CHARACTERIZATION, CLASSIFICATION, AND PRODUCTIVITY STUDIES OF TYPIC HAPLUDULT MAPPING UNITS IN THE SOUTHERN PIEDMONT OF VIRGINIA

by

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(ABSTRACT)

Two studies were initiated in the Virginia southern Piedmont to assess characterization, classification, and productivity of soils mapped as Cecil-Pacolet (clayey, kaolinitic, thermic Typic Hapludults). Effects of erosion on Ap and Bt soil properties and soybean grain yields were studied in Pittsylvania and Lunenburg counties. Relationships between soil properties, soybean yields, and erosion classes were not observed until the soils became severely eroded. Water contents at -10kPa and -1500kPa increased as clay content increased but plant available water remained at 0.09 m^3 m^{-3} across erosion classes. Available phosphorus (P) decreased with severity of erosion and was significantly correlated with soybean yield. The highest grain yields were on slightly and moderately eroded soils and were attributed to available P levels above 18 mg P kg^{-1} critical level for optimum crop production. Low yields on the severely eroded sites corresponded to available P below 18 mg kg^{-1}.

A second study on composition and variability of the Cecil-Pacolet map unit in Appomattox County showed large variation in soil properties and taxonomic classes. Variability is attributed to intrusions of mafic materials in the map unit. Variability was extreme within delineated soil bodies and was reflected in taxonomic classification in which up to six taxa can occur within the same delineation. Cecil and Pacolet soils comprise 62 percent of the map unit. Similar soils comprise 70 percent of the map unit and dissimilar soils make up the remaining 30 percent. The map unit is named Pacolet-Cecil and dissimilar soils are included in the mapping unit description.

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DEDICATION

To my grandfathers

for their inspiration

Table of Contents

CHAPTER 1 1

Introduction 2

CHAPTER 2 5

Literature Review 6

Processes of Soil Erosion by Water 6

Factors Affecting Erosion 9

Rainfall Intensities 9

Topography 9

Soil Factors 10

USLE 12

Introduction 12

USLE Equation 12

Use and Misuse of the USLE 14

Processes of Soil Erosion by Wind 17

Mechanics 17
Control Practices 18
T-Values 19
Erosion Losses 21

Soil Erosion and Soil Productivity 24
Experimental Methods for Quantifying Erosion and Productivity 24
Introduction 24
Field and Laboratory Analysis 26
Ways Erosion Reduces Productivity 29
Introduction 29
Nutrients 29
Plant Available Water 30
Degradation of Soil Structure 31
Nonuniform Removal 31
Early Studies on Yield Declines 33
Recent Yield Studies 35
Southeast 35
Midwest 36
Great Plains 36
Topsoil Thickness 40
Regional Studies 43
Introduction 43
Southeast 43
Midwest 46

Simulating Erosion-Productivity With Mathematical Models 47
Introduction 47

EPIC 49
Model Description 50
Model Application 52
Summary 53
NTRM 56
Model Components 56
Model Application 57
Summary 57
Productivity Index 60
Model Description 60
Model Application 60
Summary 64
Other Models 65
SPUR 65
CREAMS 65
ALMANAC 65
SPAW 65
Literature Cited 66

CHAPTER 3 74

Effects of Erosion on Productivity of Cecil-Pacolet Soils in the Virginia Piedmont 75
Abstract 75
Introduction 77
Materials and Methods 79
Results and Discussion 82
Soil Properties 82
Soybean Grain Yields 87

Summary and Conclusions 93
Literature Cited 95

CHAPTER 4 ..... **97**

Characterization and Classification of the Pacolet-Cecil Mapping Unit in Appomattox County, Virginia **98**
Abstract 98
Introduction 100
Materials and Methods 102
Study Area 102
Laboratory Methods 106
Statistical Methods 107
Results and Discussion 110
Variability of Soil Properties 110
Taxonomic Variability 116
Conclusions and Recommendations 124
Literature Cited 125

CHAPTER 5 ..... **127**

Conclusions **128**
Erosion-Productivity Study 128
Mapping Unit Study 130

APPENDICES **131**

Appendix A. Chemistry of Soil Aluminum **132**

Introduction 132
Weathering 133
Aluminum Bonding 134
Aluminum Reactions in Soils 135
Hydrolysis of aluminum 135
Reactions with anions 136
Aluminum Toxicity in Soils 138
Inhibitory effects of aluminum 139
Tolerance of plants to aluminum 140
Summary 142
Literature Cited 143

Appendix B. Linear Regression Techniques 145
Introduction 145
Variable Selection Techniques 146
Measures of Model Adequacy 146
Multicollinearity 150
Literature Cited 152

Appendix C. Data Tables 153
Appomattox County 154
Pittsylvania County 236
Lunenburg County 312

Vita 358

List of Illustrations

Figure 1. Water erosion on cropland in the U.S. 22

Figure 2. Wind erosion on cropland in the U.S. 23

Figure 3. Corn grain yields for Fayette, Dubuque, and Dakota soils at various erosion depths. 58

Figure 4. Location of study areas in the Virginia Piedmont. 80

Figure 5. Soybean grain yields as affected by erosion class. 88

Figure 6. Response curve for available P. 91

Figure 7. Available P and soybean grain yields as affected by erosion class. 92

Figure 8. Location of study area in the Virginia Piedmont. 103

Figure 9. Cross-section of a Cecil landscape. 104

Figure 10. Diagrammatic representation of the nested sampling design. Adapted from Edmonds et al. (1985). 105

Figure 11. Variability of base saturation and content control section properties for delineations. 123

Figure 12. Solubility of aluminum as affected by pH (McLean, 1976). 137

Figure 13. Patterns for residual plots. (a) Satisfactory. (b) Funnel. (c) Double bow. (d) Nonlinear. (Montgomery and Peck, 1982). 148

Figure 14. Plot of residual verses fitted values for soybean yield data. 149

List of Tables

Table 1. Soil Conservation Service guidelines for T-values. 20

Table 2. Crop yield reductions associated with soil erosion on Ultisols and Alfisols of the southern U.S.†. 37

Table 3. Comparison of simulated and measured sediment yield in Texas. 54

Table 4. Comparison of simulated and long-term average measured crop yields. 55

Table 5. PI values for Putnam and Creldon soils. 62

Table 6. Erosion analysis of corn yields† for Putnam and Creldon soils. 63

Table 7. Mean values and standard deviations of selected morphological properties among erosion classes of Cecil-Pacolet soils. 83

Table 8. Mean values and standard deviations of selected physical properties among erosion classes of Cecil-Pacolet soils. 84

Table 9. Mean values and standard deviations of selected chemical properties among erosion classes of Cecil-Pacolet soils. 85

Table 10. Analysis of variance table for two-level nested design. 109

Table 11. Descriptive statistics for chemical properties of Cecil-Pacolet map unit. 111

Table 12. Descriptive statistics for particle size distributions and depths of Cecil-Pacolet map unit. 112

Table 13. Percent of total variation contributed by delineations, sites, and profiles: Particle size distributions and depths. 114

Table 14. Percent of total variation contributed by delineations, sites, and profiles: Chemical Properties. 115

Table 15. Classification of soils in the Cecil-Pacolet mapping unit, Appomattox County, Virginia. 118

Table 16. Composition of Cecil-Pacolet Mapping Unit, Appomattox County, Virginia. . . . 119

Table 17. Data summary for series in Cecil-Pacolet mapping unit: Physical and morphological properties. 120

Table 18. Data summary for series in Cecil-Pacolet mapping unit: Chemical properties. . . . 121

Table 19. Sensitivity of selected agronomic and horticultural crops to Al toxicity. 141

CHAPTER 1

Introduction

Soils and man have been interdependent throughout man's existence on earth. Man uses the soil to grow food, provide foundations for homes, and dispose of wastes. Likewise, preservation of soils is dependent upon the use or misuse man makes of this resource. Man-accelerated erosion is one of the most common and most devastating abuses of the soil. The decline of many ancient civilizations is believed to have been partially attributable to soil erosion. Three periods of excessive soil loss have occurred in the United States; the first in the 18th and 19th centuries, the second in the 1930's, and the most recent in the early 1970's.

The early Europeans who settled the U.S. found an abundance of natural resources. Unlike the American Indians, who used only what they needed to survive, the European settlers treated the land as if it were indestructible and inexhaustable. At the time of the American Revolution, a 160-km strip of land from Maine to Georgia had been settled and three-quarters of the area had been cleared for cultivation. By the Civil War, the highly erodible Piedmont portion of this area was losing soil at extremely high rates. The aftermath of this accelerated soil loss was an agriculturally-abandoned landscape, scarred by deep gullies. Soil conservation measures, implemented in the 1930's and carried on through the present, have decreased the rate of soil loss due to erosion. Through these conservation efforts, and modern fertilization practices, a considerable portion of eroded land in the Piedmont has been returned to agricultural production.

The degradation of soil resources in the eastern U.S. prompted a new era of migration of settlers to the west. The Homestead Act of 1862 further encouraged the move to the west by offering 65 ha (160 acres) of land to anyone who would settle and farm the land for five years. The breaking of fragile sod in this region, coupled with a severe drought, spawned the great ecological disaster of the 20th century, the "Dust Bowl." The impact of the Dust Bowl was felt from Texas to the Dakotas with some 80 million ha of land damaged by the severe wind erosion.

It was not until the 1930's, after the Piedmont had lost almost 10 cm of topsoil and the Great Plains suffered through the Dust Bowl, that anything significant was done to control soil loss. Through the efforts of Hugh Hammond Bennett and other soil conservation pioneers, the federal government became involved in the control of soil erosion. From the mid-1930's to the early 70's, soil loss by erosion decreased sharply. Federally financed erosion control projects could be seen on much of the nation's highly erodible land. However, a new era of soil erosion began when farmers became involved in the export business. Massive sales of grain to the Soviet Union in 1972 set grain prices soaring. Earl Butz, then Secretary of Agriculture, urged farmers to plow "fencerow to fencerow." Not only were the fencerows plowed, but terraces, diversion ditches, and other erosion control structures fell under the impact of the plow. Soil once again was on the move.

Despite these accelerated erosion rates, crop yields have been increasing for years. Erosion damage is believed to have been masked by technology, particularly the increase in commercial fertilizer use. As fuel, fertilizer, and other production input prices have skyrocketed, the need to know how erosion reduces soil productivity has become a crucial issue. Congress passed the Soil and Water Resources Conservation Act in 1977 requiring that information be gathered on soil losses and the effects of soil erosion on productivity. Subsequent studies found that soil loss greater than tolerance limits occurs on only ten percent of land. The areas with the highest rates of soil loss are the High Plains region of Texas, the Palouse Hills of eastern Washington state, and the loess-capped hills along the Missouri and Mississippi Rivers. At current erosion rates, estimates of productivity losses a hundred years from now will be very high in these areas, but nationwide the loss of yields may be no more than five to ten percent. As a result, the Reagan Administration and Congress have targeted federal funds to areas where the erosion rates are high. The farm bill of 1985

is aiding these conservation efforts by denying crop subsidies to landowners who plow up erodible land.

Chapter 2 of this thesis contains a thorough review of past and current research on soil erosion effects on productivity. Chapter 3 represents the results of research conducted in 1984 to ascertain these same relationships in two counties of the Virginia Piedmont on soils mapped as Cecil-Pacolet.

Soils in the Piedmont region of Virginia are derived from mixed felsic and mafic parent materials that occur in a random pattern on the landscape. These complex interrelationships make it difficult to decipher the soil pattern. The objective of a soil survey is to interpret this pattern and make proper interpretations about a variety of soil and land uses. Chapter 4 presents results of a study in Appomattox County, Virginia to assess composition and variability of Cecil-Pacolet mapping units.

CHAPTER 2

Literature Review

Processes of Soil Erosion by Water

Soil erosion is a two-phase process consisting of the detachment of individual particles from the soil mass and their transport by erosive agents such as flowing water and wind (Morgan, 1979; Evans, 1980).

Detachment

Raindrop erosion occurs as a result of the impact of falling raindrops on the soil surface (Schwab et al., 1981). Tremendous quantities of soil can be splashed into the air by raindrop impact. On a bare soil it is estimated that as much as 224 mt ha^{-1} (100 t a^{-1}) of soil are splashed into the air by heavy rains (Schwab et al., 1981). Soil particles can be carried as high as 1 meter and as far as 1.5 meters in a single splash (Ellison, 1944).

The energy available for the erosion process is obtained from the kinetic energy (KE) of falling raindrops and is given by the equation

$$KE = \tfrac{1}{2}mv^2$$

where m is mass of raindrops and v is terminal velocity of the falling raindrops (Morgan, 1979).

The force that a drop exerts on a bare soil surface increases asymptotically as drop mass, or size, increases (Foster et al., 1985) with most drops having diameters between 0.2 and 6 mm (Smith and Wischmeier, 1962; Schwab et al., 1981).

Drop sizes vary for different types of rain. In orographic rain, where raindrops form at low altitudes and under warm cloud conditions, the drops usually do not exceed 2 mm. Erosivity of these rains are low compared to nonorographic rain where drop diameters commonly are 4 to 6 mm in diameter (Smith and Wischmeier, 1962).

Drop size is also affected by rainfall intensity. Based on studies of rain in the eastern United States, Laws and Parsons (1943) showed that drop size increases with increasing rainfall intensity and reaches a maximum diameter of 5 mm at 100 mm hr^{-1} rainfall (4 inches hr^{-1}).

Terminal velocities range from 1 m sec^{-1} at drop sizes of 0.25 mm to 9.3 m sec^{-1} at 6 mm diameter drop sizes (Laws, 1940). A horizontal wind increases drop velocity by 17 percent and kinetic energy by 36 percent (Smith and Wischmeier, 1962).

With drop size and terminal velocity constant, the factors affecting raindrop splash are the depth of the water film on the soil surface and the resistance of the soil to deformation by the drops. Ellison (1944) reported that maximum splash occurred shortly after the soil surface was wetted and splash erosion increased as the thickness of the surface water layer increased. This is believed to be due to the turbulence imparted to the surface water by impacting raindrops. There is a critical depth, however, at which erosion decreases due to the dissipation of the energy throughout the water film. Laboratory experiments have shown that the critical depth is approximately equal to the diameter of the raindrop (Palmer, 1964).

Soil particle size strongly influences detachment. Ease of detachment increases as size of soil particles increase. Therefore, medium and coarse-size particles (silts and sands, respectively) are the most easily detached from the soil mass and clay particles are most resistant to detachment. Clay may be more resistant because raindrop energy has to overcome the adhesive or binding forces of the clay colloids (Farmer, 1973).

Transport

Raindrop impact disperses soil particles, fills soil pores and forms a soil crust that reduces infiltration and increases surface runoff (Ellison, 1944). Runoff as sheet and rill (microchannel) flow is the second phase of the water erosion process. Rill erosion accounts for up to 80% of the sediment transported by water by streams. Sheet erosion accounts for most of the within field soil loss (Mutchler and Young, 1975).

Raindrop impact and splash have high detachment but low transport capacity. Sheet and rill flow have low detachment but high transport capacity (Smith and Wischmeier, 1962). Under field conditions, with mixed particle sizes, the finer particles are protected by the coarser grains so that the fine-sized materials are not removed until flow velocity is great enough to transport the larger grains. Counteracting this effect, however, is the action of raindrop splash which may detach soil particles and throw them into the flow (Smith and Wischmeier, 1962; Morgan, 1979).

Factors Affecting Erosion

Rainfall Intensities

Wischmeier and Smith (1958) evaluated several rainfall characteristics most correlated with soil loss. Results indicated that soil loss was not due to the *amount* of rainfall, but to an energy product term, kinetic energy of a storm times maximum 30-minute intensity. This rainfall-erosion index (EI) was later adapted for use in the Universal Soil Loss Equation (Wischmeier and Smith, 1978).

Topography

Soil loss is affected by degree, length, and curvature of slopes (Smith and Wischmeier, 1962). Erosion is expected to increase as both slope steepness and slope length increase due to respective increases in velocity and volume of surface runoff (Morgan, 1979).

In England, most erosion occurs on gently rolling landscapes. The landforms are typified by long gentle ridgetops and short convex-concave sideslopes (Evans, 1980). Slopes are generally less than 10 percent. Similar erosion losses have been observed on similar landscapes in the United States (Ellison, 1947).

Ellison (1947) outlined a sequence of events for erosion to occur on gently rolling landscapes. The erosion process begins once rainfall exceeds infiltration. The water that does not infiltrate remains on the surface of the ridgetops. Once storage capacity is exceeded runoff begins at the convex point on the landscape. Incision drains water from the ridgetops and rills and gullies cut deeper as water flow continues. The channels extend upslope by rapid retreat of the headcut. Once the rills and gullies become established erosion occurs rapidly.

Soil Factors

Some soils are more susceptible to erosion than others. Soil erodibility, the resistance of a soil to detachment and transport, is primarily affected by soil texture, aggregate stability, and infiltration capacity (Morgan, 1979).

Soil Texture

The ease with which soil particles may be detached and transported is termed soil detachability and soil transportability, respectively. Soil detachability increases as the size of soil particles increase; soil transportability decreases with an increase in particle size (Farmer, 1973; Schwab et al., 1981). Clay particles, therefore, are more difficult to detach than sand particles, but clay particles are more easily transported (Schwab et al., 1981). Large particles (coarse and medium sands) are resistant to transport because of the greater force required to move these particles downslope. Fine particles are resistant to detachment because of their cohesiveness (Morgan, 1979). The least resistant particles to both detachment and transport are the silt and fine sands.

Aggregate Stability

The ability of soil particles to aggregate has long been recognized to be important in the retardation of soil erosion (Middleton, 1930). Sandy soils, although resistant to transport, are erodible because they have less tendency to aggregate and slake more readily under raindrop impact. Soils with high clay (> 35%) and organic matter (> 2%) contents have more stable aggregates because of the strong bonds between the clay and organic colloids and thus these soils are less susceptible to detachment from raindrop splash (Greenland, 1965).

When the organic matter content in a soil is less than two percent, erodibility is increased (Smith et al., 1945). Under undisturbed conditions and over time, soil organic matter attains a steady state level. Absolute amounts of organic matter, which promote stable aggregates, varies from as low as two percent or less in forested, coarse-textured soils (sands) to as much as six percent in medium-textured, native prairie grassland soils. Under continuous cultivation the organic matter

content of a soil will decline as organic matter is oxidized, unless additions of organic matter are made annually to offset decomposition. Sandy soils are less well-structured and more susceptible to erosion even under native, organic-rich conditions. Cultivation seriously endangers the resistance of sandy-textured soils to erosion. Soils high in organic matter maintain aggregation longer under cultivation, yet, even these soils will become low enough in organic matter under long-term tillage to become susceptible to erosion (Stevenson, 1986).

Infiltration

In poorly aggregated soils, soil particles, that are dispersed as a result of raindrop impact, may clog soil pores and form an impenetrable crust on the soil surface. Infiltration can be as much as 2000 times less under these conditions as compared to well-aggregated soils (Evans, 1980). The soil crust not only results in less water permeating the soil for plant uptake, it also can physically impede seedling emergence and reduce plant populations. One of the most visible effects of erosion is the sparseness of vegetation on severely eroded soils.

Plant cover

Growing vegetation has the effect of reducing soil erosion. Plant cover decreases the susceptibility of soils to erosion in several ways. The major role of vegetation is in the interception of raindrops so that the kinetic energy of the raindrops is imparted to the vegetation rather than to the soil (Morgan, 1979). Ground cover can also reduce the flow velocity of running water thus decreasing soil loss (Schwab et al., 1981). Roots and plant residues improve aggregation and porosity of the soil through the addition of organic matter (Morgan, 1979).

USLE

Introduction

The Universal Soil Loss Equation, USLE, provides estimates of long-term sheet and rill erosion losses from cultivated fields for combinations of crop systems and management practices (Wischmeier and Smith, 1978). Developed for cropland east of the Rocky Mountains, USLE has since been tested in western states and Europe and on rangeland and forested areas (Wischmeier and Smith, 1965; Wischmeier and Smith, 1978).

USLE Equation

The USLE is a five-factor product term given by

$$A = R \bullet K \bullet LS \bullet C \bullet P$$

where A = estimated average annual soil loss, mt ha^{-1} yr^{-1}

R = rainfall and runoff factor, (mt $m^{-1}ha^{-1}hr^{-1}$) yr^{-1}

K = soil erodibility factor, mt ha^{-1} / (mt $m^{-1}ha^{-1}hr^{-1}$)

LS = slope length and steepness factor, dimensionless

C = cropping management factor, dimensionless

P = erosion control practice factor, dimensionless

Rainfall Erosion Index Factor (R)

Wischmeier (1959) found that amount of erosion was most closely related to kinetic energy (E) and the maximum 30-minute intensity (I) of a storm. The rainfall erosion index, *R* , is the sum of the EI products for all the moderate and severe storms in an area during an average year. *R*

values in the United States were calculated from weather station data for 2,000 areas in the eastern two-thirds of the United States. The R values are plotted on an isoerodent map of the U.S. (Wischmeier and Smith, 1978). The average annual R values from the isoerodent map for Blacksburg, Virginia is about 280, for the Virginia Piedmont R is 350, and for the sub-humid region of central Nebraska the R value is 125.

Soil Erodibility Factor (K)

The differences in soil properties cause some soils to erode more easily than others. The soil erodibility factor, K , accounts for these differences (Wischmeier and Smith, 1978).

In USLE, K is an experimentally-derived, quantitative value measured on fallow plots 22.1 m long with slopes of 9 percent. K has values of 0 to 1 with 0 being least erodible and 1 being most erodible. Values of K for most of the soil types and textures can be obtained from soil erodibility tables (Wischmeier and Smith, 1978) or from Soil Conservation Service (SCS) Soils-5 forms for soil series. Exact values for a specific site can be computed by use of a soil erodibility nomograph if organic matter contents, sand percentages, soil structure, and soil permeability are known (Wischmeier and Smith, 1978). Examples of K values are, for a Lodi loam in Virginia $K = 0.39$ and for a Cecil sandy loam in the Piedmont region $K = 0.37$. A Dunkirk silt loam in New York has a value of 0.69 while a Tifton loamy sand in Georgia has a K value of 0.10.

Slope Factor (LS)

LS is the expected ratio of soil loss per unit area from a specific field slope compared to that soil loss from a slope 22.1 m in length with uniform 9% slope. The LS factor can be easily obtained from a slope effect chart (Wischmeier and Smith, 1978) if percent slope and slope length are known. For example, a slope length of 100 m with 6% slope has an LS value of 0.3 whereas the LS for a 12 percent slope of same length is 0.8.

Crop Management Factor (C)

The crop mangement factor, C, is the ratio between the amount of soil lost under a specific crop management system and the soil lost from fallow fields cultivated up and down the slope. C

has values of 0 to 1 with 0 corresponding to complete vegetative cover and 1 representing fallow fields under continuous, clean-tilled cultivation.

This is the most difficult factor to evaluate due to the diversity of cover and crop management systems. Crops can be grown continuously or in sequence; seedbeds can be clean tilled, minimum tilled, or no-tilled; crop residues can be removed, left on the surface, or incorporated into the soil surface. Values of *C*, computed for many varieties and combinations of cropping systems, are available in the USLE handbook (Wischmeier and Smith, 1978).

Erosion Control Practice Factor (P)

Providing continuous ground cover does not always prevent erosion. Special practices are often required to provide additional protection. For cropland, these practices include contour cultivation, contour strip cropping, and terracing. *P*, the erosion control practice factor, is the fractional amount of erosion that occurs with erosion control practices compared to soil loss without these practices. Values of *P* for the three practice factors range from 0.00, no soil loss, to 1.00, or soil loss equivalent to soil lost without practice factors (Wischmeier and Smith, 1978).

Use and Misuse of the USLE

Soil losses computed with the USLE are, at best, only estimates, not absolute values. The equation is most accurate for medium-textured soils with slope lengths of less than 400 feet and slope gradients of three to eighteen percent. W.H. Wischmeier, the project leader for the USLE development, outlined some of the uses and misuses of the soil loss equation (Wischmeier, 1977).

The primary application of the equation is for predicting average annual soil loss from a given field slope under a specific land use and management condition. Depending on the situation chosen, soil loss can be estimated for a particular crop in a rotation or for a particular crop growth stage (e.g., establishment, maturity).

The USLE has been used to determine the crop management and conservation practices required to keep annual soil losses within some tolerable level. The practices selected can either be a specific cropping system (C) or a particular support practice (P) such as contouring or terracing. If a farmer changes either his cropping system or support practice, the increase or decrease in soil loss from the change can be estimated (Wischmeier, 1977).

There are as many misuses of the USLE as there are valid applications. The USLE can be used to compute average sheet and rill erosion in various parts of a watershed, but deposition and channel-type erosion must be estimated by other methods (Wischmeier and Smith, 1978). Predicting an average soil loss for a complex watershed by using overall average values of slope length and gradient with estimated average values for K and C factors is an incorrect use of the USLE (Wischmeier, 1977). Combining overall averages does not reflect the way the factors are actually combined in different parts of the watershed. Neither does it show which position of the watershed contributes most of the sediment yield. If the watershed is divided into areas for which soil types, slope length and gradient, cover, and erosion-control practices can be defined, the USLE can be used to compute sheet and rill erosion for each area (Wischmeier and Smith, 1978).

Soil losses cannot be computed for a specific rainfall event. EI values used to compute the rainfall factor, R, represent 22-year averages. If applied to a specific rain event and using the EI for that particular storm in calculating R, the USLE will estimate the average soil loss for a large number of storms of that particular size. Soil losses from any storm event may differ widely from the estimated 22-year average because of interactions with other USLE parameters (Wischmeier and Smith, 1978). For example, the soil erodibility factor, K, is an average for a given soil. However, soil loss per unit of EI varies from storm to storm because of fluctuations in soil conditions and in storm characteristics. When rain falls on a dry soil, it may infiltrate before runoff begins resulting in a low soil loss for that particular storm. When rain falls on a saturated soil, runoff begins quickly and soil loss may be high. Some storms are further accompanied by high winds that increase the velocity and impact energy of raindrops. Other storms occur under fairly calm conditions. High intensity storms may quickly seal the soil surface so that runoff is high (Wischmeier, 1977). Soil loss over a growing season is also variable. In the early stages of crop growth, soil loss will be higher

than average losses because the canopy cover is small. Later in the growing season soil loss may be lower than average because of maximum canopy cover (Wischmeier and Smith, 1978). The irregular fluctuations in the USLE parameters greatly influence specific storms so that soil losses cannot be predicted for a specific period of time. Using average soil loss per EI unit for a particular soil is permissable but when used for estimating losses for a particular rain event, USLE is inadequate.

The greatest potential source of error in USLE prediction is the selection of the factor values. If the selected values do not accurately represent the conditions to be evaluated, soil loss estimates will be incorrect. Evaluating the factors on too broad a base, such as a single C value for all cropland or a single K value in an area with extreme soil variability, will result in inaccurate soil loss estimates (Wischmeier, 1977; Wischmeier and Smith, 1978).

A primary hazard in misusing the USLE factors is in extrapolating factor relationships beyond the range of the data. This applies primarily to L and S. The equation was derived for data obtained on slopes less than 20 percent and lengths less than 1,000 feet. The relationship between soil loss, slope length and slope gradient above these limits is not clearly understood (Wischmeier, 1977).

Evaluating irregular slopes using USLE parameters for uniform gradients will also result in inaccurate soil loss estimates. A convex slope loses more soil than both uniform and concave slopes. It would be logical to divide the irregular slopes into uniform segments but the segments cannot be evaluated as independent slopes when runoff flows from one segment to the next. Soil loss can be estimated for above and below deposition areas but cannot predict total sediment moved for complex slopes because USLE does not predict deposition (Wischmeier and Smith, 1978).

Processes of Soil Erosion by Wind

Mechanics

Large areas in the semiarid and arid regions of the United States are affected by wind erosion. The Great Plains region, occupying about 20% of the total land area in the U.S., is contained within these dry climatic zones.

Conditions conducive to wind erosion exist when the soil is loose, dry, and finely granulated; when the soil surface is smooth and vegetation is sparse or absent; and when the wind is strong and turbulent enough to move the soil (Lyles et al., 1985).

The transport of soil particles by wind takes place by suspension, surface creep, and saltation. *Suspension* describes the movement of fine particles, usually less than 0.2 mm in diameter, high in the air and over long distances. *Surface creep* is the rolling of coarse grains along the ground surface. *Saltation* is the process of grain movement in a series of jumps (Morgan, 1979) and is caused by the pressure of the wind on the soil particles and their collision with other particles (Schwab et al., 1981). Saltation is the major cause of aggregate breakdown during wind erosion (Lyles et al., 1985).

Soil movement is initiated as a result of turbulence and velocity of the wind. Except very near the surface and at low velocities (less than 1 m sec^{-1}), the surface wind is always turbulent. Wind speeds in excess of 5 m sec^{-1} are usually considered erosive (Chepil, 1945).

The rate of movement of soil particles increases with distance from the windward edge of a field due to the increasing amounts of particles causing greater abrasion and loosening. Fine particles drift and accumulate on the leeward side of wind-affected fields (Schwab et al., 1981).

Control Practices

The two types of wind erosion control measures are those that reduce surface wind velocities and those that affect soil characteristics.

Vegetation is generally the most effective means of controlling wind erosion. Cultivated crops reduce wind velocity and hold soil against the forces of the wind. Close-growing crops, such as grasses, are more effective than intertilled crops like corn and cotton (Coldwell, 1942). The best practice is to seed the crop perpendicular to prevailing winds (Schwab et al., 1981).

Windbreaks formed with shrubs and trees are a common practice in wind-erosion hazard areas. Windbreaks should be moderately dense from ground level to treetops if they are to be effective in filtering the wind and lifting it from the surface. A typical windbreak in the Great Plains consists of a tight row of shrubs on the windward side combined with conifers and low, medium, and tall deciduous trees (Schwab et al., 1981).

Conserving moisture is important for wind erosion control as well as for optimal crop production. Moisture can be conserved by increasing infiltration, reducing evaporation, and preventing unnecessary plant growth. These objectives can be accomplished by terracing, contouring, strip cropping, mulching, and weed control (Schwab et al., 1981).

Tillage is an additional wind erosion control measure. Primary and secondary tillage produces a rough, cloddy surface and exposes some plant residue on the surface both which reduce the wind velocity. To obtain substantial roughness, fields are usually tilled as soon after a rain as possible and furrows are plowed normal to direction of prevailing winds (Chepil and Milne, 1941).

T-Values

USLE predicts the average annual soil loss from field systems. How much soil loss can a system incur without productivity being seriously affected? The tolerable soil loss value (T-value) is a measure used to determine tolerable erosion rates and is defined as the maximum rate of soil erosion that will permit the indefinite maintenance of soil productivity (Logan, 1982; Elfring, 1983).

T-values are determined by the SCS at state and national levels and are based primarily on favorable rooting depth. Maximum tolerance levels have been set at five tons per acre per year (11.2 mt ha^{-1} yr^{-1}) for deep, permeable, well-drained soils. Table 1 provides the guidelines for establishing the T-values on most soil types. The minimum soil loss rate, one ton per acre per year (2.2 mt ha^{-1} yr^{-1}), is for shallow soils and for soils that have unfavorable rooting characteristics in the subsoil (USDA, 1981).

The 5 t a^{-1} yr^{-1} T-value is a rough estimate of the annual rate of A horizon formation. An inch of topsoil forms from the subsoil every 30 years at this rate. However, the weathering of parent material occurs at much slower rates and as a result the rooting zone becomes shallower as erosion occurs. On most cropland the average annual rate of soil renewal is thought to be 0.5 t a^{-1} yr^{-1} (Logan, 1982; McCormack et al., 1982).

The inability to accurately estimate T-values prompted the National Soil Erosion-Soil Productivity Research Committee to comment:

> "SCS periodically reviews the soil loss tolerance limits ... for all major soils ... *There is essentially no research base to support T-values*; they were established and are revised on the basis of collective judgements by soil scientists."

T-values can provide farmers and conservationists with a realistic target to aim for as they work to reduce erosion rates. However, it is imperative to remember that the values are not to be used to suggest that the long-term productivity of the land is being sustained (Elfring, 1983).

Table 1. Soil Conservation Service guidelines for T-values.

	T-value (mt ha^{-1} yr^{-1})				
Depth Criteria	11.2	9.0	6.7	4.5	2.2
> 100 cm to bedrock	X				
> 100 cm to sand or gravel	X				
50-100 cm to bedrock		X			
50-100 cm to sand or gravel		X			
50-100 cm to fragipan		X			
50-100 cm to claypan		X			
25-50 cm to bedrock				X	
25-50 cm to sand or gravel			X		
10-50 cm to claypan			X		
< 50 cm to fragipan			X		
< 25 cm to bedrock					X
< 25 cm to sand or gravel				X	
< 10 cm to claypan					X

Modified from Logan (1982).

Erosion Losses

Most of the soil materials lost by erosion are from cropland. One-half of all sheet and rill erosion and 60 percent of all wind erosion occurs on cropland. Sheet and rill erosion account for 30% of soil loss on rangeland with 40% of all erosion on rangeland being attributed to wind erosion (USDA, 1981).

The SCS National Resources Inventory of 1977 (USDA, 1978) shows that on 27% of our cropland, erosion is occurring at a rate greater than respective T-values. On 23% of cropland erosion exceed 11.2 mt ha^{-1} yr^{-1} (5 t a^{-1} yr^{-1}) and erosion losses are higher than 22.5 mt ha^{-1} yr^{-1} (10 t a^{-1} yr^{-1}) on one-tenth of all cropland.

By crop production region, the Appalachian states of Tennessee, Kentucky, and Alabama have the highest annual rate of erosion losing on the average about 20 mt ha^{-1} yr^{-1} (9 t a^{-1} yr^{-1}). This is attributed to the very rolling terrain and high rainfall of the region. The Corn Belt and Delta States regions follow closely behind with soil losses of approximately 15.7 mt ha^{-1} yr^{-1} (7 t a^{-1} yr^{-1}). Soil losses are high in these regions due to the abundance of silt in the topsoil (USDA, 1981).

The national average loss of soil on cropland attributed to water erosion is estimated to be approximately 4.8 tons per acre. Tennessee has the highest amount of annual soil loss from water erosion, estimated at 14 tons per acre, followed by Hawaii with 13.7 tons per acre, Missouri with 11.3 tons per acre, and Mississippi with 10.9 tons per acre (Figure 1) Texas had the highest amount of wind erosion with an average annual loss of 14.9 tons per acre, followed by New Mexico with 11.5 tons per acre, and Colorado with 8.9 tons per acre (Figure 2). If water erosion losses are added to wind erosion losses, Texas experiences the greatest amount of soil loss. Tennessee, Hawaii, and New Mexico follow close behind (Batie, 1983).

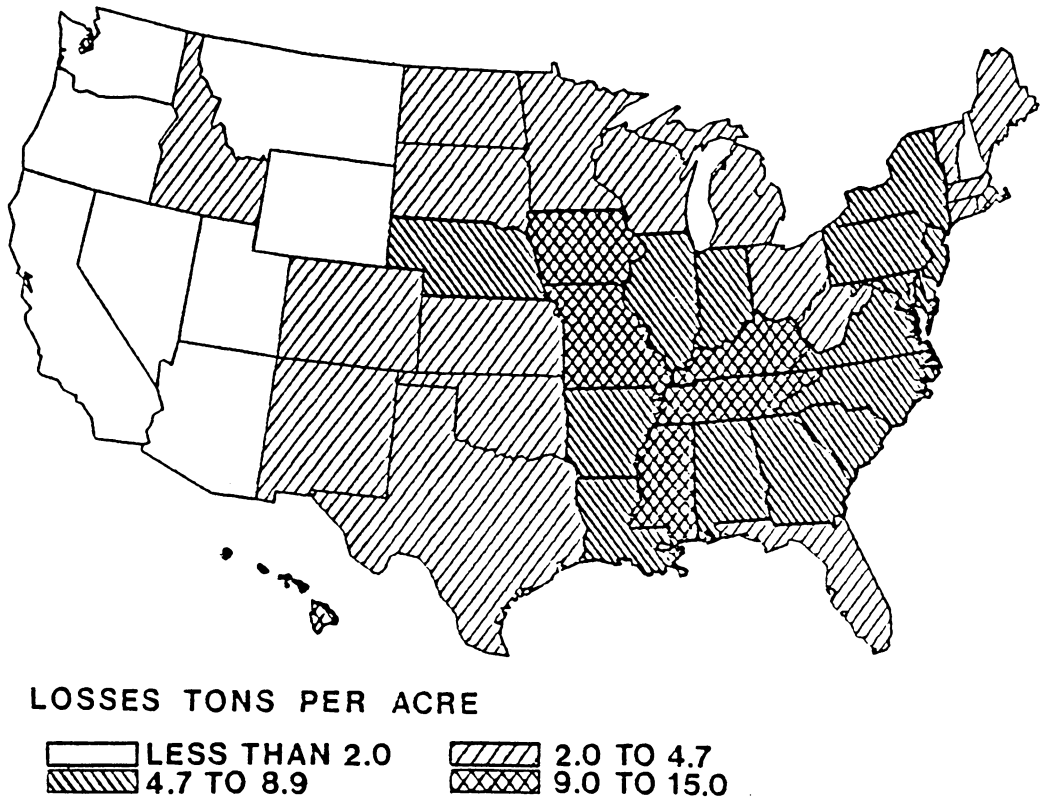

Figure 1. Water erosion on cropland in the U.S.

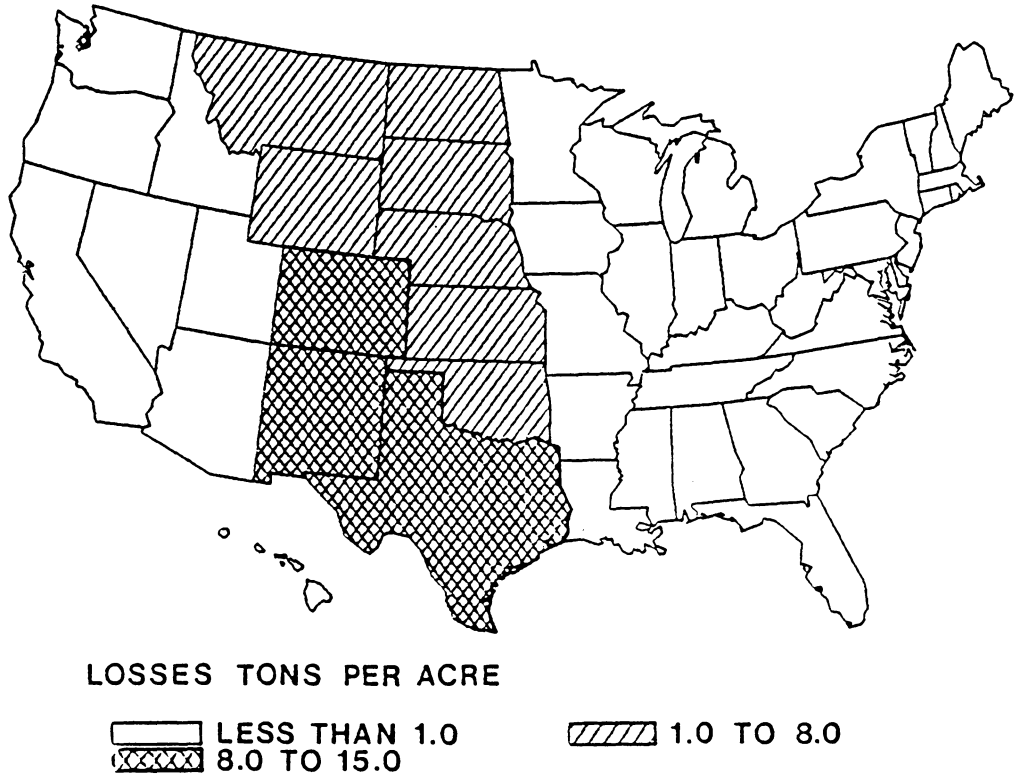

Figure 2. Wind erosion on cropland in the U.S.

Soil Erosion and Soil Productivity

Experimental Methods for Quantifying Erosion and Productivity

Introduction

Erosion-productivity research has been conducted in studies on two types of field plots: plots that have been naturally eroded and plots from which varying amounts of surface soil has been artificially removed. Laboratory experiments are limited due to the difficulty of correlating laboratory results with field observations. Computer simulations are currently being developed that will allow for rapid analysis of erosion-productivity relationships.

Variable Past Erosion

A major advantage of conducting erosion-productivity experiments on farm fields with variable degrees of past erosion is that the erosion conditions are natural, not artificially induced. However,

the research needs to be carefully planned, conducted, and interpreted. Meyer et al. (1985) listed several questions that need to be answered prior to implementation of research:

- How can treatment sites (erosion levels) be selected to ensure their comparability?
- Is soil variability due to erosion or to other factors?
- How can the extent of previous erosion be accurately determined?
- If erosion differences are studied at different locations on a slope, will runoff from upslope be permitted or restricted on lower slopes?
- Should downslope areas, on which sediment from erosion is deposited, be included in the study?
- How can unnatural differences in fertility, insects, and disease, i.e., management factors, be avoided?

It is the last point which is most responsible for confounding results from erosion-productivity studies. To insure accurate interpretations, management factors must be equally imposed on all plots. This entails uniformity in plant populations, fertility levels, time of planting, tillage methods, pest control, and other management factors. The resulting yields would then be a reflection of the unmanageable properties, e.g., erosion. However, if imposing uniformity is impossible, then the inclusion of manageable factors into the experiment is necessary (Langdale and Shrader, 1982; Meyer et al., 1985).

Simulated Erosion

The difficulty of establishing carefully controlled plots in farm-cooperator fields has led to the development of a method of surface alteration designed to simulate erosion. The primary disadvantage of this method is that removing soil manually does not simulate the actual erosion process. In natural erosion, the soil is removed slowly over a period of many years. As a result, annual cultivation mixes remaining topsoil with some of the underlying subsoil. Erosion also selectively removes various particle size fractions; silt and clay particles are easily removed by erosion leaving sand and well-aggregated clays on the soil surface. In simulated erosion, an entire layer of soil is removed at one time. There is no mixing and no separation of size fractions. Therefore, interpreting the results from this method of analysis must be approached with caution. However, it can provide useful insights into general modes of erosion-productivity interactions.

Field and Laboratory Analysis

Soil productivity is usually measured in terms of crop yields. Yields are the result of the interaction of many environmental factors. Although it is impossible to measure all the factors, measurements can be made on some of the relevant parameters. The selection of the factors will determine the success of the research goal. Meyer et al. (1985) compiled an extensive list of the properties that determine crop yields.

Soil Environment

Physical Properties

- Water-retention characteristics are needed to determine available water content
- Bulk density is needed to measure available water capacity and to identify restrictive horizons
- Particle-size distribution is needed to evaluate water-transmissive characteristics
- Strength measurements are needed to evaluate crusts that affect root penetration
- Aggregate stability measurements are needed when crusting is a growth-limiting factor
- Infiltration capacity measurements are needed to assess and predict infiltration and runoff
- Shrink-swell potentials are needed to be known when high sodium levels are a problem

Chemical Properties

Measurements of nutrient supplies and other nutrient-related properties are essential for evaluation of productivity.

- Organic Carbon
- Total Nitrogen
- Carbon - Nitrogen Ratio
- Nitrate and ammonium
- Total phosphorus
- Organic phosphorus
- Inorganic phosphorus
- Cation exchange capacity
- Base saturation
- pH

Other nutrients or chemical properties that affect productivity because of deficiency or toxicity:

- Aluminum saturation

- Sulfur
- Micronutrients
- Soluble salt concentration
- Sodium adsorption ratio (SAR)

Biological Properties

- Heterotropic index
- Soil respiration

Landscape Characterisitcs

- Slope steepness
- Slope length
- Landscape position
- Aspect

Ambient Environment

Since water is the factor most limiting to plant growth, a measure of the elements which affect water supply is essential.

- Precipitation -- date, amount, intensity
- Irrigation -- date, amount, distribution
- Total and net solar radiation
- Maximum and minimum air temperature
- Wind speed and direction
- Potential evapotranspiration
- Canopy and soil temperature

Plant Measurements

- Plant population
- Leaf area index (LAI), every two weeks
- Yield components, e.g., number of seeds per plant, seed weight, etc.
- Crop yield
- Root distribution

Management Practices

- Type and frequency of tillage
- Seeding rate, row spacing, and seeding depth
- Cropping sequence
- Crop residues

- Rate, time, and placement of fertilizers and pesticides

Acquisition of data for each of these factors is not feasible for most erosion-productivity studies. For example, aluminum saturation is an important indicator of root growth in the south-eastern U.S. However, a measure of aluminum saturation in Mollisols in the Midwest would be meaningless since Al is not a growth-limiting factor in these soils. Properties for analysis should be applicable to the soil conditions under study. For simulation modeling on a national scale, as with the Erosion-Productivity Impact Calculator (EPIC), all properties should be measured or simulated (Langdale and Shrader, 1982; Williams et al., 1981).

Ways Erosion Reduces Productivity

Introduction

One reason for the lack of extensive erosion-productivity research is because of the complex interrelationships among the factors involved. Soils differ greatly in profile characteristics and susceptibility to erosion. Some crops are severely affected by erosion-induced changes, while the affect on other crops is negligble.

The difficulty of detecting losses in productivity is confounded by the nonlinear nature of the erosion process. Erosion increases runoff due to reduced infiltration. Increasing the runoff reduces the amount of water available in the soil for plant uptake and growth. Decreased plant growth means less residue at the end of the growing season to protect the soil from erosion. The reduced cover results in increased runoff and the erosion process begins again (Williams et al., 1981).

The National Soil Erosion-Soil Productivity Research Planning Committee has identified four major ways erosion reduces productivity (Williams et al., 1981): 1) loss of available nutrients, 2) reduction of plant available water, 3) degradation of soil structure, and 4) nonuniform removal of soil within a field. Each of these processes will be discussed separately.

Nutrients

Early in erosion-productivity research, the reductions in yield due to the indigenous soil fertility lost by erosion was of major concern. Many studies found that deficiencies of N and P were primarily responsible for reduced yields on eroded soils (Latham, 1940; Rost, 1940; Whitney et al., 1950; Heilman and Thomas, 1961; Eck et al., 1965). Nitrogen and P are lost as organic matter and clay particles are removed by erosion. Under undisturbed and unfertilized conditions, almost all

of the N and 50-65% of the P available for plant uptake is contained in organic matter. Most of the inorganic P is bound to clay colloids (Langdale and Shrader, 1982). The loss of these nutrients is the primary reason that soils must be fertilized.

Many subsoils exposed by erosion are naturally infertile. In humid regions, organic matter percentages are frequently less than two percent, N is less than 0.1 percent, and P is fixed by Fe and Al hydrous oxides and is plant unavailable (Latham, 1940). Potassium deficiencies have been reported in some of the humid regions, but no deficiencies occur in the semiarid and subhumid areas (Meyer et al., 1985).

The example of a soil loss of 1 mt ha^{-1} (0.5 t a^{-1}) will result in a reduction of topsoil depth of 0.008 cm, and a loss of 13, 3.5, and 1 kg ha^{-1} of N, P, and K, respectively, for a medium-textured soil (Logan, 1982).

Plant Available Water

Individual soil properties such as structure, texture, bulk density, infiltration, favorable rooting depth, and water-holding capacity are so interrelated that a change in one property may result in a change in other properties. However, of all these properties, erosion damage is probably expressed best by reduction of the plant available water-holding capacity of the soil (Williams et al., 1981).

As erosion proceeds, organic matter bound to clay particles is lost from the soil. This loss of organic matter can result in the loss of stable soil aggregates. The destruction of aggregates, along with the incorporation of high clay subsoil material, results in smaller pore sizes and a parallel decrease in plant available water-holding capacity (Williams et al., 1981; Frye et al., 1985).

Erosion can also decrease plant available water by decreasing the depth to restrictive horizons. On Fragiudalfs in Kentucky, susceptibility to water stress increased and grain yields decreased with decreasing depth to the fragipan layer (Frye et al., 1983; Frye et al., 1985). The fragipan soils lose 40% of their water-holding capacity when the depth to the fragipan decreases from 60 to 20 cm (Frye et al., 1985).

In soils of the southeastern U.S., restrictive horizons may be chemical rather than physical. At pH levels below 5, Al becomes soluble. High levels of soluble Al affect the cytological, physiological, and biochemical processes of root growth (Foy, 1974). Yields of corn and soybeans are drastically reduced at Al saturations above 44 and 20 percent, respectively (Kamprath, 1970).

Degradation of Soil Structure

As stated previously, the destruction of soil structure can lead to the reduction of the available water-holding capacity of a soil. Degradation of soil structure also enhances the erosion process by increasing soil erodibility and by surface sealing and crusting. Surface sealing and crusting, along with the associated increase in bulk density, reduces seedling emergence and can eventually cause reductions in plant populations and yields (Williams et al., 1981).

Nonuniform Removal

Erosion also reduces productivity through the nonuniform removal of soil within a field. The most severe erosion occurs at points of diverging water flow. In geomorphic terminology, this includes ridge crests and shoulder slopes. The least eroded areas are associated with converging water flow, such as footslopes (Daniels et al., 1985; Stone et al., 1985).

Selecting management strategies to maximize production on fields with varying degrees of erosion is difficult. An example is illustrated by fertilizer application. Fertilizers are usually applied uniformly across a field. If the fertilizer is applied at rates to maximize nutrient availability on noneroded areas of the field, the eroded areas may be deficient in nutrients. It is impossible to have optimum productivity in all areas of the field (Williams et al., 1981).

Nonuniform erosion also affects the timing of field operations. Fields in which the clayey subsoil is exposed may be too wet for tillage when uneroded areas become suitable. The farmer must either avoid these wet areas or wait until the entire field is dry (Williams et al., 1981).

Early Studies on Yield Declines

Early research on quantifying erosion-induced productivity losses was carried out at erosion experiment stations throughout the United States on plots desurfaced to simulate soil loss.

Cotton yields declined an average of 68 percent on a desurfaced sandy clay soil in east Texas. Soil loss was two times greater on the desurfaced plots compared to control plots. An average of three to eight millimeters of soil was lost each year over a 10-year period (Pope et al., 1946).

Yields on a cotton-corn-oats rotation at Temple, Texas on a clay soil declined about 66 percent on desurfaced plots. Soil loss was 1.5 times greater on the desurfaced plots compared to the uneroded control plot (Hill et al., 1944).

In the Rolling Red Plains region of Oklahoma, cotton production declined 40 percent over an 11-year period. Runoff was twice that on the artificially eroded plots as compared to normal soil profiles (Daniel et al., 1943).

Winter wheat yields on a desurfaced Mollisol in the Palouse region of Washington state were 60 percent less than on the uneroded counterpart. Runoff and soil loss were 2.5 and 9 times greater, respectively, on the desurfaced plots over a 10-year period (Horner et al., 1944).

Yields of corn on a desurfaced clay loam Argiudoll in Missouri were 53 percent lower than corn yields on the silt loam surface of the same soil. Runoff and soil loss were greater on the control plot than on the desurfaced plot (Smith et al., 1945). This increase in runoff and soil loss on the control plots can be attributed to the physical and mineralogical composition of the Bt horizons. The subsoils of these soils generally contain about 60% shrink-swell clays. These clays form large stable aggregates which do not detach upon impact by raindrops. When the surface dries, wide cracks form on the soil surface enhancing infiltration (Jamison et al., 1968).

Continuous corn yields on a desurfaced plot in the Missouri Valley loess region of Iowa declined 80 percent compared to control plots over a four-year period. Runoff and soil loss were considerably greater on the desurfaced plots (Musgrave and Norton, 1937). Grain yields in

Minnesota and Wisconsin on severely eroded soils were 33 and 25 percent less, respectively, than yields on slightly eroded soils (Hays et al., 1949).

During a nine year period in Ohio, 18 cm of a Dystrochrept eroded from a plot in continuous corn (an average of 1.9 cm per year). Corn yields declined from 2475 kg ha^{-1} to 125 kg ha^{-1} (40 bu a^{-1} to 2 bu a^{-1}) over the same nine year period (Borst et al., 1945). Cotton yields on desurfaced plots of Cecil sandy clay loam in North Carolina were 53 percent less than yields on the control plots. Although the desurfaced plots experienced yield reductions, the runoff and soil loss were equal on both the control and the desurfaced plots (Copley et al., 1944).

In rangelands of New Mexico, percent plant cover is used to estimate productivity. Under normal erosion, cover density was 35 percent. For advanced phases of erosion, cover density was 25 percent and for excessive soil loss, a 13 percent cover density was observed (Cooperrider and Hendricks, 1937).

Recent Yield Studies

Southeast

Although corn yields have increased more than 100 percent on both eroded and noneroded soils in the southern Piedmont since the 1940's, relative yield differences have remained the same. Yield reductions on eroded soils averaged at least 40 percent unless corrective treatments were applied (Langdale et al., 1979). Soybean yield reductions on Cecil soils in Georgia averaged 52 percent (Langdale et al., 1985).

There is very little recent research available on erosion-induced yield declines in the Coastal Plain region of the U.S. This area had not been considered to be susceptible to erosion until recently (Langdale et al., 1985). McDaniel and Hajek (1982) conducted a survey of crop yields on slightly and moderately eroded Paleudults in Alabama. Corn and soybean yields were reduced 26 and 43 percent, respectively on eroded soils. However, on some fields, crop yields on moderately eroded sites equaled or exceeded yields on slightly eroded sites. This unexpected result has been observed in other areas of the Southeast (Stone et al., 1985).

Yield reductions on Alfisols in the Southeast are not as pronounced as reductions on Ultisols, possibly due to the more favorable rooting zone characteristics of the Alfisols. Soybean yield reductions for Fragiudalfs and Paleudalfs in the southern loess region were 36 and 23 percent, respectively (Langdale et al., 1985). In Alfisols formed over limestone in central Kentucky, corn yields on eroded soils were between 12 and 21 percent lower than yields on uneroded Alfisols (Frye et al., 1982).

