SOIL GENESIS STUDIES OF UPLAND SOILS FORMED IN TRANSPORTED MATERIALS OVERLYING THE VIRGINIA PIEDMONT USING TREND-SURFACE ANALYSES

by

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(ABSTRACT)

Soils overlying residuum on upland divides and interfluves that formed from transported material are common in the Virginia Piedmont. They are thought to occur on the oldest landscapes in the region. A study was initiated in Appomattox County and a small portion of Buckingham County encompassing an area of 238 square miles. The origin, age and characterization of these soils is studied. Mapping units comprised of red subsoil components and mapping units with non-red subsoil components are compared. Trend-surface analysis of the elevations at which they occur and chemical and physical data from twenty-four pedons in Appomattox County are used.

The mapping units contain a complex mixture of taxonomic classifications that encompass pedons with and without palic clay distributions. Wetness due to perched water tables at variable depths also affects classifications.

The red subsoil mapping units tend to occupy the older landscapes. Age estimates are derived from a comparison of trend-surface elevations between the transported soils and the

present-day surface. These comparisons result in age estimates of 0.8 million years to 6.25 million years BP. Therefore, the oldest geomorphic surfaces in the south central Piedmont of Virginia may be estimated as late Pliocene to Miocene age landscapes. These soil materials were deposited through a process of landscape inversion dominated by subsidence and colluviation.

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Chapter 1

Introduction

The Piedmont Province of Virginia has long been recognized as an erosional surface. The soils of this region have been traditionally associated with specific metamorphic, igneous, and sedimentary rock parent material, or transported sediments originating from these rock types. The upland soils have been traditionally identified with divides/interfluves (ridgetop or summit) and shoulder/backslope (sideslope) positions. Soils on traditional depositional surfaces such as footslopes, toeslopes, terraces, and alluvial plains, have been described in terms of the *transported* material from which they have weathered. Such soils have been moved by water (alluvium) and gravity (colluvium) by flowing streams and erosional processes that are evident.

These two primary surfaces (erosional uplands versus depositional lowlands) have been kept seperate by classification because they behave differently for agriculture and urban uses. The dominant characteristic that separates them is their behavior to water movement. The upland residual catenas are normally considered permeable to water infiltration (except for some highly plastic soils derived from mixed mafic and acid rock). The transported soils often have restricted permeability, thus affecting their use and management.

Soil scientists have discovered that this premise is not necessarily correct. Soils with characteristics consistent with the depositional or transported soils have been observed and mapped on the upland landforms. In the past, these upland transported soils were not recognized, or their classification as such, discouraged. They were grouped with a similar morphological residual soil. Recently, they have been recognized and mapped by both soil scientists and geologists.

What is the origin and genesis of these soils? Understanding this can enable prediction of their geographical and geomorphic extent and location. This is necessary for accurate delineation and mapping of these soils.

This thesis will attempt to study the genesis of these soils and their distribution within landscapes, using laboratory pedon sample data and trend-surface analysis. The pedon data will assist in characterizing the physical and chemical aspects of the soils. The trend-surface analysis will predict regional trends for the soils, enabling estimations of age and genesis/origin.

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Chapter 2

Literature Review

Geology

Historic Continental Geology

The present eastern United States is part of the Appalachian orogenic belt (Levin, 1994). The depositional basin that formed this belt during the Paleozoic has shales, limestones, and sandstones to the west and metamorphosed graywackes, volcanics, and siliceous shales intruded by masses of granite to the east. The eastern material now underlies the Blue Ridge and Piedmont Appalachian provinces (Levin, 1994). During the late Paleozoic, this was a great chain of mountains awaiting the approach of Africa for the formation of the continent Pangea. This collision caused the deformation known as the Acadian orogeny. In this case, mountains were pushed up folded, faulted and metamorphosed at extreme heat and pressure. The most intense metamorphism took place nearer to the Blue Ridge than the coast. This began a period of erosion and deposition.

During the Mesozoic, the break-up of the super continent Pangea began. The first episode occurred during the Triassic when volcanism and rifting broached the crust at fault zones. Erosional materials from the Appalachians filled the troughs formed in late Triassic and early Jurassic time, becoming the Newark Group of rocks. These were coarse sediments carried by streams flowing off the highlands to the west of these basins. Lakes formed in some places, while basaltic magma rose from faults and flowed over the sediment. Volcanic ash was deposited over everything.

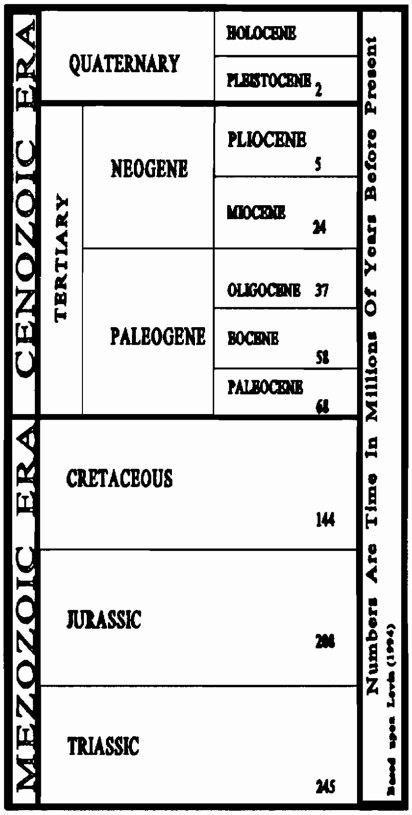


Figure 1. Geologic time scale.

Historic Regional Geology

Fgure 1 shows the geologic time scale as proposed by Levin (1994). There is current debate over the Pleistocene/Pliocene boundary.

During Jurassic and early Cretaceous time, the mountains were further reduced by erosion. The eastern Piedmont geomorphic province was a flat erosional surface. During this time the western part of Virginia, including the Blue Ridge and western sections of the Piedmont, drained to the west (Dietrich, 1990). There has been a westward migration of the Atlantic/Gulf divide since this time and the Atlantic watershed has become larger, in Virginia over this period. The Atlantic Coastal Plain is underlain by Triassic sediments over older crystalline rocks. During Cretaceous time, the coastal areas were flooded by the Atlantic Ocean, probably at least as far west as the Fall Line. The Atlantic Coastal Plain had been eroding since the Mesozoic and began to subside. The Appalachians were elevated, poised for great erosion. Thick deposits of deltaic and marine sediments, which thickened seaward, were laid down. The seas transgressed and regressed until the end of the Miocene. The climate was probably like that of Georgia and Florida today. Late Cretaceous saw the most flooding, to the point where North America was split into two large islands.

Periodic uplift and subsequent erosion and stream intrusion occurred during the Cenozoic. The Coastal Plain gently tilted seaward during this time. Intense soil formation is considered to have occurred during Miocene, as well as cave formation and alluviation (Dietrich, 1990). Much weathering, erosion, and deposition also took place. Upland gravel deposits were laid down during the Pliocene. Beach sands and gravels were deposited in the Pleistocene and during episodes of high sea levels, Coastal Plain terrace formations were laid down.

Geology of the Piedmont

The Piedmont geologic record has been obscured by metamorphism and deformation, such that chronological ordering of the rocks is unclear. The geomorphic provinces of the Blue Ridge and Piedmont do not always coincide with the geologic provinces. There is Piedmont geology in the Blue Ridge geomorphic province and Blue Ridge geology in the Piedmont geomorphic province. The rocks in the Blue Ridge Complex are considered to be the oldest rocks in Virginia. Rocks east of the Blue Ridge Complex geologic unit are younger and were formed from metamorphosed sedimentary and volcanic material (Dietrich, 1990).

Mica schists are very resistant to chemical weathering and, therefore, develop shallow soils. The schists tend to form parent material of many soils in the upland and mountainous areas. Chemical weathering readily decomposes gneisses and gabbros. These rocks produce deep soils which are common in lowlands and basins. Metabasalts, amphibolites, diabase, and ultramafic rocks are also readily weathered by chemical processes. This group of rocks often underlies hilly or mountainous landscapes (Conley, 1985).

Geology of the Study Area

The study area is comprised of Stratified (88%) rocks of the Western Piedmont that occur two and one-half to three miles west of Pamplin and Hixburg and rocks of the Central Virginia Volcanic-Plutonic belt (12%), which occur east of these points. Among those of the Western Piedmont rocks are those of the *Fork Mountain Formation*, which are mica schists, garnetiferous biotite gneisses, and rare white marble. In the Appomattox and Buckingham areas, the predominant rock is yellowish-gray chloritoid-chlorite-muscovite quartzose phyllite and quartz-rich mica schist (Virginia Division of Mineral Resources, 1993). This unit occurs at Piney Mountain in Appomattox County and areas in the western part of the study area. About 29 percent of the area consists of metagraywacke, quartzose schist, and melange. The quartzose mica schists in Buckingham and Appomattox Counties along the western edge of the geologic unit are very similar to the schists in the *Fork Mountain Formation* (Virginia Division of

Mineral Resources, 1993). This occurs in approximately a three to six mile wide band running from Spring Mill in the southwestern part of the study area to Toga in the northeast part. About 25 percent is mapped as interlayered Felsic and Mafic Metavolcanic and Sedimentary rocks, of which approximately eight percent is felsic metatuff, mica schist, and gneiss. This has small interlayering of greenstone, metabasalt, and amphibole gneiss. The remaining 17 percent of this unit contains greenstone or amphibole gneiss with minor interlayers of dacitic metatuff, quartz-muscovite schist, and biotite-muscovite gneiss (Virginia Division of Mineral Resources, 1993). This unit occurs in the central to northwestern part of the study area.

The largest unit within the Volcanic Plutonic belt is the Interlayered Mafic and Felsic Metavolcanic rocks, of which foliated felsite is the primary member. This member contains muscovite-feldspar-quartz schist, gneiss, metatuff, ashflow tuff, mafic gneiss, and felsic gneiss. There are common granitic dikes and sills. Amphibolite, amphibole gneiss and schist, and ferruginous quartzite are common. This occupies the southeastern portion of the study area. Other members are: Amphibolite, hornblende-biotite gneiss and schist, lineated biotite granite gneiss, and plagiogranite. A small component of the Volcanic-Plutonic belt is the *Arvonia Formation*. Two members of this component that occur in the northeast section of the study area are slate and porphyroblastic schist and porphyroblastic garnet-biotite schist (Virginia Division of Mineral Resources, 1993).

The Virginia Piedmont

The Appalachian Piedmont is an old erosional surface or peneplain. It has a gentle rolling topography with occasional occurrences of *monadnocks*, such as Piney Mountain in Appomattox County or Willis Mountain in Buckingham County. These are singular mountains underlain by very weathering-resistant rock. They are often surrounded by an apron of colluvial material that accumulated at the base of their slopes. Fenneman (1938) proposed that the original peneplain was near the top of these *monadnocks*.

In Virginia, the Piedmont Province occupies 16,734 square miles (Brown, 1953). It is about 160 miles wide at the southern state border and about thirty miles wide on the northern border. This province is bordered on the east by the Coastal Plain Physiographic Province and on the west by the Blue Ridge Physiographic Province. Elevations range from about 1,350 feet to 300 feet above sea level (Dietrich, 1990).

Paleoenvironment

From late Cretaceous to early Miocene the climate of the Virginia Piedmont was tropical (Cleaves, 1989). This maintained an environment conducive to chemical weathering, as well as erosional and depositional processes. Piedmont landscapes had subdued relief. The fall zone was not present at that time and the area was capped by sediments. Major rivers were not deeply incised, but occupied courses similar to the present. Easterly and southeasterly river flow have remained relatively unaltered since the late Jurassic to early Cretaceous. The climate changed in late Miocene to one that was favorable for dominantly physical weathering. There have been at least seven major glacial periods in the last 700,000 years. These contrasting climates have created the greatest influence on the shaping of the landscape although the area itself was not glaciated. Alternating freezing, thawing, and snow melt would cause run-off and fluvial erosion. The Pleistocene saw great fluviation and colluviation (Pavich, 1989). Terraces display the release of frost-bound debris during climatic change, such as periglacial times when large sediment loads were deposited (Clark and Ciolkosz, 1988). Glacial advance promoted increased precipitation in the Piedmont. Warmer and drier climates would prevail during interglacial periods (Whitehead and Barghoorn, 1962).

Historic Geomorphology

The general interpretation of the Piedmont surface is that of a peneplain or series of peneplains (Cleaves and Costa, 1979) which are in *"the terminal phase of landscape evolution"* (Wysocki, 1979). Daniels et al. (1978) describe the landscape as being in a process of *"mutual adjustment"* and that relict landforms probably do not exist. Another concept proposes that there can be geomorphic landscape stability under certain parameters (Daniels, et al.,1978). An uneroded surface can remain unaltered for longer than ten million years (Pavich, 1989). Cleaves and Costa (1979) described the Piedmont of Maryland as being *"a landscape in dynamic equilibrium"*. They reported that erosion had been episodic on a surface developed by late Cretaceous and that there were no deposits of marine origin on this surface. According to them, fluvial erosion and recurring uplift were accelerated in the Cretaceous and Miocene.

During late Cretaceous to late Miocene, the Piedmont surface was near sea level with low relief (Cleaves and Costa, 1979). Wysocki (1979) describes this paleosurface as being pre-Miocene to late Miocene in age, with possibly Oligocene age Coastal Plain sediments extending inland over much of it. Saprolite weathered over crystalline rocks is likely to be late Cretaceous to Tertiary in age (Overstreet, et al., 1968). Plaster and Sherwood (1971) felt residual Piedmont soils were Miocene age. Markewich et al. (1990) described the uplands of the Georgia Piedmont as being a Pleistocene landscape with Miocene-Pliocene regolith remnants; *"soils and isotopic data indicate resident times consistent with Pleistocene age for most Piedmont soils."* They define upland divides as being *geographic models* because they are the oldest geomorphic landscapes. These divides control hydrology and sediment supply. The oldest landscapes are covered by Miocene fluvial gravel (Markewich et al.,1990).

Surficial material of different ages unconformably overlies the Piedmont residual soils. Kerr (1881) postulated that some deposits were not of stream origin; he attributed them to frost action during the Pleistocene (Overstreet et al., 1968). King (1949) found *"ancient gravels and sands"* associated with Pleistocene deposits in the Shenandoah Valley of Virginia. Based upon similar strata in Georgia and Alabama found with plant remains, he dated these cappings to be from Tertiary time. The deposits he described did not show signs of mineralization or deep weathering, demonstrating little soil development in Pleistocene or earlier sediments. The occurrence of upland gravels far removed from the Blue Ridge inspired Bloomer and Werner (1955) to postulate a *"peneplain-like erosion surface"* on which *"a mantle of gravel might spread some tens of miles from the source area"*. Parizek and Woodruff (1957) proposed that a *"high percentage"* of Piedmont soils are colluvial rather than residual, as evidenced by stone lines. They suggested many southeastern soils that overlie these stone lines, and had been previously classified as residual, are actually produced by the weathering of colluvial material. Interstream divides in the Coastal Plain are considered to be among the oldest landscapes in the United States. Paleudults and plinthic Paleudults (Soil Survey Staff, 1990)occur on some of these surfaces and are considered to be the oldest soils there. They are derived from Miocene and early Pliocene sediments (Daniels et al.,1978). Pavilides (1980) describes Coastal Plain deposits west of the Fall Line occurring on interfluves. Upland gravels on the Potomac River, near Washington, D.C., are thought to be late Miocene or Pliocene in age (approximately 5 million years) (Reed, 1981). McCracken et al. (1989) date the southern Piedmont's erosional history to at least Cretaceous time. They justify this assumption upon the presence of thin Cretaceous sediments along the Fall Line, as well as remnants of Coastal Plain sediments west of the Fall Line and within the Piedmont. Turbeville soils found on James River terraces near Richmond, Virginia, are considered to be late Tertiary (Miocene) in age (Howard et al., 1992). The James River or its predecessor has been in existence since at least early Miocene. This is demonstrated by gravel casts in Richmond that have a Blue Ridge origin (Howard et al., 1992).

Divides within the Piedmont have scattered areas of gravel. Some are considered to be as old as Cretaceous and Tertiary in the Georgia Piedmont. Periods of alternating deposition and erosion left Cecil soils in Virginia covered with sediment and gravel (Overstreet et al., 1968). Pavich (1985) suggested that some of the outer Piedmont was covered by nonmarine sediments of Cretaceous or younger age. He described Paleocene fluvial material in Georgia and Miocene material overlying the Piedmont near the Fall Line in Virginia. He also proposed that the Piedmont of Maryland and Virginia had sediment cover until late Cenozoic time. Remnant geomorphic depositional surfaces west of the fall zone are approximately 10.8 to 13.0 million years (Miocene) in age (Howard et al.,1992). During the Paleocene, Baker Mountain in

Prince Edward County, Virginia, which is part of the kyanite belt, was exposed and washed down the pre-Appomattox River into a Coastal Plain delta near Petersburg, Virginia. This is evidenced by the presence of glauconite sands in this area. Therefore, upland gravels being deposited in the study area could be this age, Cretaceous, or older (personal communication, Gene Rader, Geologist with the Virginia Division of Mineral Resources, 1993).

Subsidence and Incision

Elevation has been reduced by erosion and incision at an average rate of 27 meters per million years (Pavich, 1985). Pavich (1986) also estimated surface lowering at a rate of 20 meters per million years based upon sediment yields from forested areas. He reported estimated lowering rates

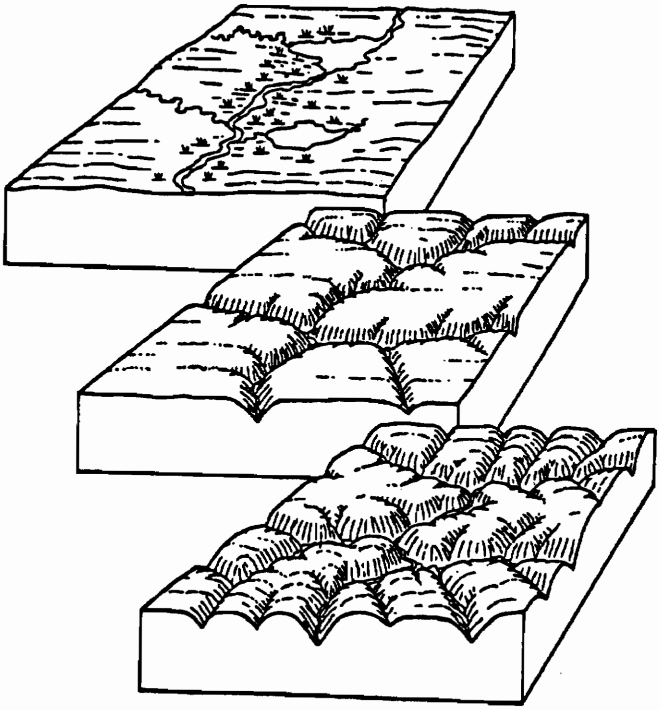


Figure 2. Subsequent incision into a geomorphic surface.

of eight meters per million years as evidenced by the location of Miocene fluvial gravel deposits. Markewich et al. (1990) define surface lowering during the Cenozoic to be about ten meters per million years. The area has also been uplifted at approximately ten to 40 meters per million years since late Cenozoic (Pavich, 1985). Neotectonic activity may have caused the New River to incise more because of uplifting relative to the river. Incision of the New River was estimated at a rate of 40mm to 300mm per 1,000 years (Mills, 1986). Cleaves (1989) describes uplifting of the Piedmont relative to the Coastal Plain along the Fall Line from early Cretaceous to Miocene and possibly as recently as Holocene. Pliocene to Pleistocene regional uplift caused stream "*entrenchment*" into the Miocene surface (Howard, 1978).

Soil Development and Age Estimation

Predictions about soil weathering time are many. Researchers have reported contrasting time frames for this development. Pavich (1986) estimated 12 meters of saprolite can form in three million years and that twelve meters of saprolite can weather to form three meters of soil in about the same period. Howard (1978) proposed that red soils were older than non-red soils. He conjectured that was due to an increase of hematite (red) relative to goethite (red-orange) over time. Mills (1977) postulated that yellowish red B horizons take at least ten thousand years to develop. Red soils with well developed Bt horizons high in clay are older than these non-red soils. The color of soil is related to the hydration state of iron oxides/hydroxides. Soils forming during dry conditions produce the hydrated form of iron which is hematite (red). Humid, temperate climatic conditions, like those of the present, demonstrate themselves in the form of goethite, which forms yellowish-orange soils. The climate under which the soil was deposited can be inferred by these properties (Velbel, 1987). Pavich (1986) reported that reticulate mottling, often found at the discontinuity in transported soils, not only reflects impeded drainage but also degradation of the argillic horizon in old soils. The argillic horizon thickness begins to decrease and B horizon thickness increases in soils older than ten million years (Howard et al., 1992).

Soil Creep and Stone Lines

Formation of cappings has often been attributed to soil creep, but Parizek and Woodruff (1956) found stone lines in areas where there was no evidence of this process. They submitted that soil creep was not necessarily the method by which stone lines occur. However, a year later, Parizek and Woodruff (1957) described carpets of stones or *"carpedoliths"* below summits of interfluves. They ascribed sheet erosion and colluviation (soil creep) as the likely methods to account for the accumulation of overburden above these carpedoliths. Mudflows were considered to be unlikely avenues of formation, as evidenced by the lack of large boulders which can be moved great distances by this process. Rhue (1958) suggested that stone lines occur as a result of a creeping soil mass that detaches the stones from dikes and carries them along at the base of this mass. He also conjectured that these stones may be surface deposits later covered. He described an African scenario in which termites continually carry finer material to the surface while leaving the coarser material below. Stone lines in Georgia were found to slope less than the present surface and were truncated downslope by the present surface. This suggests a flatter geomorphology when they were deposited (Rhue, 1958). Wilson et al. (1983) reported that researchers have speculated stones were initially concentrated by fines being removed through wind, sheet erosion, and frost action. Then during climatic changes, such as times of glacial advances, erosional conditions occur which result in deposition over the stone-covered surface. Stone lines may be found in transported materials or the stones may be found diffused throughout the profile (Wilson et al., 1983). Pavich (1986) reported that soil creep has been estimated on slopes greater than 15 percent, at a .5-6 centimeters depth, to be approximately .5-1 meters per million years. Other research, according to Pavich, indicates creep may occur forty-five centimeters deep. He sites an example in which a rod driven 60 centimeters had moved during seven years. Pavich (1986) concluded that soil creep is at least active to one meter on slopes, but removes very little from uplands.

Colluvium

African *"granite hills"* have colluvium at their base, derived from loamy material upslope that has eroded and crept downslope. A thick red soil forms in this material. At the discontinuity, a *"clinker-like horizon"* composed of *"granitic grit in a black and rusty ferruginous cement"* forms (Rhue, 1960). This same process is common in the Piedmont; waste cover or colluvium occurs at the base of *inselbergs*. This cover can be quite deep, extending to deeper than 100 feet in some places (Kesel, 1974). In areas of the western North Carolina Piedmont, deeply weathered red colluvial soils are considered to be the thickest and best-formed soils in the inner Piedmont. These soils appear to be older than Wisconsin age soils found with wood debris and *"muck"* layers in the same region.

Kessel (1974) suggested chemical weathering to be the dominant force in the rounding of fragments in lieu of transportation processes that would occur over relatively short distances. Material is transported primarily by freeze-thaw action, resulting in mass wasting. Surface wash, tree throw, gullying, and to a small extent, creep, also contribute to colluviation. High intensity, low frequency events promote gullying (Kesel, 1974). The freeze-thaw process implies Pleistocene climatic conditions. Pavich (1986) considered surface wash to be a viable process on the Piedmont as evidenced by surface gravel.

Colluvium can be difficult to distinguish from alluvium. They are formed by similar events; water and gravity transport both. Mills (1977) noted that the colluvium at the base of a slope in South Carolina joined an alluvial area and that it was difficult to distinguish between them. He suggested that gelifluction and frost creep during the Pleistocene may have contributed to the depositional processes. Debris flows and floods during rare catastrophic events were also considered likely means of transport. He estimated an event such as this would occur about once every 500 to 1,000 years. Yet, the soils he observed were well developed and these kinds of events appear to be too frequent to allow this degree of development. The question evolves; is deposition spread out through time or is it concentrated? Mills (1977) postulates that past processes *"now in-active"* may account for these events. The Piedmont is relatively *"insensitive to catastrophic storms"*. This is reflected in the great age of the sediments (Jacobson et al., 1989). Landsliding is uncommon in the Piedmont during storms because the Piedmont saprolite allows infiltration of moisture, thus preventing critical levels of moisture to build up (Jacobson et al., 1989).

Landscape Inversion

"Gully planation" is the result of alternating erosion and colluviation between gullies and nose slopes (Mills, 1981). Material washes into gullies, thus shielding them.

They become more resistant to erosion than adjacent *noses* resulting in their elevating relative to the now eroding nose slopes. The original gully is now a nose slope and the cycle begins again. This concept is the "close-up" view of landscape inversion. Landscape inversion is a common explanation for the formation of these transported soils. Parizek and Woodruff (1957) suggest that these soils may have developed as a result of ancient intermittent stream channels and gullies active during periods of erosion. Howard (1978) proposed that deposits of gravel on wide interstream divides and interfluves were laid down in valleys by meandering or braided streams, associated with alluvial fans. Topography inversion then took place, leaving these deposits stranded on the ridgetops. Whittecar (1985), while making a pipeline transect in northern Virginia, discovered *"stony deposits"* on interfluves filling in shallow narrow channels. He attributed this to inverted landscapes caused by "*armoring*" from quartz pebbles and sand.

Marine Influence

Howard (1978) suggests that marine extension west of the Fall Line is unlikely, due to restrictions imposed by an uplifted Piedmont. The Piedmont's higher elevation provided source material for sediments at the Fall Zone. He proposed that the upland gravels had their origins as colluvium in coalescing alluvial fans. These fans were composed of coarser and less well sorted local materials than river terraces. In contrast, Pavich (1985) described Eocene limestone in Raleigh, North Carolina, at 150 meter elevation, thus demonstrating Tertiary sea level in that area (figure 3). William Henika, geologist with the Virginia Division of Mineral Resources, speculated that these upland non-red cappings may have been deposited in an estuarine environment (personal communication, 1994).

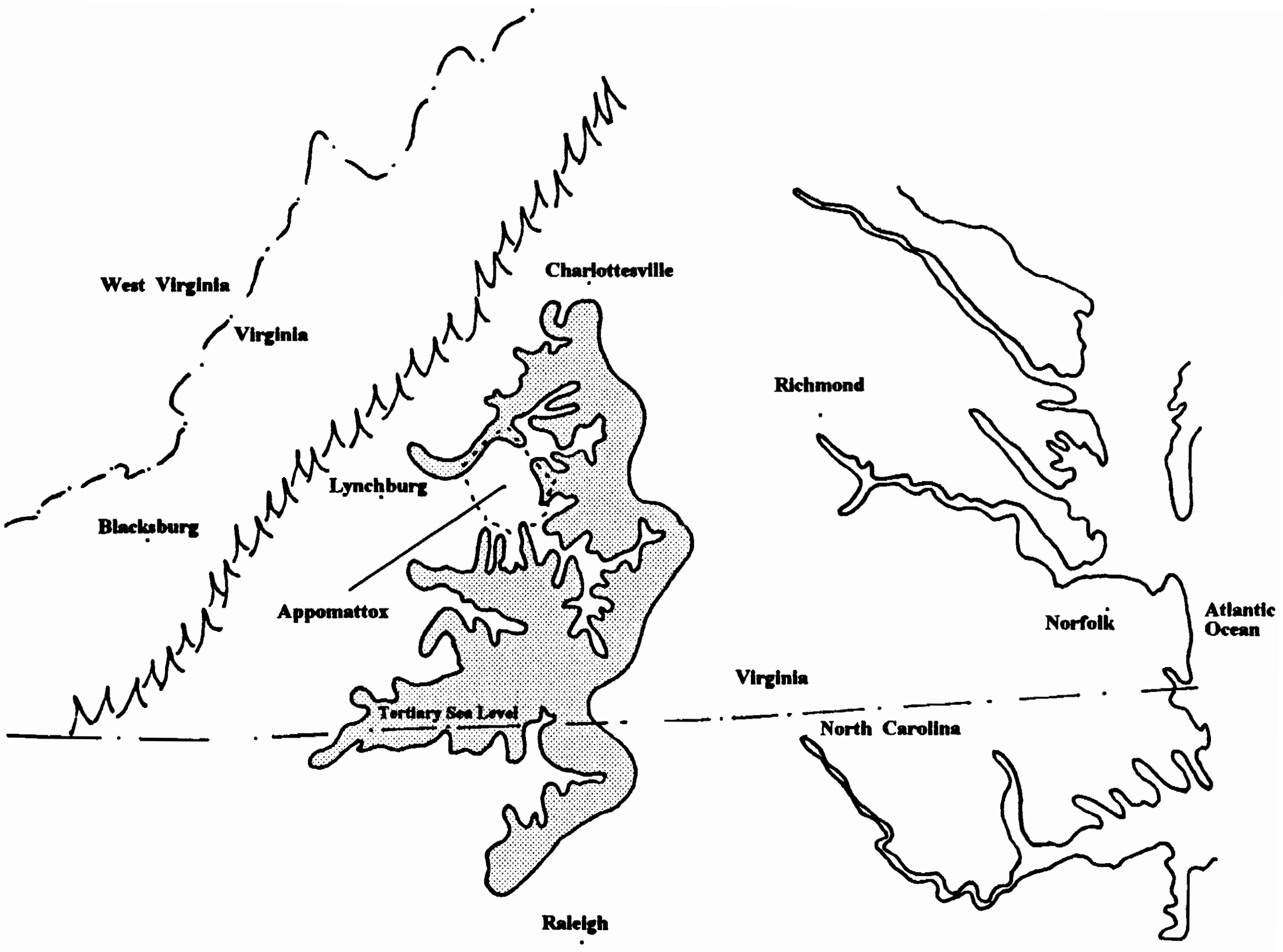


Figure 3. Shaded area represents approximate westward extension of Tertiary sea level (based upon Pavich, 1985).

Past Soil Survey Interpretation

Colluvium and alluvium have been recognized in some form throughout the history of Soil Survey activities. Many early concepts were hypotheses rather than based upon data and their validity may be in question. The 1911 Soil Survey Of Campbell County, Virginia recognized a *Water-worked phase* of the Cecil Soil Series. This soil was recognized by the presence of water rounded cobbles and gravels in the vicinity of the Staunton (Roanoke) River. By 1918, the Pittsylvania County, Virginia Soil Survey was actively mapping stream terrace soils such as the Wickham and Altavista Soil Series. But the upland transported soils were not mapped. The report describes small areas of surface material that is covered with rounded gravel and stones and that this material is thought to have a *"water-laid origin"*. This is qualified by describing the subsoil as being Cecil material. The Altavista Soil Series is described as being the terrace equivalent of the Durham Soil Series (considered to be a residual soil derived from gneiss and granite). Durham is described as having a yellow sandy clay subsoil with red or gray mottles, depending on drainage. It was said to occupy areas of subdued relief.

The Prince Edward County Virginia Soil Survey field work was completed in 1949 and the Nottoway County Virginia Soil Survey was completed in 1954. These counties adjoin one another and had some mappers in common. The Durham Soil Series was described in these counties as being well to moderately well drained with a surface layer thicker than any upland soil in the county. It had a mottled, slightly compact clayey layer beneath which silty textures begin. Today we would describe this as a discontinuity. In the vicinity of the Southern Piedmont Research Station at Blackstone, the map units were predominantly Durham and some Appling. Recently, VA Tech mappers have mapped Coastal Plain soils at this site (personal communication William F. Kitchel who assisted with this mapping). The Colfax Soil Series was also termed a residual soil, yet it was mapped at the heads of intermittent drainageways and on divides between major drains. It was somewhat poorly drained and had a fragipan.

The Orange County Virginia Soil Survey was made between 1959 and 1964. No upland transported soils are recognized. Nason and Tatum are mapped against Spotsylvania County's (approved 1980) Brockroad and Catharpin Soil Series (upland transported soils).

The earliest central Virginia piedmont county soil surveys to recognize and map upland transported soils were

Charlotte County (1963-1968) and Campbell County and City of Lynchburg (1963-1971). The Charlotte County Soil Survey team was resistant to map these soils, but were forced to join with Campbell County (personal communication Jerry C. McDaniel, former party member in Campbell County). The Masada Soil Series was used in the final 1974 publication of the Charlotte County Virginia Soil Survey. The Soil Survey described the Masada soil as occurring in colluvial areas and on terraces along major streams. It was only mapped near Red House against the Campbell County line. The Campbell County and City of Lynchburg, Virginia Soil Survey, published in 1977, recognized the Masada soil series as the upland non-red capping and the Turbeville Soil Series as the upland red capping. Turbeville and Masada were described as being derived from old alluvium that was "higher than, and some distance from, present flood plains" (pg. 45 Campbell County Soil Survey).

Mapping these cappings became more acceptable, although many counties still did not map them consistently. The Lunenburg County Virginia Soil Survey (1972-1977) recognized the Caroline Soil Series as their upland transported soil. This was the first inner piedmont county to describe these types of soils as being fluviomarine in origin.

Development of Mapping Concepts in the Study Area

The Soil Survey Of Appomattox County Virginia was begun in 1982. These transported soils were identified early in the survey. In 1984 a new soil series was set-up to describe the soil associated with the red capping in Appomattox County. The idea of using a river terrace for what appeared to be colluvium was inappropriate. This soil was named Appomattox. It is most often observed on colluvial landscapes or inner-stream divides.

The series used to describe the non-red capping was Mattaponi, which is a soil of fluviomarine origin. It is observed primarily on inner-stream divides and interfluves. During the early stages of the survey, the concept of a Coastal Plain cap best described the genesis of this soil for mapping purposes. The map unit seemed to be extremely variable in its extent over short distances. As a result it was mapped as a complex with a residual soil.

Characteristics of the Appomattox Soil Series

The Appomattox series is classified as: clayey, mixed, thermic Typic Hapludults (Soil Survey, 1988). The series was established in Appomattox County Virginia. When the series was established, ten samples were taken to determine the mineralogy of these soils. Five were found to have oxidic mineralogy, four were found to be kaolinitic and one was mixed. Oxidic mineralogy had been expected due to the extreme age and weathering of the soils. The series was classified as mixed considering it to be an intergrade between kaolinitic and oxidic (unpublished data, Appomattox County Soil Survey).

Appomattox soils are very deep, well drained, and according to the official series description (Soil Survey, 1988) have moderately slow permeability. They are formed in alluvium or colluvium from a mixture of crystalline rocks over residuum. These soils occur on *"summits, saddles, side slopes, foot slopes, and colluvial fans of the southern Piedmont uplands"* (Soil Survey, 1988). They can be found on slopes ranging from 0 to 45 percent but are most commonly observed on 2 to 6 percent slopes.

The series has solum thicknesses ranging from 40 to 60 inches or more. Hard bedrock may be found at depths greater than 72 inches. The thickness of the capping is variable, but ranges from about 3 feet to more than 12 feet. Rock fragments range from 0 to 35 percent in the upper horizons and 0 to 60 percent in the lower part of the subsoil. The C horizon rock fragment content is variable. These fragments normally consist of gravel and cobblestones of igneous and metamorphic rock. Plinthite and *"reticulate/lithochromic features"* are found in the lower part of the subsoil in some pedons (Soil Survey, 1988).

The Appomattox Soil Series has a red or dark red subsoil with hues of 10R or 2.5YR . It characteristically has platy structure in the lower subsoil and perched water tables often extending well above iron and manganese depletions and accumulations (low-chroma mottles) (unpublished data, Appomattox County Soil Survey). This platy structure occurs near and above the discontinuity between the residuum and the overlying transported material. The perched water table is defined as greater than 4 feet from the surface in the official series description.

Soil series that have similar classifications or occur on associated landscapes are many. The following list of soils have similar characteristics to Appomattox, with regard to their genesis: Brockroad, Catharpin, Masada, Mattaponi, Turbeville, and Braddock soils. Brockroad and Catharpin soils series criteria require the discontinuity between the residuum and the capping to occur between 24 inches and 50 inches of the surface. Masada soils have non-red subsoils and occur on alluvial terraces. Mattaponi soils have non-red subsoils. Turbeville soils have palic clay distributions, and occur on alluvial terraces. Braddock soils are defined as mountain colluvium occurring in areas of mesic temperatures (Soil Survey, 1988).

Figure 4. Profile of a pedon representative of the red mapping unit. Note the stone line. This is the Appomattox Series.

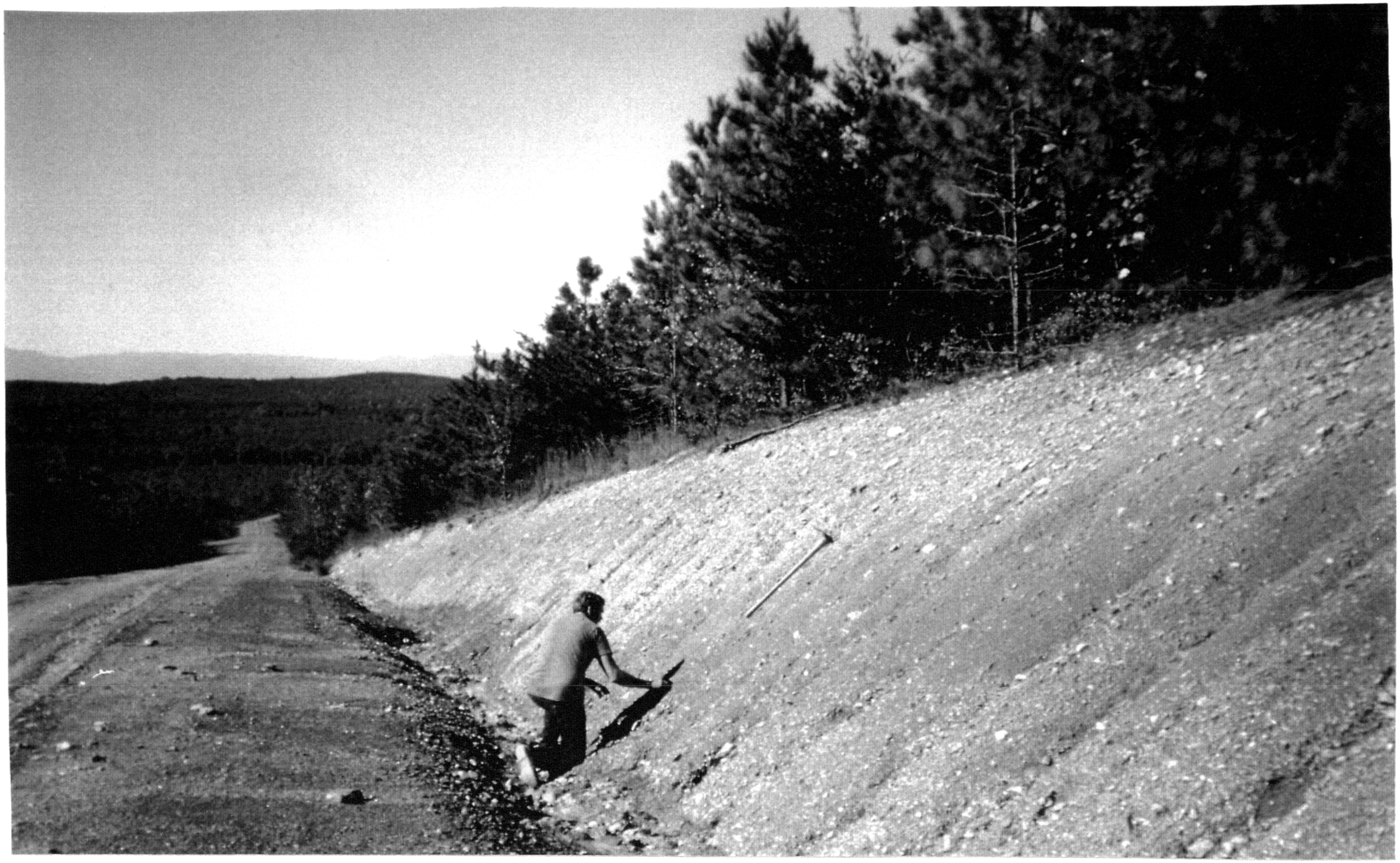


Figure 5. Roadcut in the red mapping unit on a colluvial landscape with the Blue Ridge Mountains to the west in the far background. Subrounded gravel along the roadcut is evidence of colluviation.

Characteristics of the Mattaponi Soil Series

The Mattaponi Soil Series is classified as: clayey, mixed, thermic Typic Hapludults (Soil Survey, 1991). No mineralogical data exists in the survey area but data from other areas indicates some pedons are kaolinitic (one pedon in each Bedford and Pittsylvania Counties) and some are mixed (one pedon in Greensville County and one pedon in Lunenburg County). The series was established in Spotsylvania County Virginia. These soils are very deep and moderately well drained. They have moderately slow permeability. Mattaponi soils are weathered from Coastal Plain sediments and cappings in the Piedmont. They occur on *"convex upland divides"* (Soil Survey, 1991). The range of slope for the series is 0 to 25 percent, with the majority of the units on 2 to 6 percent slopes.

The series has solum thicknesses ranging from 30 to more than 60 inches. There is less than 30 percent silt in the particle size control section. Hard bedrock may be found at depths greater than 60 inches. The thickness of the capping is not defined. Rock fragments consisting of rounded quart gravel range from 0 to 50 percent in the surface horizons, 0 to 35 percent in the subsoil and 0 to 50 percent in the C horizon (Soil Survey, 1991).

The Mattaponi soil series is characterized as having a non-red subsoil dominated by differing shades of brown (hues of 7.5YR through 2.5Y). It has chroma 3 mottles in the upper subsoil with high and low chroma mottles in the lower subsoil (Soil Survey, 1991). Perched water tables occur above the level at which iron and manganese depletions and concentrations are visible (personal observations and unpublished data, Appomattox County Soil Survey). The perched water table is defined to be within 3 feet to 6 feet from the surface(Soil Survey, 1991.

Soil series that have similar classifications or occur on associated landscapes are: Appomattox, Brockroad, Caroline, Catharpin, Emporia, Masada, and Turbeville soils. Appomattox soils have red subsoils. Brockroad and Catharpin soils require the discontinuity between the residuum and the capping to occur between 24 inches and 50 inches of the surface. Masada soils occur on alluvial terraces. Turbeville soils have palic clay distributions, red subsoils, and occur on alluvial terraces. Caroline soils have palic distributions and are well drained. Emporia soils have fine-loamy textural control sections (Soil Survey, 1988 and 1991).

