70 cm. Coarse fragment content was 1/4 of the volume, which contributed to the low water-holding capacity of this shallow soil.

Soil 1S (Figure 28, page 110) had 14 cm of available water to 155 cm. Soil 3S (Figure 30, page 112) had 8 cm of available water to 96 cm. In both soils coarse fragment content was greater than 50% by volume below 50 cm. Both soils have limited available water, but the greater depth and lower position on the landscape make 1S more suitable for plant growth.

Soil 2S (Figure 29, page 111) had 12 cm of available water to 100 cm. It had <15% by volume coarse fragments in horizons above 100 cm but contained >35% by weight clay in B2 horizons. Thus, silty clay loam textures are responsible for the water held tightly by clay particles (15 bar water). This water is considered unavailable to plants (Figure 29, page 111).

Soil 4S (Figure 31, page 113) had 17 cm of available water to 140 cm. One-fourth of its volume was occupied by coarse fragments, but due to

loam textures and thick solum, there was adequate available water-holding capacity (Figure 31, page 113).

The coarse fragment content is a major factor when evaluating the ability of forest soils to store water. The quantity of available water is even more limited in shallow soils with high percentages of coarse fragments. This is a definite limiting factor to forest production. In forest studies, the coarse fragment factor is often neglected or overlooked, and the <2 mm fraction considered alone when determining available water-holding capacity.

Field state bulk densities were measured but not included in this presentation since they were approximately equal to the 1/3 bar bulk densities. This equality was due to moist field conditions at the time of sampling. Bulk densities at 1/3 bar were as expected, approximately 1.3 g/cm^3 in A horizons and 1.5 to 1.6 g/cm^3 in B horizons. Lower values in A horizons were due to organic matter content and structure. Values varied little among soils. Higher oven dry values for bulk density reflect the shrinkage of soil material upon drying (Tables 13, page 54, to 28, page 77).

Values of coefficient of linear extensibility (COLE) for the 2 mm fraction and for the entire clod were very low (Tables 13 to 28). COLE values express the soil material's relative ability to shrink and swell on wetting and drying. This is a value important in engineering, and the low values reported are considered noncritical according to degree of hazard.

Mineralogy. The average composition of the clay size fraction (<0.002 mm) in the B horizons for some soils in the study was:

Vermiculite	Kaolinite	Illite	Interstratified 2:1 - 2:2 minerals
X	XX	XX	X

where "X" designates a relative amount.

Kaolinite and illite were probably weathered from the parent material from which the soil developed. The vermiculite and interstratified 2:1 - 2:2 minerals were weathering products from illite.

The findings in this study are similar to those of Franzmeier (1969) and Losche (1970). However, Franzmeier (1969) in a geologically and topographically similar area did not find any interstratified 2:1 - 2:2 minerals. He suggested that the principal mineral weathering sequence was the conversion of mica to vermiculite with kaolinite weathering in the solum. Losche (1970) found kaolinite and interstratified 2:1 - 2:2 minerals to be the most stable clay minerals in a southwest Virginia study in acid sandstone and shale parent material. In southwest North Carolina, Losche (1970) found different mineralogies on opposing aspects. Due to granitic biotite gneiss parent material with a greater variety of precursor minerals and a high annual precipitation, kaolinite and interstratified 2:1 - 2:2 minerals were found on north-facing slopes, while gibbsite was present in large amounts on south-facing slopes.

Classification. Of the soils studied in the laboratory, soils on north aspects had cambic horizons, while those on south aspects had argillic horizons. Pedons 1N and 4N had umbric epipedons. All other soils had ochric epipedons.

Pedons 1N and 4N were unnamed fine-loamy, mixed, mesic Typic ^{Cutshu} Haplumbrepts. These were considered taxadjuncts of the Zenith series which is a member of the fine-loamy, siliceous, mesic family of Umbric Dystrochrepts. Both soils had umbric epipedons greater than 18 cm thick.