Studies have been conducted in Virginia and Tennessee on soils derived from limestone in the Ridge and Valley province. Soybean yields were 20 percent lower on eroded Paleudults compared to the uneroded counterpart in eastern Tennessee (Langdale et al., 1985). In western Virginia, on a Groseclose soil, from which the topsoil was removed, corn yields averaged 20 percent of those

areas with topsoil remaining. Applications of fertilizer, lime, and mulch increased eroded yields to 80 percent of uneroded yields (Batchelder and Jones, 1972).

Reductions in soybean and corn yields on severely eroded Ultisols average 38 and 37 percent, respectively (Table 2). On Alfisols, yield reductions were 16 and 17 percent for soybeans and corn, respectively (Table 2). Generally, yield reductions were greater on shallow and coarse-textured soils than on deep, medium-textured soils. The inherent infertility and toxic Al levels in subsoils of the Ultisols exposed by erosion can severely damage crop productivity if corrective measures, such as fertilitzers, are not incorporated (Langdale and Shrader, 1982; Langdale et al., 1985).

Midwest

The midwestern area of our nation, although extremely productive, has not escaped the ravages of erosion. Yield reductions are not as severe as on soils in the southeast. Crop yield reductions on exposed subsoils of Mollisols and Alfisols are less than 50 percent of the yield reductions on Ultisols (Langdale and Shrader, 1982). A crop yield survey by Fenton et al. (1971) in Iowa shows that only the most severely eroded Mollisols have yield reductions equivalent to those on Ultisols.

Yield reductions average 10 percent for major crops on eroded Mollisols. Aquic Argiudolls and Udorthents exhibited yield losses of approximately 18 percent for the major crops (Fenton et al., 1971). A comparison of yield reductions on eroded Hapludalfs and Argiudolls in Indiana show similar trends. The Mollisols have smaller yield decreases than the Alfisols (Schertz et al., 1985).

Great Plains

The Great Plains occupy the subhumid regions of the United States from Kansas westward to the Rocky Mountains and northward from Texas to North Dakota and into the Canadian provinces. Early conservationists warned of the erosion that would occur if the area was settled. As

Table 2. Crop yield reductions associated with soil erosion on Ultisols and Alfisols of the southern U.S.†.

Study	Family classification	Percent Reduction	
		Corn	Soybeans
Adams (1949)	clayey, kaolintic, thermic Typic Hapludults	41	-
Langdale et al. (1979)	clayey, kaolinitic, thermic Typic Hapludults	52	-
Stone et al. (1985)	clayey, kaolinitic, thermic Typic Hapludults	17	-
White et al. (1983)	clayey, kaolintic, thermic Typic Hapludults	-	52
Simpson (1974)‡	clayey, kaolinitic, thermic Typic Paleudults	-	21
Rhoton (1975)‡	clayey, kaolintic, thermic Typic Paleudults	-	24
Batchelder and Jones (1972)	clayey, mixed, mesic Typic Hapludults	20	-
McDaniel and Hajek (1982)	fine-loamy, siliceous, thermic Typic Paleudults	29	38
McDaniel and Hajek (1982)	fine-loamy, siliceous, thermic Plinthic Paleudults	23	48
Ultisol average		**37**	**38**
Denton (1978)‡	fine-silty, mixed, thermic Typic Hapludalfs	-	1
Denton (1978)	fine-silty, mixed, thermic Glossic Fragiudalfs	-	12
Denton (1978)	fine-silty, mixed, thermic Typic Paleudalfs	-	18
Frye et al. (1982)	fine, mixed, mesic Typic Paleudalfs	12	-
Frye et al. (1982)	fine-silty, mixed, mesic Typic Paleudalfs	21	-
Alfisol average		**17**	**16**

†Adapted from Langdale et al. (1985).
‡M.S. Thesises University of Tennessee, Knoxville, TN.

homesteading and agriculture progressed, erosion, particularly wind erosion, became increasingly serious. The drought of the 1930's and the subsequent Dust Bowl focused national attention and federal money towards evaluating the effect of erosion on productivity (Burnett et al., 1985).

The most serious effect of erosion on soil productivity in the Great Plains is the reduction in total soil N and organic carbon. Yields of all crops decreased with the exception of wheat (Haas et al., 1957). Wheat yields were lower with continuous cropping than with alternate cropping and fallow during drought periods (Baver, 1951; Haas et al., 1957). Much of the other published data on crop yields in the Great Plains considers the effects of variable erosion, precipitation, soil types, and varying crop varieties on productivity. Thus, actual productivity declines due to erosion could not be quantified.

There is a large pool of information from land-leveling studies in which the topsoil is artificially removed. Interpretation of results from these studies must be carefully scrutinized because the time scale of artificial soil removal is different from the "natural" process. In most cases, instantaneous removal of topsoil probably has a more drastic effect on productivity than would the slow removal of soil by "natural" processes (Meyer et al., 1985). Useful information on general trends and yield approximations can be derived from land-leveling studies.

Olson (1977) studied the effect of artificial topsoil removal on corn production on a Beadle silty clay loam (fine, montmorillonitic, mesic Typic Argiustoll) on the eastern margin of the Great Plains. The Beadle soil has a sodic claypan at a depth of 15 to 30 cm. Removal of 30 cm of topsoil resulted in an 18 percent reduction in corn yields. Removal of an additional 15 cm of soil did not further decrease yields. Initial yield reduction was contributed to the toxic effect of sodic materials. Removal of a second increment of soil only exposed more sodic material and therefore yields remained the same.

A long-term simulated erosion experiment was conducted by Smith et al. (1967) on an Austin clay (fine-silty, carbonatic, thermic Entic Haplustoll) in Texas. Two plots, desurfaced to a depth of 38 cm, were established in 1931. One plot was reseeded to native grasses and observed for organic matter accumulation. The other plot was planted in a variety of crop sequences from 1931 to 1965 for comparision with uneroded soils. Fertilized desurfaced plots gave higher yields than

unfertilized, uneroded soils. However, yields on fertilized, uneroded plots were higher than fertilized, desurfaced plots. On plots reseeded to native grass, organic matter increased to two percent in the surface comparable to the organic matter contents in the undisturbed plots. On cultivated desurfaced plots, organic matter remained stable at 1.4 percent during the 30 year study period.

Topsoil Thickness

Much of the erosion-productivity research has focused on topsoil thickness, especially in the Great Plains and Palouse regions of the nation. Topsoil thickness directly affects many soil properties. Removal of topsoil by erosion results in the reduction of organic matter. Lower levels of organic matter reflect declines in organic pools of N and P; reduced aggregate stability; and reduced plant available water-holding capacity. Loss of topsoil also can affect rooting depth of soils. A reduction in rooting volume may decrease the depth to unfavorable rooting characteristics in the subsoil, e.g., fragipans or high Al levels. Plant available water-holding capacity can also be drastically diminished (Williams et al., 1981).

The effect of decreasing topsoil thickness has variable effects on soils. On deep, medium-textured soils in the Midwest, yield declines following topsoil removal were 8 to 30 percent for corn, 11 to 24 percent for small grains, 20 to 40 percent for soybeans, 12 to 20 percent for cotton, and 5 to 17 percent for forages (Spomer et al., 1973; Buntley and Bell, 1976). On shallow medium and coarse textured soils in the Southeast, yield reductions for corn was from 36 to 44 percent, cotton from 35 to 38 percent, soybeans 22 to 37 percent, small grains 22 to 34 percent, and forages from 22 to 25 percent (Adams, 1949; Batchelder and Jones, 1972; Buntley and Bell, 1976; Langdale et al., 1979). In general, yield reductions after topsoil removal was greater on coarse-textured and shallow medium-texured soils than on deep, medium-textured soils.

The most extensive research on the effects of topsoil thickness on crop productivity has been done in the Palouse region of western Idaho and eastern Washington state (Papendick et al., 1985; Bramble-Brodahl et al., 1985). Linear regression techniques have been most commonly employed for distinguishing yield declines due to decreases in thickness of topsoil. Wetter (1977) found a linear relationship between wheat yields and thickness of the mollic epipedon. Yields decreased an average of 54 kg ha^{-1} per cm decrease of mollic epipedon thickness over a range of 0 to 61 cm of epipedon depth.

In another Palouse area study, yields on a Palouse soil (Ultic Haploxeroll) were linear in response to mollic epipedon thickness in 1982 and curvilinear in 1983 (Bramble-Brodahl et al., 1985). The linear regression model, with an R^2 of 0.43, described a 38 kg ha^{-1} increase in wheat yields per cm increase in mollic epipedon thickness from a base yield of 3438 kg ha^{-1} at 0 cm of mollic epipedon thickness. In comparison, the nonlinear response in 1983 had an R^2 of 0.32 and was weaker in terms of estimating yields. The reason for the diminished predictive capacity of the nonlinear model is that most of the data collected in the study clustered in the linear portion of the nonlinear curve. Therefore, actual yields were much less than predicted. The difference in response in yields between 1982 and 1983 was given as a function of growing season conditions. Wheat yields were normal in 1982, but optimal climatic and moisture conditions in 1983 resulted in exceptional yields.

Christensen and McElyea (1985) examined yield and topsoil depth relationships for benchmark soils in the Palouse region of Washington state and in the Piedmont region of Georgia with mathematical models. The models consider the soil a capital good for use in crop production, and soil erosion represents a depreciation in the value of this capital good. The critical factor affecting yields was assumed to be topsoil depth.

Soils in the Palouse are typically Mollisols that have formed in thick loess deposits with similar textures throughout entire soil profiles. Therefore, as the soil erodes and the subsoil becomes mixed with the topsoil, the mechanical, or textural, composition of the topsoil remains the same. If the topsoil is of uniform texture, the yield-topsoil depth relationship can be given by the single factor Mitscherlich-Spillman (M-S) function

$$Y = A + B(1 - R^x)$$

where Y = winter wheat yield

A = yield at zero topsoil

B = maximum yield increment

R = constant ratio

x = topsoil depth

The M-S function for the Palouse area soils is concave to the horizontal axis with increasing slope and decreasing yield as topsoil decreases.

The Cecil series was used to investigate the yield-topsoil depth relationship in Georgia. These soils generally have sandy loam surface horizons when only slightly eroded with clayey, moderately dense subsoils. As topsoil erodes, the clayey subsoil is mixed into the topsoil by plowing, resulting in increased clay content in the Ap horizon. In this case, where the topsoil changes in textural characteristics, the M-S function becomes sigmoidal or "S" shaped and is given by

$$Y = A + B(1 - R^{f(x)})$$

where Y = crop yield

A = intercept

B = maximum yield increment

R = constant ratio

f = function limiting factor

x = topsoil depth

These yield-topsoil depth functions can have important economic applications. For the M-S equation on Palouse soils, the loss of income due to erosion on these deep soils may be low enough that applying conservation measures may not be worth additional costs.

For the sigmoidal curve associated with the Cecil soil, yield damage is initially very small for slightly eroded soils. Damage increases rapidly, however, as erosion progresses. Yield damage decreases to almost zero once the soil becomes severely eroded -- productivity can be damaged no further. As a result, the farmer may not have the economic incentive to apply conservation measure on slightly and severely soils (Christensen and McElyea, 1985).

Regional Studies

Introduction

Determining relationships between erosion, soil properties, and crop yields is, at best times, a difficult and perplexing task. Simple relationships do not always exist. One can generally show that by increasing the severity of erosion crop yields will be reduced, but how these reductions occur is not always evident.

Crop yields are not usually influenced by a single soil property but instead crop growth is determined by a combination of properties. Most research on evaluating the effects of soil erosion on crop productivity has involved the study of the interactions of multiple soil properties.

Southeast

In the Piedmont region of Georgia, soybean yields related positively to depth of the Ap horizon, depth to the top of the Bt horizon, and solum thickness. There was a negative correlation between yields and clay content in the Ap horizon. Extractable P was lower on severely eroded sites and was another major factor contributing to yield losses. In contrast, concentrations of K and Ca were high in severely and moderately eroded surface soils. The researchers concluded that higher clay contents and the associated increase in CEC resulted in the higher levels of K and Ca on the severely eroded soils. Moderately and severely eroded sites showed less favorable soil water regimes during critical growth stages than did the slightly eroded sites. The ineffective recharge of the root zone after rainfall was cited as being a major factor contributing to yield reductions on eroded areas (Langdale et al., 1979; White et al., 1985).

Stone et al. (1985) studied the relationships between soil erosion, soil properties, and soil productivity on the Cecil soil on slightly, moderately, and severely eroded plots in five farmer operated fields in the North Carolina Piedmont. Corn grain yields were highest on moderately eroded plots compared to slightly and severely eroded sites. The higher yielding moderately eroded treatment had slightly higher available water-holding capacity than the other two levels of erosion. However, in 1981, a very dry year, the yield on some severely eroded plots had the highest yields. Organic matter in the Ap horizon increased as the severity of erosion increased. The researchers contributed this to the formation of stable clay-organic complexes in the more eroded soils. However, the difference in organic matter content between erosion classes was of little significance due to the inherently low organic matter content of these soils. The -1500kPa water content increased as erosion severity increased and paralleled the increase in clay content. The differences in available water-holding capacity were small across erosion classes. The researchers were unable to discern any affects on soil productivity due to the small differences. The most profound effect of erosion on soil properties was observed with soil test P. Available P decreased going from slight erosion to moderate erosion and was attributed to increased P-fixing capacity of the clay in the eroded soils. However, the P levels were above the critical value of P required for optimal plant growth (Stone et al., 1985).

Thomas and Cassel (1979) used regression analysis to account for corn yield differences associated with changes in physical and chemical soil properties due to erosion. The soil variables, ranked in order of declining importance are: 1) A horizon thickness, 2) plant available P, 3) bulk density, 4) available water-holding capacity, 5) organic matter content, and 6) plant available K. Soils included in the study were Goldsboro (fine-loamy, siliceous, thermic Aquic Paleudult), Lynchburg (fine-loamy, siliceous, thermic Aeric Paleaquult), and Rains (fine-loamy, siliceous, thermic Typic Paleaquult). The thickness of the A horizon was of primary importance because the subsoils of these Ultisols generally contain high levels of aluminum. The A horizon also had superior water retaining conditions conducive to plant growth.

McDaniel and Hajek (1985) conducted an extensive erosion-productivity study in the Lower Coastal Plain, Black Belt Prairies, and Tennessee Valley regions of Alabama. The diversity of the

soils between the regions is extreme. Dothan and Malbis (Plinthic Paleudults); Bama and Orangeburg (Typic Paleudults); and Lucedale and Red Bay (Rhodic Paleudults) were the soils chosen for study in the Coastal Plain region. Black Belt Prairie soils were Oktibbeha and Vaiden (Vertic Hapludalfs); Sumter (Rendollic Eutrochrept); and Demopolis (shallow Typic Udorthent). Decatur (Rhodic Paleudult) and Dewey (Typic Paleudult) were soils observed in the Tennessee Valley.

In the Coastal Plain region, yields of soybeans were highest on slightly eroded Dothan as compared to other slightly eroded soils in the region. However, overall yield reductions in the Coastal Plain were the highest on the moderately eroded Dothan map unit. Yield reductions on all moderately eroded Coastal Plain soils averaged 25 percent (McDaniel and Hajek, 1985).

The highest yield reductions in the Black Plains region were observed on the Demopolis soil with an average yield decline of 30 percent. In 1983, a drought year, Vaiden soils experienced yield reductions of only 3 percent possibly due to the superior water-retaining characteristics of this soil. In the same drought year, yields in the Tennessee Valley were reduced an average of 22 percent on Decatur soil and 69 percent on the Dewey soil.

Although the soils exhibited a wide range of soil physical and chemical characteristics, yield declines on the soils was attributed to the same set of properties. Included were decreased surface soil thickness and organic matter contents, affecting both water-holding and nutrient supplying capacities, and soil test P, affecting availability of P for plant uptake (McDaniel and Hajek, 1985).

In the Bluegrass region of Kentucky, the effects of moderate erosion were determined on certain physical and chemical soil properties (Frye et al., 1982). Soils in the study were Maury and Crider series (fine-silty, mixed, mesic Typic Paleudalfs). Corn yields were 12 and 21 percent lower on the eroded Maury and Crider soils, respectively. The most important yield-limiting effect was the decrease in available water-holding capacity associated with the increase in clay content in the surface horizon as erosion severity increased. Actual water-holding capacity was 4 to 6 percent lower, on a volume basis, on the eroded soils compared to uneroded soils. Bulk density was higher on eroded than on the uneroded soils. This was probably due to increased clay contents and decreased organic matter contents in the eroded soils (Frye et al., 1982). Fertility status of the surface

horizon was not a yield-limiting factor in these soils since both had been limed and fertilized prior to the experiment. However, the Crider soil is lower in natural fertility, and erosion probably will have a more detrimental effect on productivity in the long-term even with proper fertility maintenance (Frye et al., 1982).

Midwest

In most states of the Midwest, yield estimates are derived from models. From these models, soil scientists are able to establish trends in the effect of slope and erosion and yields (Englestad and Shrader, 1961; Englestad et al., 1961; Fenton et al., 1971; Rust and Hanson, 1975; Bone and Norton, 1981). In most instances, however, yields are not specifically related to soil properties (Mannering et al., 1985).

Efforts have been initiated in several states to provide additional field data relating soil loss to crop productivity and to soil properties. A cooperative study between USDA-ARS and Purdue University is evaluating three major soil series in the Midwest: Corwin (fine-loamy, mixed, mesic Typic Argiudoll); Miami (fine-loamy, mixed, mesic Typic Hapludalf); and Morley (fine, mixed, mesic Typic Hapludalf). Slight, moderate, and severe erosion classes were selected for each soil in three counties (Mannering et al., 1985).

The Corwin prairie soil, inherently higher in organic matter than Miami or Morley soils, lost significant amounts of organic matter as erosion increased in severity. Available P levels were high in the Ap horizon but decreased significantly as soil erosion increased from uneroded to severely eroded. Corn yield paralleled the decrease in organic matter and available P. Yields were significantly lower on severely eroded sites than on slightly and moderately eroded sites.

Simulating Erosion-Productivity With Mathematical Models

Introduction

Mathematical models are being developed that can simulate some of the ecosystem processes and lead to a better understanding of the intricacies of natural processes. As with any new scientific method, there is both praise and criticism. The Erosion-Productivity Impact Calculator (EPIC) has advantages over long-term field studies (Williams et al. 1981). The model is efficient. Many years can be simulated quickly for various soil and management strategies. The models are useful in determining long-term effects for an unlimited number of management strategies. Modeling is a learning exercise that increases knowledge about processes involved.

The one major disadvantage with modeling is not so much a negative attribute as it is a limitation. The description and understanding of complex biological systems is limited by our ability to comprehend these systems. The limitations sometimes lead to models that have no basis in reality (i.e., represent unreal systems) or are too simplified to explain the complex processes involved (Woodmansee and Lauenroth, 1983).

Three erosion-productivity models will be reviewed in this section. *EPIC* was developed to assess the relationship between erosion and productivity on a national basis and is currently being used by the USDA to make long-term policy decisions concerning soil resources. *NTRM* -- Nitrogen-Tillage-Residue Management -- was designed to study the relationship between the soil environment and crop growth and is being used for soils in the Midwest. *Productivity Index* has only three inputs in its model. The inputs, all soil properties, are being used to evaluate the erosion - productivity relationships in Missouri and the upper Midwest.

EPIC

The Soil and Water Resources Conservation Act of 1977 requires the Secretary of Agriculture to make periodic assessments of soil and water resources. One major focus has been on the depletion of soil resources by erosion. Methods exist to predict erosion rates; for example, USLE -- Universal Soil Loss Equation (Wischmeier and Smith, 1978); and to estimate sediment yields, CREAMS -- Chemicals, Runoff, and Erosion from Agricultural Management Systems (Knisel, 1980). However, there is no reliable method of evaluating the effects of erosion on long-term soil productivity. In response to this need, the USDA appointed a National Soil Erosion-Soil Productivity Committee to develop a working mathematical model to assess the erosion-productivity relationship. The result was EPIC -- Erosion-Productivity Impact Calculator. EPIC is composed of physically based components for simulating erosion, crop growth, and related processes and economic components for assessing the cost of erosion, determining optimum management strategies, etc. (Williams et al., 1982; Williams et al., 1983).

Most EPIC input data is obtained from a computer filing system designed specifically for EPIC. The EPIC model uses readily available input data from a variety of sources including SCS handbooks and weather data. The detailed soils information for the model is obtained from the SCS SOILS-5 database. Other data, where not directly available, is estimated using mathematical relationships simulating the processes involved (Williams and Renard, 1985).

EPIC can simulate hundreds of years of erosion and is capable of computing the effects of management changes on outputs (Williams et al., 1985). The outputs (crop yields, cost, erosion rates, etc.) will be entered into the CARD (Center for Agricultural and Rural Development) linear programming model for soil resources analysis.

Model Description

The drainage area considered by EPIC is about 1 hectare and soil management practices are assumed to be spatially homogeneous. The soil profile is divided into a maximum of 10 layers. The top layer thickness is set at 10 mm. The remaining soil layers may have variable thicknesses. As erosion proceeds, the second layer is incorporated into the top layer by the amount of eroded thickness. The new top layer soil properties are interpolated from the mixing of the two layers. When the second layer thickness becomes zero, the top layer moves into the third layer and so on.

The EPIC model has eight major components or submodels -- hydrology, weather, erosion, nutrients, soil temperature, crop growth, tillage, and economics. (Williams and Renard, 1985; Williams et al., 1985). Each of these components will be briefly discussed.

Hydrology

The hydrology model simulates surface runoff given daily rainfall. Other hydrology parameters include peak runoff rate, percolation, lateral subsurface flow, drainage, evapotranspiration, irrigation, and snowmelt.

Weather

The weather model includes four components: precipitation (both rain and snow), air temperature, solar radiation, and wind.

Precipitation, temperature, and radiation can be read in directly from available climatic input data or each can be simulated with various mathematical formulae. Wind velocity and direction are simulated using the Richardson's wind simulation model (Richardson, 1981) and is used when wind erosion is estimated.

Erosion

Water erosion is estimated using the Onstad and Foster modification (1975) of the Universal Soil Loss Equation (USLE) (Wischmeier and Smith, 1978). The USLE energy factor considers only rainfall whereas the Onstad and Foster modification uses rainfall and runoff parameters.

Erosion caused by furrow irrigation is estimated using MUSLE -- Modified USLE (Williams, 1975) where the rainfall factor is replaced by an irrigation factor.

Wind erosion is predicted using the wind erosion equation (Woodruff and Siddoway, 1965). The model was modified to convert from annual to daily predictions.

Nutrients

EPIC considers two plant nutrients -- nitrogen and phosphorus. Nitrogen processes simulated include nitrate loss by surface runoff, nitrate leaching, transport of nitrate by evaporation, transport of organic nitrogen by sediment, denitrification, mineralization, immobilization, fixation, rainfall, fertilizers, and crop uptake.

Phosphorus processes simulated include mineralization, immobilization, soluble phosphorus losses by runoff, cycling of mineral phosphorus, sorption-desorption, transport of phosphorus by sediment, fertilizers, and crop uptake.

Soil Temperature

Daily average temperature is simulated for use in the hydrology and nutrient cycling submodels. The temperature of the soil surface is estimated using maximum and minimum air temperature, surface albedo, and daily solar radiation. Soil temperature is predicted for each soil layer as a function of soil surface temperature, bulk density, soil water, mean annual air temperature, and the annual amplitude of daily average temperature.

Tillage

The tillage component of EPIC simulates changes in bulk density, the mixing of nutrients and residues within the plow layer, and the conversion from standing to flat residue for various tillage operations. Other factors in the tillage model are row height and surface roughness.

Crop Growth

Growth of eleven crops can be simulated with EPIC -- corn, grain sorghum, wheat, barley, oats, sunflowers, soybeans, alfalfa, cotton, peanuts, and grasses. Potential increases in biomass per day is estimated as the product of intercepted energy and a parameter for converting energy into biomass. Crop yields at the end of the growing season are calculated as a function of biomass and potential solar radiation for the growing season.

Stresses may cause potential reductions in biomass and yields. Stress factors considered in the crop growth model include N and P deficiencies, soil texture, bulk density, temperature, aeration, and aluminum toxicity.

Economics

The economic inputs are divided into two categories -- fixed costs and variable costs. Fixed cost inputs include depreciation, interest or return on investment, taxes, and capital improvements (drainage, irrigation, conservation practices, etc.). Variable cost inputs include machinery repairs, fuel costs, seed, fertilizer, lime, pesticides, labor, and irrigation. Total cost is the sum of fixed and variable costs.

Gross income is determined for the simulated annual crop yields. Net profit is the difference between gross income and total costs.

Model Application

EPIC can generate several types of output. The first is an Erosion-Productivity Index (EPI) which gives relative productivity for a particular soil within a Major Land Resource Area (MLRA). Two runs are made covering the range of soil conservation management practices. The first run assumes perfect conservation, i.e. no erosion. Maximum erosion, or no conservation, is the sce-

nario for the second run. EPI is calculated over a period of 100 years for yields obtained under each management situation and is given by the equation

$$EPI = Ye,i \; / \; Yu,i$$

where Yi refers to yield for year i; e and u represent eroded and uneroded conditions, respectively.

The EPI can be transformed into an E/P which relates the EPI to accumulated erosion. Once the E/P is developed for a particular soil, various management strategies can be evaluated if erosion rates are known (Williams et al., 1985).

EPIC can also produce estimates of annual sediment yields as shown by Table 3 (Williams and Renard, 1985). This component of the model has been extensively tested and provides good estimates of sediment yields (Knisel, 1980).

One of EPIC's potentially most useful evaluations is the estimation of long-term crop yields (Williams and Renard, 1985). Table 4 provides comparisons between observed long-term research yields and those simulated with EPIC. Although the yield estimations are high compared to measured yields, this method of analysis can be useful in observing trends, e.g., will productivity increase or decrease over the next 50 to 100 years.

Summary

EPIC, like many of the other process models, is at times too complex and makes too many assumptions concerning dynamic soil processes that may or may not be valid, or at least, are not thoroughly tested. The EPIC modeling team does acknowledge this problem and are continuing to evaluate and refine many of the simulation submodels in EPIC.

Table 3. Comparison of simulated and measured sediment yield in Texas.

Watershed	Annual sediment yield	
	Measured	Simulated
	---------- tons ha^{-1} ----------	
W-10	0.08	0.08
SW-11	1.33	1.11
Y-14	0.82	1.04

Modified from Williams and Renard (1985).

Table 4. Comparison of simulated and long-term average measured crop yields.

State	Years	Crop	Yield	
			Measured	Simulated
			-------- Mg ha^{-1} --------	
AL	-	Soybeans	1.89	1.91
		Corn	5.29	5.35
		Wheat	1.23	1.58
ND	29	Corn	1.62	2.06
		Wheat	1.02	0.84
MT	31	Corn	0.66	1.04
		Wheat	0.80	0.56
WY	32	Corn	0.82	1.16
		Wheat	0.69	0.82

Modified from Williams and Renard (1985).

NTRM

NTRM (Nitrogen-Tillage-Residue Management) was developed for studying management of tillage practices, crop residues, and N fertilizers (Shaffer et al., 1983; Molina et al., 1985). The model can, within its framework, simulate the effect of erosion on both short- and long-term productivity of soils (Shaffer, 1985).

NTRM was developed over a period of about four years incorporating existing submodels into the comprehensive NTRM model and developing new submodels where needed. Corn is the only crop being modeled thus far. Other crops will be added as the model is further developed (Molina et al., 1985).

Model Components

There are five basic components to NTRM: climate, soil properties, landscape parameters, management practices, and plant growth. *Climatic* variables include daily precipitation, maximum and minimum air temperature, evaporation, wind, and solar radiation. *Soil properties* entered into the model are soil water characteristic curves, soil water content, soil temperature, bulk density, texture, nutrient and salt concentration, nitrogen transformations, profile geometry, soil and residue reflection coefficients, and random roughness. *Landscape* characteristics include percent slope, slope length, aspect, site latitude, and elevation. *Management* techniques include nitrogen fertilizer application dates, amounts, and types; dates, types, and amounts of crop residues; tillage dates and types; dates, amounts and salinity of irrigation applications; and corn maturity class, populations, and emergence dates. *Plant growth* processes simulated are photosynthesis, respiration, growth of leaf area and stover, grain filling, transpiration, and N uptake. A submodel for simulating root growth is also incorporated (Shaffer, 1985).

Model Application

NTRM was used to assess the impact of soil erosion on both short- and long-term corn yields for three soils in southern Minnesota, southwestern Wisconsin, and northeastern Iowa (Shaffer, 1985). The soils selected were Fayette silt loam (Typic Hapludalf), a deep loess soil; Dubuque silt loam (Typic Hapludalf), shallow to bedrock and; Dakota fine sandy loam (Typic Argiudoll), shallow loess over coarse sand. The soils were each eroded (simulated) at 0, 0.3, and 0.6 m depths. Corn yields were simulated for 10 year and again for 100 year time intervals. The model was run with wet, average, and dry climatic sequences for each erosion-soil combination.

Yields were higher in each soil for the 10 year simulation (Figure 3). Shaffer (1985) reports that this is due to the higher average precipitation during this time period. The increase in yields after 0.3 m of erosion on the Fayette silt loam is explained by the improvement in infiltration and rooting environment at this depth. Unfavorable subsoil conditions reflect the decrease in yields in the Dakota and Dubuque profiles.

Another NTRM application is assessing the benefits of various management techniques. The application of fertilizer, irrigation, and conservation tillage dramatically increased corn grain yields on the eroded Dubuque and Dakota soils, whereas the Fayette silt loam responded well to only fertilizer applications (Shaffer, 1985).

Summary

NTRM provides a rapid means to estimate the erosion-productivity relationship and to assess the influence of various management techniques on the same. NTRM, however, has a narrow field of application. The model was specifically developed for sub-humid regions of the Midwest. As a result, many of the process models, such as salinity analysis, have little or no application to more

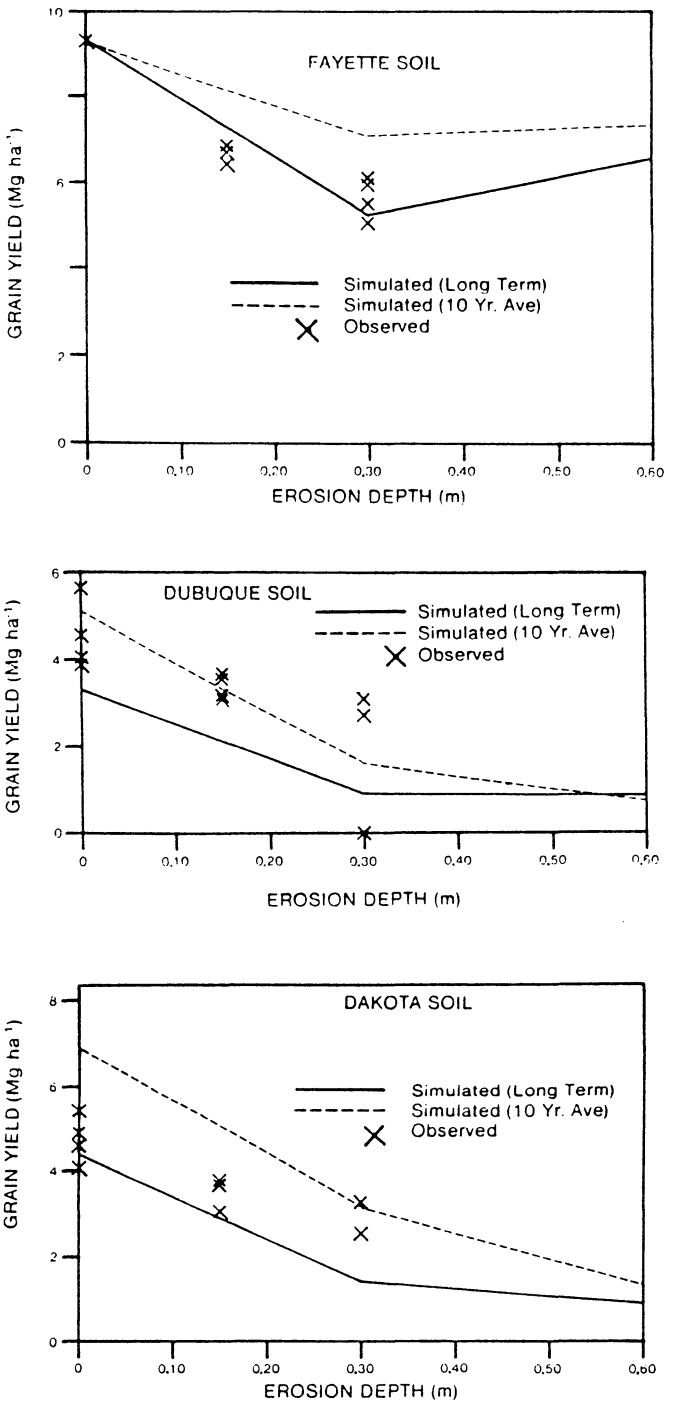

Figure 3. Corn grain yields for Fayette, Dubuque, and Dakota soils at various erosion depths.

humid regions. Therefore, the use of NTRM to simulate the impact of soil erosion on short and long-term soil productivity should be restricted to the sub-humid Corn Belt soils.

Productivity Index

Model Description

Scrivner and associates at the University of Missouri have developed a productivity index (PI) for quantifying the effects of erosion on soil productivity (Scrivner et al., 1985b). The model, modified from Kiniry and others (1983), determines the suitability of the soil for root growth from sufficiencies of three soil properties: available water capacity, bulk density, and pH. A sufficiency of 1.0 indicates no root restriction while a sufficiency of 0.0 refers to total root restriction. The sufficiency values for each 10 cm soil layer are multiplied together and then corrected by an ideal root weighting factor. The products of all soil layers, to a maximum depth of 100 cm, are summed to obtain PI. The PI will have a value of between 0.000 and 1.000 with 1.000 representing maximum productivity (Kiniry et al., 1983; Scrivner et al., 1985a; Scrivner et al., 1985b).

The most productive soil materials (highest sufficiencies) are usually at the soil surface and the less desirable materials, or lower sufficiencies, are in the subsoil. When a soil erodes, the best soil materials at the surface are removed, exposing the undesirable subsoil material. Productivity is therefore lowered. The amount of decline in productivity can be calculated with PI. A soil is computer-eroded to a depth of 10 cm. The new surface then becomes the 10-20 cm layer. As a result, sufficiencies for the eroded 0-10 layer are removed and a new PI is calculated to a depth of 100 cm. The result should be a reduced PI (Scrivner et al., 1985b).

Model Application

The soils data needed to compute PI can be obtained either from direct field measurements or from SOILS-5 and NRI (National Resources Inventory) SCS data bases. The SOILS-5 data base

contains soil descriptions, ,physical and chemical properties, crop yields, land capability classes and limitations for every soil series in the United States. The NRI data base has information on acreage, ownership, land use, and erosion for all soil mapping units (Kiniry et al., 1983).

The soil and land use data from 500 farm-field plots in Missouri have been assembled into a computer software package. The quantitative analysis of erosion effects on productivity can be analyzed in terms of four numbers: PI_0, PI_{30}, *FPI*, and *V*. PI_0 describes the productivity of a soil at the present time relative to ideal soils (PI = 1.000). PI_{30} is a measure of the loss in potential productivity after 30 cm of erosion. ***FPI*** represents the fractional loss of productivity relative to PI_0. for each cm of soil loss. This value is determined for a particular tract of land where the yield potential is known and is calculated as

$$(PI_{30} - PI_0) / PI_0 / 30 \text{ cm}$$

V, vulnerability, is similar to *FPI* in that it represents the loss in productivity resulting from 1 cm of erosion (Pierce et al., 1984). It differs from *FPI*, however, in that the loss is not relative to a particular site. *V* is useful for comparing one soil with another (Scrivner et al., 1985b).

Three of the four values -- PI_0, PI_{30}, and *V* -- can be converted to estimated yields by multiplying the value by ideal yields. For corn and soybeans the ideal yields are 200 and 60 bu/a, respectively. Yields related to *FPI* are calculated by multiplying *FPI* by yields potential for the particular site. The effects of liming (top 20 cm) on both PI values and yields can be estimated within the computer program. Liming effects are calculated by adjusting the sufficiency of pH (Scrivner et al., 1985b).

Tables 5 and 6 give erosion analysis for two Missouri soils, the Putnam (Mollic Albaqualf) and the Creldon (Mollic Fragiudalf). These two soils both have desirable topsoil properties however the Creldon possesses a fragipan which is limiting to productivity. The subsoil properties of the Putnam soil are more conducive to plant growth.

The Creldon soil is more sensitive to erosion than is the Putnam soil, as expressed by the *V* values in Table 5 and Table 6. This is due to the presence of the fragipan in the Creldon soil. The Creldon soil sustains a 3 bu a^{-1} loss in corn yields for every cm of erosion, whereas the Putnam

Table 5. PI values for Putnam and Creldon soils.

	Unlimed				Limed			
Soil	PI_0	PI_{30}	FPI	V	PI_0	PI_{30}	FPI	V
Putnam	.772	.457	-.0136	-.0105	.782	.569	-.0091	-.0071
Creldon	.592	.139	-.0255	-.0151	.613	.298	-.0171	-.0105

Modified from Scrivner (1985b).

Table 6. Erosion analysis of corn yields for Putnam and Creldon soils.†

Soil	Unlimed				Limed			
	PI_0	PI_{30}	FPI	V	PI_0	PI_{30}	FPI	V
	bu a^{-1}							
Putnam	154	91	-2.6	-2.1	156	114	-1.8	-1.4
Creldon	118	28	-5.1	-3.0	123	60	-3.4	-2.1

†Assumed corn yield is 200 bu a^{-1}.
Modified from Scrivner (1985b).

soil experiences 2.1 bu a^{-1} loss. Both soils respond to liming with 0.7 and 0.9 bu a^{-1} increase in yields on the Putnam and Creldon soils, respectively.

The PI approach has been used in the Corn Belt region for quantifying erosion effects on productivity for the large Major Land Resource Areas (Pierce et al., 1983; Pierce et al., 1984). This analysis has shown that the loss in productivity over the next 100 years will be about 8 percent (Pierce et al., 1984).

Summary

Once the PI model is perfected, the farmer will be able to determine what type of a response he/she would obtain from liming or how much productivity is being lost due to erosion (Anonymous, 1984). This approach to quantifying the erosion-productivity relationship is is probably the path that needs to be taken because the relationship is based solely on soil properties. The complex process models, such as EPIC and NTRM, include too many simulations which are based on assumptions that may or may not be correct.

Other Models

Below is a listing and brief description of some of the models related to the erosion process but not specifically to erosion and productivity.

SPUR

Simulation of Production and Utilization of Rangelands (Wight, 1983)

- physically based rangeland simulation model to aid in predicting herbage yields, livestock production, runoff and erosion

CREAMS

Chemicals, Runoff, and Erosion from Agricultural Management Systems (Knisel, 1980).

- developed to assess nonpoint source pollution
- provides estimates of field-scale losses of soil, nutrients, and pesticides
- quantify responses from alternative management systems
- evaluates best management practices

ALMANAC

Agricultural Land Management Alternatives with Numerical Assessment Criteria

- developed for use in decision making and research from farm size to national level
- model inputs similar to EPIC

SPAW

Soil-Plant-Air-Water

- uses simplified components to link crop growth and production to soil moisture availability
- separates major climatic, crop, and soil effects and emphasizes graphical representation

Literature Cited

Adams, W.E. 1949. Loss of topsoil reduces crop yields. J. Soil Water Conserv. 4:130.

Anonymous. 1984. Digging deep for yields. Early Riser 7(2):8.

Batchelder, A.R., and J.N. Jones, Jr. 1972. Soil management factors and growth of *Zea mays* L. on topsoil and exposed subsoil. Agron. J. 64:648-652.

Batie, S. 1983. Soil erosion: Crisis in America's croplands? The Conservation Foundation, Washington, DC.

Baver, L.D. 1951. How serious is soil erosion? Soil Sci. Soc. Am. Proc. 15:1-5.

Bone, S.D., and L.D. Norton. 1981. Ohio soils with yield data and productivity index. Coop. Ext. Serv. Bull. 685. The Ohio State University, Columbus.

Borst, H.L., A.G. McCall, and F.G. Bell. 1945. Investigations in erosion control and reclamation of eroded land at the Northwest Appalachian Conservation Experiment Station, Zanesville, Ohio, 1934-42. USDA Tech. Bull. 888. U.S. Government Printing Office, Washington, DC.

Bramble-Brodahl, M., M.A. Fosberg, D.J. Walker, and A.L. Falen. 1985. Changes in soil productivity related to changing topsoil depth on two Idaho Palouse soils. p. 18-27. *In* Erosion and soil productivity. Proc. Natl. Symp. on Erosion and Soil Productivity, New Orleans, LA. 10-11 December 1984. American Society of Agricultural Engineers, St. Joseph, MI.

Browning, G.M., G.L. Parish, and J. Glass. 1947. A method for determining the use and limitations of rotation and conservation practices in the control of soil erosion in Iowa. J. Am. Soc. Agron. 39:65-73.

Buntley, G.J., and F.F. Bell. 1976. Yield estimates for the major crops grown on the soils of west Tennessee. Tenn. Agric. Exp. Stn. Bull. 561.

Burnett, E., B.A. Stewart, and A.L. Black. 1985. Regional effects of soil erosion on crop productivity -- Great Plains. p. 285-304. *In* R.F. Follett and B.A. Stewart (ed.) Soil erosion and crop productivity. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, WI.

Chepil, W.S. 1945. Dynamics of wind erosion: I. Nature of movement of soil by wind. Soil Sci. 60:305-320.

Chepil, W.S., and R.A. Milne. 1941. Wind erosion of soil in relation to roughness of surface. Soil Sci. 52:417-431.

Christensen, L.A., and D.E. McElyea. 1985. Economic implications of soil characteristics and productivity in the southern Piedmont, with comparisons to the Pacific Northwest. p. 233-242. *In* Erosion and soil productivity. Proc. Natl. Symp. Erosion and Soil Productivity, New Orleans, LA. 10-11 December 1984. American Society of Agricultural Engineers, St. Joseph, MI.

Coldwell, A.E. 1942. The relation of various types of vegetative cover to soil drift. Am. Soc. Agron. J. 34:702-710.

Cooperrider, C.K., and B.A. Hendricks. 1937. Soil erosion and stream flow on range and forest lands of the Upper Rio Grande Watershed in relation to land resources and human welfare. USDA Tech. Bull. 567. U.S. Government Printing Office, Washington, DC.

Copley, T.L., L.A. Forrest, A.G. McCall, and F.G. Bell. 1944. Investigations in erosion control and reclamation of eroded land at the Central Piedmont Conservation Experiment Station, Statesville, North Carolina, 1930-40. USDA Tech. Bull. 873. U.S. Government Printing Office, Washington, DC.

Daniel, H.A., H.M. Elwell, and M.B. Cox. 1943. Investigations in erosion control and reclamation of eroded land at the Red Plains Conservation Experiment Station, Guthrie, Oklahoma, 1930-40. USDA Tech. Bull. 837. U.S. Government Printing Office, Washington, DC.

Daniels, R.B., J.W. Gilliam, D.K. Cassel, and L.A. Nelson. 1985. Soil erosion class and landscape position in the North Carolina Piedmont. Soil Sci. Soc. Am. J. 49:991-995.

Eck, H.V., V.L. Hauser, and R.H. Ford. 1965. Fertilizer needs for restoring productivity on Pullman silty clay loam after various degrees of soil removal. Soil Sci. Soc. Am. Proc. 29: 209-213.

Elfring, C. 1983. Land productivity and agricultural technology: A study by the Office of Technology Assessment. J. Soil Water Conserv. 38:7-9.

Ellison, W.D. 1944. Studies of raindrop erosion. Agric. Eng. 25:131-136.

Ellison, W.D. 1947. Soil erosion studies. VI. Soil detachment by surface flow. Agric. Eng. 28:442-444, 450.

Englestad, O.P., and W.D. Shrader. 1961. The effect of surface soil thickness on corn yields: II. As determined by an experiment using normal surface soil and artificially-exposed subsoil. Soil Sci. Soc. Am. Proc. 25:497-499.

Englestad, O.P., W.D. Shrader, and L.E. Dumenil. 1961. The effect of surface soil thickness on corn yields: I. As determined by a series of field experiments in farmer-operated fields. Soil Sci. Soc. Am. Proc. 25:494-497.

Evans, R. 1980. Mechanics of water erosion and their spatial and temporal controls: An empirical viewpoint. p. 109-128. *In* M.J. Kirkby and R.P.C. Morgan (ed.) Soil erosion. John Wiley and Sons, New York.

Farmer, E.E. 1973. Relative detachability of soil particles by simulated rainfall. Soil Sci. Soc. Am. Proc. 37:629-633.

Fenton, T.E., E.R. Duncan, W.D. Shrader, and L.C. Dumenil. 1971. Productivity levels of some Iowa soils. Iowa Agric. Exp. Stn. Spec. Rpt. 66.

Foster, G.R., R.A. Young, M.J.M. Romkens, and C.A. Onstad. 1985. Processes of soil erosion by water. p. 137-162. *In* R.F. Follett and B.A. Stewart (ed.) Soil erosion and crop productivity. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, WI.

Foy, C.D. 1974. Effects of aluminum on plant growth. p. 601-642. *In* E.W. Carson (ed.) The plant root and its environment. University Press of Virginia, Charlottesville.

Frye, W.W., O.L. Bennett, and G.J. Buntley. 1985. Restoration of crop productivity on eroded or degraded soils. p. 335-356. *In* R.F. Follett and B.A. Stewart (ed.) Soil erosion and crop pro-

ductivity. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, WI.

Frye, W.W., S.A. Ebelhar, L.W. Murdock, and R.L. Blevins. 1982. Soil erosion effects on properties and productivity of two Kentucky soils. Soil Sci. Soc. Am. J. 46:1051-1055.

Frye, W.W., L.W. Murdock, and R.L. Blevins. 1983. Corn yield-fragipan depth relations on a Zanesville soil. Soil Sci. Soc. Am. J. 47:1043-1045.

Greenland, D.J. 1965. Interaction between clays and organic compounds in soils. Part I. Mechanisms of interaction between clays and defined organic compounds. Soils Fert. 28:415-425.

Haas, H.J., C.E. Evans, and E.F. Miles. 1957. Nitrogen and carbon change in Great Plains soils as influenced by cropping and soil treatments. USDA Tech. Bull. 1164. U.S. Government Printing Office, Washington, DC.

Hays, O.E., A.G. McCall, and F.G. Bell. 1949. Investigations in erosion control and reclamation of eroded land at the Upper Mississippi Valley Conservation Experiment Station near LaCrosse, Wisconsin, 1933-43. USDA Tech. Bull. 973. U.S. Government Printing Office, Washington, DC.

Heilman, M.D., and J.R. Thomas. 1961. Land leveling can adversely affect soil fertility. J. Soil Water Conserv. 16:71-72.

Hill, H.O., W.J. Peevy, A.G. McCall, and F.G. Bell. 1944. Investigations in erosion control and reclamation of eroded land at the Blackland Conservation Experiment Station, Temple, Texas, 1931-41. USDA Government Printing Office, Washington, DC.

Horner, G.M., A.G. McCall, and F.G. Bell. 1944. Investigations in erosion control and the reclamation of eroded land at the Palouse Conservation Experiment Station, Pullman, Washington, 1931-42. USDA Tech. Bull. 860. U.S. Government Printing Office, Washington, DC.

Jamison, V.C., D.D. Smith, and J.F. Thornton. 1968. Soil and water research on a claypan soil. USDA-ARS Tech. Bull. 1379. U.S. Government Printing Office, Washington, D.C.

Kamprath, E.J. 1970. Exchangeable aluminum as a criterion for liming leached mineral soils. Soil Sci. Soc. Am. Proc. 34:252-254.

Kiniry, L.N., C.L. Scrivner, and M.E. Keener. 1983. A soil productivity index based upon predicted water depletion and root growth. Missouri Agric. Exp. Stn. Res. Bull. 1051.

Knisel, W.G. 1980. CREAMS: A field scale model for chemicals, runoff, and erosion from agricultural management systems. USDA Conservation Res. Rep. 26, Tuscon, AZ.

Langdale, G.W., J.E. Box, Jr., R.A. Leonard, A.P. Barnett, and W.G. Fleming. 1979. Corn yield reduction on eroded Southern Piedmont soils. J. Soil Water Conserv. 34:226-228.

Langdale, G.W., H.P. Denton, A.W. White, Jr., J.W. Gilliam, and W.W. Frye. 1985. Effects of soil erosion on crop productivity of southern soils. p. 251-270. *In* R.F. Follett and B.A. Stewart (ed.) Soil erosion and crop productivity. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, WI.

Langdale, G.W., and W.D. Shrader. 1982. Soil erosion effects on soil productivity of cultivated cropland. p. 41-51. *In* B.L. Schmidt (ed.) Determinants of soil loss tolerance. Spec. Pub. 45. American Society of Agronomy, Madison, WI.

Latham, E.E. 1940. Relative productivity of the A horizon of the acid sandy loam and the B and C horizons exposed by erosion. J. Am. Soc. Agron. 32:950-954.

Laws, J.O. 1940. Recent studies in raindrops and erosion. Agr. Engr. 21:431-433.

Laws, J.O., and D.A. Parsons. 1943. The relationship of raindrop size to intensity. Trans. Am. Geophys. Union 24:452-460.

Logan, T.J. 1982. Improved criteria for developing soil loss tolerance levels for cropland. p. 131-138. *In* B.L. Schmidt (ed.) Determinants of soil loss tolerance. Spec. Pub. 45. American Society of Agronomy, Madison, WI.

Lyles, L., G.W. Cole, and L.J. Hagen. 1985. Wind erosion: Processes and prediction. p. 163-172. *In* R.F. Follett and B.L. Schmidt (ed.) Soil erosion and crop productivity. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, WI.

Mannering, J.V., D.P. Franzmeier, D.L. Schertz, W.C. Moldenhauer, and L.D. Norton. 1985. Regional effects of soil erosion on crop productivity -- Midwest. p. 271-284. *In* R.F. Follett and B.A. Stewart (ed.) Soil erosion and crop productivity. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, WI.

Meyer, L.D., A. Bauer, and R.D. Heil. 1985. Experimental approaches for quantifying the effect of soil erosion on productivity. p. 213-234. *In* R.F. Follett and B.A. Stewart (ed.) Soil erosion and productivity. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, WI.

Middleton, H.E. 1930. Properties of soils which influence erosion. USDA Tech. Bull. 178. U.S. Government Printing Office, Washington, DC.

Molina, J.A.E., M.J. Shaffer, R.H. Dowdy, and J.F. Power. 1985. Simulation of tillage, residue and nitrogen management. p. 413-430. *In* R.F. Follett and B.A. Stewart (ed.) Soil erosion and crop productivity. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, WI.

Morgan, R.P.C. 1979. Soil erosion. Longman Inc., New York.

Murdock, L.W., W.W. Frye, and R.L. Blevins. 1980. Economic and production effects of soil erosion. p. 31-35. *In* Proc. Southeastern Soil Erosion Control and Water Quality Workshop, Nashville, TN. November 1980. National Fertility Development Center, Muscle Shoals, AL.

Musgrave, G.W., and R.W. Norton. 1937. Soil and water conservation investigations at the Soil Conservation Experiment Station, Missouri Valley Loess Region, Clarinda, Iowa. USDA Tech. Bull. 558. U.S. Government Printing Office, Washington, DC.

Mutchler, C.K., and R.A. Young. 1975. Soil detachment by raindrops. p. 113-117. *In* Present and prospective technology for predicting sediment yields and sources. USDA-ARS Pub. ARS-S-40. U.S. Government Printing Office, Washington, D.C.

McCormack, D.E., K.K. Young, and L.W. Kimberlin. 1982. Current criteria for determining soil loss tolerance. p. 95-111. *In* B.L. Schmidt (ed.) Determinants of soil loss tolerance. Spec. Pub. 45. American Society of Agronomy, Madison, WI.

McDaniel, T.A., and B.F. Hajek. 1982. Past erosion reduces current yields. Alabama Agric. Exp. Stn. Highlights of Agric. Res. 29(3):10.

McDaniel, T.A., and B.F. Hajek. 1985. Soil erosion effects on crop productivity and soil properties in Alabama. p. 48-57. *In* Erosion and soil productivity. Proc. Natl. Symp. on Erosion and Soil Productivity, New Orleans, LA. 10-11 December 1984. American Society of Agricultural Engineers, St. Joseph, MI.

Olson, T.C. 1977. Restoring the productivity of a glacial till soil after topsoil removal. J. Soil Water Conserv. 32:130-132.

Onstad, C.A., and G.R. Foster. 1975. Erosion modeling on a watershed. Am. Soc. Agric. Eng. Trans. 18:288-292.

Palmer, R.S. 1964. The influence of a thin water layer on waterdrop impact forces. Int. Assoc. Scient. Hydrol. Pub. 65:141-148.

Papendick, R.I., D.L. Young, D.K. McCool, and H.A. Krauss. 1985. Regional effects of soil erosion on crop productivity -- The Palouse area of the Pacific Northwest. p. 305-320. *In* R.F. Follett and B.A. Stewart (ed.) Soil erosion and crop productivity. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, WI.

Pierce, F.J., R.H. Dowdy, W.E. Larson, and W.A.P. Graham. 1984. Soil productivity in the Corn Belt: An assessment of erosion's long-term effects. J. Soil Water Conserv. 39:131-136.

Pierce, F.J., W.E. Larson, R.H. Dowdy, and W.A.P. Graham. 1983. Productivity of soils: Assessing long-term changes due to erosion. J. Soil Water Conserv. 38:39-44.

Pope, J.B., J.C. Archer, P.R. Johnson, A.G. McCall, and F.G. Bell. 1946. Investigations in erosion control and reclamation of eroded sandy clay lands of Texas, Arkansas, and Louisiana at the Conservation Experiment Station, Tyler, Texas, 1931-40. USDA Tech. Bull. 916. U.S. Government Printing Office, Washington, DC.

Richardson, C.W. 1981. Stochastic simulation of daily precipitation, temperature, and solar radiation. Water Resources Res. 17:182-190.