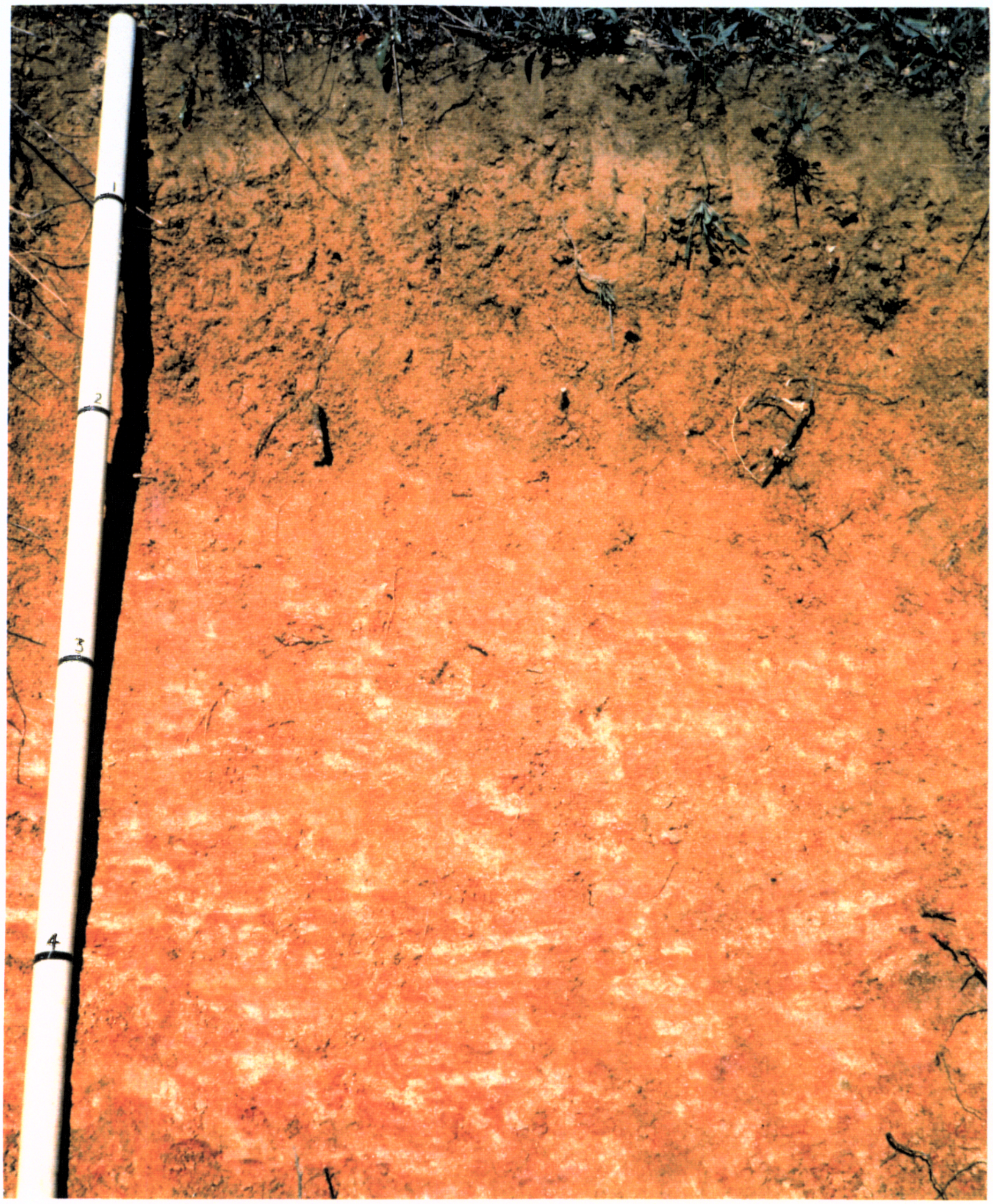


Figure 6. Profile of a pedon representative of the non-red mapping unit. Note reticulate mottling in the lower part of the profile. This is the Mattaponi Series.

Trend Surface

Trend Surface analysis is a method of evaluating change over geographic area. This method can be used to *"support inferences about the nature of physical processes"* (Slaymaker and Church, 1971). Trend Surface analysis was developed before computers emerged in the late fifties and early sixties. It was primarily used for geologic studies. Since then, it has been used to study subjects such as soil pH, extent of glacial effects on landscapes or parent material, census and population data, rainfall, and other climatic information (Unwin, 1975). This method is useful for the study of regional rather than local trends (Robinson, 1982). Regional versus local are relative terms based upon a point of reference. The entire study area may be a ten-acre field, a county or state. The study area is some defined geographic area rather than a given point.

Trend surface analysis evaluates spatially distributed variables as two components, a component associated with regional trends, and one associated with local effects (Unwin, 1975, Davis, 1986). Regression techniques are used to produce a *best-fit surface*. The Trend Surface predicted values are for estimating the regional influence. The local influences that are different from the calculated values are referred to as *residuals*. They are the difference between the observed and predicted values. *Mathematically,*

observed value of surface = trend component at that point + residual at that point

(Unwin, 1975). The *trend component* is the predictable element and the *residuals* are the unpredictable elements that occur randomly over the study area.

To use this method of analysis three values are needed: spatial coordinates (X,Y) of each point and the coordinate of the Z value. The Z value is the variable being studied over a geographic area. Maps are created by plotting contour lines along the coordinates of equal value. There are different rationales for mapping this data, including making predictions of Z values at a given point over the geographic area, or using the map as a model for testing a hypothesis concerning the spatial relationships of the data (Unwin, 1975). This second concept applies in this study, which is the use of Trend Surface analysis to detect potential regional trends in the genesis of these transported soils.

By the method of least squares, an estimate of the population regression parameters (b's) can be made. In the case of a first order trend surface, the equation ($\hat{Y}i$ = bo +

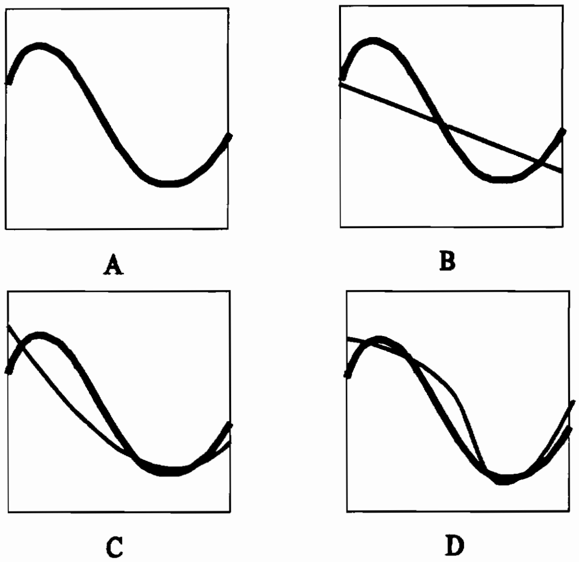
b1X1 + b2X2) is used to define an estimated (□) dependent variable, where (X1) and (X2) are the independent variables. A method is needed to minimize the sum of deviations between (□i) and (Yi) (the actual value). Using regression, a straight line can be fitted to the data, minimizing the deviations. The *goodness-of-fit* is the ratio of the predicted standard deviation to the actual standard deviation. When there is an accurate representation of the data, this figure will be near 1.00. A surface that passes through every data point would have a *goodness-of-fit* of 1.00. The square root of the *goodness-of-fit* is the multiple correlation coefficient (R).

Table 1. Terms to estimate the strength of a trend based upon the *goodness-of-fit* (redrawn from Unwin, 1975).

Goodness-of-fit	Correlation Coeficient	Description
< .04	< 0.2	slight; almost negligible
.04 - .16	0.2 - 0.4	low; definite but small trend
.16 - .49	0.4 - 0.7	moderate - substantial trend
.50 - .80	0.7 - 0.9	high; marked trend
.81 - 1.00	0.9 - 1.0	very marked trend

An ANOVA will give an estimate of the variance in a correct model and will estimate the variance plus the amount of bias if the model is incorrect. Using the regression sum of squares, the ANOVA can determine if the observations are too variable or if the model is incorrect. When using higher order trend surfaces, it is necessary to use curvilinear regression. This allows the trend lines to be curved. A polynomial expansion equation is used to determine the shape of the curve. This equation ($\hat{Y}i = bo + b1Xi + b2Xi^2 + b3Xi^3 + \ldots$), is the summation of integer powers of the independent variable. Adding successive powers allows the original straight line in the first order trend surface to bend. These powers provide the flexibility for the line to more closely represent the data. Should the powers reach (n-1), the line would follow through every data point. The highest power in the equation defines the degree of the equation (i.e., a power of three would be a third degree polynomial). Residuals are the difference between the observed and predicted variables. The residuals should form a uniform band around the regression line without clumping (autocorrelation), indicating a constant variance (homoscedasticity).

A first order surface or first degree polynomial is linear or a straight line. A second order or second degree polynomial is quadratic or a parabola. A third degree polynomial will form a third order surface and is a cubic polynomial. Low order polynomials are usually smooth and follow a median direction with data points falling on either side of the projected surface. The *goodness-of-fit* usually improves slightly with increasingly higher order surfaces (Robinson, 1982).



A is the original line function. B is a first-order trend line fitted to the function. C is the second-order trend line, and D is the fourth-order trend line. Residuals are the difference between the original curve and the computed trend lines. Positive residuals are where the original line is above the computed trend (re-drawn from Robinson, 1982).

Figure 7. Polynomial trend lines fitted to data.

Natural trends are not well represented by first order surfaces due to over simplification by the surface. Higher order surfaces are too influenced by local elements, therefore obscuring the regional trend (Wermund and Jenkins, 1970). Trend Surface analysis is useful for isolating the residual variance from the regional component for further investigation (Slaymaker and Church, 1971).

Three assumptions need to be followed in the distribution of data points when using Trend Surface analysis:

(1) there should be a reasonable number of points

(2) there should be an even distribution of points and

(3) there should be a map strip which is not greatly longer than it is wide (Doveton and Parsley, 1970).

Elongated study areas will result in trend surfaces that may be parallel to this elongation regardless of randomness of the data points (Doveton and Parsley, 1970). The original study area was to be an elongated region extending from Bedford to Pamplin. This area, because of its elongation, was deemed unsuitable and the final boxed-shaped study area was chosen.

This means of analysis can only be used to approximate nature. To assume that natural forces follow patterns that are linear or bounded by polynomials would be an extreme conceptual error. These methods can only hope to approximate the forces of nature, and possibly, our understanding of them.

Significance Testing of the Surface

Although the *goodness-of-fit* may be close to 1.00, is the significance of the trend surface different from zero? An *F-test* can answer this question. If the calculated F from an *F-test* is higher than the F derived from an *F table,* the H_o is rejected. If it is lower, H_o is accepted. H_o or the null hypothesis states that the variance between the two populations is the same and that the trend does not account for variation in the data. The alternate hypothesis, H_1 states that their variances are not the same and that the trend accounts for the variation in the data (Unwin, 1975, Davis, 1986). The *percentage reduction in sum of squares achieved or %RSS* is needed to calculate the F-value. It is derived by multiplying the *goodness-of-fit* by 100(%) (Unwin, 1975).

$$F = \frac{\%\ RSS\ /\ df_1}{(\,100\ -\ \%\,RSS\,)\ /\ df_2}$$

df_1 = Surface degrees of freedom, are equal to the number of constants (Orders = Constants: 1=3, 2=6, 3=10, 4=15) in the trend equation less one.
df_2 = Residual degrees of freedom, are equal to total ($N-1$) degrees of freedom in the data, less df_1.
$df_2 = N - 1 - df_1$
N = Sample size
(Unwin, 1975).

Using the calculated *F*-value in comparison with the *F*-value in an *F*-table at different significance levels will determine whether the trend is statistically significant (Unwin, 1975). If the calculated (observed) value of *F* is higher than the tabulated *F*-value, the trend can be considered to be significant.

Testing the significance of increasing the order of a surface can be achieved by dividing the mean squares due to increasing the surface order by the mean squares due to deviation for the higher order surface. The mean squares due to increasing the surface order is derived by dividing the positive difference between the sum of squares due to regression of the two surfaces by the difference in regression degrees of freedom (Edmonds and Campbell, 1984).

$$F = \frac{\left[\dfrac{\%\, RSS_{\text{higher order surface}} - \%\, RSS_{\text{lower order surface}}}{df_{1\ \text{higher order surface}} - df_{1\ \text{lower order surface}}} \right]}{[(100 - \%\, RSS) / df_2]_{\text{higher order surface}}}$$

Chapter 3

Materials and Methods

Pedon Study

In November 1986, twenty-four pedons of upland transported soils were sampled in Appomattox County. Twelve sites in the non-red mapping units were sampled at random and twelve sites were selected at random within the red mapping units. A United States Department of Agriculture Soil Conservation Service Soil Survey probe truck was used to provide the cores for sampling and morphologic descriptions. Samples were taken for chemical and physical characterization. These sites were located based upon unpublished soil survey maps of the area. When residual soils were encountered, an alternate site was chosen. The cappings are separated from residuum in the field by their sticky consistence and the occurrence of stone lines in some pedons. Indications of permeability impairment such as low chroma mottles and platy structure are also used to identify transported soils. The intent was to characterize the transported material, not residuum.

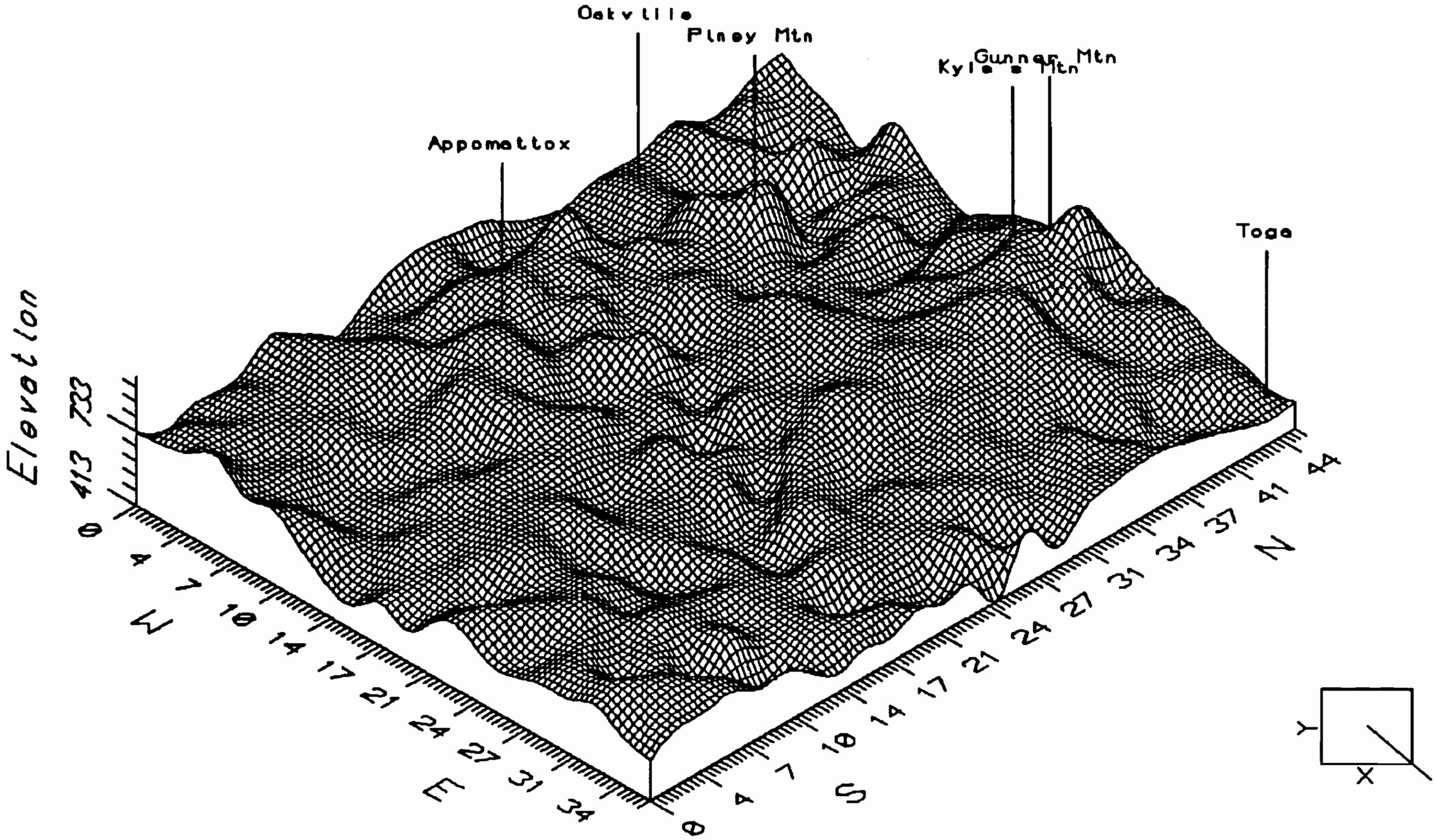


Figure 8. Geomorphology of the study area.

Laboratory Methods

Particle size distribution of the samples was determined by pipette (Gee and Bauder, 1986). Soil pH was determined using a 1:1 soil:water suspension. Extractable acidity, H^+, was determined using the modified $BaCl_2$-triethanolamine method (Peech, 1965). Exchangeable Al was determined by N KCL extraction and titration to pH 7 with 0.1N NaOH (Thomas, 1982). Exchangeable bases (Ca^{2+}, Mg^{2+}, K+) were extracted with 1*M* NH_4OAc, pH 7.0 and measured by atomic absorption spectrophotometry. Cation exchange capacity (Effective CEC) is calculated by the summation of exchangeable bases and exchangeable Al. Using Al (which is normally measured at pH = 7) will better estimate the CEC or *Effective* CEC. For the purposes of this study, Effective CEC will be discussed. Percent base saturation is calculated by the sum of basic cations divided by CEC or Effective CEC.

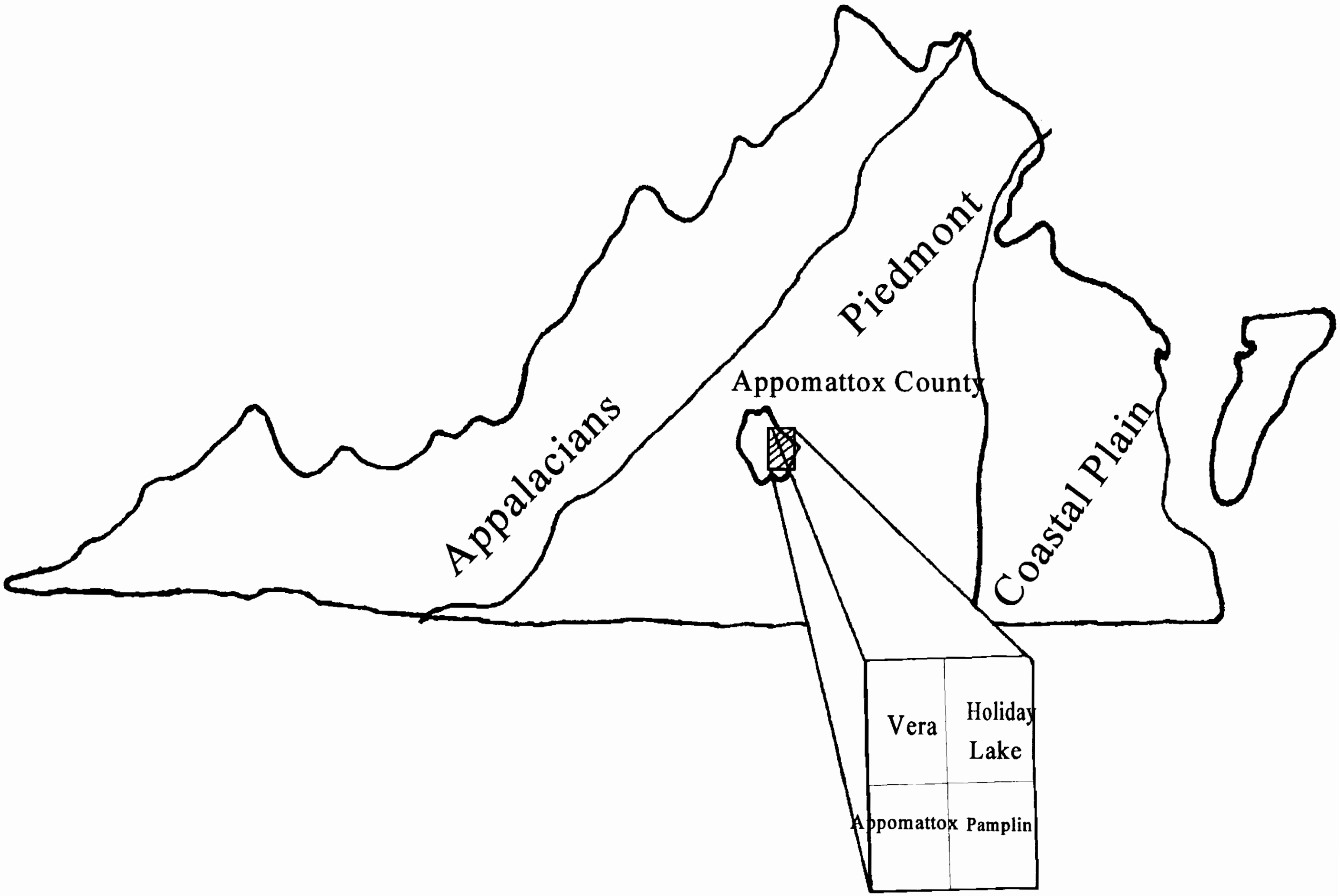


Figure 9. Location of the study area

Trend-Surface Analysis

Soil map units of transported soils were examined in Appomattox and Buckingham Counties. Data was collected from unpublished mapping for the Soil Surveys of these two counties. Buckingham County is presently being mapped at a scale of 1:24,000; Appomattox was mapped at a scale of 1:15,840. Both survey areas have the same soil series and similar map units. They were mapped by William F. Kitchel and the author. Four percent of the study area extended into Prince Edward County, but these soils were not recognized in that county when it was mapped, therefore, no data exists for this small portion of the region. Buckingham County encompasses eleven percent and Appomattox County eighty-five percent. There are 238 square miles in the study area.

Mapping units comprising the Appomattox Soil Series and the Mattaponi Soil Series were identified and delineated on 1:24,000 USGS 7.5 minute topographic quadrangles. Four quadrangles were used: Appomattox, Holiday Lake, Pamplin, and Vera. Elevations were taken from each unit to represent the generally highest point within that unit. Promontories or unusual lone *high* or *low* areas were not used as representative elevations. Each map unit was classified based upon the general color of the Bt horizon (red versus non-red) and its landscape position (colluvial versus interfluve). Map units in which the landscape position was unclear were classified both ways.

Trend-surface analysis was used to predict surfaces for each of these four categories as well as all the units combined. First-degree through fourth-degree surfaces were generated for each of the five groups. The study area was digitized with points taken at least at one inch intervals square. The same trend-surfaces were calculated for this *actual* surface for comparison.

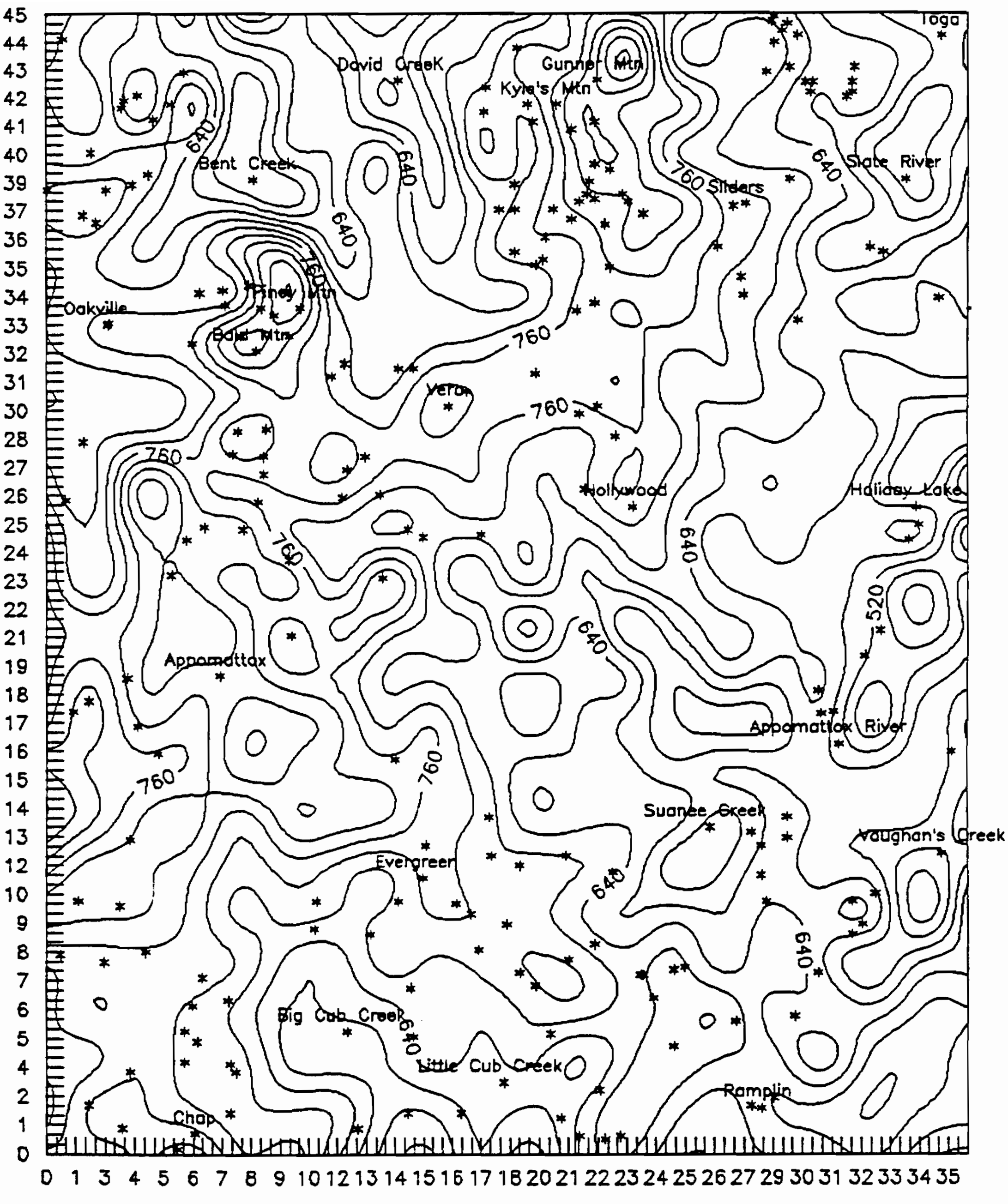


Figure 10. Distribution of data points in the study area.

Chapter 4

Results and Discussion

Pedon Study

Statistical summaries of the percent sand, percent silt, and percent clay in the Ap, upper Bt, and lower Bt horizons are given in table three for the non-red mapping units and table four for the red mapping units. Statistical summaries of chemical properties of the non-red mapping unit are given in table five and chemical property summaries for the red mapping unit are given in table six. Statistical summaries of capping thickness are given in the following table:

Table 2. Statistical summary of capping thickness.

Statistical Summary of Capping Thickness (in.)				
	Mean	**Max**	**Min**	***S***
Non-Red Mapping Units	56.3	73	44	10.1
Red Mapping Units	48.4	90	30	16.5

These tables include the mean, maximum, minimum, and standard deviation of the data. Chemical and physical data for each pedon are in individual tables in Appendix A. Full pedon descriptions are also located in Appendix A. Summaries for pedon classifications are listed in tables seven and eight. These classifications are done without consideration for the kandic versus haplic issue. Virginia is thought to be on the border between these two classifications. Samples may fit either, depending upon laboratory techniques. As a result, the Cooperative Soil Survey in Virginia is not currently recognizing Kandic soils. For the purpose of making comparisons, this paper will follow this trend as well.

Four of the twelve sites selected in the areas of non-red soils were red. Therefore, the descriptions and data for these four sites are included with the red mapping units. All pedons classified as clayey udults. Mixed mineralogy and thermic temperature regime are assumed for comparison purposes.

The red soils separated into two classifications, Paleudults (9) versus Hapludults (7). The Turbeville Soil Series has a palic clay distribution and does not allow a discontinuity above residuum. Catharpin and Appomattox soils are Typic Hapludults. Catharpin soils require the discontinuity between the capping and the residuum to be between 24 and 50 inches. Appomattox soils call for the discontinuity to be greater than three feet. Appomattox soils do not allow residual horizons unless they are C horizons, whereas, Catharpin soils allow both 2C and 2Bt horizons. The mapping unit was ultimately named Appomattox because it spanned these three concepts with regard to capping thickness.

The non-red mapping units are more complex. They are comprised of Paleudults (3) versus Hapludults (5), as well as the aquic subgroup (3) versus the typic subgroup (5). The unit was ultimately named Mattaponi. Mattaponi encompasses some parts of each the aquic and typic classifications. The palic clay distributions found in three of the pedons is not addressed by this soil series. For most use and management practices, water tables are the limiting variables.

Thickness of the capping is similar between the red and non-red units. Percent base saturation is also similar between the units. Utilizing a *t*-test comparing two independent sample means from different populations, there is 95 percent confidence that statistically the sand and clay content of the Ap horizons are different between the two mapping units. This implies that there may be more sand in the Ap of the non-red units and more clay in the red units. The greater clay content in the red mapping unit's Ap horizon suggests greater age due to intense weathering of sand to clay. There was no significant difference between any other chemical or physical data in the following summary tables.

Table 3. Statistical summary of physical properties of the non-red mapping units.

Statistical Summary of Physical Data												
Non-Red Mapping Units												
	Percent Sand				Percent Silt				Percent Clay			
	$\bar{X}$	Max	Min	S_{Dev}	$\bar{X}$	Max	Min	S_{Dev}	$\bar{X}$	Max	Min	S_{Dev}
Ap	57.01	71.9	44.4	9.81	32.1	43.3	19.9	7.58	10.9	16.4	5.4	03.48
Bt	33.27	59.3	9	13	16.9	30.6	8.1	5.41	49.8	74.3	24.7	12.58

Table 4. Statistical summary of physical properties of the red mapping units.

Statistical Summary of Physical Data												
Red Mapping Units												
	Percent Sand				Percent Silt				Percent Clay			
	$\overline{X}$	Max	Min	S_{Dev}	$\overline{X}$	Max	Min	S_{Dev}	$\overline{X}$	Max	Min	S_{Dev}
Ap	47.08	61.7	19.4	9.99	35.7	75.6	21.5	11.8	17.2	32.5	5	06.74
Bt	25.35	42.5	10.5	9.16	19.4	34	10.5	5.82	55.2	77	29.7	12.11

Table 5. Statistical summary of chemical properties of the non-red mapping units.

Statistical Summary of Chemical Data								
Non-Red Mapping Units								
	Percent Base Saturation				Percent Effective Base Saturation			
	$\bar{X}$	Max	Min	S_{Dev}	$\bar{X}$	Max	Min	S_{Dev}
Ap	26.85	64.22	4.76	20.77	57.74	98.63	12.62	33.74
Upper Bt	19.26	57.97	4.91	15.74	41.49	79.45	12.4	20.86
Lower Bt	8.48	40.03	1.12	10.87	21.45	98.4	2.5	26.54
Residuum	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 6. Statistical summary of chemical properties of the red mapping units.

Statistical Summary of Chemical Data								
Red Mapping Units								
	Percent Base Saturation				Percent Effective Base Saturation			
	$\bar{X}$	Max	Min	S_{Dev}	$\bar{X}$	Max	Min	S_{Dev}
Ap	21.61	64.07	1.41	19.11	52.17	98.76	6.25	35.6
Upper Bt	18.93	37.45	5.1	10.03	48.99	98.85	14.54	26.24
Lower Bt	5.92	9.84	1.16	2.84	17.66	38.14	2.11	12.27
Residuum	2.61	6.75	0.85	1.65	9.49	36.17	1.76	8.79

Table 7. Summary of pedon classifications for the red mapping units.

Summary of Pedon (16) Classifications for the Red Mapping Unit			
%	**Classification**	**%**	**Series**
44.0	Clayey, mixed, thermic Typic Paleudults	44.0	Turbeville
56.0	Clayey, mixed, thermic Typic Hapludults	37.0	Catharpin
		19.0	Appomattox

Table 8. Summary of pedon classifications for the non-red mapping units.

Summary of Pedon (8) Classifications for the Non-Red Mapping Unit			
%	**Classification**	**%**	**Series**
25.0	Clayey, mixed, thermic Typic Paleudults	25	Caroline
37.5	Clayey, mixed, thermic Typic Hapludults	25	Masada
		13	Brockroad
25	Clayey, mixed, thermic Aquic Hapludults	25	Dogue
12.5	Clayey, mixed, thermic Aquic Paleudults	13	Ackwater

Trend-Surface Analysis

There were 193 mapping units delineated. Within these 193 units, 42 were classified as occurring on interfluves (and divides), 165 on colluvial landscapes, 85 were non-red, and 108 were red. There are 11.9 square miles (5 percent) of transported soils delineated in this area. The average mapping unit is 40 acres with a minimum of 2.6 acres and a maximum of 1,200 acres. The average elevation is 737 feet with a minimum of 570 feet and a maximum of 980 feet.

Trend-surface analysis was used to study the origin of these soils. Table B.2 is a summary of the *F-test* calculations for each surface found to be significant (H_o rejected). The trend-surfaces might be viewed as representative of a paleolandscape that existed during the depositional period that provided the parent material for the formation of these soils. Increasingly higher order surfaces may represent increasing direction toward a landscape similar to the present. All the significant surfaces (*F*-test) are discussed in the following section whether or not increasing the surface order showed a significant increase in regression over the previous surface (table 9). It is the conjecture of this thesis that these trend-surfaces may reflect a geomorphic model in which the lower order surfaces represent an older peneplain that evolves forward in time with increasing surface order. This concept suggests greater dissection of this plain with increasingly higher order surfaces. A close study of the residuals and the trend-surfaces reveals a possible landscape genesis at specific locations within the study region.

The second-degree trend-surface seems to be the best fit for the observed values for all data points, suggesting overall regional influences on the development of these soils. This second-degree surface seems to be best suited for the colluvial landscapes as well. The interfluve landscapes are best represented by the fourth-degree trend-surface, suggesting local influences as the controlling factor on the evolution of these terrains. The fourth-degree trend surface is the best fit for the non-red mapping units reflecting local effects as the dominant influence. The red mapping units are best represented by a third-degree trend-surface. The R^2 is low and the deviations do not seem to reflect local effects.

The following discussion is subdivided by surface order and suggests observations that may reveal the evolution of these landscapes. This interpretation of these surfaces is different from that which is normally recorded in the literature, but may provide another method of landscape analysis.

Table 9. *F* value and significance for increasing the degree of the polynomial trend-surface equation.

Data	Increase	*F* value	$\alpha(F)$
All Data Points	1 to 2	25.55	<0.001
All Data Points	2 to 3	1.33	>0.01
Colluvium	1 to 2	24.08	<0.001
Colluvium	2 to 3	0.586	>0.01
Interfluves	2 to 3	10.62	<0.001
Interfluves	3 to 4	26.54	<0.001
Non-Red	1 to 2	16.15	<0.001
Non-Red	2 to 3	7.66	<0.001
Non-Red	3 to 4	31.69	<0.001
Red	2 to 3	2.39	<0.05

First-Degree Surfaces

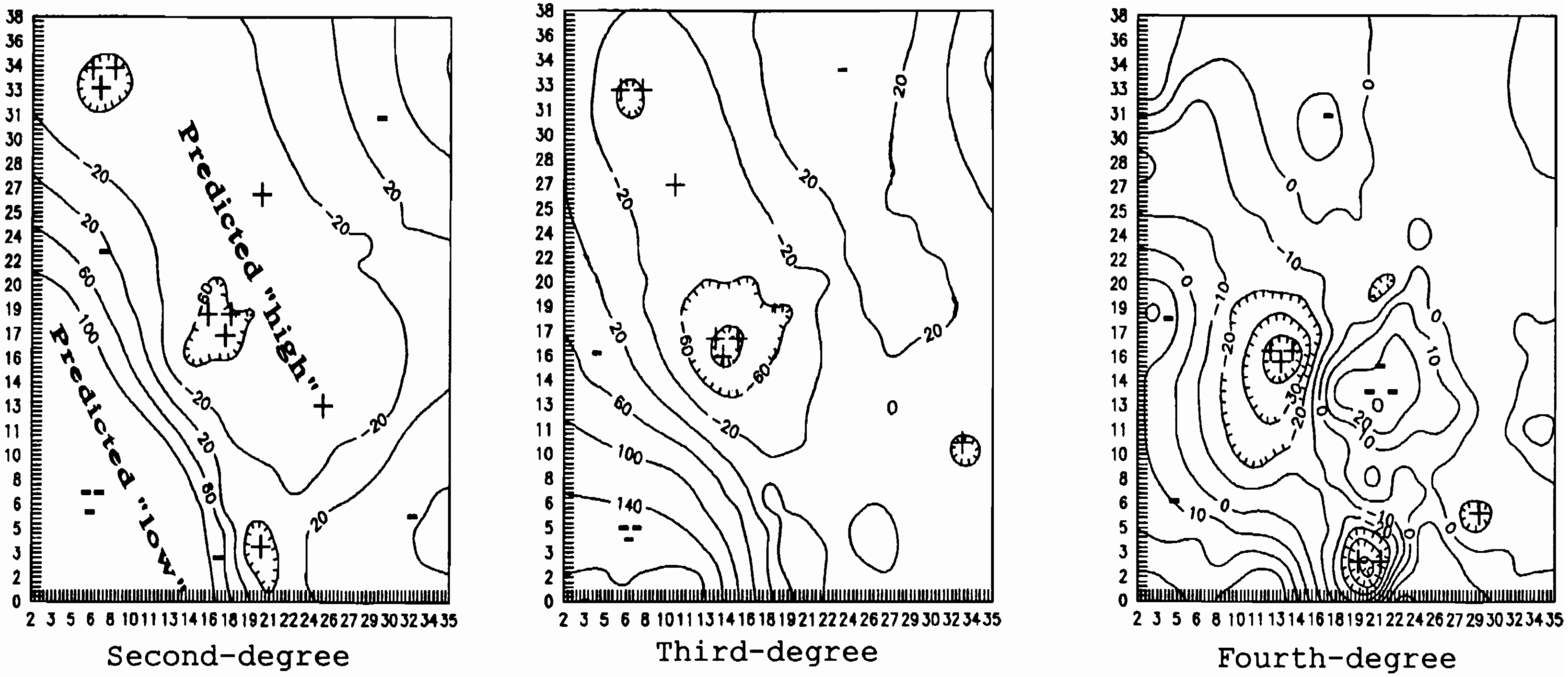
First-degree trend-surfaces of the interfluve and non-red mapping units were not significant at a 90 percent confidence level. The other surfaces (all units combined, colluvial, and non-red) trended in the same general direction as the actual surface, northwest to southeast. The predicted surfaces of the transported soils are 40 to 70 feet higher than the predicted actual surface. This demonstrates the regional lowering of the surface since deposition.

The Kyles and Gunner Mountain areas are predicted lower than they actually occur. The resistant schists that form these mountains have kept them and their surrounding apron of transported material elevated relative to the subsiding nearby landscape. The residual maps indicate the capping in this area to be approximately 80 feet above the peneplain type surface that is predicted most accurately (zero residual values). This corroborates the subsidence estimate (40 to 70 feet) previously discussed.

Areas surrounding present day Bent and David Creeks are predicted higher (low residual values) than they presently occur. An explanation might hypothesize that these areas have been lowered by continued incision by the creeks and their drainage and that the deposition of the transported material pre-dates these drainages. This trend also occurs in the area of the town of Appomattox. A similar explanation would ascribe down-cutting by the Appomattox and Falling Rivers as well as the Cub Creek watershed. Deposition of the transported material might also pre-date these drainage systems.

Second-Degree Surfaces

All the second-degree trend surfaces show a major ridge running north to south. This is consistent with the predicted actual surface. The predicted elevations of the transported soils relative to the predicted actual surface ranges from 20 feet higher (colluvium) at Pamplin to 150 feet higher (interfluves) at Vera. The interfluve landscape has been lowered the greatest amount relative to the predicted actual surface and the colluvial landscape the least. The greater subsidence has occurred near Vera. The smaller surface lowering has occurred near the Pamplin area. The difference between the predicted actual surface and the predicted capping surface for any given classification varies dramatically across the study area, indicating different degrees of lowering for different landscapes at any given location.



Second-degree

Third-degree

Fourth-degree

Figure 11. Progression of residual plots of the interfluve landscape.

Continued incision by drainage systems is demonstrated by low residuals in these areas. High residual values (low predicted surface) seem to occur not only in the area of resistant ridges but also on toe positions; this may indicate depositional processes taking place on these landscapes. The surface in these areas is predicted lower than it actually occurs. There is not a resistant ridge or small mountain present, therefore, the position may have been filled and elevated. Colluvial and interfluve landscapes, as well as non-red, soils show these high residual areas near Chap and Pamplin. This also agrees with the smaller amount of lowering relative to the predicted actual surface mentioned earlier in this section. The residual map (figure 11) shows a ridge that may have colluviated onto a surface in the Pamplin area for all predicted (capping) surfaces. The red soil residuals are low in these areas, demonstrating a possible genetic difference.

There is clear influence by the Appomattox River on this surface. The colluvial surface is less affected by the river than the interfluve landscape. Interfluves are likely more affected by regional influences, whereas colluvium may be locally derived.

Third-Degree Surfaces

The same north-south running ridge is evident on these surfaces. The capping trend-surfaces range from 20 feet lower (colluvium) at Pamplin to 180 feet higher (non-red soils) at Chap than the predicted actual surface. The interfluves have a predicted surface that is about the same as the predicted actual surface at Chap, 80 feet higher at Vera, and 40 feet higher at Pamplin. This may indicate relative age of these units. The higher the capping's predicted surface relative to the predicted actual surface, the older the landscape.

A graphical representation (figure 12) of this concept where zero is the elevation of the actual predicted surface, shows the third-degree trend surface of non-red soils in the Vera area to be on the oldest landform. In the vicinity of Chap the non-red units are again on the oldest landscapes. The colluvial landscapes in Pamplin are actually predicted as lower than the predicted actual surface. This implies that colluvium in that area is younger than the present landform and that it is derived from recent localized material.

The residuals for the non-red soils indicate the erosion of a high ridge in an area primarily between Appomattox and

Vera that colluviated into a fan in the Chap area. The vicinity near Chap likely took the most material, filling in a drainage system as indicated by the high residual values.