Pedons 2N and 3N had ochric epipedons over cambic horizons. Pedon 2N was in the Muskingum series and a member of the fine-loamy, mixed, mesic family of Typic Dystrochrepts. Pedon 3N was an unnamed soil in the fine-loamy, mixed, mesic family of Typic Dystrochrepts and a taxadjunct of the Muskingum series. This pedon had silty clay loam textures in the B horizons.

Pedons 2S and 4S had ochric epipedons and argillic horizons. Both soils were members of the fine-loamy, mixed, mesic family of Typic Hapludults. Pedon 2S was in the Gilpin series; pedon 4S was in the Jefferson series.

Pedons 1S and 3S had ochric epipedons and argillic horizons. Soil 1S was in the Grimsley series and a member of the loamy-skeletal, siliceous, mesic family of Typic Hapludults. Soil 3S was an unnamed soil in the loamy-skeletal, siliceous, mesic family of Typic Hapludults and a taxadjunct of the Gilpin series. This pedon had more than 35% coarse fragments.

Mineralogy of the sand and silt fractions was not determined, thus family mineralogy placement is tentative.

CHAPTER VI

SUMMARY AND CONCLUSIONS

In the Cumberland Mountains in Campbell County, Tennessee, many of the relationships among soil, site and vegetation variables as they relate to soil formation and forest productivity are not fully understood and explained. A study by north-south transects and by pedon sampling was designed to collect information about site, vegetation and morphological, physical and chemical properties of soils in order to make inferences and draw conclusions about relationships among soil-site-vegetation variables.

In the study area, the mean annual soil temperature was 14°C, and the mean annual precipitation was between 120 cm and 145 cm. The soils were developed from Pennsylvanian shales, siltstones, sandstones and colluvium. The soils were similar in their well-drained appearance, yellowish-brown colors, silt-loam textures, low pH values and low base saturations. Major differences included: coarse fragment content, depth and thickness of horizons, evidence of clay translocation and clay content.

A study of 28 north-south transects showed a definite pattern of soils characteristic of these mountains. Fifty-seven percent were Hapludults; Gilpin and Shelocta were most common. Forty-three percent were Dystrochrepts; Muskingum, Berks and Petros were most common. Seventy-six percent of the soils on south aspects were Hapludults; the remainder were Dystrochrepts. On north aspects, soils were 59% Dystrochrepts and 41% Hapludults.

Correlation analysis suggested that soils vary in properties according to slope gradient, aspect, slope shape, position, elevation and parent material. Colluvium was more prevalent in concave positions and greater distances from ridgetops than in other positions. Thin soils, thin argillic horizons and less clay in the A and B horizons resulted from an increase in slope gradient. Fragments >2 mm increased as slope gradient increased. Thus, available water-holding capacity decreased when slope gradient increased. Al horizons on north-facing slopes were thickest at high elevations. Depth to bedrock, thickness of argillic horizon and surface stoniness decreased with increasing elevation. Darker colors were evident at higher elevations. Thicker and darker Al horizons and less B horizon development were evident at higher elevations and on north aspects.

Correlations among soil variables without stratification indicated thicker Al horizons, thicker argillic horizons, and stronger structures as soil depth increased. Discontinuities in particle size (coarse fragments and fine earth) were seldom encountered. Horizon differentiation was not great.

On south aspects, thick A2 horizons, thick solum, deep bedrock and a few coarse fragments were indicators of increasing clay content in B horizons and structural development. On north aspects, transition zones between horizons were thicker and translocated clay was less evident. Also, less horizon differentiation occurred with an increase in coarse fragments.

An oak forest predominated on south aspects, while mesophytic species occupied positions on north aspects. Chestnut oak and black oak

were on soils developed from residuum, while beech and hickory were on soils developed from colluvium. Beech was uncommon at higher elevations. Canopy cover was greatest on north aspects, and fire damage was greatest on south aspects.