Rost, C.O. 1940. The relative productivity of humid subsoils. Soil Sci. Soc. Am. Proc. 4:281-287.

Rust, R.H., and L.D. Hanson. 1975. Crop equivalent rating guide for soils of Minnesota. Minnesota Agric. Exp. Stn. Misc. Rpt. 132. University of Minnesota, St. Paul.

Schertz, D.L., W.C. Moldenhauer, D.P. Franzmeier, and H.R. Sinclair, Jr. 1985. Field evaluation of the effect of soil erosion on crop productivity. p. 9-17. *In* Erosion and soil productivity. Proc. Natl. Symp. on Erosion and Soil Productivity, New Orleans, LA. 10-11 December 1984. American Society of Agricultural Engineers, St. Joseph, MI.

Schwab, G.O., R.K. Frevert, T.W. Edminster, and K.K. Barnes. 1981. Soil and water conservation engineering. 3rd ed. John Wiley, New York.

Scrivner, C.L., Conkling, and P.G. Koenig. 1985a. Soil productivity indices and soil properties for farm-field sites in Missouri. Missouri Agric. Ext. Cir. 947.

Scrivner, C.L., P.G. Koenig, and B.L. Conkling. 1985b. The effects of soil erosion upon soil productivity in Missouri farm-fields. Missouri Agric. Ext. Cir. 950.

Shaffer, M.J. 1985. Simulation model for soil erosion-productivity relationships. J. Environ. Qual. 14:144-150.

Shaffer, M.J., S.C. Gupta, D.R. Linden, J.A.E. Molina, C.E. Clapp, and W.E. Larson. 1983. Simulation of nitrogen, tillage, and residue management effects on soil fertility. p. 525-544. *In* Proc. Third Int. Conf. on State-of-the-Art in Ecological Modelling, Colorado State University, Ft. Collins, CO. 24-28 May 1982. International Society for Ecological Modeling, Copenhagen, Denmark.

Smith, D.D., D.M. Whitt, A.W. Zingg, A.G. McCall, and F.G. Bell. 1945. Investigations in erosion control and reclamation of eroded Shelby and related soils at the Conservation Experiment Station, Bethany, Missouri, 1930-42. USDA Tech. Bull. 883. U.S. Government Printing Office, Washington, DC.

Smith, D.D., and W.H. Wischmeier. 1962. Rainfall erosion. Adv. Agron. 14:109-148.

Smith, R.M., R.C. Henderson, E.D. Cook, J.E. Adams, and D.O. Thompson. 1967. Renewals of desurfaced Austin clay. Soil Sci. 103:126-130.

Spomer, R., W.D. Shrader, P. Rosenberry, and E.L. Miller. 1973. Level terraces with stabilized backslopes on loessial cropland in the Missouri Valley -- A cost-effectiveness study. J. Soil Water Conserv. 28:127-131.

Stevenson, F.J. 1986. Cycles of soil: Carbon, nitrogen, phosphorus, sulfur, micronutrients. John Wiley and Sons, New York.

Stone, J.R., J.W. Gilliam, D.K. Cassell, R.B. Daniels, L.A. Nelson, and H.J. Kleiss. 1985. Effect of erosion and landscape position on productivity of Piedmont soils. Soil Sci. Soc. Am. J. 49:987-991.

Thomas, D.J., and D.K. Cassel. 1979. Land-forming Atlantic Coastal Plain soils: Crop yield relationships to soil physical and chemical properties. J. Soil Water Conserv. 34:20-24.

Trimble, S.W. 1974. Man-induced soil erosion on the southern Piedmont: 1700-1970. Soil Conservation Society of America, Ankeny, IA.

Troeh, F.R., J.A. Hobbs, and R.L. Donahue. 1980. Soil and water conservation for productivity and environmental protection. Prentice-Hall, Inc., Englewood Cliffs, NJ.

USDA. 1938. Soils and men. Yearbook of Agriculture. U.S. Government Printing Office, Washington, DC.

USDA. 1978. National resources inventory. U.S. Government Printing Office, Washington, DC.

USDA. 1981. Soil, water, and related resources in the United States. 1980 RCA Appraisal, Part I. U.S. Government Printing Office, Washington, DC.

Wetter, F. 1977. The influence of topsoil depth on yield. USDA-SCS Tech. Note 10. U.S. Government Printing Office, Washington, DC.

White, A.W., Jr., R.R. Bruce, A.W. Thomas, G.W. Langdale, and H.F. Perkins. 1985. Characterizing productivity of eroded soils in the Southern Piedmont. p. 83-95. *In* Erosion and soil productivity. Proc. Natl. Symp. on Erosion and Soil Productivity, New Orleans, LA. 10-11 December 1984. American Society of Agricultural Engineers, St. Joseph, MI.

White, A.W., Jr., R.R. Bruce, A.W. Thomas, G.W. Langdale, H.F. Perkins, and R.L. Wilson. 1983. Effect of soil erosion on soybean production in the Southern Piedmont of Georgia. Agron. Abstr. 75:205.

Whitney, R.S., R. Gardner, and D.W. Robertson. 1950. The effectiveness of manure and commercial fertilizers in restoring the productivity of subsoils exposed by leveling. Agron. J. 42:239-245.

Wight, J.R. (ed.) 1983. SPUR -- Simulation of production and utilization of rangelands: A rangeland model for management and research. USDA-ARS Misc. Pub. 1431.

Williams, J.R. 1975. Sediment yield prediction with universal equation using runoff energy factor. p. 224-252. *In* Present and prospective technology for predicting sediment yields and sources. USDA-ARS-S-40. U.S. Government Printing Office, Washington, DC.

Williams, J.R., R.R. Allmaras, K.G. Renard, L. Lyles, W.C. Moldenhauer, G.W. Langdale, L.D. Meyer, and W.J. Rawls. 1981. Soil erosion effects on soil productivity: A research perspective. J. Soil Water Conserv. 36:82-90.

Williams, J.R., P.T. Dyke, and C.A. Jones. 1983. EPIC -- A model for assessing the effects of erosion on soil productivity. p. 553-572. *In* Proc. Third Int. Conf. on State-of-the-Art in Ecological Modelling, Colorado State University, Ft. Collins, CO. 24-28 May 1982. International Society for Ecological Modeling, Copenhagen, Denmark.

Williams, J.R., J.W. Putnam, and P.T. Dyke. 1985. Assessing the effect of soil erosion on productivity with EPIC. p. 215-226. *In* Erosion and soil productivity. Proc. Natl. Symp. on Erosion and Soil Productivity, New Orleans, LA. 10-11 December 1984. American Society of Agricultural Engineers, St. Joseph, MI.

Williams, J.R., and K.G. Renard. 1985. Assessment of soil erosion and crop productivity with process models (EPIC). p. 67-103. *In* R.F. Follett and B.A. Stewart (ed.) Soil erosion and crop productivity. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, WI.

Williams, J.R., K.G. Renard, and P.T. Dyke. 1983. EPIC: A new method for assessing erosion's effect on soil productivity. J. Soil Water Conserv. 38:381-383.

Wischmeier, W.H. 1959. A rainfall erosion index for a universal soil-loss equation. Soil Sci. Soc. Am. Proc. 23:246-249.

Wischmeier, W.H. 1977. Use and misuse of the universal soil loss equation. p. 371-378. *In* Soil erosion: Prediction and control. Proc. Natl. Conf. on Soil Erosion, Purdue University, West Lafayette, IN. 24-26 May 1976. Soil Conservation Society of America, Ankeny, IA.

Wischmeier, W.H., and D.D. Smith. 1958. Rainfall energy and its relationship to soil loss. Am. Geophy. Union Trans. 39:285-291.

Wischmeier, W.H., and D.D. Smith. 1965. Predicting rainfall-erosion losses from cropland east of the Rocky Mountains -- Guide for selection of practices for soil and water conservation. USDA Agric. Handb. 282. U.S. Government Printing Office, Washington, DC.

Wischmeier, W.H., and D.D. Smith. 1978. Predicting rainfall erosion losses: A guide to conservation planning. USDA Agric. Handb. 537. U.S. Government Printing Office, Washington, DC.

Woodmansee, R.G., and W.K. Lauenroth. 1983. Modeling Reality: Fact, Fancy, and Fiction. p. 39-42. *In* Proc. Third Int. Conf. on State-of-the-Art in Ecological Modelling, Colorado State University, Ft. Collins, CO. 24-28 May 1982. International Society for Ecological Modeling, Copenhagen, Denmark.

Woodruff, N.P., and F.H. Siddoway. 1965. A wind erosion equation. Soil Sci. Soc. Am. Proc. 29:602-608.

CHAPTER 3

Effects of Erosion on Productivity of Cecil-Pacolet Soils in the Virginia Piedmont

Abstract

A study was initiated in two counties in the southern Virginia Piedmont to assess the effects of erosion on soil properties and crop productivity. Plots were established in farmer-cooperator fields on slightly, moderately, and severely eroded Cecil and Pacolet soils (clayey, kaolinitic, thermic Typic Hapludults). Definite relationships were not observed between most of the soil properties when related to slight and moderate erosion classes. The magnitude of difference between non-eroded and severely eroded soils is difficult to assess because of the absence of uneroded upland Piedmont soils by which such comparisons are made. Thus, estimates of the severity of erosion may be incorrect. Relationships between erosion class and soil properties as the soils became more severely eroded were observed. Thickness of the Ap horizon was less as severity of erosion increased although no differences were observed for Bt and solum thicknesses. Clay content of the Ap horizon increased as the severity of erosion increased. Increases in clay content were reflected by several soil properties. The volumetric water contents at -10kPa and -1500kPa increased with

clay content of the Ap but the differences in plant available water between the two remained at 0.09 $m^3\ m^{-3}$. Thus, the effect of erosion on plant available water, observed over the three erosion classes in both the Ap and Bt horizons, was negligible. Cation exchange capacity (CEC) and effective CEC were higher on the severely eroded sites. Exchangeable aluminum (Al) expressed as percent of the exchange complex and as concentration in the soil, was lower than expected and had no apparent adverse impact on yields. Available phosphorus (P) decreased with severity of erosion and was significantly correlated with soybean grain yield. The highest grain yield was obtained on the moderately eroded sites but the yields were similar to those on the slightly eroded sites. The similarity between yields was attributed to levels of available P above the 18 mg kg^{-1} of P critical level for optimal crop growth. Low yields on the severely eroded sites corresponded to available P values below 18 mg kg^{-1}.

Introduction

The southern Piedmont is one of the most severely eroded agricultural areas in the United States. Most of the soil loss occurred between 1700 and 1860 when exploitation of the soil was encouraged by the abundance of cheap land. The continuous and abusive cultivation of corn, cotton, and tobacco attributed to the loss of about 18 cm of topsoil in the Virginia Piedmont to approximately 30 cm from the Piedmont region in South Carolina. When the land became exhausted and no longer productive, it was abandoned and slowly reconverted to scrubland and forest. Soil conservation measures, implemented in the 1930's and carried on through the present, have decreased the rates of soil loss due to erosion. Through these conservation efforts, and modern fertilization practices, a considerable portion of eroded land in the Piedmont has been returned to agricultural production (Trimble, 1974).

Research has been conducted sporadically since the 1930's on the effect of severity of erosion on productivity of soils in the Piedmont. Latham (1940) and Copley et al. (1944) reported cotton yield reductions as great as 50 percent on severely eroded soils. Under modern technology, yields have increased more than 100 percent on both eroded and noneroded soils, but relative yield differences between the two have remained the same. Yield reductions on eroded soils now average 40 percent unless corrective treatments, other than fertilizers, are applied (Langdale et al., 1979).

Soybean yields on a Typic Hapludult in the Georgia Piedmont were positively correlated with Ap thickness, depth to the top of the Bt horizon, solum thickness, and extractable P in the surface horizon (White et al., 1985). Similar studies have been conducted in the Piedmont region of North Carolina (Stone et al., 1985). Topsoil depth and available P in the plow layer decreased with increasing severity of erosion, although P levels were high enough to be considered adequate for crop growth. Organic matter and plant available water-holding capacity of the Ap horizon tended to be slightly higher on the more eroded sites but not high enough to significantly affect yields (Stone et al., 1985).

Studies of the effects of erosion on soil productivity should not be restricted only to the A horizon. Although the primary rooting zone of most agricultural crops is in the upper 10-20 cm, the underlying horizons are important because they may restrict water movement and rooting depth. These subsoil horizons often become the rooting zone due to removal of the surface layer by erosion. On Fragiudalfs in Kentucky, susceptibility to water stress and grain yields decreased with decreasing depth to the restrictive fragipan horizon (Frye et al., 1982; Frye et al., 1985). In soils in the southeastern U.S., restrictive subsurface horizons are often thought to be due to chemical rather than physical restrictions. At pH values below 5.5, Al^{3+} becomes soluble and can be toxic to crop growth at high levels. Yields of corn and soybeans are drastically reduced at Al saturations above 44 and 20 percent, respectively (Kamprath, 1970).

The Cecil and thinner-solum Pacolet series are major agricultural soils in the southern Piedmont region of the United States and are also the major agricultural soils in Virginia's southern Piedmont. Most erosion-productivity studies in the Piedmont have been conducted on these soils. Cecil and Pacolet soils are typified by sandy loam surface horizons where only slightly eroded and sandy clay loam to clay loam surfaces where more severely eroded. The underlying B horizon is red, well-structured, and contains 40 to 60 percent clay. These soils are naturally infertile with low cation exchange capacities and low base saturations. They should be conducive, however, to optimal crop growth with proper management.

The objective of this research was to determine the effects of erosion on selected soil morphological, physical, and chemical properties of the A and B horizons of Cecil and Pacolet soils and to relate these properties to soybean yields.

Materials and Methods

Three farmer-operated fields in Pittsylvania and Lunenburg counties in the Virginia Piedmont were located in 1984 to evaluate the effects of erosion on productivity (Figure 4). All fields were planted to minimum-tilled soybeans (*Glycine max* L. cv. Essex, Ransom). The fields were fertilized, limed, and seeded at rates recommended by the Virginia Cooperative Extension Service so that all fields were maintained at moderate to high management levels. Fields in the study areas were mapped as either Cecil or Pacolet (clayey, kaolinitic, thermic Typic Hapludults) with B slopes (2-6%).

Thirty-six plots were randomly located in the three fields. Twenty-five of the plots were located in Pittsylvania County and the other 11 plots were in Lunenburg County. The plots were selected without regard to erosion classes since the primary emphasis of the study was on soil properties. However, to determine erosion-soil property relationships, slight, moderate, and severe erosion classes were described at each plot according to Soil Conservation Service (SCS) guidelines (Soil Survey Staff, 1984). The criteria most commonly used for field identification of erosion severity in the Piedmont, are color and clay content of the surface horizon. In general, a soil with 10YR sandy loam surface horizon is considered slightly eroded, 7.5YR sandy clay loam surface horizon is moderately eroded, and 5YR sandy clay loam to clay loam surface indicates severely eroded conditions.

All erosion classes were not expected in each field and therefore were not evenly distributed between the two counties. Of the 36 total plots, 10 were slightly eroded, 17 were moderately eroded, and 9 were severely eroded. Each plot was 1.5-m wide and 7-m long.

Three locations within each plot were randomly selected and 7.5-cm diameter cores taken to a depth of 2-m with a truck-mounted hydraulic-powered "Bull"[1] probe. Profile descriptions were made on each core and samples were collected from the Ap and Bt horizons for physical and

[1] Use of brand names does not imply endorsement by Virginia Polytechnic Institute and State University.

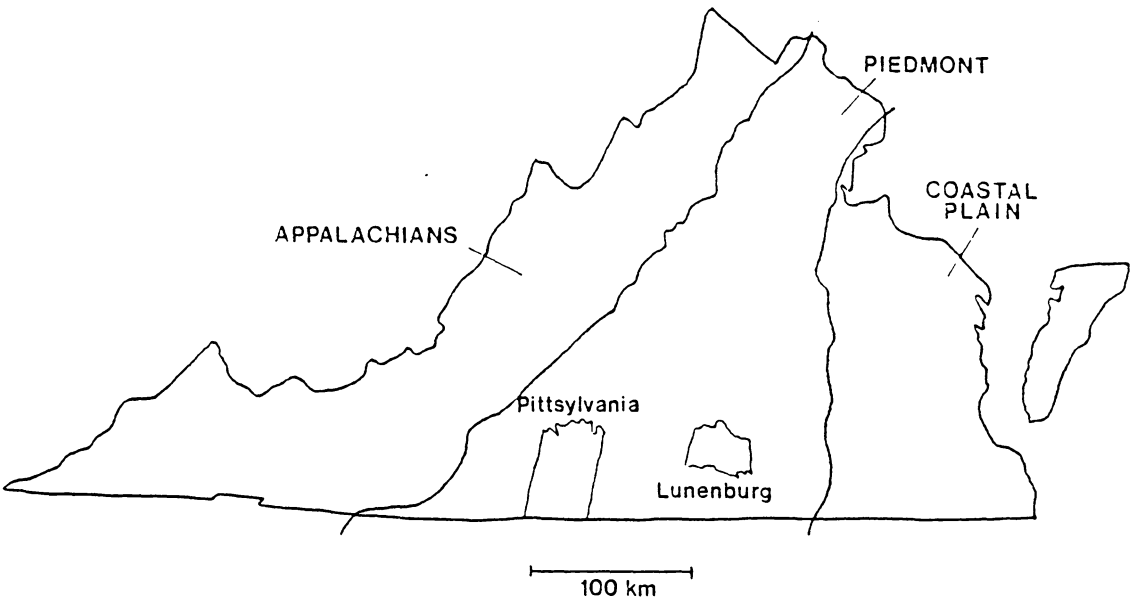

Figure 4. Location of study areas in the Virginia Piedmont.

chemical analysis. Separate 4.8-cm x 2.5-cm core samples were taken, one per plot per horizon, with a double cylinder, hammer-driven core sampler for determination of bulk density and volumetric water contents.

Particle size distribution of the samples was determined by sieving and hydrometer (Day, 1965). Bulk density and -10kPa volumetric water content were determined on the double-cylinder soil cores. Volumetric water content at -1500kPa was determined on crushed and sieved core samples used previously for the -10kPa determinations (Richards, 1965).

Chemical properties analyzed included pH, cation exchange capacity (CEC), effective CEC (sum of exchangeable bases plus exchangeable Al), organic matter, and available P. Soil pH was measured in a 1:1 soil to water paste. Hydronium ion (H_3O^+) concentrations for pH were used for all statistical analyses. Exchangeable bases (Ca^{2+}, Mg^{2+}, K^+) were extracted with 1 *M* NH_4OAc and determined by atomic absorption photometry. Extractable acidity was determined by extraction with $BaCl_2$-triethanolamine (Peech, 1965). Exchangeable Al was extracted with 1 *M* KCl (Yuan, 1959). Soil organic matter was determined using the Walkley-Black method (Allison, 1965). Available P was determined following extraction with 0.05 *M* HCl + 0.013 *M* H_2SO_4 (Mehlich, 1953). The Murphy-Riley colormetric procedure (Watanbe and Olsen, 1965) was used to measure P in the extracts.

Soybeans were harvested at maturity from a 7-m long segment on four 18-cm drilled rows in each plot. Grain yields were adjusted for 13 percent moisture.

A one-way analysis of variance procedure for unequal numbers and with subsampling was used to detect differences between erosion classes for grain yields and soil properties. Stepwise regression techniques were used to isolate soil properties significantly correlated to soybean yields (SAS, 1985).

Results and Discussion

Soil Properties

One of the criteria for determining erosion classes is comparing how much of the original A horizon is remaining to the thickness of uneroded original A horizon. In the Piedmont, this task is made difficult because very few areas have escaped damage by erosion and thus few soils have any of their original topsoil remaining (Trimble, 1974). Ap thickness generally is a good indicator of erosion severity in Piedmont soils because cultivating the more severely eroded soils, with thinner original surface horizons, requires plowing in the clayey Bt horizon. This entails expending more energy to plow into the high clay subsoil and thus tillage implements may not penetrate as deeply as they would if the soil was less eroded. In our study, Ap thickness was significantly less as the soils became more eroded (Table 7). Typically, the severity of erosion is often extrapolated using soil characteristics believed to be correlated with erosion. In the Piedmont, these characteristics are color and clay content of surface horizon. The Munsell hue shifts through 10YR, 7.5YR to 5YR as the soils become more eroded (Table 7). Changes in clay content do not directly parallel the change in color across erosion classes until the soil becomes severely eroded (Table 8).

Although Ap thickness is less as soils become more eroded, there is no apparent effect on solum thickness and depth to the bottom of the Bt horizon due to erosion. This is in contradiction to other findings. In general, soils erode more rapidly than new soil material is formed. As a result, overall solum thickness is reduced. Moderately and severely eroded Cecil soils in Georgia had decreasing Bt thicknesses with increasing severity of erosion (White et al., 1985).

Clay content of the Ap horizon increases as the severity of erosion increases (Table 8). Increases in clay content affects both physical and chemical soil properties of the Ap horizon. Bulk density normally would be expected to decrease as the clay percentage increases but we observed no significant effect of increasing erosion severity and increasing clay contents on bulk density.

Table 7. **Mean values and standard deviations of selected morphological properties among erosion classes of Cecil-Pacolet soils.**

Soil Property	Erosion Classes			Sig. level‡ PR > F
	Slight	Moderate	Severe	
	n = 10	n = 17	n = 9	
Ap thickness *(cm)*	24a ± 6	15b ± 5	17b ± 6	0.0001
Bt depth (bottom) *(cm)*	75a ± 30	65a ± 23	75a ± 27	0.1198
Solum thickness *(cm)*	113a ± 42	121a ± 31	127a ± 39	0.4058
Color (Ap) *(Munsell hue)*	10YR	7.5YR	5YR	.

†Values within a row followed by the same letter are not significantly different at the 0.05 probability level by the *t*-test.
‡Probability that no differences exists within a row.

Table 8. Mean values and standard deviations of selected physical properties among erosion classes of Cecil-Pacolet soils.

Soil Property	Horizon	Erosion Classes			Sig. level‡
		Slight	Moderate	Severe	PR > F
		n = 10	n = 17	n = 9	
Clay	Ap	19.9a† ±4.8	18.4a ±6.0	28.8b ±5.7	0.0001
(%)	Bt	48.6a ±7.8	48.7a ±6.5	52.7b ±7.2	0.0206
Bulk Density	Ap	1.54a ±0.24	1.61a ±0.17	1.53a ±0.17	0.5742
(Mg m^{-3})	Bt	1.56a ±0.09	1.52a ±0.10	1.49a ±0.10	0.2895
-10kPa	Ap	0.26a ±0.03	0.27a ±0.06	0.33b ±0.07	0.0330
(m^3 m^{-3})	Bt	0.42a ±0.04	0.44a ±0.05	0.46a ±0.05	0.2076
-1500kPa	Ap	0.18a ±0.04	0.18a ±0.05	0.24b ±0.09	0.0345
(m^3 m^{-3})	Bt	0.35a ±0.06	0.36a ±0.05	0.38a ±0.05	0.4525
Plant Available Water	Ap	0.08a ±0.04	0.09a ±0.06	0.09a ±0.04	0.8553
(m^3 m^{-3})	Bt	0.07a ±0.04	0.08a ±0.06	0.08a ±0.04	0.9125

†Values within a row followed by the same letter are not significantly different at the 0.05 probability level by the *t*-test.
‡Probability that no differences exists within a row.

Table 9. Mean values and standard deviations of selected chemical properties among erosion classes of Cecil-Pacolet soils.

Soil Property	Horizon	Erosion Classes			Sig. level‡
		Slight	Moderate	Severe	PR > F
		n = 10	n = 17	n = 9	
pH	Ap	5.5a ±0.5	5.8b ±0.4	5.5a ±0.2	0.0006
	Bt	4.8a ±0.3	4.8a ±0.3	4.9a ±0.2	0.0875
CEC	Ap	6.6a ±1.2	6.4a ±2.2	8.8b ±2.2	0.0001
(cmol (+) kg^{-1})	Bt	12.3ab ±2.8	11.5b ±2.1	13.5a ±2.3	0.0029
Effective CEC	Ap	3.0a ±0.9	2.8a ±0.8	3.3a ±0.7	0.0695
(cmol (+) kg^{-1})	Bt	5.1a ±1.2	4.5b ±0.8	5.0ab ±1.1	0.0113
Exchangeable Al^{3+}	Ap	0.2a ±0.3	0.1b ±0.1	0.2a ±0.2	0.0005
(cmol (+) kg^{-1})	Bt	1.9a ±1.2	1.4a ±0.9	1.6a ±0.8	0.0934
Organic Matter	Ap	14.8a ±4.1	14.2a ±3.7	12.8a ±4.1	0.0600
(g kg^{-1})	Bt	4.7a ±1.9	4.0a ±1.5	4.6a ±1.7	0.1203
Available P	Ap	25.4a ±26.6	23.1a ±22.3	8.9b ±12.6	0.0099
(mg kg^{-1})					

†Values within a row followed by the same letter are not significantly different at the 0.05 probability level by the *t*-test.
‡Probability that no differences exists within a row.

There is an increase in both -10kPa water content, the upper limit of plant available water, and -1500kPa water content, the lower limit of plant available water, in the Ap horizon as the severity of erosion and clay content increases. There is no difference in water contents in the Bt horizon across erosion classes, although the values do reflect the increasing clay contents of the argillic horizon. The amount of plant available water, defined as the difference between -10kPa and -1500kPa water contents, does not significantly change with degree of erosion. Similar low water contents were observed by Starner (1985)[2] for a Cecil soil in Nottoway County, Virginia and by an SCS study on Cecil and related soils throughout the southern U.S. Piedmont (USDA-SCS, 1979). The soil in Nottoway County, Virginia yielded only 16 percent water by volume from near saturation to wilting point in the A horizon. The Bt horizon contained even less plant available water with an average value of five percent water by volume. The SCS report lists average plant available water contents, from -33kPa to -1500kPa, of no higher than nine percent in both A and B horizons. These data suggest than in a year drier than normal, the Cecil soil would not be able to meet crop demands for water.

Exchange capacities of the surface horizon parallel the clay content in the three erosion classes (Table 9). Clay increases the amount of negative charge and thus increases the cation holding capacity of the soil. Organic matter decreased in the Ap horizon as severity of erosion increased although the differences were small. It is possible that the decrease in organic matter is due to removal of organic matter-clay complexes by erosion. Stone et al. (1985) found that organic matter increased with increasing severity of erosion. The increase was presumed to be related to formation of the stable organic-clay complexes which reduce the rate of organic matter decomposition. The differences in organic matter contents in the North Carolina soils were similar to the small differences observed in the Virginia Piedmont soils.

Erosion had a dramatic impact on available P in the surface horizon (Table 9). Increasing clay contents in the surface horizon as the soil becomes more eroded enhances the possibility of P fixation. The clays in the highly weathered southern Piedmont soils are coated with Fe and Al

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[2] Starner, D.E. 1985. Field and laboratory characterization of soil water desorption properties and comparison of plant available water for two Virginia soils. Unpubl. M.S. Thesis. Virginia Polytechnic Institute and State University, Blacksburg.

hydrous oxides. The mechanism of P fixation occurs primarily as an absorption reaction between $H_2PO_4^-$ and a OH^- associated with Al or Fe hydrous oxide (Hsu, 1965). As much as 90 percent of applied P may end up in combination with Al or Fe (Yuan et al., 1960).

Bt horizon properties show little relation to erosion class (Tables 8 and 9). Subsoils usually escape erosion damage and thus the properties do not change appreciably. The significance in CEC and effective CEC between erosion classes is probably related to the increase in clay content from the Ap to the Bt horizon.

Soybean Grain Yields

Soybean grain yields were not significantly different among the three erosion classes (Figure 5). Yields averaged 2.0, 2.1, and 1.4 Mg ha^{-1} on slightly, moderately, and severely eroded soils, respectively. Although there were no statistically detectable differences in yields, there was a trend for yields to be higher on the slightly and moderately eroded sites compared to the severely eroded soils. Similar trends for corn grain yields have been observed on moderately eroded Cecil soils in the North Carolina Piedmont (Stone et al., 1985). On these soils, the higher-yielding moderately eroded plots had higher plant available water holding capacities than the slight and moderate erosion classes. The differences, however, were believed to have no significant effect on yields. In our study, low plant available water contents among erosion classes were not necessarily reflected in crop yields. Precipitation data from nearby weather stations recorded precipitation five cm greater than normal in July and August of 1984 (HISARS, 1985). However, the low plant available water-holding capacities of these soils did not allow for storage of this excess water in the soil between rain events.

Although the data presented showed that several soil properties are significantly affected by erosion, regression analysis indicated only two properties to be correlated with soybean grain yields. Yields can be estimated by the equation

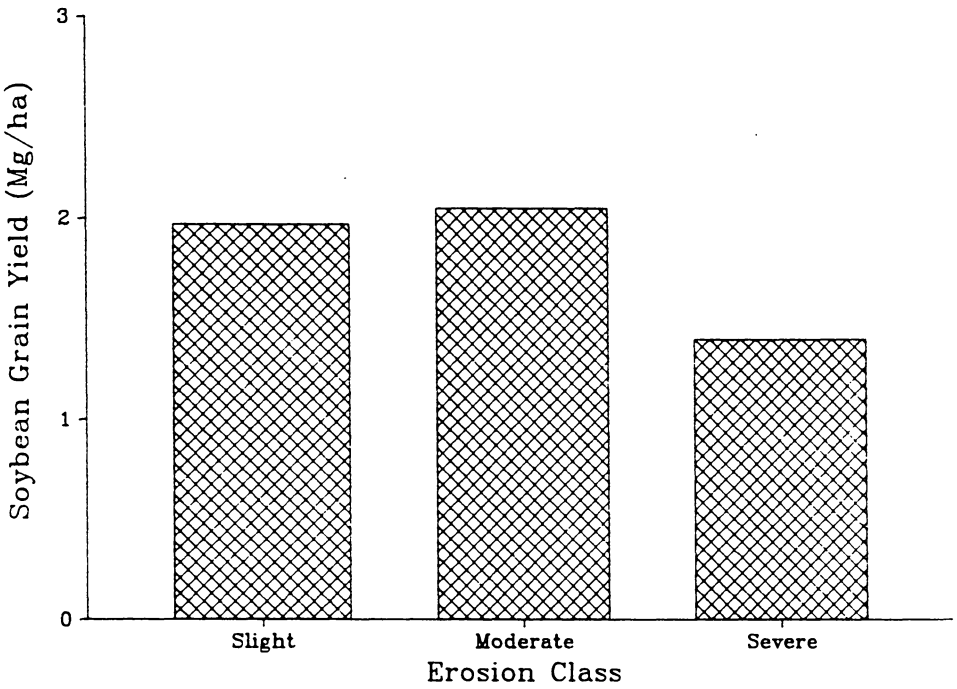

Figure 5. Soybean grain yields as affected by erosion class.

$$\bar{y} = 0.05 + 0.95 \log P + 0.008S$$

where $\bar{y}$ is estimated soybean yield in Mg ha^{-1}, P is available P in mg kg^{-1}, and S is solum thickness in cm. The prediction equation has an R^2 of 0.73. Available P has a beneficial effect in terms of the amount of P for crop uptake. An examination of the chemical condition of the subsoil reveals that solum thickness should have a negative impact on yields. According to Kamprath (1970) soybean roots should not penetrate zones with Al saturations greater than 20 percent. Aluminum saturations in the Bt horizon exceed this limit in all three erosion classes (Table 9). Therefore, theoretically, the soybean roots should not be penetrating into the subsoil. However, regression analysis did not isolate either Al concentrations or exchange complex saturations as affecting yields. Field examination of rooting distributions showed that roots were proliferating into the B horizon.

The Al concentrations and saturations in the Bt horizon are not consistent with long-held assumptions about acidity in soils of the southeastern U.S. (Coleman and Thomas, 1967). Acidity in soils is due almost entirely to trivalent Al. Below water pH values of about 5.5, Al^{3+} occurs in amounts significant enough to produce conditions of potential Al toxicity (McCart and Kamprath, 1965). Since roots in the Cecil soils of this study are proliferating in the subsoil, the Al^{3+} presumably does not occur in great enough amounts to cause reductions or cessation of root growth.

Although Al^{3+} concentrations are not high in our study, pH values in the Bt horizons are strongly acid, ranging from 4.4 to 5.8. Unpublished data from C.I. Rich also noted the lack of high amounts of exchangeable Al in other acid soils of the Virginia Piedmont. Another source for the hydronium ions must be present in these soils. Manganese (Mn) or iron (Fe) would be the logical proton donator, however, this hypothesis was not investigated in this study.

Single factor regression analysis of both variables indicated that available P was the best single predictor of soybean yields. An R^2 of 0.62 was attained with the logarithmic function

$$\bar{y} = 0.92 + 1.01 \log P$$

where $\bar{y}$ is estimated soybean yield in Mg ha^{-1}, and P is available P in mg kg^{-1}. At low levels of available P, yields increase rapidly with small increments of available P (Figure 6). Yields reach a maximum response point at which response to available P occurs at a much reduced rate. The maximum response point occurs near 18 mg kg^{-1}, the critical value for P in Virginia soils (Donohue and Hawkins, 1979).

Soybean grain yields were comparative to the amount of available P in the three erosion classes (Figure 7). Levels of available P occur above the 18 mg kg^{-1} critical level for both the slight and moderate classes and below the critical level on the severely eroded sites. Yields on the slight and moderate erosion classes are nearly equal and this similarity may be due to the availability of adequate P levels in these soils. Conversely, on severely eroded soils where P is below the level for optimum crop growth, yields are low. Available P between erosion classes within the individual fields was consistently lower on the severely eroded sites even with high overall P levels observed on one farm.

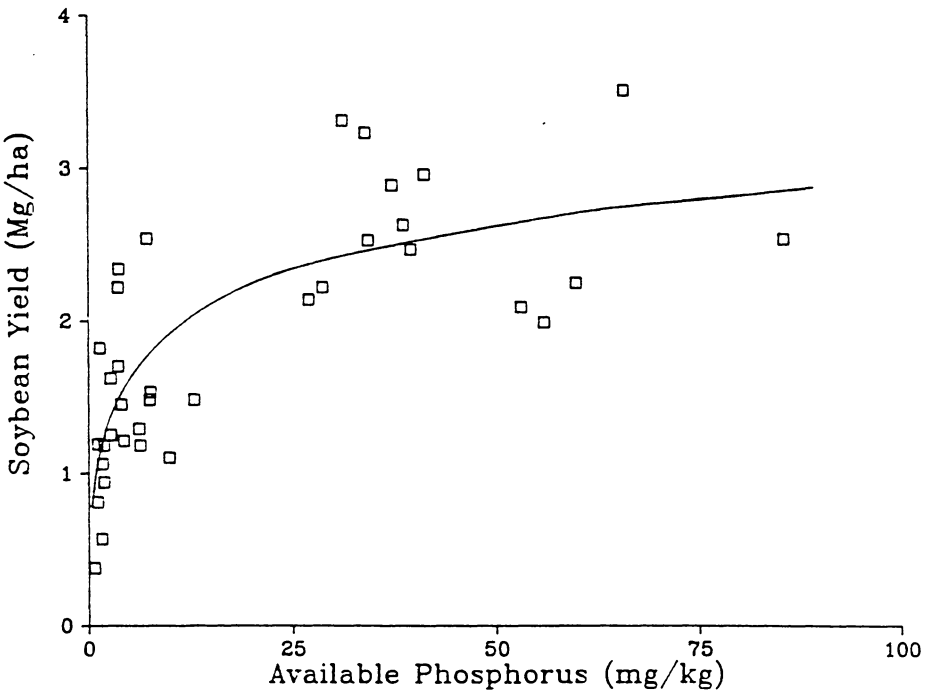

Figure 6. Response curve for available P.

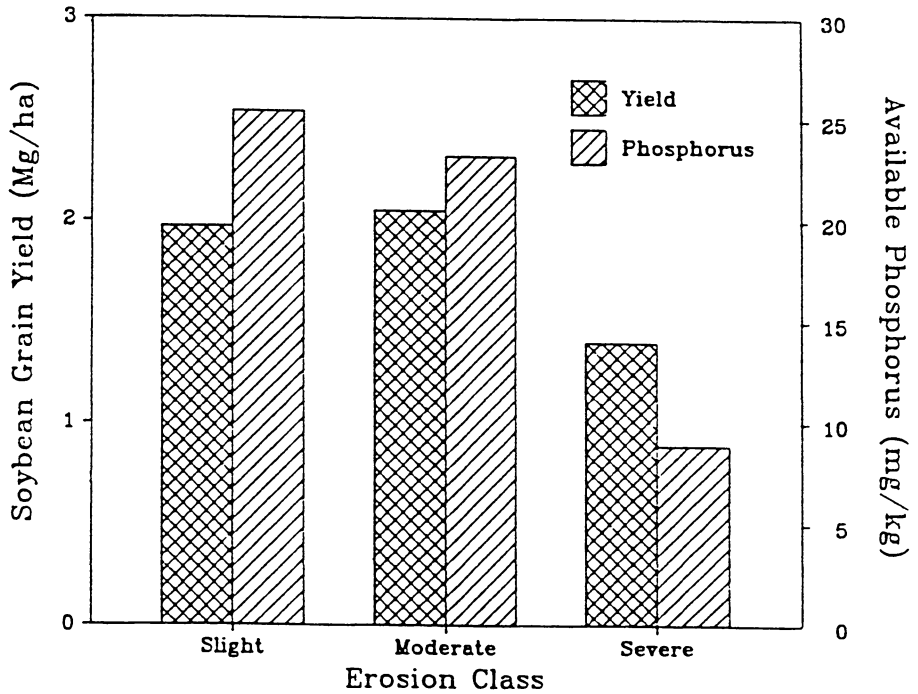

Figure 7. Available P and soybean grain yields as affected by erosion class.

Summary and Conclusions

Degree of erosion is typically equated with how much of the original A horizon is left yet soils that had thin A horizons to begin with would show up as being highly eroded. These sites in fact may have lost less soil than soils with originally much thicker A horizons. A typical Piedmont landscape would have the thinnest A horizons occurring on areas with diverging water flows, or the shoulder positions. Thickest A horizons would occur on summit and footslope positions with converging water flows. It is highly unlikely that, even in an uneroded state, Cecil and Pacolet A horizons were of uniform thickness over all landscape positions. Although only general observations were made about landscape position at initiation of the study, this relationship would be expected. Daniels et al. (1985) noted a close relationship between landscape position and erosion classes in Cecil landscapes in the North Carolina Piedmont. They suggested that large variations in original thickness of surface horizons may have contributed to present distribution of erosion classes.

The degree of erosion between slight and moderate erosion classes exhibited no relationship with most of the observed soil properties. Because slight and moderate erosion exhibit similar soil properties, the differences in the degree of soil loss between the two classes may be smaller than the indicator soil properties of color and clay content of the surface horizon suggest. As the soils reach the severely eroded level, relationships between soil properties and erosion classes were evident. Ap thickness is reduced and clay contents increase as the soils become more eroded. The decrease in surface soil thickness as soil material is removed by erosion requires plowing into the underlying clayey B horizon, which incorporates higher amounts of clay into the new surface horizon. The higher clay contents significantly affect the amount of water at -10kPa and -1500kPa water contents but did not affect the amount of plant available water. Plant available water contents for the Ap and Bt horizons were not greater than 0.09 $m^3\ m^{-3}$. Thus, in many years, the soil could not supply the water required by the crop. A concurrent increase in CEC and effective CEC was observed with the increase in clay content. Aluminum saturations in the Bt horizon are above the 20 percent

estimated tolerance limit for soybeans but there was no apparent detrimental effect on yields. The observed Al concentrations (< 2 cmol (+) kg^{-1}) did not concur with the low pH values ($\cong 4.8$) in the B horizon. Another source for the hydronium ions must be considered. The most significant effect of erosion was on the distribution of available P among the erosion classes. The decrease in available P as erosion severity increased was attributed to the high P-fixing capacity of the hydrous oxide-rich clays in the surface horizon.

There were no significant differences in soybean grain yields among the slight, moderate, and severe erosion classes. There was a trend, however, in which the yields on the slightly and moderately eroded soils were somewhat higher than the yields on the severely eroded soils. Available P in the Ap horizon was the soil property most related to soybean yield.

The problem of optimum P management for fields with varying degrees of erosion is evident in our study. If P fertilizer is applied at a rate suggested for the slight and moderate erosion classes, severely eroded soils will not receive the P required for optimum crop growth. However, if P fertilizer is applied at a higher rate suggested for soils deficient in P, slightly and moderately eroded soils will receive P in excess of what the crop requires, and excess P is not economically justified. The correct rate of fertilizer to apply to the soils to obtain the most economic returns may be dependent on the distribution of erosion classes in a field whereby fertilizer is applied at a rate recommended for the most frequently occurring erosion class.

Available P was responsible for differences in yields between erosion classes. However, plant available water caused low overall yields, regardless of the degree of erosion. Thus, in most years, even with adequate rainfall, these soils could not supply the water required by the crop. To maximize productivity on eroded southern Piedmont soils, the relationship between severity of erosion, plant available water, available P, and crop yields needs further study.

Literature Cited

Allison, L.E. 1965. Organic carbon. *In* C.A. Black (ed.) Methods of soil analysis. Part 2. Chemical and microbiological properties. Agronomy 9:1367-1378.

Coleman, N.T., and G.W. Thomas. 1967. The basic chemistry of soil acidity. *In* R.W. Pearson (ed.) Soil acidity and liming. Agronomy 12:1-41.

Copley, T.L., L.A. Forrest, A.G. McCall, and F.G. Bell. 1944. Investigations in erosion control and reclamation of eroded land at the Central Piedmont Conservation Experiment Station, Statesville, North Carolina, 1930-1940. USDA Tech. Bull. 873. U.S. Government Printing Office, Washington, DC.

Daniels, R.B., J.W. Gilliam, D.K. Cassel, and L.A. Nelson. 1985. Soil erosion class and landscape position in the North Carolina Piedmont. Soil Sci. Soc. Am. J. 49:991-995.

Day, P.R. 1965. Particle fractionation and particle-size analysis. *In* C.A. Black (ed.) Methods of soil analysis. Part 1. Physical and mineralogical properties, including statistics of measurement and sampling. Agronomy 9:545-567.

Donohue, S.J., and G.W. Hawkins. 1979. Guide to computer programmed soil test recommendations in Virginia. Va. Coop. Ext. Serv. Publ. 834, Blacksburg, Virginia.

Frye, W.W., O.L. Bennett, and G.J. Buntley. 1985. Restoration of crop productivity on eroded or degraded soils. p. 335-356. *In* R.F. Follett and B.A. Stewart (ed.) Soil erosion and crop productivity. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, WI.

Frye, W.W., S.A. Ebelhar, L.W. Murdock, and R.L. Blevins. 1982. Soil erosion effects on properties and productivity of two Kentucky soils. Soil Sci. Soc. Am. J. 46:1051-1055.

HISARS. 1985. Monthly precipitation data for Danville and Chase City, Virginia calendar year 1984. Hydraulic Information Storage and Retrieval System. Va. Water Resources Research Center, Blacksburg.

Hsu, P.H. 1965. Fixation of phosphate by aluminum and iron in acidic soils. Soil Sci. 99:398-401.

Kamprath, E.J. 1970. Exchangeable aluminum as a criterion for liming leached mineral soils. Soil Sci. Soc. Am. Proc. 34:252-254.

Langdale, G.W., J.E. Box, Jr., R.A. Leonard, A.P. Barnett, and W.G. Fleming. 1979. Corn yield reduction on eroded Southern Piedmont soils. J. Soil Water Conserv. 34:226-228.

Latham, E.E. 1940. Relative productivity of the A horizon of the acid sandy loam and the B and C horizons exposed by erosion. J. Am. Soc. Agron. 32:950-954.

McCart, G.D., and E.J. Kamprath. 1965. Supplying Ca and Mg for cotton on sandy, low cation exchange capacity soils. Agron. J. 57:404-406.

Martin, J.H., W.H. Leonard, and D.L. Stamp. 1976. Principles of field crop production. Third edition. Macmillan Publ. Co., New York.

Mehlich, A. 1953. Determination of P, Ca, Mg, K, Na, and NH_4 by North Carolina soil testing laboratory. N.C. State Univ., Raleigh.

Peech, M. 1965. Exchange acidity. *In* C.A. Black (ed.) Methods of soil analysis, Part 2. Chemical and microbiological properties. Agronomy 9:914-926.

Richards, L.A. 1965. Physical condition of water in soil. *In* C.A. Black (ed.) Methods of soil analysis, Part 1. Physical and mineralogical properties, including statistics of measurement and sampling. Agronomy 9:128-152.

SAS. 1985. SAS user's guide: Statistics. Version 5 edition. SAS Institute Inc., Cary, NC.

Soil Survey Staff. 1984. Soil survey manual. USDA-SCS. U.S. Government Printing Office, Washington, DC.

Stone, J.R., J.W. Gilliam, D.K. Cassel, R.B. Daniels, L.A. Nelson, and H.J. Kleiss. 1985. Effect of erosion and landscape position on productivity of Piedmont soils. Soil Sci. Soc. Am. J. 49:987-991.

Trimble, S.W. 1974. Man-induced soil erosion on the southern Piedmont, 1700-1970. Soil Conservation Society of America, Ankeny, IA.

USDA-SCS. 1979. Interpretations for Cecil and related soils of the southern Piedmont. USDA-SCS. South Technical Service Center, Fort Worth, TX.

Watanbe, F.S., and S.R. Olsen. 1965. Test of an ascorbic acid method for determining phosphorus in water and $NaHCO_3$ extracts from soil. Soil Sci. Soc. Am. Proc. 29:677-678.

White, A.W., Jr., R.R. Bruce, A.W. Thomas, G.W. Langdale, and H.F. Perkins. 1985. Characterizing productivity of eroded soils in the southern Piedmont. p. 83-95. *In* Erosion and soil productivity. Proc. Natl. Symp. on Erosion and Soil Productivity. 10-11 December 1984. New Orleans, LA. Am. Soc. Agric. Eng., St. Joseph, MI.

Yuan, T.L. 1959. Determination of exchangeable hydrogen in soils by a titration method. Soil Sci. 88:164-167.

Yuan, T.L., W.K. Robertson, and J.R. Neller. 1960. Forms of newly fixed P in three acid soils. Soil Sci. Soc. Am. Proc. 24:447-450.

CHAPTER 4

Characterization and Classification of the Pacolet-Cecil Mapping Unit in Appomattox County, Virginia

Abstract

A study was initiated in Appomattox County in the southern Piedmont of Virginia to assess composition and variability of Typic Hapludult mapping units. Five delineations of the Cecil-Pacolet (clayey, kaolintic, thermic Typic Hapludult) mapping unit, three to eight sites within each delineation, and three profiles within each site were randomly located in a two-level nested sampling scheme. Soil physical, chemical, and morphological data were collected from the Ap, Bt, and C horizons of each profile. Reaction (pH) throughout the profile was extremely acid. Percent base saturation and percent effective base saturation decreased with increasing depth in the profile. Maximum clay distribution occurred in the Bt horizon. Thickness of the Ap horizon was uniform throughout the map unit reflecting uniform plow depths. The Bt and solum exhibited large variation in thickness. Subsoil properties important to mapping (percent base saturation in the chem-

ical control section, percent clay in the particle-size control section, and Bt and solum thickness) exhibited considerable variation within delineations but the variability was consistent from delineation to delineation. Inclusions of mafic material into the felsic crystalline system, from which Cecil and similar soils form, accounts for variability in the soil properties. Sixty-two percent of the 81 profiles are either Cecil or Pacolet series with 27 percent classifying as Cecil and 35 percent being Pacolet series. Nine percent of the profiles are soils similar to Cecil and Pacolet. The remaining 27 percent are dissimilar inclusions. Thus, the map unit name would be Pacolet-Cecil and the map unit description would include dissimilar soils.

Introduction

A major objective of soil survey is to accurately determine the kind and extent of soils as components of soil mapping units. This is necessary to make useful and proper interpretations with regard to soil and land use. This information is most effectively transmitted to the public sector by an accurate taxonomic classification and a descriptive mapping unit name.

Soils represent a continuum on the landscape thus some spatial variability is expected in mapping units. This variability can be either systematic variation which is dependent on regular or normal distributions where soil features change with landform, slope, vegetation, etc. There also may exist random variation due to non-predictable and non-regular distributions such as that imposed by non-homogeneous parent materials. Those soil properties, whose distributions are usually related to landscape positions, homogeneous parent material, and observable morphologic features, are used as a criteria by the mapper to delineate soil map units. Where spatial variability is due to randomness, the mapping unit description must account for these ranges in characteristics since further delineation may be impractical in a second-order soil survey as imposed by time and scale restrictions (Wilding and Drees, 1978).

Variability within single mapping units has come under investigation over the past several years. In the Georgia Piedmont, inclusions make up 30 percent or more of the Cecil mapping unit (Powell and Springer, 1965). Ransom et al. (1981) examined three mapping units in Arkansas for taxonomic composition. Dissimilar soils comprised from 0 to 50 percent of the map units. Three map units from three physiographic provinces in Virginia were studied by Edmonds et al. (1985) for taxonomic variability. Soil profiles in the map units could be placed in three to 14 taxa and many of the field observable properties were not mappable at the given scale. These studies suggested that either series concepts be adjusted to correspond to map units or the properties and pattern of occurrence of soils in the map unit be recorded.

The objectives of this study were to i) examine the variability of laboratory-measured and field-observable soil properties in the Pacolet-Cecil map unit in one Virginia county, ii) evaluate

variability of soil properties contributed by delineated soil bodies, sites within delineations, and profiles within sites, and iii) discuss taxonomic variability in the map unit.

Materials and Methods

Study Area

Appomattox County is located in the south-central Piedmont region of Virginia (Figure 8). The Piedmont physiographic province is underlain by deformed, highly metamorphosed, eugeosynclinal felsic crystalline rocks of late Precambrian to early Paleozoic age. Extensive faulting and folding have caused intrusions of mafic rock into the felsic crystalline system (Fisher, 1970). The scale of the intrusions is variable ranging in magnitude from one or two meters wide to large intrusions of several kilometers (Figure 9). The study area in Appomattox County is underlain by the Shelton granite gneiss with dikes of hornblende gabbro and hornblende gneiss interspersed throughout the unit (Calver, 1963).

The Cecil and Pacolet series are members of the clayey, kaolinitic, thermic family of Typic Hapludults. These soils were chosen for the study because they and similar soils comprise a large proportion of the soils in the Piedmont regions of Virginia. These soils are well-drained occurring on summits, shoulders, and sideslope positions of the Piedmont uplands. The Cecil and thinner-solum Pacolet series are typified by sandy loam to clay loam surface horizons depending on the degree of erosion. The underlying Bt horizon is red, well-structured, and contains 40 to 60 percent clay. The soils are naturally infertile with low cation exchange capacities and low base saturations.

Five delineations of the Cecil-Pacolet mapping unit, three to eight sites within each delineation, and three profiles within each site were randomly located in a two-level nested sampling scheme (Figure 10). The 7-m dimension for sites was chosen because soil variability within this distance cannot be mapped at the scale used by the National Cooperative Soil Survey. All delineations occurred on one farm in one- to five-hectare strip-cropped fields on B slopes (2-6%). Profiles were observed and described to a depth of 1.8 m with a bucket auger and samples taken from the Ap, Bt, and C horizons.

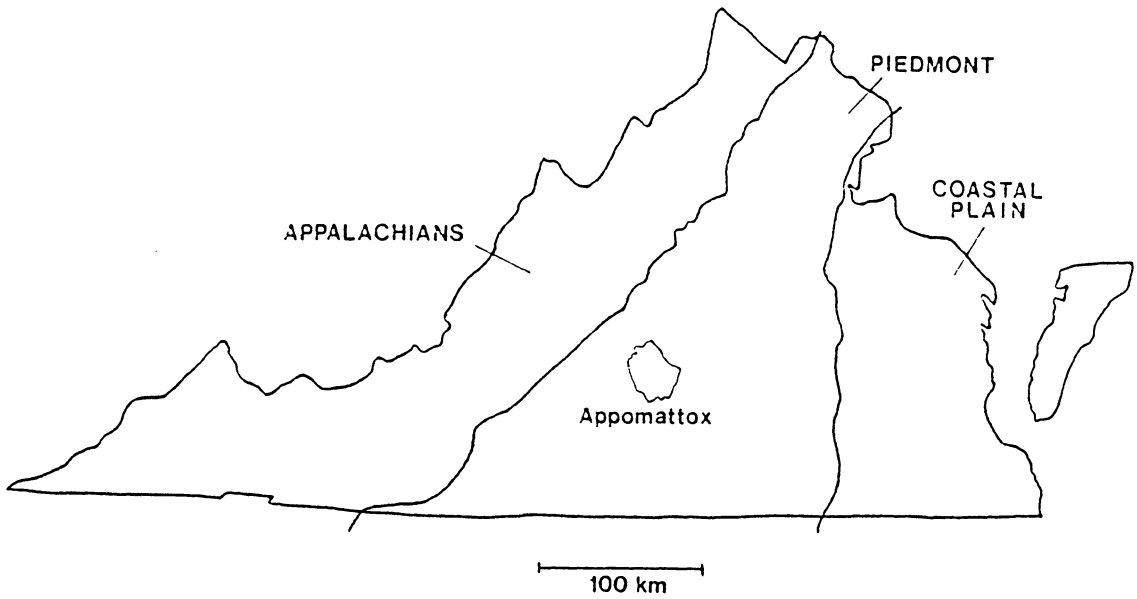

Figure 8. Location of study area in the Virginia Piedmont.