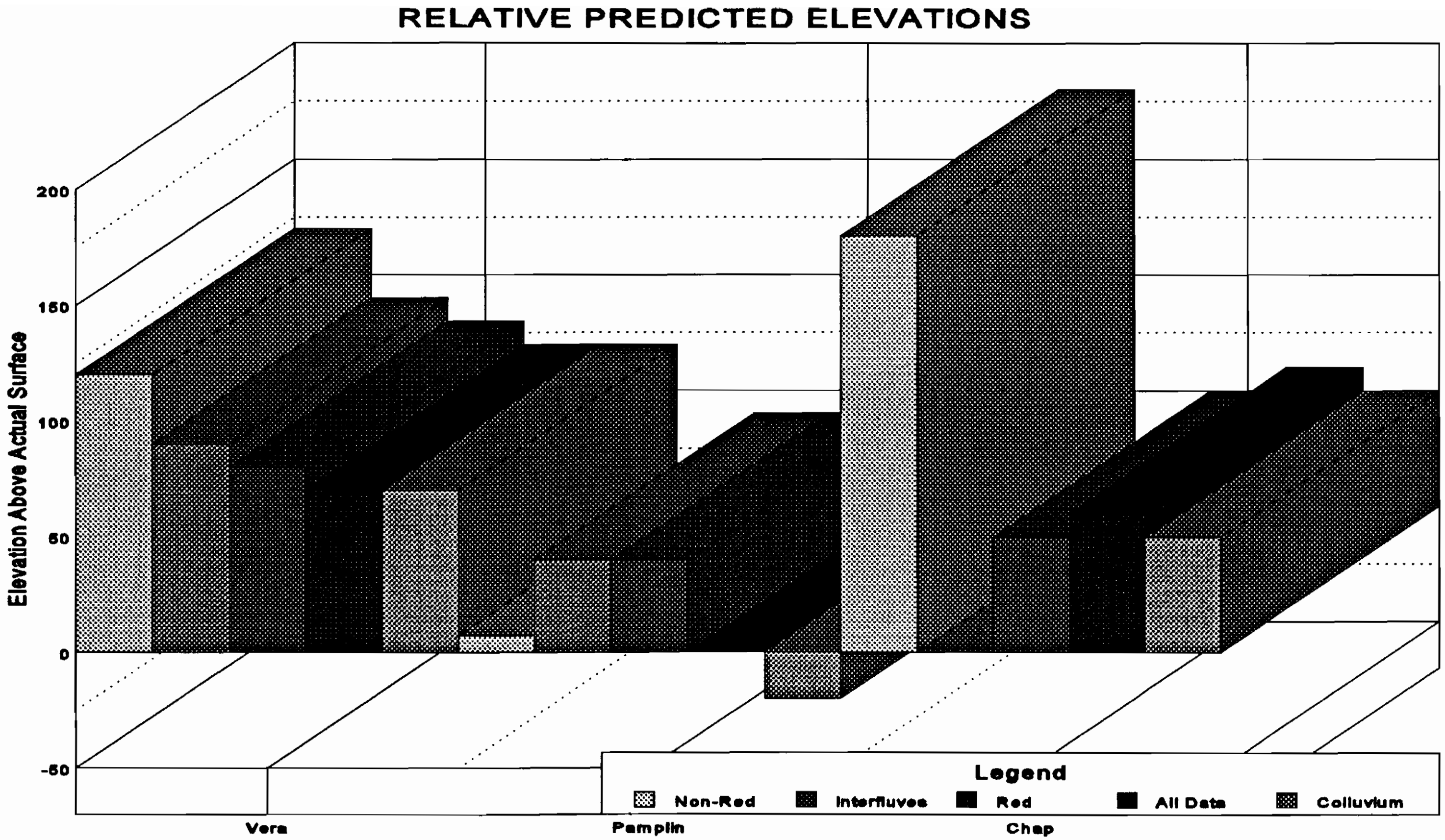


Figure 12. Relative predicted elevations of a third-degree surface.

This fan shielded the landscape while surrounding areas eroded and subsided (or inverted), leaving the capping on a higher landscape than previously existed.

The interfluve residual map (figure 11) shows stabilization of the plain around Pamplin that had been colluviated upon in the second-degree surface. These maps may represent a surface that progresses forward in time with increasing surface order, resulting in a time elapse scenario thatn can be visualized. Ridges recede and diminish as low areas fill and remain mostly unchanged relative to the lowering ridges. The residual map of colluvium shows this area still actively receiving material as demonstrated by high residuals from Pamplin eastward and low residuals from Pamplin northwestward. This is corroborated by the relative ages of the landscapes.

Fourth-Degree Surfaces

The linear north-south trending ridge visible on the lower order surfaces has degraded to a series of individual

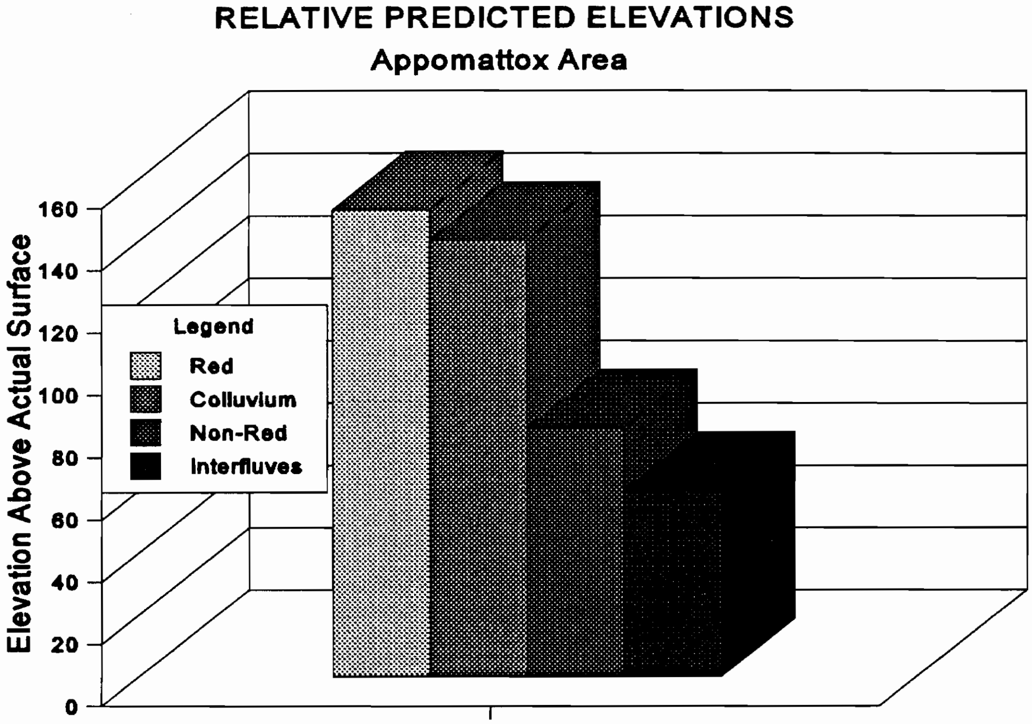


Figure 13. Relative Predicted Elevations.

ridges and promontories on the fourth-degree surface. Figure 11 demonstrates the recession of this ridge using residual maps. Red soils and colluvium occupy the predicted highest and, therefore, potentially oldest landforms in the Appomattox area (figure 13). The interfluve position and non-red soils are predicted to be upon a lower landscape, suggesting different periods of deposition. In this area of the county, interfluve landforms tend to be dominated by non-red soils and the colluvial landforms are usually capped by red soils. This same relative positioning occurs in a region between Sliders and Kyles/Gunner mountain.

The difference between the capping surfaces and the actual surface is less in this area than around Appomattox, suggesting less subsidence. The greater lowering near Appomattox may be explained by the continued incision by the Appomattox River, Big Cub Creek, and Falling River drainage systems. The geology of this area is less resistant to weathering due to the occurrence of interlayered Felsic and Mafic Metavolcanic and Sedimentary rocks surrounding a resistant ridge of *Fork Mountain Formation* schists (Virginia Division of Mineral Resources, 1993). These watersheds encroach toward the divide that occurs on this formation at Appomattox. The unyielding of the Kyle's Mountain area to subsidence is likley due to the resistant quartz-rich schists (resembling *Fork Mountain Formation* type rocks) that dominate the entire area (Virginia Division of Mineral Resources, 1993). The red units may dominate these areas due to the age of the subsidence-resistant landscapes. The red map units may occur as a result of longer weathering times on these old and stable surfaces.

In the vicinity of Big Cub Creek, colluvium and interfluves are the predicted highest landforms, followed by red soils and finally non-red soils. The greatest predicted subsidence has occurred here with a range of 100 to 160 feet. The predicted high surface in this area is located in the present drainage system of Big Cub Creek. The incision into

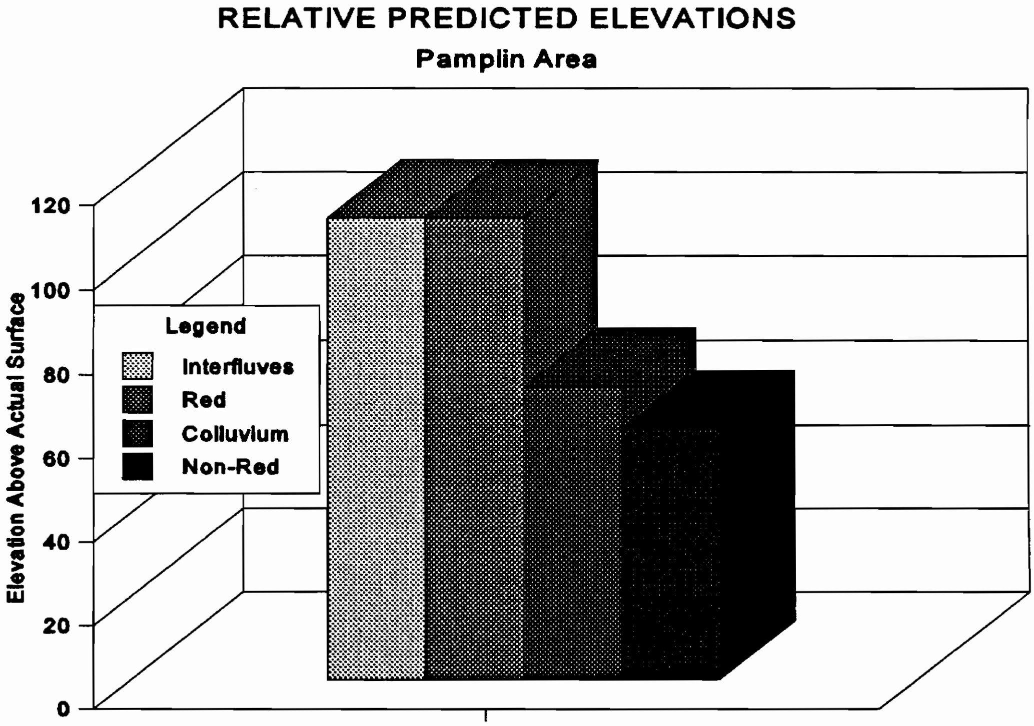


Figure 14. Relative Predicted Elevations.

the present-day surface by the creek would have drastically lowered it relative to the surrounding landscape. In the Pamplin proximity, the interfluve position and red soils occupy the highest landscape and potentially the oldest landform (figure 14). As in the third-degree surface, the predicted trend of the colluvial and non-red soils occupies the lowest relative position. This indicates younger soils on these landscapes. The interfluves may have formed from large colluvial fan deposits originating from the west (mentioned in the second-degree discussion). These deposits have since (higher order surfaces) begun to colluviate themselves onto localized terrains. The third-degree surface showed the colluvium and non-red soils to be at or lower than the predicted actual surface, whereas the fourth-degree surface displays them relatively higher. Conclusions may be drawn that the colluviating of the third-degree interfluve surface lowered itself and, in effect, raised the non-red colluvium relative to it. This is indicated on the fourth-degree trend.

Chapter 5

Summary, Conclusions and Recommendations

Pedon Study

Classification Recommendations

Defining the non-red mapping units in terms of Soil Taxonomy, implies a continuity to the units that is unrealistic in the study area. There are too many taxonomic classifications upon the same landscape, i.e., Typic/Aquic Paleudults/Hapludults. Not only are these classification parameters in question with regard to the cappings, but the soils also occur intermingled with residual soils. In order to define a landscape draped with these soils, a soil complex recognizing a residual soil and a transported soil will likely serve the task best. The transported soil series selected to represent as many of these recognized properties as possible is the Mattaponi Soil Series. It encompasses the potential wetness as well as an allowed, but not required, discontinuity. The palic clay curve has less impact upon the management of surface operations than the wetness.

The red soils encompass two major classification parameters, those being Hapludults/Paleudults. Other concerns are wetness due to reduced permeability, which usually occurs at the discontinuity of the capping and residual underlying material. The Appomattox Soil Series, as defined, takes into account the permeablity variable. It also allows, but does not require, a discontinuity within the profile. Again, like the non-red soils, these soils are intimately associated and intermingled with residual soils, thus demonstrating a need for a soil complex to define the map unit. The redder colors relative to the non-red soils also suggest greater age.

Trend-Surface Analysis

Some of the low-ordered trends are slightly significant because they follow the overall regional trend of this area of the Piedmont. This may be the nearest representation to an old erosional surface or peneplain that can be postulated.

The two landscape positions, interfluve/colluvial, seem to have similar properties with respect to elevation relative to the actual surface. Quantitative values vary at given points on given degrees of trend, but overall the predicted elevations are similar. This study implies that all sites are colluvial and, therfore, these two landforms should have similar predicted elevations. The primary difference between them seems to be contingent upon when the material was deposited. Recent colluvium on small localized terrain trends differently than old, larger (regional?) deposits. Local influences due to climate, geology and vegetation may have a greater impact on an individual map unit than regional influence. The Pamplin area consistently displays trends that imply recent colluviation relative to older interfluves. There seem to be localized forces promoting these recent colluvial episodes.

Residual plots of second-degree and fourth-degree surfaces show more area of predicted high terrains for red soils relative to non-red soils than the reverse. The red soils dominantly trend at higher elevations than the non-red soils relative to the actual surface. These elements suggest a generally greater age for the red soils.

The study area was gridded and elevations were recorded at least at one inch intervals from the four USGS 7.5 minute topographic quadrangles. First through fourth-degree trend surfaces were generated for this *actual* surface. The difference in elevation between the *actual* trend-surface and the capping trend-surface was derived at localities in the study area. Age estimates were calculated using these differences and estimated surface reduction rates recorded in the literature. The following surface reduction rates have been hypothesized: 27 meters per million years (Pavich, 1985), 20 meters per million years (Pavich, 1986), 10 meters per million years (Markewich et al., 1990), and 8 meters per million years (Pavich, 1986). Using all data points on a first-degree trend surface, there has been an overall surface reduction of approximately 22 meters. Hypothetically, the age of the capping surfaces can be estimated based upon these surface reduction rates to be approximately 0.8 million years to 2.75 million years in age, depending on the surface reduction factor used. Using a fourth-degree surface of interfluves in the vicinity of Big Cub Creek, an age estimation of 1.85 million years (Pleistocene) to 6.25 million years (Pliocene-Miocene) B.P. can be estimated. The lower-ordered surfaces tend to average the entire region, leaving out high (old) and low (young) points. The oldest remnants should be more definable on higher-ordered surfaces.

Summary

In the Appomattox and Buckingham County Soil Surveys, these map units have a whole range of properties that are grouped under the Appomattox and Mattaponi Soil Series.

Within these map units are found many different soils. There is little difference between the average characteristics of these two mapping units based upon laboratory data from twenty-four pedons. Yet, they appear very different in the field due to their color. Mills (1977) and Howard et al. (1993) suggest a greater age for red soils relative to non-red. Velbel (1987) proposed that color may also indicate the climatic conditions under which the soil parent material was deposited. Red soil parent material would have been deposited during warm dry climates. Yellow-orange soil parent material would have been deposited in humid temperate climates. These color differentiations are due to the hydration state of iron oxide/oxyhydroxides in the soil. The relative age estimation is corroborated by many of the trend-surface studies in which the red soils seem to occupy the oldest landscape positions. Utilizing a fourth-degree trend-surface, the red soils can be estimated at 1.4 million years to 4.6 million years B.P. at specific sites within the study area. The non-red soils can be estimated at 0.8 million years to 2.75 million years B.P. A selection of sites on the fourth order surface demonstrates the red soils are older than the non-red. This is derived from an average surface lowering of four sites to be approximately 120 feet for the red mapping units and 70 feet for the non-red units. An age estimate using the Markewich et al. (1990) surface reduction rate would be 2.15 million years for the non-red mapping units and 3.7 million years for the red units.

Based upon the literature, I feel these age estimates are low. These soils certainly demonstrate development to suggest ages greater than Holocene and Pleistocene. The oldest estimate (6.25 million years), which would be Pliocene-Miocene, seems to be at least half the age I would expect. Howard et al. (1993) estimated soils with about 60 percent clay to be up to 13 million years in age. The soils from some pedons in this thesis have clay contents greater than 70 percent in the Bt horizon, demonstrating potential ages consistant with Howard's oldest units. This method provides age estimates similar to many reported in the literature. The technique appears to provide viable age estimates of one geomorphic surface relative to another in a study area. The surface reduction rates have the greatest affect upon the absolute age estimate. These rates may be in serious question. Based upon Howard's (et al., 1993) age estimates, a surface reduction rate of approximately 5 meters or less per million years can be hypothesized.

This study, sadly, does not support an exciting dynamic genesis for these soils, such as marine or river terrace. A scenario unfolds in which a north-south trending ridge lowers and retreats, leaving colluvium in its wake. The colluvium shields the lower landscapes while the higher unprotected areas subside (inversion), leaving the colluvium on the higher landscapes. This occurs continually, with alternating incision and subsidence, erosion and deposition.

These soils are difficult to identify and map. I continue to find traces of transported material in areas previously mapped as residuum (often in areas I have mapped). The influence of these soils upon use and management will appear to increase in the future as we become more proficient at identifying them.

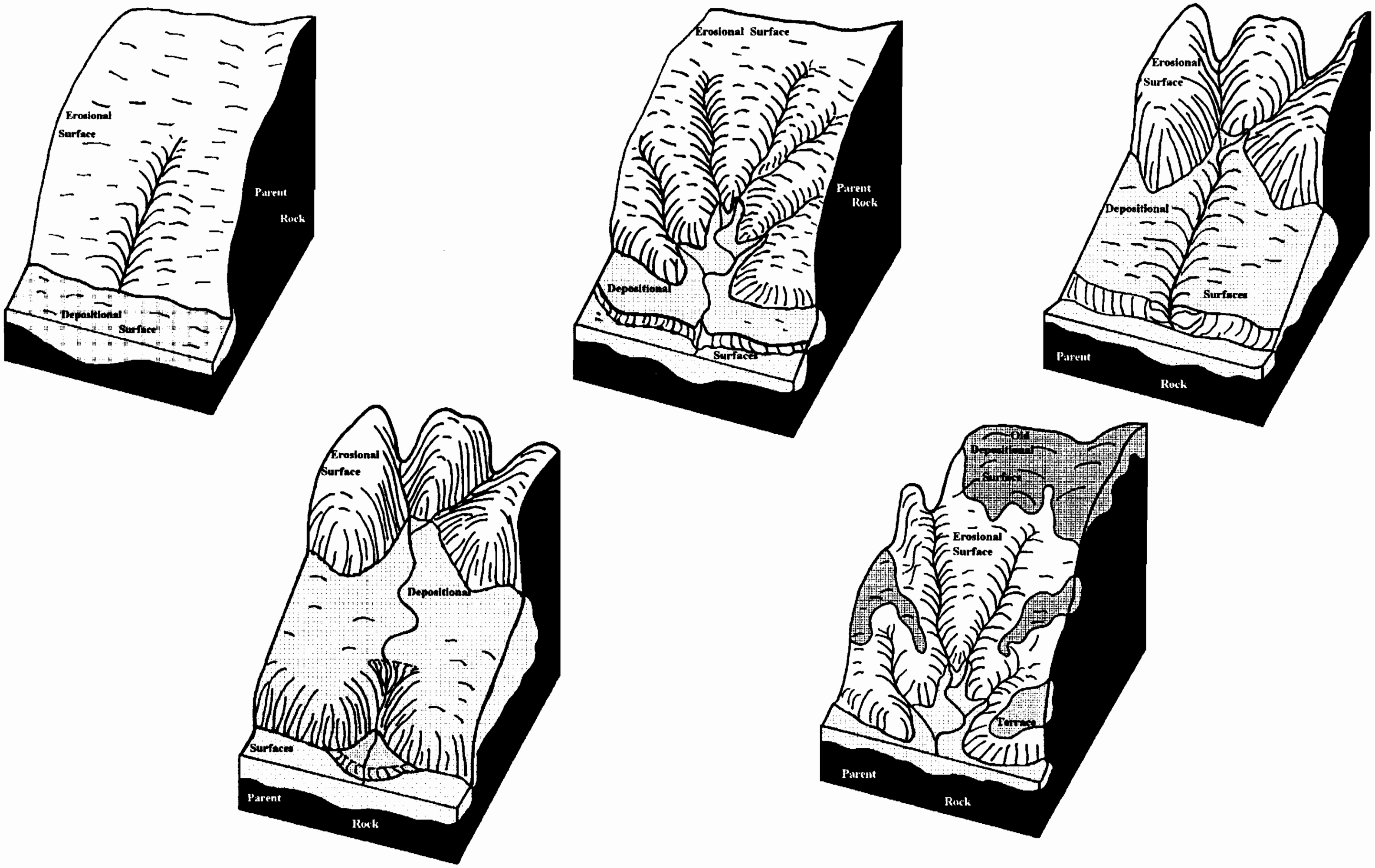


Figure 15. Sequence of subsidence and inversion on a Piedmont surface, as interpreted by the author.

Literature Cited

Bloonwe, E.O., and H.J. Werner. 1955. Geology of the Blue Ridge Region in Central Virginia. Bulletin of the Geological Society of America 66:579-606.

Brown, W. 1953. Structural framework and mineral resources of the Virginia Piedmont. Kentucky Geological Survey Special Publication. No. 1.

Brown, W. R. 1958. Geology and mineral resources of the Lynchburg quadrangle, Virginia. Virginia Division Mineral Resources. Bulletin 74.

Bullard, C. F. 1977. Soil Survey of Campbell County and City of Lynchburg, Virginia. USDA-SCS, U.S. Government Printing Office, Washington, D.C.

Carter, J.B. 1971. Soil Survey of Orange County, Virginia. USDA-SCS, U.S. Government Printing Office, Washington, D.C.

Carter, J.B. 1976. Soil Survey of Louisa County, Virginia. USDA-SCS, U.S. Government Printing Office, Washington, D.C.

Clark, G.M. and E.J. Ciolkosz. 1988. Periglacial geomorphology of the Appalachian highlands and interior highlands south of the glacial border. Geomorphology. 1:191-220.

Cleaves, E.T. and J. E. Costa. 1979. Equilibrium cyclicity and problems of scale - Maryland's Piedmont landscape. Dept. of Nat. Res. Maryland Geological Survey, Info. Circ. 29.

Cleaves, E.T. 1989. Appalacian Piedmont landscapes from the Permian to the Holocene. Geomorphology. 2:159-179.

Coasta, J.E. and E.T. Cleaves. 1984. The Piedmont of Maryland: A New Look at an Old Problem. Earth Surface Processes and Landforms 9:59-74.

Coleman, C.S. 1960. Soil Survey of Nottoway County, Virginia. USDA-SCS, U.S. Government Printing Office, Washington, D.C.

Conley, J.F. 1978. Geology of the Piedmont of Virginia Interpretations and Problems. Contributions to Virginia Geology III. Virginia Division of Mineral Resources. Pub 7. p.115-149.

Conley, J.F. 1985. Geology of the Southwestern Virginia Piedmont. Virginia Division of Mineral Resources, Pub. 9.

Daniels, R.B., E.E. Gamble, and W.H. Wheeler. 1978. Age of Soil Landscapes in the Coastal Plain of North Carolina. Soil Science Society of America Journal 42:98-105.

Darmody, R.G. and J.E. Foss. 1982. Soil Genesis, Morphology and Classification. Soil Science Society of America Journal 46:588-592.

Davis, J.C. 1986. Statistics and Data Analysis in Geology. John Wiley and Sons, New York.

DeLorme Mapping Company. 1989. Virginia Atlas and Gazetteer. Freeport, Maine.

Dietrict, R.V. 1990. Geology and Virginia. Dept. of Mines, Minerals, and Energy. Div. of Mineral Resources. Charlottesville, VA.

Doveton, J.H. and A.J. Parsley. 1970. Experimental Evaluation of Trend Surface Distortions Induced by Inadequate Data Point Distributions. Extract from Transactions/Section B of the Institution of Mining Metallurgy. Vol. 49.

Eargle, D.H. 1977. Piedmont Pleistocene Soils of the Spartanburg area, South Carolina. South Carolina Div. of Geol. vol. 21, no. 2, p.57-74.

Edmonds, W.J. and J.B. Campbell. September 1984. Spatial Estimates of Soil Temperature. Soil Science, Vol. 1388, no. 3.

Edmonds, W.J., P.B. Sabo, and C.D. Peacock. February 1984. Supplemental Data for Soil Survey Report of Greensville County, Virginia. Virginia Agricultural Experimental Station. Virginia Polytechnic Institute and State University. Bulletin 84-2.

Edmonds, W.J. 1989. Soil Survey of Greensville County, Virginia. USDA-SCS, U.S. Government Printing Office, Washington, D.C.

Elder, J.H. 1985. Soil Survey of Spotsylvania County, Virginia. USDA-SCS, U.S. Government Printing Office, Washington, D.C.

Fenneman, N.M. 1938. Physiography of the Eastern United States. McGraw Hill Book Co., Inc., New York.

Gee, G.W. and J.W. Bauder. 1986. Particle-size Analysis. p. 383-409. *In* A. Klute (ed.) Methods of Soil Analysis. Part 1. 2nd ed. Agron. monogr. 9. ASA and SSSA, Madison, WI.

Gilluly, J., A.C. Waters, and A.O. Woodford. 1959. Principles of Geology. W.H. Freeman and Company, San Francisco and London, 2nd ed.

Genther, M.H.. 1990. The Variability and Geomorphology of Appling, Cecil, and Davidson Soils on Sideslopes in the Virginia Piedmont. M.S. thesis. Virginia Polytechnic Institute and State University, Blacksburg.

Henry, E.F. 1958. Soil Survey of Prince Edward County, Virginia. USDA-SCS, U.S. Government Printing Office, Washington, D.C.

Hodges, R.L. 1980. Soil Survey of Hanover County, Virginia. USDA-SCS, U.S. Government Printing Office, Washington, D.C.

Howard, J.L., D.F. Amos, and W.L. Daniels. 1993. Quaternary Research 39:201-213. Alluvial Soil Chronosequence in the Inner Coastal Plain, Central Virginia.

Howard, J.L. 1978. Geological and Pedologic Studies of the James, Roanoke, and New River Basins, Virginia. Progress Report.

Jacobson, R.B., A.J. Miller, and J.A. Smith. 1989. The Role of Catastrophic Geomorphic Events in Central Appalachian Landscape Evolution. Geomorphology 2:257-284.

Kesel, R.H. 1974. Inselbergs on the Piedmont of Virginia, North Carolina, and South Carolina: Types and Characteristics. Southeastern Geology vol.16, no.8, p.1-30.

King, P.B. 1949. The floor of the Shenandoah Valley. American Journal of Science.

Kirk, N.M. 1922. Soil Survey of Pittsylvania County, Virginia. U.S. Department of Agriculture Bureau of Soils, Washington, D.C.

Knuepfer,L.D. 1990. Soils and Landscape Evolution-Proceedings of the 21st Binghampton Symposium in Geomorphology. Geomorphology 3:417-447.

Legrand, H.E. 1960. Geology and Groundwater Resources of Pittsylvania and Halifax Counties. Virginia Division of Mineral Resources. Bulletin 75.

Levin, H.L. 1994. The Earth through Time. Fourth edition. Saunders College Publishers, Fort Worth.

McCracken, R.J., R.B. Daniels and W.E. Fulcher. 1989. Undisturbed Soils, Landscapes and Vegetation in a North Carolina Piedmont Virgin forest. Soil Science Society of America Journal 53:1146-1152.

McDaniel, J.C. 1989. Soil Survey of Bedford County, Virginia. USDA-SCS, U.S. Government Printing Office, Washington, D.C.

McDaniel, J.S. 1981. Soil Survey of Lunenburg County, Virginia. USDA-SCS, U.S. Government Printing Office, Washington, D.C.

Merriam, G. & C. 1974. The Merriam-Webster Dictionary. Pocket Books Publishers, New York.

Mills, H.H. 1981. Boulder Deposits and the Retreat of Mountain Slopes of "Gully Gravure" Revisited. Journal of Geology 89:649-660.

Mills, H.H. 1986. Possible Differential Uplift of New River Terraces in Southwestern Virginia. Neotectonics: An International Journal of Crustal Dynamics 1:75-86.

Mills, H.H. 1977. Slope Deposits on the North Side of Little Pinnacle Mountain, South Carolina. South Carolina Division of Geology, State Development Board, Geologic Notes 21:150-163.

Nicholson, J. 1980. Soil Survey of Goochland County, Virginia. USDA-SCS, U.S. Government Printing Office, Washington, D.C.

Overstreet, W.C. et al. 1968. Fluvial Monazite Deposits in the Southeastern United States. USGS Prof. Paper #568.

Parizek, E.J. and J.F. Woodruff. 1956. Apparent Absence of Soil Creep in the East Georgia Piedmont. Bulletin of the Geological Society of America 67:1111-1116.

Parizek, E.J. and J.F. Woodruff. 1957. Description and Origin of Stone Layers in Soils of the Southeastern States. Journal of Geology 65:24-34.

Pavich, M.J. 1985. Tectonic Geomorphology. Allen & Unwin, London.

Pavich, J.J. 1986. Processes and Rates of Saprolite Production and Erosion on a Foliated Granitic Rock of the Virginia Piedmont. Chapter 23. In S.M. Colman and D.P. Dethier (ed.) Rates of Chemical Weathering of Rocks and Minerals. Academic Press, Inc., Orlando, Florida.

Pavich, M.J. 1989. Regolith Residence Time and the Concept of Surface Age of the Piedmont "Peneplain". Geomorphology 2:181-196.

Pavlides, L. 1980. Revised Nomenclature and Stratigraphic Relationships of the Fredericksburg Complex and Quantico Formation of the Virginia Piedmont. Geological Survey Professional Paper 1146. U.S. Gov. Printing Office. Washington, D.C.

Plaster, R.W. and W.C. Sherwood. 1971. Bedrock Weathering and Residual Soil Formation in Central Virginia. Geological Society of American Bulletin 82:2813-2826.

Porter, H.C. 1958. Soil Survey of Fluvanna County, Virginia. USDA-SCS, U.S. Government Printing Office, Washington, D.C.

Reed, J.C. 1981. Disequilibrium Profile of the Potomac River Near Washington, D.C. A Result of Lowered Base Level or Quaternary Tectonics Along the Fall Line. U.S. Geological Survey, Federal Center, Denver, CO. Geology 9:445-450.

Robinson, J.E. 1982. Computer Applications in Petroleum Geology. Hutchinson Ross Pub. Co. Ruhe, R.V. 1958. Stonelines in Soils. Iowa Agricultural Experimental Station Journal Paper 3440.

Ruhe, R.V. 1960. Elements of the Soil Landscape. Seventh Congress of Soil Science, Madison, WI. Vol. 23.

Ruhe, R.V. 1968. Hillslope Models and Soil Formation. Ninth International Congress of Soil Science Transactions. Paper 57. 551-560.

Slaymaker, H.O. 1971. The Use of Trend Surface Analysis in the Interpretation of Quaternary Deposits. Research Methods in Pleistocene Geomorphology. Second Guelph Symposium on Geomorphology. University of Guelph, Ontario, Canada.

Soil Survey Staff. 1985. Ackwater. Established Soil Series.

Soil Survey Staff. 1988. Appomattox. Established Soil Series.

Soil Survey Staff. 1981. Brockroad. Established Soil Series.

Soil Survey Staff. 1990. Caroline. Established Soil Series.

Soil Survey Staff. 1985. Catharpin. Established Soil Series.

Soil Survey Staff. 1992. Masada. Established Soil Series.

Soil Survey Staff. 1991. Mattaponi. Established Soil Series.

Soil Survey Staff. 1988. Turbeville. Established Soil Series.

Soil Survey Staff. 1990. Keys to Soil Taxonomy. SMSS Technical Monograph No. 19.

Thomas, P.J. 1987. Characterization, Classification, and Productivity Studies of Typic Hapludult Mapping Units from the Southern Piedmont of Virginia. M.S. thesis. Virginia Polytechnic Institute and State University, Blacksburg.

Unwin, D.J. 1975. Concepts and Techniques in Modern Geography. An Introduction to Trend Surface Analysis.

VanDine, J. W. 1974. Soil Survey of Charlotte County, Virginia. USDA-SCS, U.S. Government Printing Office, Washington, D.C.

Velbel, M.A. 1987. Alluvial Fan Origin for Terrace Deposits of the Southeast Prentiss Quadrangle near Otto, NC. Southeastern Geology 28:87-103.

Virginia Division of Mineral Resources. 1993. Geologic Map of Virginia Expanded Explanation. Charlottesville.

Walker, P.H., G.F. Hall and R. Protz. 1968. Soil Trends and Variability Across Selected Landscapes in Iowa. Soil Sci. Soc. Amer. Proc. 32: 101-104.

Wermund, E.G. and W.A. Jenkins, Jr. 1970. Deltaic Sedimentation Modern and Ancient. Society of Economic Paleontologists and Mineralogists. Pub. No. 15.

Whittecar, G.R. 1985. Stratigraphy and Soil Development in Upland Alluvium and Colluvium, North Central Virginia Piedmont. Southeastern Geol. 26(2): 117-129.

Whitehead, D.R. and E.S. Barghoon. 1962. Pollen Analytical Investigation of Pleistocene Deposits from Western North Carolina and South Carolina. Ecological Monographs. 32(4): 347-369.

Wilson, M.A., L.W. Zelany, and J.C.Baker. March 1983. An Investigation of Soils within the Tatum Elioak Mapping Units in the Virginia Piedmont. Virginia Agricultural Experimental Station. Bulletin 83-1.

Winston, R.A. 1911. Soil Survey of Campbell County, Virginia. USDA-SCS, U.S. Department of Agriculture Bureau of Soils. Washington, D.C.

Wysocki, D.A. 1979. Characterization, Classification and Genesis of Cullen Soils from the Virginia Piedmont. M.S. thesis. Virginia Polytechnic Institute and State University, Blacksburg.

Appendix A

Table A1. Physical properties of pedon 09.

		Sand*								
Horizon	**Depth (in.)**	**VC**	**C**	**M**	**F**	**VF**	**Total**	**Silt****	**Clay****	**Textural Class**
Ap	0-9	2.5	5	9.4	23.2	21	61.1	31	7.9	sl
Bt1	9-32	2.1	2.8	5.3	14.5	13	37.7	16.9	45.5	c
Bt2	32-45	2.5	3.1	4.7	11.1	10.9	32.2	13.5	54.3	c
Bt3	45-65	1.7	2.6	5.7	15.9	11.4	37.3	17.5	45.1	c

*** Determined by sieving**
**** Determined by pipette**
NES = Not Enough Sample

Table A2. Physical properties of pedon 135.

		Sand*								
Horizon	**Depth (in.)**	**VC**	**C**	**M**	**F**	**VF**	**Total**	**Silt****	**Clay****	**Textural Class**
Ap	0-9	4.8	5.9	8	18.8	16	53.6	33.5	12.9	sl-l
Bt1	9-21	2.5	3.3	4	9.6	7.9	27.2	20.4	52.4	c
Bt2	21-44	1.1	2.1	2.7	6.1	5.7	17.6	15	67.5	c
2BC	44-70	1.1	1.4	1.9	6.1	6.5	17	19.1	63.8	c

*** Determined by sieving**
**** Determined by pipette**
NES = Not Enough Sample

Table A3. Physical properties of pedon 136.

		Sand*								
Horizon	**Depth (in.)**	**VC**	**C**	**M**	**F**	**VF**	**Total**	**Silt****	**Clay****	**Textural Class**
Ap	0-10	1.1	3.7	8.1	17	15	45	43.3	11.7	l
Bt1	10-24	0.8	2.3	5.1	10.8	11.7	30.8	30.6	38.7	cl-c
Bt2	24-47	0.9	1.9	3.3	7.2	8.1	21.4	16.5	62	c
2BC	47-80	1.1	4.2	2.4	4.5	5.4	17.7	47.8	34.5	sicl

*** Determined by sieving**
**** Determined by pipette**
NES = Not Enough Sample

Table A4. Physical properties of pedon 138.

		Sand*								
Horizon	**Depth (in.)**	**VC**	**C**	**M**	**F**	**VF**	**Total**	**Silt****	**Clay****	**Textural Class**
Ap	0-10	2.4	6.5	14.9	36.2	11.1	71.2	19.9	8.9	sl
Bt1	10-21	1.1	4.7	10.2	19.3	6.2	41.5	10.8	47.6	c
Bt2	21-30	2.2	4.5	9.3	15	5.1	36.2	8.1	55.7	c
Bt3	30-48	1.6	5.9	14.6	26.1	8.2	56.4	10.2	33.4	scl

* Determined by sieving
** Determined by pipette
NES = Not Enough Sample

Table A5. Physical properties of pedon 139.

		Sand*								
Horizon	**Depth (in.)**	**VC**	**C**	**M**	**F**	**VF**	**Total**	**Silt****	**Clay****	**Textural Class**
Ap	0-8	2.9	6.6	15.2	34.1	13.1	71.9	22.6	5.4	sl
E	8-19	3.3	7.6	15.4	33.4	12.2	72	22.6	5.4	sl
Bt1	19-38	5.9	8.8	11.6	26	7.1	59.3	16	24.7	scl
Bt2	38-73	4.9	9.7	10.5	10.8	3.5	39.5	11.6	48.9	c
2C	73+	3	8.8	10.3	11.8	4.3	38.2	12.3	49.5	c

* Determined by sieving
** Determined by pipette
NES = Not Enough Sample

Table A6. Physical properties of pedon 141.

		Sand*								
Horizon	**Depth (in.)**	**VC**	**C**	**M**	**F**	**VF**	**Total**	**Silt****	**Clay****	**Textural Class**
Ap	0-11	1.4	4.9	10.3	20.8	18	55.4	35.6	9	sl
Bt1	11-37	1.3	2.8	6	12.6	13.4	36.2	24	39.8	cl-c
Bt2	37-54	1.1	1.5	2.6	5.8	7	18.1	15	67	c
2BC	54-82	1.8	1.6	1.8	4.3	6.7	16.2	32.6	51.1	c

* Determined by sieving
** Determined by pipette
NES = Not Enough Sample

Table A7. Physical properties of pedon 143.

		Sand*								
Horizon	**Depth (in.)**	**VC**	**C**	**M**	**F**	**VF**	**Total**	**Silt****	**Clay****	**Textural Class**
Ap	0-8	1.3	3.5	11.3	25.7	11.6	53.5	30.1	16.4	sl-l
BE	8-18	1.6	2.6	6	17.4	11.4	39.1	24.4	36.5	cl
Bt1	18-28	2.3	2.7	5.8	14.8	8.4	33.9	19.9	46.2	c
Bt2	28-68	4.4	4.8	9.3	19.6	8.5	46.4	17.6	35.9	scl-sc

*** Determined by sieving**
**** Determined by pipette**
NES = Not Enough Sample

Table A8. Physical properties of pedon 134.

		Sand*								
Horizon	**Depth (in.)**	**VC**	**C**	**M**	**F**	**VF**	**Total**	**Silt****	**Clay****	**Textural Class**
Ap	0-7	3.6	4.3	5.7	13.8	16.9	44.4	40.8	14.8	l
Bt1	7-21	1.6	2.0	2.5	5.9	6.0	18.1	24.6	57.3	c
Bt2	21-52	0.8	1.0	0.8	2.5	3.8	9.0	16.8	74.3	c
2C	52-70	3.9	3.5	3.2	6.5	10.1	27.1	41	32	cl

*** Determined by sieving**
**** Determined by pipette**
NES = Not Enough Sample

Table A9. Chemical properties of pedon 133.

		Sand*								
Horizon	**Depth (in.)**	**VC**	**C**	**M**	**F**	**VF**	**Total**	**Silt****	**Clay****	**Textural Class**
Ap	0-9	1.1	2.4	7.2	28.4	22.6	61.7	21.5	16.8	sl
Bt1	9-17	1	1.7	4.7	16.6	12.8	36.9	16.8	46.4	c
Bt2	17-48	1.8	1.5	3.9	14.5	13.1	34.9	12.6	52.5	c
Bt3	48-83	1.9	2.1	5.1	17.9	15.5	42.5	17.7	39.8	cl-c-sc
Bt4	83-90									NES

*** Determined by sieving**
**** Determined by pipette**
NES = Not Enough Sample

Table A10. Physical properties of pedon 137.

		Sand*								
Horizon	**Depth (in.)**	**VC**	**C**	**M**	**F**	**VF**	**Total**	**Silt****	**Clay****	**Textural Class**
Ap	0-6	1	5.7	9.7	17.3	14.2	48	39.6	12.4	l
Bt1	6-18	0.7	3.3	6	11	10	31	31.9	37.1	cl
Bt2	18-47	0.7	2.2	3.5	6.1	5.6	18.1	24.2	57.7	c
2BC	47-75	1.8	4.2	6.1	8	6.4	26.6	38.3	35.2	cl

*** Determined by sieving**
**** Determined by pipette**
NES = Not Enough Sample

Table A11. Physical properties of pedon 140.

		Sand*								
Horizon	**Depth (in.)**	**VC**	**C**	**M**	**F**	**VF**	**Total**	**Silt****	**Clay****	**Textural Class**
Ap	0-10	1.9	3.7	6.8	18.6	18.6	49.7	39.4	10.9	l
Bt1	10-25	1.5	2.4	4.2	11.3	13.2	32.6	21.8	45.6	c
Bt2	25-35	0.9	0.9	1.5	3.9	4.6	11.9	11	77	c
2Bt3	35-70	0.9	1.1	1.5	3.6	6	13.2	19.8	67	c

*** Determined by sieving**
**** Determined by pipette**
NES = Not Enough Sample

Table A12. Physical properties of pedon 142.

		Sand*								
Horizon	**Depth (in.)**	**VC**	**C**	**M**	**F**	**VF**	**Total**	**Silt****	**Clay****	**Textural Class**
Ap	0-6	3.4	2.8	4.6	12.9	14	37.7	38.9	23.4	l
Bt1	6-44	1.4	1	1	3.1	4.1	10.6	17.2	72.1	c
Bt2	44-60	1.4	1.3	1.2	2.4	4.1	10.5	19.7	69.9	c
2BC	60-70	2.1	1.7	1.6	3.5	5.8	14.8	26.9	58.4	c

*** Determined by sieving**
**** Determined by pipette**
NES = Not Enough Sample

Table A13. Physical properties of pedon 144.

		Sand*								
Horizon	Depth (in.)	VC	C	M	F	VF	Total	Silt**	Clay**	Textural Class
Ap	0-6	2.9	3.7	6.9	17.8	10.2	41.6	41	17.4	l
Bt1	6-16	1.4	2.2	3.8	10.8	5.8	24.1	27	48.9	c
Bt2	16-36	1.1	1.3	1.5	5.5	4.4	13.9	12.9	73.2	c
2BC	36-70	0.3	2	1.5	10.5	11	25.4	25.5	49.1	c

* Determined by sieving
** Determined by pipette
NES = Not Enough Sample

Table A14. Physical properties of pedon 145.

		Sand*								
Horizon	Depth (in.)	VC	C	M	F	VF	Total	Silt**	Clay**	Textural Class
Ap	0-8	4	4.9	6.9	15.9	8.7	40.4	29.8	29.8	cl
Bt	8-33	7	4.6	4.2	8.1	4.5	28.4	14.2	57.4	c
2BC	33-53	3.6	4.9	5.3	9.4	11.5	34.6	24.8	40.5	c-cl

* Determined by sieving
** Determined by pipette
NES = Not Enough Sample

Table A15. Physical properties of pedon 146.