Trees were also seen to segregate according to moisture conditions of the soil. Petros had drought-resistant trees but supported more mesophytic trees as the aspect approached north. Berks and Muskingum had more variety in taxa than Petros. Muskingum, Gilpin (tax) and Shelocta (tax) had less variety and more drought-resistant trees than Muskingum (tax), Gilpin and Shelocta which had deeper bedrock and fewer coarse fragments.

Eight soils on north and south aspects at elevations ranging from 520 m to 920 m in the Wartburg Basin were selected for morphological, chemical, physical and mineralogical study. Morphological differentiation between A and B horizons was stronger on south than on north aspects. The soils on north aspects had darker colored A horizons and B horizons with hues less red than those on south aspects. Clay films were more common in B horizons on south slopes than on north. Differences in structure were slight for all eight soils.

All eight soils had pH_w values between 4.5 and 5.5 and low base saturations. Soils on north aspects had higher pH values in upper horizons; pH values were uniform throughout the solum on south aspects.

Organic carbon was greatest in the soils on north aspects and at high elevations.

Al horizons in soils on north aspects and at high elevations had Ca/Mg ratios >3.5. All other ratios were <2.4.

All eight soils were high in silt with a clay content between 22 and 37%. Soils on south aspects had argillic horizons; those on north aspects did not. Soil 1S had 35% sand in horizons above 40 cm and <25% below. Soil 2S had >30% sand in A horizons and <15% in B2 horizons. Horizons in other soils showed less variation in sand content.

Bulk densities at 1/3 bar were 1.3 g/cm^3 in A horizons and 1.5 to 1.6 g/cm^3 in B horizons.

Coarse fragment content and depth to bedrock greatly influenced each soil's capacity to hold water. Soils 3S and 4N had 8 to 9 cm of available water in contrast to soils 1N and 4S with 17 to 18 cm of available water. Soils 1S, 2S, 2N and 3N ranged from 12 to 14 cm of available water.

The mineralogical composition of the clay size fraction was vermiculite, kaolinite, illite and interstratified 2:1 - 2:2 minerals.

Two soils on north aspects were Haplumbrepts; the others were Dystrochrepts. All four soils on south slopes were Hapludults.

The transect and pedon studies present evidence suggesting that available water as influenced by coarse fragment content and depth to bedrock was a prime factor determining differences in plant growth. This effect was most evident on south aspects, where a shallow soil with many coarse fragments was less able to support a good stand of trees than a deep soil with fewer coarse fragments.

Site factors (aspect, slope gradient, slope shape, position, elevation and parent material) influenced the distribution of water and the amount of evapotranspiration. The amount of soil water recharge and

rate of water loss were results of an interaction among soil-site factors. The soil's physical properties were responsible for interception and storage of this water which was then available for plant utilization.

In both studies, difference in soil development was related chiefly to relief (topography and elevation) which caused differences in micro-environments on similar parent material. On north aspects and high elevations, A1 horizons were thicker and darker than those of other positions, and on south aspects clay translocation and B horizon development were greater than on north aspects. Thus, direction and intensity of soil formation were determined by differences in the microenvironments developed from varied topography and elevation.

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APPENDIXES



APPENDIX A

Transect:
 Stop no.:
 Date
 Location:
 Parent Material:
 Slope shape:
 Elevation:
 Slope gradient:
 Aspect:
 Stoniness:
 Canopy closure:
 Shrub cover:
 Fire damage:
 Soil type:
 Classification:
 Additional notes:

Shortleaf P.
 Virginia P.
 Northern Red O.
 Scarlet O.
 White O.
 Black O.
 Post O.
 Sand O.
 Chestnut O.
 Southern Red O.
 Sugar Maple
 Red Maple
 Tulip Poplar
 Black Gum
 Sourwood

Dogwood
 Am. Beech
 Pignut H.
 Mockernut H.
 Shagbark H.
 Bitternut H.
 Yl. Buckeye
 Black Walnut
 White Ash
 Sassafras