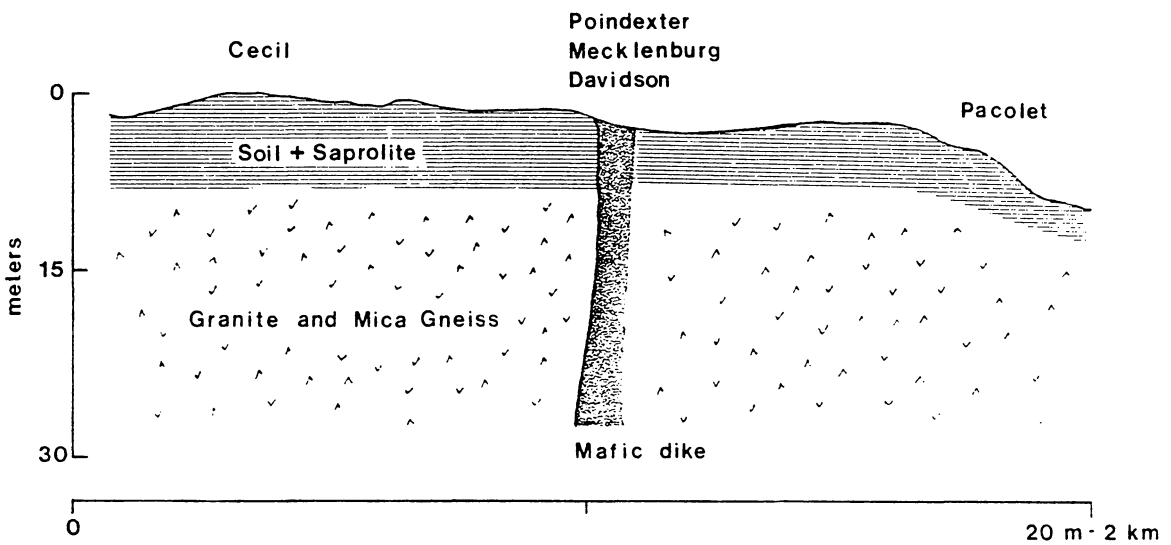

Figure 9. Cross-section of a Cecil landscape.

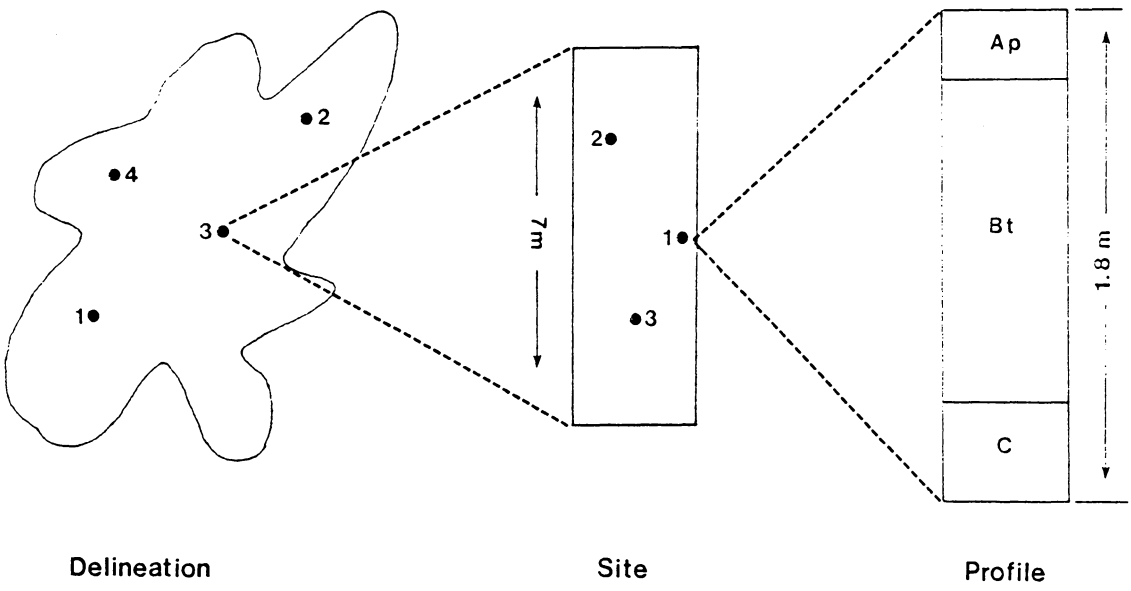

Figure 10. Diagrammatic representation of the nested sampling design. Adapted from Edmonds et al. (1985).

Laboratory Methods

Samples were air-dried, ground and sieved to remove coarse fragments greater than 2 mm. Clay contents (< 2μm) of the soils were determined by the hydrometer method of Day (1965). The sand was fractionated into five fractions: very coarse sand (2.0 to 1.0 mm), coarse sand (1.0 to 0.5 mm), medium sand (0.5 to 0.25 mm), fine sand (0.25 to 0.1 mm), and very fine sand (0.1 to 0.05 mm). Silt was determined by difference. Active acidity, pH, was determined in a 1:1 soil to water suspension. Hydronium ion, H_3O^+, concentrations for pH were used for all statistical analyses. Extractable acidity, H^+, was determined with the modified $BaCl_2$-triethanolamine method of Peech (1965). Exchangeable aluminum, Al^{3+}, was determined by a modification of the procedure by Yuan (1959). Exchangeable bases (Ca^{2+}, Mg^{2+}, K^+) were extracted with 1 *M* NH_4OAc, pH 7.0 and measured by atomic absorption spectrophometry. Cation exchange capacity, CEC, is the sum of exchangeable bases and extractable acidity. Effective CEC is the sum of exchangeable bases and exchangeable Al. Percent base saturation (B.S.) is the sum of basic cations divided by CEC and effective B.S. is given as the sum of basic cations divided by effective CEC.

Subsamples for mineralogical analysis were selected from six of the Bt horizons to ascertain parent material-mineralogy relationships. Five samples were selected from felsic materials and one sample was from mafic materials. The subsamples were pretreated with 30% H_2O_2 buffered to pH 5.0 with NaOAc and dithonite-citrate-bicarbonate to remove organic and oxide coatings, respectively. Sand was separated by wet sieving. Silt and clay were separated by centrifugation. Oriented clay mounts were prepared by depositing clay suspensions on ceramic tiles using a suction apparatus. Clay mineralogy was determined by x-ray diffraction (XRD) using a Diano 8000 x-ray diffractometer. X-ray diffraction patterns were obtained of K-saturated samples at 25, 110, 300, and 500 °C, and Mg-saturated, glycerol-solvated samples at 25 and 110 °C. Quantitative analysis of kaolinite and gibbsite in the clay fraction was performed using a Dupont 1090 Thermal Analyzer. Semi-quantitative estimates of other clay minerals were obtained by proportioning intergrated XRD

peak areas, using kaolinite as an internal standard and assuming the minerals detected equaled 100 percent (Harris et al., 1980).

Statistical Methods

Descriptive statistics of mean, standard deviation, minimum, and maximum values were estimated for each variable by the SAS univariate procedure (SAS, 1985a). Comparisions were made between horizons for all soil properties and series and between delineations for taxa-limiting soil properties.

Observations (Y_{ijk}), e.g., pH, percent clay, base saturation, etc., in the map unit were described by the linear model

$$Y_{ijk} = \mu + D_i + S_{ij} + \varepsilon_{ijk}$$

where μ represents an overall mean, D_i represents the effect due to a particular delineation, S_{ij} represents the effect due to a particular site, and ε_{ijk} represents variation among the profiles within a given site as well as errors in sampling and laboratory procedures. Usual normality properties of D_i, S_{ij}, and ε_{ijk} were assumed, i.e. these components are normally and independently distributed with zero means and respective variances of σ_D^2 , σ_S^2, and σ_ε^2 (Edmonds et al., 1982).

Analysis of variance was used to evaluate statistical differences among sites and among delineations for the measured soil properties (SAS, 1985b). Differences among delineations were evaluated by an F-test using mean squares for sites. Differences among sites were evaluated by an F-test using residual mean square.

Percent of the total variance contributed by each component in the sampling scheme was estimated by dividing variance contributed by the individual components by total variance (Sokal and Rohlf, 1985). Variance contributed by delineations, σ_D^2, is estimated by

$$\sigma_D^2 = \frac{(MS_D - MS_S)}{s'p}$$

where MS_D is the mean square for delineations and MS_S is the mean square for sites, s' is the number of sites per delineation and p is the number of profiles per site. Variance contributed by sites, σ_S^2, was estimated by

$$\sigma_S^2 = \frac{(MS_S - MS_E)}{p}$$

where MS_E is mean square for profiles and error. Residual variance, σ_ε^2, is estimated by MS_E. Total variance, σ_T^2, is estimated by

$$\sigma_T^2 = \sigma_D^2 + \sigma_S^2 + \sigma_\varepsilon^2$$

With unequal number of sites per delineation, a modification of the estimation of σ_D^2 was required. The correction factor, s', for sites is given by

$$s' = \frac{[n - s\sum_i \frac{p_i^2}{p}]}{(d - 1)}$$

where n is total number of observations; s is number of sites at each iteration, i, where i equals five iterations of $\frac{p_i}{p}$; p is the number of profiles; and d is the number of delineations (Lentner and Bishop, 1986). Estimates of variance components are obtained from an ANOVA table (Table 10).

Table 10. Analysis of variance table for two-level nested design.

Source of Variation	df	Sums of Squares	Mean Squares	Estimated Mean Square
Delineations	d-1	SS_D	$\frac{SS_D}{d-1}$	$\sigma_\varepsilon^2 + p\sigma_S^2 + s'\sigma_D^2$
Sites	$d(s'$-1)	SS_S	$\frac{SS_S}{d(s'-1)}$	$\sigma_\varepsilon^2 + p\sigma_S^2$
Profiles	$ds'(p$-1)	SS_ε	$\frac{SS_\varepsilon}{ds'(p-1)}$	σ_ε^2
Total	n-1	SS_T		

Results and Discussion

Variability of Soil Properties

Chemical properties for the map unit are given in Table 11. Sum of basic cations, Ca^{2+}, Mg^{2+}, and K^{+}, is low averaging less than 5 cmol (+) kg^{-1} throughout the profile. The low values for basic cations are possibly due to the Ca-Mg poor granite gneiss parent rock. Potassium (K^{+}) was very low in all horizons due to leaching. Calcium ($^{+2}$) was the dominant basic cation in the Ap and Bt horizons. Magnesium ($^{+2}$) was the dominant basic cation in the C horizon.

Average reaction in all three horizons was extremely acid (Table 11). Ranges in pH were consistent throughout the profile ranging from a low of 4.0 to a high of about 6.5. Acidity, both as extractable H^{+} and as exchangeable Al^{3+}, was low in these soils. The highest average exchangeable Al was less than three cmol (+) kg^{-1}. Percent base saturation and percent effective base saturation decreased with increasing depth in the profile. The higher base status of the Ap horizon probably is due to liming practices on the farm fields. The disparity between minimum and maximum values for base saturations, especially in the lower horizons, is a reflection of non-homogeneous parent material interspersed throughout the map unit.

Particle size distributions for the map unit are given in Table 12. Statistical analysis of the five sand fractions is not reported due to the lack of large amounts of variation in these particle sizes. Sum of the sand fractions is reported as total sand. Clay distribution was at a maximum in the Bt horizon and approximately 20 percent less in the Ap and C horizons. Silt fractions were constant throughout the profile. The large variation in clay contents in the Ap horizon was attributed to varying degrees of erosion ranging from slight to severe in the map unit.

The Bt horizon and solum exhibited large variation in thickness, as depicted by both minimum and maximum values and standard deviations (Table 12). Standard deviations for the Ap horizon

Table 11. **Descriptive statistics for chemical properties of Cecil-Pacolet map unit.**

Property†	Horizon	Mean	STD	Minimum	Maximum
pH	Ap	4.7	0.8	3.8	6.7
	Bt	5.0	0.6	4.2	6.7
	C	4.7	0.4	4.0	6.1
Ca^{2+}	Ap	2.8	1.0	0.9	5.3
	Bt	3.2	1.4	0.8	6.8
	C	1.5	1.8	0.1	9.5
Mg^{2+}	Ap	1.0	0.4	0.2	2.1
	Bt	1.7	1.1	0.6	7.3
	C	1.6	2.3	0.2	14.8
K^{+}	Ap	0.18	0.08	0.04	0.49
	Bt	0.12	0.12	0.04	1.10
	C	0.11	0.05	0.02	0.29
H^{+}	Ap	5.4	1.8	1.8	9.2
	Bt	8.0	3.4	3.6	21.9
	C	7.6	3.9	2.6	24.5
Al^{3+}	Ap	0.3	0.4	0.0	2.0
	Bt	1.1	2.6	0.0	13.0
	C	2.5	3.1	0.1	16.4
CEC	Ap	9.4	2.3	4.8	14.5
	Bt	13.0	3.8	7.8	27.0
	C	10.8	6.2	3.4	40.7
Effective CEC	Ap	4.3	1.2	2.1	7.3
	Bt	6.2	3.3	3.2	19.7
	C	5.7	5.4	2.1	32.6
B.S.	Ap	42.6	11.4	17.9	73.8
	Bt	39.4	12.8	12.9	66.1
	C	26.3	16.7	5.2	73.7
Effective B.S.	Ap	91.8	11.2	47.3	100.0
	Bt	87.0	19.4	28.3	100.0
	C	54.8	30.6	12.3	99.5

†pH expressed as $-\log[H_3O^+]$; Ca^{2+}, Mg^{2+}, K^+, H^+, Al^{3+}, CEC, and effective CEC expressed as cmol (+) kg^{-1}; B.S. and effective B.S. expressed as percent.

Table 12. Descriptive statistics for particle size distributions and depths of Cecil-Pacolet map unit.

Property†	Horizon	Mean	STD	Minimum	Maximum
Sand	Ap	56.5	9.0	32.7	72.1
	Bt	35.2	10.2	5.5	58.0
	C	50.5	11.8	14.2	70.9
Silt	Ap	20.3	4.8	6.8	34.0
	Bt	19.4	6.5	9.2	41.8
	C	20.7	7.3	4.7	44.1
Clay	Ap	23.2	8.9	8.9	46.9
	Bt	45.3	12.0	25.8	75.2
	C	28.9	7.8	15.7	53.2
Horizon Thickness	Ap	17	7	8	51
	Bt	69	21	30	180
	Solum	103	34	56	180
Color	Ap	10YR		5YR	10YR
	Bt	5YR		2.5YR	7.5YR
	C	5YR		2.5YR	7.5YR

†All particle sizes expressed as percent; depths expressed in cm; color is Munsell hue.

were comparatively less reflecting uniform plow depths. The maximum value of 51 cm Ap thickness occurred on one site in an overwash area.

The percentage of total variance contributed by delineations, sites, and profiles in the sampling design and the probability of rejecting the null of equal group means is given for all measured soil properties in Tables 13 and 14. Where there is no variation depicted for a particular component, the mean square for that component was smaller than the mean square for the next lower component. In these instances, the sum of squares and degrees of freedom were pooled into the next lower component. Large values of profile variance indicated large amounts of short-range variability. Where profile variation is small, moderate- and wide-range variability is indicative. Estimates of short-, moderate-, and wide-range variability can be used to determine whether classes (e.g., fine-loamy vs. clayey, Alfisol vs. Ultisol) of soils, based on the dissection of specific variables (clay and B.S.), can be mapped at a given scale.

Soil chemical properties are not observable in a mapping context. Depths can be quickly determined with an auger or other sampling tool. Textures can usually be estimated by a soil scientist. Geology is used as an aid for estimating chemical properties particularly for base saturation. In the Southern Piedmont, felsic saprolites such as granites and granite gneisses produce soils low in B.S. Soils higher in bases are formed from mafic rocks such as hornblende gneiss and greenstone.

The subsoil properties important to mapping can be narrowed to clay content in the upper 50 cm of the Bt (particle-size control section); percent B.S. in the chemical control section (usually the C horizon), which can be estimated by parent material associations; Bt thickness; and solum thickness (Tables 13 and 14). The remaining soil properties necessary for classification are left to chance on the assumption that they are accessory to the observed soil characteristics. Thus about 24 percent of the variance in clay percentages was contributed by profiles and error. About 77 percent of the variance was cumulative within delineations but the delineations were not significantly different. There is considerable variation but the variation is consistent from delineation to delineation. Thus, we could expect fine-loamy and fine (clayey) soils in the same delineation. For B.S., 15 percent of the variance was contributed by profiles. Fifty-one percent of the variance was cumulative within delineations and the delineations were significantly different at the 1% level.

Table 13. **Percent of total variation contributed by delineations, sites, and profiles: Particle size distributions and depths.**

Property†	Level				
	Delineation		Site		Profile‡
	%	*p*§	%	*p*	%
		Ap Horizon			
Sand	58	0.13	34	< 0.01	26
Silt	60	< 0.01	14	< 0.01	26
Clay	28	0.15	61	< 0.01	11
Depth	8	0.21	60	< 0.01	32
		Bt Horizon			
Sand	50	0.01	31	< 0.01	19
Silt	48	0.01	24	< 0.01	28
Clay	23	0.12	53	< 0.01	24
Depth	-	-	60	< 0.01	40
		C Horizon			
Sand	35	< 0.01	15	0.02	50
Silt	60	< 0.01	12	0.03	28
Clay	39	0.08	13	0.01	48
Depth (Solum)	-	-	88	< 0.01	12

†Particle sizes expressed as percent; depth is expressed in cm.
‡Includes error variance.
§Probability (*p*) of rejecting the null hypothesis of equal group means.

Table 14. **Percent of total variation contributed by delineations, sites, and profiles: Chemical Properties.**

Property†	Level				
	Delineation		Site		Profile‡
	%	*p*§	%	*p*	%
		Ap Horizon			
pH	4	0.27	40	< 0.01	55
Ca^{2+}	11	0.17	70	< 0.01	19
Mg^{2+}	16	0.11	66	< 0.01	18
K^{+}	10	0.15	44	< 0.01	46
H^{+}	9	0.12	23	0.02	68
Al^{3+}	27	0.03	61	< 0.01	12
CEC	15	0.07	39	< 0.01	46
Effective CEC	12	0.16	68	< 0.01	20
B.S.	6	0.25	51	< 0.01	43
Effective B.S.	7	0.25	67	< 0.01	26
		Bt Horizon			
pH	32	< 0.01	14	0.05	54
Ca^{2+}	57	< 0.01	28	< 0.01	15
Mg^{2+}	78	< 0.01	6	0.02	16
K^{+}	-	-	7	0.28	93
H^{+}	42	< 0.01	37	< 0.01	21
Al^{3+}	46	< 0.01	44	< 0.01	8
CEC	67	< 0.01	15	< 0.01	18
Effective CEC	79	< 0.01	14	< 0.01	7
B.S.	38	< 0.01	37	< 0.01	25
Effective B.S.	36	< 0.01	33	< 0.01	31
		C Horizon			
pH	26	< 0.01	-	-	74
Ca^{2+}	54	< 0.01	34	< 0.01	12
Mg^{2+}	67	< 0.01	-	-	33
K^{+}	31	< 0.01	27	< 0.01	42
H^{+}	79	< 0.01	3	0.12	18
Al^{3+}	83	< 0.01	8	< 0.01	9
CEC	78	< 0.01	1	0.35	21
Effective CEC	80	< 0.01	-	-	20
B.S.	49	< 0.01	36	< 0.01	15
Effective B.S.	36	0.01	51	< 0.01	13

†pH expressed as $-\log[H_3O^+]$; Ca^{2+}, Mg^{2+}, K^+, H^+, Al^{3+}, CEC, and effective CEC expressed as cmol (+) kg^{-1}; B.S. and effective B.S. expressed as percent.
‡Includes error variance.
§Probability (*p*) of rejecting the null hypothesis of equal group means.

Base saturation is not as consistent from delineation to delineation as is clay content. Therefore, Alfisols and Ultisols may or may not occur within the same delineation. About 40 percent of the total variance in Bt depth and 12 percent of the total variance in solum thickness was attributed to profiles and error. All of the variation (100%) was cumulative within delineations for both Bt thickness and solum thickness. Therefore, we would expect highly variable Bt and solum thicknesses within the same delineation but the variation in thickness is consistent from delineation to delineation.

Taxonomic Variability

Each profile was classified based on the data available from chemical, particle size, and morphologic features. Mineralogy was determined on clay fractions from four felsic profiles and one mafic profile. The remaining profiles with clay family particle size classes were assessed based on clay mineralogy and parent material relationships observed and reported elsewhere (Rich, 1959). Those profiles with fine-loamy particle size classes were assumed to have mixed mineralogy. Table 15 gives classification of the eight soil series in the map unit. Four of the series are Ultisols and the remaining four are Alfisols. Characteristics of the profiles are given in Tables 16 and 17. Cecil, Pacolet, and Wedowee soils are similar having formed from felsic material, with the major differentiating characteristics being solum depth, Bt depth, and subsoil color. Cecil and Pacolet soils both have red (2.5YR 4/6) subsoils. The Cecil soil has a solum thickness of 100 to 150 cm (40 to 60 in.) and the Bt extends to a depth of 76 to 150 cm (30 to 60 in.) below the soil surface. The Pacolet differs from the Cecil by a Bt depth less than 76 cm. The Wedowee soil is less red (7.5YR) than the Pacolet. The less red equivalent to Cecil (such as a 7.5YR Appling series), was not observed in this study. The Cecil taxadjunct is similar to the Cecil central concept but has less clay in the Bt horizon thereby placing the taxadjunct profiles in the fine-loamy particle size class. All soils formed from felsic materials appear to have kaolinite as the dominant clay mineral fraction as

determined by mineralogical analysis. The fine-loamy Cecil taxadjunct is assumed to have mixed mixed mineralogy.

The Mecklenburg soils are formed from mafic materials but are similar morphologically to Cecil. The Mecklenburg taxadjunct, like the Cecil taxadjunct, is in the fine-loamy particle-size class. Poindexter soils, also mafic, are similar to Wedowee in morphology (7.5YR subsoil) but the Poindexter has greater than 60 percent base saturation in the chemical control section and has less clay throughout the profile. The Poindexter taxadjunct and the Poindexter series have a difference of only seven percent clay in the Bt horizon, however, this results in placement of the taxadjunct into a fine-loamy particle size class. In mafic soils no one clay mineral predominates thus the mineralogy is mixed (Rich, 1959).

Table 18 gives a breakdown by delineation of the soil series in the map unit. Delineation 2 is the most taxonomically pure unit having 92 percent of the profiles being classified as either Cecil or Pacolet series. The remaining eight percent are similar soils. The other four delineations contain inclusions of mafic soils ranging from 25 to 75 percent of the total. Delineations 1 and 3 contain more of the 7.5YR Poindexter and Poindexter taxadjunct while Delineations 4 and 5 contain more of the 2.5YR Mecklenburg and Mecklenburg taxadjunct. Cecil and Pacolet comprise 22, 25, 58, and 67 percent of Delineations 1, 3, 4, and 5, respectively.

Of the 81 profiles evaluated in the map unit in Appomattox County, 58 profiles or 70 percent are of the same subgroup as the Cecil and Pacolet series. Fifty-six, or 69 percent, of the profiles were of the same family. Sixty-two percent of the profiles were either Cecil or Pacolet series with 27 percent of the 81 profiles being Cecil and 35 percent classifying as Pacolet series. Dissimilar soils comprise 30 percent of the map unit.

Based on the composition discussed above, the appropriate map unit name is Pacolet-Cecil and the dissimilar soils in the map unit would be allowed by using such a name. Although considerable variation exists, it is beyond the control of the field soil scientist to make further separations, thus the map unit is adequately named.

Figure 11 gives variability of chemical and particle size control section propeties for each delineation. If two-thirds of the distribution of the base saturation in the chemical control section and

Table 15. Classification of soils in the Cecil-Pacolet mapping unit, Appomattox County, Virginia.

clayey, kaolinitic, thermic Typic Hapludults
Cecil, Pacolet, Wedowee
fine-loamy, mixed, thermic Typic Hapludults
Cecil Taxadjunct
fine-loamy, mixed, thermic Ultic Hapludalfs
Mecklenburg Taxadjunct
fine, mixed, thermic Ultic Hapludalfs
Mecklenburg
fine-loamy, mixed, thermic Typic Hapludalfs
Poindexter Taxadjunct
fine, mixed, thermic Typic Hapludalfs
Poindexter

Table 16. Composition of Cecil-Pacolet Mapping Unit, Appomattox County, Virginia.

Delineation	No. Profiles	Cecil†	Pacolet	Wedowee	Cecil Tax.‡	Meck. Tax.	Mecklenburg	Poindexter Tax.	Poindexter
		% of No. Profiles (No. Profiles)							
1	9	11 (1)	11 (1)	33 (3)	-	-	11 (1)	22 (2)	11 (1)
2	24	54 (13)	38 (9)	4 (1)	4 (1)	-	-	-	-
3	12	-	25 (3)	-	-	33 (4)	-	33 (4)	8 (1)
4	12	33 (4)	25 (3)	17 (2)	-	25 (3)	-	-	-
5	24	17 (4)	50 (12)	-	4 (1)	25 (6)	4 (1)	-	-
Total	(81)	27 (22)	35 (28)	7 (6)	2 (2)	16 (13)	2 (2)	7 (6)	2 (2)

†See Table 15 for taxonomic classification of soil series.
‡Tax. = Taxadjunct.

Table 17. Data summary for series in Cecil-Pacolet mapping unit: Physical and morphological properties.

Property†	Cecil‡	Pacolet	Wedowee	Cecil Tax.§	Meck. Tax.	Meck-lenburg	Poindexter Tax.	Poin-dexter
(No. Profiles)	(27)	(35)	(7)	(2)	(16)	(2)	(7)	(2)
				Ap Horizon				
Sand	57.6	53.4	48.2	64.0	64.5	56.4	59.0	59.8
Silt	19.5	18.9	24.0	19.9	19.5	22.2	26.2	27.3
Clay	22.8	27.7	27.8	16.2	16.0	21.4	14.8	12.9
Depth	17	15	14	13	16	18	25	36
Color	10YR	7.5YR	10YR	5YR	10YR	10YR	10YR	10YR
				Bt Horizon				
Sand	32.7	35.5	18.3	54.9	44.8	34.1	36.0	31.3
Silt	16.1	15.9	19.3	19.1	23.0	23.1	32.1	31.4
Clay	51.5	48.6	62.4	26.0	30.5	42.8	30.3	37.3
Depth	93	58	63	51	76	57	102	110
Color	2.5YR	2.5YR	7.5YR	5YR	5YR	5YR	7.5YR	7.5YR
				C Horizon				
Sand	57.1	70.9	59.4	50.7	50.8	43.9	39.2	27.9
Silt	26.2	34.0	34.5	16.2	21.8	30.4	31.7	34.5
Clay	42.8	38.2	53.0	33.1	27.4	25.7	29.1	37.6
Depth(Solum)	135	64	85	103	102	74	102	110
Color	2.5YR	2.5YR	7.5YR	2.5YR	5YR	7.5YR	5YR	2.5YR

†All particle sizes expressed as percent; depth expressed in cm; color is Munsell hue.
‡See Table 15 for taxonomic classification of soil series.
§Tax. = Taxadjunct.

Table 18. Data summary for series in Cecil-Pacolet mapping unit: Chemical properties.

Property† (No. Profiles)	Cecil‡ (27)	Pacolet (35)	Wedowee (7)	Cecil Tax.§ (2)	Meck. Tax. (16)	Meck-lenburg (2)	Poindexter Tax. (7)	Poin-dexter (2)
				Ap Horizon				
pH	4.8	4.7	4.3	5.4	4.9	4.4	5.0	5.8
Ca^{2+}	2.5	3.2	2.2	2.8	2.2	2.4	2.9	3.5
Mg^{2+}	0.9	1.2	1.2	0.9	0.7	1.1	0.9	1.1
K^{+}	0.19	0.18	0.16	0.16	0.19	0.15	0.17	0.09
H^{+}	5.2	5.7	7.3	3.6	5.8	5.7	4.3	3.8
Al^{3+}	0.2	0.2	1.2	0.1	0.3	0.7	0.3	0.1
CEC	8.8	10.2	10.9	7.5	8.9	9.4	8.3	8.5
ECEC	3.8	4.8	4.5	4.0	3.5	4.3	4.3	4.7
B.S.	41.7	44.4	32.4	51.8	35.6	39.2	47.5	55.8
E.B.S.	92.5	94.9	75.3	97.2	84.6	88.1	92.4	98.9
				Bt Horizon				
pH	5.0	5.0	4.5	5.4	5.5	4.6	5.6	5.4
Ca^{2+}	2.6	3.2	2.1	2.4	3.9	2.2	5.6	5.7
Mg^{2+}	1.2	1.4	2.9	1.1	1.3	2.8	2.6	4.4
K^{+}	0.11	0.13	0.09	0.08	0.12	0.09	0.12	0.08
H^{+}	8.6	7.8	15.9	5.1	5.6	10.1	5.6	7.4
Al^{3+}	0.9	0.6	8.0	0.1	0.2	4.2	0.1	0.1
CEC	12.6	12.4	20.9	8.6	10.8	15.3	13.9	17.6
ECEC	4.8	5.2	13.0	3.6	5.6	9.5	8.4	10.2
B.S.	31.9	37.8	26.6	41.6	50.1	37.1	59.5	57.8
E.B.S.	83.9	90.0	49.6	97.2	96.1	71.7	98.6	99.5
				C Horizon				
pH	4.5	4.7	4.6	5.1	5.1	4.6	5.3	5.4
Ca^{2+}	0.5	0.9	1.4	1.5	4.2	1.4	6.4	5.4
Mg^{2+}	0.6	0.8	3.8	1.0	2.0	7.0	4.2	6.2
K^{+}	0.11	0.11	0.09	0.12	0.11	0.08	0.17	0.16
H^{+}	7.4	6.8	15.0	7.6	6.5	13.8	5.7	7.0
Al^{3+}	2.6	2.1	7.7	1.4	0.4	7.8	0.4	0.8
CEC	8.5	8.6	20.2	10.2	12.8	22.3	16.5	18.8
ECEC	3.7	3.9	12.9	4.0	6.7	16.2	11.2	12.5
B.S.	13.3	21.5	26.7	25.6	47.7	37.3	64.9	62.3
E.B.S.	29.1	52.0	50.6	70.7	92.7	67.7	96.9	93.7

†pH expressed as $-\log[H_3O^+]$; Ca^{2+}, Mg^{2+}, K^+, H^+, Al^{3+}, CEC, and ECEC expressed as cmol (+) kg^{-1} of soil; B.S. and E.B.S. expressed as percent.
‡See Table 15 for taxonomic classification of soil series.
§Tax. = Taxadjunct.

clay content in the particle size control section is represented by one standard deviation from the mean (Webster, 1977), then fine-loamy, Typic Hapludults and fine-loamy and fine, Ultic Hapludalfs would occur in the map unit in addition to the clayey, Typic Hapludult. Minimum and maximum observed values would add two additional taxonomic groups; fine, Ultic and Typic Hapludalfs, for a total of six taxa representing two soil orders. Although very fine, Ultic and Typic Hapludalfs are indicated by minimum and maximum values, these particular combinations of B.S. and clay were not encountered. The high clay values occurred with a Typic Hapludult.

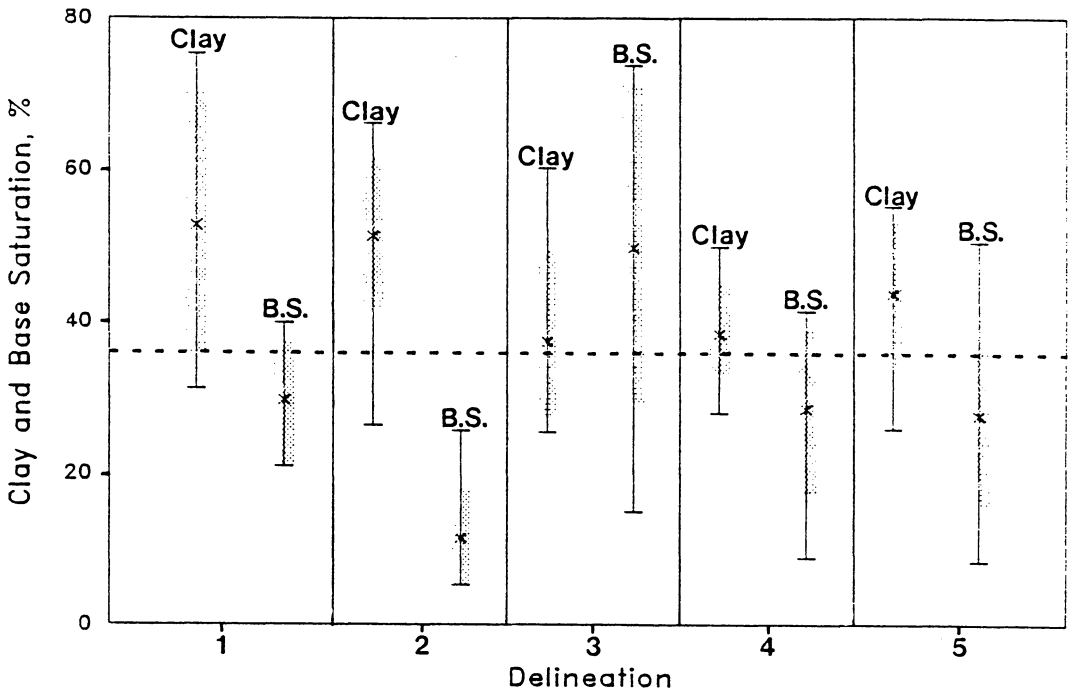

Figure 11. Variability of base saturation and content control section properties for delineations.

Conclusions and Recommendations

The Cecil-Pacolet map unit in Appomattox County, Virginia shows large variation in measured soil variables and taxonomic classes. Chemical properties were generally more variable than physical and morphological properties. Variability was primarily attributed to intrusions of mafic materials in the map unit. Statistical analysis shows that variability was extensive within delineated soil bodies but that the variability occurred in all delineations. Variability was reflected in taxonomic classification in which up to six different taxa can occur in the same delineation.

Cecil and Pacolet soils make up 62 percent of the map unit. Similar soils, with similar interpretations, comprise a total of 70 percent of the map unit. Dissimilar soils, such as Mecklenburg, Poindexter and their taxadjuncts, make up the remaining 30 percent. It is recommended that the mapping unit be named Pacolet-Cecil and that any description of the map unit in Appomattox County include description and extent of the intrusions of dissimilar soils.

Due to the random nature in which mafic intrusions are dispersed in the felsic parent materials, variability cannot be avoided and most of the variation is due to these intrusions. Mapping unit descriptions should call attention to these intrusions. Even with the variation observed in this mapping unit, the name Pacolet-Cecil, along with similar soil components, accurately describes the unit in accordance with the Soil Survey Manual (1984). Dissimilar soils should be discussed in map unit descriptions.

Literature Cited

Calver, J. 1963. Geologic map of Virginia. Va. Div. Mineral Resources and U.S. Geol. Surv.

Day, P.R. 1965. Particle fractionation and particle-size analysis. *In* C.A. Black (ed.) Methods of soil analysis. Part I. Physical and mineralogical properties, including statistics of measurement and sampling. Agronomy 9:545-567.

Edmonds, W.J., J.C. Baker, and T.W. Simpson. 1985. Variance and scale influences on classifying and interpreting soil map units. Soil Sci. Soc. Am. J. 49:957-961.

Edmonds, W.J., S.S. Iyengar, L.W. Zelazny, M. Lentner, and C.D. Peacock. 1982. Variability in family differentia of soils in a second-order soil survey mapping unit. Soil Sci. Soc. Am. J. 46:88-93.

Fisher, G.W. 1970. Introduction: The Piedmont. p. 295-298. *In* G.W. Fisher et al. (ed.) Studies of Appalachian geology: Central and southern. John Wiley and Sons, New York.

Harris, W.G., S.S. Iyengar, L.W. Zelazny, J.C. Parker, D.A. Lietzke, and W.J. Edmonds. 1980. Mineralogy of a chronosequence formed in New River alluvium. Soil Sci. Soc. Am. J. 44:862-868.

Lentner, M., and T. Bishop. 1986. Experimental design and analysis. Valley Book Co., Blacksburg, VA.

Peech, M. 1965. Exchange acidity. *In* C.A. Black et al. (ed.) Methods of soil analysis. Part 2. Chemical and microbiological properties. Agronomy 9:905-913.

Powell, J.C., and M.E. Springer. 1965. Composition and precision of classification of several mapping units of the Appling, Cecil, and Lloyd series in Walton County, Georgia. Soil Sci. Soc. Am. Proc. 29:454-458.

Ransom, M.D., W.W. Phillips, and E.M. Rutledge. 1981. Suitability for septic tank filter fields and taxonomic composition of three soil mapping units in Arkansas. Soil Sci. Soc. Am. J. 45:357-361.

SAS. 1985a. SAS User's Guide: Basics. Version 5 Edition. SAS Institute, Cary, NC.

SAS. 1985b. SAS User's Guide: Statistics. Version 5 Edition. SAS Institute, Cary, NC.

Sokal, R.R., and F.J. Rohlf. 1985. Biometry. Second edition. W.H. Freeman and Co., San Francisco, CA.

Soil Survey Staff. 1984. Soil survey manual. U.S. Government Printing Office, Washington, D.C.

Rich, C.I. 1959. Certain properties of selected southeastern United States soils and mineralogical procedures for their study. Southern Cooperative Series Bull. 61. Va. Agric. Exp. Stn., Blacksburg.

Webster, R. 1977. Quantitative and numerical methods in soil classification and survey. Oxford University Press, Oxford, Great Britain.

Wilding, L.P., and L.R. Drees. 1978. Spatial variability: A pedologist's viewpoint. p. 1-12. *In* M. Drosdoff et al. (ed.) Diversity of soils in the tropics. Spec. Pub. 34. American Society of of Agronomy, Soil Science Society of America, Madison, WI.

CHAPTER 5

Conclusions

Erosion-Productivity Study

1. The degree of erosion between slight and moderate erosion classes exhibited no relationship with most of the observed soil properties in the Pacolet-Cecil map unit. As soils became severely eroded, definite relationships were observed. The magnitude of difference between non-eroded and eroded soils is difficult to assess because of the absence of any uneroded upland Piedmont soils by which such comparisons are made. Thus, estimates of the severity of erosion may be incorrect and may be an explanation as to why few differences are observed in soil properties between slight and moderate erosion.
2. Volumetric water contents at -10kPa, the lower limit of plant available water, and -1500kPa, the upper limit of plant available water, increased with increasing clay content in both Ap and Bt horizons. The difference in plant available water between -10 and -1500kPa remained at nine percent water by volume (approximately five percent gravimetrically) for both Ap and Bt horizons. These data, supported by additional studies throughout the southern Piedmont, suggest that, in most years, the Cecil soil would not be able to meet crop demands for water.

3. Available phosphorus (P) decreased with severity of erosion. Increased clay contents in the surface horizon as the soil becomes more severely eroded, enhances the possibility of P fixation by Fe and Al hydrous oxides.
4. The low Al^{3+} concentrations in these soils do not coincide with the strongly acid pH values. There must be another ion generating H_3O^+. A logical proton donator would be manganese (Mn), however, this assumption was not investigated in the course of this study.
5. There were no significant differences in soybean grain yields among the slight, moderate, and severe erosion classses. There was a trend, however, in which the yields on the slightly and moderately eroded soils were somewhat higher than the yields on the severely eroded soils.
6. Available P and solum thickness were significantly related to soybean grain yields, with an R^2 of 0.73. Available P was the soil property most correlated to yields having 62 percent of the variation explained by this variable.
7. Soybean grain yields parallel the amount of available P in the three erosion classes. In Virginia soils, the critical level of P for optimum crop yield occurs at 18 mg P kg^{-1}. On both slight and moderate erosion classes available P is above the 18 mg kg^{-1} critical level. Yields on these erosion classes are nearly equal and may be due to the availability of adequate P. On severely eroded soils, where P is below the critical level, yields are low.
8. According to previous research, soybean roots should not be proliferating into soil zones with Al saturations greater than 20 percent. Aluminum saturations in the Bt horizons in our study exceed this limit on all three erosion classes by 15 to 18 percent. However, roots were growing into the subsoil. Aluminum in these soils may not be occurring in high enough concentrations to adversely affect root growth.

Mapping Unit Study

1. Soil profiles in the Cecil-Pacolet map unit in Appomattox County are, in general, acidic and low in bases. Maximum percent clay occurs in the Bt horizon. Thickness of Ap horizon was uniform while Bt and solum thicknesses were extremely variable. Chemical properties were more variable than physical and morphological properties. Variability was primarily attributed to intrusions of mafic materials, primarily hornblende gneisses in Appomattox, in the map unit.
2. The soil properties relative to mapping -- percent base saturation in the chemical control section (usually the C horizon), percent clay in the family particle size control section (usually the Bt horizon), Bt and solum thickness -- exhibited considerable variation within delineations, but the variation occurred in nearly all delineations.
3. Cecil and Pacolet soils comprise 62 percent of the map unit with the Pacolet series being the dominant of the two. Similar soils make up a total of 70 percent of the map unit. Dissimilar soils comprise the remaining 30 percent. It is recommended that the map unit be named Pacolet-Cecil and that any description of the map unit include description and extent of dissimilar soils.

APPENDICES

Appendix A. Chemistry of Soil Aluminum

Introduction

Aluminum (Al) is one of the most studied soil elements and has greatly enhanced the understanding of soil chemical processes. The increased understanding has resulted in improved interpretations of phenomena such as soil acidity and lime requirement, cation exchange capacity, acid-base buffering, phosphate reactions, plant toxic substances, and mineral weathering (McLean, 1976). Aluminum is the second member of the Group III elements with boron, gallium, indium, and thallium, all of which have three electrons in their outer shell. Aluminum is the third most abundant element in the earth's crust (8.1%), the second most plentiful oxide, and the most abundant metallic element (Metcalfe et al., 1974). Aluminum, as Al_2O_3, makes up 14.9, 15.4, 4.8, and 0.8% of igneous, shale, sandstone, and sedimentary rocks, respectively (Bohn et al., 1979). The trivalent state predominates for all the metallic Group III elements and Al exhibits both ionic and covalent properties. Aluminum is generally a good reducing agent but is not as active as the Group I and Group II metals (Metcalfe et al., 1974).

Weathering

The initial step of weathering involves the hydrolytic breaking of the Si-O-Al linkage in primary minerals, mainly the feldspars and micas, releasing Al^{3+} into solution. The Al^{3+} is immediately neutralized by OH^- to form Al-OH (Hsu, 1977). These Al-OH compounds can then recombine with Si-OH to precipitate as kaolinite and other secondary minerals (Birkeland, 1984). The overall reaction, using feldspars and kaolinite as examples, is

$$\underset{\text{feldspar}}{2KAlSi_3O_8} + H^+ + 9H_2O \rightleftharpoons \underset{\text{kaolinite}}{H_4Al_2Si_2O_9} + 4H_4SiO_4 + K^+$$

The Al^{3+} initially released in weathering may also convert to crystalline aluminum hydroxide, $Al(OH)_3$ (Hsu, 1977). The most abundant Al hydroxide polymorph, gibbsite, can be formed with the breaking of the Si-O-Al bonds. However, if percolating water moves slowly and does not remove Si from the system, Si may gradually accumulate and recombine with Al to form kaolinite (Hsu, 1977).

Gibbsite usually exists in equilibrium with kaolinite (Birkeland, 1984) as given by the following equation

$$\underset{\text{kaolinite}}{Al_2Si_2O_5(OH)_4} + 5H_2O \rightleftharpoons \underset{\text{gibbsite}}{2Al(OH)_3} + 2Si(OH)_4$$

At $Si(OH)_4$ activities less than 10^{-5}, gibbsite is stable and any kaolinite present will decompose to gibbsite. At $Si(OH)_4$ activities greater than 10^{-5} kaolinite is stable; gibbsite is unstable and will react with $Si(OH)_4$ to form kaolinite (Hsu, 1977).

Crystalline gibbsite is the most abundant free Al hydoxide in soils. Gibbsite is the stable low temperature form of Al hydoxide. Brehmite, an Al hydroxyoxide (AlOOH), occurs in highly weathered soils (Hsu, 1977).

Aluminum Bonding

Trivalent aluminum with an ionic radius of 0.51 Å fits between six oxygen atoms in a six-fold coordination (McLean, 1976; Bohn et al., 1979). Bonding between Al and O in the layer silicates is either sp^3 or sp^3d^2 due to the covalent character of the Al-O bond. The sp^3 bonding gives rise to the tetrahedral coordination with four oxygen atoms surrounding Al, while octahedral coordination has the sp^3d^2 bonding with six oxygens around Al. In low temperature minerals the octahedral coordination predominates. At lower temperatures, Al^{3+} will subsitute for Si^{4+} and assume tetrahedral coordination (Bohn et al., 1979).

Polymerization can occur with Al-O tetrahedrons or octahedrons if two Al-O molecules share a pair of electrons. The formation of Al-O-Al bonds (alumina sheets), along with Si-O-Si bonds (silica sheets), are important in defining the structure of layer silicates. The silica and alumina are held together by Si-O-Al bonds (Bohn et al., 1979).

Aluminum ions on clay surfaces bond through oxygen to form a wide variety of functional groups. Aluminum ranks second behind Si as an oxygen coordinator in soil minerals and is similar to carbon as a coordinating ion for organic matter (Jackson, 1963).

The bonding arrangements in soil mineral structures (M) are as follows (Jackson, 1963):

1. bonded to exchangeable cations (Mz)

$$XAl\text{-}O\text{-} \ldots Mz^+$$

2. bonded to structural cations represented by Na

$$XAl\text{-}ONa + H_2O \rightleftharpoons XAl\text{-}OH + Na^+$$

3. bonded to protons (exchanged in neutralization, liming)

$$2(XAl\text{-}O\text{-} \ldots Y\text{-}OHn)$$

4. oxygen shared with radicals (anion exchange and fixation)

$XAl\text{-}OPO_3\text{-}AlX$ or $Al\text{-}OSO_3AlX$

5. held protons forming hydrogen bond in soil aggregates

$XAl\text{-}OH_2$ ... OX and XAl-OH ... OX

These five types of aluminum bonding are essential characteristics in soil acidity, retention of anions, and soil aggregation.

Aluminum Reactions in Soils

Hydrolysis of aluminum

The acidic nature of soils in the southeastern U.S. has been presumed to be due to the presence of Al in various forms (Coleman and Thomas, 1967). Trivalent Al, upon release from clay minerals, hydrolyzes to monomeric and polymeric hydroxyaluminum complexes (Bohn et al., 1979). The hydrolysis of Al occurs only when basic cations are leached from clay colloids (Lindsay, 1979) and when hydronium ions (OH^-) are neutralized, usually at pH values around 4.2 and 4.8 (Yuan, 1963; McLean, 1976). Aluminum hydrolysis is responsible for both low soil pH of solutions containing Al ions and the buffer capacity of soils. The primary reason for liming acid soils is to neutralize this Al (Coleman and Thomas, 1967).

The hydrolysis reactions of monomeric aluminum (in 6-fold coordination with H_2O) are (Lindsay, 1979)

$$Al^{3+} \rightleftharpoons Al(OH)^{2+} + H^+$$

$$Al(OH)^{2+} \rightleftharpoons Al(OH)_2{}^+ + H^+$$

$$Al(OH)_2{}^+ \rightleftharpoons Al(OH)_3 + H^+$$

$$Al(OH)_3 \rightleftharpoons Al(OH)_4^- + H^+$$

$$Al(OH)_4^- \rightleftharpoons Al(OH)_5^{2-} + H^+$$

$$Al(OH)_5^{2-} \rightleftharpoons Al(OH)_6^{3-} + H^+$$

Soil pH determines which of these forms will occur. At pH values below 4.7 Al^{3+} predominates, between pH 4.7 and 6.5 $Al(OH)^{2+}$ predominates, between 6.5 and 8 $Al(OH)_3$ predominates, and above pH 8 $Al(OH)_4^-$ predominates (Bohn et al., 1979). The $Al(OH)^{2+}$ ion exists only over a narrow pH range. The $Al(OH)_5^{2-}$ occurs at pH values above the range of normal soil pH. Figure 12 shows the solubility of the monomeric Al polymers as a function of pH. The graph indicates that from about pH 4.7 to 7.5 the solubility of Al is low. In this pH range, Al is precipitated as insoluble $Al(OH)_3$. Below pH 4.7 and above 7.5 the concentration of Al in solution increases. At pH below 4.0 and above 9.2 the Al in solution is extremely high (McLean, 1976).

Reactions with anions

Many anions can be retained by aluminum hydroxides. The strength of their retention is an important factor in governing their mobility in soils. Hsu (1977) has suggested four anion mobility categories based on their affinity for Al^{3+}:

1. Anions with weak affinity, such as NO_3^-, ClO_4^-, and Cl^-. These anions can be present only in the diffuse layer except in completely dehydrated systems.

2. Anions with moderate affinity, such as sulfates. These anions are able to be chemically adsorbed on the surface of aluminum hydroxide involving an exchange with the H_2O ligand.

3. Anions with strong affinity, such as the phosphates. The affinity of Al^{3+} for this ion is strong enough to displace OH^- from clay surfaces or liberate H^+ from H_3PO_4, $H_2PO_4^-$, and HPO_4^{2-}.

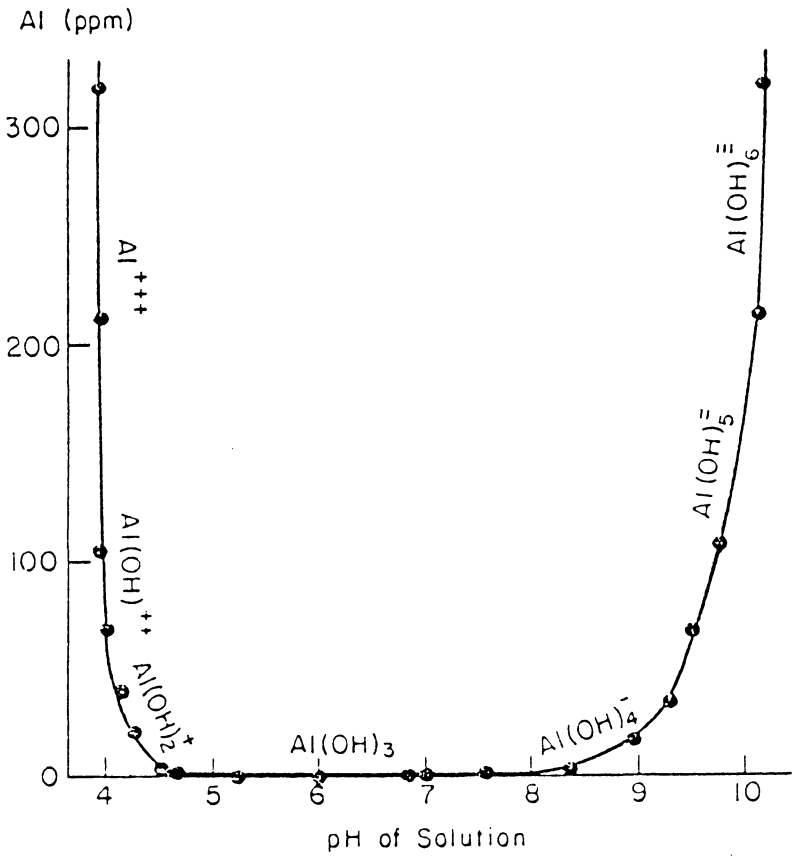

Figure 12. Solubility of aluminum as affected by pH (McLean, 1976).

4. Anions with very strong affinity, such as F^{2-}. These anions can break Al-OH-Al bonds and shatter the Al hydroxide structure.

Aluminum Toxicity in Soils

Aluminum toxicity is an important growth-limiting factors in many acid soils. Low soil pH, with Al at toxic levels, reduces root penetration and increases the probability of injury by drought (Adams and Lund, 1966). The solubility of Al and the severity of Al toxicity to plants are affected by many soil factors, including soil pH, type of clay mineral, and organic matter (Foy, 1974).

In general, Al toxicity does not occur in soils with pH values above 5.5 (McCart and Kamprath, 1965) but is severe below pH 5.0 where the solubility of Al increases sharply (Foy, 1974). The soil pH at which Al becomes soluble in toxic concentrations, however, is different in different soils. In the Coastal Plain region of the southeastern U.S., a Norfolk subsoil (fine-loamy, siliceous, thermic Typic Paleudult) contained toxic levels of Al for cotton growth at pH of 5.4, while a Bladen subsoil (clayey, mixed, thermic Typic Albaquult) did not contain toxic levels of Al even at pH values as low as 4.9 (Adams and Lund, 1966). In the same study, levels of exchangeable Al required for toxicity was 0.1 cmol (+) kg^{-1} for the Norfolk soil and 2.5 cmol (+) kg^{-1} for the Bladen soil. Thus, Al is toxic at higher soil pH levels and at lower levels of exchangeable Al in a Norfolk subsoil, whose predominant clay mineral is kaolinite. In the Bladen soil whose major clay mineral component is montmorillonite, Al is toxic at lower soil pH levels and higher levels of exchangeable Al. These investigators also found that no single critical Al concentration in soil solutions would apply to all of the soils studied. However, placing soil solution Al on a molar activity basis resulted in similar critical values for all soils.

Organic soils have lower critical pH values for crop growth than mineral soils (Welch and Nelson, 1950). The addition of organic matter to acid soils results in a decrease in Al solubility (Foy, 1974). The reduction in Al toxicity is due to the formation of Al-organic matter complexes

of lower solubilities (Schnitzer and Skinner, 1963; Hargrove and Thomas, 1981) or to chelates of Al in water-soluble forms (Foy, 1974).

Inhibitory effects of aluminum

Aluminum toxicity in plants is often characterized by symptoms resembling those of P deficiency (overall stunting; small, abnormally dark green leaves; purpling of stems, leaves, and veins; and yellowing and death of leaf tips), or of Ca deficiency (cupping or rolling of young leaves and collapse of plant apex and petioles) (Foy, 1974). Aluminum-injured roots are often stubby and root tips inhibited and brown. The root system as a whole exhibits inhibited and thickened lateral roots but lacks fine branching (Fleming and Foy, 1968). Aluminum-injured root systems appear to lack resistance to fungal infection (Foy, 1974).