		Sand*								
Horizon	Depth (in.)	VC	C	M	F	VF	Total	Silt**	Clay**	Textural Class
Ap	0-6	2.2	2.6	4.9	20.6	19.6	50.1	37.2	12.7	l-sl
Bt	6-40	0.8	0.5	1.1	4.2	10.3	17	18.9	64.1	c
2BC	40-50	0.1	0.2	1.6	4.1	16.1	22.1	28.8	49.1	c

* Determined by sieving
** Determined by pipette
NES = Not Enough Sample

Table A16. Physical properties of pedon 147.

		Sand*								
Horizon	Depth (in.)	VC	C	M	F	VF	Total	Silt**	Clay**	Textural Class
Ap	0-10	1.3	2.2	3.3	6.9	5.8	19.4	75.6	5	sil
Bt1	10-18	2.2	4.1	5.1	14.2	10.8	36.3	34	29.7	cl
Bt2	18-60	1.5	2.1	2.6	6.3	5	17.4	14	68.6	c
2BC	60-73	4.5	3.6	2.7	6.7	6.7	24.2	20.6	55.1	C

* Determined by sieving
** Determined by pipette
NES = Not Enough Sample

Table A17. Physical properties of pedon 148.

		Sand*								
Horizon	Depth (in.)	VC	C	M	F	VF	Total	Silt**	Clay**	Textural Class
Ap	0-5	1.6	2.7	5.6	16.3	20.4	46.6	40.2	13.2	l
Bt1	5-28	0.8	1.3	3.2	8.8	10.9	25	23.7	51.2	c
Bt2	28-62	0.7	0.9	1.5	8.2	16.5	27.9	21.6	50.6	c

* Determined by sieving
** Determined by pipette
NES = Not Enough Sample

Table A18. Physical properties of pedon 149.

		Sand*								
Horizon	Depth (in.)	VC	C	M	F	VF	Total	Silt**	Clay**	Textural Class
Ap	0-5	2.1	2.6	4.5	13.6	13.9	36.8	30.7	32.5	cl
Bt	5-21	0.9	1.1	1.7	6	10.6	20.4	26.9	52.6	c
2BC	21-40	0	0.5	1.4	5.4	15.1	22.4	34.3	43.3	c
2C	40	0.5	0.7	1.2	7.6	23.8	33.9	28.3	37.8	cl

* Determined by sieving
** Determined by pipette
NES = Not Enough Sample

able A19. Physical properties of pedon 150.

		Sand*								
Horizon	Depth (in.)	VC	C	M	F	VF	Total	Silt**	Clay**	Textural Class
Ap	0-5	1.6	2.1	4.6	20.3	22.8	51.5	30.9	17.5	sl-l
Bt	5-30	0.5	1.1	1.6	6.7	7.3	17.2	15.6	67.2	c
2BC	30-45	2.1	2	2.7	7.8	8.5	23.1	20.7	56.2	c
2C	45-75	1.1	1.7	2.8	14.1	18	37.8	23.9	38.3	cl-c

* Determined by sieving
** Determined by pipette
NES = Not Enough Sample

Table A20. Physical properties of pedon 151.

		Sand*								
Horizon	Depth (in.)	VC	C	M	F	VF	Total	Silt**	Clay**	Textural Class
Ap	0-5	2.8	5	13.4	21.9	11	54.1	27.9	18	sl
Bt	5-25	2.2	3	5.9	9.6	6	26.8	17.5	55.7	c
2BC	25-37	6.6	6.6	6.1	9.4	7.1	35.8	14.3	49.8	c
2C	37-58	10.3	9.1	8.7	13.6	11.8	53.5	16.1	30.4	scl

* Determined by sieving
** Determined by pipette
NES = Not Enough Sample

Table A21. Physical properties of pedon 152.

		Sand*								
Horizon	Depth (in.)	VC	C	M	F	VF	Total	Silt**	Clay**	Textural Class
Ap	0-6	3.7	5.9	10.5	16.5	11.4	48	29.9	22.2	l-scl
Bt1	6-36	2.4	2	3.9	7.5	5.9	21.7	17.8	60.5	c
Bt2	36-70	0.8	1.7	3.2	6.7	5.9	18.3	19.3	62.3	c

* Determined by sieving
** Determined by pipette
NES = Not Enough Sample

Table A22. Physical properties of pedon 153.

		Sand*								
Horizon	Depth (in.)	VC	C	M	F	VF	Total	Silt**	Clay**	Textural Class
Ap	0-10	0.8	1.3	4.2	26.3	22.9	55.6	31	13.4	sl
Bt	10-32	0.4	0.7	1.8	14.6	15.5	33.1	16.7	50.2	c
2BC	32-62	0.4	1	1.6	19.2	18.3	40.7	16.7	42.6	c

* Determined by sieving
** Determined by pipette
NES = Not Enough Sample

Table A23. Physical properties of pedon 154.

		Sand*								
Horizon	Depth (in.)	VC	C	M	F	VF	Total	Silt**	Clay**	Textural Class
Ap	0-10	5.8	5.3	10.4	22.3	16.1	59.8	24.9	15.3	sl
Bt1	10-24	2.6	2.6	3.9	7.7	5.8	22.5	10.5	67	c
Bt2	24-44	4.7	4.2	5.2	9	8.3	31.4	15.2	53.4	c

* Determined by sieving
** Determined by pipette
NES = Not Enough Sample

Table A24. Physical properties of pedon 155.

		Sand*								
Horizon	Depth (in.)	VC	C	M	F	VF	Total	Silt**	Clay**	Textural Class
Ap	0-14	2.6	3.9	9.5	22.3	13.9	52.2	32.5	15.3	sl-l
Bt1	14-34	2.8	3.2	6.5	18.4	11.4	42.3	23.6	34.1	cl
Bt2	34-50	1.8	2.8	5.2	13.5	8.5	31.7	21.9	46.3	c

* Determined by sieving
** Determined by pipette
NES = Not Enough Sample

Table A25. Chemical properties of pedon 09.

VA-011-	Lab#	Horizon	Depth (in.)	pH	Ca	Mg	K	H^+	Al	Sum Bases	Total CEC	% Base Sat.	Total Eff. CEC	% Eff. Base Sat
09-1	843	Ap	0-9	4.9	0.06	0.02	0.05	2.6	0.9	0.13	2.73	4.76	1.03	12.62
09-2	844	Bt1	9-32	4.95	0.07	0.46	0.1	12.2	4.45	0.63	12.83	4.91	5.08	12.40
09-3	845	Bt2	32-45	5.08	0	0.26	0.07	15.2	6.4	0.33	15.53	2.12	6.73	4.90
09-4	846	Bt3	45-65	4.88	0.01	0.13	0.06	17.6	7.8	0.2	17.8	1.12	8.00	2.50

Table A26. Chemical properties of pedon 134.

VA-011-	Lab#	Horizon	Depth (in.)	pH	Ca	Mg	K	H^+	Al	Sum Bases	Total CEC	% Base Sat.	Total Eff. CEC	% Eff. Base Sat
134-1	835	Ap	0-7	4.8	0.1	0.08	0.09	4.6	1.35	0.27	4.87	5.54	1.62	16.67
134-2	836	Bt1	7-21	5.02	0.15	1.09	0.28	11.6	2.65	1.52	13.12	11.59	4.17	36.45
134-3	837	Bt2	21-52	5.1	0.03	0.39	0.13	14.8	3.2	0.55	15.35	3.58	3.75	14.67
134-4	838	2C	52-70	4.98	0.01	0.07	0.04	10.6	5.65	0.12	10.72	1.12	5.77	2.08

Table A27. Chemical properties of pedon 135.

VA-011-	Lab#	Horizon	Depth (in.)	pH	Ca	Mg	K	H^+	Al	Sum Bases	Total CEC	% Base Sat.	Total Eff. CEC	% Eff. Base Sat
135-1	839	Ap	0-9	5.07	0.64	0.17	0.12	4.2	0.85	0.93	5.13	18.13	1.78	52.25
135-2	840	Bt1	9-21	4.79	0.8	0.69	0.09	14.2	3.2	1.58	15.78	10.01	4.78	33.05
135-3	841	Bt2	21-44	4.9	0.09	0.51	0.08	13.8	3.9	0.68	14.48	4.7	4.58	14.85
135-4	842	2BC	44-70	5	0.02	0.19	0.06	14.8	4.95	0.27	15.07	1.79	5.22	5.17

Table A28. Chemical properties of pedon 136.

VA-011-	Lab#	Horizon	Depth (in.)	pH	Ca	Mg	K	H^+	Al	Sum Bases	Total CEC	% Base Sat.	Total Eff. CEC	% Eff. Base Sat
136-1	847	Ap	0-10	5.36	1.13	0.23	0.14	4.4	0.75	1.5	5.9	25.42	2.25	66.67
136-2	848	Bt1	10-24	4.88	1.06	0.67	0.19	11.2	2.95	1.92	13.12	14.63	4.87	39.43
136-3	849	Bt2	24-47	4.6	0.13	0.55	0.11	13.2	4.45	0.79	13.99	5.65	5.24	15.08
136-4	850	2BC	47-80	4.72	0.02	0.17	0.04	13.8	4.85	0.23	14.03	1.64	5.08	4.53

Table A29. Chemical properties of pedon 138.

VA-011-	Lab#	Horizon	Depth (in.)	pH	Ca	Mg	K	H^+	Al	Sum Bases	Total CEC	% Base Sat.	Total Eff. CEC	% Eff. Base Sat
138-1	855	Ap	0-10	4.88	0.13	0.07	0.04	2.2	0.65	0.24	2.44	9.84	0.89	26.97
138-2	856	Bt1	10-21	4.8	0.34	0.77	0.11	10.4	3.3	1.22	11.62	10.5	4.52	26.99
138-3	857	Bt2	21-30	4.88	0.31	1.2	0.12	12.2	3.95	1.63	13.83	11.79	5.58	29.21
138-4	858	Bt3	30-48	4.9	0.22	0.15	0.05	6	2.95	0.42	6.42	6.54	3.37	12.46

Table A30. Chemical properties of pedon 139.

VA-011-	Lab#	Horizon	Depth (in.)	pH	Ca	Mg	K	H^+	Al	Sum Bases	Total CEC	% Base Sat.	Total Eff. CEC	% Eff. Base Sat
139-1	859	Ap	0-8	5.56	1.1	0.33	0.09	3	0.15	1.52	4.52	33.63	1.67	91.02
139-2	860	E	8-19	5.66	0.45	0.08	0.05	0.2	0.15	0.58	0.78	74.36	0.73	79.45
139-3	861	Bt1	19-38	5.12	0.71	0.41	0.07	5	1.6	1.19	6.19	19.22	2.79	42.65
139-4	862	Bt2	38-73	4.5	0.16	0.48	0.08	13.2	6.85	0.72	13.92	5.17	7.57	9.51
139-5	863	2C	73	4.35	0.15	0.39	0.08	13.2	13.95	0.62	13.82	4.49	14.57	4.26

Table A31. Chemical properties of pedon 141.

VA-011-	Lab#	Horizon	Depth (in.)	pH	Ca	Mg	K	H^+	Al	Sum Bases	Total CEC	% Base Sat.	Total Eff. CEC	% Eff. Base Sat
141-1	868	Ap	0-11	5.96	2.88	0.68	0.03	2	0.05	3.59	5.59	64.22	3.64	98.63
141-2	869	Bt1	11-37	5.38	1.8	0.91	0.06	8.2	1.65	2.77	10.97	25.25	4.42	62.67
141-3	870	Bt2	37-54	4.68	0.31	0.39	0.09	18.4	5.35	0.79	19.19	4.12	6.14	12.87
141-4	871	2BC	54-82	4.54	0.08	0.19	0.06	11.4	7.1	0.33	11.73	2.81	7.43	4.44

Table A32. Chemical properties of pedon 143.

VA-011-	Lab#	Horizon	Depth (in.)	pH	Ca	Mg	K	H^+	Al	Sum Bases	Total CEC	% Base Sat.	Total Eff. CEC	% Eff. Base Sat
143-1	876	Ap	0-8	5.64	4.03	0.71	0.28	4.4	0.15	5.02	9.42	53.29	5.17	97.10
143-2	877	BE	6-18	5.93	3.87	0.62	0.1	4.8	0.05	4.59	9.39	48.88	4.64	98.92
143-3	878	Bt1	18-28	6.1	3.99	0.61	0.09	3.4	0.15	4.69	8.09	57.97	4.84	96.90
143-4	879	Bt2	28-68	5.82	2.6	0.4	0.07	4.6	0.05	3.07	7.67	40.03	3.12	98.40

Table A33. Chemical properties of pedon 133.

VA-011-	Lab#	Horizon	Depth (in.)	pH	Ca	Mg	K	H^+	Al	Sum Bases	Total CEC	% Base Sat.	Total Eff. CEC	% Eff. Base Sat
133-1	830	Ap	0-9	5.87	1.47	0.54	0.15	3.8	0.2	2.16	5.96	36.24	2.36	91.53
133-2	831	Bt1	9-17	4.85	1.75	0.74	0.17	7.8	1.65	2.66	10.46	25.43	4.31	61.72
133-3	832	Bt2	17-48	4.72	0.45	0.37	0.06	9.8	3.15	0.88	10.68	8.24	4.03	21.84
133-4	833	Bt3	48-83	4.78	0.02	0.03	0.02	8.6	3.25	0.07	8.67	0.81	3.32	2.11
133-5	834	Bt4	83-90	No	Sample	Taken								

Table A34. Chemical properties of pedon 137.

VA-011-	Lab#	Horizon	Depth (in.)	pH	Ca	Mg	K	H^+	Al	Sum Bases	Total CEC	% Base Sat.	Total Eff. CEC	% Eff. Base Sat
137-1	851	Ap	0-6	5.22	1.23	0.51	0.14	5.2	0.7	1.88	7.08	26.55	2.58	72.87
137-2	852	Bt1	6-18	5.4	1.77	0.97	0.25	8.0	0.9	2.99	10.99	27.21	3.89	76.86
137-3	853	Bt2	18-47	5.12	0.39	0.69	0.16	11.8	3.25	1.24	13.04	9.51	4.49	27.62
137-4	854	2BC	47-75	4.76	0.01	0.11	0.07	8.0	3.85	0.19	8.19	2.32	4.04	4.70

Table A35. Chemical properties of pedon 140.

VA-011-	Lab#	Horizon	Depth (in.)	pH	Ca	Mg	K	H^+	Al	Sum Bases	Total CEC	% Base Sat.	Total Eff. CEC	% Eff. Base Sat
140-1	864	Ap	0-10	482	0.08	0.05	0.08	4.8	1.35	0.21	5.01	4.19	1.56	13.46
140-2	865	Bt1	10-25	4.81	0.1	0.48	0.13	8.8	3.05	0.71	9.51	7.47	3.76	18.88
140-3	866	Bt2	25-35	5.06	0.03	0.58	0.19	14	6.95	0.8	14.8	5.41	7.75	10.32
140-4	867	2Bt	35-70	5.08	0	0.11	0.08	13.8	3.8	0.19	13.99	1.36	3.99	4.76

Table A36. Chemical properties of pedon 142.

VA-011-	Lab#	Horizon	Depth (in.)	pH	Ca	Mg	K	H^+	Al	Sum Bases	Total CEC	% Base Sat.	Total Eff. CEC	% Eff. Base Sat
142-1	872	Ap	0-6	5.64	3.08	0.95	0.25	2.4	0.15	4.28	6.68	64.07	4.43	96.61
142-3	873	Bt1	6-44	4.82	1.09	0.99	0.11	15.2	4.95	2.19	17.39	12.59	7.14	30.67
142-3	874	Bt2	44-60	4.52	0.18	0.32	0.08	17	7.4	0.58	17.58	3.3	7.98	7.27
142-4	875	2BC	60-70	4.48	0.01	0.14	0.05	17.2	11.05	0.2	17.4	1.15	11.25	1.78

Table A37. Chemical properties of pedon 144.

VA-011-	Lab#	Horizon	Depth (in.)	pH	Ca	Mg	K	H^+	Al	Sum Bases	Total CEC	% Base Sat.	Total Eff. CEC	% Eff. Base Sat
144-1	880	Ap	0-6	4.84	0.13	0.05	0.07	3.8	1.15	0.25	4.05	6.17	1.40	17.86
144-2	881	Bt1	6-16	4.9	0.08	0.92	0.12	11.6	2.4	1.12	12.72	8.81	3.52	31.82
144-3	882	Bt2	16-36	5.24	0.03	0.92	0.16	14.2	1.8	1.11	15.31	7.25	2.91	38.14
144-4	883	2BC	36-70	5.18	0.01	0.19	0.06	9.2	2	0.25	9.45	2.65	2.25	11.11

Table A38. Chemical properties of pedon 145.

VA-011-	Lab#	Horizon	Depth (in.)	pH	Ca	Mg	K	H^+	Al	Sum Bases	Total CEC	% Base Sat.	Total Eff. CEC	% Eff. Base Sat
145-1	884	Ap	0-8	5.02	1.88	0.49	0.23	8.6	0.6	2.6	11.2	23.21	3.20	81.25
145-2	885	Bt	8-33	5.48	2.86	1.37	0.12	9.8	0.1	4.35	14.15	30.74	4.45	97.75
145-3	886	2BC	33-53	5.02	0.16	0.43	0.09	9.4	1.2	0.68	10.08	6.75	1.88	36.17

Table A39. Chemical properties of pedon 146.

VA-011-	Lab#	Horizon	Depth (in.)	pH	Ca	Mg	K	H^+	Al	Sum Bases	Total CEC	% Base Sat.	Total Eff. CEC	% Eff. Base Sat
146-1	887	Ap	0-6	5.1	0.38	0.14	0.12	6.6	1.1	0.64	7.24	8.84	1.74	36.78
146-2	888	Bt	6-40	5.12	0.37	0.77	0.17	12	2.8	1.31	13.31	9.84	4.11	31.87
146-3	889	2BC	40-50	4.94	0	0.13	0.05	12.2	3.45	0.18	12.38	1.45	3.63	4.96

Table A40. Chemical properties of pedon 147.

VA-011-	Lab#	Horizon	Depth (in.)	pH	Ca	Mg	K	H^+	Al	Sum Bases	Total CEC	% Base Sat.	Total Eff. CEC	% Eff. Base Sat
147-1	890	Ap	0-10	5.44	1.18	0.34	0.1	4.6	0.25	1.62	6.22	26.05	1.87	86.63
147-2	891	Bt1	10-18	5.34	0.82	0.64	0.12	5.4	1	1.58	6.98	22.64	2.58	61.24
147-3	892	Bt2	18-60	5.38	0.2	0.49	0.14	11.8	2.4	0.83	12.63	6.57	3.23	25.70
147-4	893	2BC	60-73	4.78	0.01	0.08	0.05	10	2.5	0.14	10.14	1.38	2.64	5.30

Table A41. Chemical properties of pedon 148.

VA-011-	Lab#	Horizon	Depth (in.)	pH	Ca	Mg	K	H^+	Al	Sum Bases	Total CEC	% Base Sat.	Total Eff. CEC	% Eff. Base Sat
148-1	894	Ap	0-5	4.62	0.18	0.05	0.08	4.8	1.5	0.31	5.11	6.07	1.81	17.13
148-2	895	Bt1	5-28	4.8	0.03	0.45	0.09	10.6	2.6	0.57	11.17	5.1	3.17	17.98
148-3	896	Bt2	28-62	4.91	0	0.08	0.04	10.2	3	0.12	10.32	1.16	3.12	3.85

Table A42. Chemical properties of pedon 149.

VA-011-	Lab#	Horizon	Depth (in.)	pH	Ca	Mg	K	H^+	Al	Sum Bases	Total CEC	% Base Sat.	Total Eff. CEC	% Eff. Base Sat
149-1	897	Ap	0-5	4.24	0.05	0.05	0.1	14	3	0.2	14.2	1.41	3.20	6.25
149-2	898	Bt1	5-21	4.8	0.02	0.45	0.1	7.6	3.35	0.57	8.17	6.98	3.92	14.54
149-3	899	2Bt2	21-40	4.87	0.02	0.11	0.03	4.6	3.5	0.16	4.76	3.36	3.66	4.37
149-4	900	2BC	40	4.82	0	0.04	0.03	8.2	3.9	0.07	8.27	0.85	3.97	1.76

Table A43. Chemical properties of pedon 150.

VA-011-	Lab#	Horizon	Depth (in.)	pH	Ca	Mg	K	H^+	Al	Sum Bases	Total CEC	% Base Sat.	Total Eff. CEC	% Eff. Base Sat
150-1	901	Ap	0-5	5.8	3.67	0.48	0.11	3.4	0.25	4.26	7.66	55.61	4.51	94.46
150-2	902	Bt	5-30	5.2	1.63	1.03	0.12	10.6	1.2	2.78	13.38	20.78	3.98	69.85
150-3	903	2BC	30-45	4.86	0.06	0.21	0.08	9.2	3	0.35	9.55	3.66	3.35	10.45
150-4	904	2C	45-75	4.74	0.18	0.13	0.06	8.2	2.6	0.37	8.57	4.32	2.97	12.46

Table A44. Chemical properties of pedon 151.

VA-011-	Lab#	Horizon	Depth (in.)	pH	Ca	Mg	K	H^+	Al	Sum Bases	Total CEC	% Base Sat.	Total Eff. CEC	% Eff. Base Sat
151-1	905	Ap	0-5	5.16	0.22	0.06	0.05	2.6	0.55	0.33	2.92	11.26	0.88	37.50
151-2	906	Bt	5-25	5.07	0.72	0.37	0.1	5.2	2.1	1.19	6.39	18.62	3.29	36.17
151-3	907	2BC	25-37	5.01	0.06	0.27	0.06	9.6	1.6	0.39	9.99	3.9	1.99	19.60
151-4	908	2C	37-58	4.86	0.02	0.02	0.03	6.6	1.5	0.07	6.67	1.05	1.57	4.46

Table A45. Chemical properties of pedon 152.

VA-011-	Lab#	Horizon	Depth (in.)	pH	Ca	Mg	K	H^+	Al	Sum Bases	Total CEC	% Base Sat.	Total Eff. CEC	% Eff. Base Sat
152-1	909	Ap	0-6	5.48	3.08	0.78	0.12	5.4	0.05	3.98	9.38	42.43	4.03	98.76
152-2	910	Bt1	6-36	6.08	2.84	1.4	0.07	7.2	0.05	4.31	11.51	37.45	4.36	98.85
152-3	911	Bt2	36-70	5.3	0.2	0.5	0.12	10.2	1.45	0.82	11.02	7.44	2.27	36.12

Table A46. Chemical properties of pedon 153.

VA-011-	Lab#	Horizon	Depth (in.)	pH	Ca	Mg	K	H^+	Al	Sum Bases	Total CEC	% Base Sat.	Total Eff. CEC	% Eff. Base Sat
153-1	912	Ap	0-10	4.84	0.05	0.02	0.09	4.6	1.15	0.16	4.76	3.36	1.31	12.21
153-2	913	Bt	10-32	4.93	0.34	0.61	0.27	9.6	2.15	1.22	10.82	11.28	3.37	36.20
153-3	914	2BC	32-62	4.92	0.02	0.18	0.11	9.6	2.5	0.31	9.91	3.13	2.81	11.03

Table A47. Chemical properties of pedon 154.

VA-011-	Lab#	Horizon	Depth (in.)	pH	Ca	Mg	K	H^+	Al	Sum Bases	Total CEC	% Base Sat.	Total Eff. CEC	% Eff. Base Sat
154-1	915	Ap	0-10	4.45	0.02	0.02	0.08	4.4	1.8	0.12	4.52	2.65	1.92	6.25
154-2	916	Bt1	10-24	5.06	0.42	1.03	0.09	3	2.6	1.54	4.54	33.92	4.14	37.20
154-3	917	Bt2	24-44	5.06	0.01	0.21	0.05	12.8	3.4	0.27	13.07	2.07	3.67	7.36

Table A48. Chemical properties of pedon 155.

VA-011-	Lab#	Horizon	Depth (in.)	pH	Ca	Mg	K	H^+	Al	Sum Bases	Total CEC	% Base Sat.	Total Eff. CEC	% Eff. Base Sat
155-1	918	Ap	0-14	5.12	0.63	0.12	0.09	2.2	0.45	0.84	3.04	27.63	1.29	65.12
155-2	919	Bt1	14-34	5	0.96	0.66	0.15	5.6	1.1	1.77	7.37	24.02	2.87	61.67
155-3	920	Bt2	34-50	4.96	0.02	0.27	0.1	9.6	2.4	0.39	9.99	3.9	2.79	13.98

Table A49. Profile description of pedon:

VA-011-09-(1-4)

Location: About 10,600' east 99 degrees south of the junction of VA-649 and VA-603 and 8,000 north 354 degrees east of the junction of VA-649 and VA-644.

Elevation: 715'

Landscape: Narrow ridgetop on a summit of a finger ridge

Vegetation: cut-over and pine plantation

Slope: 2-3 percent

Remarks: Capping is estimated to be 7'-8'thick at this site

Description:

Ap -- 0-9 inches; brown (10YR 5/3) sandy loam; non-sticky, non-plastic; many angular and subrounded quartz gravel; clear smooth boundary.

Bt1 -- 9-32 inches; strong brown (7.5YR 5/6)clay with strong brown (7.5YR 4/6) mottles; weak medium and coarse subangular blocky structure; friable, sticky, slightly plastic;common angular and subrounded quartz gravel; gradual smooth boundary.

Bt2 -- 32-45 inches; strong brown (7.5YR 5/6)clay with red (2.5YR 4/8) mottles; weak medium platy parting to weak medium subangular blocky structure; sticky, slightly plastic.

Bt3 -- 45-65 inches; strong brown (7.5YR 5/6)clay with pinkish gray (7.5YR 7/2) mottles; weak medium platy parting to moderate medium and coarse subangular blocky structure; sticky, slightly plastic; few angular quartz gravel.

Classification: Clayey, mixed, thermic Typic Paleudult

Series: Caroline

Table A50. Profile description of pedon:

VA-011-134-(1-4)

Location: About 200' north 3520 degrees west of the junction of VA-694 and VA-727 and 9,400' south 170 degrees east of the junction of VA-638 and VA-727.

Elevation: 705'

Landscape: nearly level interfluve - sampled on the most stable landscape portion

Vegetation: cut-over woodland

Slope: 0-2 percent

Remarks:

Description:

Ap -- 0-7 inches; yellowish brown (10YR 5/4) loam; slightly sticky, non-plastic; few subrounded quartz gravel.

Bt1 -- 7-21 inches; strong brown (7.5YR 5/6) clay; moderate fine and medium subangular blocky structure; sticky and slightly plastic.

Bt2 -- 21-52 inches; yellowish red (5YR 5/8) clay with strong brown (7.5YR 5/6) mottles; weak medium and coarse subangular blocky structure; sticky and plastic.

2C -- 52-70+ inches; red (2.5YR 4/6) clay loam with strong brown (7.5YR 4/6) and white (7.5YR 8/0) mottles; rock controlled structure.

Classification: Clayey, mixed, thermic Typic Hapludult

Series: Masada

Table A51. Profile description of pedon:

VA-011-135-(1-4)

Location: About 3,100' east 89 degrees north of the junction of VA-727 and VA-644 and 2,00' east 104 degrees south of the junction of VA-644 and VA-636.

Elevation: 705'

Landscape: narrow (100' wide) ridge top

Vegetation: small grain

Slope: 0-2 percent

Remarks: This is a good cap, the upper part of which is typical of the "coastal plain (in appearance) type cap"

Description:

Ap -- 0-9 inches; brown (10YR 4/3) sandy loam-loam; friable, non-sticky, non-plastic; common subrounded quartz gravel; abrupt smooth boundary.

Bt1 -- 9-21 inches; strong brown (7YR 5/6) clay; weak medium and coarse subangular blocky structure; friable; slightly sticky, slightly plastic; few iron stained rounded quartz gravel; clear smooth boundary.

Bt2 -- 21-44 inches; strong brown (7.5YR 5/6) and red (2.5YR 4/6) (*"tiger stripes"*) clay; weak medium platy parting to weak medium and coarse subangular blocky structure; few iron stained rounded quartz gravel.

2BC -- 44-70 inches; red (2.5YR 4/6) and strong brown (7.5YR 5/6) clay; moderate medium platy structure; gravel line at the top of this horizon.

Classification: Clayey, mixed, thermic Typic Paleudult

Series: Caroline (discontinuity not allowed)

Table A52. Profile description of pedon:

VA-011-136-(1-4)

Location: About 3,600' west 284 degrees of the junction of VA-644 and VA-694 and 7,000' east 128 degrees south of the junction of VA-644 and VA-604.

Elevation: 760'

Landscape: broad gently sloping interfluve

Vegetation:

Slope: 0-2 percent

Remarks:

Description:

Ap -- 0-10 inches; dark brown (10YR 3/3) loam.

Bt1 -- 10-24 inches; dark yellowish brown (10YR 4/4) clay loam-clay; weak medium subangular blocky structure; friable; common subrounded quartz gravel.

Bt2 -- 24-47 inches; yellowish red (5YR 4/6) clay with strong brown (7.5YR 5/8) mottles; weak fine, medium and coarse subangular blocky structure; common rounded and subrounded quartz gravel.

2BC -- 47-80 inches; red (2.5YR 4/6) silty clay loam; weak medium and coarse angular blocky structure; quartz stringers and 10-15 percent schist channers.

Classification: Clayey, mixed, thermic Typic Hapludult

Series: Brockroad

Table A53. Profile description of pedon:

VA-011-138-(1-4)

Location: About 4,500' north 6 degrees east of the junction of VA-638 and VA-628 and 11,800' north 30 degrees east of the Junction of VA-638 and VA-691.

Elevation: 685'

Landscape: very narrow (50' wide) ridge

Vegetation:

Slope: 2-3 percent

Remarks: The lower part of the Bt2 is very compact and rejected efforts to probe; 30"-48" is very compact and too tough to get through

Description:

Ap -- 0-10 inches; yellowish brown (10YR 5/6) sandy loam; friable; non-sticky, non-plastic.

Bt1 -- 10-21 inches; yellowish red (5YR 4/6) clay with red (2.5YR 4/6) mottles; weak medium and coarse subangular blocky structure; slightly sticky, slightly plastic; few subrounded quartz pebbles.

Bt2 -- 21-30 inches; yellowish red (5YR 4/6), red (2.5YR 4/6) and light gray (10YR 7/2) clay; weak medium and coarse subangular blocky structure; slightly sticky, slightly plastic; few subrounded quartz pebbles.

Bt3 -- 30-48 inches; yellowish red (5YR 4/6), red (2.5YR 4/6) and light gray (10YR 7/2) sandy clay loam; weak medium platy structure.

Classification: Clayey, mixed, thermic Aquic Hapludult

Series: Dogue (yellowish red in the Bt not allowed)

Table A54. Profile description of pedon:

VA-011-139-(1-5)

Location: About 800' north 15 degrees east of the junction of VA-601 and VA-460 and 600' east 126 degrees south of the junction of VA-628 and VA-601.

Elevation: 715'

Landscape: gently sloping upland sampled at the summit position of a ridge

Vegetation:

Slope: 0-2 percent

Remarks: There are indications of wetness "gray colors" at the top of the Bt1 at approximately 19"-20"

Description:

Ap -- 0-8 inches; dark grayish brown (10YR 4/2) sandy loam; very friable; non-sticky, non-plastic; common angular and subrounded quartz pebbles; abrupt smooth boundary.

E -- 8-19 inches; pale brown (10YR 6/3) sandy loam very friable; non-sticky, non-plastic; common angular and subrounded quartz pebbles; clear smooth boundary.

Bt1 -- 19-38 inches; yellowish brown (10YR 5/4) sandy clay loam with strong brown (7.5YR 5/8) and pinkish gray (7.5YR 7/2) mottles; weak medium subangular blocky structure; friable; slightly sticky slightly plastic; common angular and subrounded quartz pebbles; clear smooth boundary.

Bt2 -- 38-73 inches; yellowish brown (10YR 5/4) clay with weak red (10R 4/4), strong brown (7.5YR 5/8) and pinkish gray (7.5YR 7/2) mottles; moderate medium and coarse platy parting to moderate medium and coarse subangular blocky structure; firm; sticky, slightly plastic.

2C -- 73 inches; multi colored clay; rock controlled structure; friable; slightly sticky, slightly plastic.

Classification: Clayey, mixed, thermic Aquic Paleudult
Series: Ackwater (sandy loam Ap horizon not allowed)

Table A55. Profile description of pedon:

VA-011-141-(1-4)

Location: About 1,000' south 178 degrees east of the junction of VA-630 and VA-633 and 3,600' north 16 degrees east of the junction of VA-675 and VA-630.

Elevation: 740'

Landscape: nearly level interfluve

Vegetation:

Slope: 0-2 percent

Remarks:

Description:

Ap -- 0-11 inches; dark brown (10YR 3/3) sandy loam; friable; non-sticky, non-plastic.

Bt1 -- 11-37 inches; strong brown (7.5YR 4/6) clay loam-clay with red (2.5YR 4/8) mottles; weak medium subangular blocky structure; friable; slightly sticky, slightly plastic; few subrounded quartz gravel.

Bt2 -- 37-54 inches; strong brown (7.5YR 4/6) clay; weak medium platy parting to weak medium and coarse subangular blocky structure; sticky, slightly plastic; gradual smooth boundary.

2BC -- 54-82 inches; red (2.5YR 4/8) clay with reddish yellow (5YR 6/8) mottles.

Classification: Clayey, mixed, thermic Typic Hapludult

Series: Masada

Table A56. Profile description of pedon:

VA-011-143-(1-4)

Location: About 700' east 80 degrees north of the junction of VA-641 and VA-727 and 3,100' west 265 degrees south of the junction of VA-635 and VA-460.

Elevation: 800'

Landscape: off the side slope of a gentle "finger ridge" shoulder position

Vegetation: meadow - broomsedge

Slope: 3-4 percent

Remarks: Beginning to rain

Description:

Ap -- 0-8 inches; very dark grayish brown (10YR 3/2) sandy loam-loam.

BE -- 8-18 inches; dark gray (7.5YR 4) clay loam; weak medium subangular blocky structure; slightly sticky, slightly plastic; few rounded quartz pebbles.

Bt1 -- 18-28 inches; strong brown (7.5YR 4/6) clay with red (2.5YR 4/6) mottles; weak medium subangular blocky structure.

Bt2 -- 28-68 inches; strong brown (7.5YR 4/6) sandy clay loam-sandy clay with pinkish gray (7.5YR 7/2) mottles; weak medium subangular blocky structure.

Classification: Clayey, mixed, thermic Aquic Hapludult

Series: Dogue

Table A57. Profile description of pedon:

VA-011-133-(1-4)

Location: About 3,700' north 3480 degrees west of the junction of VA-638 and VA-727 and 5,600 south 175 degrees east of the junction of VA-694 and VA-727.

Elevation: 725'

Landscape: Gently sloping interstream divide - sampled at the most stable point on the ridge

Vegetation: pasture

Slope: 0-2 percent

Remarks: Still within the capping material at 90"

Description:

Ap -- 0-9 inches; brown (7.5YR 4/4) sandy loam.

Bt1 -- 9-17 inches; red (2.5YR 4/6) clay; moderate fine and medium subangular blocky structure; friable, slightly sticky, slightly plastic; clear smooth boundary.

Bt2 -- 17-48 inches; red (2.5YR 4/6) clay; moderate medium and coarse subangular blocky structure; friable, slightly sticky, slightly plastic; few iron stained subrounded quartz pebbles.

Bt3 -- 48-83 inches; red (2.5YR 4/6) clay loam-clay-sandy clay with yellowish red (5YR 5/6) mottles; moderate medium and coarse subangular blocky structure; friable, slightly sticky, slightly plastic.

Bt4 -- 82-90 inches; red (2.5YR 4/6) clay with yellowish red (5YR 5/6) and pinkish gray (5YR 6/2) mottles; moderate medium and coarse subangular blocky structure; friable, slightly sticky, slightly plastic.

Classification: Clayey, mixed, thermic Typic Hapludult

Series: Appomattox

Table A58. Profile description of pedon:

VA-011-137-(1-4)

Location: About 1,000' south 144 degrees east of the junction of VA-604 and VA-603 and 7,200' south 182' degrees west of the junction of VA-604 and VA-650.

Elevation: 760'

Landscape: near the top of the slope at the edge of the interfluve

Vegetation: fescue pasture

Slope: 3 percent

Remarks:

Description:

Ap -- 0-6 inches; dark yellowish brown (10YR 4/4) loam; friable; non-sticky, non-plastic.

Bt1 -- 6-18 inches; strong brown (7.5YR 4/6) clay loam; weak medium subangular blocky structure; friable; sticky, slightly plastic.

Bt2 -- 18-47 inches; red (2.5YR 4/8), strong brown (7.5YR 5/6) and yellowish brown (10YR 5/4) ("*tiger stripes*") clay; weak medium platy parting to moderate fine and medium subangular blocky structure; sticky, slightly plastic; few schist fragments.

2BC -- 47-75 inches; red (2.5YR 5/8) clay loam with yellow (10YR 7/6) mottles; weak medium subangular blocky structure; sticky, slightly plastic; few angular quartz and schist fragments.

Classification: Clayey, mixed, thermic Typic Hapludult

Series: Catharpin

Table A59. Profile description of pedon:

VA-011-140-(1-4)

Location: About 3,100' south 168 degrees east of the junction of VA-633 and VA-460 and 6,600' east 118' degrees south of VA-630 and VA-633.

Elevation: 725'

Landscape: summit position - broad ridge top

Vegetation: cut-over pine with hardwoods

Slope: 3 percent

Remarks: capping is thinner here

Description:

Ap -- 0-10 inches; yellowish brown (10YR 5/4) loam;.

Bt1 -- 10-25 inches; strong brown (7.5YR 5/6) clay; friable, slightly sticky slightly plastic.

Bt2 -- 25-35 inches; red (2.5YR 4/6) clay; friable, slightly sticky slightly plastic.

2Bt -- 35-70 inches; red (2.5YR 4/6) clay.

Classification: Clayey, mixed, thermic Typic Paleudult

Series: Turbeville (discontinuity not allowed, kandic)

Table A60. Profile description of pedon:

VA-011-142-(1-4)

Location: About 1,200' north 3 degrees east of the junction of VA-630 and VA-460 and 4,700' east 125 degrees south of the junction of VA-634 and Va-460.

Elevation: 745'

Landscape: at the break in slope from a gently sloping interfluve (shoulder position)

Vegetation: meadow grasses

Slope: 1-2 percent

Remarks: still raining like *h*...

Description:

Ap -- 0-6 inches; brown (10YR 4/3) loam; sticky, non-plastic.

Bt1 -- 6-44 inches; red (2.5YR 4/6) clay with strong brown (7.5YR 4/6) mottles; weak medium subangular blocky structure; sticky, slightly plastic.

Bt2 -- 44-60 inches; red (2.5YR 4/6) clay with strong brown (7.5YR 4/6) mottles; weak medium subangular blocky structure; sticky, slightly plastic.

2BC -- 60-70 inches; red (2.5YR 4/6) clay with white (5YR 8/1) mottles; weak coarse subangular blocky structure.

Classification: Clayey, mixed, thermic Typic Paleudult

Series: Turbeville (discontinuity not allowed, kandic)

Table A61. Profile description of pedon:

VA-011-144-(1-4)

Location: About 1,000' east 102 degrees south of the junction of VA-26 and VA-663 and 7,700' north 5 degrees east of the junction of VA-26 and VA-615.

Elevation: 730'

Landscape: summit of a long gently sloping finger ridge

Vegetation: woodlands

Slope: 2-3 percent

Remarks:

Description:

Ap -- 0-6 inches; dark yellowish brown (10YR 4/4) loam; friable; non-sticky, non-plastic; common rounded and subrounded quartz gravels.

Bt1 -- 6-16 inches; yellowish red (5YR 4/6) clay; weak fine subangular blocky structure; friable; sticky, slightly plastic; few rounded and subrounded quartz gravels.

Bt2 -- 16-36 inches; red (2.5YR 4/6) clay; friable; moderate fine and medium subangular blocky structure; few rounded and subrounded quartz gravels.

2BC -- 36-70 inches; red (2.5YR 4/6) clay with reddish yellow (7.5YR 6/6) parent material mottles; weak medium and coarse subangular blocky structure; friable; sticky, slightly plastic.

Classification: Clayey, mixed, thermic Typic Hapludult

Series: Catharpin

Table A62. Profile description of pedon:

VA-011-145-(1-3)

Location: About 1,500' east 102 degrees south of the junction of VA-26 and VA-663 and 7,700' north 5 degrees east of the junction of VA-26 and VA-615.

Elevation: 730'

Landscape: summit position of a wide, long gently sloping finger ridge

Vegetation: meadow grasses - pasture

Slope: 2-3 percent

Remarks: sun is shining

Description:

Ap -- 0-8 inches; dark yellowish brown (10YR 4/4) clay loam; friable; non-sticky, non-plastic; common angular and subrounded quartz gravel.

Bt -- 8-33 inches; red (2.5YR 4/6) clay; moderate medium subangular blocky structure; friable; sticky, slightly plastic; few gravels at base of horizon.

2BC -- 33-53 inches; red (2.5YR 4/6) clay-clay loam with reddish yellow (7.5YR 6/6) parent material mottles; weak medium and coarse subangular blocky structure; friable; sticky, slightly plastic.

Classification: Clayey, mixed, thermic Typic Hapludult

Series: Catharpin

Table A63. Profile description of pedon:

VA-011-146-(1-3)

Location: About 4,100' west 280 degrees north of the junction of VA-608 and VA-657 and 10,300' east 930 degrees south of the junction of VA-608 and VA-26.

Elevation: 810'

Landscape: summit to shoulder position of a prominent ridge top

Vegetation: cut-over and cleared woodland

Slope: 4 percent

Remarks:

Description:

Ap -- 0-6 inches; dark brown (7.5YR 4/4) loam-sandy loam; common subrounded gravel.

Bt -- 6-40 inches; dark red (2.5YR 3/6) clay with reddish yellow (7.5YR 6/8) mottles; moderate fine and medium subangular blocky structure; friable; sticky, slightly plastic; few iron-stone and quartz gravel.

2BC -- 40-50 inches; dark red (2.5YR 3/6) clay; weak medium and coarse subangular blocky structure; friable; sticky, slightly plastic.

Classification: Clayey, mixed, thermic Typic Hapludult

Series: Appomattox (2BC not allowed)

Table A64. Profile description of pedon:

VA-011-147-(1-4)

Location: About 600' north 330 degrees west of the junction of VA-608 and VA-657 and 14,100' east 90 degrees of the junction of VA-608 and VA-26

Elevation: 845'

Landscape: side slope (200 meters from summit) on a prominent upland ridge top

Vegetation: meadow

Slope: 3 percent

Remarks:

Description:

Ap -- 0-10 inches; dark brown (7.5YR 4/2) silt loam.

Bt1 -- 10-18 inches; strong brown (7.5YR 4/6) clay loam; weak medium and coarse subangular blocky structure; friable; slightly sticky, slightly plastic; few quartz gravel.

Bt2 -- 18-60 inches; dark red (2.5YR 3/6) clay; moderate fine and medium subangular blocky structure; sticky, slightly plastic; common rounded quartz gravel.

2BC -- 60-73 inches; dark red (10R 3/6) clay; weak fine and medium subangular blocky structure.