APPENDIX B



Table B-1. Relative densities of canopy trees without subdivision
in a transect study in Campbell County, Tennessee.^a

Taxa	RD
Red maple <u>Acer rubrum</u>	14
Chestnut oak <u>Quercus prinus</u>	12
Black gum <u>Nyssa sylvatica</u>	9
Dogwood <u>Cornus florida</u>	9
Tulip poplar <u>Liriodendron tulipifera</u>	8
Sugar maple <u>Acer saccharum</u> , including <u>A. nigrum</u>	8
Black oak <u>Quercus velutina</u>	6
White oak <u>Quercus alba</u>	5
Pignut hickory <u>Carya glabra</u>	4
American beech <u>Fagus grandifolia</u>	3
Mockernut hickory <u>Carva tomentosa</u>	3
Northern red oak <u>Quercus rubra</u>	2
Sourwood <u>Oxydendrum arboreum</u>	2
Sassafras <u>Sassafras albidum</u>	2



Table B-1, continued

<u>Taxa</u>	<u>RD</u>
Shortleaf pine <u>Pinus echinata</u>	2
Scarlet oak <u>Quercus coccinea</u>	2
Shagbark hickory <u>Carya tomentosa</u>	2
Basswood <u>Tilia americana</u> , including <u>T. heterophylla</u>	2
Bitternut hickory <u>Carya cordiformis</u>	1
Black locust <u>Robinia pseudoacacia</u>	1
Virginia pine <u>Pinus virginiana</u>	+
Post oak <u>Quercus stellata</u>	+
Southern red oak <u>Quercus falcata</u>	+
Yellow buckeye <u>Aesculus octandra</u>	+
Black walnut <u>Juglans nigra</u>	+
Sweetgum <u>Liquidambar styraciflua</u>	+
Black cherry <u>Prunus serotina</u>	+
White ash <u>Fraxinus americana</u>	+
Red hickory <u>Carva ovalis</u>	+

Table B-1, continued

Taxa	RD
Cucumber tree <u>Magnolia acuminata</u>	+
Hophornbean <u>Ostrya virginiana</u>	+
Bitternut hickory <u>Carya cordiformis</u>	+
Pitch pine <u>Pinus rigida</u>	+
Carolina buckthorn <u>Rhamnus caroliniana</u>	+
Sweet birch <u>Betula lenta</u>	+
Chumard oak <u>Quercus shumardii</u>	+
Red mulberry <u>Morus rubra</u>	+
American elm <u>Ulmus americana</u>	+
Silverbells <u>Halesia carolina</u>	+

^aTrees totaled 2,192.

Table B-2. Relative densities of canopy trees by aspect in a transect study in Campbell County, Tennessee.

South ^a		North ^b	
Taxa	RD	Taxa	RD
Chestnut oak	15	Red maple	14
Blackgum	14	Tulip poplar	11
Red maple	12	Sugar maple	11
White oak	8	Dogwood	11
Black oak	8	Chestnut oak	6
Dogwood	7	American beech	6
Sugar maple	5	Black oak	4
Tulip poplar	5	Black gum	4
Sourwood	4	Pignut hickory	4
Northern red oak	3	Mockernut hickory	4
Scarlet oak	3	White oak	3
Pignut hickory	3	Basswood	3
Mockernut hickory	3	Northern red oak	2
Shortleaf pine	1	Sourwood	2
Sassafras	1	Shagbark hickory	2
Shagbark hickory	1	Black locust	2
Basswood	1	Shortleaf pine	1
American beech	1	Bitternut hickory	1

^aTrees totaled 1,070.

^bTrees totaled 1,122.