At Al concentrations above 0.5 mg kg^{-1} the growth of cotton seedling roots is prevented due to inhibition of cell division in meristematic regions of the roots (Rios and Pearson, 1964). Biochemical effects of aluminum toxicity decreases the sugar content, increases the ratio of non-protein to protein N, and decreases P content of leaves. Bronzing in rice, due to Al toxicity, has been associated with interference in the synthesis of starch and protein and reduced translocation of sugars (Foy, 1974). Huck (1972) found that Al reduced the ability of cotton roots to use sucrose in building cell-wall polysaccharides.

Many investigators have associated Al toxicity with reduced uptake of several essential nutrient elements by plants. Reduced Ca uptake is commonly observed in Al-injured plants. Lance and Pearson (1969) found that Al at 0.3 mg kg^{-1} reduced Ca uptake by cotton seedlings within one hour. Increasing the solution Ca concentration to 600 mg kg^{-1} restored Ca uptake. Clarkson (cited in Foy, 1974) suggested that Al either blocks, neutralizes, or reverses the negative charge on the pores of the free spaces in barley roots thereby reducing the ability of the pores to bind Ca. Lee (1971) found that Al inhibited the transport of P to potato plant tops; decreased the absorption

of Ca, Mg, and Zn by roots; and caused the accumulation of P, Al, Mn, Cu, and Fe in roots. Potassium absorption was enhanced by 1 to 2 mg kg^{-1} Al but inhibited by 5 to 100 mg kg^{-1}.

Aluminum toxicity often appears as a P deficiency in plants grown on acid soils (Foy, 1974). Yuan and others (1960) have shown that up to 90% of applied P fertilizer ends up in combination with either Al or Fe. At low pH values, when the activity of Al is high, there is a tendency for P to precipitate out of solution as an Al-phosphate rendering P unavailable for plant uptake as illustrated by the following reaction (Bohn et al., 1979)

$$Al^{3+} + H_2PO_4^- + 2H_2O \rightleftharpoons 2H^+ + Al(OH)_2H_2PO_4$$

$$Ksp = 10^{-30}$$

The stability of the precipitated compounds in solution depends on the solubility constant of the compounds. In general, Al-P is less soluble with increasing acidity. An increase in the activity of Al will also decrease solubility, but an increase in ionic strength from other soil ions will increase the solubility of the phosphorus compounds (McLean, 1976; Bohn et al., 1979).

At more neutral pH values, fixation of P is likely to occur on surfaces of Al hydroxides by three possible adsorption mechanisms (Bohn et al., 1979). Two of the mechanisms involve a ligand exchange between $H_2PO_4^-$, H_2O, and OH^- groups on the hydroxide surfaces. These are termed chemisorption reactions because of the high-energy nature of the bonds. The third adsorption reaction involves a low-energy, electrostatic, non-specific anion attraction to the hydroxide surfaces (Parliff et al., 1977).

Tolerance of plants to aluminum

Plant species differ widely in tolerance to excess soluble or exchangeable Al in acid soils (Foy, 1974). Table 19 classifies plant species in relation to aluminum tolerance. The tomato is very sensitive to Al and has been used as an indicator of Al availability in soils (Rees and Sidrak, 1961). Alfalfa and cotton are injured by as little as 0.5 mg kg^{-1} Al in soil solutions (Rios and Pearson, 1964). The cranberry plant is extremely tolerant to Al, requiring 150 mg kg^{-1} Al added to solution

Table 19. Sensitivity of selected agronomic and horticultural crops to Al toxicity.

Sensitivity	Common Name	Scientific Name
Very Sensitive	barley	*Hordeum vulgare*
	alfalfa	*Medicago sativa*
	soybeans	*Glycine max*
	cotton	*Gossypium* sp.
	timothy	*Phleum pratense*
	lettuce	*Lactuca sativa*
	sugarbeets	*Beta vulgaris*
	tomato	*Lycopersicon esculentum*
Sensitive	corn	*Zea mays*
	rice	*Oryza sativa*
	wheat	*Triticum aestivum*
	oats	*Avena sativa*
	rye	*Secale cereale*
	sorghum	*Sorghum bicolor*
	cabbage	*Brassica oleracea capitata*
	peas	*Pisum sativum*
	cucumber	*Cucumis sativus*
	brussel sprouts	*Brassica oleracea gemmifera*
Tolerant	white clover	*Trifolium repens*
	perennial ryegrass	*Lolium perenne*
	potatoes	*Solanum tuberosum*
	turnips	*Brassica rapa*
	cranberries	*Vaccinium macrocarpon*

Condensed from Foy (1974).

for reduction of shoot growth (Medappa and Dana, 1968). In acid soils, Kamprath (1970) found that corn made good growth at Al saturations up to 44% but soybeans could not tolerate above 20%.

Plant varieties within species also differ widely in Al tolerance. Differential tolerance among varieties and species is associated with ability of the varieties and species to alter pH of their respective root zones. A lower plant-induced pH in the root zone increases the solubility and potential toxicity of Al (Foy, 1974).

Due to the difference tolerance to Al by varieties, plant breeders have begun to select for Al-tolerant plant varieties. Aluminum tolerance in certain winter barley and wheat varieties is controlled by a single dominant gene (Kerridge and Kronstad, 1968).

Summary

Understanding aluminum reactions in the soil can lead to better interpretations of soil chemical processes. Aluminum is soluble below pH 5.0 and is easily hydrolyzed. The form of Al hydrous oxides depends upon the pH of the soil solution. At pH values between 4.7 and 7.5 Al exists in an insoluble form. Below pH 4.7, Al^{3+} predominates and above pH 8 $Al(OH)_4^-$ is the major form of Al in the soil. Aluminum hydroxides easily enter into various soil chemical reactions including bonding to clay surfaces, anion adsorption, and precipitation. Toxic levels of Al hydroxides have detrimental effects on plant growth, including reduction of nutrient uptake and inhibition of root growth.

Literature Cited

Adams, F., and Z.F. Lund. 1966. Effect of chemical activity of soil solution aluminum on cotton root penetration of acid subsoils. Soil Sci. 101:193-198.

Birkeland, P.W. 1984. Soils and geomorphology. Oxford University Press, New York.

Bohn, H.L., B.L. McNeal, and G.A. O'Connor. 1979. Soil chemistry. John Wiley and Sons, New York.

Brady, N.C. 1974. The nature and properties of soils. Eighth Edition. MacMillan Publishing Co., New York.

Coleman, N.T., and G.W. Thomas. 1967. The basic chemistry of soil acidity. *In* R.W. Pearson (ed.) Soil acidity and liming. Agronomy 12:1-41. American Society of Agronomy, Madison, WI.

Fleming, A.L., and C.D. Foy. 1968. Root structure reflects differential aluminum tolerance in wheat varieties. Agron. J. 60:172-176.

Foy, C.D. 1974. Effects of aluminum on plant growth. p. 601-642. *In* E.W. Carson (ed.) The plant root and its environment. University Press of Virginia, Charlottesville, VA.

Hargrove, W.L., and G.W. Thomas. 1981. Effect of organic matter on exchangeable aluminum and plant growth in acid soils. p. 151-166. *In* R.H. Dowdy (ed.) Chemistry in the soil environment. Spec. Pub. 40. American Society of Agronomy, Soil Science Society of America, Madison, WI.

Hsu, P.H. 1977. Aluminum hydroxides and oxyhydroxides. p. 99-143. *In* J.B. Dixon and S.B. Weed (ed.) Minerals in soil environments. Soil Science Society of America, Madison, WI.

Huck, M.G. 1972. Impairment of sucrose utilization for cell wall formation in the roots of aluminum damaged cotton seedlings. Plant Cell Physiol. 13:7-14.

Jackson, M.L. 1963. Aluminum bonding in soils: A unifying principle in soil science. Soil Sci. Soc. Am. Proc. 27:1-10.

Kamprath, E.J. 1970. Exchangeable aluminum as a criterion for liming leached mineral soils. Soil Sci. Soc. Am. Proc. 34:252-254.

Kerridge, P.C., and W.E. Kronstad. 1968. Evidence of genetic reistance to wheat (*Triticum aestivum* Vill, host). Agron. J. 60:710-711.

Lance, J.C., and R.W. Pearson. 1969. Effect of low concentrations of aluminum on growth and water and nutrient uptake by cotton roots. Soil Sci. Soc. Am. Proc. 33:95-98.

Lee, C.R. 1971. Influence of aluminum on plant growth and mineral nutrition of potatoes. Agron. J. 63:604-608.

Lindsay, W.L. 1979. Chemical equilibria in soils. John Wiley and Sons, New York.

McCart, G.D., and E.J. Kamprath. 1965. Supplying Ca and Mg for cotton on sandy, low cation exchange capacity soils. Agron. J. 57:404-406.

McLean, E.O. 1976. Chemistry of soil aluminum. Commun. Soil Sci. Plant Anal. 7:619-636.

Medappa, K.C., and M.N. Dana. 1968. Influence of pH, calcium, iron and aluminum on the uptake of radiophosphorus by cranberry plants. Soil Sci. Soc. Am. Proc. 32:381-383.

Metcalfe, H.C., J.E. Williams, and J.F. Castka. 1974. Modern chemistry. Holt, Rinehart and Winston, Inc., New York.

Parliff, R.L., A.R. Fraser, J.D. Russel, and V.C. Farmer. 1977. Adsorption of hydrous oxides, II. Oxalate benzoate and phosphate on gibbsite. J. Soil Sci. 28:40-47.

Rees, W.J., and G.H. Sidrak. 1961. Plant nutrition on fly ash. Plant Soil 8:141-159.

Rios, M.A., and R.W. Pearson. 1964. Some chemical factors in cotton root development. Soil Sci. Soc. Am. Proc. 28:232-235.

Schnitzer, M., and S.I.M. Skinner. 1963. Organo-metallic interactions in soils: I. Reactions between a number of metal ions and the organic matter of a podzol Bh horizon. Soil Sci. 96:86-93.

Welch, C.D., and W.L. Nelson. 1950. Calcium and magnesium requirements of soybeans as related to the degree of base saturation of the soil. Agron. J. 42:9-13.

Yuan, T.L. 1963. Some relationships among hydrogen, aluminum, and pH in solution and soil systems. Soil Sci. 95:155-163.

Yuan, T.L., W.K. Robertson, and J.R. Neller. 1960. Forms of newly fixed P in three acid soils. Soil Sci. Soc. Am. Proc. 24:447-450.

Appendix B. Linear Regression Techniques

Introduction

Multiple linear regression analysis is one the most widely used statistical techniques for investigating and modeling the relationship between variables. Its broad appeal results from the conceptually simple process of using an equation to express the relationship between a set of variables (Montgomery and Peck, 1982).

The regression equation has the general form

$$y = \beta_o + \beta_1 x_1 + \ldots + \beta_k x_k + \varepsilon$$

where y is the dependent or regressor variable; β_o is the intercept; β_1, β_2, and β_k are slopes or regressor coefficients for the independent or regressor variables; x_1 , x_2 thru x_k; and ε is error.

There are two important objectives in regression analysis. The first is to estimate the unknown parameters in the model. This process is also called fitting the model to the data. The second phase of regression analysis is called model adequacy checking. In this procedure, the appropriateness of the model is studied and the quality of fit is ascertained (Montgomery and Peck, 1982; Sokal and Rohlf, 1985).

Variable Selection Techniques

Several techniques exist for model building. One of the easiest is to examine all possible regression equations. If there are k regressors then there are 2^k possible regression equations. If k is large, the number of submodels is very large. In the SAS PROC RSQUARE procedure, k has a maximum of 14 regressors giving a total of 16,384 possible equations.

The most useful variable selection technique is stepwise regression. Variables to be included in the model are selected on the basis of the F-test. Significance of a variable is tested in the presence of all the other variables. The most significant variable is entered into the model first. The model is rerun and the second most significant variable enters the model. If a variable is insignificant, in the presence of the other variables, the variable is dropped from the model. When variables in the model are significant the regression procedure ends. In SAS, the PROC STEPWISE procedure performs these operations (SAS, 1985).

Measures of Model Adequacy

The validity of regression equations are generally examined in terms of R^2, the coefficient of determination. R-square values are the proportion of total variation of the response variable, y, explained by the independent or predictor variables, $x's$, through the model. An R^2 of 0 indicates that there is no relationship between x and y. Values of R^2 close to 1 imply that most of the variability in y is explained by the regression model.

The R^2 statistic should be used with caution. Adding variables to the model will always increase the R^2. Also, the size of R^2 for a "good" model varies depending on the situation. In controlled experiments, high R^2 values are expected. For example, if varying amounts of nitrogen fertilizers are added to a soil, one would expect to observe a y response in wheat yields with x in-

crements of fertilizer. R-square values in these experiments generally range from 0.95 to 0.99. In observational studies, the x variables are not manipulated. Instead x is an observed or random variable. For example, in erosion-productivity studies, selected soil properties believed to be affected by erosion, are measured to determine which of the properties is most influential in determining the yields of crops. Strong correlations between x and y are frequently not observed. The R^2 statistics in these studies usually occur in the range of 0.5 to 0.8.

Although R^2 is an important indicator of model adequacy or predictability, it is not the only statistic to be considered in model validation. The mean square error (MSE) is an estimate of σ^2, the natural variability about the fitted regression line. The MSE depends on the distribution of predicted y variables around the actual or observational y variables. Where the observed data is widely scattered, the MSE will be large. The predictive capacity of a model will be greatly enhanced if MSE is small (Montgomery and Peck, 1982).

Another statistic employed in variable selection is Mallow's statistic (Cp). The Cp statistic is a measure of the variance and bias of the estimated model. A model that exhibits large bias usually provides estimates that are too high or too low (Zar, 1984). The smaller the variance and bias, the smaller the Cp statistic and the more valid the model (Montgomery and Peck, 1982).

Another test of model validity is residual analysis. A plot of the residuals (e_i), predicted y minus observed y, against the fitted value of y, or $\hat{y}$, is useful in detecting several types of model inadequacies. The pattern in Figure 13 *a* with residuals in a horizontal band indicates that there are no obvious model defects. Plots of e_i against $\hat{y}$ that resemble any of the patterns in Figures 13 *b, c,* and *d* are symptomatic of model deficiencies (Montgomery and Peck, 1982). Figure 14 is a residual plot of soybean yields for the erosion-productivity model described in Chapter 3 with the equation

$$\hat{y} = 0.91 + 1.01 log(P)$$

where $\hat{y}$ is soybean yield in Mg ha^{-1} and P is available phosphorus in mg kg^{-1}. The residuals are distributed in a horizontal band indicating a satisfactory model.

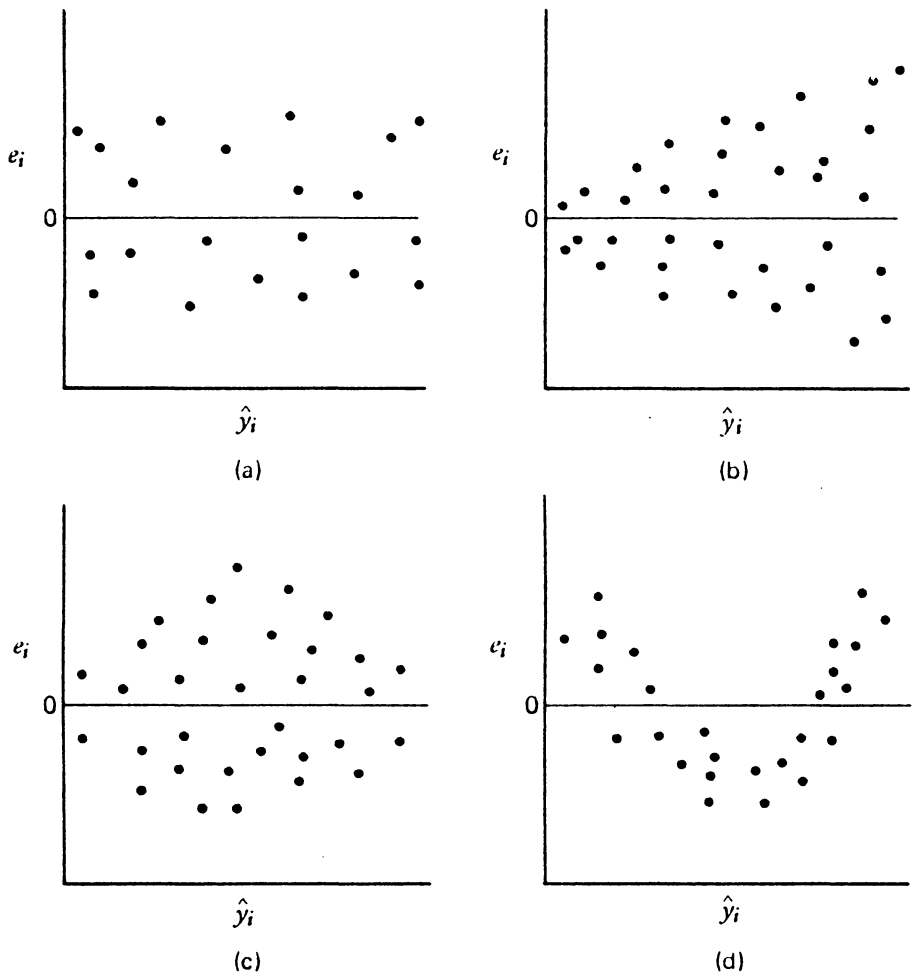

Figure 13. Patterns for residual plots. (a) Satisfactory. (b) Funnel. (c) Double bow. (d) Nonlinear. (Montgomery and Peck, 1982).

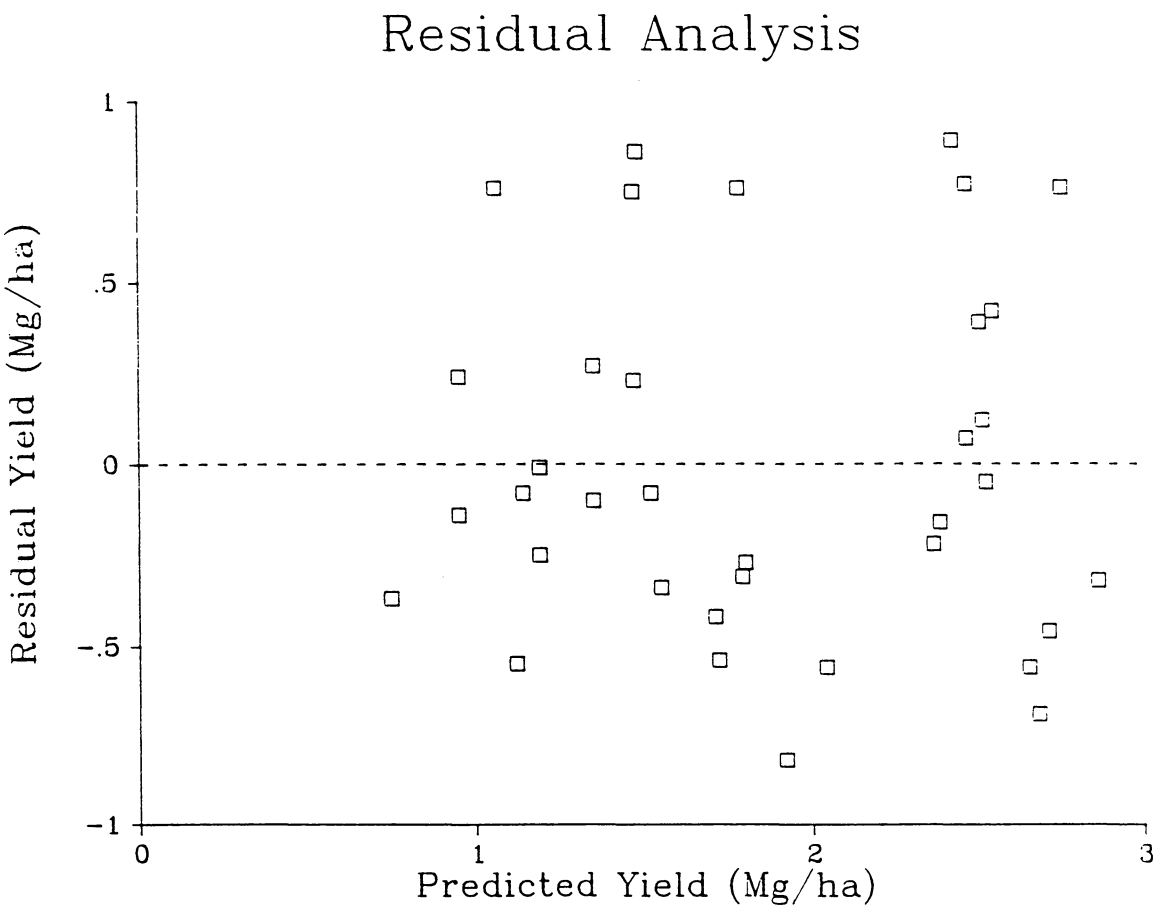

Figure 14. Plot of residual verses fitted values for soybean yield data.

Multicollinearity

If there is no linear relationship between the x variables then they are said to be orthogonal. Unfortunately in most applications of regression, orthogonality does not exist. When the x variables are empirically correlated through the data, the condition of *multicollinearity* exists.

There are several diagnostic techniques for detecting multicollinearity. A very simple measure is the correlation matrix between pairs of x variables. Correlations higher than 0.9 generally indicate linear dependency. However, this technique is useful only where two regressors are involved. Where more than two regressors exhibit linear dependency, there is no assurance that any of the pairwise correlations will be large (Montgomery and Peck, 1982).

The signs and magnitudes of the regression coefficients will sometimes provide an indication that multicollinearity is present. If the signs of the coefficients are opposite of what logic dictates or if the deletion of a variable results in large changes in the regression coefficients, we should be alert to possible multicollinearity problems.

A statistical parameter exists for detecting multicollinearity in *variance inflation factors* (VIF). In general, VIF's reflect the increase in the variance for each of the regression coefficients due to linear dependencies among the regressors. One or more VIF's greater than 10 indicate multicollinearity (Montgomery and Peck, 1982).

Several methods have been proposed for dealing with multicollinearity. The best method is to collect additional data at points designed to break up any potential linear dependencies. However, collecting additional data is not always possible because of either economic constraints or because the process being studied is no longer available for sampling. Multicollinearity can also be lessened by respecifying the model. For example, if x_1, x_2, and x_3 are linearly related, it may be possible to find some function such as $x = \frac{(x_1 + x_2)}{3}$ or $x = x_1x_2x_3$ that preserves the information content in the original regressors but reduces the ill-conditioning. Another widely used approach is variable elimination. If x_1, x_2, and x_3 are nearly linearly dependent, eliminating one

or two of the regressors may be helpful in combating multicollinearity (Montgomery and Peck, 1982).

Literature Cited

Montgomery, D.C., and E.A. Peck. 1982. Introduction to linear regresssion analysis. John Wiley and Sons, New York.

SAS. 1985. SAS User's Guide: Statistics. Version 5 edition. SAS Institute, Cary, NC.

Sokal, R.R., and F.J. Rohlf. 1985. Biometry. Second edition. W.H. Freeman and Co., San Francisco, CA.

Zar, J.H. 1984. Biostatistical analysis. Second edition. Prentice-Hall, Inc., Englewood Cliffs, NJ.

Appendix C. Data Tables

Appomattox County

Table 1. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A1-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-13	1.60	1.42	3.12	25.28	15.92	47.34	24.90	27.76	scl
Bt	13-75	0.05	0.12	0.72	8.82	9.10	18.81	20.25	60.94	c
C	97-180	0.52	0.85	2.40	23.92	20.12	47.81	33.99	18.20	l

Horizon	Depth	pH	Exchangeable cations					CEC	ECEC	B.S.	E.B.S.
			Ca	Mg	K	H	Al				
	cm		cmol (+) kg^{-1}							%	
Ap	0-13	4.72	3.50	1.84	0.13	6.17	0.55	11.64	6.02	46.99	90.86
Bt	13-75	4.65	2.94	3.10	0.09	13.66	5.55	19.79	11.68	30.98	52.48
C	97-180	4.50	0.87	4.70	0.09	14.33	9.35	19.99	15.01	28.31	37.71

Horizon	Depth	Color	Structure
	cm		
Ap	0-13	10YR5/6	2,gr
Bt	13-75	5YR5/8	2,sbk
BC	75-97	5YR5/8	1,sbk
C	97-180	7.5YR6/8	1,sbk

Table 2. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A1-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-19	2.52	1.50	3.18	21.78	16.50	45.48	27.35	27.17	scl,cl,l
Bt	19-58	0.45	0.55	1.30	10.48	6.92	19.70	26.79	53.51	c
C	76-180	0.15	0.88	7.42	18.68	8.62	35.75	41.73	22.52	l

Horizon	Depth	pH	Exchangeable cations					CEC	ECEC	B.S.	E.B.S.
			Ca	Mg	K	H	Al				
	cm		cmol (+) kg^{-1}							%	
Ap	0-19	4.48	2.95	1.78	0.14	4.73	0.85	9.60	5.72	50.73	94.28
Bt	19-58	4.35	1.17	3.20	0.07	12.74	4.75	17.78	9.79	28.35	51.48
C	76-180	4.50	0.95	11.10	0.07	20.90	13.85	33.02	25.97	36.71	46.67

Horizon	Depth	Color	Structure
	cm		
Ap	0-19	10YR5/6	2,gr
Bt	19-58	5YR6/8	2,sbk
BC	58-76	5YR6/8	2,sbk
C	76-180	7.5YR6/8	1,sbk

Table 3. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A1-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-13	1.20	1.15	2.78	23.22	13.78	42.13	22.80	35.07	cl
Bt	13-66	0.12	0.30	0.60	2.30	2.22	5.54	21.97	72.49	c
C	81-180	0.02	0.12	1.05	11.18	8.78	21.15	34.50	44.35	c

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-13	4.50	3.32	2.10	0.12	8.36	0.85	13.90	6.39	39.86	93.61
Bt	13-66	4.32	2.00	2.90	0.07	16.12	8.05	21.90	13.02	23.57	38.17
C	81-180	5.00	0.61	3.60	0.07	16.24	10.25	20.52	14.53	20.86	29.46

Horizon	Depth	Color	Structure
	cm		
Ap	0-13	10YR5/6	2,gr
Bt	13-66	5YR5/6	2,sbk
BC	66-81	5YR5/6	2,sbk
C	81-180	7.5YR5/6	1,sbk

Table 4. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A2-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-11	2.80	1.98	3.52	23.08	15.60	46.98	27.55	25.47	scl
Bt	28-74	0.18	0.28	1.00	8.68	5.55	15.69	18.61	65.70	c
C	99-180	0.15	1.95	7.78	19.45	12.40	41.73	28.59	29.68	cl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-11	4.15	1.63	1.07	0.15	6.11	1.95	8.96	3.70	31.81	47.30
Bt	28-74	4.92	1.72	3.50	0.08	19.21	10.85	24.51	16.15	21.62	32.82
C	99-180	4.50	0.36	4.10	0.05	16.32	8.75	20.83	12.26	21.65	34.01

Horizon	Depth	Color	Structure
	cm		
Ap	0-11	10YR6/6	1,gr
BA	11-28	7.5YR5/6	2,sbk
Bt	28-74	5YR5/6	2,sbk
BC	74-99	5YR6/8	1,sbk
C	99-180	7.5YR6/8	1,sbk

Table 5. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A2-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	3.95	2.18	3.78	24.65	16.70	51.26	19.14	29.60	scl
Bt	18-51	0.25	0.40	0.80	4.20	7.48	13.13	11.70	75.17	c
C	97-180	0.32	0.65	2.08	6.72	4.42	14.19	32.81	53.00	c

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-18	4.30	1.55	0.85	0.15	9.15	1.65	11.70	4.20	21.79	60.71
Bt	18-51	4.20	1.12	3.90	0.09	21.89	12.95	27.00	18.06	18.93	28.29
C	97-180	4.38	2.57	6.10	0.15	20.50	11.65	29.32	20.97	30.08	43.09

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	10YR6/6	1,gr
Bt	18-51	5YR6/8	2,sbk
BC	51-97	7.5YR6/8	0,m
C	97-180	10YR6/8	0,m

Table 6. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A2-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-14	1.82	1.95	4.12	27.45	14.78	50.12	25.48	24.40	scl
Bt	14-46	0.25	0.68	2.20	15.62	7.75	26.50	26.32	47.18	c
C	64-180	0.10	0.45	1.55	7.80	8.95	18.85	44.15	37.00	sicl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-14	4.00	2.13	1.54	0.20	6.11	1.35	9.98	5.22	38.78	74.14
Bt	14-46	4.40	1.78	5.90	0.13	16.92	11.85	24.73	19.66	31.58	39.73
C	64-180	4.64	1.31	14.80	0.08	24.48	16.45	40.67	32.64	39.81	49.60

Horizon	Depth	Color	Structure
	cm		
Ap	0-14	10YR4/6	1,gr
Bt	14-46	5YR5/6	2,sbk
BC	46-64	5YR5/6	1,sbk
C	64-180	7.5YR5/8	1,sbk

Table 7. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A3-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-33	1.25	3.00	5.28	23.88	17.02	50.43	33.95	15.62	l
AB	33-46	0.68	2.00	4.08	20.85	16.30	43.91	37.34	18.75	l
Bt	46-180	1.22	1.75	2.92	15.60	9.22	30.71	28.17	31.12	cl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-33	4.68	3.26	0.92	0.17	6.38	0.20	10.73	4.55	40.54	95.60
AB	33-46	6.24	3.95	1.12	0.09	6.14	0.10	11.30	5.26	45.66	98.10
Bt	46-180	5.65	6.17	3.90	0.07	5.57	0.15	15.71	10.29	64.54	98.54

Horizon	Depth	Color	Structure
	cm		
Ap	0-33	7.5YR5/4	2,gr
AB	33-46	7.5YR5/6	1,sbk
Bt	46-180	7.5YR5/8	2,sbk

Table 8. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A3-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-51	0.85	2.52	5.05	25.10	17.45	50.97	33.32	15.71	l
Bt1	51-94	0.80	1.28	2.18	11.03	10.65	25.94	39.09	34.97	cl
Bt2	94-180	0.50	0.65	1.38	8.62	8.10	19.25	41.49	39.26	cl,sicl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-51	5.60	4.17	1.34	0.07	4.78	0.05	10.36	5.63	53.86	99.11
Bt1	51-94	5.80	5.28	7.30	0.07	8.76	0.05	21.41	12.70	59.08	99.61
Bt2	94-180	5.30	4.00	8.90	0.08	7.16	0.15	20.14	13.13	64.45	98.86

Horizon	Depth	Color	Structure
	cm		
Ap	0-51	7.5YR4/4	2,gr
Bt1	51-94	7.5YR5/6	2,sbk
Bt2	94-180	2.5YR4/6	2,sbk

Table 9. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A3-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-41	1.42	2.80	5.68	23.45	16.65	50.00	33.13	16.87	l
Bt1	61-91	1.00	1.12	1.95	11.02	10.82	25.91	41.77	32.32	cl
Bt2	91-180	0.80	2.00	3.75	10.75	7.70	25.00	39.97	35.03	cl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-41	5.26	3.73	1.10	0.11	3.98	0.05	8.92	4.99	55.38	99.00
Bt1	61-91	6.38	4.94	4.60	0.11	4.95	0.05	14.60	9.70	66.10	99.48
Bt2	91-180	5.56	3.75	5.50	0.05	5.97	0.05	15.27	9.35	60.90	99.47

Horizon	Depth	Color	Structure
	cm		
Ap	0-41	7.5YR4/4	2,gr
AB	41-61	7.5YR6/6	1,sbk
Bt1	61-91	7.5YR5/6	2,sbk
Bt2	91-180	2.5YR4/6	3,sbk

Table 10. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A4-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	0.75	5.05	17.62	33.78	8.28	65.48	21.86	12.66	fsl
Bt1	18-51	0.15	2.65	7.50	10.98	4.12	25.40	12.14	62.46	c
Bt2	51-107	0.15	4.60	11.98	17.42	7.42	41.57	15.48	42.95	c
C	107-180	0.28	6.22	14.20	19.82	8.88	49.40	16.42	34.18	scl

Horizon	Depth	pH	Exchangeable cations					CEC	ECEC	B.S.	E.B.S.
			Ca	Mg	K	H	Al				
	cm		cmol (+) kg^{-1}							%	
Ap	0-18	5.00	2.16	0.60	0.15	2.99	0.15	5.90	3.06	49.32	95.10
Bt1	18-51	4.94	3.02	1.30	0.13	12.28	1.45	16.73	5.90	26.60	75.42
Bt2	51-107	4.86	1.46	0.74	0.09	9.70	2.85	11.99	5.14	19.10	44.55
C	107-180	4.66	0.45	0.28	0.08	10.30	3.55	11.11	4.36	7.29	18.58

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	10YR4/3	2,gr
Bt1	18-51	5YR6/8	2,sbk
Bt2	51-107	2.5YR5/8	2,sbk
C	107-180	5YR5/8	1,sbk

Table 11. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A4-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-14	0.85	5.02	19.40	34.32	8.62	68.21	20.35	11.44	fsl
Bt1	14-71	0.15	1.72	7.15	11.58	4.50	25.10	12.04	62.86	c
Bt2	71-102	0.28	4.88	10.30	15.18	7.05	37.69	16.95	45.36	c
C	102-180	0.25	5.15	13.05	21.52	9.85	49.82	20.26	29.92	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-14	5.66	2.01	0.46	0.26	4.55	0.15	7.28	2.88	37.50	94.79
Bt1	14-71	5.50	4.22	1.97	0.24	8.51	0.20	14.94	6.63	43.04	96.98
Bt2	71-102	4.70	1.06	0.77	0.08	10.49	3.55	12.40	5.46	15.40	71.83
C	102-180	4.00	0.26	0.26	0.08	7.72	3.55	8.32	4.15	7.21	14.46

Horizon	Depth	Color	Structure
	cm		
Ap	0-14	10YR4/3	2,gr
Bt1	14-71	5YR6/8	2,sbk
Bt2	71-102	2.5YR5/6	2,sbk
C	102-180	5YR6/8	1,sbk

Table 12. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A4-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-20	0.78	5.50	20.58	33.55	7.45	67.86	16.64	15.50	fsl
Bt1	20-46	0.42	2.62	9.52	15.65	5.35	33.56	14.21	52.23	c
Bt2	46-97	0.45	3.10	8.42	14.38	5.60	12.78	31.78	55.44	c
C	97-180	0.50	4.93	12.22	19.62	8.22	45.49	18.13	36.38	sc,cl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-20	5.02	2.08	0.48	0.30	5.97	0.05	8.83	2.91	32.39	98.28
Bt1	20-46	5.95	3.63	1.66	0.33	6.14	0.10	11.76	5.72	47.79	98.25
Bt2	46-97	4.90	1.14	0.82	0.11	11.09	4.15	13.16	6.22	15.73	33.28
C	97-180	4.78	0.37	0.35	0.10	9.90	3.45	10.72	4.27	7.65	19.20

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	10YR4/3	2,gr
Bt1	20-46	5YR6/8	2,sbk
Bt2	46-97	2.5YR5/6	2,sbk
C	97-180	5YR5/6	1,sbk

Table 13. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A5-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-13	1.65	6.85	17.35	26.85	8.30	61.00	20.80	18.20	fsl
Bt	13-74	0.48	3.08	7.30	11.68	5.20	27.74	11.87	60.29	c
C	74-180	0.88	8.48	14.55	23.78	10.12	57.81	13.52	28.67	scl

Horizon	Depth	pH	Exchangeable cations					CEC	ECEC	B.S.	E.B.S.
			Ca	Mg	K	H	Al				
	cm		cmol (+) kg^{-1}							%	
Ap	0-13	5.05	1.75	0.64	0.44	5.54	0.75	8.37	3.58	33.81	79.05
Bt	13-74	5.01	1.86	1.18	0.10	11.48	1.75	14.62	4.89	21.48	64.21
C	74-180	4.92	0.40	0.35	0.10	2.57	2.35	3.42	3.20	24.85	26.56

Horizon	Depth	Color	Structure
	cm		
Ap	0-13	10YR5/6	1,gr
Bt	13-74	2.5YR5/8	2,sbk
C	74-180	2.5YR4/8	1,sbk

Table 14. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A5-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-15	0.43	5.50	18.15	30.83	8.30	63.21	16.53	20.26	scl
Bt	15-79	0.55	4.98	7.08	9.00	4.60	26.21	14.53	59.26	c
C	79-180	0.70	6.50	14.22	22.18	10.88	54.48	20.43	25.09	scl

Horizon	Depth	pH	Exchangeable cations					CEC	ECEC	B.S.	E.B.S.
			Ca	Mg	K	H	Al				
	cm		cmol (+) kg^{-1}							%	
Ap	0-15	4.15	1.20	0.31	0.14	7.56	0.55	9.21	2.20	17.92	75.00
Bt	15-79	4.96	2.00	1.16	0.10	10.30	1.65	13.56	4.91	24.04	66.40
C	79-180	4.25	0.10	0.31	0.08	8.76	2.45	9.25	2.94	5.30	16.67

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	10YR5/6	1,gr
Bt	15-79	2.5YR5/8	2,sbk
C	79-180	2.5YR4/8	1,sbk

Table 15. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A5-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	1.28	5.65	16.48	26.48	7.00	56.89	21.89	21.22	scl
Bt	18-71	0.22	3.48	8.52	12.80	5.90	30.92	13.53	55.55	c
C	71-180	0.38	5.50	13.62	19.30	12.38	51.18	18.45	30.37	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-18	4.10	1.52	0.66	0.43	3.35	0.55	5.96	3.16	43.79	82.59
Bt	18-71	4.20	1.83	0.94	0.11	8.76	1.45	11.64	4.33	24.74	66.51
C	71-180	4.95	0.11	0.23	0.05	7.13	2.75	7.52	3.14	5.19	12.42

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	10YR5/6	1,gr
Bt	18-71	2.5YR5/8	2,sbk
C	71-180	2.5YR4/8	1,sbk

Table 16. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A6-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-15	0.90	4.88	15.98	28.13	7.50	57.39	17.51	25.10	scl
Bt	15-74	0.25	2.75	7.50	12.50	5.50	28.50	14.64	56.86	c
C	74-180	0.40	4.92	12.45	17.72	8.60	44.09	22.71	33.20	cl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-15	4.40	2.37	0.71	0.20	8.56	0.20	11.84	3.48	27.70	94.25
Bt	15-74	4.52	2.28	1.24	0.08	10.10	1.05	13.70	4.65	26.28	77.42
C	74-180	4.12	0.14	0.31	0.08	8.32	3.15	8.85	3.68	5.99	14.40

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	7.5YR5/4	1,gr
Bt	15-74	5YR5/6	2,sbk
C	74-180	2.5YR5/8	1,sbk

Table 17. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A6-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-13	0.45	3.95	14.22	26.10	6.95	51.67	28.08	20.25	l,sl,scl
Bt	13-51	0.51	1.80	7.12	12.42	5.12	26.61	15.84	57.55	c
C	51-180	0.22	1.80	11.05	26.62	11.52	51.01	19.57	29.42	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-13	4.56	2.17	0.62	0.25	4.38	0.15	7.42	3.19	40.97	95.30
Bt	13-51	4.56	2.17	1.28	0.11	10.55	1.05	14.11	4.61	25.23	77.22
C	51-180	4.23	0.40	0.39	0.08	7.16	2.25	8.03	3.12	10.83	27.88

Horizon	Depth	Color	Structure
	cm		
Ap	0-13	7.5YR5/4	2,gr
Bt	13-51	2.5YR4/8	2,sbk
C	51-180	5YR5/8	1,sbk

Table 18. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A6-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-13	0.62	4.22	16.08	28.23	9.45	58.60	16.23	25.17	scl
Bt	13-76	0.18	2.25	7.35	14.20	5.62	29.60	14.82	55.58	c
C	76-180	0.20	4.05	13.18	23.55	10.85	51.83	25.00	23.17	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-13	4.54	2.27	0.71	0.23	7.36	0.15	10.57	3.36	30.37	95.54
Bt	13-76	4.80	2.44	1.39	0.07	9.55	0.95	13.45	4.85	29.00	95.15
C	76-180	4.20	0.08	0.25	0.07	7.16	2.85	7.56	3.25	5.29	12.31

Horizon	Depth	Color	Structure
	cm		
Ap	0-13	10YR5/4	1,gr
Bt	13-76	2.5YR5/8	2,sbk
C	76-180	2.5YR5/8	1,sbk

Table 19. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A7-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-13	2.15	8.30	17.25	22.20	5.58	55.48	26.52	18.00	fsl
Bt	13-69	1.78	6.02	10.62	15.92	5.92	40.26	17.26	42.48	c
C	69-180	3.28	9.00	14.75	28.40	8.72	64.15	13.11	22.75	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-13	3.80	1.23	0.36	0.31	4.14	1.05	6.04	2.95	31.46	64.41
Bt	13-69	4.65	2.12	1.05	0.16	7.92	1.05	11.25	4.38	29.60	76.03
C	69-180	5.15	0.42	0.49	0.18	4.95	2.05	6.04	3.14	18.05	34.71

Horizon	Depth	Color	Structure
	cm		
Ap	0-13	7.5YR5/6	2,gr
Bt	13-69	5YR5/8	2,sbk
C	69-180	5YR5/8	1,sbk

Table 20. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A7-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-23	2.88	9.60	18.00	23.53	6.18	60.19	16.96	22.85	scl
Bt	23-76	2.08	6.58	10.30	14.95	4.85	38.76	17.95	43.29	c
C	76-180	2.60	8.72	14.30	22.90	8.55	57.07	15.43	27.50	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-23	4.42	1.60	0.40	0.28	7.76	0.55	10.04	2.83	22.71	80.57
Bt	23-76	4.75	2.34	1.26	0.15	8.76	0.45	12.51	4.20	29.98	89.29
C	76-180	4.50	0.32	0.56	0.12	6.95	2.45	7.97	3.45	12.55	28.99

Horizon	Depth	Color	Structure
	cm		
Ap	0-23	10YR5/6	2,gr
Bt	23-76	2.5YR5/8	2,sbk
C	76-180	2.5YR5/8	1,sbk

Table 21. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A7-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-30	3.40	9.82	17.78	23.58	5.55	60.13	23.53	16.34	fsl
Bt	30-76	2.22	6.45	10.62	14.72	4.30	58.31	18.85	42.84	sc
C	91-180	1.50	5.25	9.72	16.72	7.98	41.17	26.24	32.59	cl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-30	4.72	1.40	0.41	0.27	5.15	0.85	7.23	2.93	28.77	70.99
Bt	30-76	5.24	1.86	0.92	0.26	10.30	0.95	13.34	3.99	22.79	76.19
C	91-180	4.30	0.52	0.62	0.18	6.97	2.85	8.29	4.17	15.92	31.65

Horizon	Depth	Color	Structure
	cm		
Ap	0-30	10YR5/6	2,gr
Bt	30-76	5YR6/8	2,sbk
BC	76-91	2.5YR5/8	1,sbk
C	91-180	2.5YR5/8	1,sbk

Table 22. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A8-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-9	1.48	6.65	15.45	22.52	5.62	51.72	16.65	31.63	scl
Bt	9-51	0.48	2.80	7.82	15.40	5.90	32.40	17.40	50.20	c
C	51-180	0.42	4.45	11.75	20.85	10.40	47.87	20.23	31.90	scl

Horizon	Depth	pH	Exchangeable cations					CEC	ECEC	B.S.	E.B.S.
			Ca	Mg	K	H	Al				
	cm		cmol (+) kg^{-1}							%	
Ap	0-9	6.28	3.86	1.67	0.15	3.37	0.05	9.05	5.73	62.76	99.13
Bt	9-51	5.62	2.92	1.41	0.08	7.13	0.05	11.54	4.46	38.21	98.88
C	51-180	5.01	0.55	0.43	0.09	7.92	2.25	8.99	3.22	11.90	32.23

Horizon	Depth	Color	Structure
	cm		
Ap	0-9	7.5YR5/6	1,sbk
Bt	9-51	5YR5/8	2,sbk
C	51-180	5YR6/8	1,sbk

Table 23. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A8-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-8	1.45	4.38	9.62	17.90	6.15	39.80	16.75	43.45	c
Bt	8-41	0.62	3.85	9.55	16.88	6.35	37.25	19.60	43.15	c
C	61-180	0.78	5.30	10.60	22.53	9.68	48.89	17.80	33.31	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-8	6.30	3.93	1.70	0.17	4.16	0.05	9.96	5.85	58.23	99.15
Bt	8-41	5.65	3.30	1.39	0.09	6.37	0.05	11.15	4.83	42.87	98.96
C	61-180	4.24	0.34	0.32	0.09	8.96	1.75	9.71	2.50	7.72	30.00

Horizon	Depth	Color	Structure
	cm		
Ap	0-8	7.5YR5/8	1,sbk
Bt	8-41	5YR5/8	2,sbk
BC	41-61	5YR5/8	1,sbk
C	61-180	5YR6/8	1,sbk

Table 24. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A8-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-20	0.40	4.68	12.60	24.02	7.35	49.05	18.86	32.09	scl
Bt	20-64	0.30	3.70	11.28	19.18	7.15	41.61	15.20	43.19	c
C	91-180	0.30	4.45	11.75	20.85	10.40	47.87	20.23	31.90	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-20	5.92	3.99	1.46	0.13	4.18	0.05	9.76	5.63	57.17	99.11
Bt	20-64	4.75	2.26	1.03	0.06	7.52	0.35	10.87	3.70	30.82	90.54
C	91-180	5.30	0.26	0.20	0.06	5.15	1.85	5.67	2.37	10.90	38.44

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	7.5YR5/6	1,sbk
Bt	20-64	5YR5/8	2,sbk
BC	64-91	5YR5/8	1,sbk
C	91-180	5YR6/8	1,sbk

Table 25. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A9-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-10	1.50	3.28	10.92	24.28	7.35	47.33	23.17	29.50	scl
Bt	10-81	0.70	1.60	3.28	8.25	4.28	18.11	20.96	60.92	c
BC	81-180	9.28	10.10	7.20	9.65	5.72	41.75	18.23	40.02	cl,c

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-10	6.05	3.72	1.24	0.18	3.96	0.05	9.10	5.19	56.48	99.04
Bt	10-81	5.12	2.77	1.34	0.07	8.76	0.05	12.94	4.23	32.30	98.82
BC	81-180	4.88	0.21	0.21	0.16	7.13	2.25	7.71	2.83	7.52	20.49

Horizon	Depth	Color	Structure
	cm		
Ap	0-10	7.5YR4/6	2,gr
Bt	10-81	2.5YR4/8	3,sbk
BC	81-180	2.5YR4/8	3,sbk

Table 26. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A9-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-15	1.18	2.98	7.02	20.82	8.75	40.75	23.45	35.80	cl
Bt1	15-99	0.50	1.30	2.98	8.22	4.28	17.28	16.64	66.08	c
Bt2	99-180	1.15	3.38	6.68	16.75	7.20	35.16	22.06	42.78	c

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-15	5.90	3.60	1.45	0.12	5.15	0.05	10.32	5.22	50.10	99.04
Bt1	15-99	4.90	2.74	1.51	0.05	9.55	0.35	13.85	4.65	31.05	92.47
Bt2	99-180	4.90	0.28	0.27	0.10	8.91	2.35	9.56	3.00	6.80	21.67

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	5YR5/6	2,gr
Bt1	15-99	2.5YR4/8	2,sbk
Bt2	99-180	2.5YR4/8	3,sbk

Table 27. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A9-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-15	1.68	3.28	7.58	21.02	8.08	41.64	24.70	33.66	cl
Bt1	15-97	0.75	1.50	3.38	9.28	4.95	19.86	18.98	61.16	c
Bt2	97-180	9.28	10.10	7.20	9.65	5.72	41.95	18.03	40.02	cl,c

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-15	5.50	3.27	1.27	0.11	5.17	0.10	9.82	4.75	47.35	97.89
Bt1	15-97	4.30	0.76	0.79	0.07	10.95	1.65	12.57	3.27	12.89	49.54
Bt2	97-180	5.10	0.19	0.14	0.09	6.93	1.95	7.35	2.37	5.71	17.72

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	5YR5/6	2,gr
Bt1	15-97	2.5YR4/8	2,sbk
Bt2	97-180	2.5YR4/8	2,sbk

Table 28. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A10-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-16	0.98	6.25	19.88	34.42	8.92	70.45	19.21	10.34	fsl
Bt1	16-48	1.02	4.65	14.78	24.72	6.60	51.77	21.93	26.30	scl
BC	69-180	0.40	1.90	7.55	16.58	5.42	31.85	18.53	49.62	c

Horizon	Depth	pH	Exchangeable cations					CEC	ECEC	B.S.	E.B.S.
			Ca	Mg	K	H	Al				
	cm		cmol (+) kg^{-1}							%	
Ap	0-16	5.40	2.18	0.60	0.08	2.97	0.05	5.83	2.91	49.06	98.28
Bt1	16-48	5.50	2.08	1.00	0.05	6.14	0.10	9.27	3.23	33.76	96.90
BC	69-180	5.05	1.23	0.75	0.10	8.91	2.75	10.99	4.83	18.93	43.06

Horizon	Depth	Color	Structure
	cm		
Ap	0-16	7.5YR4/4	2,gr
Bt1	16-48	7.5YR5/8	1,sbk
Bt2	48-69	5YR5/8	2,sbk
BC	69-180	2.5YR4/8	2,sbk

Table 29. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A10-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-11	1.00	6.02	19.42	36.02	9.65	72.11	18.44	9.45	fsl
Bt	20-97	0.65	3.08	8.60	15.70	5.22	33.25	17.62	49.13	c
C	97-180	0.85	6.22	15.15	24.00	9.30	55.52	16.75	27.73	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-11	5.92	2.55	0.64	0.04	1.78	0.05	5.01	3.28	64.47	98.48
Bt	20-97	4.90	2.68	1.07	0.06	9.35	0.55	13.16	4.36	28.95	87.39
C	97-180	4.34	0.20	0.34	0.07	5.74	2.35	6.35	2.96	9.61	20.61

Horizon	Depth	Color	Structure
	cm		
Ap	0-11	10YR4/4	2,gr
BA	11-20	5YR5/8	1,sbk
Bt	20-97	2.5YR5/8	2,sbk
C	97-180	5YR5/8	1,sbk

Table 30. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A10-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-20	1.12	6.20	19.85	35.12	9.42	71.71	18.14	10.15	fsl
BA	20-36	0.90	5.42	16.35	27.78	7.45	57.90	21.16	20.94	scl
Bt	36-71	0.90	3.92	9.85	15.82	5.32	35.81	18.78	45.41	c
C	71-180	2.32	8.75	14.58	23.82	9.05	58.52	14.84	26.64	scl

Horizon	Depth	pH	Exchangeable cations					CEC	ECEC	B.S.	E.B.S.
			Ca	Mg	K	H	Al				
	cm		cmol (+) kg^{-1}							%	
Ap	0-20	5.56	1.92	0.58	0.08	2.79	0.05	5.37	2.63	48.04	98.10
BA	20-36	5.85	1.61	0.72	0.05	5.57	0.05	7.95	2.43	29.94	97.94
Bt	36-71	4.55	2.12	0.94	0.07	8.76	0.95	11.89	4.08	26.32	76.72
C	71-180	5.00	0.42	0.41	0.08	6.73	2.05	7.64	2.96	11.91	66.22

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	10YR5/4	2,gr
BA	20-36	5YR6/8	2,sbk
Bt	36-71	2.5YR5/8	2,sbk
C	71-180	5YR5/8	1,sbk

Table 31. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A11-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-13	0.98	7.08	16.82	24.75	6.75	56.38	16.58	27.04	scl
Bt1	13-48	1.28	8.10	15.10	16.28	4.78	45.54	9.15	45.31	sc,c
Bt2	48-84	0.22	2.35	6.45	18.32	7.50	34.84	21.80	43.36	c
C	84-180	0.18	1.08	8.20	25.38	9.50	44.34	24.99	30.67	cl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-13	5.95	2.74	1.05	0.08	3.58	0.05	7.45	3.92	51.95	98.72
Bt1	13-48	6.45	3.70	1.20	0.09	6.14	0.05	11.13	5.04	44.83	99.01
Bt2	48-84	5.05	2.70	1.41	0.10	7.16	0.15	11.37	4.36	37.03	96.56
C	84-180	5.26	1.01	0.84	0.13	5.74	2.25	7.72	4.23	25.65	46.81

Horizon	Depth	Color	Structure
	cm		
Ap	0-13	10YR5/4	1,sbk
Bt1	13-48	7.5YR6/8	2,sbk
Bt2	48-84	2.5YR5/8	2,sbk
C	84-180	2.5YR4/8	1,sbk

Table 32. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A11-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	1.05	6.64	17.78	30.55	8.82	64.85	16.23	18.92	fsl
Bt	18-91	0.50	3.15	7.38	18.38	7.42	36.83	16.88	46.29	c
C	91-180	0.40	3.52	9.00	28.20	10.05	51.17	16.74	32.09	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-18	6.70	2.60	0.99	0.09	2.97	0.00	6.65	3.68	55.34	100.0
Bt	18-91	4.80	2.16	1.23	0.07	10.35	0.75	13.81	4.21	25.05	82.19
C	91-180	4.55	0.14	0.29	0.17	8.96	2.85	9.56	3.45	6.28	17.39

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	10YR5/6	2,sbk
Bt	18-91	2.5YR5/8	2,sbk
C	91-180	5YR5/8	1,sbk

Table 33. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A11-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-14	1.02	6.35	17.50	31.62	8.75	65.24	14.01	20.75	scl
BA	14-38	0.70	5.12	10.30	14.10	3.72	33.94	18.91	47.15	c
Bt	38-89	0.88	3.92	8.82	19.38	7.15	40.15	20.01	39.84	cl,c
C	89-180	0.20	0.48	5.92	30.98	10.82	48.22	21.48	30.30	scl

Horizon	Depth	pH	Exchangeable cations					CEC	ECEC	B.S.	E.B.S.
			Ca	Mg	K	H	Al				
	cm		cmol (+) kg^{-1}							%	
Ap	0-14	6.40	2.68	1.02	0.16	2.97	0.05	6.83	3.91	56.52	98.72
BA	14-38	5.92	3.21	1.46	0.09	6.53	0.15	11.29	4.91	42.16	98.32
Bt	38-89	4.60	1.64	1.15	0.08	8.56	6.45	11.43	9.32	25.11	30.79
C	89-180	4.16	0.46	0.57	0.11	9.15	3.65	10.29	4.79	11.08	23.80