Classification: Clayey, mixed, thermic Typic Paleudult

Series: Turbeville (kandic)

Table A65. Profile description of pedon:

VA-011- 148-(1-3)

Location: About 2,600' north 300 degrees east of the junction of VA-616 and VA-24 and 1,100' south 210 degrees west of VA-654 and VA-24.

Elevation: 820'

Landscape: shoulder position off an interstream divide

Vegetation: mixed hardwood - pine forest

Slope: 3 percent

Remarks: The lower part of the Bt2 at approximately 65" has the reticulate mottling pattern commonly associated with plinthite materials, but plinthic materials were not vertical at the site. Bored with hand auger; probe truck couldn't penetrate it.

Description:

Ap -- 0-5 inches; dark brown (7.5YR 4/4) loam; few rounded and subrounded gravels.

Bt1 -- 5-28 inches; dark red (2.5YR 3/6) clay; weak fine, medium and coarse subangular blocky structure; friable; sticky, slightly plastic; few rounded and subrounded gravels.

Bt2 -- 28-62 inches; red (10R 4/6) clay with pinkish gray (7.5YR 7/2) and strong brown (7.5YR 5/6) mottles; moderate medium platy parting to weak medium angular blocky structure; friable; sticky, slightly plastic; common rounded and subrounded gravels.

Classification: Clayey, mixed, thermic Aquic Paleudult

Series: Turbeville (chroma 2 at 28 inches not allowed, kandic)

Table A66. Profile description of pedon:

VA-011-149-(1-4)

Location: About 500' north 348 degrees west of the junction of VA-627 and VA-631 and 2,800' east 120 degrees south of the junction of VA-627 and VA-24.

Elevation: 825'

Landscape: narrow ridge top - summit position

Vegetation: cut-over hardwood forest

Slope: 0-2 percent

Remarks:

Description:

Ap -- 0-5 inches; yellowish red (5YR 4/6) clay loam.

Bt1 -- 5-21 inches; red (2.5YR 4/6) clay; moderate medium and coarse subangular blocky structure; friable; slightly sticky, slightly plastic.

2Bt2 -- 21-40 inches; red (2.5YR 4/6) clay; moderate medium subangular blocky structure; friable; slightly sticky, slightly plastic.

2BC -- 40- inches; dark red (2.5YR 3/6) clay loam; weak medium and coarse subangular blocky structure; slightly sticky, slightly plastic.

Classification: Clayey, mixed, thermic Typic Hapludult

Series: Catharpin

Table A67. Profile description of pedon:

VA-011-150-(1-4)

Location: About 3,200' north 348 degrees west of the junction of VA-24 and VA-26 and 4,600' west 281 degrees north of the junction of VA-656 and VA-24.

Elevation: 890'

Landscape: ridge top - summit position

Vegetation: meadow grasses

Slope: 0-2 percent

Remarks:

Description:

Ap -- 0-5 inches; dark brown (7.5YR 3/4) sandy loam-loam.

Bt -- 5-30 inches; red (2.5YR 4/6) clay with reddish yellow (7.5YR 6/6) mottles; moderate fine and medium subangular blocky structure; friable; slightly sticky, slightly plastic; few subrounded quartz pebbles.

2BC -- 30-45 inches; red (10R 4/6) clay; weak medium and coarse subangular blocky structure; friable; sticky, slightly plastic.

2C -- 45-75 inches; red (10R 4/6) clay loam-clay with strong brown (7.5YR 4/6) mottles; weak medium and coarse subangular blocky structure; friable.

Classification: Clayey, mixed, thermic Typic Hapludult

Series: Catharpin

Table A68. Profile description of pedon:

VA-011-151-(1-4)

Location: About 3,000' west 268 degrees south of the junction of VA-691 and VA-647 and 500' south 194 degrees west of the junction of VA-648 and VA-460.

Elevation: 845'

Landscape: on the summit of an approximately 100 meter wide finger ridge

Vegetation: edge of oak woods

Slope: 0-2 percent

Remarks:

Description:

Ap -- 0-5 inches; dark yellowish brown (10YR 4/4) sandy loam.

B -- 5-25 inches; dark red (2.5YR 3/6) clay; weak medium and coarse subangular blocky structure; friable; sticky, slightly plastic.

2BC -- 25-37 inches; red (10R 4/6) clay; weak fine and medium subangular blocky structure; sticky, slightly plastic.

2C -- 37-58 inches; red (10R 4/6) sandy clay loam with reddish yellow (7.5YR 6/6) parent material mottles; rock controlled structure.

Classification: Clayey, mixed, thermic Typic Hapludult

Series: Catharpin (dark red Bt not allowed)

Table A69. Profile description of pedon:

VA-011-152-(1-3)

Location: About 1,000' west 394 degrees north of the junction of VA-691 and VA-647 and 1,900' east 83 degrees north of the junction of VA-648 and VA-460.

Elevation: 845'

Landscape: summit position at the end of a very long gently sloping ridge top

Vegetation:

Slope: 0-2 percent

Remarks: This landscape is on a finger ridge or colluvial fan that is lower in elevation than a major ridge 600 meters away. The whole portion sampled appears to be capping material (>70"). This is a very uniform material.

Description:

Ap -- 0-6 inches; dark brown (7.5YR 4/4) loam-sandy clay loam.

Bt1 -- 6-36 inches; dark red (2.5YR 3/6) clay; moderate fine and medium subangular blocky structure; friable; sticky, slightly plastic.

Bt2 -- 36-70 inches; dark red (2.5YR 3/6) clay; weak medium platy parting to weak medium subangular blocky structure; friable; sticky, slightly plastic.

Classification: Clayey, mixed, thermic Typic Paleudult

Series: Turbeville (kandic)

Table A70. Profile description of pedon:

VA-011-153-(1-3)

Location: About 7,00' east 115 degrees south of the junction of VA-691 and VA-647 and 2,350' west 242 degrees south of the junction of VA-691 and VA-643.

Elevation: 795'

Landscape: side slope - shoulder position

Vegetation: hardwood and young pine

Slope: 3-4 percent

Remarks: some sandy strata in the 2BC

Description:

Ap -- 0-10 inches; dark yellowish brown (10YR 4/4) sandy loam; common subrounded gravel.

Bt -- 10-32 inches; red (2.5YR 4/6) clay with strong brown (7.5YR 5/6) mottles in the lower part; weak fine and medium subangular blocky structure; friable; sticky, slightly plastic.

2BC -- 32-62 inches; dark red (10R 3/6) clay with red (2.5YR 5/6) mottles in the lower part;moderate coarse platy parting to moderate medium and coarse subangular blocky structure; friable; sticky, slightly plastic.

Classification: Clayey, mixed, thermic Typic Paleudult

Series: Turbeville (discontinuity not allowed, kandic)

Table A71. Profile description of pedon:

VA-011-154-(1-3)

Location: About 1,300' north 318 degrees west of the junction of VA-719 and VA-691 and 6,100' west 292 degrees north of the junction of VA-727 and VA-641.

Elevation: 845'

Landscape: very broad nearly level upland position

Vegetation: Virginia pine and black jack oak

Slope: 0-2 percent

Remarks: The material examined is capping material, but the underlying layers rejected the probe efforts. Below 44" was very compact.

Description:

Ap -- 0-10 inches; dark yellowish brown (10YR 4/4) sandy loam.

Bt1 -- 10-24 inches; red (2.5YR 4/6) clay; weak medium and coarse subangular blocky structure; friable; sticky, slightly plastic.

Bt2 -- 24-44 inches; dark red (2.5YR 3/6) clay with reddish yellow (7.5YR 6/8) mottles; weak medium platy parting to weak coarse angular blocky structure; firm; slightly sticky, slightly plastic; common angular and subrounded quartz gravel.

Classification: Clayey, mixed, thermic Typic Hapludult

Series: Appomattox

Table A72. Profile description of pedon:

VA-011-155-(1-3)

Location: About 100' north 356 degrees west of the junction of VA-631 and VA-460 and 2,100' north 319 degrees west of the junction of VA-635 and VA-460.

Elevation: 835'

Landscape: summit positionon a broad gentle interfluve

Vegetation: acorn mulch - residential lot

Slope: 2 percent

Remarks: This profile was buried under 12" over-burden fill. 14"-34" is very *"pan-like"* and compact but since we got the probe through it, no *"X"* designation is used.

Description:

Ap -- 0-14 inches; dark yellowish brown (10YR 4/4) sandy loam-loam; few subrounded gravel.

Bt1 -- 14-34 inches; mottled red (2.5YR 4/6) clay loam with strong brown (7.5YR 5/6) mottles; weak fine and medium platy parting to weak fine subangular blocky structure; very firm; slightly sticky, slightly plastic.

Bt2 -- 34-50 inches; dark red (2.5YR 3/6) clay with few strong brown (7.5YR 3/6) mottles; weak fine platy parting to weak fine subangular blocky structure; friable; slightly sticky, slightly plastic.

Classification: Clayey, mixed, thermic Typic Paleudult

Series: Turbeville (kandic)

Appendix B

Table B1. Data.

QUADRANGLE	X	Y	Elev	Size(in^2)	Landscape	Color
Appomattox	003.20	001.25	790	0.08	C	R
Appomattox	004.10	008.10	740	0.07	C	R
Appomattox	014.50	006.70	780	0.09	C	R
Appomattox	006.10	004.60	790	0.12	C	R
Appomattox	001.95	002.10	790	0.19	C	R
Appomattox	005.90	006.00	790	0.28	C	R
Appomattox	014.60	004.80	770	0.70	C	R
Appomattox	003.15	009.90	790	0.12	C	R
Appomattox	010.85	010.10	790	0.028	C	R
Appomattox	009.80	020.65	705	0.12	C	Y
Appomattox	002.50	007.75	770	0.08	C	R
Appomattox	014.45	001.80	760	0.06	C	R
Appomattox	001.50	010.10	730	0.06	C	R
Appomattox	001.30	017.60	755	0.06	C	Y
Appomattox	017.20	008.20	705	0.10	C	Y
Appomattox	000.80	008.00	720	0.05	C	R
Appomattox	016.90	009.60	725	0.12	C	Y
Appomattox	014.00	010.10	730	0.12	C	Y
Appomattox	005.65	005.05	800	0.40	C	R
Appomattox	001.95	018.05	740	0.09	C	Y
Appomattox	016.30	010.00	740	0.19	C	Y
Appomattox	004.60	015.90	740	0.07	C	Y
Appomattox	012.95	008.85	795	0.06	C	R
Appomattox	016.50	001.80	705	0.06	C	Y
Appomattox	003.50	003.45	830	0.40	C	R
Appomattox	007.40	003.70	825	0.62	C	Y
Appomattox	005.65	003.80	825	0.44	C	Y
Appomattox	007.40	001.80	835	0.13	C	R
Appomattox	005.30	000.40	890	1.08	C	R
Appomattox	007.35	006.25	865	0.20	C	R
Appomattox	003.50	012.50	820	1.0	C	Y
Appomattox	006.30	007.15	835	0.07	C	R
Appomattox	007.60	003.45	830	0.19	C	R
Appomattox	003.80	017.00	765	1.50	I	Y
Appomattox	015.15	012.30	740	3.0	I	Y
Appomattox	017.75	011.90	725	0.40	I	Y
Appomattox	013.95	015.70	700	0.12	I	Y
Appomattox	003.40	018.90	760	13.00	I	Y
Appomattox	010.70	009.05	850	0.13	I	Y
Appomattox	012.45	001.20	850	1.20	I	R

Table B1. Data (continued).

Appomattox	017.60	013.40	735	1.0	I	Y
Holiday Lake	021.45	038.15	805	0.06	C	R
Holiday Lake	021.55	038.60	860	0.06	C	R
Holiday Lake	023.60	037.30	880	0.13	C	Y
Holiday Lake	018.65	035.80	750	0.14	C	R
Holiday Lake	019.45	035.30	725	0.07	C	R
Holiday Lake	022.30	039.10	890	0.12	C	R
Holiday Lake	020.80	040.70	930	0.44	C	R
Holiday Lake	019.70	035.50	745	0.12	C	R
Holiday Lake	021.10	029.40	760	0.07	C	R
Holiday Lake	019.80	036.40	830	0.08	C	R
Holiday Lake	022.50	028.50	750	0.05	C	Y
Holiday Lake	021.70	033.80	805	0.10	C	R
Holiday Lake	021.05	033.55	800	0.14	C	R
Holiday Lake	020.80	037.15	800	0.08	C	R
Holiday Lake	021.10	037.80	820	0.13	C	R
Holiday Lake	022.30	035.20	795	0.06	C	Y
Holiday Lake	022.10	036.95	835	0.31	C	R
Holiday Lake	021.75	037.90	830	0.08	C	R
Holiday Lake	019.10	041.75	750	0.12	C	R
Holiday Lake	019.30	041.00	770	0.14	C	R
Holiday Lake	023.05	037.80	840	0.07	C	Y
Holiday Lake	021.80	029.70	805	0.40	C	R
Holiday Lake	020.10	037.50	840	0.06	C	R
Holiday Lake	022.80	038.15	840	0.06	C	Y
Holiday Lake	021.30	026.40	790	0.07	C	R
Holiday Lake	021.70	039.30	980	0.06	C	R
Holiday Lake	018.60	038.50	700	0.12	C	R
Holiday Lake	018.60	037.55	690	0.56	C	R
Holiday Lake	034.30	025.05	620	0.19	C	Y
Holiday Lake	033.95	024.40	610	0.13	C	R
Holiday Lake	019.45	031.00	830	2.10	I/	R
Holiday Lake	032.40	036.00	570	0.10	C	R
Holiday Lake	028.70	044.20	685	0.19	C	R
Holiday Lake	032.90	035.85	570	0.06	C	Y
Holiday Lake	029.20	045.00	640	0.08	C	Y
Holiday Lake	031.85	043.25	635	0.31	C	R
Holiday Lake	028.65	045.15	655	0.08	C	Y
Holiday Lake	029.00	044.70	655	0.62	C	R
Holiday Lake	027.40	034.80	745	0.08	C	R
Holiday Lake	030.20	042.65	630	0.08	C	Y
Holiday Lake	018.70	044.00	750	0.08	C	Y
Holiday Lake	028.70	045.31	680	0.08	C	Y

Table B1. Data (continued).

Holiday Lake	029.90	042.65	670	0.56	C	R
Holiday Lake	029.60	033.10	670	0.25	C	Y
Holiday Lake	026.55	036.05	760	0.22	C	Y
Holiday Lake	031.55	042.00	635	0.25	C	Y
Holiday Lake	030.10	042.25	640	0.06	C	Y
Holiday Lake	027.50	034.10	720	0.08	C	Y
Holiday Lake	029.35	043.20	675	0.62	C	Y
Holiday Lake	021.70	041.00	950	0.19	C	R
Holiday Lake	029.65	044.50	610	0.06	C	Y
Holiday Lake	029.30	038.75	700	0.08	C	Y
Holiday Lake	031.70	042.60	620	0.25	C	Y
Holiday Lake	028.40	043.00	700	0.40	C	Y
Holiday Lake	031.75	042.25	630	0.30	C	R
Holiday Lake	035.10	034.00	600	3.50	I	Y
Holiday Lake	027.10	037.60	770	1.30	I/	Y
Pamplin	031.70	008.80	650	0.1	C	Y
Pamplin	031.70	010.10	600	0.05	C	Y
Pamplin	025.20	007.50	660	0.10	C	Y
Pamplin	022.40	011.20	660	0.06	C	Y
Pamplin	035.60	016.00	600	0.13	C	Y
Pamplin	019.40	006.80	710	0.25	C	Y
Pamplin	022.70	000.90	715	0.06	C	Y
Pamplin	023.60	007.20	715	0.19	C	R
Pamplin	020.00	004.90	670	0.10	C	Y
Pamplin	030.40	007.35	630	0.06	C	Y
Pamplin	028.40	010.10	625	0.06	C	Y
Pamplin	028.70	002.40	685	0.20	C	Y
Pamplin	029.50	005.60	650	0.25	C	Y
Pamplin	018.80	007.30	720	0.4	C	Y
Pamplin	027.80	002.10	670	0.19	C	Y
Pamplin	020.40	001.60	650	0.06	I	Y
Pamplin	028.20	011.10	660	0.28	I	Y
Pamplin	032.10	009.20	660	0.18	I	Y
Pamplin	032.60	010.40	650	0.25	I	Y
Pamplin	029.20	013.40	630	0.12	I	R
Pamplin	024.80	007.40	705	0.25	I	Y
Pamplin	020.60	011.90	710	1.4	I	Y
Pamplin	020.70	007.80	730	2.5	I	Y
Pamplin	024.00	006.30	710	1.0	I	Y
Pamplin	027.20	005.40	720	6.0	I	Y
Pamplin	024.80	004.40	745	1.0	I	Y
Pamplin	018.30	009.20	730	0.12	I	Y
Pamplin	018.80	011.50	710	1.0	I	Y

Table B1. Data (continued).

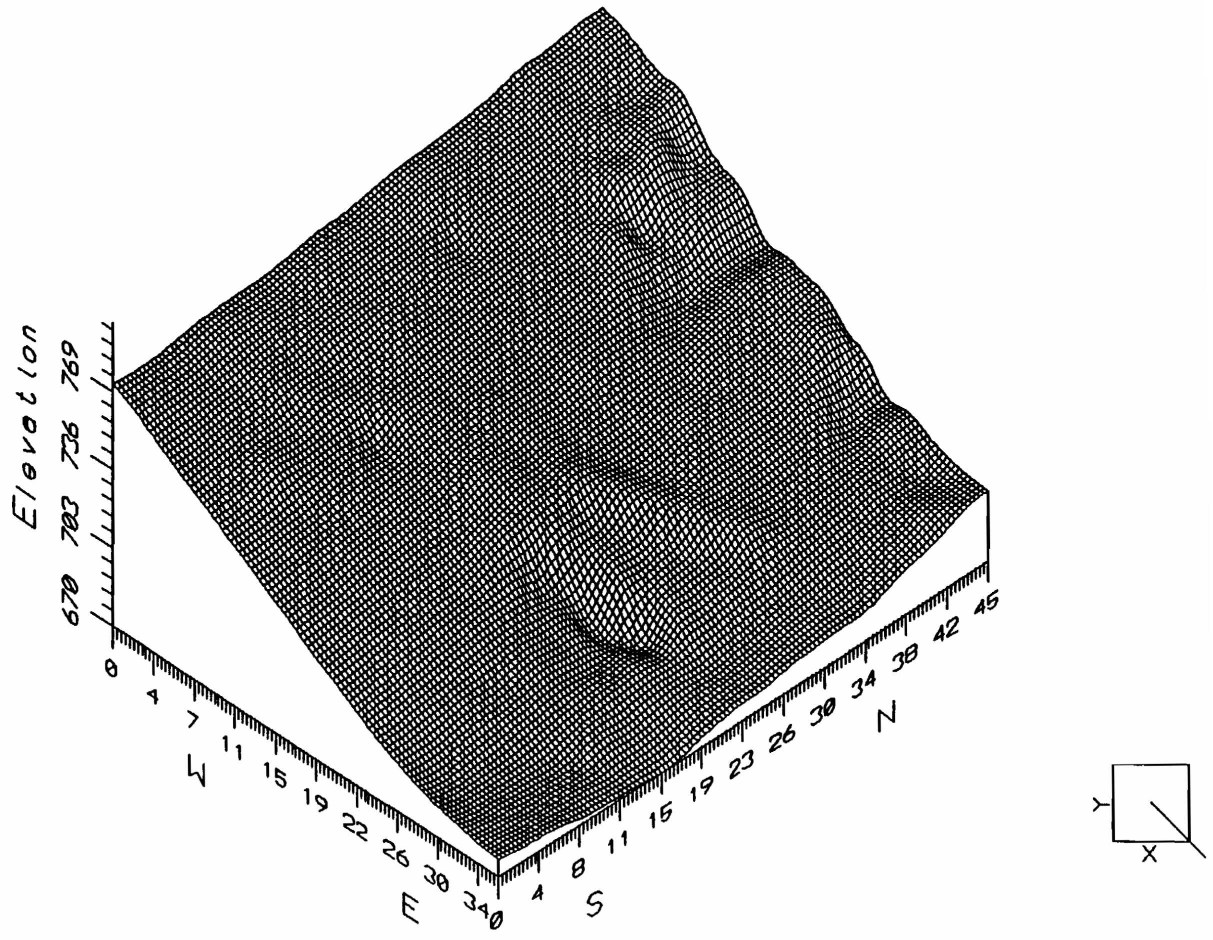
Pamplin	021.90	002.70	680	0.08	I	Y
Pamplin	021.70	008.40	700	0.31	I	Y
Pamplin	028.20	012.30	680	0.19	I	Y
Pamplin	023.50	007.20	700	0.4	I	R
Pamplin	021.10	000.90	681	0.06	I/	Y
Pamplin	030.40	018.40	630	0.13	I/	Y
Pamplin	022.80	000.20	690	0.19	I/	Y
Pamplin	030.50	017.50	620	0.06	I/	Y
Pamplin	029.20	012.60	630	0.12	I/	Y
Pamplin	031.00	017.60	620	0.19	I/	Y
Pamplin	027.80	012.80	660	0.4	I/	Y
Pamplin	022.10	000.80	710	0.12	I/	Y
Pamplin	032.80	020.80	590	0.09	I/	Y
Pamplin	032.20	019.80	605	0.19	I/	Y
Vera	008.75	027.70	830	0.50	C	R
Vera	007.50	027.80	820	0.50	C	R
Vera	017.35	024.60	700	0.07	C	R
Vera	015.00	024.55	710	0.19	C	R
Vera	005.10	023.00	880	0.35	C	R
Vera	002.20	037.05	725	0.25	C	Y
Vera	007.10	034.30	730	0.20	C	R
Vera	005.10	041.70	630	0.12	C	R
Vera	006.40	024.90	830	0.06	C	R
Vera	007.75	028.70	840	0.19	C	R
Vera	009.70	032.50	850	1.4	C	R
Vera	013.40	022.95	850	0.4	C	R
Vera	005.70	024.40	850	1.0	C	R
Vera	008.80	028.80	850	0.40	C	R
Vera	014.40	024.80	720	0.28	C	R
Vera	003.80	042.15	625	0.08	C	R
Vera	011.90	031.45	720	0.12	C	R
Vera	017.45	041.40	760	0.15	C	R
Vera	000.90	044.40	814	1.75	C	R
Vera	007.90	024.80	820	1.0	C	R
Vera	008.10	034.50	750	0.19	C	R
Vera	009.75	023.60	817	0.10	C	R
Vera	012.75	027.70	785	0.40	C	R
Vera	009.10	033.30	780	0.12	C	R
Vera	012.00	027.20	775	0.15	C	Y
Vera	004.40	041.10	680	0.12	C	R
Vera	001.00	026.05	755	0.06	C	R
Vera	008.50	025.90	770	0.08	C	R
Vera	014.00	031.25	785	0.12	C	R

Table B1. Data (continued)

Vera	002.00	039.85	670	1.0	C	R
Vera	017.50	042.45	755	0.4	C	R
Vera	008.60	033.65	770	0.13	C	R
Vera	002.60	038.35	755	0.31	C	R
Vera	014.60	031.20	785	0.9	C	R
Vera	007.25	033.70	750	0.4	C	R
Vera	001.75	037.30	750	2.0	C	R
Vera	006.20	034.20	695	0.10	C	R
Vera	008.75	027.00	790	0.09	C	R
Vera	011.45	030.90	760	0.19	C	R
Vera	007.80	032.50	810	0.09	C	R
Vera	018.00	037.50	700	0.13	C	R
Vera	003.20	041.65	640	0.12	C	R
Vera	005.60	043.00	640	0.06	C	R
Vera	003.35	041.90	640	0.15	C	R
Vera	000.30	038.35	730	0.13	C	R
Vera	011.80	026.10	800	0.06	C	R
Vera	003.65	038.50	690	0.15	C	R
Vera	004.25	038.90	655	0.12	C	Y
Vera	013.30	026.20	770	0.10	C	R
Vera	016.70	030.30	820	2.0	I	R
Vera	002.75	033.00	748	0.12	I	R
Vera	005.95	032.20	765	0.09	I/	R
Vera	001.70	028.35	720	0.09	I/	R

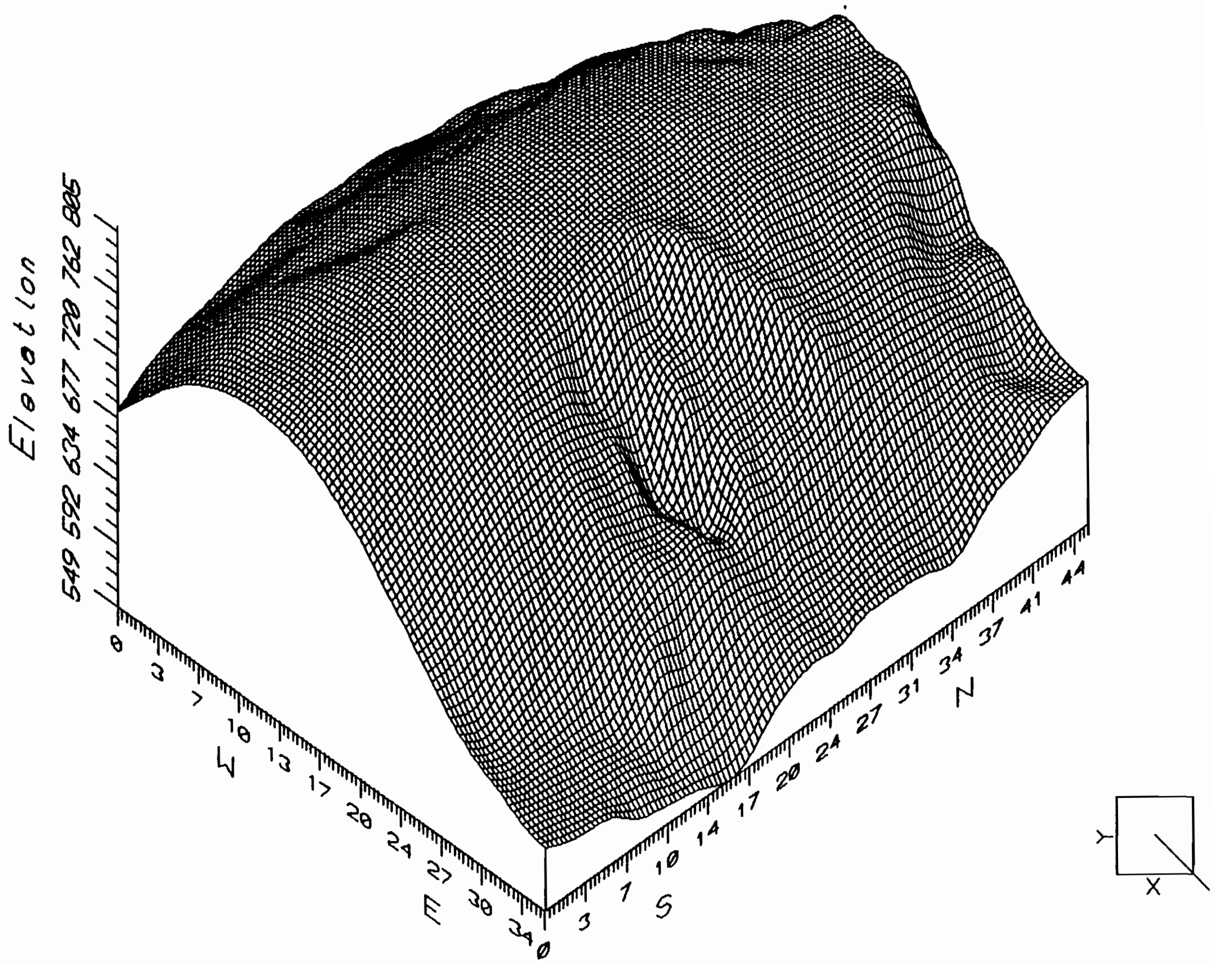
Table B2. Statistics of the significant trend surfaces.

STATISTICS OF TREND SURFACES									
Data	**Degree of Trend**	**Deviation**	**Total Variation**	**Goodness-of-Fit**	**Correlation Coeficient**	**Calculated *F* Value**	***F*** $_{\alpha.01}$ **(90%)**	***F*** $_{\alpha.001}$ **(99.9%)**	**Confidence level at which surface is significant**
All Data Points	1	1533204.16	1734676.42	0.11614	0.3408	12.49		6.91	0.999
All Data Points	2	1087771.4	173476.42	0.37293	0.61068	22.26		4.1	0.999
All Data Points	3	1057516.4	1734676.42	0.39037	0.62479	13.02		3.1	0.999
All Data Points	4	575296.07	1734676.42	0.66836	0.81753	25.67		2.59	0.999
Colluvium	1	1477692.1	1631509.11	0.09428	0.30705	8.42		6.91	0.999
Colluvium	2	1017933.1	1631509.11	0.37608	0.61325	19.29		4.1	0.999
Colluvium	3	1002905.7	1631509.11	0.38529	0.62072	10.79		3.1	0.999
Colluvium	4	501116.33	1631509.11	0.69285	0.83238	24.15		2.63	0.999
Interfluves	2	244789.74	657548	0.62772	0.79229	12.14		5.15	0.999
Interfluves	3	105188.28	657548	0.84003	0.91653	18.67		4	0.999
Interfluves	4	17918.57	657548	0.97275	0.98628	69.48		3.45	0.999
Non-Red	1	790418.67	841549.3	0.06076	0.24649	2.7	2.38		0.9
Non-Red	2	489679.75	841549.3	0.41812	0.64662	11.36		4.65	0.999
Non-Red	3	347860.73	841549.3	0.58664	0.76593	11.85		3.6	0.999
Non-Red	4	106505.13	841549.3	0.87344	0.93458	34.47		3.03	0.999
Red	2	884047.46	1182231.74	0.25222	0.50222	6.88		4.73	0.999
Red	3	805566.29	1182231.74	0.31861	0.56445	5.09		3.65	0.999
Red	4	369645.14	1182231.74	0.68733	0.82906	14.61		3.03	0.999



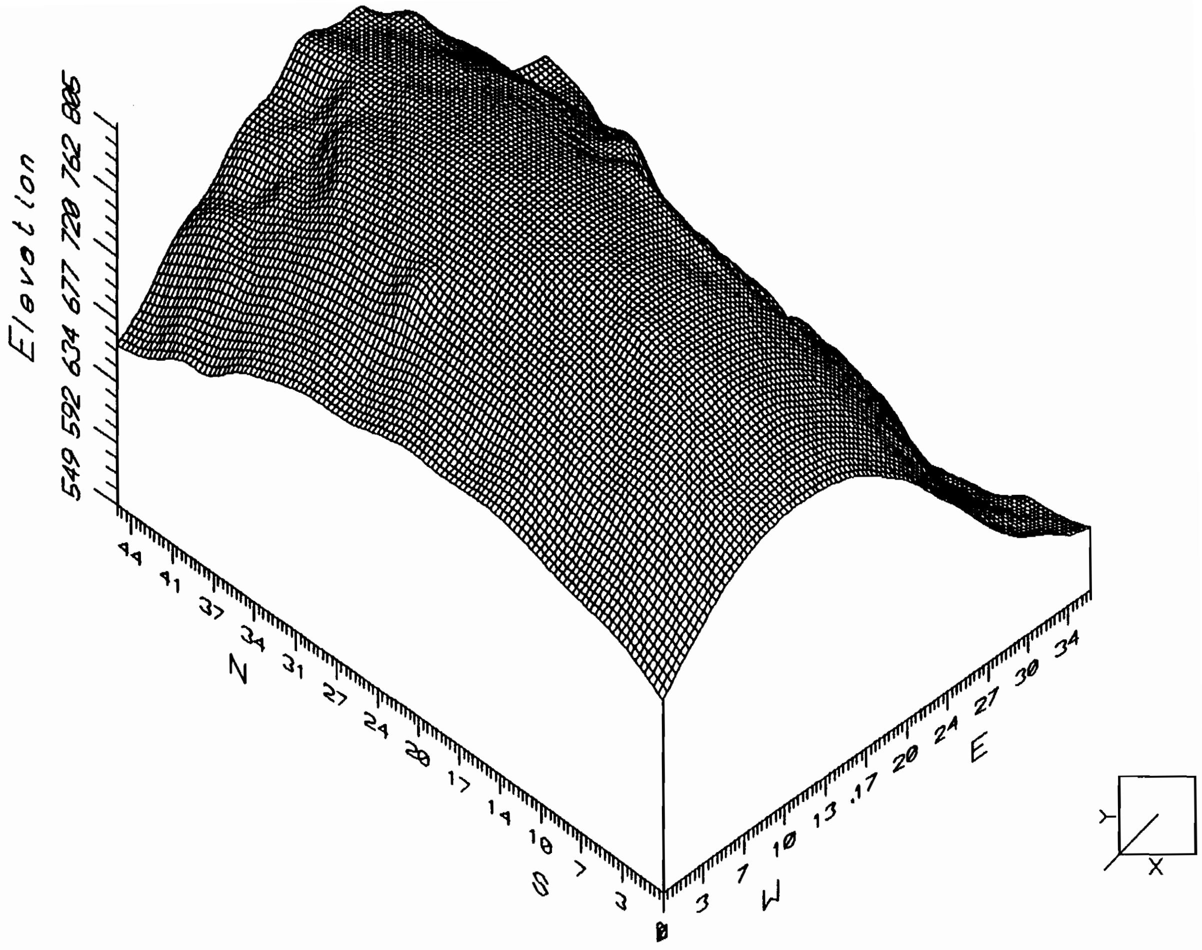
First-degree trend surface of all data points.

Figure B1. First-degree trend surface of all data points.



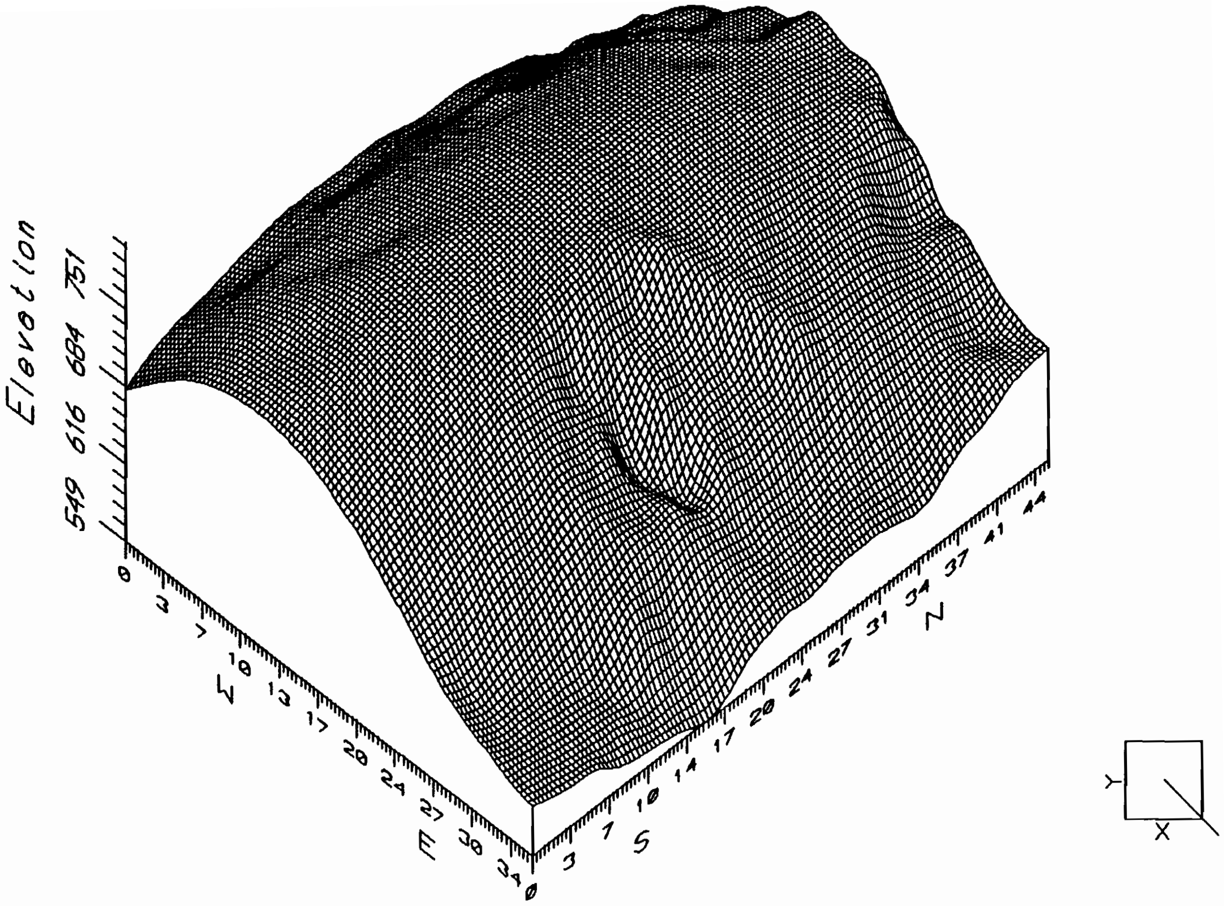
Second-degree trend surface of all data points.

Figure B2. Second-degree trend surface of all data points.



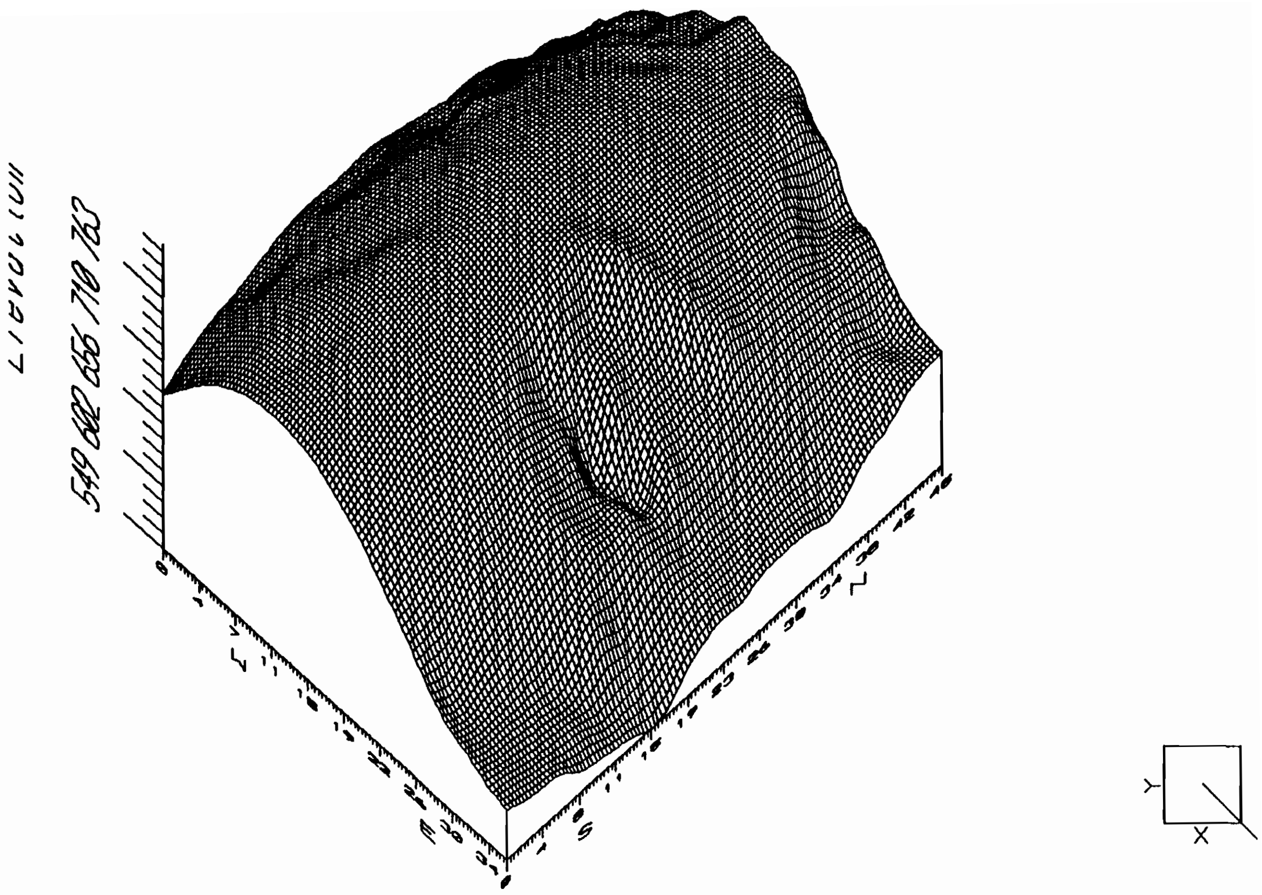
Second-degree trend surface of all data points.

Figure B3. Second-degree trend surface of all data points.



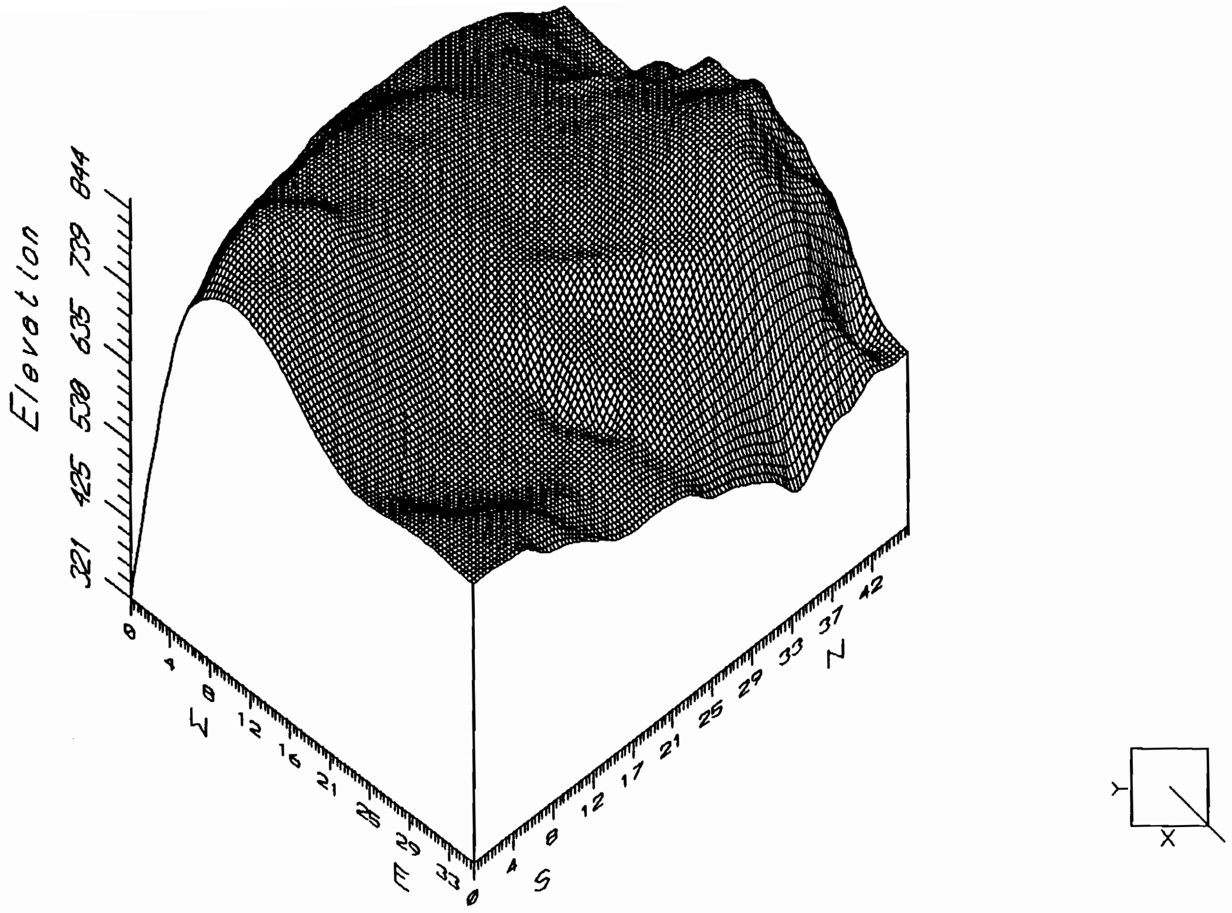
Third-degree trend surface of all data points.