Table B-3. Relative densities of canopy trees by soil series in a transect study in Campbell County, Tennessee.^a

Taxa	RD	Taxa	RD
<u>Petros</u> ^b		<u>Berks</u> ^c	
Chestnut oak	34	Red maple	13
Red maple	15	Dogwood	12
Tulip poplar	10	American beech	11
Black gum	10	Tulip poplar	8
Sugar maple	8	White oak	6
Black oak	7	Sugar maple	6
Dogwood	4	Chestnut oak	5
Pignut hickory	4	Black oak	5
Black locust	4	Mockernut hickory	5
Northern red oak	2	Sassafras	4
Mockernut hickory	2	Basswood	4
White oak	1	Black gum	3
Sourwood	1	Pignut hickory	3
Black walnut	1	Northern red oak	2
Basswood	1	Shagbark hickory	2
		Yellow buckeye	2
		Sourwood	1
		Black locust	1
		Sweetgum	1

Table B-3, continued

Taxa	RD	Taxa	RD
<u>Muskingum</u> ^d		<u>Muskingum (tax)</u> ^e	
Red maple	16	Red maple	16
Dogwood	9	Sugar maple	10
Sugar maple	8	Black gum	10
White oak	7	Dogwood	9
Tulip poplar	7	Black oak	8
Black gum	7	Tulip poplar	7
Chestnut oak	7	American beech	6
Pignut hickory	6	Mockernut hickory	5
American beech	5	White oak	4
Mockernut hickory	5	Sourwood	4
Basswood	4	Chestnut oak	3
Sassafras	3	Pignut hickory	2
Shagbark hickory	2	Southern red oak	1
Bitternut hickory	2	Sassafras	1
Northern red oak	1	Basswood	1
Yellow buckeye	1	Black locust	1
Black cherry	1	Black cherry	1

Table B-3, continued

Taxa	RD	Taxa	RD
<u>Gilpin (tax)^f</u>		<u>Gilpin^g</u>	
Red maple	17	Red maple	17
Black gum	15	Chestnut 'oak	15
Chestnut oak	14	Black gum	11
Sugar maple	10	Dogwood	10
Dogwood	8	Black oak	9
White oak	7	Sugar maple	7
Black oak	6	Tulip poplar	7
Tulip poplar	5	White oak	4
Northern red oak	3	Pignut hickory	4
Sourwood	3	Northern red oak	3
Pignut hickory	3	Sourwood	3
Mockernut hickory	2	Black locust	3
Black locust	2	Scarlet oak	2
Basswood	1	Sassafras	2
		American beech	2
		Mockernut hickory	2
		Basswood	2
		Shortleaf pine	1
		Bitternut hickory	1

Table B-3, continued

Taxa	RD	Taxa	RD
<u>Shelocta (tax)</u> ^h		<u>Shelocta</u> ⁱ	
Red maple	11	Red maple	11
Black gum	11	Sugar maple	10
Tulip poplar	10	Tulip poplar	9
Dogwood	9	Dogwood	9
Chestnut oak	8	White oak	8
White oak	7	Black gum	8
Black oak	6	Chestnut oak	7
Sugar maple	5	Sourwood	5
Sourwood	5	Pignut hickory	5
Scarlet oak	4	Northern red oak	4
Pignut hickory	4	Black oak	4
Mockernut hickory	4	Mockernut hickory	4
Shortleaf pine	3	Shortleaf pine	3
Northern red oak	3	Sassafras	3
Shagbark hickory	3	Scarlet oak	2
Sassafras	2		
Basswood	2		

^a tax = taxadjunct.^c Trees totaled 236.^e Trees totaled 139.^g Trees totaled 450.ⁱ Trees totaled 445.^b Trees totaled 113.^d Trees totaled 371.^f Trees totaled 143.^h Trees totaled 277.