Horizon	Depth	Color	Structure
	cm		
Ap	0-14	10YR5/6	2,gr
BA	14-38	7.5YR5/8	1,sbk
Bt	38-89	2.5YR5/8	2,sbk
C	89-180	2.5YR5/8	1,sbk

Table 34. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A12-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-20	1.35	8.20	18.70	30.05	10.32	68.62	21.36	10.02	fsl
Bt	20-69	2.23	7.85	9.53	11.93	5.15	36.69	23.68	39.63	cl,c
C	69-180	0.45	3.98	8.73	14.73	8.65	36.54	27.50	35.96	cl

Horizon	Depth	pH	Exchangeable cations					CEC	ECEC	B.S.	E.B.S.
			Ca	Mg	K	H	Al				
	cm		cmol (+) kg^{-1}							%	
Ap	0-20	6.35	2.75	0.92	0.11	2.77	0.05	6.55	3.83	57.71	98.69
Bt	20-69	5.25	6.17	1.48	0.10	5.97	0.05	13.72	7.80	56.49	99.36
C	69-180	5.54	6.85	3.40	0.23	6.93	1.35	17.41	11.83	60.20	88.59

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	10YR4/4	2,gr
Bt	20-69	7.5YR5/8	2,sbk
C	69-180	5YR5/8	1,sbk

Table 35. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A12-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-20	2.00	9.65	19.30	27.78	9.05	67.78	16.02	16.20	fsl
Bt	20-89	1.78	7.68	10.00	12.30	4.90	36.66	31.37	31.97	cl
C	89-180	1.98	9.42	10.22	11.10	6.72	39.44	31.57	28.99	cl

Horizon	Depth	pH	Exchangeable cations					CEC	ECEC	B.S.	E.B.S.
			Ca	Mg	K	H	Al				
	cm		cmol (+) kg^{-1}							%	
Ap	0-20	5.12	2.50	0.82	0.14	3.78	0.15	7.24	3.61	47.79	95.84
Bt	20-89	5.68	4.79	1.31	0.08	7.76	0.05	13.94	6.23	44.33	99.20
C	89-180	4.92	5.77	3.50	0.20	4.14	0.05	13.61	9.52	69.58	99.47

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	10YR4/4	1,gr
Bt	20-89	5YR5/8	2,sbk
C	89-180	2.5YR5/8	1,sbk

Table 36. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A12-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-20	1.02	7.90	18.55	30.50	10.20	68.17	22.97	8.86	fsl
Bt	20-84	1.85	8.72	10.80	12.88	5.12	39.37	31.50	29.13	cl
C	84-180	1.35	6.50	8.20	9.92	7.18	33.15	34.30	32.55	cl

Horizon	Depth	pH	Exchangeable cations					CEC	ECEC	B.S.	E.B.S.
			Ca	Mg	K	H	Al				
	cm		cmol (+) kg^{-1}							%	
Ap	0-20	5.28	1.82	0.51	0.23	2.97	0.15	5.58	2.71	46.29	94.46
Bt	20-84	5.50	5.90	1.59	0.16	5.37	0.05	13.02	7.70	58.76	99.35
C	84-180	5.54	6.85	3.40	0.23	6.93	1.35	17.41	11.83	60.20	88.59

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	10YR4/4	2,gr
Bt	20-84	5YR5/8	2,sbk
C	84-180	7.5YR5/8	1,sbk

Table 37. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A13-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-15	0.95	8.48	18.65	29.20	8.52	65.80	19.91	14.29	fsl
BA	15-36	2.05	7.90	14.53	20.53	7.90	52.91	22.12	24.97	scl
Bt1	36-64	3.28	10.20	13.30	15.80	5.30	47.88	25.97	26.15	scl
BC	102-180	0.68	4.62	9.72	16.00	9.22	40.24	24.49	35.27	cl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-15	5.52	2.71	0.80	0.18	6.77	0.05	10.46	3.74	35.28	98.66
BA	15-36	5.50	2.57	1.05	0.11	3.98	0.05	7.71	3.78	48.38	98.68
Bt1	36-64	5.72	3.66	1.06	0.12	6.35	0.15	10.19	4.99	47.50	96.99
C	102-180	5.40	7.02	2.50	0.14	7.52	0.05	17.18	9.71	56.23	99.49

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	10YR4/4	2,gr
BA	15-36	7.5YR5/6	1,sbk
Bt1	36-64	5YR5/6	2,sbk
Bt2	64-102	5YR5/8	2,sbk
BC	102-180	2.5YR5/8	1,sbk

Table 38. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A13-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-20	1.95	9.62	18.75	27.00	8.68	66.00	16.00	18.00	fsl
BA	20-46	1.55	8.50	15.18	18.55	6.38	50.16	24.23	25.61	scl
Bt	46-97	1.65	10.10	12.80	13.58	5.50	43.63	23.67	32.70	cl
C	97-180	1.05	11.18	16.28	18.48	8.70	55.69	19.79	24.52	scl

Horizon	Depth	pH	Exchangeable cations					CEC	ECEC	B.S.	E.B.S.
			Ca	Mg	K	H	Al				
	cm		cmol (+) kg^{-1}							%	
Ap	0-20	5.50	2.63	0.74	0.20	8.76	0.05	12.33	3.62	28.95	98.62
BA	20-46	6.10	2.75	1.17	0.11	3.58	0.05	7.61	4.08	52.96	98.77
Bt	46-97	6.25	5.35	1.44	0.13	5.35	0.05	12.27	6.97	56.40	99.28
C	97-180	5.15	4.34	1.13	0.10	4.95	0.05	10.52	5.62	52.95	99.11

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	10YR4/4	2,gr
BA	20-46	7.5YR5/6	1,sbk
Bt	46-97	5YR5/8	2,sbk
C	97-180	7.5YR6/8	1,sbk

Table 39. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A13-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	1.85	9.48	19.85	28.28	9.08	68.54	19.64	11.82	fsl
BA	18-38	1.52	9.88	16.55	22.30	7.08	57.33	24.51	18.16	fsl
Bt1	38-61	1.53	6.70	12.10	18.85	7.80	46.98	22.20	30.82	scl
Bt2	61-74	0.18	2.03	6.50	16.80	6.80	32.31	28.60	39.09	cl,c

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-18	6.15	2.91	0.98	0.19	3.17	0.05	7.25	4.13	56.28	98.78
BA	18-38	5.75	2.22	1.00	0.19	2.99	0.05	6.40	3.46	53.28	98.55
Bt1	38-61	5.75	4.09	1.41	0.24	10.75	0.05	16.49	5.79	34.81	99.14
Bt2	61-74	5.62	8.00	2.70	0.12	9.95	0.05	20.77	10.87	52.09	99.54

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	10YR4/4	2,gr
BA	18-38	7.5YR5/7	1,sbk
Bt1	38-61	5YR5/8	2,sbk
Bt2	61-74	5YR5/8	2,sbk
C	74-180	5YR5/8	1,sbk

Table 40. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A14-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-14	2.13	8.37	14.83	22.03	6.73	54.09	24.51	21.40	scl
Bt	14-61	1.35	5.25	6.62	7.70	4.15	25.07	14.70	60.23	c
C	84-180	2.25	11.55	13.12	17.92	12.68	57.52	23.68	18.80	fsl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-14	6.32	4.94	1.66	0.10	2.38	0.05	9.08	6.75	73.79	99.26
Bt	14-61	6.60	6.22	2.10	0.14	7.72	0.05	16.18	8.51	52.29	99.41
C	84-180	5.10	1.61	1.06	0.29	7.13	4.05	10.09	7.01	29.34	42.23

Horizon	Depth	Color	Structure
	cm		
Ap	0-14	5YR4/4	1,gr
Bt	14-61	2.5YR4/6	2,sbk
BC	61-84	2.5YR4/6	1,sbk
C	84-180	2.5YR5/8	1,sbk

Table 41. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A14-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-15	1.35	7.20	13.08	18.70	5.52	45.85	18.96	35.19	cl,scl,sc
Bt	15-64	0.88	5.95	8.12	8.62	5.00	28.57	17.76	53.67	c
C	91-180	1.02	7.95	15.50	20.75	12.55	57.77	22.75	19.48	fsl,scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-15	6.45	5.30	1.80	0.11	5.17	0.05	12.38	7.26	58.24	99.31
Bt	15-64	6.05	6.18	2.00	0.10	7.52	0.05	15.80	8.33	52.41	98.20
C	91-180	5.36	0.65	0.76	0.19	9.11	5.45	10.71	7.05	14.94	22.70

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	5YR4/4	1,gr
Bt	15-64	2.5YR4/6	2,sbk
BC	64-91	2.5YR4/6	1,sbk
C	91-180	2.5YR5/8	1,sbk

Table 42. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A14-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-15	1.45	7.53	16.10	23.80	6.60	55.48	14.15	30.37	scl
Bt	15-69	0.88	5.40	8.02	8.95	4.42	27.67	17.80	54.53	c
C	97-180	1.90	9.75	11.11	14.55	10.75	48.06	28.12	23.82	l,scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-15	6.30	5.34	1.75	0.13	6.17	0.05	13.39	7.27	53.92	99.31
Bt	15-69	6.70	6.00	2.00	0.13	5.54	0.00	13.67	8.13	59.47	100.0
C	97-180	5.50	0.78	0.78	0.14	6.53	3.95	8.23	5.65	20.66	30.09

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	5YR4/4	1,gr
Bt	15-69	2.5YR4/6	2,sbk
BC	69-97	2.5YR4/6	1,sbk
C	97-180	2.5YR5/8	1,sbk

Table 43. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A15-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-14	1.05	7.15	15.38	25.35	8.20	57.13	25.51	17.36	fsl
Bt	14-43	1.15	6.20	11.45	17.80	8.08	44.68	29.06	26.26	l,cl,scl
C2	58-180	5.98	15.98	17.08	14.88	6.82	60.74	23.54	15.72	sl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-14	4.85	4.77	1.83	0.26	4.78	0.15	11.64	7.01	58.93	97.87
Bt	14-43	5.25	6.18	2.30	0.14	5.15	0.35	13.77	8.97	62.60	96.10
C2	58-180	5.14	9.50	5.80	0.25	5.54	0.55	21.09	16.10	73.73	98.59

Horizon	Depth	Color	Structure
	cm		
Ap	0-14	10YR4/4	1,gr
Bt	14-43	7.5YR5/6	2,sbk
C1	43-58	5YR5/6	1,sbk
C2	58-180	5YR5/6	1,sbk

Table 44. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A15-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-15	1.23	6.83	16.45	27.95	9.78	62.24	18.87	18.89	fsl
BA	23-41	2.50	7.22	14.28	23.55	9.58	57.13	26.60	16.27	fsl
Bt	41-66	0.35	2.12	8.32	14.45	8.32	33.56	34.84	31.60	cl
C	89-180	0.20	3.98	10.42	14.08	8.95	37.63	34.83	27.54	l,cl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-15	4.72	2.67	0.91	0.14	8.36	0.35	12.08	4.07	30.79	91.40
BA	23-41	5.78	3.22	0.80	0.12	3.56	0.40	7.70	4.54	53.77	91.19
Bt	41-66	5.82	6.78	2.30	0.14	5.15	0.35	14.37	9.57	64.16	96.34
C	89-180	5.72	5.55	3.10	0.15	6.53	0.15	15.53	8.95	57.40	98.32

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	10YR4/4	2,gr
AB	15-23	7.5YR5/6	1,gr
BA	23-41	5YR5/6	1,sbk
Bt	41-66	5YR5/6	2,sbk
BC	66-89	2.5YR5/6	2,sbk
C	89-180	2.5YR5/6	1,sbk

Table 45. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A15-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-20	1.08	5.02	14.62	28.62	11.40	60.74	25.40	13.86	fsl
BA	20-38	1.78	5.18	12.55	22.85	8.55	50.91	27.13	21.96	l,sl,scl
Bt	38-94	0.68	3.52	10.05	17.18	7.05	38.48	30.52	31.00	cl
C	94-180	0.20	1.95	9.40	16.05	9.80	37.40	29.30	33.30	cl

Horizon	Depth	pH	Exchangeable cations					CEC	ECEC	B.S.	E.B.S.
			Ca	Mg	K	H	Al				
	cm		cmol (+) kg^{-1}							%	
Ap	0-20	5.05	1.56	0.46	0.12	3.76	0.85	5.90	2.99	36.27	71.57
BA	20-38	4.65	2.62	0.55	0.11	3.78	0.45	7.06	3.73	46.46	87.94
Bt	38-94	5.73	5.67	1.63	0.13	4.85	0.05	12.28	7.48	60.50	98.95
C	94-180	6.11	6.16	2.90	0.14	6.14	0.15	15.34	9.35	59.97	98.40

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	10YR4/4	2,gr
BA	20-38	7.5YR5/6	1,sbk
Bt	38-94	5YR5/6	2,sbk
C	94-180	5YR5/6	1,sbk

Table 46. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A16-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-20	2.55	10.65	18.38	21.98	6.30	59.86	23.67	16.47	sl
Bt	20-71	0.30	4.88	10.48	13.65	6.78	36.09	18.40	45.51	c
C	71-180	2.55	11.92	15.80	22.05	10.05	62.37	12.34	25.29	scl

Horizon	Depth	pH	Exchangeable cations					CEC	ECEC	B.S.	E.B.S.
			Ca	Mg	K	H	Al				
	cm		cmol (+) kg^{-1}							%	
Ap	0-20	4.90	2.84	0.87	0.28	6.17	0.25	10.16	4.24	39.27	94.10
Bt	20-71	5.80	3.93	1.42	0.10	5.57	0.05	11.02	5.50	49.41	99.09
C	71-180	5.10	1.32	1.10	0.11	6.14	1.35	8.67	3.88	29.18	65.21

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	10YR4/4	1,gr
Bt	20-71	5YR5/8	3,sbk
C	71-180	5YR5/6	1,sbk

Table 47. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A16-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-23	2.00	10.32	20.68	22.65	5.55	61.20	22.55	16.26	sl
Bt	23-76	0.78	5.18	8.75	11.55	5.08	31.34	18.89	49.77	c
C	76-180	0.80	7.98	13.38	21.68	10.98	54.82	17.55	27.63	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-23	5.10	2.64	0.88	0.32	5.54	0.20	9.38	4.04	40.94	95.05
Bt	23-76	5.66	4.18	1.48	0.15	7.52	0.05	13.33	5.87	43.59	99.15
C	76-180	5.12	1.19	1.00	0.14	5.54	2.30	7.87	4.63	29.61	50.32

Horizon	Depth	Color	Structure
	cm		
Ap	0-23	10YR5/4	2,gr
Bt	23-76	5YR5/8	3,sbk
C	76-180	7.5YR6/8	1,sbk

Table 48. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A16-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-30	1.58	9.28	18.90	23.12	6.02	58.90	25.56	15.54	fsl
Bt	30-81	0.52	5.15	11.68	14.80	7.12	39.27	21.84	38.89	cl,c
C	81-180	0.52	5.28	14.60	23.88	11.82	56.10	18.77	25.13	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-30	5.25	2.84	1.07	0.49	5.35	0.25	9.75	4.65	45.13	94.62
Bt	30-81	5.30	3.40	1.43	0.11	7.56	0.05	12.50	4.99	39.52	99.00
C	81-180	5.06	1.15	1.40	0.13	5.74	1.55	8.42	4.23	31.83	63.36

Horizon	Depth	Color	Structure
	cm		
Ap	0-30	10YR4/4	2,gr
Bt	30-81	5YR5/8	2,sbk
C	81-180	7.5YR6/8	1,sbk

Table 49. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A17-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-19	2.50	10.12	20.40	31.02	7.40	71.44	18.01	10.55	fsl
BA	19-33	1.60	8.38	15.15	19.70	5.15	49.98	23.68	26.34	scl
Bt	33-91	1.42	8.08	13.05	16.25	5.95	44.75	21.98	33.27	cl,scl
C	91-180	1.02	8.58	18.00	23.45	7.98	59.03	15.64	25.33	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-19	4.60	1.21	0.44	0.30	6.34	0.55	8.29	2.50	23.52	78.00
BA	19-33	4.72	2.05	0.75	0.10	5.77	0.15	8.67	3.05	33.45	95.08
Bt	33-91	5.35	3.28	1.15	0.07	5.77	0.10	10.27	4.60	43.82	97.83
C	91-180	5.10	2.06	1.63	0.09	5.37	0.45	9.15	4.23	41.31	89.36

Horizon	Depth	Color	Structure
	cm		
Ap	0-19	10YR4/4	2,gr
BA	19-33	5YR5/8	2,sbk
Bt	33-91	5YR5/8	1,sbk
C	91-180	5YR5/8	0,m

Table 50. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A17-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-15	1.10	7.93	19.63	32.50	8.60	69.76	17.76	12.48	fsl
AB	15-30	1.58	9.82	18.68	23.35	5.92	59.35	23.33	17.32	fsl
Bt	30-91	2.00	9.60	13.10	15.58	5.82	46.10	23.20	30.70	cl,scl
CB	91-180	2.25	8.90	15.25	20.22	6.92	53.54	16.21	30.25	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-15	4.96	0.90	0.20	0.17	3.56	0.85	4.83	2.12	26.29	59.91
AB	15-30	5.85	1.62	0.53	0.10	2.57	0.25	4.82	2.50	46.68	90.00
Bt	30-91	5.50	3.04	1.08	0.10	3.56	0.45	7.78	4.65	54.24	90.36
CB	91-180	4.70	1.91	1.67	0.10	5.97	1.15	9.65	4.83	38.13	76.19

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	10YR5/4	2,gr
AB	15-30	10YR5/6	1,gr
Bt	30-91	2.5YR5/8	2,sbk
CB	91-180	5YR5/8	1,sbk

Table 51. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A17-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	1.22	8.35	20.70	32.35	7.98	70.60	18.87	10.53	fsl
AB	18-38	1.50	9.05	18.45	23.15	5.75	57.90	24.09	18.01	fsl
Bt	38-94	1.42	8.02	14.98	16.30	7.25	47.97	24.17	27.86	scl
CB	94-180	2.02	10.45	17.35	21.02	7.02	57.86	13.84	28.30	scl

Horizon	Depth	pH	Exchangeable cations					CEC	ECEC	B.S.	E.B.S.
			Ca	Mg	K	H	Al				
	cm		cmol (+) kg^{-1}							%	
Ap	0-18	4.95	0.88	0.31	0.27	5.74	0.85	7.20	2.31	20.28	63.20
AB	18-38	4.48	1.37	0.48	0.11	5.37	0.35	7.33	2.31	26.74	84.85
Bt	38-94	5.42	2.82	0.94	0.11	3.96	0.45	7.83	4.32	49.43	89.58
CB	94-180	4.75	2.39	1.24	0.07	6.78	1.15	10.45	4.87	35.60	76.39

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	10YR5/4	2,gr
AB	18-38	10YR5/6	1,sbk
Bt	38-94	5YR5/8	2,sbk
CB	94-180	5YR5/8	1,sbk

Table 52. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A18-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-13	3.20	9.58	16.28	20.45	6.95	56.46	17.75	25.79	sl
Bt	13-61	1.38	9.10	18.00	19.90	5.38	53.76	10.89	35.35	scl,sc
C	61-180	5.60	10.90	12.08	21.18	8.40	58.16	19.01	22.83	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-13	4.84	2.70	0.97	0.23	6.14	0.75	10.04	4.65	38.84	83.87
Bt	13-61	5.63	2.48	1.28	0.10	4.55	0.55	8.41	3.91	45.90	98.72
C	61-180	4.80	0.13	0.37	0.17	6.97	2.35	7.64	3.02	8.77	22.19

Horizon	Depth	Color	Structure
	cm		
Ap	0-13	5YR4/6	1,gr
Bt	13-61	2.5YR5/8	2,sbk
C	61-180	2.5YR4/8	1,sbk

Table 53. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A18-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-15	1.38	11.42	17.92	20.65	5.48	56.85	16.10	27.05	scl
Bt	15-81	2.65	9.50	13.58	13.38	4.58	43.69	14.04	42.30	c
C	81-180	6.38	11.30	10.92	17.65	8.38	54.63	18.73	26.64	scl

Horizon	Depth	pH	Exchangeable cations					CEC	ECEC	B.S.	E.B.S.
			Ca	Mg	K	H	Al				
	cm		cmol (+) kg^{-1}							%	
Ap	0-15	4.24	2.15	0.70	0.18	7.16	0.65	10.19	3.68	29.74	82.34
Bt	15-81	5.30	2.95	1.39	0.05	5.57	0.05	9.96	4.44	44.08	98.87
C	81-180	4.45	0.48	0.63	0.12	6.37	2.05	7.60	3.28	16.18	37.50

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	5YR4/6	2,gr
Bt	15-81	5YR5/6	2,sbk
C	81-180	2.5YR5/8	1,sbk

Table 54. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A18-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-13	2.52	9.05	15.18	19.90	6.12	52.77	19.14	28.09	scl
Bt	13-43	2.90	8.10	11.50	15.80	5.60	43.90	14.91	41.19	cl,c
C	43-180	1.90	8.25	17.90	25.10	6.50	59.65	12.46	27.89	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-13	4.48	2.98	1.12	0.20	4.73	0.65	9.03	4.95	47.62	99.35
Bt	13-43	5.12	2.54	1.36	0.09	8.76	0.05	12.75	4.04	31.29	98.76
C	43-180	4.45	0.31	0.65	0.21	10.15	2.65	11.32	3.82	10.34	30.63

Horizon	Depth	Color	Structure
	cm		
Ap	0-13	5YR5/6	1,sbk
Bt	13-43	2.5YR5/8	2,sbk
C	43-180	2.5YR4/8	1,sbk

Table 55. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A19-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-15	3.38	9.55	15.75	17.62	6.15	52.45	26.33	21.22	scl
Bt	15-61	3.35	8.15	8.02	14.08	5.30	38.90	24.85	36.25	cl
C	61-180	2.45	11.75	12.98	22.72	9.52	59.42	20.03	20.55	fsl,scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-15	4.32	2.27	0.75	0.21	5.71	0.45	8.94	3.68	36.13	99.55
Bt	15-61	5.35	3.36	1.22	0.10	6.37	0.05	11.05	4.73	42.35	98.94
C	61-180	4.96	2.08	1.36	0.10	6.77	0.15	10.31	3.69	34.34	95.93

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	10YR4/4	2,gr
Bt	15-61	7.5YR5/6	2,sbk
C	61-180	7.5YR6/8	1,sbk

Table 56. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A19-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-15	2.52	11.22	18.68	23.38	6.48	62.28	22.10	15.53	sl
Bt	30-91	3.30	8.10	10.38	15.15	5.82	42.75	14.06	43.19	c
C	91-180	5.20	9.12	12.22	20.88	7.85	55.27	22.59	24.14	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-15	4.30	1.68	0.50	0.14	6.57	0.40	8.89	2.72	26.10	85.29
Bt	30-91	5.54	2.98	0.99	0.07	4.36	0.10	8.40	4.14	48.10	97.58
C	91-180	4.80	1.26	1.24	0.11	5.77	1.15	8.38	3.76	31.15	69.41

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	7.5YR4/4	2,gr
BA	15-30	5YR5/6	1,sbk
Bt	30-91	2.5YR5/8	2,sbk
C	91-180	7.5YR6/8	1,sbk

Table 57. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A19-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	2.38	10.30	18.02	24.20	6.62	61.52	19.38	19.10	sl,scl
Bt	18-51	5.48	9.42	9.22	14.00	5.62	43.74	20.38	35.88	cl
C	71-180	3.70	12.25	13.58	26.28	10.45	66.26	17.13	16.61	fsl

Horizon	Depth	pH	Exchangeable cations					CEC	ECEC	B.S.	E.B.S.
			Ca	Mg	K	H	Al				
	cm		cmol (+) kg^{-1}							%	
Ap	0-18	4.50	2.05	0.61	0.16	7.96	0.35	10.78	3.17	26.16	88.96
Bt	18-51	5.25	3.24	1.11	0.09	5.97	0.15	10.41	4.59	42.65	96.73
C	71-180	4.75	1.45	1.01	0.12	4.78	0.45	7.36	3.03	35.05	85.15

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	10YR5/4	2,gr
Bt	18-51	7.5YR5/6	2,sbk
BC	51-71	7.5YR5/8	1,sbk
C	71-180	7.5YR6/8	1,sbk

Table 58. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A20-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-11	1.88	10.52	20.25	27.00	7.08	66.73	14.64	18.63	sl
Bt	11-64	1.98	9.15	14.38	16.85	5.48	54.27	10.63	35.10	scl,sc
C	64-180	1.68	9.62	14.18	18.78	7.68	51.94	15.97	32.09	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-11	4.78	2.10	0.53	0.07	5.77	0.05	8.47	2.75	31.88	98.18
Bt	11-64	5.20	2.52	1.17	1.10	5.77	0.05	10.56	4.84	45.36	98.97
C	64-180	4.70	1.85	1.07	0.05	5.94	0.45	8.91	3.42	33.33	86.84

Horizon	Depth	Color	Structure
	cm		
Ap	0-11	7.5YR4/4	1,gr
Bt	11-64	2.5YR5/8	2,sbk
C	64-180	2.5YR5/8	1,sbk

Table 59. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A21-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-10	1.68	9.60	18.10	28.12	6.95	64.45	19.28	16.27	fsl
Bt	10-56	0.88	7.00	12.30	14.92	5.48	40.58	15.45	43.97	c
C	56-180	0.98	7.90	12.45	16.31	7.62	45.34	18.98	35.68	l,cl,scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-10	4.60	1.75	0.53	0.12	3.74	0.25	6.14	2.65	39.09	99.75
Bt	10-56	5.90	3.05	1.27	0.09	5.37	0.05	9.78	4.46	45.09	98.88
C	56-180	5.48	2.35	1.24	0.08	7.13	0.25	10.80	3.92	33.98	93.62

Horizon	Depth	Color	Structure
	cm		
Ap	0-10	7.5YR4/4	2,gr
Bt	10-56	5YR5/8	2,sbk
C	56-180	5YR6/8	1,sbk

Table 60. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A20-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-20	3.90	12.18	19.70	25.58	6.95	68.31	16.77	14.92	sl
Bt	20-74	3.52	9.90	13.12	15.00	4.92	46.46	18.97	34.57	l,cl,scl
C	74-180	0.95	8.45	15.12	21.10	9.05	54.67	18.74	26.59	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-20	5.75	2.28	0.56	0.09	4.16	0.15	7.09	3.08	41.33	95.13
Bt	20-74	5.30	2.73	1.07	0.06	4.58	0.05	8.44	3.91	45.73	98.72
C	74-180	4.46	1.96	0.98	0.06	4.98	0.35	7.98	3.35	37.59	89.55

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	10YR5/4	2,gr
Bt	20-74	5YR5/8	2,sbk
C	74-180	5YR5/6	1,sbk

Table 61. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A21-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-10	2.22	8.78	14.98	19.22	5.85	51.05	18.95	30.00	scl
Bt	10-33	2.45	8.40	9.35	9.70	4.00	33.90	15.67	50.43	c
C	33-180	2.25	12.92	17.38	19.55	8.42	47.60	29.81	22.59	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-10	5.02	3.28	1.04	0.13	6.14	0.05	10.59	4.50	42.02	98.89
Bt	10-33	5.90	3.75	1.26	0.08	7.76	0.05	12.85	5.14	39.61	99.03
C	33-180	4.70	1.68	0.53	0.04	6.97	0.35	9.22	2.60	24.40	86.54

Horizon	Depth	Color	Structure
	cm		
Ap	0-10	5YR5/6	1,sbk
Bt	10-33	2.5YR5/8	2,sbk
C	33-180	5YR5/8	1,sbk

Table 62. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A21-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-14	2.18	8.92	14.30	19.02	6.10	50.52	23.53	25.95	scl
Bt	14-46	2.15	7.70	8.65	8.58	3.42	30.50	16.58	52.92	c
C	46-180	1.20	9.68	17.92	19.50	7.98	56.28	19.28	24.44	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-14	5.10	3.67	1.12	0.12	4.95	0.10	9.86	5.01	49.80	98.00
Bt	14-46	5.50	3.15	1.21	0.06	10.55	0.05	14.97	4.47	29.53	98.88
C	46-180	4.54	0.26	0.89	0.10	7.36	0.95	8.61	2.20	14.52	56.82

Horizon	Depth	Color	Structure
	cm		
Ap	0-14	5YR4/6	1,sbk
Bt	14-46	2.5YR5/8	2,sbk
C	46-180	5YR5/8	1,sbk

Table 63. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A21-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-8	2.00	9.40	17.55	21.32	5.85	56.12	19.88	24.00	scl
Bt	8-43	1.50	6.32	8.35	8.45	3.93	28.55	18.07	53.38	c
C	43-180	3.88	16.68	14.28	14.25	6.42	55.51	18.16	26.33	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-8	5.02	3.78	1.31	0.18	5.97	0.25	11.24	5.52	46.89	95.47
Bt	8-43	6.16	3.55	1.48	0.11	7.52	0.05	12.66	5.19	40.60	99.04
C	43-180	5.30	0.72	1.39	0.07	5.15	0.85	7.33	3.03	29.74	71.95

Horizon	Depth	Color	Structure
	cm		
Ap	0-8	5YR4/6	1,sbk
Bt	8-43	2.5YR4/8	2,sbk
C	43-180	2.5YR5/8	0,m

Table 64. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A22-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-10	3.60	10.82	14.38	20.32	6.32	55.44	20.73	23.83	scl
Bt	10-30	2.38	8.18	9.98	15.80	7.12	43.46	25.20	31.34	cl
C	71-180	4.53	10.70	12.10	23.73	11.03	62.09	15.72	22.19	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-10	5.10	3.27	1.11	0.13	5.17	0.15	9.68	4.66	46.59	96.78
Bt	10-30	5.30	3.07	1.26	0.10	4.38	0.10	8.81	4.53	50.28	97.79
C	71-180	5.14	1.64	1.23	0.09	3.58	0.10	6.54	3.06	45.26	96.73

Horizon	Depth	Color	Structure
	cm		
Ap	0-10	5YR4/6	1,sbk
Bt	10-30	5YR5/6	2,sbk
BC	30-71	5YR5/8	2,sbk
C	71-180	7.5YR5/8	1,sbk

Table 65. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A22-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-15	3.88	9.90	12.18	17.62	7.22	50.80	25.97	23.23	l,scl
Bt	15-43	2.38	8.30	11.25	17.45	6.65	46.03	24.10	29.87	scl
C3	97-180	0.02	0.62	5.28	21.25	12.90	40.07	34.15	25.81	l,cl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-15	4.60	2.98	1.14	0.15	3.94	0.05	8.21	4.32	52.01	98.84
Bt	15-43	5.25	3.35	1.31	0.10	4.78	0.10	9.54	4.86	49.90	97.94
C3	97-180	5.20	4.57	3.20	0.13	7.76	0.05	15.66	7.95	50.45	99.37

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	5YR4/6	1,sbk
Bt	15-43	5YR4/6	2,sbk
C1	43-61	5YR5/8	1,sbk
C2	61-97	5YR5/8	1,sbk
C3	97-180	7.5YR5/8	1,sbk

Table 66. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A22-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-10	3.52	9.95	13.30	21.20	9.55	57.52	20.50	21.98	scl
Bt	10-33	2.20	9.72	13.98	24.50	7.65	58.05	16.20	25.75	scl
C	56-180	7.32	12.28	13.12	26.68	10.10	69.50	13.97	16.53	sl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-10	5.38	3.51	1.23	0.23	4.16	0.20	9.13	5.17	54.44	96.13
Bt	10-33	5.40	2.65	1.15	0.10	3.98	0.10	7.88	4.00	49.49	97.50
C	56-150	5.15	1.71	1.17	0.14	6.37	0.05	9.39	3.07	32.16	98.37

Horizon	Depth	Color	Structure
	cm		
Ap	0-10	5YR4/6	1,sbk
Bt	10-33	5YR5/6	2,sbk
BC	33-56	5YR5/8	2,sbk
C	56-180	7.5YR6/8	1,sbk

Table 67. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A23-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-13	3.40	10.52	17.15	22.62	6.40	60.09	15.03	24.88	scl
Bt	13-58	1.82	8.33	8.983	16.83	7.14	43.10	15.58	41.32	c
C	58-180	2.10	10.52	13.02	31.00	11.32	67.96	14.40	17.64	fsl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-13	5.70	2.94	1.02	0.12	5.54	0.10	9.62	4.18	42.41	97.61
Bt	13-58	5.05	2.27	1.08	0.07	6.57	0.15	9.99	3.57	34.23	95.80
C	58-180	5.22	0.20	0.25	0.14	6.53	2.15	7.12	2.74	8.29	21.53

Horizon	Depth	Color	Structure
	cm		
Ap	0-13	7.5YR5/6	1,sbk
Bt	13-58	2.5YR5/8	2,sbk
C	58-180	5YR5/8	1,sbk

Table 68. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A23-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	0.05	8.70	16.38	24.08	6.25	55.36	14.38	30.26	scl
Bt	18-61	1.78	8.75	10.38	19.02	7.78	47.71	12.48	39.81	sc
C	61-180	2.15	10.03	13.55	30.73	9.38	65.84	14.89	19.27	fsl,scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-18	4.22	3.00	1.01	0.16	6.17	0.35	10.34	4.52	40.33	92.26
Bt	18-61	5.30	3.00	1.19	0.10	5.94	0.10	10.23	4.39	41.94	97.72
C	61-180	4.20	1.60	1.10	0.10	8.51	1.35	11.31	4.15	24.76	67.47

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	5YR4/6	2,gr
Bt	18-61	2.5YR5/8	2,sbk
C	61-180	5YR5/8	1,sbk

Table 69. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A23-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	1.28	7.38	14.58	21.05	5.30	49.59	26.32	24.09	scl
Bt	18-58	2.00	7.40	9.12	15.08	5.85	39.45	12.15	48.39	c
C	58-180	2.45	8.40	10.35	18.52	6.32	46.04	15.75	38.21	cl,sc

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-18	4.75	2.78	0.89	0.19	7.96	0.20	11.82	4.06	32.66	98.07
Bt	18-58	5.92	3.23	1.48	0.08	6.14	0.05	10.93	4.84	43.82	98.97
C	58-180	4.20	1.60	1.10	0.10	8.51	1.35	11.31	4.15	24.76	67.47

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	5YR4/6	1,sbk
Bt	18-58	2.5YR5/8	2,sbk
C	58-180	5YR5/8	1,sbk

Table 70. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A24-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-8	1.48	7.15	19.78	21.22	9.35	58.98	13.37	27.65	scl
C	8-180	1.62	8.68	16.40	29.25	9.98	65.93	14.28	19.79	fsl,scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-8	5.60	3.34	1.26	0.14	4.95	0.15	9.69	4.89	48.92	96.93
C	8-180	4.75	1.78	0.75	0.11	4.58	0.35	7.22	2.99	36.57	88.29

Horizon	Depth	Color	Structure
	cm		
Ap	0-8	5YR5/6	1,sbk
C	8-180	5YR4/6	1,sbk

Table 71. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A24-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-13	2.60	8.45	13.60	21.18	6.90	52.73	18.98	28.29	scl
C	13-180	0.30	4.92	14.52	32.38	11.88	64.00	18.81	17.19	fsl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-13	5.42	3.98	1.38	0.15	8.71	0.10	14.22	5.61	38.75	98.22
C	13-180	5.02	1.78	0.81	0.06	3.58	0.05	6.23	2.70	42.54	98.15

Horizon	Depth	Color	Structure
	cm		
Ap	0-13	5YR5/6	1,sbk
C	13-180	5YR4/6	1,sbk

Table 72. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A24-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-9	1.58	8.42	12.52	16.90	7.32	46.74	22.97	30.29	scl
C	9-180	1.95	9.10	15.82	27.25	9.10	63.22	18.89	22.89	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-9	5.12	3.58	1.37	0.29	9.11	0.20	14.35	5.44	36.52	96.32
C	9-180	5.12	2.22	0.93	0.08	5.15	0.05	8.38	3.28	38.54	98.48

Horizon	Depth	Color	Structure
	cm		
Ap	0-9	5YR5/6	1,sbk
C	9-180	5YR4/6	1,sbk

Table 73. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A25-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-23	1.22	6.88	14.20	20.88	6.40	49.58	14.97	35.45	scl,sc
C	23-180	1.62	12.18	25.12	24.55	4.40	67.87	4.74	27.39	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-23	5.97	3.42	1.23	0.08	5.94	0.05	10.67	4.78	44.33	98.95
C	23-180	4.70	1.04	0.52	0.04	3.78	0.55	5.38	2.15	29.74	74.42

Horizon	Depth	Color	Structure
	cm		
Ap	0-23	5YR4/6	1,sbk
C	23-180	2.5YR4/8	1,sbk

Table 74. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A25-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-20	1.15	7.05	17.33	24.63	6.68	56.84	6.75	36.41	sc
C	20-180	1.95	10.82	26.42	27.12	4.62	70.93	8.05	21.02	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-20	4.75	2.74	1.14	0.14	8.16	0.05	12.18	4.07	33.00	98.77
C	20-180	5.25	0.91	0.60	0.02	5.15	0.65	6.68	2.18	22.90	70.18

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	5YR4/6	1,sbk
C	20-180	2.5YR4/8	1,sbk

Table 75. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A25-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-23	1.42	8.80	18.12	22.65	5.70	56.69	12.80	30.52	scl
C	23-180	0.82	8.88	25.88	27.92	4.72	68.22	7.11	24.67	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-23	6.00	2.88	1.27	0.13	3.96	0.05	8.24	4.33	51.94	98.85
C	23-180	4.90	1.65	0.56	0.04	2.77	0.10	5.02	2.35	44.82	95.74

Horizon	Depth	Color	Structure
	cm		
Ap	0-23	5YR4/6	1,sbk
C	23-180	2.5YR4/8	1,sbk

Table 76. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A26-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-13	2.72	7.88	8.48	12.38	4.65	36.11	17.19	46.70	c
Bt	13-30	1.55	6.58	7.15	10.90	5.02	30.30	20.92	48.78	c
C	30-180	3.62	11.05	12.48	17.42	6.80	51.37	16.43	32.20	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-13	5.20	4.50	1.87	0.15	7.96	0.05	14.48	6.57	45.03	99.24
Bt	13-30	5.20	3.01	1.65	0.16	10.69	1.55	15.51	6.37	31.08	75.67
C	30-180	4.32	0.40	0.62	0.10	8.56	4.15	9.68	5.27	11.57	21.25

Horizon	Depth	Color	Structure
	cm		
Ap	0-13	5YR5/6	1,sbk
Bt	13-30	2.5YR5/8	2,sbk
C	30-180	2.5YR5/8	1,sbk

Table 77. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A26-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	2.08	7.88	8.10	10.45	4.18	32.69	20.38	46.93	c
Bt	18-61	1.90	7.72	10.23	14.90	5.80	40.60	18.24	41.16	c
C	61-180	3.05	10.12	10.90	15.80	6.32	46.19	21.76	32.05	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-18	4.62	3.53	1.61	0.26	7.88	0.45	13.28	5.85	40.66	92.31
Bt	18-61	5.80	3.60	1.42	0.11	6.73	0.10	11.86	5.23	43.25	98.09
C	61-180	5.45	0.99	0.58	0.18	7.92	3.05	9.67	4.80	18.10	36.46

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	5YR5/6	1,sbk
Bt	18-61	2.5YR5/8	2,sbk
C	61-180	2.5YR5/8	1,sbk

Table 78. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A26-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-15	2.22	8.38	10.10	13.18	4.40	38.28	20.07	41.65	c
Bt	15-91	3.12	8.22	8.70	12.78	5.50	38.32	17.81	43.87	c
BC	91-180	3.35	9.65	11.02	14.30	5.70	44.02	20.17	35.81	cl,scl,sc

Horizon	Depth	pH	Exchangeable cations					CEC	ECEC	B.S.	E.B.S.
			Ca	Mg	K	H	Al				
	cm		cmol (+) kg^{-1}							%	
Ap	0-15	4.60	3.10	1.37	0.18	7.96	0.55	12.61	5.20	36.88	89.42
Bt	15-91	5.03	1.19	0.59	0.08	8.71	1.75	10.57	3.61	17.60	51.52
BC	91-180	5.35	0.30	0.43	0.07	8.12	3.25	8.92	4.05	8.97	19.75

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	5YR5/6	1,sbk
Bt	15-91	2.5YR5/8	2,sbk
BC	91-180	2.5YR5/8	1,sbk

Table 79. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A27-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-15	2.98	8.80	13.78	20.12	6.52	52.20	15.71	32.09	scl
Bt1	15-51	2.10	7.85	12.95	19.05	6.08	48.03	11.54	40.43	sc
Bt2	51-91	1.30	3.82	8.05	14.00	4.68	31.85	13.03	55.12	c
C	91-180	0.15	1.25	8.60	28.03	11.13	49.16	13.95	36.89	sc

Horizon	Depth	pH	Exchangeable cations					CEC	ECEC	B.S.	E.B.S.
			Ca	Mg	K	H	Al				
	cm		cmol (+) kg^{-1}							%	
Ap	0-15	5.76	3.50	1.29	0.10	7.13	0.15	12.02	5.04	40.68	97.02
Bt1	15-51	5.88	2.00	1.13	0.04	4.75	0.15	7.92	3.32	40.03	95.48
Bt2	51-91	4.50	1.35	1.73	0.09	10.15	1.05	13.32	4.42	23.80	75.12
C	91-180	4.62	0.18	0.91	0.12	10.15	3.10	11.36	4.31	10.65	28.07

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	5YR5/6	1,sbk
Bt1	15-51	2.5YR5/6	2,sbk
Bt2	51-91	2.5YR5/6	2,sbk
C	91-180	2.5YR5/8	1,sbk

Table 80. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A27-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	2.72	8.02	13.60	19.78	5.88	50.00	17.50	32.50	scl
Bt	18-91	0.70	6.00	7.88	13.28	4.68	32.54	13.21	54.25	c
C	91-180	0.35	3.35	11.60	21.42	8.85	45.57	20.38	34.05	cl,scl,sc

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-18	4.58	3.27	1.30	0.18	4.93	0.10	9.68	4.85	49.07	97.94
Bt	18-91	5.32	1.80	1.10	0.07	9.11	0.75	12.08	3.72	24.59	79.84
C	91-180	4.66	0.12	0.70	0.10	7.33	2.55	8.25	3.47	11.15	26.51

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	5YR5/6	1,sbk
Bt	18-91	2.5YR5/6	2,sbk
C	91-180	2.5YR5/6	1,sbk

Table 81. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Appomattox County, profile A27-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-15	3.35	9.80	15.32	18.12	4.02	50.61	17.34	32.05	scl
Bt	15-91	1.38	5.02	7.62	12.38	4.35	30.75	14.02	55.23	c
BC	91-180	0.28	3.48	13.18	26.70	11.20	54.84	16.02	29.14	scl

Horizon	Depth	pH	Exchangeable cations								
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.
	cm		cmol (+) kg^{-1}							%	
Ap	0-15	5.45	3.30	1.21	0.16	5.15	0.20	9.82	4.87	47.56	95.89
Bt	15-91	4.85	2.53	1.14	0.08	9.31	0.10	13.06	3.85	28.71	97.40
BC	91-180	5.64	0.40	0.50	0.20	5.94	2.15	7.04	3.25	15.63	33.85

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	5YR5/6	1,sbk
Bt	15-91	2.5YR5/6	2,sbk
BC	91-180	2.5YR5/6	1,sbk

Pittsylvania County

Table 1. Physical, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P1-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class	Water Content		Bulk Density
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total				-10kPa	-1500kPa	
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-20	0.50	5.05	18.60	23.65	8.75	56.55	23.24	20.21	fsl,scl	0.29	0.12	1.35
Bt	20-56	0.49	2.38	5.33	9.84	5.98	24.02	23.06	52.92	c	0.49	0.44	1.53
C	119-225	2.92	8.48	13.75	16.45	11.95	53.55	35.18	11.27	fsl,l	.	.	.

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		$cmol\ (+)\ kg^{-1}$							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-20	6.08	1.87	0.93	0.21	2.77	0.05	5.78	3.06	52.08	98.37	15.5	8.0
Bt	20-56	4.54	1.50	1.17	0.11	8.12	1.55	10.90	4.33	25.50	64.20	4.2	.
C	119-225	4.82	0.02	0.11	0.12	4.36	2.25	4.61	2.50	5.42	10.00	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	10YR4/4	2,gr
Bt1	20-56	2.5YR4/6	2,sbk
Bt2	56-91	2.5YR4/6	2,sbk
BC	91-119	5YR5/6	1,sbk
C	119-225	7.5YR6/6	0,m

Table 2. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P1-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	0.42	4.92	17.65	23.42	8.30	54.71	22.63	22.66	scl
Bt	18-84	0.47	3.93	7.66	10.14	4.55	26.75	23.45	49.80	c
C	109-225	2.42	8.13	13.99	16.32	11.87	52.73	32.66	14.61	fsl

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-18	6.06	1.96	0.99	0.31	3.56	0.05	6.82	3.31	47.80	98.49	14.2	4.6
Bt	18-84	4.70	1.40	1.27	0.12	6.34	1.25	9.13	4.04	30.56	69.06	2.9	.
C	109-225	4.75	0.16	0.08	0.13	1.78	1.85	2.15	2.22	17.21	16.67	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	10YR4/4	2,gr
Bt1	18-53	2.5YR4/8	2,sbk
Bt2	53-84	2.5YR4/6	2,sbk
BC	84-109	5YR5/6	1,sbk
C	109-225	7.5YR6/6	1.sbk

Table 3. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P1-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-20	0.62	5.30	15.88	22.22	8.92	52.94	24.36	22.70	scl
Bt	20-79	0.42	2.40	7.25	10.08	5.55	25.70	23.15	51.15	c
C	109-225	1.80	7.22	15.20	17.15	10.75	52.12	29.39	18.49	fsl,l,scl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-20	6.07	1.82	0.85	0.22	3.76	0.05	6.65	2.94	43.46	98.30	14.7	6.0
Bt	20-79	5.00	1.82	1.40	0.11	7.33	1.45	10.66	4.78	31.24	69.67	2.4	.
C	109-225	4.65	0.15	0.14	0.11	3.56	2.15	3.96	2.55	10.10	15.69	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	10YR4/4	2,gr
Bt	20-79	2.5YR4/6	2,sbk
BC	79-109	5YR5/6	1,sbk
C	109-225	7.5YR6/6	1,sbk

Table 4. Physical, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P2-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class	Water Content		Bulk Density
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total				-10kPa	-1500kPa	
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-18	0.83	4.55	12.12	20.05	10.88	48.43	24.97	26.60	scl	0.29	0.18	1.31
Bt	18-56	0.74	1.42	2.95	9.10	3.74	17.95	23.57	58.48	c	0.47	0.36	1.50
C2	110-225	2.19	8.43	14.55	21.98	13.37	60.52	29.99	9.49	fsl	.	.	.

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		$cmol\ (+)\ kg^{-1}$							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-18	6.08	2.05	1.15	0.27	4.16	0.05	7.63	3.52	45.48	98.58	20.6	8.9
Bt	18-56	4.81	1.99	1.00	0.12	8.71	2.45	11.82	5.56	26.31	55.94	3.8	3.1
C2	110-225	4.92	0.19	0.07	0.12	0.99	1.35	1.37	1.73	27.74	21.97	.	4.9

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	10YR4/4	2,gr
Bt	18-56	5YR4/6	2,sbk
BC	56-81	5YR5/6	1,sbk
C1	81-110	7.5YR6/8	0,m
C2	110-225	7.5YR8/2	0,m

Table 5. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P2-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-20	0.76	4.52	12.61	20.01	10.95	48.85	25.33	25.82	scl
Bt	20-58	0.41	1.27	3.41	9.29	6.77	21.15	18.31	60.54	c
C2	170-225	0.56	2.12	7.12	23.46	17.20	50.46	34.39	15.15	sl,l

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-20	6.32	2.42	1.38	0.30	2.77	0.05	6.87	4.15	59.68	98.80	17.7	11.0
Bt	20-58	4.71	1.86	1.04	0.13	10.10	2.85	13.13	5.88	23.08	51.53	3.7	.
C2	170-225	4.50	0.22	0.12	0.13	4.55	2.95	5.02	3.42	9.36	13.74	.	5.2

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	10YR4/4	2,gr
Bt	20-58	2.5YR4/6	2,sbk
BC	58-71	5YR5/8	1,sbk
C1	71-170	7.5YR6/8	1,sbk
C2	170-225	7.5YR8/2	0.m

Table 6. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P2-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-10	1.11	4.72	12.07	18.99	10.35	47.24	24.46	28.30	scl
Bt	10-43	0.41	3.76	7.83	6.79	3.38	22.17	18.01	59.82	c
C2	103-225	0.15	1.18	5.90	21.30	19.40	47.93	36.74	15.33	l

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-10	6.40	2.70	1.59	0.31	1.78	0.05	6.38	4.65	72.10	98.92	18.0	9.8
Bt	10-43	4.90	2.88	1.27	0.11	8.71	1.95	12.97	6.21	32.85	68.60	7.6	2.8
C2	103-225	4.50	0.17	0.25	0.07	6.14	3.45	6.63	3.94	7.39	12.44	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-10	10YR4/4	2,gr
Bt	10-43	2.5YR4/6	2,sbk
BC	43-66	5YR4/6	1,sbk
C1	66-103	7.5YR5/8	1,sbk
C2	103-225	7.5YR8/2	0,m

Table 7. Physical, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P3-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class	Water Content		Bulk Density
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total				-10kPa	-1500kPa	
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-20	1.62	7.73	14.77	16.69	7.15	47.96	24.97	27.07	scl	0.29	0.19	1.26
Bt	20-46	0.86	2.94	3.35	4.47	4.64	16.26	28.08	55.66	c	0.40	0.28	1.64
C2	145-225	0.73	5.83	11.23	17.04	14.57	49.40	38.83	11.77	l,sl	.	.	.

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		$cmol\ (+)\ kg^{-1}$							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-20	5.51	2.38	1.20	0.27	3.17	0.10	7.02	3.95	54.84	97.47	16.3	6.7
Bt	20-46	4.56	1.71	1.33	0.19	9.31	3.65	12.54	6.88	25.76	46.95	4.2	23.5
C2	145-225	4.78	0.21	0.18	0.15	2.77	2.55	3.31	3.09	16.31	17.48	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	10YR4/4	2,gr
Bt	20-46	2.5YR4/6	2,sbk
BC	46-55	5YR4/6	1,sbk
C1	55-145	5YR7/3	1,sbk
C2	145-225	2.5YR6/6	0,m

Table 8. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P3-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-23	1.59	7.12	13.72	16.01	7.28	45.72	29.88	24.40	l,scl
Bt	23-58	0.72	1.87	2.94	5.63	5.55	16.71	32.19	51.10	c
C2	108-225	1.93	7.13	12.88	24.53	16.28	62.75	31.34	5.91	fsl

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-23	5.60	2.34	0.97	0.38	3.56	0.15	7.25	3.84	50.90	96.09	20.6	8.0
Bt	23-58	4.71	1.64	0.84	0.08	8.91	2.85	11.47	5.41	22.32	47.32	4.0	3.1
C2	108-225	4.29	0.05	0.05	0.10	2.18	1.35	2.38	1.55	8.40	12.90	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-23	10YR4/4	2,gr
Bt	23-58	2.5YR4/6	2,sbk
BC	58-81	5YR5/6	1,sbk
C1	81-108	5YR7/3	1,sbk
C2	108-225	5YR7/6	0,m

Table 9. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P3-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-20	4.05	6.65	8.95	15.18	10.38	45.21	27.20	27.09	scl,cl,l
Bt	20-71	0.30	0.73	1.73	6.75	6.08	15.59	25.06	59.35	c
C2	193-225	1.00	5.33	11.93	17.78	13.43	49.47	38.21	12.32	l,fsl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-20	5.70	2.07	1.19	0.34	3.56	0.05	7.16	3.65	50.28	98.63	16.5	7.8
Bt	20-71	4.70	1.53	1.33	0.22	14.06	3.65	17.14	6.73	17.97	45.77	3.8	.
C2	193-225	4.34	0.08	0.14	0.11	4.36	3.95	4.69	4.28	7.04	7.71	.	3.6

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	10YR4/4	1,gr
Bt	20-71	2.5YR4/6	2,sbk
C1	71-193	5YR5/8	1,sbk
C2	193-225	7.5YR6/8	0,m

Table 10. Physical, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P4-1.

		Sand									Water Content		
Horizon	Depth	Very Coarse	Coarse	Medium	Fine	Very Fine	Total	Silt	Clay	Textural Class	-10kPa	-1500kPa	Bulk Density
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-20	4.08	6.78	12.32	17.68	9.72	50.58	28.78	20.64	fsl,l,scl	0.24	0.13	1.39
Bt	20-69	0.73	1.87	2.32	5.66	5.24	15.82	25.24	58.94	c	0.45	0.34	1.53
C	91-225	3.14	7.02	7.98	13.44	11.48	43.06	33.51	23.43	l	.	.	.