Figure B4. Third-degree trend surface of all data points.



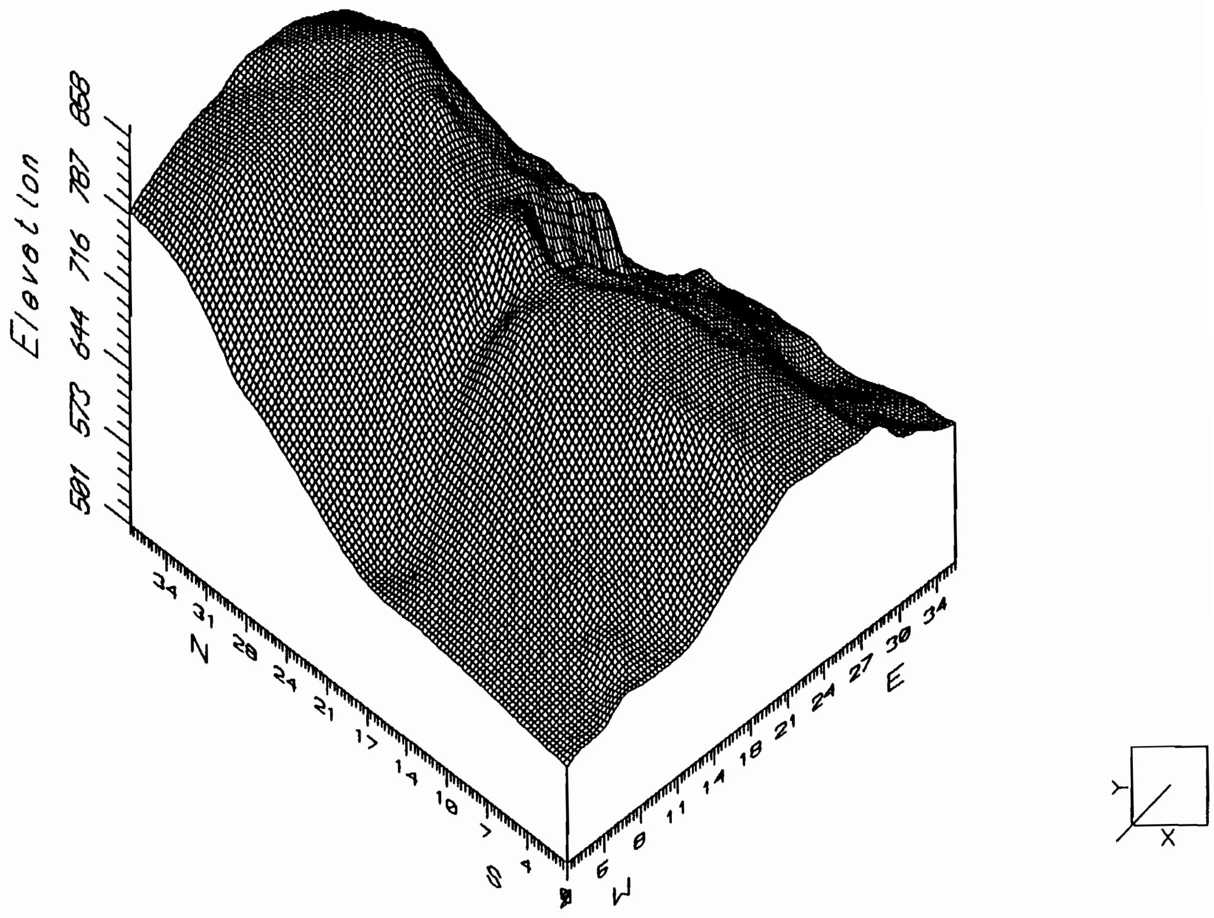
Third-degree trend surface of all data points.

Figure B5. Third-degree trend surface of all data points.



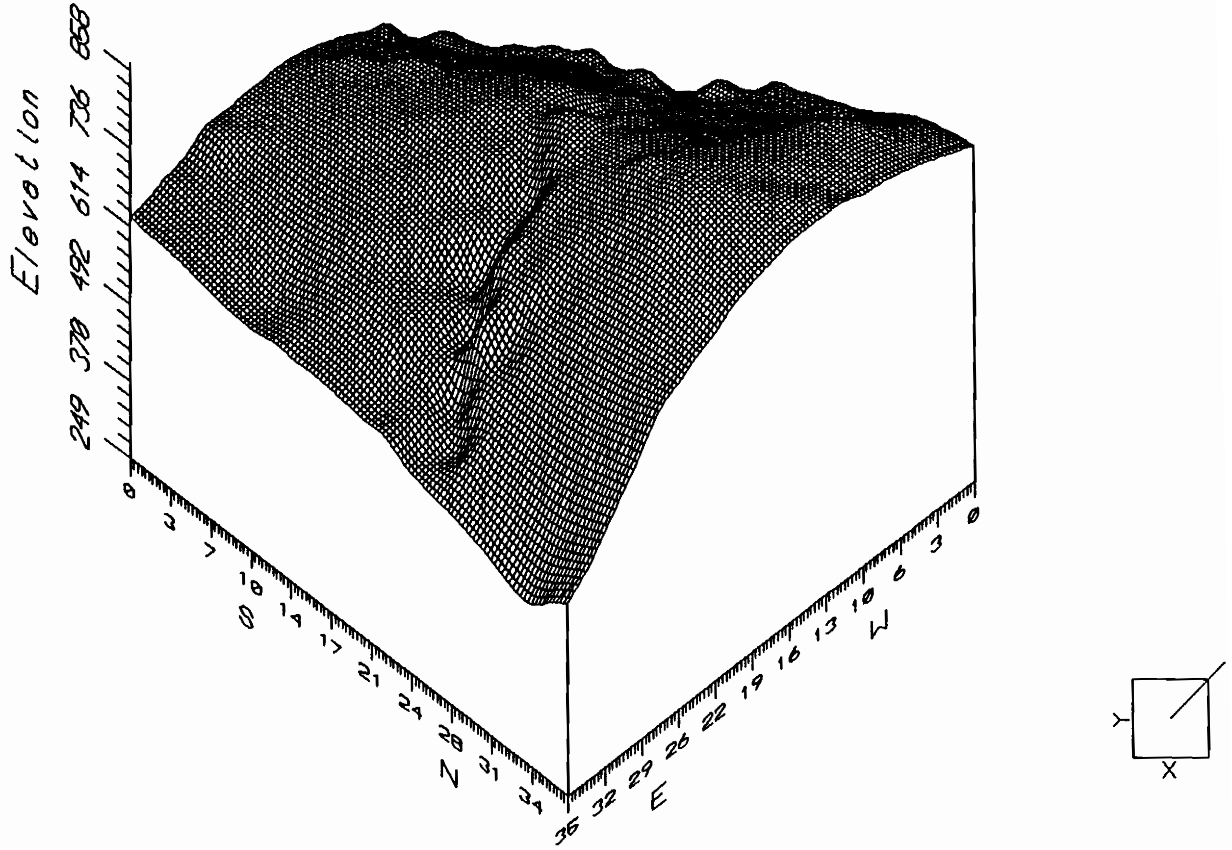
Fourth-degree trend surface of all data points.

Figure B6. Fourth-degree trend surface of all data points.



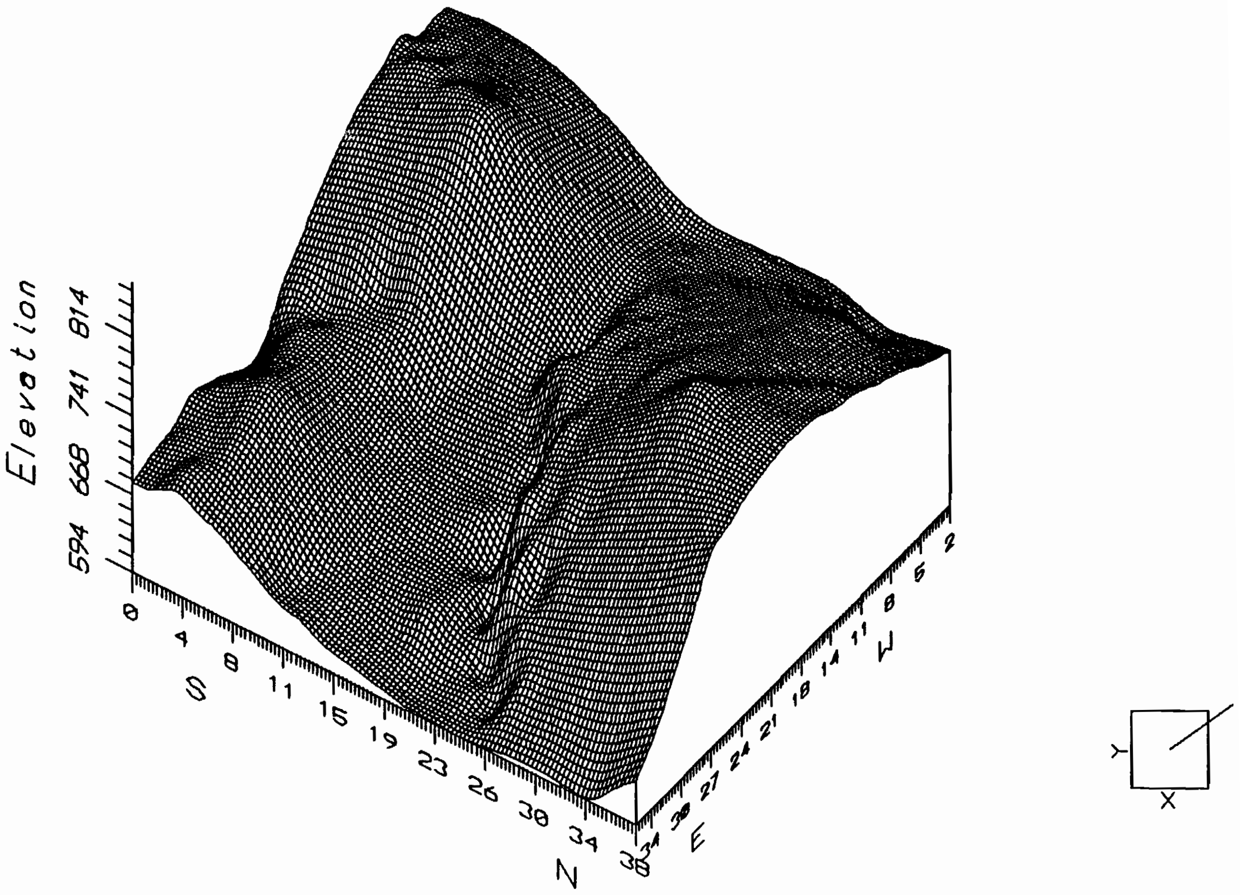
Second-degree trend surface of interfluves.

Figure B7. Second-degree trend surface of interfluves.



Second-degree trend surface of interfluves.

Figure B8. Second-degree trend surface of interfluves.



Third-degree trend surface of interfluves.

Figure B9. Third-degree trend surface of interfluves.

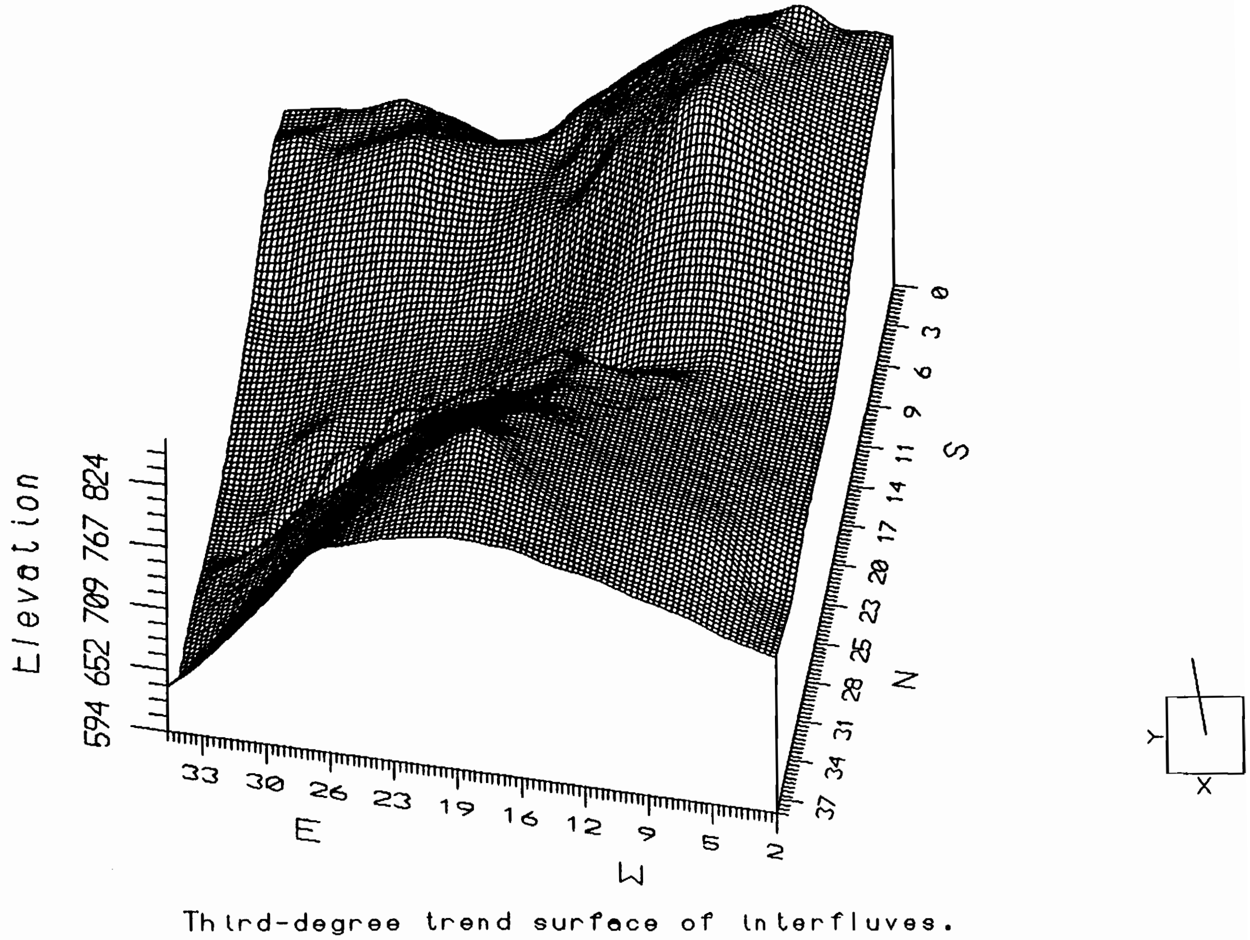
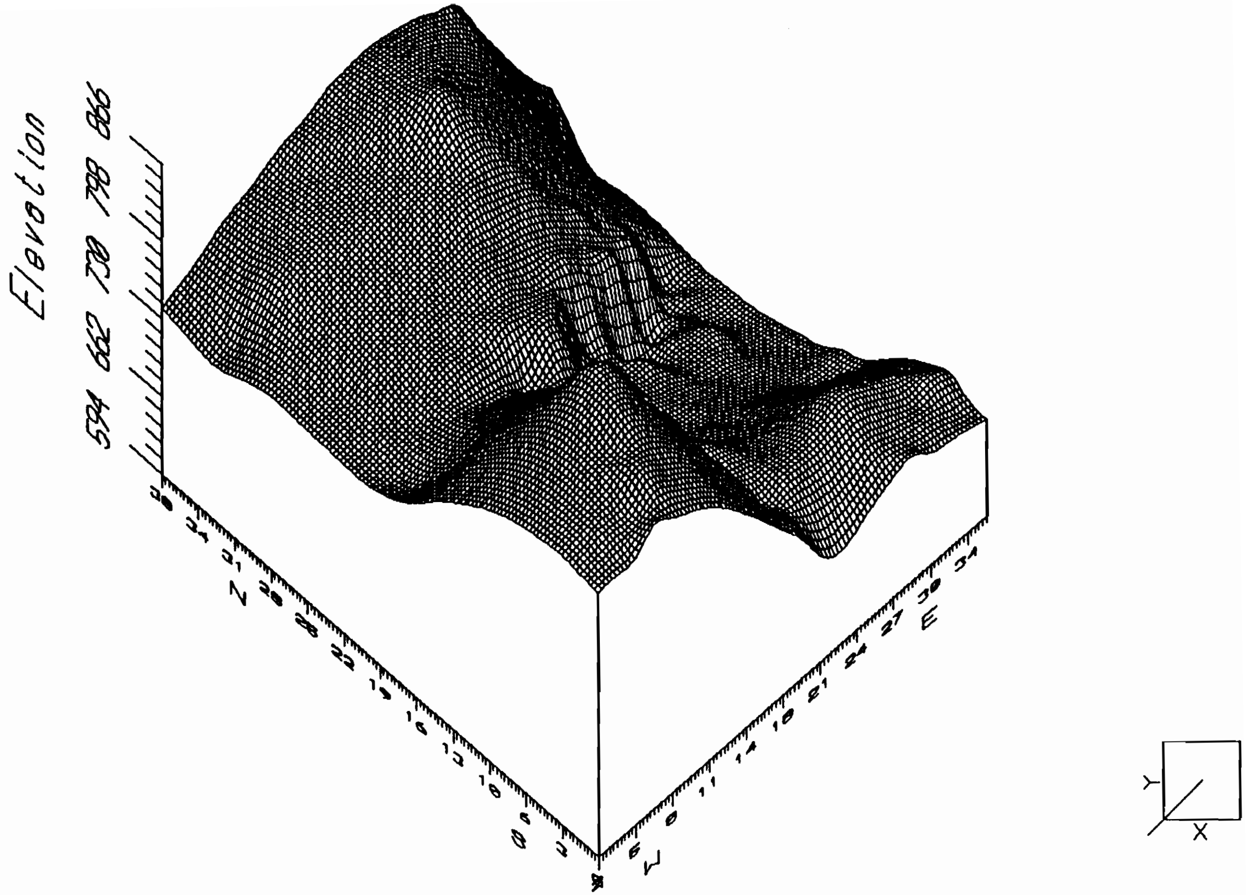
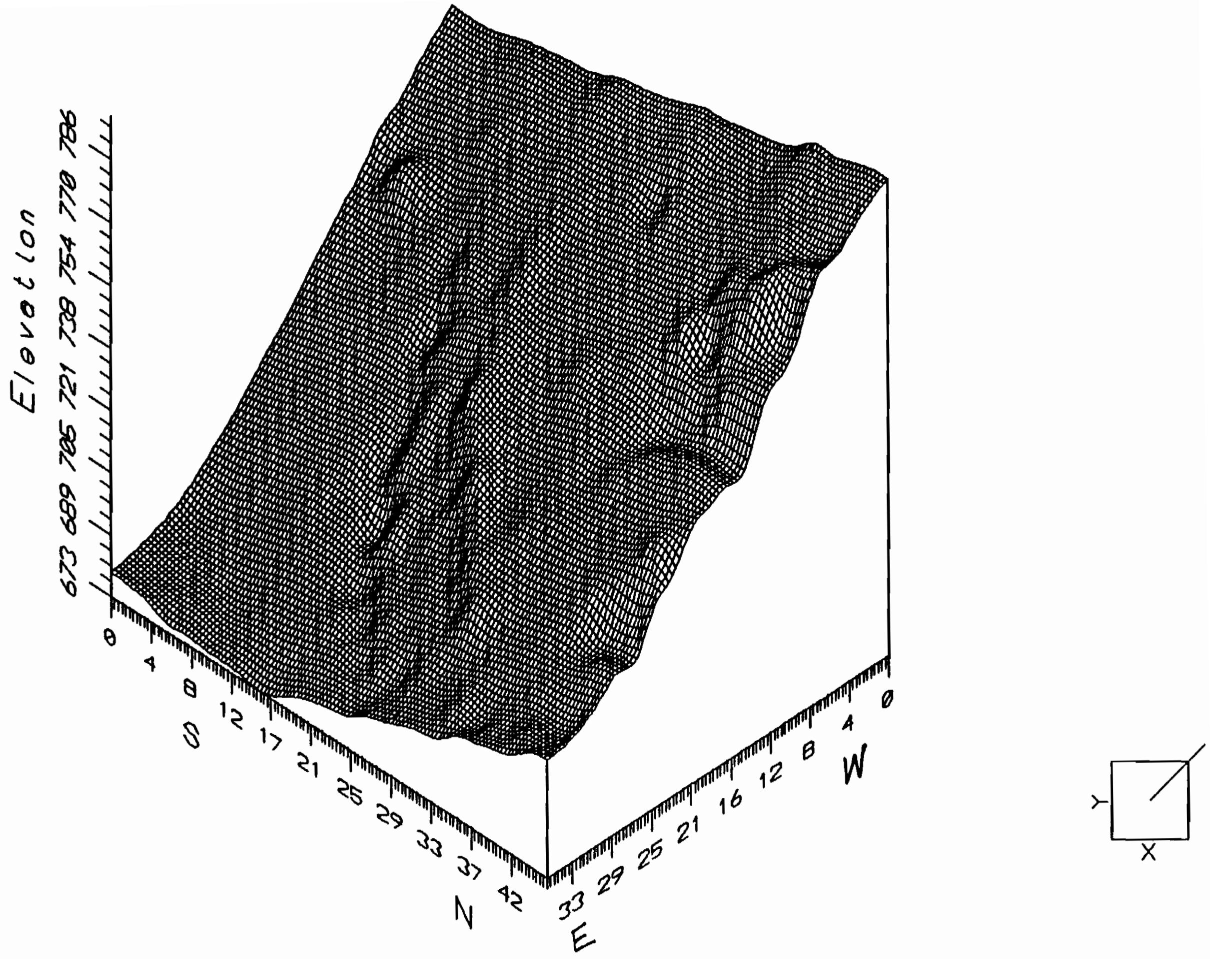


Figure B10. Third-degree trend surface of interfluves.



Fourth-degree trend surface of interfluves.

Figure B11. Fourth-degree trend surface of interfluves.



First-degree trend surface of colluvium.

Figure B12. First-degree trend surface of colluvium.

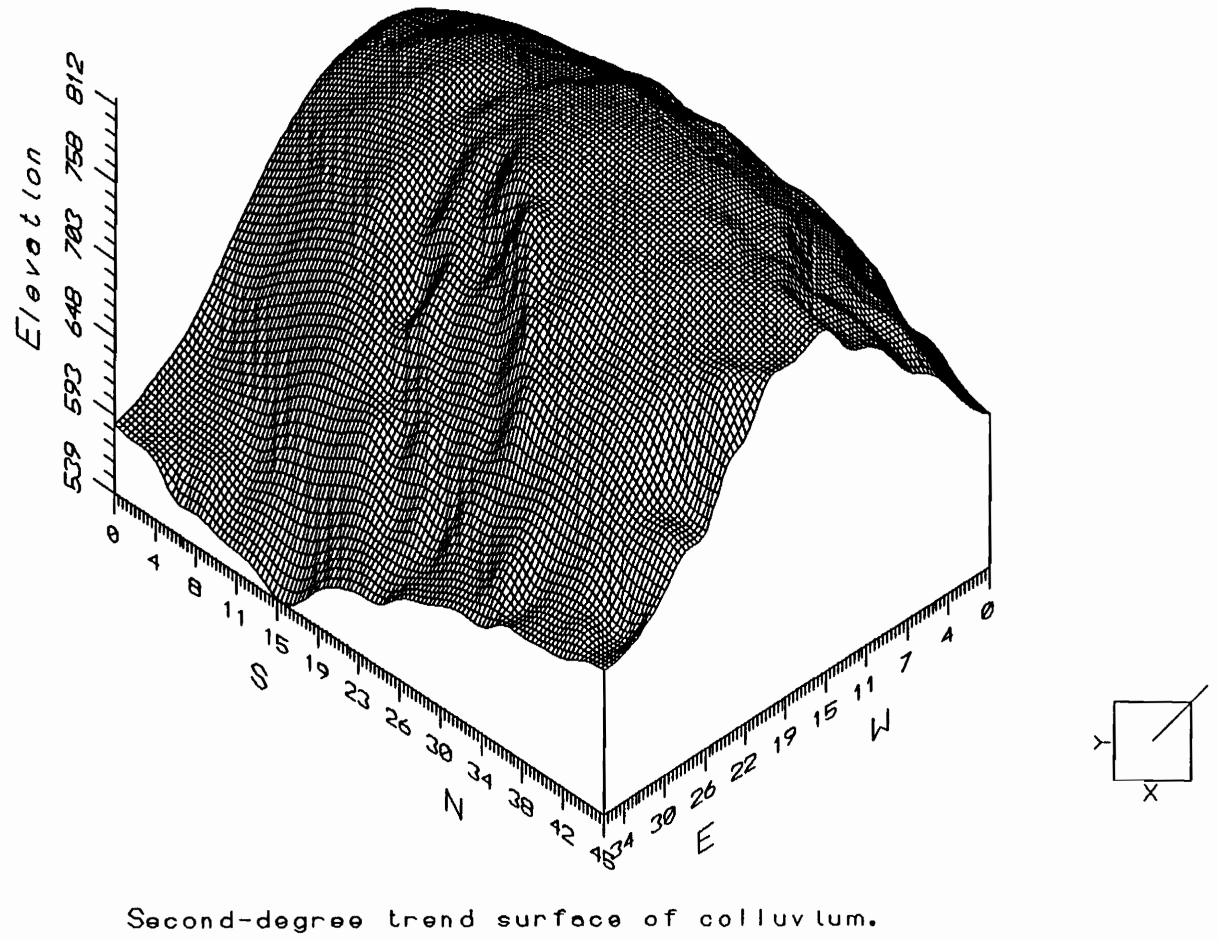
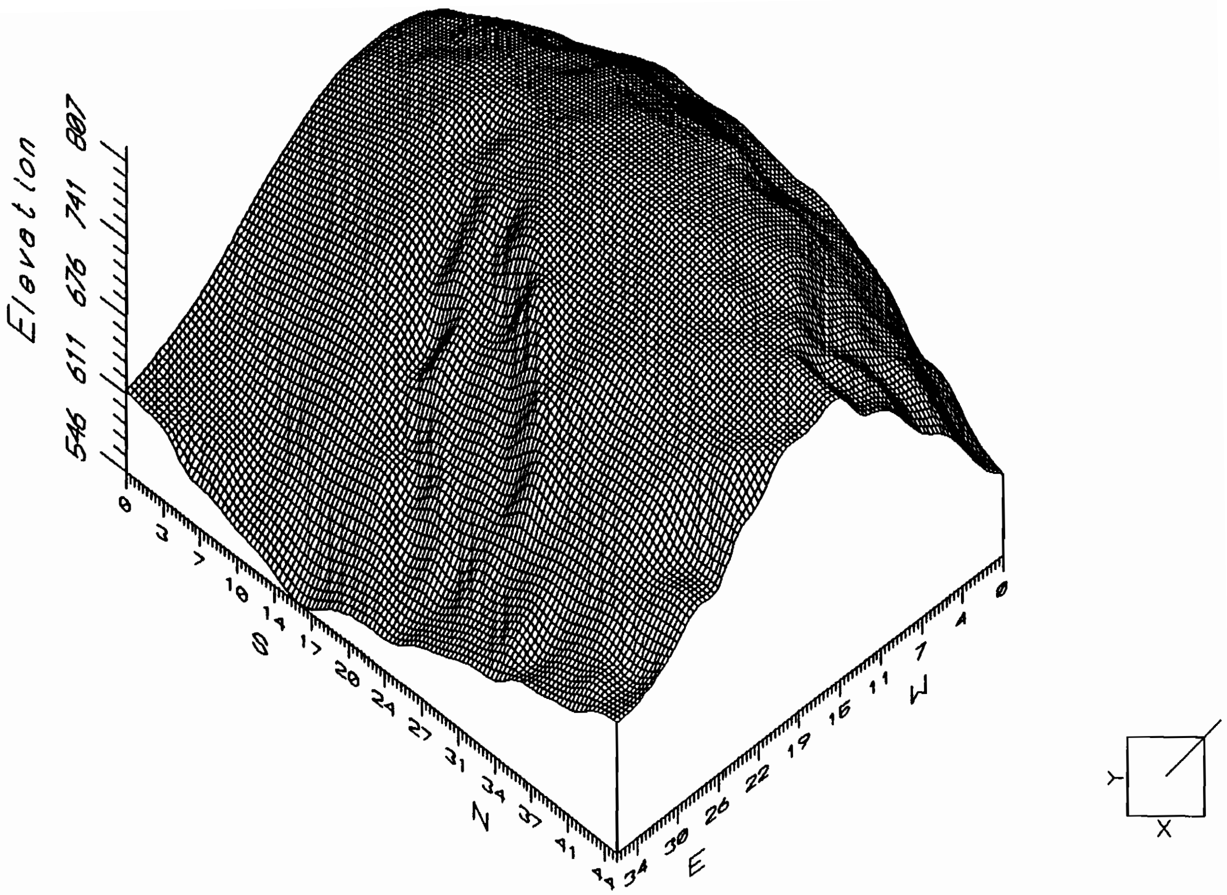
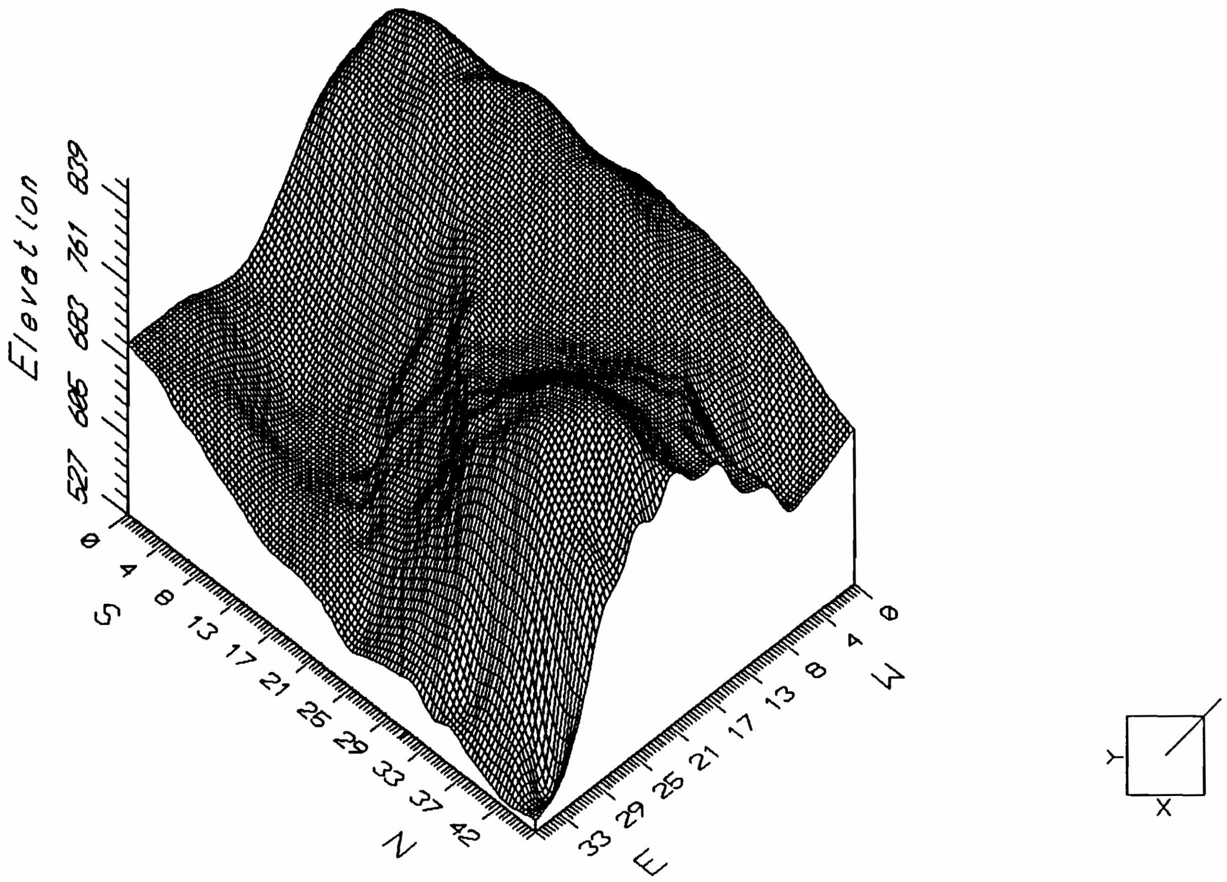


Figure B13. Second-degree trend surface of colluvium.



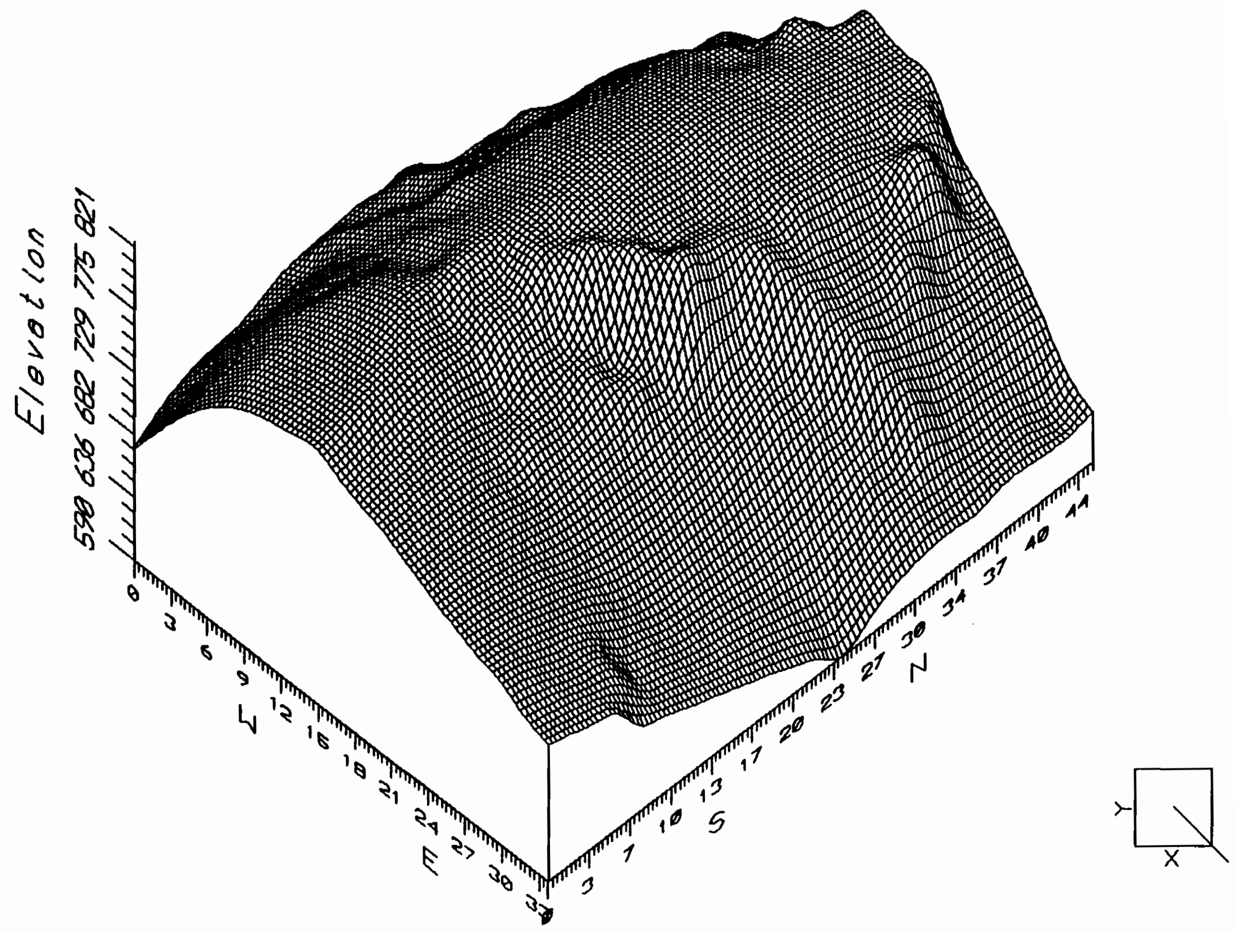
Third-degree trend surface of colluvium.

Figure B14. Third-degree trend surface of colluvium.



Fourth-degree trend surface of colluvium.

Figure B15. Fourth-degree trend surface of colluvium.



Second-degree trend surface of red soils.

Figure B16. Second-degree trend surface of red soils.

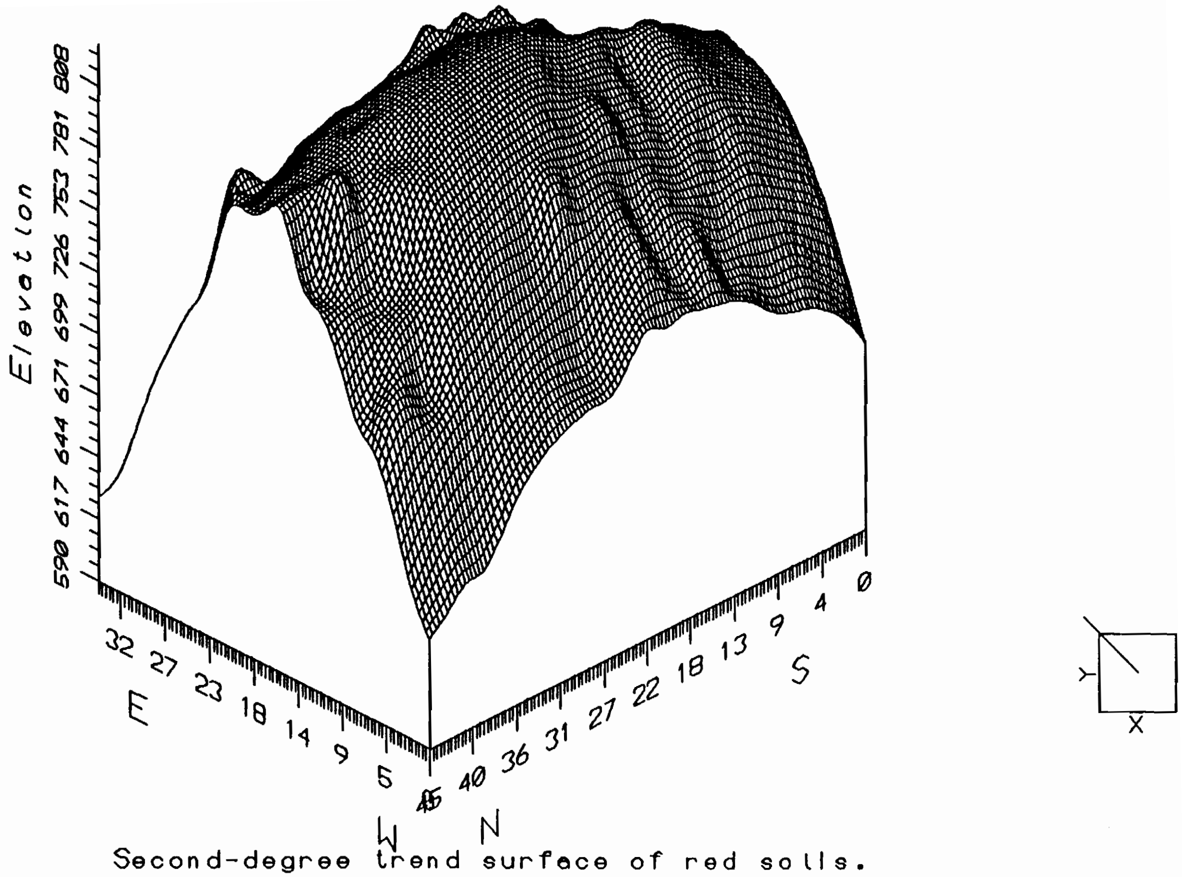
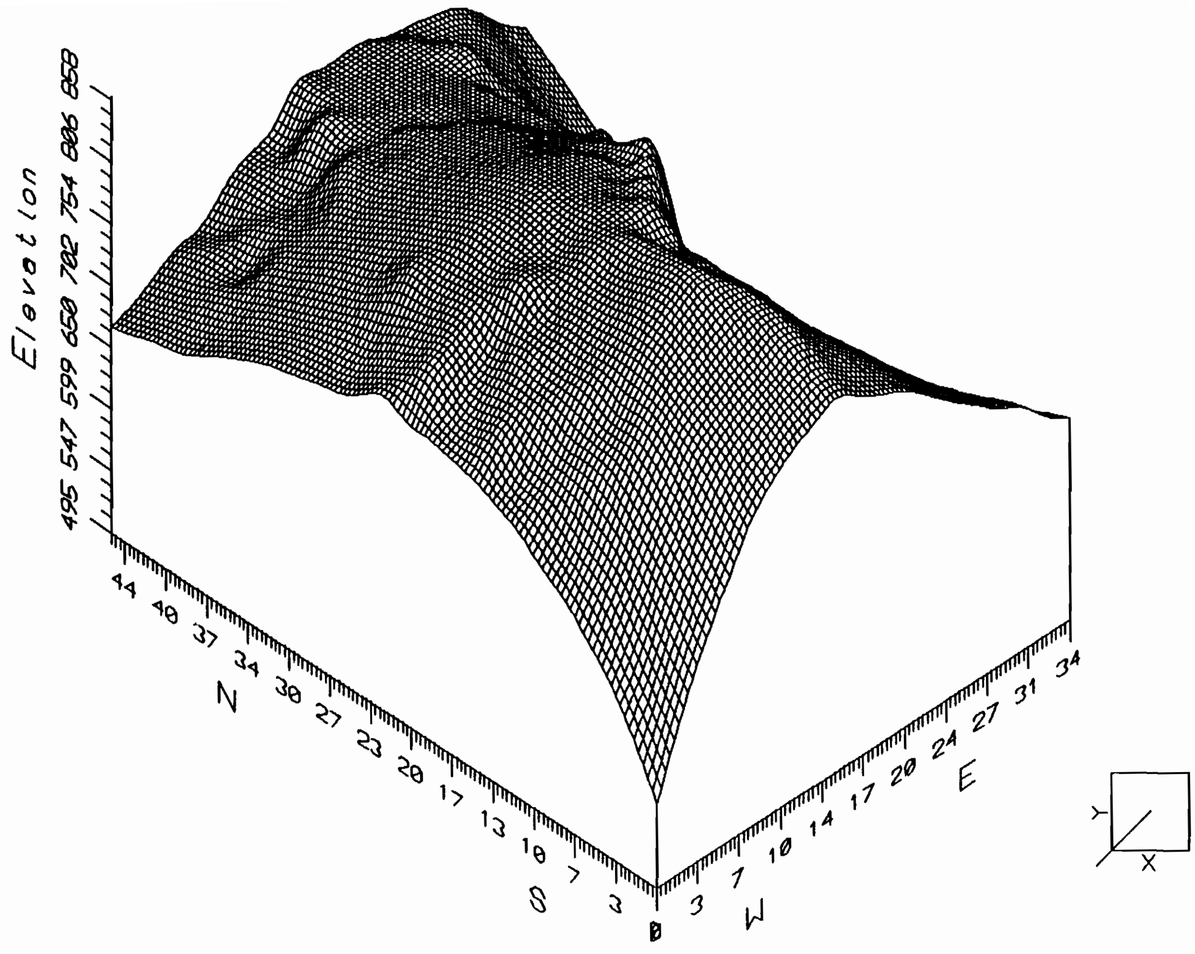
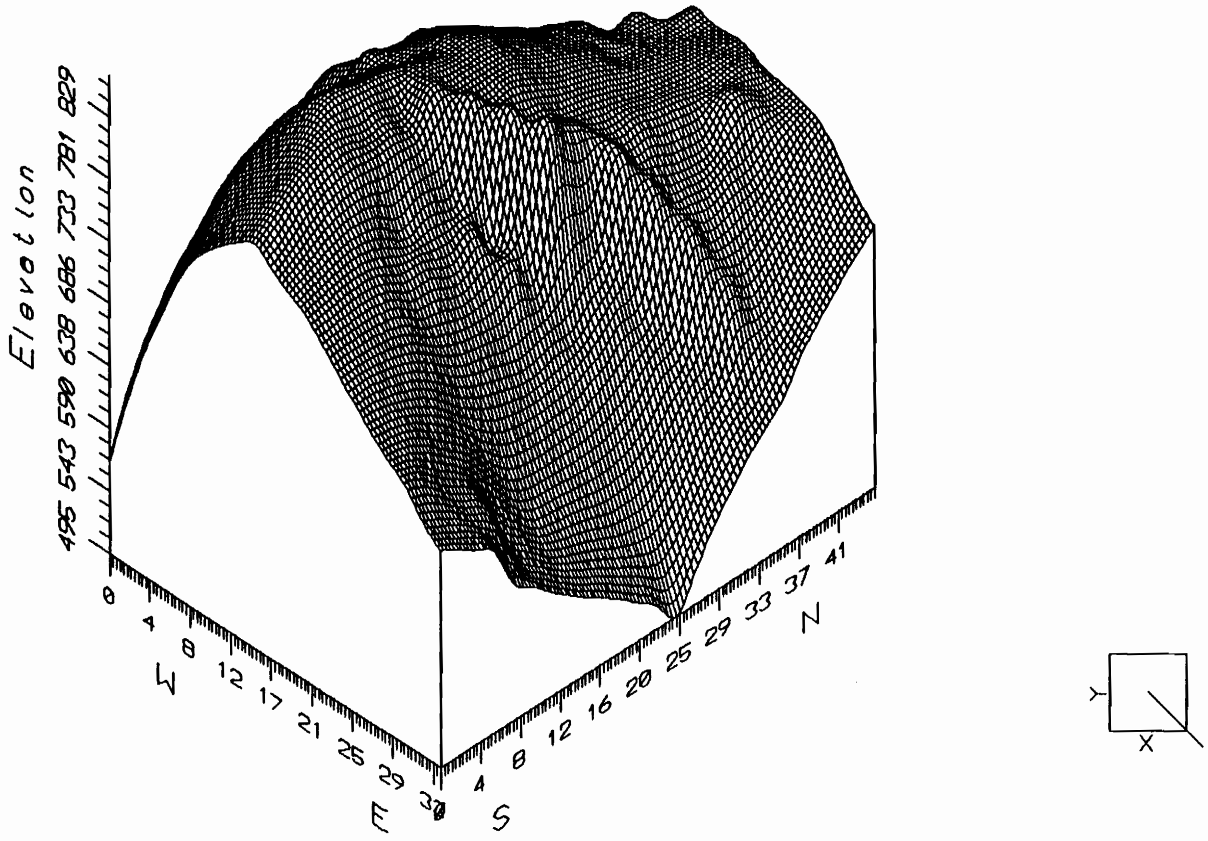


Figure B17. Second-degree trend surface of red soils.