Table B-4. Relative densities of canopy trees on south aspects by soil series in a transect study in Campbell County, Tennessee.^a

Taxa	RD	Taxa	RD
<u>Petros</u> ^b		<u>Berks</u> ^c	
Chestnut oak	45	White oak	17
Red maple	17	Chestnut oak	14
Black gum	15	Mockernut hickory	14
Black oak	6	Red maple	12
Sugar maple	3	Black gum	9
Tulip poplar	3	Sugar maple	7
Sourwood	1	Dogwood	7
Dogwood	1	Black oak	5
White oak	1	Sweetgum	5
Pignut hickory	1	Virginia pine	2
		American beech	2
		Tulip poplar	2
		Shagbark hickory	2

Table B-4, continued

Taxa	RD	Taxa	RD
<u>Muskingum</u> ^d		<u>Muskingum (tax)</u> ^e	
Black gum	19	Black gum	23
Red maple	13	Black oak	14
White oak	11	White oak	14
Chestnut oak	9	Red maple	9
Black oak	8	Mockernut hickory	9
Dogwood	8	Dogwood	7
Tulip poplar	7	Southern red oak	5
Scarlet oak	6	Tulip poplar	5
Sugar maple	6	Sourwood	5
Pignut hickory	3	Sassafras	5
American beech	2	Northern red oak	2
Mockernut hickory	2	Post oak	2
Basswood	2	Pignut hickory	2
Shortleaf pine	1		
Bitternut hickory	1		

Table B-4, continued

Taxa	RD	Taxa	RD
<u>Gilpin (tax)^f</u>		<u>Gilpin^g</u>	
Red maple	20	Chestnut oak	26
Black gum	18	Red maple	18
Chestnut oak	14	Black gum	14
White oak	10	Black oak	9
Black oak	7	Dogwood	6
Dogwood	6	Sugar maple	5
Northern red oak	5	Scarlet oak	4
Sugar maple	5	Sourwood	3
Tulip poplar	3	White oak	3
Sourwood	3	Tulip poplar	3
Pignut hickory	3	Northern red oak	2
Mockernut hickory	2	Basswood	1
Basswood	2	Bitternut hickory	1
Black locust	2	Mockernut hickory	1
Black walnut	1	Pignut hickory	1
		Shortleaf pine	1
		Sassafras	1

Table B-4, continued

Taxa	RD	Taxa	RD
<u>Shelocta (tax)^h</u>		<u>Sheloctaⁱ</u>	
Chestnut oak	18	White oak	14
Black gum	18	Red maple	10
Black oak	13	Black gum	10
Sourwood	12	Dogwood	8
Red maple	11	Northern red oak	6
Dogwood	11	Black oak	6
Sugar maple	5	Pignut hickory	6
Pignut hickory	3	Sugar maple	5
Mockernut hickory	3	Tulip poplar	5
White oak	2	Scarlet oak	4
Post oak	2	Chestnut oak	4
Black locust	2	Sourwood	4
		Sassafras	3
		Shortleaf pine	2
		American beech	2
		Virginia pine	1
		Bitternut hickory	1
		Basswood	1
		Black walnut	1

^atax = taxadjunct.^bTrees totaled 71.^cTrees totaled 63.^dTrees totaled 88.^eTrees totaled 64.^fTrees totaled 103.

Table B-4, continued

^gTrees totaled 229.

^hTrees totaled 194.

ⁱTrees totaled 217.



Table B-5. Relative densities of canopy trees on north aspects by soil series in a transect study in Campbell County, Tennessee.^a

Taxa	RD	Taxa	RD
<u>Petros</u> ^b		<u>Berks</u> ^c	
Chestnut oak	17	Red maple	12
Red maple	17	American beech	11
Black oak	10	Tulip poplar	9
Sugar maple	10	Dogwood	9
Tulip poplar	10	Sugar maple	8
Dogwood	7	Sassafras	6
Pignut hickory	7	Black oak	5
Northern red oak	5	Pignut hickory	5
Black locust	5	Basswood	5
Mockernut hickory	5	Mockernut hickory	4
Black gum	2	Northern red oak	3
Black walnut	2	White oak	3
Basswood	2	Chestnut oak	3
		Yellow buckeye	3
		Black gum	2
		Sourwood	2
		Shagbark hickory	2
		Black locust	1