			Exchangeable cations										
Horizon	Depth	pH	Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.	Organic Matter	Avail. P
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-20	5.72	1.65	1.02	0.28	4.36	0.10	7.31	3.05	40.36	96.72	17.8	9.6
Bt	20-69	4.58	2.82	1.24	0.18	13.66	2.25	17.90	6.49	23.69	65.33	6.5	.
C	91-225	4.62	0.03	0.10	0.10	5.35	2.65	5.58	2.88	4.12	7.99	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	10YR4/4	1,gr
Bt	20-69	5YR5/6	2,sbk
BC	69-91	7.5YR5/6	1,sbk
C	91-225	7.5YR7/6	0,m

Table 11. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P4-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-23	2.62	6.38	12.12	18.45	9.60	49.17	31.03	19.80	l
Bt	23-71	0.84	2.02	2.14	6.33	5.12	16.45	26.29	57.26	c
C2	190-225	2.85	7.33	8.41	13.56	10.86	43.01	35.52	21.47	l

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-23	5.80	1.90	1.23	0.29	3.76	0.05	7.18	3.47	47.63	98.56	20.1	5.3
Bt	23-71	4.55	2.42	1.25	0.17	12.47	2.95	16.31	6.79	23.54	56.55	5.7	.
C2	190-225	4.40	0.06	0.12	0.15	7.13	3.55	7.46	3.88	4.42	8.51	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-23	10YR4/4	2,gr
Bt	23-71	7.5YR5/6	2,sbk
BC	71-84	7.5YR5/6	1,sbk
C1	84-190	7.5YR7/6	0,m
C2	190-225	7.5YR7/6	0,m

Table 12. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P4-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-20	3.35	7.02	12.00	18.05	9.15	49.57	28.39	22.04	l,scl,fsl
Bt	20-51	1.18	1.95	2.58	6.65	5.25	17.61	16.97	65.42	c
C	74-225	3.38	7.05	8.50	14.98	11.35	45.26	32.08	22.66	l

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-20	6.12	2.15	1.51	0.45	4.16	0.05	8.27	4.16	49.70	98.80	21.2	8.0
Bt	20-51	4.95	2.76	1.60	0.13	11.29	2.05	15.78	6.54	28.45	68.65	4.4	.
C	74-225	4.67	0.08	0.06	0.16	4.16	3.25	4.46	3.55	6.73	8.45	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	10YR4/4	1,gr
Bt	20-51	7.5YR5/6	2,sbk
BC	51-74	7.5YR6/8	1,sbk
C	74-225	7.5YR7/6	0,m

Table 13. Physical, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P5-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class	Water Content		Bulk Density
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total				-10kPa	-1500kPa	
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-23	3.50	9.35	18.88	20.85	7.82	52.58	35.76	11.66	sl,l	0.25	0.20	1.63
Bt	23-51	3.66	6.41	7.84	10.12	6.88	34.91	20.71	44.38	c	0.38	0.35	1.67
C2	184-225	5.72	9.78	11.14	13.35	10.45	50.44	34.41	15.15	l,fsl	.	.	.

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-23	6.38	1.97	0.67	0.47	2.57	0.05	5.68	3.16	54.75	98.42	14.3	26.0
Bt	23-51	5.56	4.02	1.10	0.12	5.15	0.05	10.39	5.29	50.43	99.05	7.1	.
C2	184-225	5.76	0.12	0.34	0.14	6.14	3.85	6.74	4.45	8.90	13.48	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-23	10YR4/3	2,gr
Bt	23-51	7.5YR5/6	2,sbk
BC	51-89	7.5YR5/6	1,sbk
C1	89-184	7.5YR6/6	0,m
C2	184-225	7.5YR7/8	0,m

Table 14. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P5-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-25	3.90	9.92	19.65	19.58	7.50	60.55	26.48	12.97	sl
Bt	25-74	2.02	6.00	7.68	11.25	8.02	34.97	23.81	41.22	c,cl
C2	143-225	5.85	9.68	11.08	12.82	9.72	49.15	36.19	14.66	l,fsl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-25	6.58	2.46	0.73	0.46	2.18	0.05	5.83	3.70	62.61	98.65	13.9	24.0
Bt	25-74	5.48	3.70	0.68	0.12	4.16	0.35	8.66	4.85	51.96	92.78	1.9	.
C2	143-225	4.50	0.25	0.28	0.19	5.15	3.15	5.87	3.87	12.27	18.60	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-25	10YR4/3	2,gr
Bt	25-74	5YR5/6	2,sbk
BC	74-89	7.5YR5/6	1,sbk
C1	89-143	7.5YR6/8	0,m
C2	143-225	7.5YR7/8	0,m

Table 15. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P5-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-20	4.88	10.00	18.38	19.10	7.55	59.91	25.29	14.80	sl
Bt	20-66	4.72	6.78	8.10	7.90	4.30	31.80	22.03	46.17	c
C2	153-225	5.12	10.15	11.35	13.45	10.52	50.59	34.41	15.00	fsl,l

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-20	6.67	3.12	0.81	0.49	0.79	0.05	5.21	4.47	84.84	98.88	15.1	31.0
Bt	20-66	5.83	4.73	0.88	0.11	5.15	0.05	10.87	5.77	52.62	99.13	2.9	.
C2	153-225	4.58	0.24	0.24	0.16	4.36	3.15	5.00	3.79	12.80	16.89	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	10YR4/3	2,gr
Bt	20-66	5YR4/6	2,sbk
BC	66-97	5YR5/6	1,sbk
C1	97-153	7.5YR5/8	0,m
C2	153-225	7.5YR7/8	0,m

Table 16. Physical, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P6-1.

		Sand									Water Content		
Horizon	Depth	Very Coarse	Coarse	Medium	Fine	Very Fine	Total	Silt	Clay	Textural Class	-10kPa	-1500kPa	Bulk Density
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-8	1.18	3.43	8.15	16.63	10.15	39.54	27.82	32.64	cl	0.36	0.31	1.43
Bt	8-43	0.08	0.68	2.74	11.11	12.09	26.70	26.25	47.05	c	0.51	0.46	1.54
C	64-225	0.30	2.27	7.06	21.19	17.46	48.28	37.43	14.29	l	.	.	.

			Exchangeable cations										
Horizon	Depth	pH	Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.	Organic Matter	Avail. P
	cm		$cmol\ (+)\ kg^{-1}$							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-8	5.43	2.25	0.82	0.90	5.74	0.35	9.71	4.32	40.89	91.90	18.9	33.3
Bt	8-43	5.23	2.47	1.10	0.45	3.96	0.55	7.98	4.57	50.38	87.96	6.0	4.2
C	64-225	4.62	0.34	0.46	0.20	3.37	1.35	4.37	2.35	22.88	57.45	.	4.5

Horizon	Depth	Color	Structure
	cm		
Ap	0-8	7.5YR4/6	1,sbk
Bt	8-43	5YR4/6	2,sbk
BC	43-64	5YR5/6	1,sbk
C	64-225	10YR6/6	1,sbk

Table 17. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P6-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-13	1.03	3.00	8.35	16.42	9.59	38.39	29.96	31.65	cl
Bt	13-48	0.13	0.79	3.23	8.79	7.98	20.92	24.16	54.92	c
C	102-225	0.03	0.76	4.70	15.95	16.86	38.30	40.48	21.22	l

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-13	5.44	2.38	0.75	0.80	6.73	0.15	10.66	4.08	36.87	96.32	13.9	39.6
Bt	13-48	5.58	3.62	1.65	0.60	5.35	0.25	11.22	6.12	52.32	95.92	7.8	3.9
C	102-225	4.97	0.24	0.44	0.28	4.95	2.25	5.91	3.21	16.24	29.91	.	4.8

Horizon	Depth	Color	Structure
	cm		
Ap	0-13	7.5YR5/6	1,sbk
Bt	13-48	5YR4/6	2,sbk
BC	48-102	5YR5/6	1,sbk
C	102-225	10YR6/6	1,sbk

Table 18. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P6-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	1.06	3.58	9.65	17.54	11.24	43.07	27.93	29.00	scl,cl,l
Bt	18-81	1.15	2.75	5.22	9.50	6.59	25.21	24.99	49.80	c
C	112-225	0.08	1.32	5.16	14.14	14.30	35.00	44.83	20.17	l

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-18	5.29	2.00	0.65	0.80	4.55	0.25	8.00	3.70	43.13	93.24	18.9	46.0
Bt	18-81	4.95	2.37	1.50	0.48	5.94	1.25	10.29	5.60	42.27	77.68	6.6	3.6
C	112-225	4.76	0.12	0.45	0.26	5.35	3.15	6.18	3.98	13.43	20.85	.	3.8

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	7.5YR4/6	1,sbk
Bt	18-81	2.5YR4/6	2,sbk
BC	81-112	7.5YR5/6	1,sbk
C	112-225	7.5YR6/8	0,m

Table 19. Physical, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P7-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class	Water Content		Bulk Density
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total				-10kPa	-1500kPa	
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-23	4.36	6.69	11.48	9.16	18.31	50.00	25.91	24.09	scl,l	0.28	0.24	1.65
Bt	23-46	0.43	1.09	4.16	12.54	10.51	28.73	28.35	42.92	c,cl	0.45	0.31	1.55
C	114-225	2.42	8.96	14.90	19.31	12.16	57.75	28.43	13.82	fsl	.	.	.

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		$cmol\ (+)\ kg^{-1}$							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-23	5.81	1.86	1.04	0.50	2.97	0.05	6.37	3.45	53.38	98.55	10.3	57.0
Bt	23-46	5.05	2.76	1.32	0.37	5.15	1.05	9.60	5.50	46.35	80.91	3.8	7.2
C	114-225	4.80	0.59	0.61	0.23	2.57	1.25	4.00	2.68	35.75	53.36	.	6.6

Horizon	Depth	Color	Structure
	cm		
Ap	0-23	7.5YR5/6	1,sbk
Bt	23-46	7.5YR5/8	2,sbk
BC	46-114	7.5YR6/8	1,sbk
C	114-225	10YR6/8	0,m

Table 20. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P7-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	3.55	5.92	10.76	18.62	11.82	50.67	26.08	23.25	scl,l
Bt	18-43	0.33	1.22	5.47	11.76	9.55	28.33	26.36	45.31	c
C	109-225	0.15	1.60	7.45	16.92	12.94	39.06	35.14	25.80	l,cl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-18	5.93	1.98	1.08	0.43	2.77	0.05	6.26	3.54	55.75	98.59	8.8	45.0
Bt	18-43	5.08	2.49	1.22	0.34	6.73	1.25	10.78	5.30	37.57	76.42	8.0	3.8
C	109-225	5.12	0.44	0.96	0.33	5.35	2.45	7.08	4.18	24.44	41.39	.	3.1

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	7.5YR4/6	1,sbk
Bt	18-43	5YR5/8	2,sbk
BC	43-109	7.5YR5/6	1,sbk
C	109-225	7.5YR5/8	0,m

Table 21. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P7-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	3.25	6.22	10.96	19.13	11.62	51.18	27.27	21.55	fsl,l,scl
Bt	40-83	1.19	3.30	6.85	12.13	8.88	32.35	24.29	43.36	c
C	130-225	3.70	9.15	11.77	15.55	11.42	51.59	31.37	17.04	fsl,l

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-18	6.61	2.26	1.39	0.60	1.19	0.05	5.44	4.30	78.13	98.84	10.6	57.6
Bt	40-83	5.00	2.06	1.19	0.35	5.94	1.15	9.54	4.75	37.74	75.79	2.2	4.4
C	130-225	4.89	0.62	0.74	0.26	4.16	1.85	5.78	3.47	28.03	46.69	.	17.8

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	7.5YR4/4	1,sbk
BA	18-40	7.5YR5/6	1,sbk
Bt	40-83	2.5YR4/6	2,sbk
C1	83-130	10YR6/6	0,m
C2	130-225	10YR6/8	0,m

Table 22. Physical, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P8-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class	Water Content		Bulk Density
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total				-10kPa	-1500kPa	
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-13	1.98	3.85	9.50	19.75	11.38	46.46	27.71	25.83	l,scl	0.27	0.23	1.19
Bt	13-36	0.45	2.02	6.30	16.70	11.52	36.99	29.91	33.10	cl	0.43	0.23	1.53
C	36-225	0.22	1.18	6.98	20.05	17.80	46.23	37.45	16.32	sl,l	.	.	.

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-13	6.26	2.18	1.49	0.60	4.55	0.05	8.82	4.32	48.41	98.84	14.3	52.0
Bt	13-36	4.81	1.86	0.97	0.42	4.75	1.05	8.00	4.30	40.63	75.58	6.6	.
C	36-225	4.65	0.89	0.78	0.25	1.19	0.95	3.11	2.87	61.74	66.90	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-13	7.5YR5/6	1,sbk
Bt	13-36	7.5YR5/8	2,sbk
C	36-225	10YR7/4	0,m

Table 23. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P8-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-15	1.62	3.70	9.08	19.02	10.70	44.12	28.12	27.76	scl,l,cl
Bt	15-46	0.32	1.98	6.45	15.02	11.35	35.12	22.12	42.76	c,cl
C	46-225	0.18	1.34	6.54	21.14	16.85	46.05	39.11	14.84	l

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-15	6.36	2.45	1.65	0.70	4.75	0.05	9.55	4.85	50.26	98.97	14.3	58.0
Bt	15-46	4.89	1.87	0.87	0.40	5.74	1.05	8.88	4.19	35.36	74.94	3.7	.
C	46-225	4.55	1.14	0.58	0.23	1.58	1.05	3.53	3.00	55.24	65.00	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	7.5YR4/8	1,gr
Bt	15-46	7.5YR5/6	2,sbk
C	46-225	10YR7/4	0,m

Table 24. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P8-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-15	1.22	2.92	8.50	18.55	11.18	42.37	29.39	28.24	l,scl,cl
Bt	15-46	0.44	2.02	6.22	16.68	11.65	37.01	23.84	39.15	cl,c
C	46-225	0.10	1.22	6.88	21.18	17.10	46.48	37.97	15.55	l

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-15	6.05	2.30	1.44	0.70	4.95	0.05	9.39	4.49	47.28	98.89	12.5	58.0
Bt	15-46	4.83	1.75	0.72	0.47	4.75	1.15	7.69	4.09	38.23	71.88	5.3	.
C	46-225	4.91	1.06	0.52	0.24	1.98	1.15	3.80	2.97	47.89	61.28	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	7.5YR4/6	1,gr
Bt	15-46	7.5YR5/6	2,sbk
C	46-225	10YR7/4	0,m

Table 25. Physical, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P9-1.

		Sand									Water Content		
Horizon	Depth	Very Coarse	Coarse	Medium	Fine	Very Fine	Total	Silt	Clay	Textural Class	-10kPa	-1500kPa	Bulk Density
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-46	1.10	4.58	12.75	20.88	12.32	51.63	33.36	15.01	fsl,l	0.32	0.23	1.95
Bt	46-132	0.32	1.68	5.58	12.52	9.12	29.22	35.51	35.27	cl	0.36	0.23	1.69
C	178-225	0.78	2.25	6.10	16.65	13.78	39.56	39.12	21.32	l	.	.	.

			Exchangeable cations										
Horizon	Depth	pH	Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.	Organic Matter	Avail. P
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-46	4.81	0.41	0.15	0.34	5.94	0.85	6.84	1.75	13.16	51.43	11.1	89.2
Bt	46-132	4.86	2.32	0.50	0.39	6.14	1.25	9.35	4.46	34.33	71.97	3.4	.
C	178-225	4.79	1.20	0.55	0.22	4.55	2.75	6.52	4.72	30.21	41.74	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-46	10YR4/4	2,gr
Bt	46-132	2.5YR4/6	3,sbk
BC	132-178	7.5YR5/6	1,sbk
C	178-225	7.5YR5/8	0,m

Table 26. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P9-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-41	1.08	4.55	12.85	21.60	12.90	52.98	32.59	14.43	fsl,l
Bt	41-109	0.38	2.08	6.20	13.92	9.90	32.48	30.91	36.61	cl
C	157-225	0.58	1.95	5.10	18.38	15.55	41.56	39.72	18.72	l

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-41	4.96	0.53	0.22	0.38	4.16	0.85	5.29	1.98	21.36	57.07	9.3	88.0
Bt	41-109	4.87	2.38	0.50	0.42	6.14	1.35	9.44	4.65	34.96	70.97	3.9	.
C	157-225	4.68	0.86	0.56	0.24	4.95	2.55	6.61	4.21	25.11	39.43	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-41	10YR4/4	2,gr
Bt	41-109	5YR5/6	3,sbk
BC	109-157	5YR5/8	1,sbk
C	157-225	7.5YR5/8	0,m

Table 27. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P9-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-28	1.85	5.25	14.10	22.38	12.60	56.18	31.81	12.01	fsl
Bt	28-91	2.15	4.10	8.02	15.05	8.40	37.82	26.82	35.36	cl
C	109-225	0.42	2.25	7.28	20.85	17.28	48.08	35.37	16.55	l

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-28	5.23	0.65	0.33	0.37	3.96	0.75	5.31	2.10	25.42	64.29	12.2	79.4
Bt	28-91	4.93	2.14	0.48	0.42	5.15	0.85	8.19	3.89	37.12	78.15	2.3	.
C	109-225	4.79	0.63	0.45	0.14	5.15	1.95	6.37	3.17	19.15	38.49	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-28	10YR4/6	2,gr
Bt	28-91	5YR5/6	2,sbk
BC	91-109	5YR4/6	1,sbk
C	109-225	7.5YR5/6	0,m

Table 28. Physical, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P10-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class	Water Content		Bulk Density
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total				-10kPa	-1500kPa	
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-23	0.55	8.80	20.12	20.30	7.95	57.72	23.36	18.92	fsl,scl	0.23	0.18	1.53
Bt1	23-75	0.28	5.18	9.80	9.90	6.45	31.61	23.02	45.37	c	0.44	0.39	1.49
C	132-225	1.20	9.72	16.55	19.00	14.20	60.67	17.42	21.91	fsl,scl	.	.	.

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		$cmol\ (+)\ kg^{-1}$							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-23	5.29	0.91	0.34	0.42	5.88	0.15	7.55	1.82	22.12	91.76	13.0	28.8
Bt1	23-75	4.84	1.83	1.15	0.28	11.56	0.55	14.82	3.81	22.00	85.56	6.5	.
C	132-225	4.94	0.07	0.36	0.13	4.51	1.45	5.07	2.01	11.05	27.86	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-23	10YR4/4	2,gr
Bt1	23-75	2.5YR4/8	2,sbk
Bt2	75-107	2.5YR4/8	2,sbk
BC	107-132	2.5YR4/8	1,sbk
C	132-225	2.5YR4/8	0,m

Table 29. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P10-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-20	0.85	10.65	19.92	18.88	7.55	57.85	22.73	19.42	sl,scl
Bt	20-107	0.48	3.70	7.25	10.38	6.02	27.83	17.53	54.64	c
C	145-225	1.15	8.78	14.45	13.40	6.58	44.36	25.76	29.88	scl,cl

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-20	5.55	1.09	0.53	0.60	5.10	0.05	7.32	2.27	30.33	97.80	13.4	32.0
Bt	20-107	4.88	2.57	1.36	0.40	6.66	0.25	10.99	4.58	39.40	94.54	3.5	.
C	145-225	4.81	0.05	0.70	0.16	5.49	1.55	6.40	2.46	14.22	36.99	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	7.5YR5/6	1,sbk
Bt	20-107	2.5YR4/8	2,sbk
BC	107-145	2.5YR4/8	1,sbk
C	145-225	2.5YR5/8	0,m

Table 30. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P10-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	1.10	10.98	20.62	19.30	8.58	60.58	22.50	16.92	sl
Bt	18-122	0.45	6.02	9.78	8.70	4.78	29.73	14.94	55.33	c
C	165-225	0.15	1.02	7.30	23.95	13.18	45.60	20.57	33.83	scl,cl,sc

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-18	6.20	1.57	0.90	0.50	3.33	0.15	6.30	3.12	47.14	95.19	13.4	42.0
Bt	18-122	4.80	2.08	1.26	0.27	9.41	0.75	13.02	4.36	27.73	82.80	4.2	.
C	165-225	5.02	0.18	1.84	0.19	10.00	2.65	12.21	4.86	18.10	45.47	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	7.5YR4/6	1,gr
Bt	18-122	2.5YR4/8	2,sbk
BC	122-165	2.5YR5/8	1,sbk
C	165-225	5YR5/8	0,m

Table 31. Physical, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P11-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class	Water Content		Bulk Density
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total				-10kPa	-1500kPa	
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-10	0.48	8.95	19.55	18.72	10.52	58.22	7.87	33.91	scl,sc	0.38	0.33	1.55
Bt	10-76	0.32	3.10	5.92	9.58	7.20	26.12	17.94	55.94	c	0.44	0.40	1.56
C	119-225	1.12	9.58	13.85	13.62	10.28	48.45	34.40	17.15	l	.	.	.

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-10	6.02	1.60	0.90	0.60	5.10	0.05	8.20	3.15	37.80	98.41	10.5	23.0
Bt	10-76	4.76	1.72	1.02	0.24	9.60	0.95	12.58	3.93	23.69	75.83	5.5	.
C	119-225	4.97	0.12	0.56	0.14	3.92	1.55	4.74	2.37	17.30	34.60	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-10	5YR4/6	1,sbk
Bt	10-76	2.5YR4/8	2,sbk
BC	76-119	2.5YR5/8	1,sbk
C	119-225	5YR5/8	0,m

Table 32. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P11-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-10	0.35	5.75	15.70	18.05	7.65	47.50	29.35	23.15	l,scl
Bt1	10-50	0.70	6.42	9.78	8.58	4.65	30.13	19.52	50.35	c
C	104-225	11.25	5.95	9.65	14.65	11.32	52.82	21.13	26.05	scl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-10	5.60	1.43	0.68	0.60	6.34	0.10	9.05	2.81	29.94	96.44	9.1	38.0
Bt1	10-50	4.90	2.12	1.26	0.31	8.23	0.55	11.92	4.24	30.96	87.03	2.8	.
C	142-225	4.91	0.09	0.70	0.18	4.51	2.05	5.48	3.02	17.70	32.12	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-10	5YR5/6	1,sbk
Bt1	10-50	2.5YR4/8	2,sbk
Bt2	50-104	2.5YR5/8	2,sbk
BC	104-142	2.5YR4/6	1,sbk
C	142-225	2.5YR4/6	0,m

Table 33. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P11-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-13	0.68	10.25	21.25	19.30	7.83	59.31	12.06	28.63	scl
Bt1	13-88	1.18	5.85	10.08	13.48	7.65	38.24	22.58	39.18	cl,c
C	178-225	0.18	4.18	8.52	11.30	11.20	35.38	35.27	29.35	cl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-13	6.08	1.40	0.72	0.46	4.51	0.10	7.09	2.68	36.39	96.27	7.9	25.0
Bt1	13-88	4.76	1.70	0.96	0.32	7.84	0.75	10.82	3.73	27.54	79.89	3.5	.
C	178-225	4.76	0.04	0.77	0.13	8.62	2.85	9.56	3.79	9.83	24.80	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-13	5YR5/6	1,sbk
Bt1	13-88	2.5YR4/8	2,sbk
Bt2	88-150	2.5YR4/8	2,sbk
BC	150-178	5YR4/6	1,sbk
C	178-225	5YR4/6	0,m

Table 34. Physical, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P12-1.

		Sand									Water Content		
Horizon	Depth	Very Coarse	Coarse	Medium	Fine	Very Fine	Total	Silt	Clay	Textural Class	-10kPa	-1500kPa	Bulk Density
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-15	0.80	10.68	23.08	19.65	7.60	61.81	14.20	23.99	scl	0.28	0.24	1.53
Bt1	15-55	0.60	6.42	8.38	7.00	4.22	26.62	15.20	58.18	c	0.46	0.33	1.53
C	165-225	0.90	9.28	13.75	13.45	7.33	44.71	31.97	23.32	l	.	.	.

			Exchangeable cations										
Horizon	Depth	pH	Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.	Organic Matter	Avail. P
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-15	5.85	1.36	0.76	0.50	4.70	0.05	7.32	2.67	35.79	98.13	11.8	42.0
Bt1	15-55	4.72	1.64	1.11	0.22	7.45	1.15	10.42	4.12	28.50	72.09	3.5	.
C	165-225	4.78	0.05	0.35	0.10	5.68	2.45	6.18	2.95	8.09	16.95	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	5YR4/6	1,sbk
Bt1	15-55	2.5YR4/8	2,sbk
Bt2	55-118	2.5YR4/8	2,sbk
BC	118-165	2.5YR4/6	1,sbk
C	165-225	2.5YR5/8	0,m

Table 35. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P12-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-13	0.80	10.70	21.95	19.50	7.40	60.35	10.70	28.95	scl
Bt1	13-63	0.92	5.82	8.80	8.60	4.35	28.49	18.01	53.50	c
C	188-225	0.52	3.90	8.30	12.78	10.30	35.80	34.55	29.65	cl

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-13	5.92	1.33	0.73	0.41	6.27	0.05	8.74	2.52	28.26	98.02	10.9	36.0
Bt1	13-63	4.51	1.27	1.07	0.18	5.88	1.25	8.40	4.77	30.00	52.83	3.2	.
C	188-225	5.01	0.01	0.38	0.10	8.04	2.95	8.53	3.44	5.74	14.24	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-13	7.5YR4/6	1,gr
Bt1	13-63	2.5YR4/8	2,sbk
Bt2	63-130	2.5YR4/8	2,sbk
BC	130-188	2.5YR4/6	1,sbk
C	188-225	5YR4/6	0,m

Table 36. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P12-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-10	0.98	10.00	21.38	20.00	7.25	59.61	11.37	29.02	scl
Bt	10-89	0.50	3.48	6.53	8.13	4.40	23.04	19.67	57.29	c
C	140-225	1.00	2.10	3.98	7.18	5.15	19.41	64.11	16.48	sil

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-10	5.80	1.46	0.76	0.50	5.68	0.05	8.40	2.77	32.38	98.19	10.7	46.0
Bt	10-89	4.76	1.16	1.19	0.24	14.50	1.65	17.09	4.24	15.16	61.08	2.8	.
C	140-225	5.16	0.02	0.33	0.18	6.27	1.65	6.80	2.18	7.79	24.31	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-10	7.5YR4/6	1,gr
Bt	10-89	2.5YR4/8	2,sbk
BC	89-140	2.5YR4/8	1,sbk
C	140-225	2.5YR4/8	0,m

Table 37. Physical, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P13-1.

		Sand									Water Content		
Horizon	Depth	Very Coarse	Coarse	Medium	Fine	Very Fine	Total	Silt	Clay	Textural Class	-10kPa	-1500kPa	Bulk Density
	cm	---------- % ----------									----- $m^3\ m^{-3}$ -----		$Mg\ m^{-3}$
Ap	0-15	4.52	7.25	8.80	15.28	9.82	45.67	35.41	18.92	l	0.25	0.21	1.62
Bt1	15-58	0.40	4.90	8.70	8.30	4.95	27.25	21.35	51.40	c	0.46	0.42	1.52
C	148-225	1.15	10.02	13.78	14.28	8.88	48.11	23.74	28.15	scl	.	.	.

			Exchangeable cations										
Horizon	Depth	pH	Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.	Organic Matter	Avail. P
	cm		---------- cmol (+) kg^{-1} ----------							------- % -------		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-15	5.78	1.38	0.75	0.46	5.10	0.10	7.69	2.69	33.68	96.28	11.2	39.0
Bt1	15-58	4.73	1.40	1.34	0.33	9.70	1.15	12.77	4.22	24.04	72.75	4.0	.
C	148-225	4.79	0.17	0.56	0.17	8.51	2.85	9.41	3.75	9.56	24.00	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	7.5YR4/6	1,gr
Bt1	15-58	2.5YR4/8	2,sbk
Bt2	58-120	2.5YR4/8	2,sbk
BC	120-148	2.5YR4/8	1,sbk
C	148-225	5YR5/8	0,m

Table 38. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P13-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	0.55	9.70	22.55	20.50	7.40	60.70	15.94	23.36	scl
Bt	18-104	0.65	6.35	9.60	8.90	4.98	30.48	16.75	52.77	c
C	130-225	1.65	10.32	14.02	13.88	9.95	49.82	29.15	21.03	fsl,l,scl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-18	5.78	1.24	0.68	0.42	6.08	0.10	8.42	2.44	27.79	95.90	8.6	35.0
Bt	18-104	4.64	1.33	1.12	0.30	9.11	1.35	11.86	4.10	23.19	67.07	3.8	.
C	130-225	4.79	0.07	0.43	0.12	6.73	2.65	7.35	3.27	8.44	18.96	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	7.5YR4/6	1,gr
Bt	18-104	2.5YR4/8	2,sbk
BC	104-130	2.5YR5/8	1,sbk
C	130-225	2.5YR5/8	0,m

Table 39. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P13-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-15	0.42	9.55	23.30	21.98	7.95	63.20	15.31	21.49	sl,scl
Bt	15-91	0.30	5.52	10.95	10.00	5.55	32.32	22.30	45.38	c
C	173-225	0.62	8.62	12.50	12.45	8.40	42.59	31.86	25.55	l,cl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-15	5.64	1.15	0.57	0.44	5.15	0.05	7.31	2.21	29.55	97.74	9.9	38.0
Bt	15-91	4.88	1.94	1.35	0.33	8.51	0.65	12.13	4.27	29.84	84.78	3.2	.
C	173-225	5.13	0.13	0.71	0.18	7.72	2.15	8.74	3.17	11.67	32.18	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	7.5YR4/6	1,gr
Bt	15-91	2.5YR4/8	2,sbk
BC	91-173	2.5YR4/8	1,sbk
C	173-225	2.5YR4/8	1,sbk

Table 40. Physical, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P14-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class	Water Content		Bulk Density
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total				-10kPa	-1500kPa	
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-23	0.50	8.80	24.82	26.48	9.75	70.35	12.49	17.16	sl	0.21	0.15	1.42
Bt1	38-68	0.35	4.75	9.75	9.25	5.42	29.52	16.91	53.57	c	0.40	0.36	1.57
C	183-225	2.65	8.02	11.18	20.98	15.15	57.98	15.52	26.50	scl	.	.	.

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-23	5.56	0.69	0.32	0.34	3.17	0.05	4.52	1.40	29.87	96.43	9.8	60.0
Bt1	38-68	4.67	1.06	0.98	0.27	9.11	1.75	11.42	4.06	20.23	56.90	3.3	.
C	183-225	4.66	0.06	0.20	0.11	7.92	2.85	8.29	3.22	4.46	11.49	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-23	10YR5/4	2,gr
BA	23-38	10YR5/8	1,sbk
Bt1	38-68	2.5YR4/8	2,sbk
Bt2	68-98	2.5YR4/8	2,sbk
BC	98-183	2.5YR5/8	1,sbk
C	183-225	5YR5/8	0,m

Table 41. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P14-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-23	0.55	8.25	25.75	27.50	9.30	71.35	12.69	15.96	sl
Bt1	23-58	0.30	4.65	11.40	10.40	5.50	32.25	13.62	54.13	c
C	157-225	1.52	7.08	25.38	16.02	4.20	54.20	11.60	34.20	scl,sc

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-23	5.68	0.80	0.35	0.38	4.16	0.05	4.52	1.40	29.87	96.43	7.9	58.6
Bt1	23-58	4.57	1.48	1.10	0.32	8.91	1.35	11.81	4.25	24.56	68.24	6.5	.
C	157-225	4.62	0.07	0.17	0.14	8.71	3.05	9.09	3.43	4.18	11.08	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-23	10YR5/4	2,gr
Bt1	23-58	2.5YR4/8	2,sbk
Bt2	58-80	2.5YR4/8	2,sbk
BC	80-157	2.5YR5/8	1,sbk
C	157-225	5YR6/8	0,m

Table 42. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P14-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	0.65	8.65	25.88	26.78	10.52	72.21	8.97	18.82	sl,scl
Bt1	30-50	1.98	6.88	9.02	7.50	4.25	29.63	24.95	45.42	c
C	127-225	0.80	6.75	15.25	17.53	9.98	50.31	22.53	27.16	scl

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-18	5.66	0.80	0.32	0.43	3.17	0.10	4.72	1.65	32.89	93.94	6.6	61.2
Bt1	30-50	4.72	1.83	1.11	0.32	6.53	0.95	9.79	4.21	33.30	77.43	3.2	.
C	127-225	4.10	0.42	0.35	0.15	7.13	2.15	8.05	3.07	11.43	29.97	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	10YR5/4	2,gr
BA	18-30	10YR5/8	1,sbk
Bt1	30-50	2.5YR4/8	2,sbk
Bt2	50-75	2.5YR4/8	2,sbk
BC	75-127	2.5YR5/8	1,sbk
C	127-225	5YR6/8	0,m

Table 43. Physical, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P15-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class	Water Content		Bulk Density
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total				-10kPa	-1500kPa	
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-10	0.48	9.05	24.18	22.40	6.90	63.01	20.04	16.95	sl	0.26	0.23	1.79
Bt	10-86	0.35	5.38	9.75	7.43	3.65	26.56	27.56	45.88	c	0.44	0.40	1.56
C	175-225	0.20	9.12	16.98	16.70	9.50	52.50	21.47	26.03	scl	.	.	.

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		$cmol(+)\ kg^{-1}$							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-10	6.02	1.58	0.88	0.43	4.95	0.05	7.84	2.94	36.86	98.30	8.2	30.0
Bt	10-86	4.70	1.36	0.99	0.15	9.90	1.75	12.40	4.25	20.16	58.82	3.1	.
C	175-225	4.88	0.07	0.20	0.08	8.12	2.15	8.47	2.50	4.13	14.00	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-10	10YR4/4	2,gr
Bt	10-86	2.5YR4/8	2,sbk
BC	86-175	2.5YR5/8	1,sbk
C	175-225	2.5YR5/8	0,m

Table 44. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P15-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-8	0.60	9.90	24.95	22.70	7.38	65.53	13.61	20.86	scl,sl
Bt	20-38	0.22	6.25	14.25	11.25	4.32	36.29	22.47	41.24	c,cl
C	145-225	0.42	10.20	17.78	18.40	12.80	59.60	17.85	22.55	scl

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-8	5.98	1.25	0.70	0.41	3.17	0.05	5.53	2.41	42.67	97.93	6.8	45.4
Bt	20-38	4.58	0.82	0.72	0.14	9.11	1.85	10.79	3.53	15.57	47.59	4.2	.
C	145-225	4.77	0.40	0.30	0.20	6.14	1.35	7.04	2.25	12.78	40.00	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-8	10YR5/3	2,gr
AB	8-20	10YR6/6	1,sbk
Bt	20-38	2.5YR4/8	2,sbk
BC	38-145	2.5YR5/8	1,sbk
C	145-225	2.5YR5/8	0,m

Table 45. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P15-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-13	0.60	10.80	25.78	23.68	7.65	68.51	19.47	12.02	sl
Bt	30-56	0.18	5.80	12.80	9.98	4.40	33.16	21.05	45.79	c
C	140-225	0.78	11.48	16.62	16.78	10.22	55.88	21.33	22.79	fsl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-13	5.60	0.92	0.42	0.30	4.16	0.10	5.80	1.74	28.28	94.25	7.1	40.6
Bt	30-56	4.71	2.18	0.98	0.18	11.29	0.65	14.63	3.99	22.83	83.71	3.0	.
C	140-225	4.86	0.33	0.29	0.10	6.34	1.55	7.06	2.27	10.20	31.72	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-13	10YR5/4	2,gr
BA	13-30	10YR5/6	1,sbk
Bt	30-56	2.5YR4/8	2,sbk
BC	56-140	2.5YR4/8	1,sbk
C	140-225	2.5YR5/8	0,m

Table 46. Physical, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P16-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class	Water Content		Bulk Density
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total				-10kPa	-1500kPa	
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-20	1.15	12.82	27.48	21.40	7.75	70.60	20.34	9.06	sl	0.17	0.08	1.57
Bt1	20-40	0.38	6.80	10.98	9.05	5.82	33.03	19.07	47.90	c	0.41	0.34	1.53
C	170-225	0.85	10.25	15.18	19.08	7.52	52.88	23.05	24.07	scl	.	.	.

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		$cmol\ (+)\ kg^{-1}$							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-20	6.46	1.10	0.50	0.48	0.99	0.05	3.07	2.13	67.75	97.65	10.8	64.2
Bt1	20-40	5.09	1.72	0.57	0.20	5.74	0.65	8.23	3.14	30.26	79.30	2.5	.
C	170-225	4.94	0.10	0.29	0.13	3.56	1.65	4.08	2.17	12.75	23.96	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	10YR5/4	2,gr
Bt1	20-40	7.5YR5/6	2,sbk
Bt2	40-60	2.5YR4/8	2,sbk
BC	60-170	2.5YR4/6	1,sbk
C	170-225	2.5YR5/8	0,m

Table 47. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P16-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-15	1.40	13.60	28.15	21.42	6.80	71.37	19.52	9.11	sl
Bt1	15-35	0.40	5.60	9.15	7.92	5.10	28.17	18.53	53.30	c
C	163-225	1.38	10.78	15.22	14.38	11.40	53.16	28.80	18.04	fsl,l,scl

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-15	6.54	1.17	0.49	0.40	1.19	0.05	3.25	2.11	63.38	97.63	8.2	61.2
Bt1	15-35	5.58	2.52	1.06	0.20	5.74	0.15	9.52	3.93	39.71	96.18	4.3	.
C	163-225	4.99	0.23	0.32	0.18	4.16	1.45	4.89	2.18	14.93	33.49	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	10YR5/4	2,gr
Bt1	15-35	7.5YR5/6	2,sbk
Bt2	35-85	2.5YR4/8	2,sbk
BC	85-163	2.5YR4/8	1,sbk
C	163-225	5YR5/8	0,m

Table 48. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P16-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-20	1.35	13.65	27.12	21.78	7.32	71.22	17.22	11.56	sl
Bt	30-79	0.48	6.05	11.55	9.28	5.82	33.18	20.08	46.74	c
C	155-225	0.85	9.45	15.92	17.58	12.22	56.02	25.12	18.86	fsl,scl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-20	6.40	1.14	0.52	0.33	0.99	0.05	2.98	2.04	66.78	97.55	8.8	72.4
Bt	30-79	5.30	1.95	1.12	0.28	7.13	0.25	10.48	3.60	31.97	93.06	3.9	.
C	155-225	5.15	0.20	0.46	0.22	4.16	1.25	5.04	2.13	17.46	41.31	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	10YR5/4	2,gr
BA	20-30	5YR5/6	1,sbk
Bt	30-79	2.5YR4/6	2,sbk
BC	79-155	2.5YR4/6	1,sbk
C	155-225	2.5YR5/8	0,m

Table 49. Physical, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P17-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class	Water Content		Bulk Density
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total				-10kPa	-1500kPa	
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-28	1.02	12.28	23.95	21.60	7.82	66.67	13.71	19.62	sl,scl	0.21	0.17	1.84
Bt	28-107	0.25	5.32	12.50	13.05	6.90	38.02	17.99	43.99	c	0.45	0.40	1.51
C	180-225	0.55	11.23	18.65	16.90	9.53	56.86	21.09	22.05	sl,scl	.	.	.

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		$cmol\ (+)\ kg^{-1}$							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-28	5.40	0.61	0.30	0.37	5.54	0.25	6.82	1.53	18.77	83.66	10.9	32.0
Bt	28-107	4.93	1.62	0.82	0.23	7.13	0.65	9.80	3.32	27.24	80.42	3.1	.
C	180-225	4.89	0.11	0.36	0.20	6.86	1.45	7.53	2.12	8.90	31.60	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-28	10YR5/6	2,gr
Bt	28-107	2.5YR4/8	2,sbk
BC	107-180	2.5YR4/8	1,sbk
C	180-225	5YR4/6	0,m

Table 50. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P17-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-28	0.72	11.78	25.45	21.50	7.75	67.20	13.18	19.62	sl,scl
Bt	28-102	0.78	7.65	13.10	11.90	6.12	39.55	11.22	49.23	c
C	168-225	0.98	11.88	13.25	16.53	11.58	54.22	23.55	22.23	fsl,scl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-28	5.30	0.60	0.29	0.28	4.16	0.25	5.33	1.42	21.95	82.39	8.3	36.0
Bt	28-102	4.74	1.65	0.66	0.24	13.66	0.85	16.21	3.40	15.73	75.00	4.7	.
C	168-225	4.95	0.20	0.43	0.17	7.64	1.45	8.44	2.25	9.48	35.56	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-28	10YR4/4	2,gr
Bt	28-102	2.5YR4/8	2,sbk
BC	102-168	2.5YR4/6	1,sbk
C	168-225	2.5YR4/6	0,m

Table 51. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P17-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-25	0.75	11.48	24.95	21.50	7.90	66.58	14.45	18.97	sl,scl
Bt	25-66	0.40	5.62	9.58	9.85	5.72	31.17	20.94	47.89	c
C	173-225	0.98	10.08	14.62	13.80	10.15	49.63	30.08	20.29	fsl,l,scl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-25	5.70	0.65	0.35	0.35	5.15	0.15	6.50	1.50	20.77	90.00	9.3	34.0
Bt	25-66	4.92	2.02	0.88	0.20	7.33	0.85	10.43	3.95	29.72	21.52	3.3	.
C	173-225	4.91	0.18	0.46	0.10	8.04	1.75	8.78	2.49	8.43	29.72	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-25	10YR4/4	2,gr
Bt	25-66	2.5YR4/8	2,sbk
BC	66-173	2.5YR4/6	1,sbk
C	173-225	5YR4/6	0,m

Table 52. Physical, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P18-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class	Water Content		Bulk Density
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total				-10kPa	-1500kPa	
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-20	0.78	11.65	22.85	19.90	7.62	62.80	20.40	16.80	sl	0.21	0.14	1.50
Bt	20-76	0.32	6.65	11.90	9.55	4.25	32.67	18.97	48.36	c	0.39	0.34	1.69
C	168-225	0.25	7.95	17.32	18.10	9.62	53.24	24.24	22.52	fsl,scl	.	.	.

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-20	6.71	1.43	0.87	0.60	1.19	0.05	4.09	2.95	70.90	98.31	10.9	22.0
Bt	20-76	4.98	1.76	1.49	0.23	10.10	0.65	13.58	4.13	25.63	84.26	3.2	.
C	168-225	4.84	0.10	0.31	0.11	7.25	1.65	7.77	2.17	6.69	23.96	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	10YR4/4	2,gr
Bt	20-76	2.5YR4/6	2,sbk
BC	76-168	2.5YR4/6	1,sbk
C	168-225	5YR4/6	0,m

Table 53. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P18-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	0.70	10.70	22.40	19.92	7.40	61.12	20.77	18.11	sl,scl
Bt	18-71	0.32	6.15	11.72	4.75	4.80	27.74	23.18	49.08	c
C	124-225	1.12	10.98	15.00	19.05	11.55	57.70	21.49	20.81	fsl,scl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-18	6.58	1.50	0.96	0.36	3.17	0.05	5.99	2.87	47.08	98.26	12.5	30.0
Bt	18-71	4.99	1.70	1.36	0.14	10.30	0.65	13.50	3.85	23.70	83.12	3.8	.
C	124-225	4.97	0.12	0.35	0.16	6.86	1.75	7.49	2.38	8.41	26.47	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	10YR4/4	2,gr
Bt	18-71	2.5YR4/8	2,sbk
BC	71-124	2.5YR4/8	1,sbk
C	124-225	5YR4/6	0,m

Table 54. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P18-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-20	0.65	10.40	21.22	18.65	7.02	57.94	14.94	27.12	scl
Bt	20-66	0.18	5.25	9.82	9.15	4.08	28.48	21.09	50.43	c
C	182-225	0.92	10.50	15.08	17.85	11.52	55.87	24.20	19.93	fsl,scl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-20	6.18	1.54	0.82	0.42	5.94	0.15	8.72	2.93	31.88	94.88	11.2	41.6
Bt	20-66	5.23	2.63	1.56	0.30	8.91	0.15	13.40	4.64	33.51	96.77	2.4	.
C	182-225	4.94	0.11	0.34	0.21	5.49	1.65	6.15	2.31	10.73	28.57	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	7.5YR4/4	2,gr
Bt	20-66	2.5YR4/8	2,sbk
BC	66-182	2.5YR4/8	1,sbk
C	182-225	5YR4/6	0,m

Table 55. Physical, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P19-1.

		Sand									Water Content		
Horizon	Depth	Very Coarse	Coarse	Medium	Fine	Very Fine	Total	Silt	Clay	Textural Class	-10kPa	-1500kPa	Bulk Density
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-18	0.60	5.10	17.12	23.25	9.55	55.62	25.31	19.07	fsl,scl	0.30	0.16	1.56
Bt	18-69	0.20	2.35	7.78	10.62	5.35	26.30	25.81	47.89	c	0.46	0.39	1.48
C	112-225	1.00	6.48	13.98	18.22	10.75	50.43	31.62	17.95	fsl,l	.	.	.

			Exchangeable cations										
Horizon	Depth	pH	Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.	Organic Matter	Avail. P
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-18	6.35	1.51	0.94	0.30	1.98	0.05	4.73	2.80	58.14	98.21	10.4	4.8
Bt	18-69	4.66	1.27	0.65	0.13	8.91	2.15	10.96	4.20	18.70	48.81	2.7	.
C	112-225	4.86	0.11	0.10	0.11	1.58	2.35	1.90	2.67	16.84	11.99	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	10YR4/4	2,gr
Bt	18-69	5YR5/6	2,sbk
BC	69-112	2.5YR4/6	1,sbk
C	112-225	7.5YR6/8	0,m

Table 56. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P19-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-20	0.55	4.72	17.08	22.38	9.70	54.43	25.26	20.31	fsl,scl
Bt	20-64	0.18	2.60	8.15	11.12	5.95	28.00	22.76	49.24	c
C	91-225	0.40	4.12	12.78	19.18	13.30	49.78	37.44	12.78	l

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-20	6.27	1.64	0.94	0.22	2.18	0.05	4.98	2.85	56.22	98.25	10.9	5.2
Bt	20-64	4.73	1.42	0.81	0.15	7.72	2.25	10.10	4.63	23.56	51.40	2.8	.
C	91-225	4.77	0.10	0.15	0.13	4.55	2.55	4.93	2.93	7.71	12.97	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	10YR4/4	2,gr
Bt	20-64	5YR5/6	2,sbk
BC	64-91	2.5YR4/6	1,sbk
C	91-225	7.5YR6/8	0,m

Table 57. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P19-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	0.35	0.88	15.25	20.38	8.92	45.78	27.18	27.04	l,scl,cl
Bt	18-58	0.18	2.28	6.65	9.35	5.12	23.58	26.80	49.62	c
C	132-225	0.98	6.48	13.90	17.55	11.25	50.16	36.37	13.47	fsl,l

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-18	6.21	2.10	1.27	0.28	3.56	0.05	7.21	3.70	50.62	98.65	10.4	3.0
Bt	18-58	4.86	2.00	1.15	0.12	10.49	2.45	13.76	5.72	23.76	57.17	5.2	.
C	132-225	4.81	0.14	0.14	0.12	1.98	2.85	2.38	3.25	16.81	12.31	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	10YR4/4	2,gr
Bt	18-58	2.5YR4/6	2,sbk
BC	58-132	7.5YR4/6	1,sbk
C	132-225	7.5YR6/8	0,m

Table 58. Physical, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P20-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class	Water Content		Bulk Density
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total				-10kPa	-1500kPa	
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-25	1.03	6.02	14.02	19.31	8.96	49.34	27.47	23.19	l,scl	0.25	0.19	1.49
Bt	25-58	1.40	5.03	8.38	8.73	5.58	28.22	24.76	47.02	c	0.42	0.32	1.63
C2	113-225	1.38	8.25	14.83	16.08	11.98	52.52	34.38	13.10	fsl,l	.	.	.

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		$cmol\ (+)\ kg^{-1}$							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-25	5.27	1.80	0.78	0.28	4.16	0.55	7.02	3.41	40.74	83.87	19.0	7.2
Bt	25-58	4.77	1.70	0.97	0.19	10.49	4.15	13.35	7.01	21.42	59.20	8.8	3.6
C2	113-225	4.53	0.07	0.22	0.14	6.73	3.75	7.16	4.18	6.01	10.29	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-25	10YR4/4	2,gr
Bt	25-58	2.5YR4/6	2,sbk
BC	58-80	7.5YR5/6	1,sbk
C1	80-113	7.5YR6/8	0,m
C2	113-225	7.5YR8/2	0,m

Table 59. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P20-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-23	1.06	6.94	14.43	18.37	8.20	49.00	25.72	25.28	scl
Bt	23-43	0.30	4.40	9.60	10.62	5.78	30.70	24.05	45.25	c
C2	120-225	2.53	9.28	13.05	14.55	11.88	51.29	32.90	15.81	fsl,l

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-23	5.20	1.85	0.84	0.26	3.96	0.75	6.91	3.70	42.69	79.73	17.5	20.0
Bt	23-43	4.65	1.57	0.88	0.22	8.71	3.95	11.38	6.62	23.46	40.33	6.2	3.9
C2	120-225	4.42	0.16	0.41	0.16	6.14	5.05	6.87	5.78	10.63	12.63	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-23	10YR4/4	2,gr
Bt	23-43	2.5YR4/6	2,sbk
BC	43-80	5YR5/6	1,sbk
C1	80-120	7.5YR6/8	0,m
C2	120-225	7.5YR8/2	0,m

Table 60. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P20-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-23	1.84	7.29	15.94	17.38	7.62	50.07	24.91	25.02	scl
Bt	23-43	1.75	6.20	9.48	8.60	4.48	30.51	23.02	46.47	c
C2	105-225	0.38	2.92	6.68	9.22	5.95	25.15	57.07	17.78	sil

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-23	5.46	2.12	1.08	0.29	4.36	0.45	7.85	3.94	44.46	88.58	19.3	11.8
Bt	23-43	4.72	1.87	0.92	0.20	10.10	4.35	13.09	7.34	22.84	40.74	9.3	.
C2	105-225	4.59	0.19	0.36	0.10	4.75	4.25	5.40	4.90	12.04	13.27	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-23	10YR4/4	2,gr
Bt	23-43	5YR5/6	2,sbk
BC	43-60	5YR5/8	1,sbk
C1	60-105	7.5YR6/8	0,m
C2	105-225	7.5YR8/2	0,m

Table 61. Physical, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P21-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class	Water Content		Bulk Density
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total				-10kPa	-1500kPa	
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-20	5.05	7.78	9.30	15.33	10.48	47.94	27.52	24.54	l,scl	0.25	0.23	1.36
Bt	20-48	6.50	6.53	5.33	7.93	6.05	32.34	22.20	45.46	c	0.41	0.39	1.46
C2	88-225	8.08	12.03	9.80	13.45	12.65	56.01	34.41	9.58	fsl	.	.	.

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-20	5.20	1.68	0.91	0.25	4.16	0.45	7.00	3.29	40.57	86.32	17.5	7.5
Bt	20-48	4.82	1.94	1.32	0.14	8.51	1.65	11.91	5.05	28.55	67.33	4.3	.
C2	88-225	4.62	0.10	0.28	0.15	1.58	1.25	2.11	1.78	25.12	29.78	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	10YR4/4	2,gr
Bt	20-48	7.5YR5/8	2,sbk
C1	48-88	7.5YR7/8	0,m
C2	88-225	7.5YR8/2	0,m

Table 62. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P21-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-23	0.75	9.90	21.95	20.20	7.70	60.50	14.25	25.25	scl
Bt	23-38	2.95	5.80	6.20	9.45	7.40	31.80	23.99	44.21	c
C	38-225	1.50	2.98	6.30	18.88	15.20	44.86	37.71	17.43	l

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-23	5.60	1.86	1.10	0.21	3.76	0.15	6.93	3.32	45.74	95.48	17.2	5.0
Bt	23-38	4.92	1.98	1.14	0.12	8.51	1.65	11.75	4.89	27.57	66.26	5.5	.
C	38-225	4.46	0.08	0.29	0.17	5.15	2.75	5.69	3.29	9.49	16.41	.	3.5

Horizon	Depth	Color	Structure
	cm		
Ap	0-23	10YR4/4	2,gr
Bt	23-38	7.5YR5/8	2,sbk
C	38-225	7.5YR5/8	0,m

Table 63. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P21-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	1.65	7.03	15.30	17.48	7.75	49.21	28.24	22.55	fsl,l,scl
Bt	18-48	0.43	2.38	5.15	8.13	5.53	21.62	21.57	56.81	c
C2	145-225	0.32	7.30	14.58	13.48	8.38	44.06	49.90	6.04	fsl,l,sil

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-18	5.63	1.87	0.98	0.38	4.16	0.45	7.39	3.68	43.71	87.77	19.3	6.5
Bt	18-48	4.73	1.35	0.93	0.10	10.69	3.45	13.07	5.83	18.21	40.82	5.0	3.9
C2	145-225	4.62	0.05	0.15	0.14	3.76	2.55	4.10	2.89	8.29	11.76	.	4.6

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	10YR4/4	2,gr
Bt	18-48	5YR5/6	2,sbk
BC	48-63	5YR5/6	1,sbk
C1	63-145	7.5YR7/8	0,m
C2	145-225	7.5YR8/2	0,m

Table 64. Physical, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P22-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class	Water Content		Bulk Density
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total				-10kPa	-1500kPa	
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-23	0.25	1.65	5.58	13.95	9.95	31.38	40.00	28.62	l,cl	0.28	0.23	1.20
Bt	23-81	0.08	0.48	1.28	4.08	5.80	11.72	29.80	58.48	c	0.38	0.34	1.66
C	185-225	0.05	0.32	0.82	9.65	15.58	26.42	47.09	26.49	l,cl	.	.	.