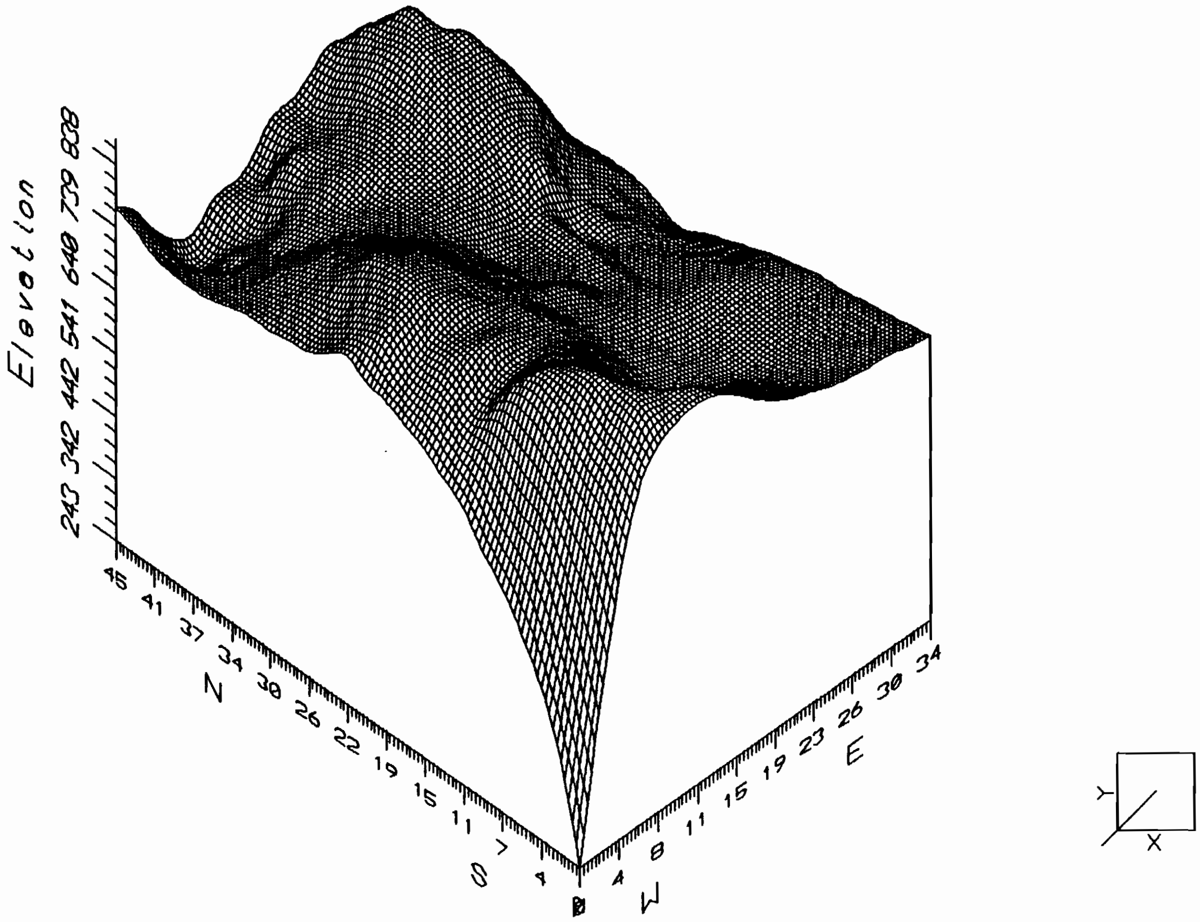
Third-degree trend surface of red soils.

Figure B18. Third-degree trend surface of red soils.



Third-degree trend surface of red soils.

Figure B19. Third-degree trend surface of red soils.



Fourth-degree trend surface of red soils.

Figure B20. Fourth-degree trend surface of red soils.

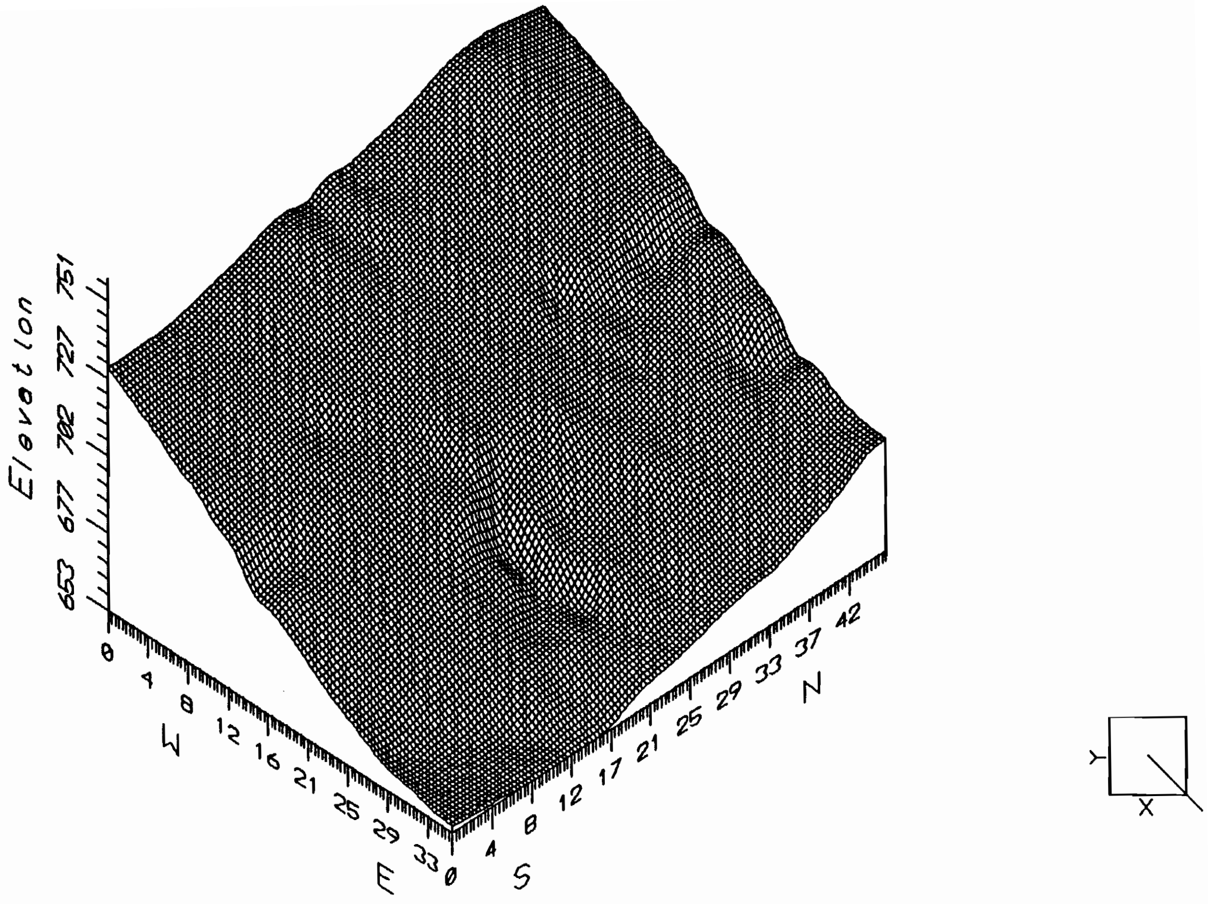


Figure B21. First-degree trend surface of non-red soils.

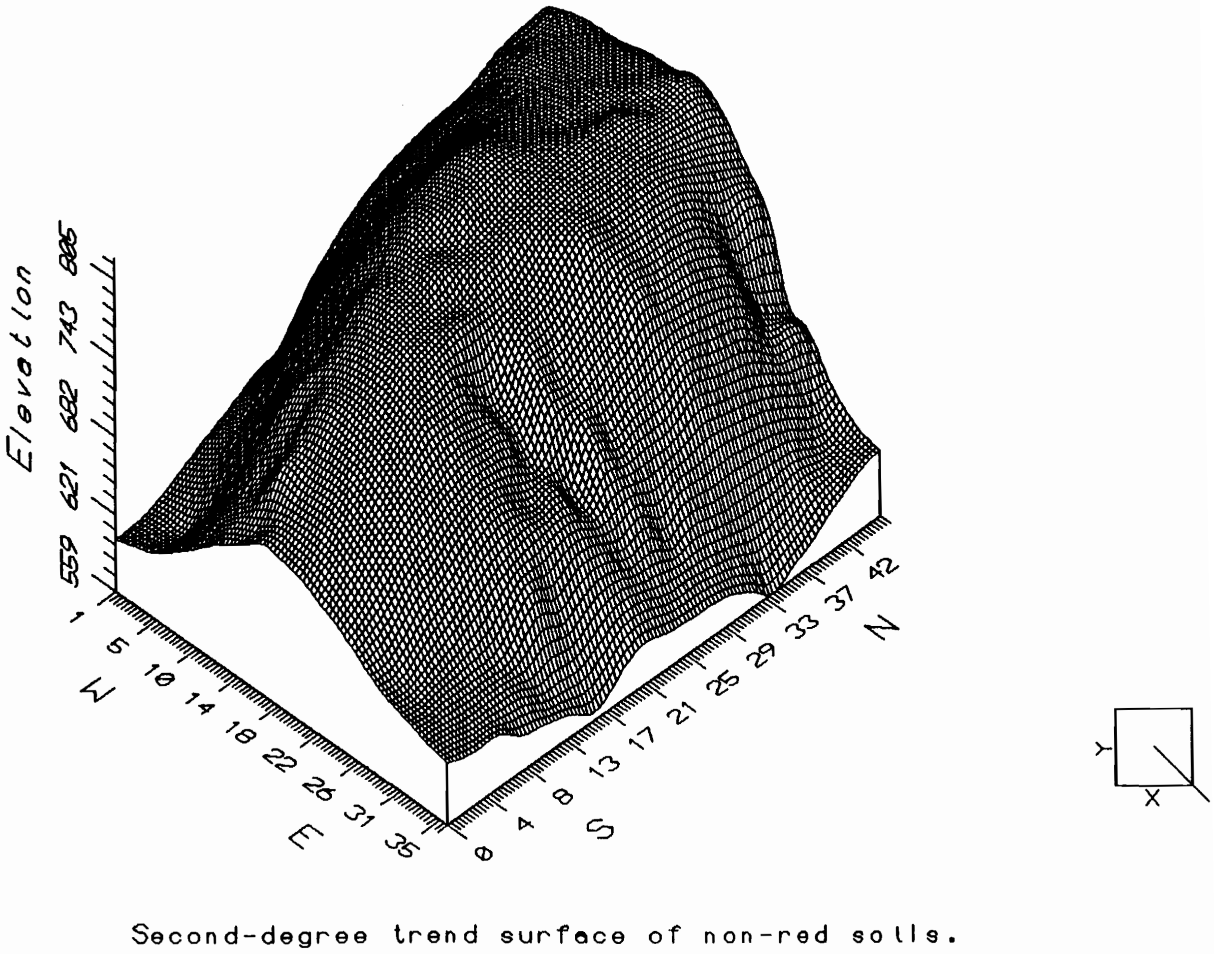
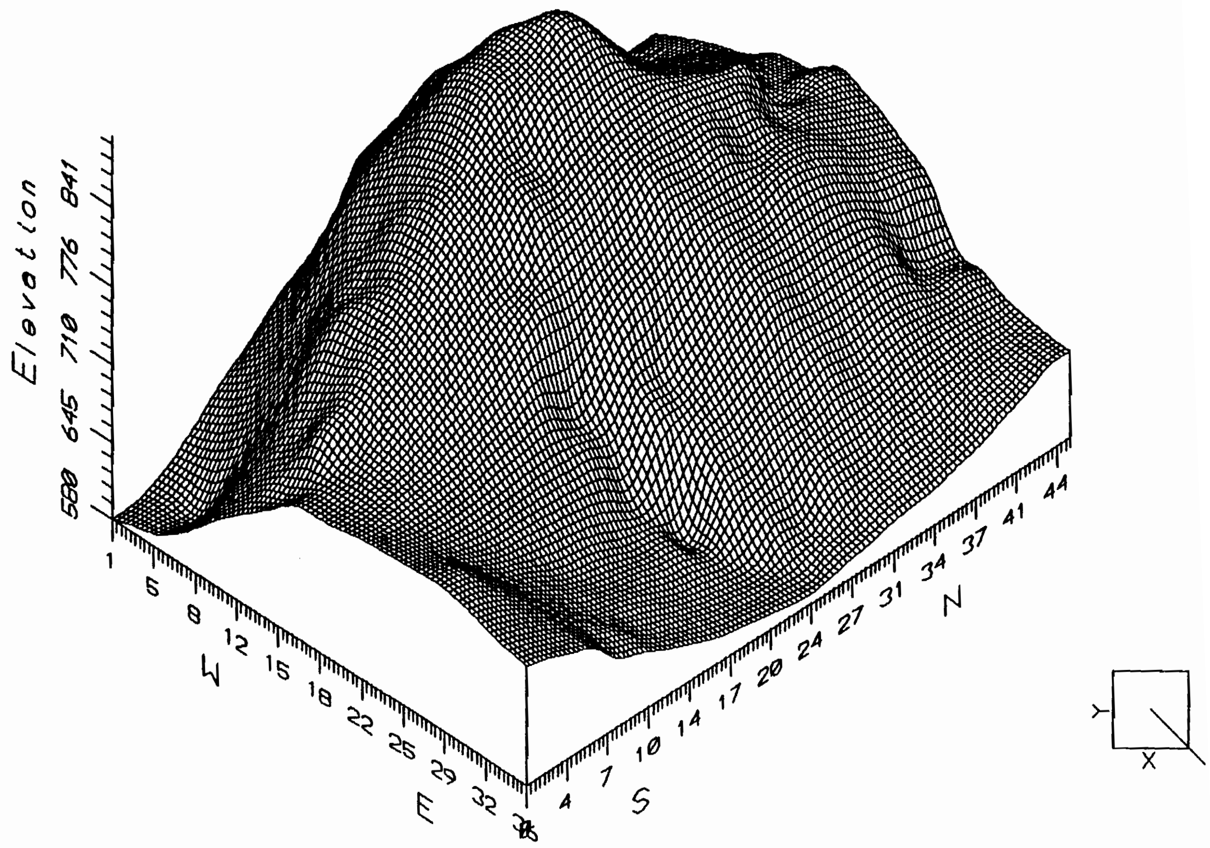
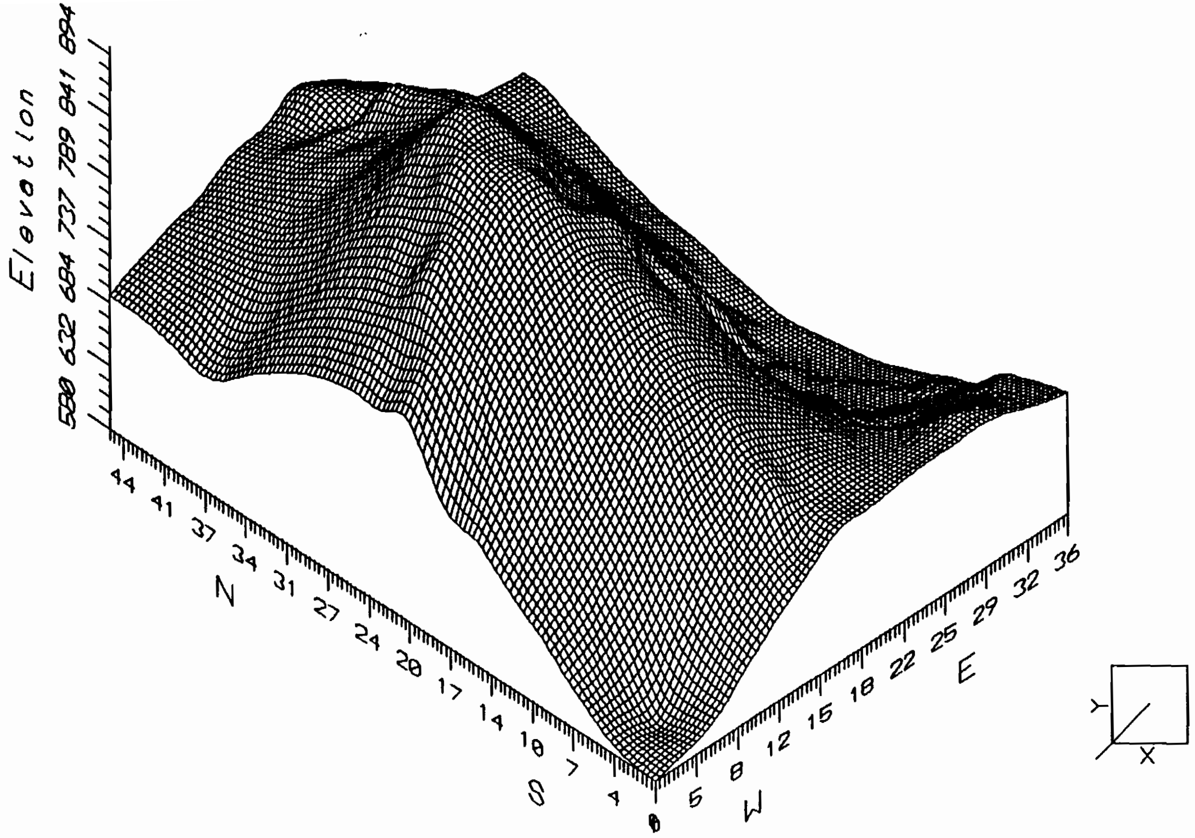


Figure B22. Second-degree trend surface of non-red soils.



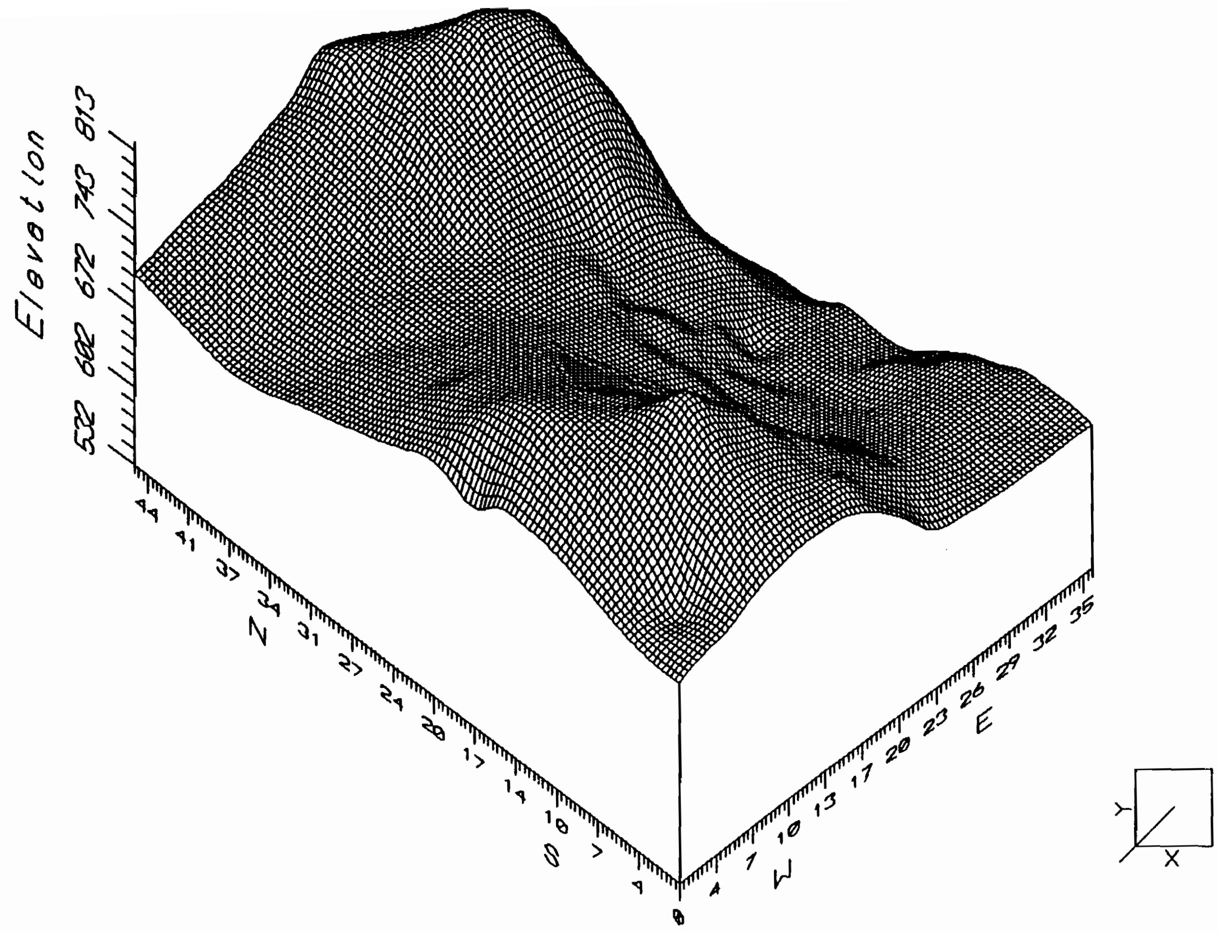
Third-degree trend surface of non-red soils.

Figure B23. Third-degree trend surface of non-red soils.



Third-degree trend surface of non-red soils.

Figure B24. Third-degree trend surface of non-red soils.



Fourth-degree trend surface of non-red soils.

Figure B25. Fourth-degree trend surface of non-red soils.

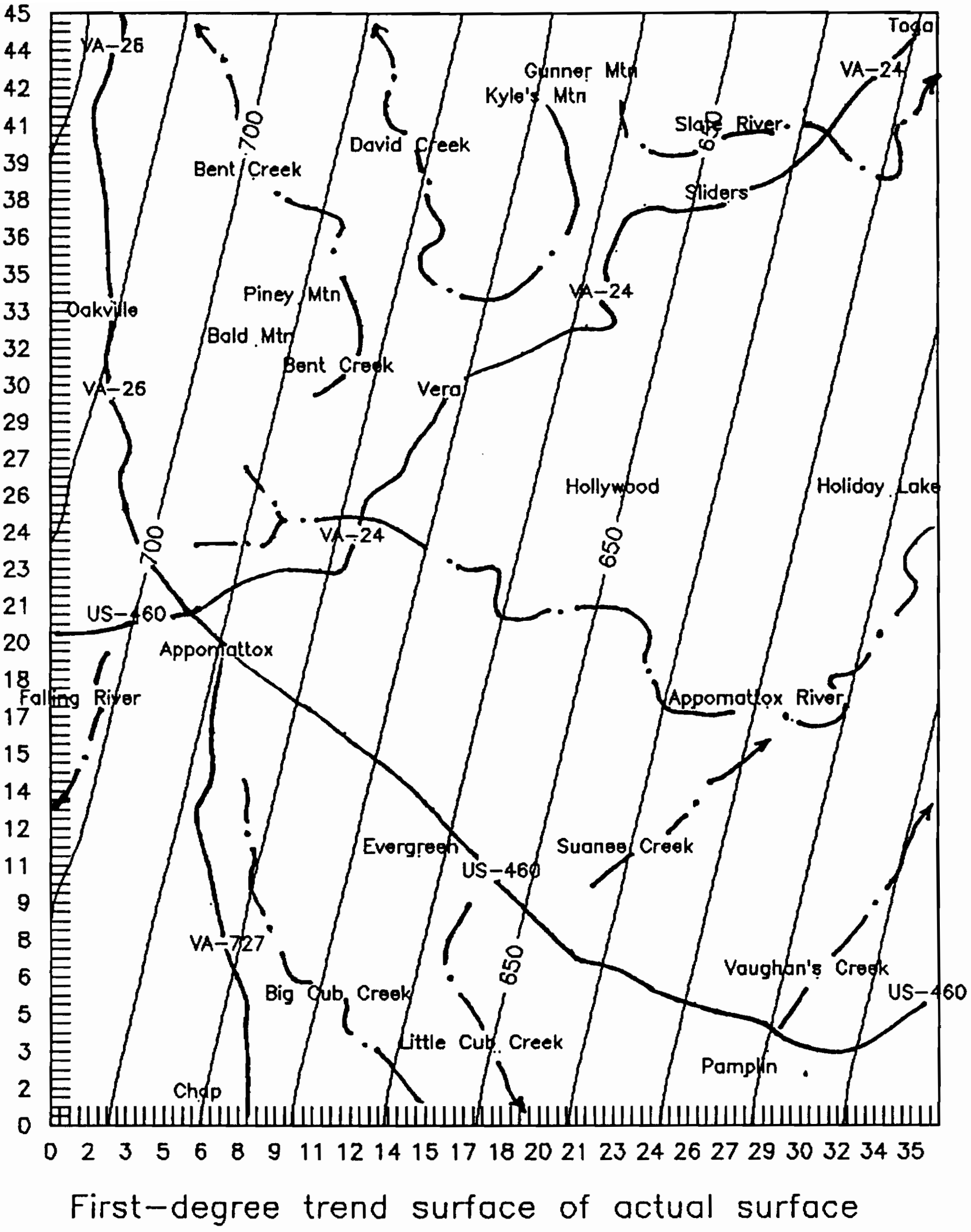


Figure B26. First-degree trend surface of the actual surface.

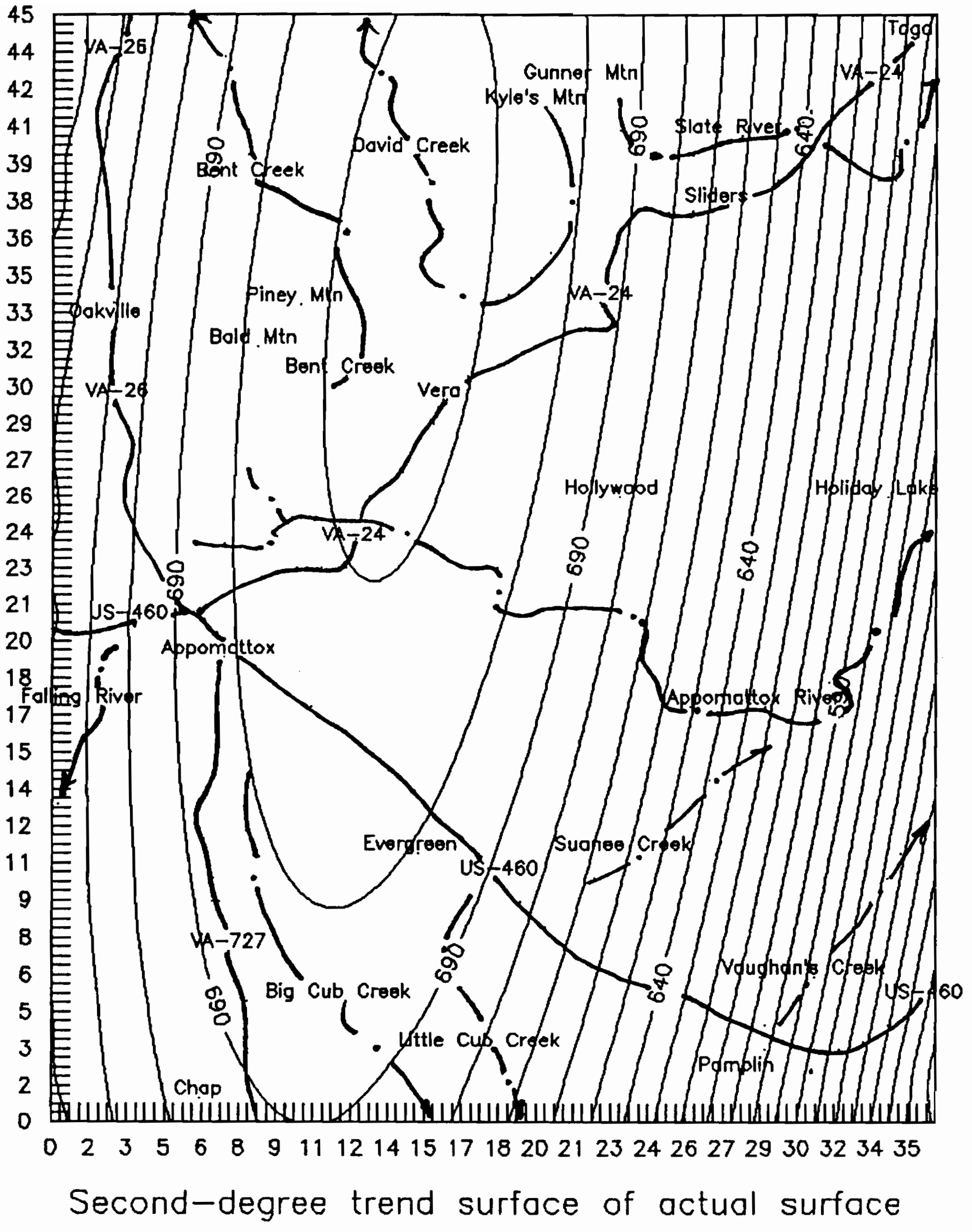


Figure B29. Second-degree trend surface of the actual surface.

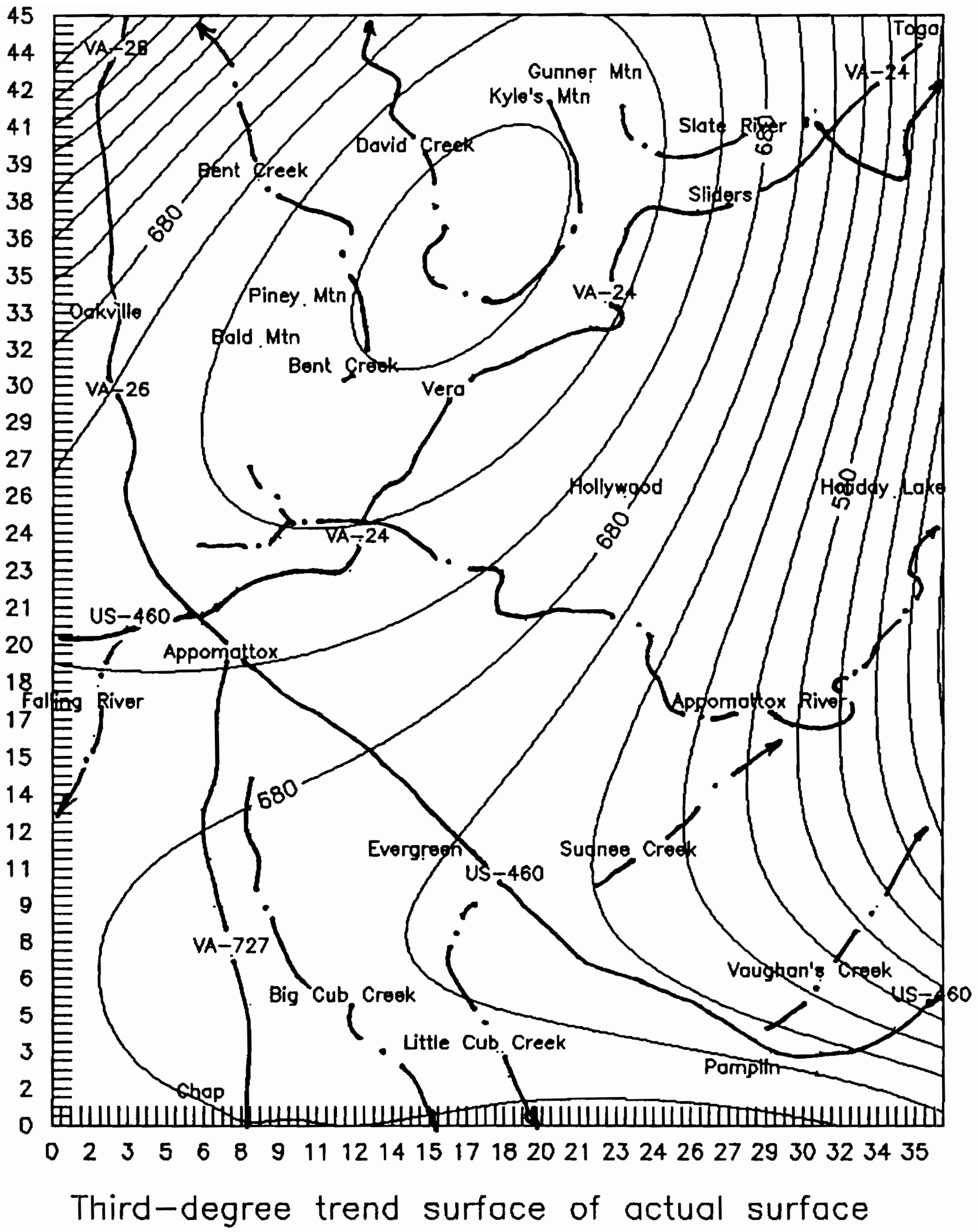


Figure B28. Third-degree trend surface of the actual surface.

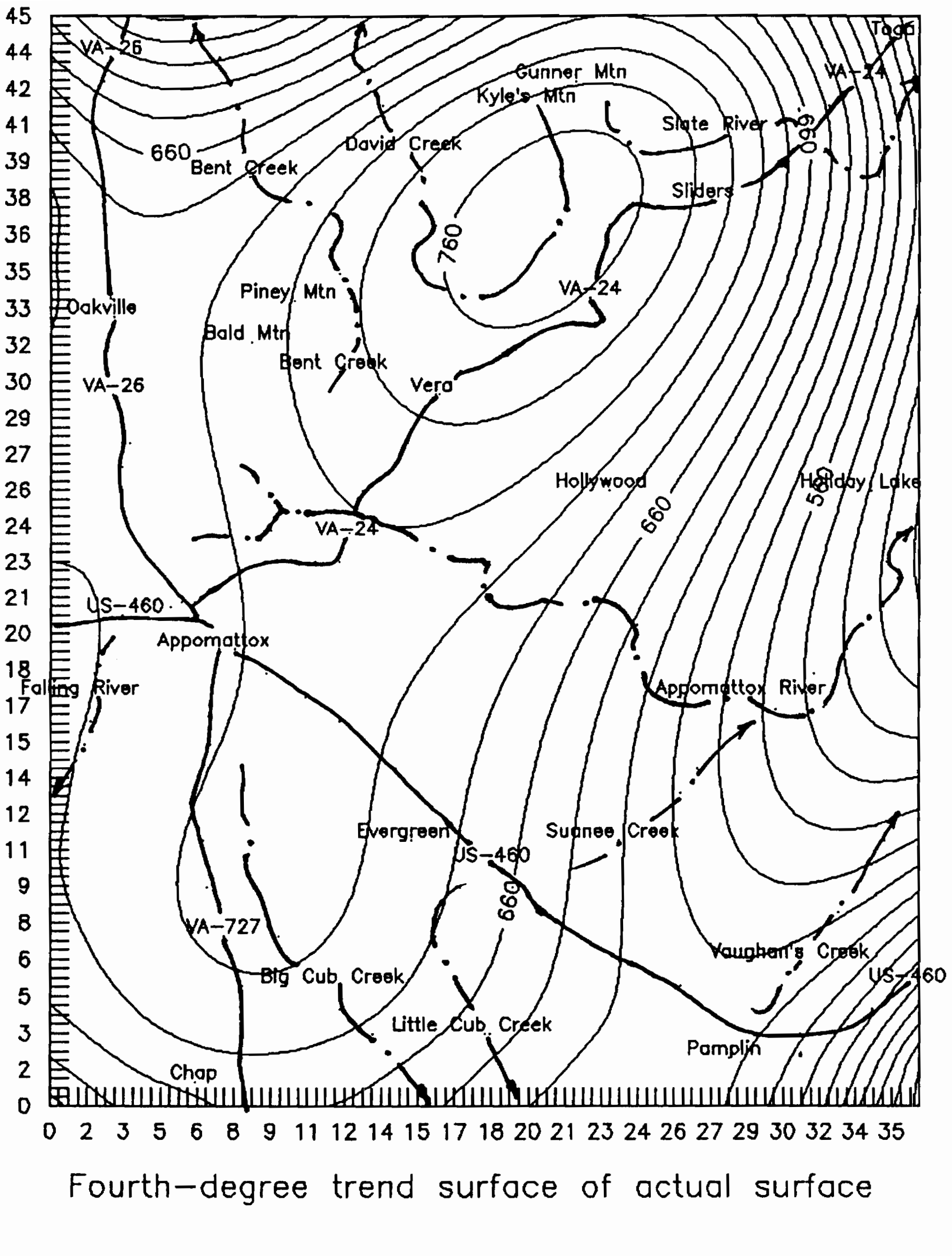
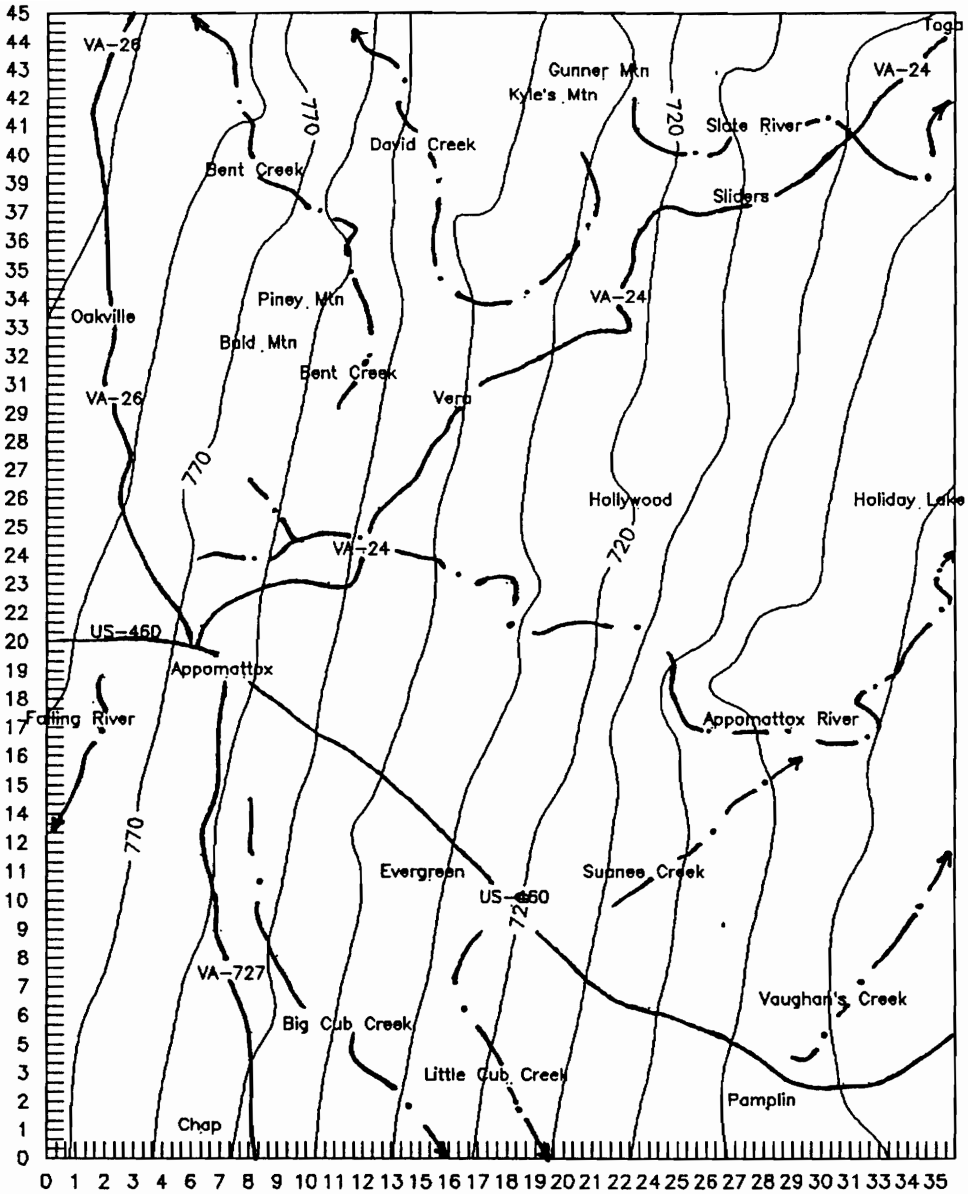
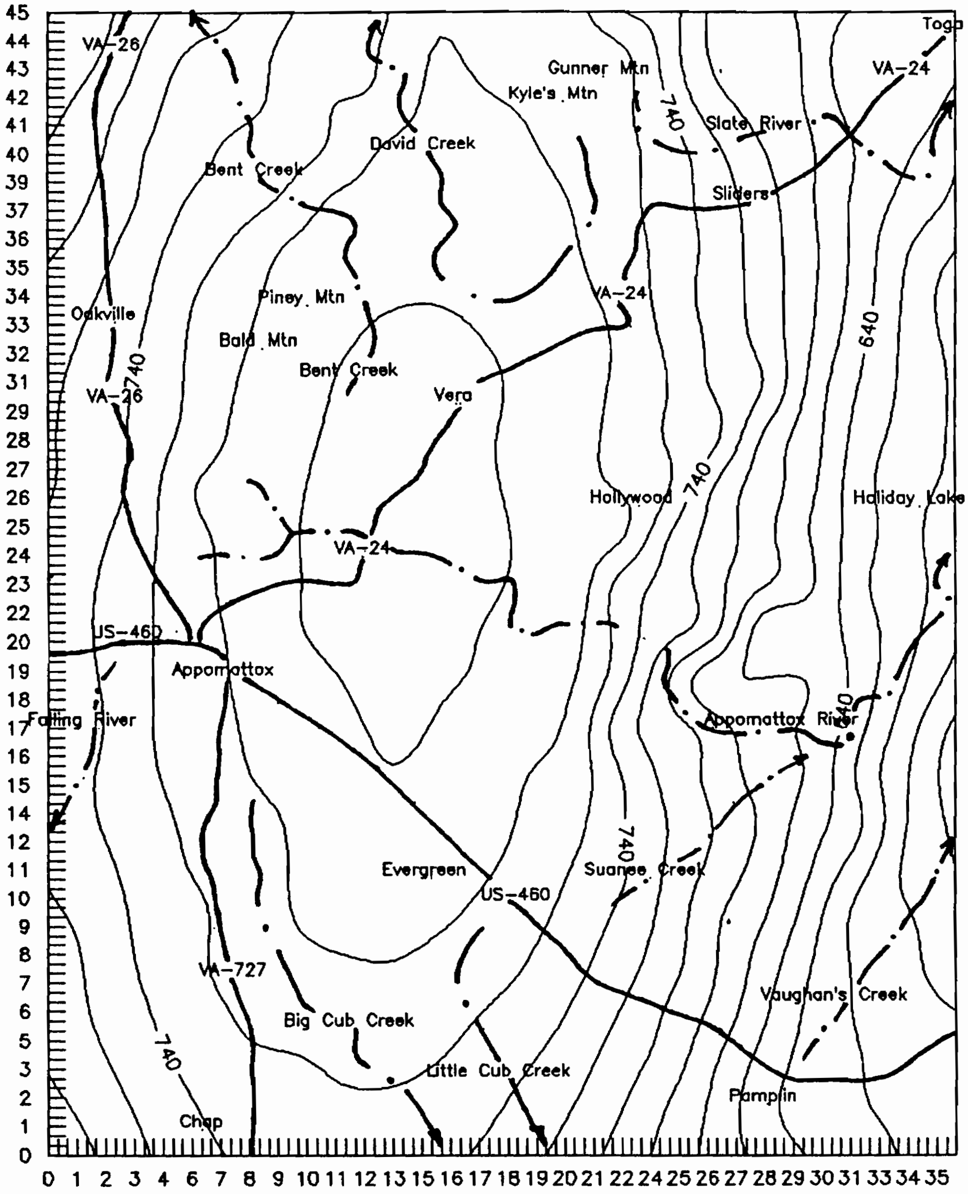


Figure B29. Fourth-degree trend surface of the actual surface.