Table B-5, continued

<u>Taxa</u>	<u>RD</u>	<u>Taxa</u>	<u>RD</u>
<u>Muskingum</u> ^d		<u>Muskingum (tax)</u> ^e	
Red maple	16	Sugar maple	13
Dogwood	10	Dogwood	11
Sugar maple	9	Tulip poplar	10
Tulip poplar	7	American beech	9
White oak	6	Black oak	5
Chestnut oak	6	Black gum	5
Pignut hickory	6	Chestnut oak	4
Sassafras	5	Sourwood	4
American beech	5	Red maple	2
Mockernut hickory	5	Black locust	2
Basswood	4	Black cherry	2
Black oak	3	Pignut hickory	2
Black gum	3	Shagbark hickory	1
Shagbark hickory	3		
Northern red oak	1		
Sourwood	1		
Yellow buckeye	1		
Black cherry	1		

Table B-5, continued

<u>Taxa</u>	<u>RD</u>	<u>Taxa</u>	<u>RD</u>
<u>Gilpin (tax)^f</u>		<u>Gilpin^g</u>	
Red maple	22	Tulip poplar	16
Chestnut oak	15	Dogwood	14
Sugar maple	14	Red maple	10
Tulip poplar	10	Black oak	6
Dogwood	13	Black gum	6
Black oak	5	Chestnut oak	5
Sourwood	3	American beech	5
Sassafras	3	Black locust	5
American beech	3	Northern red oak	4
Pignut hickory	3	Shortleaf pine	3
Mockernut hickory	3	Sassafras	3
Black locust	3	Basswood	3
		White oak	2
		Scarlet oak	1
		Southern red oak	1
		Mockernut hickory	1
		Shagbark hickory	1
		Bitternut hickory	1

Table B-5, continued

Taxa	RD	Taxa	RD
<u>Shelocta (tax)^h</u>		<u>Sheloctaⁱ</u>	
Tulip poplar	23	Tulip poplar	13
Red maple	13	Red maple	13
Dogwood	13	Sugar maple	13
Sugar maple	10	Dogwood	10
Sassafras	6	Chestnut oak	9
Northern red oak	5	Sourwood	5
Chestnut oak	5	Black gum	5
Shagbark hickory	5	Shortleaf pine	4
American beech	3	Mockernut hickory	4
Pignut hickory	3	White oak	3
Mockernut hickory	3	American beech	3
Basswood	3	Pignut hickory	3
Black cherry	2	Black oak	2
Black oak	2	Sassafras	2
		Black walnut	2
		Black locust	2
		Virginia pine	1
		Northern red oak	1
		Scarlet oak	1
		Basswood	1
		Sweetgum	1
		Black cherry	1

Table B-5, continued

^atax = taxadjunct.^bTrees totaled 193.^cTrees totaled 54.^dTrees totaled 273.^eTrees totaled 95.^fTrees totaled 45.^gTrees totaled 140.^hTrees totaled 64.ⁱTrees totaled 228.

VITA

William Robert Knight was born in Waynesburg, Pennsylvania, on November 5, 1950. He attended elementary school in Carmichaels, Pennsylvania, and was graduated from Carmichaels Area High School in June 1968. The following September he entered The Pennsylvania State University, and in December 1972 he received a Bachelor of Science degree in Agronomy.

He was employed at the Dequesne Light Warwick mine, Pennsylvania, until October 1974. He then worked for the Soil Conservation Service in Pennsylvania until he entered The Graduate School of The University of Tennessee, Knoxville, in April 1977. He worked under a graduate research assistantship after April 1978. He received the Master of Science degree with a major in Plant and Soil Science in June 1979.

The author is a member of Gamma Sigma Delta, Soil Conservation Society of America, American Society of Agronomy, Soil Science Society of America and Pennsylvania Association of Professional Soil Scientists. He will be employed with the Soil Conservation Service in Pennsylvania after graduation.