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-23	6.02	2.04	1.18	0.28	6.34	0.05	9.84	3.55	35.57	98.59	15.1	1.0
Bt	23-81	5.13	0.95	1.90	0.22	12.49	0.95	16.01	4.02	19.18	76.37	4.2	.
C	185-225	5.10	0.08	1.67	0.24	12.15	2.25	14.14	4.24	14.07	46.93	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-23	5YR4/4	1,sbk
Bt	23-81	2.5YR4/6	2,sbk
BC	81-185	2.5YR4/6	1,sbk
C	185-225	2.5YR4/6	0,m

Table 65. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P22-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-23	0.28	1.65	5.50	13.45	8.12	29.00	36.07	34.93	cl
Bt	23-76	0.08	0.80	2.85	7.78	6.45	17.96	30.33	51.71	c
C	135-225	0.12	0.48	1.35	13.00	14.35	29.30	42.86	27.84	l,cl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-23	5.54	1.91	1.17	0.22	7.72	0.15	11.02	3.45	29.95	95.65	13.0	1.2
Bt	23-76	5.06	0.54	1.62	0.23	11.29	1.15	13.68	3.54	17.47	67.51	5.3	.
C	135-225	5.11	0.10	1.66	0.21	12.74	2.65	14.71	4.62	13.39	42.64	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-23	5YR4/6	1,sbk
Bt	23-76	2.5YR4/6	2,sbk
BC	76-135	2.5YR4/6	1,sbk
C	135-225	5YR4/6	0,m

Table 66. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P22-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-23	0.35	1.65	5.18	12.78	8.42	28.38	34.06	37.56	cl
Bt	23-64	0.08	0.85	2.85	8.48	6.90	19.16	27.53	53.31	c
C	188-225	0.02	0.30	1.18	12.55	13.90	27.95	40.23	31.82	cl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-23	5.74	2.25	1.44	0.35	8.12	0.10	12.16	4.14	33.22	97.58	16.0	1.0
Bt	23-64	5.13	0.62	1.82	0.17	11.48	1.45	14.09	4.06	18.52	64.29	4.9	.
C	188-225	5.03	0.08	1.91	0.26	11.56	2.15	13.81	4.40	16.29	51.14	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-23	5YR4/6	1,sbk
Bt	23-64	2.5YR5/6	2,sbk
BC	64-188	2.5YR5/6	1,sbk
C	188-225	5YR4/6	0,m

Table 67. Physical, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P23-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class	Water Content		Bulk Density
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total				-10kPa	-1500kPa	
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-28	0.22	1.42	6.92	19.28	11.22	39.06	31.96	28.98	cl,l	0.30	0.18	1.56
Bt	28-79	0.05	0.32	1.50	4.78	4.78	11.43	33.36	55.21	c	0.43	0.38	1.37
C	132-225	0.08	1.30	8.22	16.20	13.38	39.18	36.34	24.48	l,cl	.	.	.

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-28	5.40	1.34	0.68	0.18	7.52	0.25	9.72	2.45	22.63	89.80	14.7	1.7
Bt	28-79	4.77	1.18	1.26	0.21	12.47	1.75	15.12	4.40	17.53	60.23	4.0	.
C	132-225	5.03	0.08	0.31	0.16	6.27	1.95	6.82	2.50	8.06	22.00	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-28	5YR4/6	1,sbk
Bt	28-79	2.5YR4/6	2,sbk
BC	79-132	2.5YR4/6	1,sbk
C	132-225	5YR5/8	0,m

Table 68. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P23-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-25	0.32	1.85	7.50	19.40	10.78	39.85	30.72	29.43	l,cl
Bt	25-60	0.02	0.42	1.88	6.18	6.78	15.28	31.86	52.86	c
C	137-225	0.05	0.35	2.25	9.13	11.83	23.61	45.81	30.58	cl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-25	5.25	1.38	0.78	0.27	7.13	0.20	9.56	2.63	25.42	92.40	14.7	2.0
Bt	25-60	4.88	1.21	1.18	0.18	11.48	1.65	14.05	4.22	18.29	60.90	3.4	.
C	137-225	4.99	0.10	0.46	0.22	12.74	2.45	13.52	3.23	5.77	24.15	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	5YR4/6	1,sbk
Bt	15-60	2.5YR4/6	2,sbk
BC	60-137	2.5YR4/6	1,sbk
C	137-225	2.5YR4/6	0,m

Table 69. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P23-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-28	0.20	1.45	6.42	18.78	12.18	39.03	30.35	30.62	cl
Bt	28-96	0.02	0.32	1.52	4.82	5.50	12.18	28.69	59.13	c
C	163-225	0.15	1.50	8.10	20.02	15.08	44.85	42.99	12.16	l

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-28	5.47	1.34	0.74	0.21	4.95	0.20	7.24	2.49	31.63	91.97	14.5	2.0
Bt	28-96	4.82	1.19	1.30	0.17	13.46	1.65	16.12	4.31	16.50	61.72	6.4	.
C	163-225	5.02	0.04	0.16	0.16	5.29	1.15	5.65	1.51	6.37	23.84	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-28	5YR4/6	1,sbk
Bt	28-96	2.5YR4/6	2,sbk
BC	96-163	2.5YR4/6	1,sbk
C	163-225	7.5YR7/6	0,m

Table 70. Physical, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P24-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class	Water Content		Bulk Density
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total				-10kPa	-1500kPa	
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-23	0.45	1.75	5.48	12.50	9.70	29.88	41.32	28.80	l,cl	0.40	0.28	1.73
Bt	23-81	0.05	0.58	2.16	5.37	6.00	14.16	36.73	49.11	c	0.47	0.36	1.41
C	109-225	0.08	1.14	5.23	12.71	16.35	35.51	46.97	17.52	l	.	.	.

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-23	5.60	1.50	1.00	0.21	5.15	0.15	7.86	2.86	34.48	94.76	9.7	1.3
Bt	23-81	4.98	0.83	1.42	0.28	10.98	1.95	13.42	4.48	18.85	56.47	2.2	3.9
C	109-225	4.96	0.18	0.35	0.18	3.96	2.65	4.67	3.36	15.20	21.13	.	7.2

Horizon	Depth	Color	Structure
	cm		
Ap	0-23	5YR4/4	1,sbk
Bt	23-81	2.5YR4/6	2,sbk
BC	81-109	2.5YR4/6	1,sbk
C	109-225	7.5YR7/8	0,m

Table 71. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P24-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-23	0.40	1.65	5.58	12.43	9.60	29.66	38.81	31.53	cl
Bt	23-81	0.13	0.64	2.01	5.23	5.72	13.73	35.67	50.60	c
C	122-225	0.23	3.68	10.33	15.34	14.29	43.87	41.78	14.35	l

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-23	5.44	1.32	0.88	0.20	3.76	0.35	6.16	2.75	38.96	87.27	11.7	1.0
Bt	23-81	4.84	1.00	1.38	0.24	7.52	1.65	10.14	4.27	25.84	61.36	5.5	3.2
C	122-225	5.00	0.17	0.24	0.12	3.37	1.95	3.90	2.48	13.59	21.37	.	15.9

Horizon	Depth	Color	Structure
	cm		
Ap	0-23	5YR4/4	1,gr
Bt	23-81	2.5YR4/6	2,sbk
BC	81-122	5YR4/6	1,sbk
C	122-225	5YR5/8	0,m

Table 72. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P24-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-28	0.35	1.37	4.65	10.69	8.32	25.38	42.25	32.37	cl
Bt	28-91	0.03	0.28	1.32	4.78	6.61	13.02	32.59	54.39	c
C	130-225	0.03	0.43	2.73	9.78	12.99	25.96	53.90	20.14	sil

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-28	5.20	1.67	0.86	0.18	5.35	0.55	8.06	3.26	33.62	83.13	11.6	0.9
Bt	28-91	4.84	0.77	1.34	0.20	8.71	2.65	11.02	4.96	20.96	46.57	2.8	.
C	130-225	4.76	0.18	0.43	0.17	4.55	3.65	5.33	4.43	14.63	17.61	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-28	5YR4/4	1,gr
Bt	28-91	2.5YR4/6	2,sbk
BC	91-130	5YR4/6	1,sbk
C	130-225	5YR5/8	0,m

Table 73. Physical, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P25-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class	Water Content		Bulk Density
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total				-10kPa	-1500kPa	
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-23	0.83	2.25	4.60	8.10	5.50	21.28	37.62	41.10	cl,c	0.45	0.40	1.44
Bt	23-102	0.08	0.48	1.15	3.00	3.60	8.31	31.02	60.67	c	0.56	0.43	1.39
C	170-225	0.12	0.20	0.42	4.05	10.95	15.74	55.45	28.81	sil,sicl	.	.	.

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-23	5.40	1.94	1.42	0.28	8.51	0.35	12.15	3.99	29.96	91.23	20.2	1.7
Bt	23-102	4.81	1.23	1.64	0.17	14.26	2.05	17.30	5.09	17.57	59.72	8.3	.
C	170-225	5.00	0.04	0.90	0.18	10.30	4.15	11.42	5.27	9.81	21.25	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-23	2.5YR4/8	1,sbk
Bt	23-102	2.5YR4/6	2,sbk
BC	102-170	2.5YR4/6	1,sbk
C	170-225	5YR5/8	0,m

Table 74. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P25-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-28	0.58	2.35	4.63	8.03	5.25	20.84	37.15	42.01	cl,c
Bt	28-74	0.12	0.38	1.24	2.98	3.50	8.22	32.13	59.65	c
C	183-225	0.14	0.22	0.45	4.28	11.78	16.87	55.98	27.15	sil,sicl

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-28	5.34	1.97	1.41	0.35	8.51	0.55	12.24	4.28	30.47	87.15	20.1	1.2
Bt	28-74	4.78	0.96	1.65	0.15	11.88	2.35	14.64	5.11	18.85	54.01	3.7	.
C	183-225	4.98	0.01	0.74	0.16	11.88	4.65	12.79	5.56	7.11	16.37	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-28	2.5YR4/8	1,sbk
Bt	28-74	2.5YR4/6	2,sbk
BC	74-183	2.5YR4/6	1,sbk
C	183-225	2.5YR5/8	0,m

Table 75. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Pittsylvania County, profile P25-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-25	0.85	9.72	15.28	18.25	11.65	55.75	2.23	42.02	sc
Bt	25-79	0.14	0.42	0.95	3.14	3.65	8.30	30.28	61.42	c
C	147-225	0.05	0.18	0.55	4.25	11.80	16.83	55.71	27.46	sil,sicl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-25	5.20	2.06	1.59	0.45	8.51	0.35	12.61	4.45	32.51	92.13	22.6	1.2
Bt	25-79	4.78	0.90	1.50	0.14	11.68	2.85	14.22	5.39	17.86	47.12	6.7	.
C	147-225	4.86	0.01	0.70	0.18	11.68	5.25	12.57	6.14	7.08	14.50	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-25	2.5YR4/8	1,sbk
Bt	25-79	2.5YR4/6	2,sbk
BC	79-147	2.5YR4/8	1,sbk
C	147-225	5YR5/8	0,m

Lunenburg County

Table 1. Physical, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L1-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class	Water Content		Bulk Density
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total				-10kPa	-1500kPa	
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-5	1.35	6.20	18.58	37.80	8.12	72.05	15.15	12.80	fsl	0.28	0.17	1.59
Bt	5-56	0.80	5.12	7.58	11.12	4.45	29.07	13.74	57.19	c	0.50	0.37	1.39
C	109-225	1.56	8.00	15.58	23.75	9.18	58.07	18.58	23.35	scl	.	.	.

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-5	6.42	1.73	0.64	0.08	4.55	0.05	7.00	2.50	35.00	98.00	12.2	4.0
Bt	5-56	4.67	2.08	0.68	0.04	11.48	1.15	14.28	3.95	19.61	70.89	5.8	.
C	109-225	4.66	0.17	0.07	0.08	6.14	1.95	6.46	2.27	4.95	14.10	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-5	10YR4/4	2,gr
Bt	5-55	2.5YR4/6	2,sbk
BC	55-108	2.5YR4/6	1,sbk
C	108-225	2.5YR4/6	0,m

Table 2. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L1-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-13	1.25	6.02	18.36	34.22	7.95	67.80	17.75	14.45	fsl
Bt	13-48	0.73	3.93	5.73	9.35	4.20	23.94	15.19	60.87	c
C	107-225	1.40	8.10	16.55	24.12	9.05	59.22	16.34	24.44	scl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-13	5.78	1.81	0.72	0.10	5.35	0.05	7.98	2.68	32.96	98.13	14.5	2.4
Bt	13-48	4.75	1.28	0.55	0.07	13.13	1.75	15.03	3.65	12.64	52.05	6.2	.
C	107-225	5.09	0.12	0.06	0.05	8.04	1.95	8.27	2.18	2.78	10.55	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-13	10YR4/4	2,gr
Bt	13-48	2.5YR4/6	2,sbk
BC	48-105	2.5YR4/6	1,sbk
C	105-225	2.5YR4/6	0,m

Table 3. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L1-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-10	1.18	5.90	19.15	35.88	8.42	70.53	15.59	13.88	fsl
Bt	10-69	0.63	3.95	5.66	8.96	4.00	23.20	19.45	57.34	c
C	117-225	1.28	10.02	16.22	24.28	8.98	60.78	19.50	19.72	fsl,scl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-10	5.98	2.15	0.86	0.15	4.16	0.10	7.32	3.26	43.17	96.93	15.5	1.8
Bt	10-69	4.52	0.99	0.39	0.07	9.31	1.85	10.76	3.30	13.48	43.94	3.9	.
C	117-225	4.86	0.15	0.06	0.03	8.71	2.55	8.95	2.79	2.68	8.60	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-10	10YR5/4	2,gr
Bt	10-68	2.5YR4/6	2,sbk
BC	68-115	2.5YR4/6	1,sbk
C	115-225	2.5YR4/6	0,m

Table 4. Physical, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L2-1.

		Sand									Water Content		
Horizon	Depth	Very Coarse	Coarse	Medium	Fine	Very Fine	Total	Silt	Clay	Textural Class	-10kPa	-1500kPa	Bulk Density
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-10	1.44	5.66	18.02	35.66	6.05	66.83	11.90	21.27	fsl,scl	0.25	0.17	1.78
Bt	10-36	0.80	5.38	6.64	12.45	7.66	32.93	9.43	57.64	c	0.51	0.44	1.28
C	114-225	0.71	3.60	9.98	18.42	12.90	45.61	37.06	17.33	l	.	.	.

			Exchangeable cations										
Horizon	Depth	pH	Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.	Organic Matter	Avail. P
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-10	5.50	1.98	0.80	0.15	4.75	0.25	7.68	3.18	38.15	92.14	18.8	3.2
Bt	10-36	4.53	1.00	0.41	0.05	10.10	2.65	11.56	4.11	12.63	35.52	5.2	.
C	114-225	4.92	0.20	0.04	0.10	4.75	1.55	5.09	1.89	6.68	17.99	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-10	10YR4/4	2,gr
Bt	10-35	7.5YR5/6	2,sbk
BC	35-113	2.5YR4/6	1,sbk
C	113-225	2.5YR5/8	0,m

Table 5. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L2-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-10	1.38	5.75	17.35	35.15	7.22	66.85	9.19	23.96	scl
Bt	10-112	1.12	5.40	5.58	11.32	7.94	31.36	13.09	55.55	c
C	127-225	0.58	3.65	8.72	19.52	13.40	45.87	37.87	16.26	l

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-10	6.05	2.02	0.78	0.09	5.74	0.10	8.63	2.99	33.49	96.66	16.3	4.8
Bt	10-112	4.58	0.45	0.24	0.05	9.31	3.15	10.05	3.89	7.36	19.02	2.3	.
C	127-225	4.77	0.14	0.09	0.06	8.04	4.05	8.33	4.33	3.48	6.68	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-10	10YR4/4	2,gr
Bt1	10-50	10YR6/8	2,sbk
Bt2	50-110	5YR5/6	2,sbk
BC	110-125	5YR5/6	1,sbk
C	125-225	2.5YR4/6	0,m

Table 6. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L2-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-10	1.27	5.30	17.45	34.48	7.11	65.61	10.61	23.78	scl
Bt	10-58	0.70	4.95	7.02	11.54	6.68	30.89	15.03	54.08	c
C	112-225	0.60	4.12	9.43	18.15	12.54	44.84	39.23	15.93	l

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-10	5.96	1.99	0.84	0.13	3.17	0.05	6.13	3.01	48.29	98.34	18.2	2.8
Bt	10-58	4.43	0.84	0.42	0.07	9.90	2.55	11.23	3.88	11.84	34.28	3.8	.
C	112-225	4.67	0.19	0.04	0.06	6.34	2.55	6.63	2.84	4.37	10.21	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-10	10YR4/4	2,gr
Bt	10-58	2.5YR4/6	2,sbk
BC	58-110	2.5YR4/6	1,sbk
C	110-225	5YR5/6	0,m

Table 7. Physical, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L3-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class	Water Content		Bulk Density
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total				-10kPa	-1500kPa	
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-10	1.75	6.90	14.08	22.40	6.75	51.88	17.40	30.72	scl	0.32	0.23	1.82
Bt	10-56	0.84	4.42	7.04	8.90	8.45	29.65	21.93	48.42	c	0.49	0.42	1.47
C	97-225	1.40	7.45	10.82	15.58	8.32	43.57	25.74	30.69	scl,cl	.	.	.

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-10	5.60	2.09	0.79	0.17	9.90	0.20	12.95	3.25	23.55	93.85	22.2	3.7
Bt	10-56	4.72	0.47	0.35	0.07	10.89	2.85	11.78	3.74	7.56	23.80	3.9	.
C	97-225	4.64	0.15	0.06	0.04	8.43	3.25	8.68	3.50	2.88	7.14	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-10	10YR4/4	2,gr
Bt	10-55	5YR5/6	2,sbk
BC	55-95	5YR5/6	1,sbk
C	95-225	5YR5/6	0,m

Table 8. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L3-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-8	2.15	5.94	14.32	21.84	7.05	51.30	20.26	28.44	scl
Bt	8-65	0.65	4.12	7.85	12.42	7.08	32.12	23.90	43.98	c
C	102-225	0.55	3.78	10.25	23.30	14.10	51.98	33.52	14.50	sl,l

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-8	5.22	1.97	0.74	0.19	7.33	0.35	10.23	3.25	28.35	89.23	20.5	2.1
Bt	8-65	4.82	0.22	0.29	0.07	10.19	3.25	10.77	3.83	5.39	15.14	2.5	.
C	102-225	4.67	0.24	0.08	0.04	6.34	3.25	6.70	3.61	5.37	9.97	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-8	10YR4/4	2,gr
Bt1	8-40	7.5YR5/6	2,sbk
Bt2	40-63	5YR5/6	2,sbk
BC	63-103	5YR5/6	1,sbk
C	103-225	7.5YR6/8	0,m

Table 9. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L3-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-13	1.95	6.74	13.99	22.80	6.94	52.42	17.94	29.64	scl
Bt	13-51	1.22	5.48	6.25	6.92	3.32	23.19	17.55	59.26	c
C	107-225	0.42	4.05	8.88	20.58	13.32	47.25	27.55	25.20	scl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-13	5.20	1.90	0.72	0.19	6.73	0.45	9.54	3.26	29.45	86.20	21.5	4.9
Bt	13-51	4.64	0.66	0.62	0.07	13.86	3.05	15.21	4.40	8.88	30.68	5.9	.
C	107-225	4.76	0.18	0.06	0.05	7.84	3.55	8.13	3.84	3.57	7.55	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-13	10YR4/4	2,gr
Bt	13-50	7.5YR4/6	2,sbk
BC	50-105	5YR5/6	1,sbk
C	105-225	7.5YR6/8	0,m

Table 10. Physical, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L4-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class	Water Content		Bulk Density
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total				-10kPa	-1500kPa	
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-18	1.08	5.38	13.28	22.25	5.98	47.97	23.69	28.34	scl	0.24	0.18	1.69
Bt	18-43	0.52	3.60	6.88	10.98	5.32	27.30	18.08	54.62	c	0.43	0.35	1.41
C	97-225	2.48	5.12	9.00	21.35	11.32	49.27	29.46	21.27	scl,l	.	.	.

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		$cmol\ (+)\ kg^{-1}$							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-18	5.59	2.04	0.93	0.35	6.14	0.05	9.46	3.37	35.10	98.52	18.5	3.9
Bt	18-43	4.51	0.63	0.57	0.07	11.88	3.15	13.15	4.42	9.66	28.73	2.8	.
C	97-225	4.98	0.07	0.10	0.06	7.84	3.15	8.07	3.38	2.85	6.80	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	10YR5/4	2,gr
Bt	18-43	10YR6/6	2,sbk
BC	43-95	7.5YR5/6	1,sbk
C	95-225	2.5YR4/6	0,m

Table 11. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L4-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	1.22	5.95	14.50	23.60	6.20	51.47	18.93	29.60	scl
Bt	18-69	0.55	3.58	7.18	10.98	4.25	26.54	16.79	56.67	c
C	97-225	0.12	2.78	11.65	22.65	10.08	47.28	30.63	22.09	l

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-18	5.56	1.90	0.85	0.19	4.95	0.10	7.89	3.04	37.26	96.71	20.1	4.2
Bt	18-69	4.63	0.81	0.56	0.04	13.46	2.95	14.87	4.36	9.48	32.34	4.6	.
C	97-225	4.81	0.09	0.06	0.04	6.47	3.65	6.66	3.84	2.85	4.95	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	7.5YR5/6	2,gr
Bt1	18-35	5YR5/6	2,sbk
Bt2	35-68	5YR5/6	2,sbk
BC	68-95	2.5YR5/6	1,sbk
C	95-225	2.5YR4/6	0,m

Table 12. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L4-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-15	2.38	7.20	15.30	23.20	5.75	53.83	19.13	27.04	scl
Bt	15-51	1.62	5.58	7.15	10.78	6.45	31.58	17.26	51.16	c
C	104-225	0.72	4.25	9.60	16.38	10.20	41.15	33.38	25.47	l,cl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-15	5.32	1.62	0.72	0.22	5.74	0.25	8.30	2.81	30.84	91.10	16.7	4.0
Bt	15-51	4.68	0.72	0.59	0.08	11.88	2.65	13.27	4.04	10.47	34.41	4.7	.
C	104-225	4.82	0.10	0.08	0.07	9.02	3.65	9.27	3.90	2.70	6.41	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	10YR5/6	2,gr
Bt	15-50	7.5YR4/6	2,sbk
BC	50-103	2.5YR5/6	1,sbk
C	103-225	2.5YR4/6	0,m

Table 13. Physical, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L5-1.

		Sand									Water Content		
Horizon	Depth	Very Coarse	Coarse	Medium	Fine	Very Fine	Total	Silt	Clay	Textural Class	-10kPa	-1500kPa	Bulk Density
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-20	1.98	8.52	17.98	30.32	7.72	66.52	19.04	14.44	fsl	0.25	0.15	1.76
Bt	20-56	0.22	2.52	6.35	14.28	5.10	28.47	18.45	53.08	c	0.47	0.34	1.41
C	117-225	0.58	4.35	12.75	27.82	9.80	55.30	20.63	24.07	scl	.	.	.

			Exchangeable cations										
Horizon	Depth	pH	Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.	Organic Matter	Avail. P
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-20	6.49	1.83	0.71	0.15	2.38	0.05	5.07	2.74	53.06	98.18	15.7	5.8
Bt	20-56	4.71	1.05	0.81	0.08	12.15	2.15	14.09	4.09	13.77	47.43	4.5	.
C	117-225	4.80	0.10	0.09	0.02	9.41	3.15	9.62	3.36	2.18	6.25	.	0.2

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	10YR4/4	2,gr
Bt	20-55	2.5YR4/6	2,sbk
BC	55-115	2.5YR4/6	1,sbk
C	115-225	2.5YR4/6	0,m

Table 14. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L5-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-13	1.98	9.40	20.00	28.35	6.73	66.46	20.40	13.14	sl
Bt	13-53	0.38	2.98	6.02	9.78	4.38	23.54	14.70	61.76	c
C	86-225	1.22	7.10	14.15	28.85	10.20	61.52	21.56	16.92	fsl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-13	6.36	2.42	0.79	0.28	2.97	0.10	6.46	3.59	54.02	97.21	17.1	8.0
Bt	13-53	4.64	1.68	1.00	0.07	13.86	1.85	16.61	4.60	16.56	59.78	5.8	.
C	86-225	4.93	0.08	0.09	0.03	7.25	2.95	7.45	3.15	2.68	6.35	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-13	10YR4/4	2,gr
Bt	13-53	5YR5/6	2,sbk
BC	53-85	2.5YR4/6	1,sbk
C	85-225	2.5YR4/6	0,m

Table 15. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L5-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-13	2.58	9.05	18.50	27.95	7.10	65.18	20.55	14.27	fsl
Bt	13-61	0.30	2.55	5.23	9.93	4.55	22.56	18.26	59.18	c
C	104-225	0.25	4.28	11.65	28.42	9.08	53.68	23.80	22.52	scl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-13	6.48	2.38	0.86	0.25	7.33	0.25	10.82	3.74	32.26	93.32	17.3	7.8
Bt	13-61	4.80	1.97	1.11	0.06	13.72	1.65	16.86	4.79	18.62	65.55	8.3	.
C	104-225	4.86	0.10	0.07	0.02	8.23	2.85	8.42	3.04	2.26	6.25	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-13	10YR4/4	2,gr
Bt	13-60	5YR5/6	2,sbk
BC	60-103	5YR5/6	1,sbk
C	103-225	2.5YR4/6	0,m

Table 16. Physical, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L6-1.

		Sand									Water Content		
Horizon	Depth	Very Coarse	Coarse	Medium	Fine	Very Fine	Total	Silt	Clay	Textural Class	-10kPa	-1500kPa	Bulk Density
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-8	3.14	6.88	13.50	22.48	8.32	54.32	22.34	23.34	scl	0.26	0.13	1.51
Bt	8-69	0.20	5.50	1.20	2.22	1.32	10.44	24.00	65.56	c	0.46	0.32	1.51
C	183-225	0.05	0.18	0.32	1.15	2.12	3.82	44.25	51.93	sic	.	.	.

			Exchangeable cations										
Horizon	Depth	pH	Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.	Organic Matter	Avail. P
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-8	5.74	2.02	0.64	0.23	0.79	0.10	3.68	2.99	78.53	96.66	9.8	0.6
Bt	8-69	5.26	4.27	2.70	0.21	10.10	1.15	17.28	8.33	41.55	86.19	3.6	.
C	183-225	5.04	0.18	1.57	0.42	14.65	5.65	16.82	7.82	12.90	27.75	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-8	7.5YR5/4	2,gr
Bt	8-68	2.5YR4/8	2,sbk
BC	68-180	2.5YR4/6	1,sbk
C	180-225	5YR5/6	0,m

Table 17. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L6-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-5	3.25	6.12	12.18	20.65	7.60	49.80	24.59	25.61	scl
Bt	5-48	0.50	1.82	6.05	17.92	8.62	34.91	21.37	43.72	c
C	114-225	3.65	8.42	12.02	23.00	11.55	58.64	20.86	20.50	fsl,scl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-5	5.61	2.25	0.64	0.22	3.37	0.05	6.48	3.16	47.99	98.42	9.4	0.7
Bt	5-48	5.27	2.45	1.27	0.14	7.72	1.15	11.58	5.01	33.33	77.04	1.6	.
C	114-225	5.04	0.06	0.44	0.24	5.94	3.15	6.68	3.89	11.08	19.02	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-5	7.5YR4/6	2,gr
Bt	5-48	2.5YR4/8	2,sbk
BC	48-113	2.5YR4/8	1,sbk
C	113-225	7.5YR5/6	0,m

Table 18. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L6-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-8	3.08	7.32	14.58	23.00	8.20	56.18	22.68	21.14	fsl,scl
Bt	8-35	1.00	2.98	6.68	14.58	6.58	31.82	19.97	48.21	c
C	107-225	1.18	3.82	9.85	24.50	16.18	55.53	29.42	15.05	sl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-8	5.60	1.96	0.56	0.21	2.57	0.15	5.30	2.88	51.51	94.79	8.6	0.7
Bt	8-35	5.01	2.42	1.79	0.16	7.92	1.85	12.29	6.22	35.56	70.26	3.7	.
C	107-225	4.80	0.07	0.66	0.27	6.93	4.95	7.93	5.95	12.61	16.81	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-8	5YR4/6	2,gr
Bt	8-35	2.5YR4/6	2,sbk
BC	35-105	2.5YR4/8	1,sbk
C	105-225	7.5YR6/6	0,m

Table 19. Physical, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L7-1.

		Sand									Water Content		
Horizon	Depth	Very Coarse	Coarse	Medium	Fine	Very Fine	Total	Silt	Clay	Textural Class	-10kPa	-1500kPa	Bulk Density
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-13	1.05	5.95	13.88	26.18	8.95	56.01	27.79	16.20	fsl	0.27	0.12	1.70
Bt	13-84	0.18	0.72	1.05	2.00	1.78	5.73	31.54	62.73	c	0.48	0.35	1.59
C	173-225	0.18	0.62	0.85	1.68	2.80	6.13	45.51	48.36	sic	.	.	.

			Exchangeable cations										
Horizon	Depth	pH	Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.	Organic Matter	Avail. P
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-13	5.78	1.63	0.54	0.21	3.76	0.15	6.14	2.53	38.76	94.07	12.6	1.6
Bt	13-84	5.27	1.67	2.60	0.34	13.27	2.45	17.88	7.06	25.78	65.30	4.1	.
C	173-225	4.97	0.14	1.52	0.28	15.88	5.65	17.82	7.59	10.89	25.56	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-13	7.5YR5/4	2,gr
Bt	13-83	2.5YR4/6	2,sbk
BC	83-170	2.5YR4/6	1,sbk
C	170-225	2.5YR4/6	0,m

Table 20. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L7-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-10	1.45	5.80	13.42	25.78	8.04	54.49	27.85	17.66	fsl
Bt	10-51	1.50	4.50	5.52	10.60	6.50	28.62	25.18	46.20	c
C	89-225	2.40	7.55	11.30	23.80	12.60	57.65	22.19	20.16	fsl,scl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-10	5.59	1.85	0.66	0.18	9.31	0.15	12.00	2.84	22.42	94.72	11.8	1.1
Bt	10-51	5.05	3.15	1.68	0.10	9.60	1.45	14.53	6.38	33.93	77.27	4.2	.
C	89-225	4.61	0.15	0.42	0.15	6.66	3.25	7.38	3.97	9.76	18.14	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-10	7.5YR5/4	2,gr
Bt	10-50	2.5YR4/6	2,sbk
BC	50-88	2.5YR4/6	1,sbk
C	88-225	5YR5/6	0,m

Table 21. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L7-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-10	1.50	5.72	12.95	24.22	8.18	52.57	22.99	24.44	scl
Bt	10-46	0.53	2.93	6.33	14.05	6.03	29.87	21.75	48.38	c
C	89-225	1.12	4.88	10.60	27.40	14.12	58.12	25.90	15.98	fsl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-10	5.37	2.05	0.72	0.23	4.36	0.25	7.36	3.25	40.76	92.31	11.7	2.4
Bt	10-46	5.17	3.03	1.70	0.10	9.41	1.05	14.24	5.88	33.92	82.14	4.6	.
C	89-225	4.81	0.12	0.57	0.15	8.23	4.15	9.07	4.99	9.26	16.83	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-10	7.5YR5/4	2,gr
Bt	10-45	2.5YR4/6	2,sbk
BC	45-88	2.5YR4/6	1,sbk
C	88-225	2.5YR4/6	0,m

Table 22. Physical, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L8-1.

		Sand									Water Content		
Horizon	Depth	Very Coarse	Coarse	Medium	Fine	Very Fine	Total	Silt	Clay	Textural Class	-10kPa	-1500kPa	Bulk Density
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-10	4.08	7.08	14.50	28.68	9.72	64.06	24.45	11.49	fsl	0.26	0.15	1.80
Bt	10-48	1.65	3.95	7.18	17.58	9.50	39.86	18.99	41.15	cl,c	0.43	0.33	1.64
C	124-225	3.22	6.68	11.10	27.40	15.05	63.45	23.79	12.76	fsl	.	.	.

			Exchangeable cations										
Horizon	Depth	pH	Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.	Organic Matter	Avail. P
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-10	6.05	1.52	0.44	0.30	1.19	0.05	3.45	2.31	65.51	97.84	11.1	2.4
Bt	10-48	5.12	2.76	0.60	0.28	5.35	0.35	8.99	3.99	40.49	91.23	6.1	.
C	124-225	4.95	0.24	0.15	0.18	1.98	1.65	2.55	2.22	22.35	25.68	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-10	10YR5/3	2,gr
Bt	10-48	2.5YR4/8	2,sbk
BC	48-123	2.5YR5/8	1,sbk
C	123-225	7.5YR6/8	0,m

Table 23. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L8-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-15	2.55	7.92	16.55	27.88	9.40	64.30	25.50	10.20	fsl
Bt	15-43	0.58	2.92	8.18	16.75	7.98	36.41	21.29	42.30	c
C	135-225	1.25	5.00	11.52	24.18	11.82	53.77	23.44	22.79	scl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-15	5.90	1.29	0.40	0.32	1.58	0.05	3.59	2.06	55.99	97.57	13.6	2.8
Bt	15-43	5.52	3.00	0.78	0.27	6.34	0.15	10.39	4.20	38.98	96.43	2.9	.
C	135-225	5.03	0.15	0.27	0.28	3.37	2.45	4.07	3.15	17.20	22.22	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	10YR5/3	2,gr
Bt	15-43	2.5YR4/8	2,sbk
BC	43-133	2.5YR4/8	1,sbk
C	133-225	7.5YR6/6	0,m

Table 24. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L8-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-20	2.65	8.22	15.98	24.42	8.78	60.05	30.46	9.49	fsl
Bt	20-58	1.80	5.48	9.48	18.02	7.42	42.20	18.68	39.12	cl,c
C	163-225	0.90	4.75	11.82	28.52	13.82	59.81	19.20	20.99	fsl,cl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-20	6.13	1.44	0.45	0.32	1.78	0.05	3.99	2.26	55.39	97.79	11.4	2.8
Bt	20-58	5.36	3.10	0.85	0.17	5.35	0.45	9.47	4.57	43.51	96.15	2.8	.
C	163-225	5.06	0.37	0.43	0.21	4.75	2.25	5.76	3.26	17.53	30.98	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-20	10YR5/4	2,gr
Bt	20-58	2.5YR4/8	2,sbk
BC	58-160	2.5YR6/8	1,sbk
C	160-225	7.5YR6/8	0,m

Table 25. Physical, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L9-1.

		Sand									Water Content		
Horizon	Depth	Very Coarse	Coarse	Medium	Fine	Very Fine	Total	Silt	Clay	Textural Class	-10kPa	-1500kPa	Bulk Density
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-13	4.22	8.52	15.45	26.22	8.75	63.16	23.38	13.46	fsl	0.22	0.13	1.75
Bt	13-38	3.42	6.65	7.00	10.72	6.45	34.24	18.36	47.40	c	0.44	0.34	1.48
C	97-225	3.88	9.88	14.42	22.02	10.38	60.58	20.86	18.56	fsl,cl	.	.	.

			Exchangeable cations										
Horizon	Depth	pH	Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.	Organic Matter	Avail. P
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-13	5.64	1.11	0.44	0.21	1.19	0.25	2.95	2.01	59.66	87.56	10.9	2.0
Bt	13-38	5.11	1.63	1.32	0.15	7.13	1.85	10.23	4.95	30.30	62.63	5.1	.
C	97-225	4.96	0.03	0.42	0.17	5.94	2.85	6.56	3.47	9.45	17.87	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-13	10YR5/4	2,gr
Bt	13-38	5YR5/8	2,sbk
BC	38-95	2.5YR5/8	1,sbk
C	95-225	5YR5/8	0,m

Table 26. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L9-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-10	4.20	8.55	15.22	26.24	9.26	63.47	23.21	13.32	fsl
Bt	10-51	2.05	4.52	6.52	12.30	6.48	31.87	23.61	44.52	c
C	114-225	1.80	6.10	8.98	19.02	10.22	46.12	27.76	26.12	l,cl,scl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-10	5.52	1.18	0.47	0.17	2.38	0.25	4.20	2.07	43.33	87.92	11.3	1.1
Bt	10-51	5.19	2.16	1.43	0.14	9.50	1.65	13.23	5.38	28.19	69.33	1.2	.
C	114-225	5.11	0.08	0.58	0.38	10.10	2.45	11.14	3.49	9.34	29.80	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-10	10YR5/4	2,gr
Bt	10-50	5YR5/6	2,sbk
BC	50-113	5YR5/6	1,sbk
C	113-225	5YR6/8	0,m

Table 27. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L9-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-10	4.15	8.60	14.70	26.75	9.25	63.45	23.35	13.20	fsl
Bt	10-41	1.68	4.80	8.12	15.32	6.02	35.94	21.70	42.36	c
C	107-225	3.20	8.30	12.22	23.68	11.62	59.02	57.99	17.01	fsl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-10	5.75	1.10	0.41	0.22	1.19	0.15	2.92	1.88	59.25	92.02	10.6	1.6
Bt	10-41	5.14	2.88	0.93	0.12	5.94	0.15	9.87	4.08	39.82	96.32	3.3	.
C	107-225	5.09	0.32	0.63	0.14	2.97	2.45	4.06	3.54	26.85	30.79	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-10	10YR5/4	2,gr
Bt	10-40	5YR5/6	2,sbk
BC	40-105	2.5YR4/8	1,sbk
C	105-225	5YR5/6	0,m

Table 28. Physical, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L10-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class	Water Content		Bulk Density
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total				-10kPa	-1500kPa	
	cm	%									$m^3\ m^{-3}$		$Mg\ m^{-3}$
Ap	0-10	1.70	8.50	17.22	24.85	7.78	60.05	28.68	11.27	fsl	0.22	0.10	1.68
Bt	10-36	5.85	7.32	7.10	12.05	7.40	39.72	23.12	37.16	cl	0.44	0.35	1.67
C	64-225	1.55	8.78	16.40	26.98	11.48	65.19	19.46	15.35	fsl	.	.	.

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-10	5.51	1.18	0.43	0.18	3.56	0.15	5.35	1.94	33.46	92.27	17.4	5.0
Bt	10-36	5.06	2.74	1.43	0.11	7.13	1.45	11.41	5.73	37.51	74.69	3.1	.
C	64-225	5.06	0.13	0.41	0.20	5.54	2.35	6.28	3.09	11.78	23.95	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-10	10YR5/4	2,gr
Bt	10-35	2.5YR5/8	2,sbk
BC	35-63	2.5YR5/8	1,sbk
C	63-225	5YR6/8	0,m

Table 29. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L10-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	2.18	9.15	18.78	26.98	7.75	64.84	21.18	13.98	sl
Bt	18-41	3.30	6.42	6.98	13.43	8.80	38.93	23.23	37.84	cl
C	79-225	7.68	11.98	11.82	18.85	9.50	59.83	27.58	12.59	sl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-18	5.79	0.95	0.35	0.16	3.76	0.15	5.22	1.61	27.97	90.68	13.6	4.4
Bt	18-41	5.27	3.58	1.85	0.10	4.75	0.65	10.28	6.18	53.79	89.48	4.2	.
C	79-225	4.99	0.25	1.12	0.21	6.14	3.75	7.72	5.33	20.47	29.64	.	.

Horizon	Depth	Color	Structure
	cm		
Ap1	0-8	10YR5/4	2,gr
Ap2	8-18	7.5YR5/6	2,gr
Bt	18-40	5YR5/8	2,sbk
BC	40-78	2.5YR5/8	1,sbk
C	78-225	2.5YR5/8	0,m

Table 30. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L10-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-15	3.22	9.30	17.58	27.20	9.68	66.98	18.66	14.36	sl
Bt	15-56	1.88	6.15	7.80	13.68	9.28	38.79	22.23	38.98	cl,c
C	114-225	2.60	7.82	9.58	23.40	15.00	58.40	25.21	16.39	fsl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-15	5.73	1.01	0.42	0.19	3.17	0.15	4.79	1.77	33.82	91.53	11.8	1.8
Bt	15-56	5.09	1.70	1.48	0.10	7.92	2.45	11.20	5.73	29.29	57.24	3.8	.
C	114-225	5.01	0.08	0.98	0.20	8.32	5.35	9.58	6.61	13.15	19.06	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-15	7.5YR6/6	2,gr
Bt	15-55	2.5YR4/8	2,sbk
BC	55-113	2.5YR4/8	1,sbk
C	113-225	2.5YR4/6	0,m

Table 31. Physical, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L11-1.

		Sand									Water Content		
Horizon	Depth	Very Coarse	Coarse	Medium	Fine	Very Fine	Total	Silt	Clay	Textural Class	-10kPa	-1500kPa	Bulk Density
	cm	---------- % ----------									----- $m^3\ m^{-3}$ -----		$Mg\ m^{-3}$
Ap	0-10	3.50	8.05	14.22	22.62	8.95	57.34	24.35	18.31	fsl	0.29	0.16	1.64
Bt	10-43	0.42	2.15	5.75	17.78	10.70	36.80	18.15	45.05	c	0.44	0.35	1.55
C	91-225	0.90	2.25	7.32	30.32	16.00	56.79	38.70	18.09	fsl,scl	.	.	.

			Exchangeable cations										
Horizon	Depth	pH	Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.	Organic Matter	Avail. P
	cm		---------- cmol (+) kg^{-1} ----------							------- % -------		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-10	5.65	1.50	0.58	0.19	3.17	0.10	5.44	2.37	41.73	95.78	12.8	2.0
Bt	10-43	4.97	2.12	0.82	0.18	7.52	1.35	10.64	4.47	29.32	69.80	6.3	.
C	91-225	5.03	0.09	0.27	0.15	5.15	2.35	5.66	2.86	9.01	17.83	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-10	10YR5/4	2,gr
Bt	10-43	2.5YR5/8	2,sbk
BC	43-90	2.5YR5/8	1,sbk
C	90-225	5YR6/8	0,m

Table 32. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L11-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-13	3.50	8.45	15.52	23.98	8.65	60.10	26.64	13.26	fsl
Bt	13-61	1.32	4.60	8.30	14.70	8.72	37.64	23.39	38.97	cl,c
C	91-225	3.42	7.82	10.88	20.42	10.45	52.99	25.87	21.14	fsl,scl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-13	5.66	1.42	0.53	0.19	3.17	0.05	5.31	2.19	40.30	97.72	10.6	2.0
Bt	13-61	4.98	2.45	0.80	0.13	8.12	2.05	11.50	5.43	29.39	62.25	2.3	.
C	91-225	4.77	0.29	0.51	0.17	7.13	3.65	8.10	4.62	11.98	21.00	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-13	10YR5/3	2,gr
Bt	13-60	2.5YR5/8	2,sbk
BC	60-90	5YR5/8	1,sbk
C	90-225	5YR5/8	0,m

Table 33. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L11-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-10	3.62	8.88	16.02	26.52	9.02	64.06	24.53	11.41	fsl
Bt	10-69	1.72	4.08	6.50	11.32	7.15	30.77	26.31	42.92	c
C	112-225	0.28	3.12	12.22	27.72	12.00	55.34	19.51	25.15	scl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-10	6.07	1.31	0.52	0.15	0.59	0.05	2.57	2.03	77.04	97.54	9.9	1.8
Bt	10-69	5.19	3.68	1.25	0.14	8.12	0.55	13.19	5.62	38.44	90.21	2.6	.
C	112-225	5.22	0.28	0.42	0.22	6.14	1.85	7.06	2.77	13.03	33.21	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-10	10YR5/4	2,gr
Bt	10-68	2.5YR5/8	2,sbk
BC	68-110	2.5YR5/8	1,sbk
C	110-225	5YR6/8	0,m

Table 34. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L12-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	5.32	6.98	11.65	13.40	5.34	42.69	25.55	31.76	cl
Bt	18-43	1.30	3.58	7.42	13.40	4.88	30.58	26.96	42.46	c
C	104-225	0.28	4.84	18.32	31.95	11.48	66.87	20.98	12.15	fsl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-18	5.53	2.53	1.21	0.50	7.33	0.35	11.57	4.59	36.65	92.37	21.7	6.0
Bt	18-43	4.70	1.37	1.21	0.16	10.69	3.85	13.43	6.59	20.40	41.58	3.3	.
C	104-225	4.70	0.16	0.63	0.11	9.11	4.85	10.01	5.75	8.99	15.65	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	7.5YR5/4	2,gr
Bt	18-43	5YR5/6	2,sbk
BC	43-103	5YR5/6	1,sbk
C1	103-138	10YR8/1	0,m
C2	138-225	2.5YR5/8	0,m

Table 35. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L12-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	5.50	7.32	10.52	13.48	5.22	42.04	26.07	31.89	cl
Bt	18-48	1.40	3.40	6.98	13.22	5.28	30.28	20.12	49.60	c
C	94-225	0.30	4.88	17.78	32.38	11.65	66.99	20.81	12.20	fsl

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-18	5.24	2.48	1.19	0.41	7.92	0.55	12.00	4.63	34.00	88.12	19.1	5.0
Bt	18-48	5.02	2.03	1.67	0.17	12.28	2.75	16.15	6.62	23.96	58.46	4.8	.
C	94-225	4.76	0.03	0.69	0.15	6.73	3.45	7.60	4.32	11.45	20.14	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	7.5YR5/4	2,gr
Bt	18-48	5YR5/6	2,sbk
BC	48-93	5YR5/6	1,sbk
C	93-225	7.5YR6/8	0,m

Table 36. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L12-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	5.28	7.35	10.88	13.58	4.95	42.04	25.04	32.92	cl
Bt	18-43	1.32	3.62	7.18	13.34	5.00	30.46	13.27	56.27	c
C	99-225	0.32	4.94	17.65	32.36	11.75	67.02	20.78	12.20	fsl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-18	5.29	2.92	1.42	0.41	7.72	0.45	12.47	5.20	38.09	91.35	21.0	4.7
Bt	18-43	4.84	2.06	1.84	0.23	12.47	2.35	16.60	6.48	24.88	63.73	6.3	.
C	99-225	5.04	0.16	0.54	0.18	7.72	2.95	8.60	3.83	10.23	22.98	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	7.5YR5/4	2,gr
Bt	18-43	2.5YR4/8	2,sbk
BC	43-98	2.5YR4/8	1,sbk
C	98-225	7.5YR5/4	0,m

Table 37. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L13-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	5.05	7.76	9.25	15.46	7.34	44.86	25.05	30.09	cl,scl
Bt	18-46	2.15	4.70	5.55	7.98	5.02	25.40	13.27	61.33	c
C	89-225	2.92	8.84	13.58	16.54	12.00	53.88	24.86	21.26	fsl,l,scl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-18	5.18	2.17	1.03	0.42	8.71	0.35	12.33	3.97	29.36	91.41	21.3	3.4
Bt	18-46	4.88	1.46	1.80	0.19	9.70	1.75	13.15	5.20	26.24	66.35	4.2	.
C	89-225	5.14	0.18	0.37	0.12	5.94	1.65	6.61	2.32	10.14	28.88	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	7.5YR4/4	2,gr
Bt	18-45	2.5YR4/6	2,sbk
BC	45-88	2.5YR4/6	1,sbk
C	88-225	7.5YR5/8	0,m

Table 38. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L13-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	4.78	6.85	12.50	17.02	5.90	47.05	17.29	35.66	scl,sc
Bt	18-46	3.66	4.62	5.64	8.34	4.85	27.11	13.42	59.47	c
C	76-225	2.24	8.32	14.04	16.24	11.86	52.70	22.67	24.63	scl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		$g\ kg^{-1}$	$mg\ kg^{-1}$
Ap	0-18	5.47	2.44	1.21	0.39	6.93	0.15	10.97	4.19	36.83	96.42	14.9	3.0
Bt	18-46	4.57	1.90	2.20	0.18	12.08	1.75	16.36	6.03	26.16	70.98	4.8	.
C	76-225	5.00	0.08	0.53	0.16	10.30	2.35	11.07	3.12	6.96	24.68	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	7.5YR4/4	2,gr
Bt	18-45	2.5YR4/4	2,sbk
BC	45-75	5YR5/6	1,sbk
C	75-225	2.5YR4/6	0,m

Table 39. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L13-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	6.62	8.00	12.60	16.65	5.78	49.65	16.21	34.14	scl,sc
Bt	18-36	4.50	4.78	5.65	8.60	4.25	27.78	9.75	62.47	c
C	71-225	1.08	7.22	15.02	17.52	10.56	51.40	20.13	28.47	scl

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-18	5.36	2.16	1.10	0.35	6.14	0.35	9.75	3.96	37.03	91.16	14.8	3.0
Bt	18-36	5.11	2.28	2.10	0.22	10.89	0.35	15.49	4.95	29.70	92.93	5.9	.
C	71-225	4.57	0.18	0.55	0.17	5.74	1.75	6.64	2.65	13.55	33.96	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	7.5YR4/4	2,gr
Bt	18-35	5YR4/6	2,sbk
BC	35-70	5YR5/6	1,sbk
C	70-225	5YR5/6	0,m

Table 40. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L14-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	1.60	3.85	9.56	17.44	11.42	43.87	26.05	30.08	scl,cl
Bt	18-46	4.20	7.65	7.52	12.38	5.80	37.55	20.77	41.68	cl,c
C	122-225	0.85	10.78	16.62	13.80	7.02	49.07	31.54	19.39	l

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-18	5.74	2.09	1.24	0.37	4.75	0.25	8.45	3.95	43.79	93.67	14.7	2.4
Bt	18-46	5.17	1.34	1.71	0.26	7.33	0.75	10.64	4.06	31.11	81.53	2.9	.
C	122-225	4.76	0.34	0.94	0.37	11.68	1.75	13.33	3.40	12.38	48.53	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	7.5YR5/4	2,gr
Bt	18-45	5YR5/6	2,sbk
BC	45-120	5YR5/6	1,sbk
C	120-225	7.5YR5/6	0,m

Table 41. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L14-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	1.11	4.72	12.36	17.76	10.88	46.83	24.75	28.42	scl,cl
Bt	18-46	3.65	6.14	7.72	11.90	6.68	36.09	20.46	43.45	c
C	104-225	0.98	9.45	15.58	14.44	7.62	48.07	34.52	17.41	l

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-18	5.86	2.44	1.27	0.42	3.37	0.05	7.50	4.18	55.07	98.80	12.9	3.0
Bt	18-46	5.00	1.88	1.64	0.28	10.30	1.25	14.10	5.05	26.95	75.25	3.5	.
C	104-225	5.00	0.16	0.43	0.23	6.73	1.95	7.55	2.77	10.86	29.60	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	7.5YR5/4	2,gr
Bt	18-45	5YR5/6	2,sbk
BC	45-103	5YR5/6	1,sbk
C	103-225	7.5YR5/6	0,m

Table 42. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L14-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	1.18	3.34	8.15	16.54	10.20	39.41	31.59	29.00	cl
Bt	18-43	2.22	6.38	7.85	12.80	6.40	35.65	20.17	44.18	c
C	99-225	1.28	11.48	17.45	12.08	7.04	49.33	26.73	23.94	l,scl

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-18	5.98	2.17	1.23	0.50	3.76	0.10	7.66	4.00	50.91	97.50	15.2	3.0
Bt	18-43	5.05	1.38	1.74	0.17	9.31	1.35	12.60	4.64	26.11	70.91	1.0	.
C	99-225	5.32	0.02	0.34	0.12	5.74	1.85	6.22	2.33	7.72	20.60	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	7.5YR5/4	2,gr
Bt	18-43	5YR5/6	2,sbk
BC	43-98	5YR5/6	1,sbk
C	98-225	7.5YR6/8	0,m

Table 43. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L15-1.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	1.81	3.43	8.52	16.36	10.52	40.64	28.56	30.80	cl
Bt	18-41	0.50	2.84	5.33	9.48	5.86	24.01	26.39	49.60	c
C	84-225	6.45	12.08	12.85	16.65	9.55	57.88	25.73	16.39	sl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-18	5.75	2.04	0.99	0.48	5.74	0.10	9.25	3.61	37.95	97.23	12.5	3.0
Bt	18-41	5.10	1.80	2.60	0.19	10.30	1.75	14.89	6.34	30.83	72.40	3.6	.
C	84-225	4.93	0.12	1.32	0.18	5.94	3.95	7.56	5.57	21.43	29.08	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	7.5YR5/4	2,gr
Bt	18-40	5YR5/6	2,sbk
BC	40-83	7.5YR5/6	1,sbk
C	83-225	7.5YR5/6	0,m

Table 44. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L15-2.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	1.30	3.00	8.54	16.24	9.60	38.68	32.91	28.41	l,cl
Bt	18-53	0.52	3.48	7.65	10.42	4.98	27.05	18.56	54.39	c
C	104-225	0.65	3.58	16.28	31.85	9.28	61.64	20.78	17.58	fsl

Horizon	Depth	pH	Exchangeable cations							B.S.	E.B.S.	Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC				
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-18	5.38	1.90	0.87	0.33	4.75	0.20	7.85	3.30	39.49	93.94	11.8	2.5
Bt	18-53	4.91	1.44	1.88	0.24	6.73	1.35	10.29	4.91	34.60	72.51	1.2	.
C	104-225	4.93	0.40	2.20	0.30	12.74	3.85	15.64	6.75	18.54	42.96	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	7.5YR5/4	2,gr
Bt	18-53	7.5YR5/6	2,sbk
BC	53-103	7.5YR6/8	1,sbk
C	103-225	7.5YR7/6	0,m

Table 45. Particle size distributions, chemical and morphological properties of Cecil mapping unit, Lunenburg County, profile L15-3.

Horizon	Depth	Sand						Silt	Clay	Textural Class
		Very Coarse	Coarse	Medium	Fine	Very Fine	Total			
	cm	%								
Ap	0-18	1.60	3.85	9.55	17.45	11.42	43.87	28.14	27.99	l,cl
Bt	18-51	0.42	2.04	7.52	10.80	5.56	26.34	23.66	50.00	c
C	130-225	0.81	11.94	12.46	20.04	8.78	54.03	27.54	18.43	fsl

Horizon	Depth	pH	Exchangeable cations									Organic Matter	Avail. P
			Ca	Mg	K	H	Al	CEC	ECEC	B.S.	E.B.S.		
	cm		cmol (+) kg^{-1}							%		g kg^{-1}	mg kg^{-1}
Ap	0-18	5.73	2.02	0.95	0.34	3.96	0.05	7.27	3.36	45.53	98.51	13.5	3.4
Bt	18-51	4.84	2.00	2.20	0.21	8.91	1.85	13.32	6.26	33.11	70.45	3.2	.
C	130-225	4.79	0.92	3.50	0.23	9.11	3.35	13.76	8.00	33.79	58.12	.	.

Horizon	Depth	Color	Structure
	cm		
Ap	0-18	7.5YR5/4	2,gr
Bt	18-50	7.5YR5/4	2,sbk
BC	50-128	7.5YR5/6	1,sbk
C	128-225	7.5YR6/6	0,m

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