First-degree trend surface of all data points.

Figure B30. First-degree trend surface of all data points.



Second-degree trend surface of all data points.

Figure B31. Second-degree trend surface of all data points.

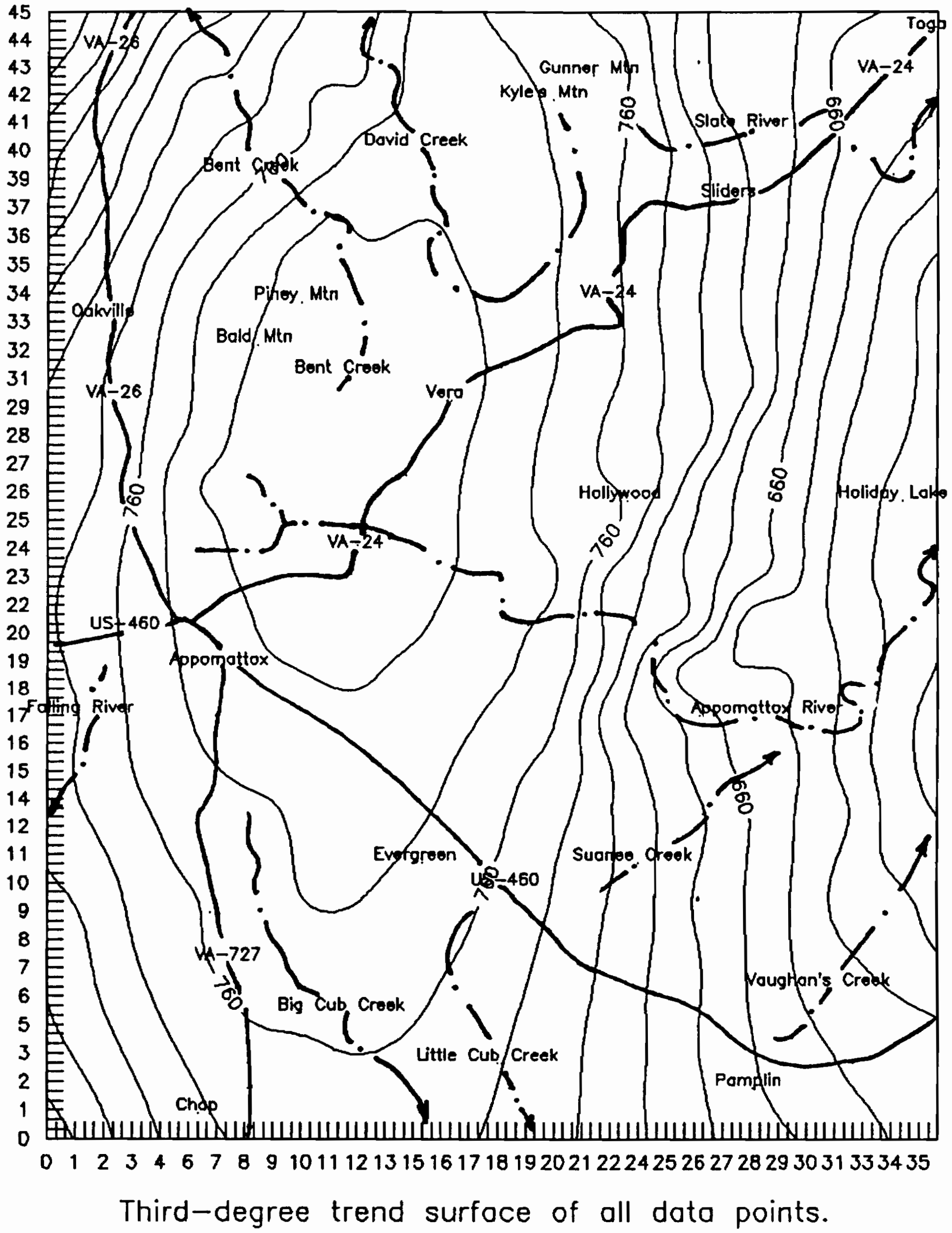
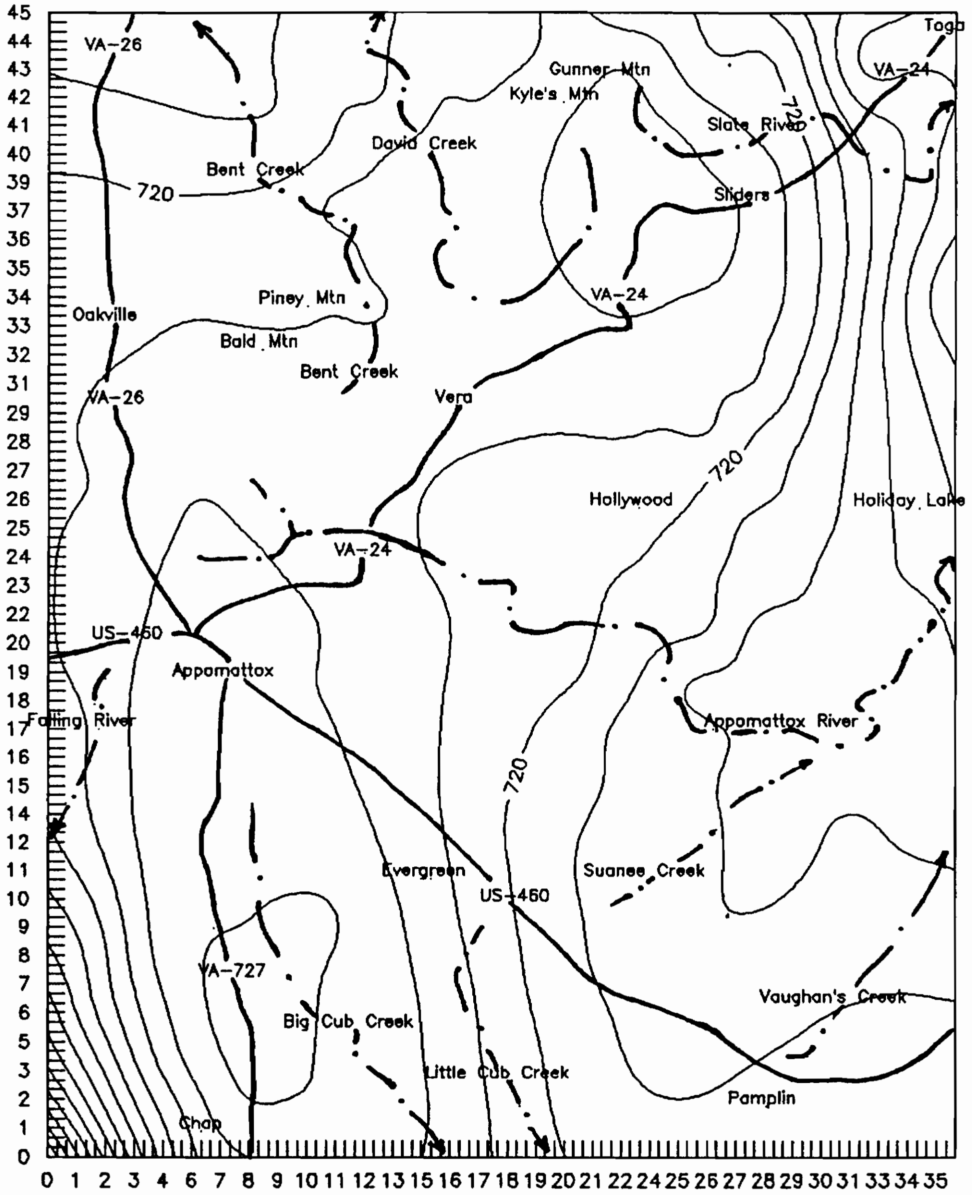
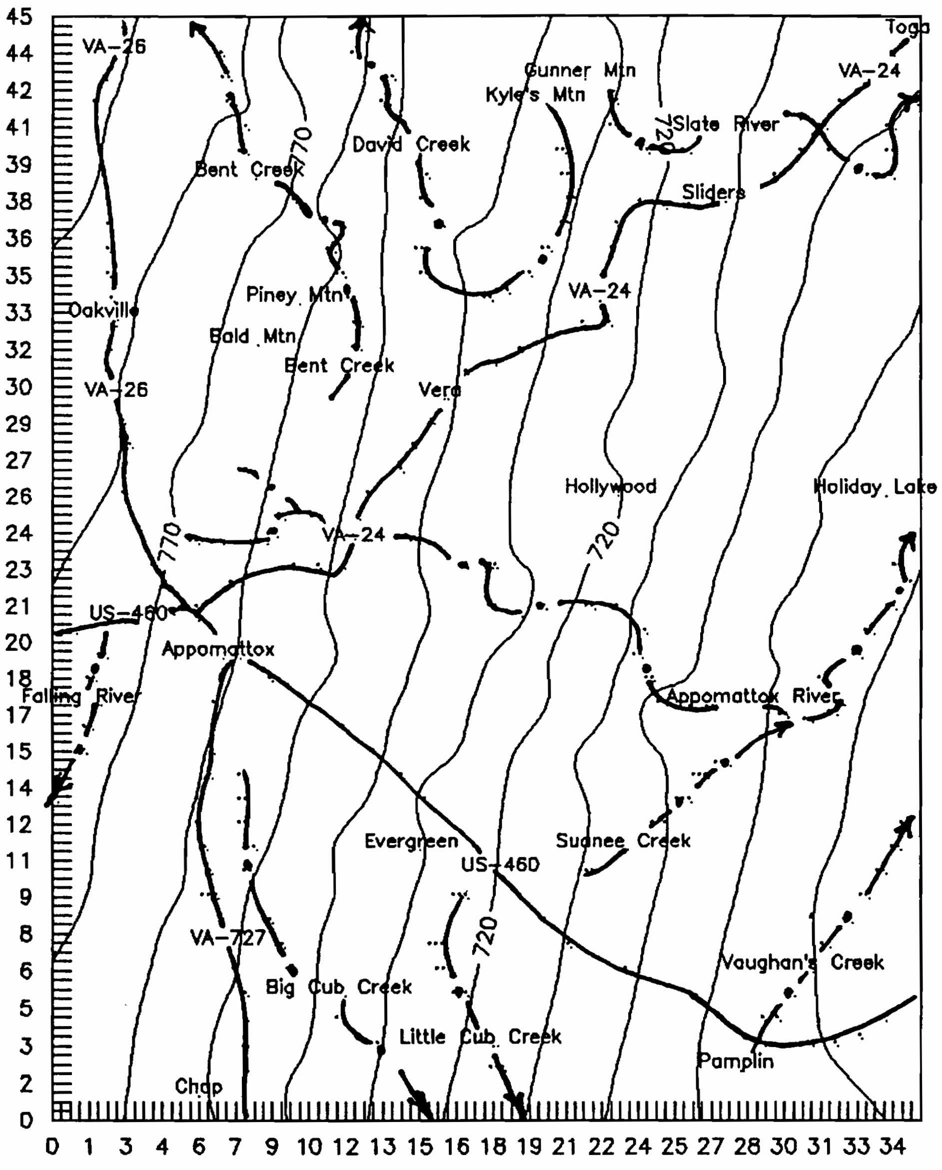


Figure B32. Third-degree trend surface of all data points.



Fourth–degree trend surface of all data points.

Figure B33. Fourth-degree trend surface of all data points.



First-degree trend surface of colluvium.

Figure B34. First-degree trend surface of colluvium.

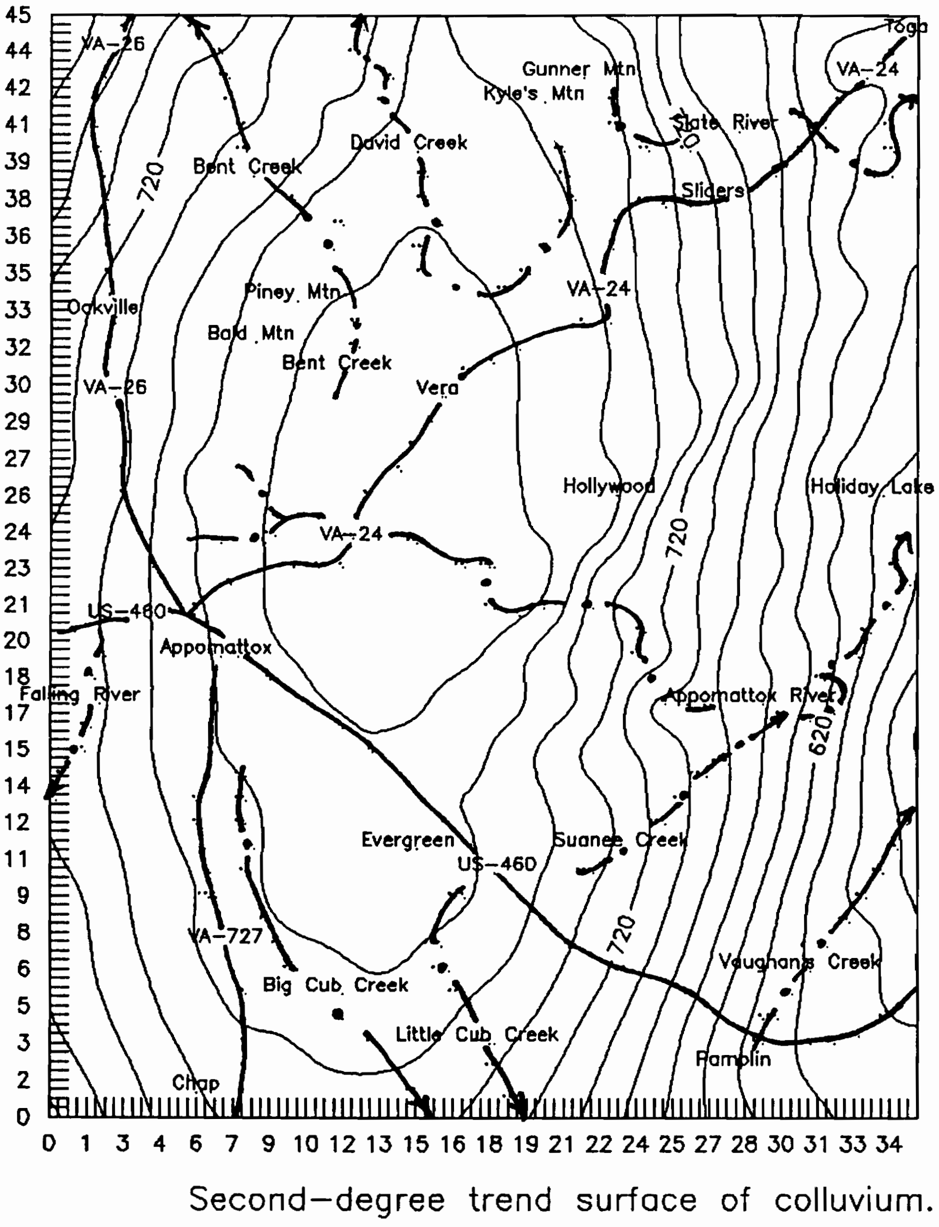


Figure B35. Second-degree trend surface of colluvium.

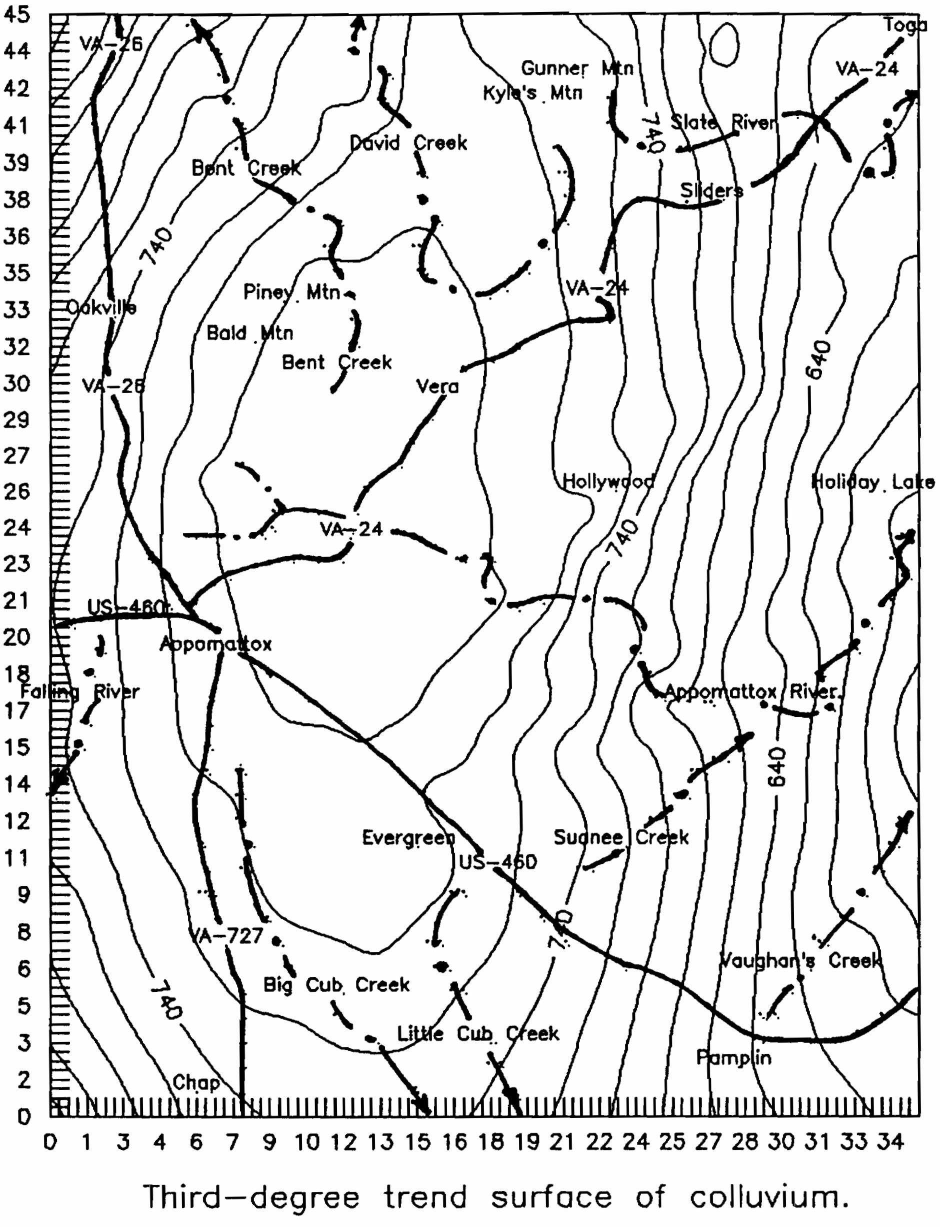
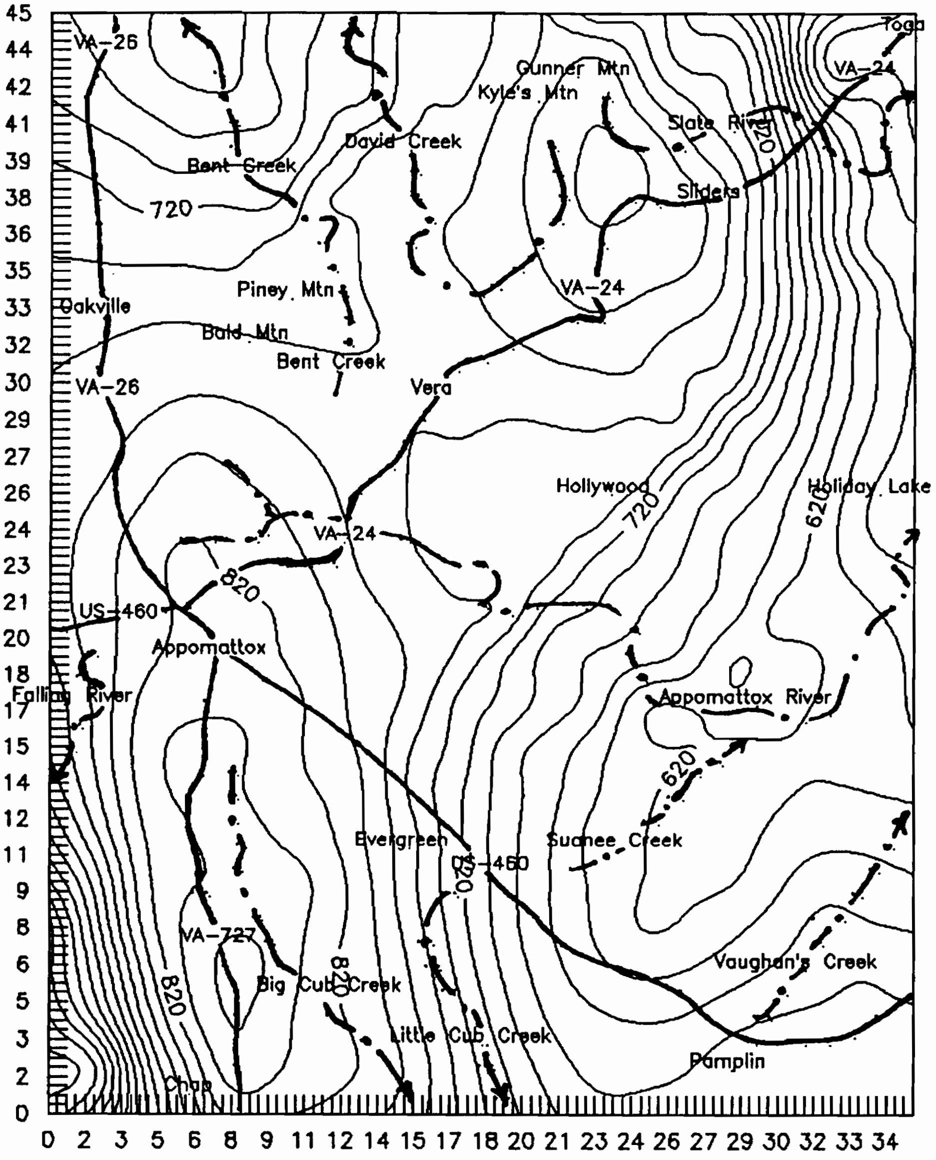


Figure B36. Third-degree trend surface of colluvium.



Fourth-degree trend surface of colluvium.

Figure B37. Fourth-degree trend surface of colluvium.

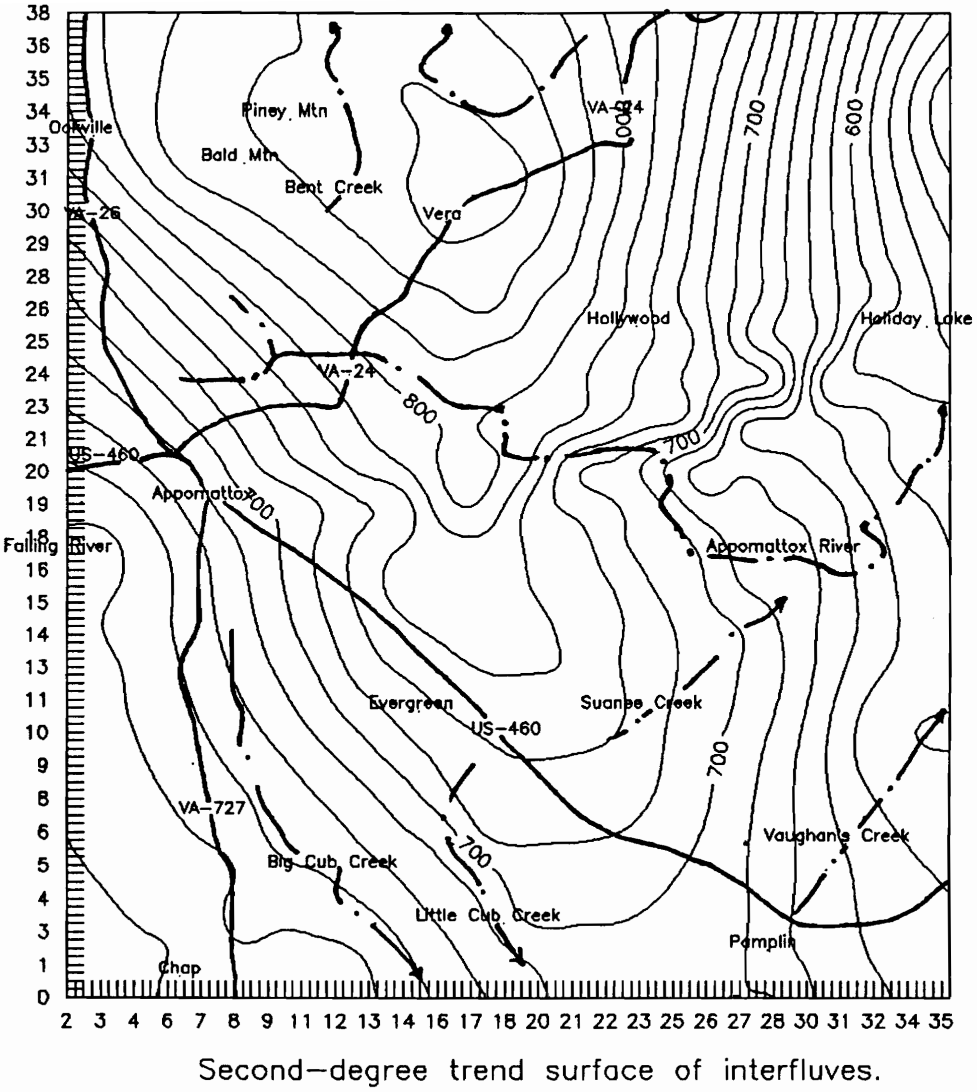


Figure B38. Second-degree trend surface of interfluves.

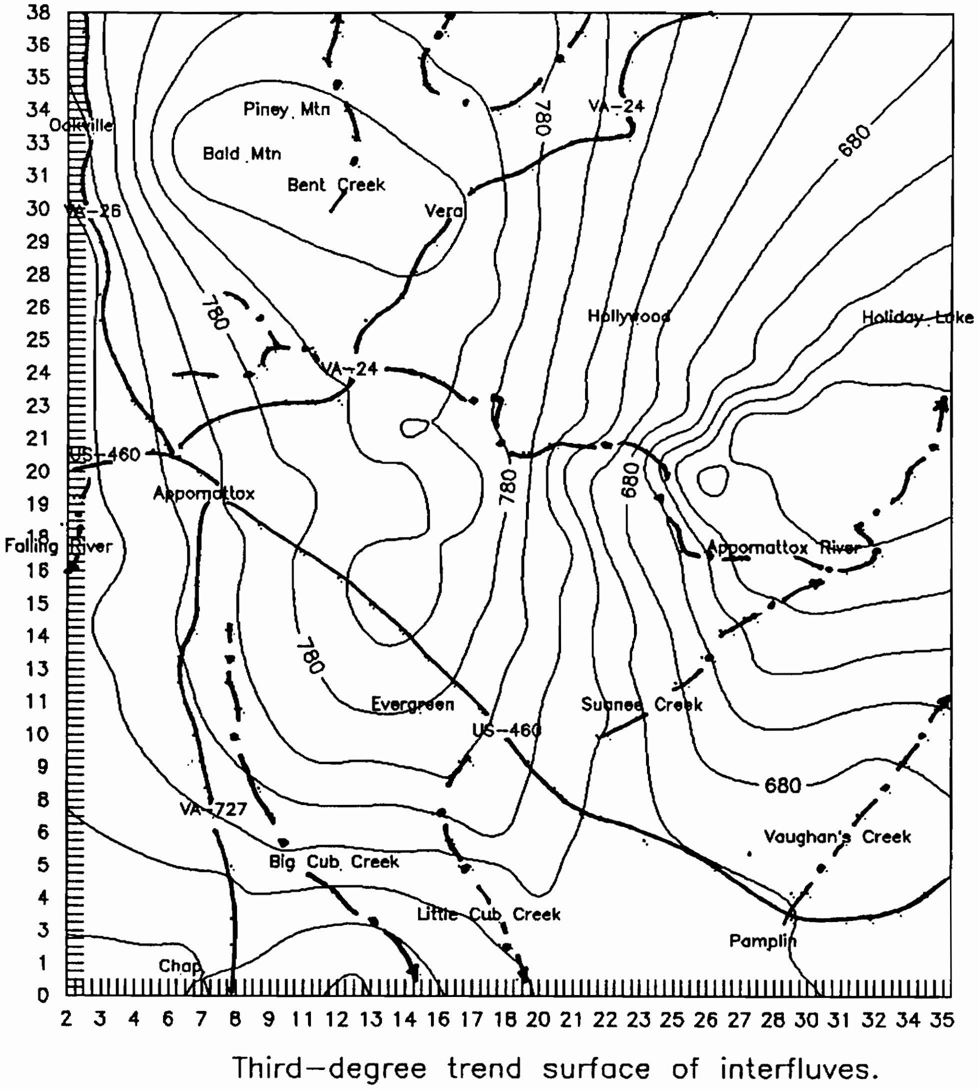
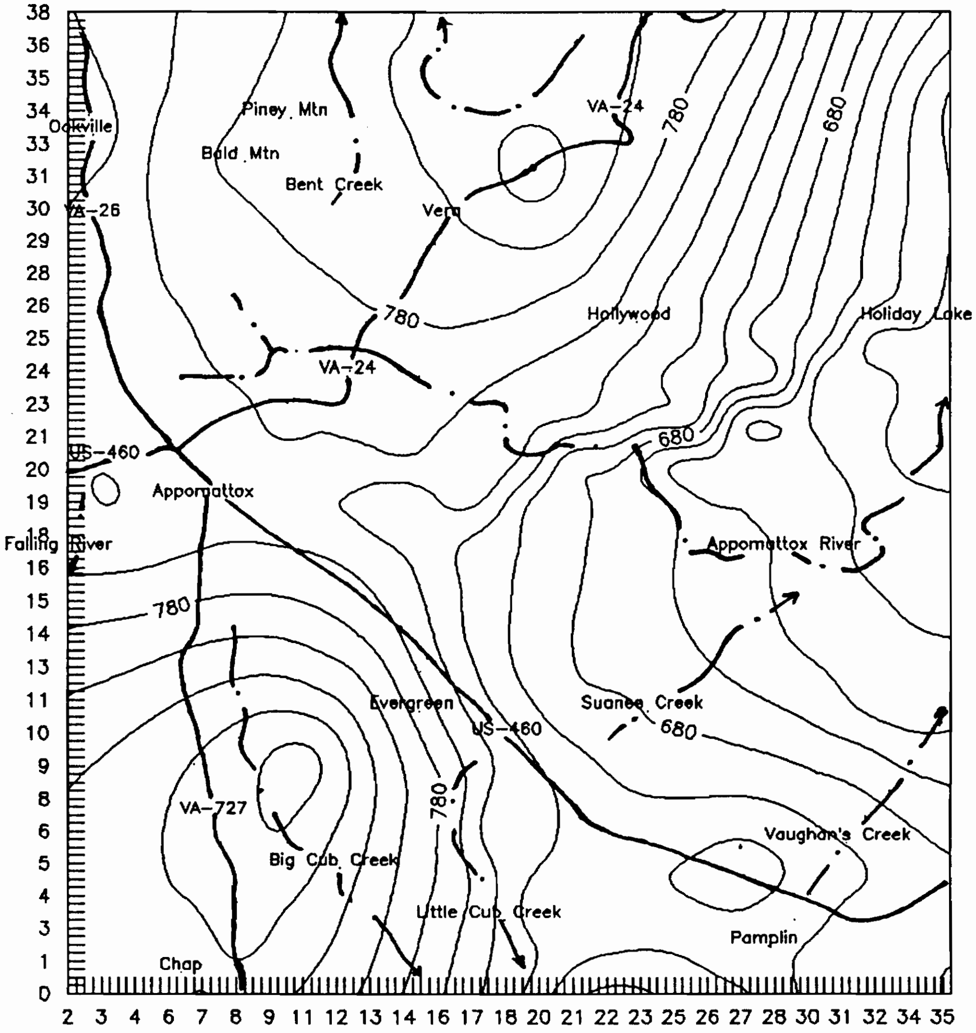
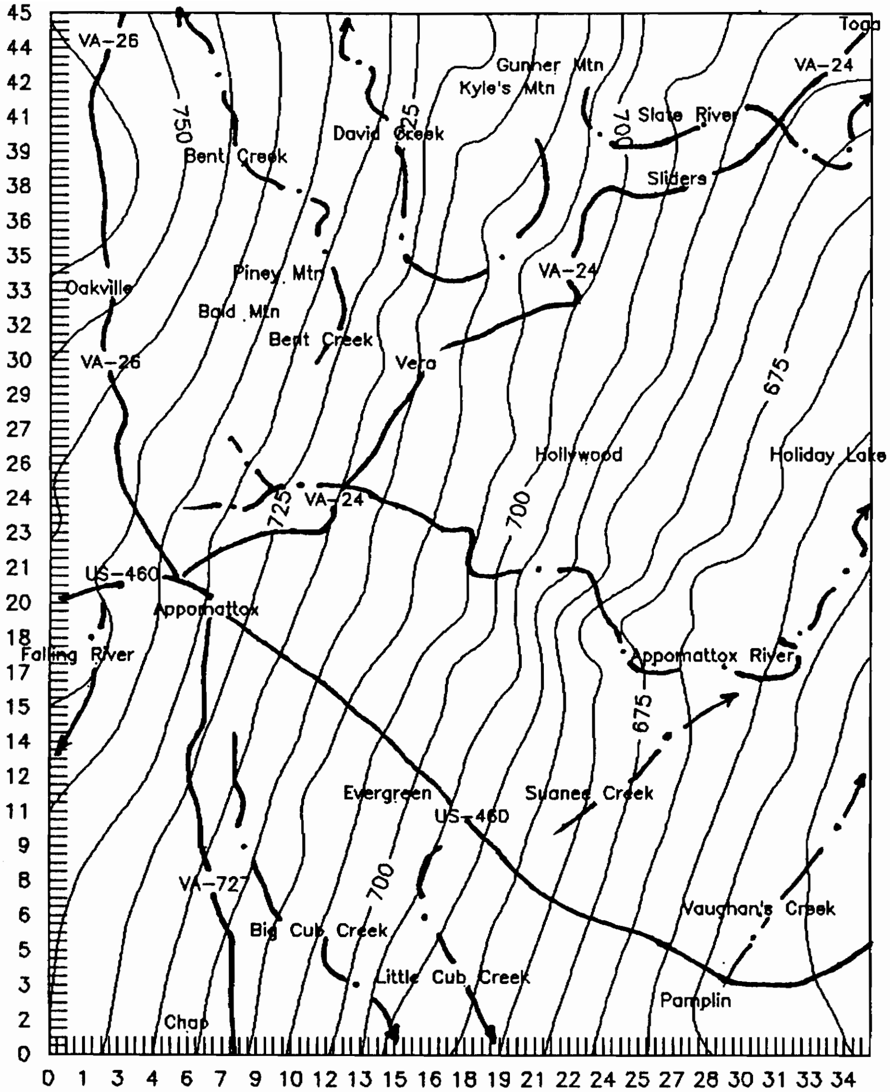


Figure B39. Third-degree trend surface of interfluves.



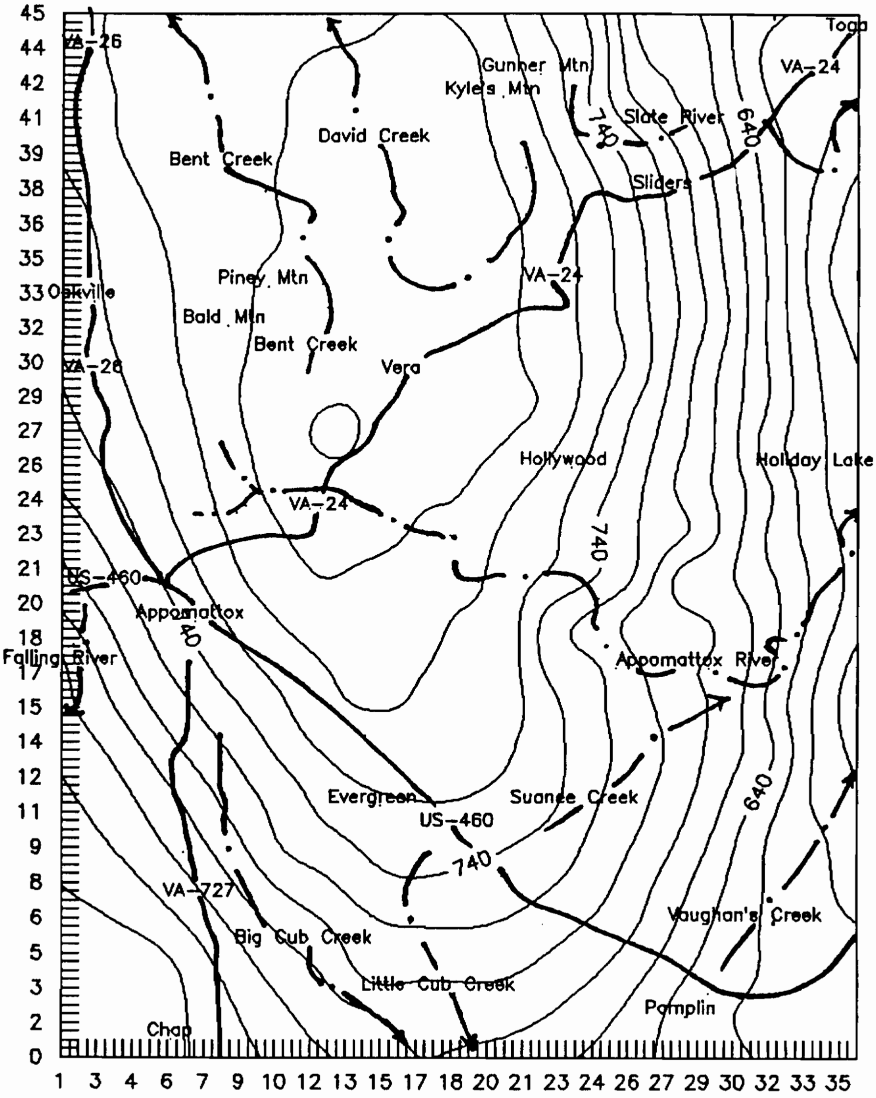
Fourth-degree trend surface of interfluves.

Figure B40. Fourth-degree trend surface of interfluves.



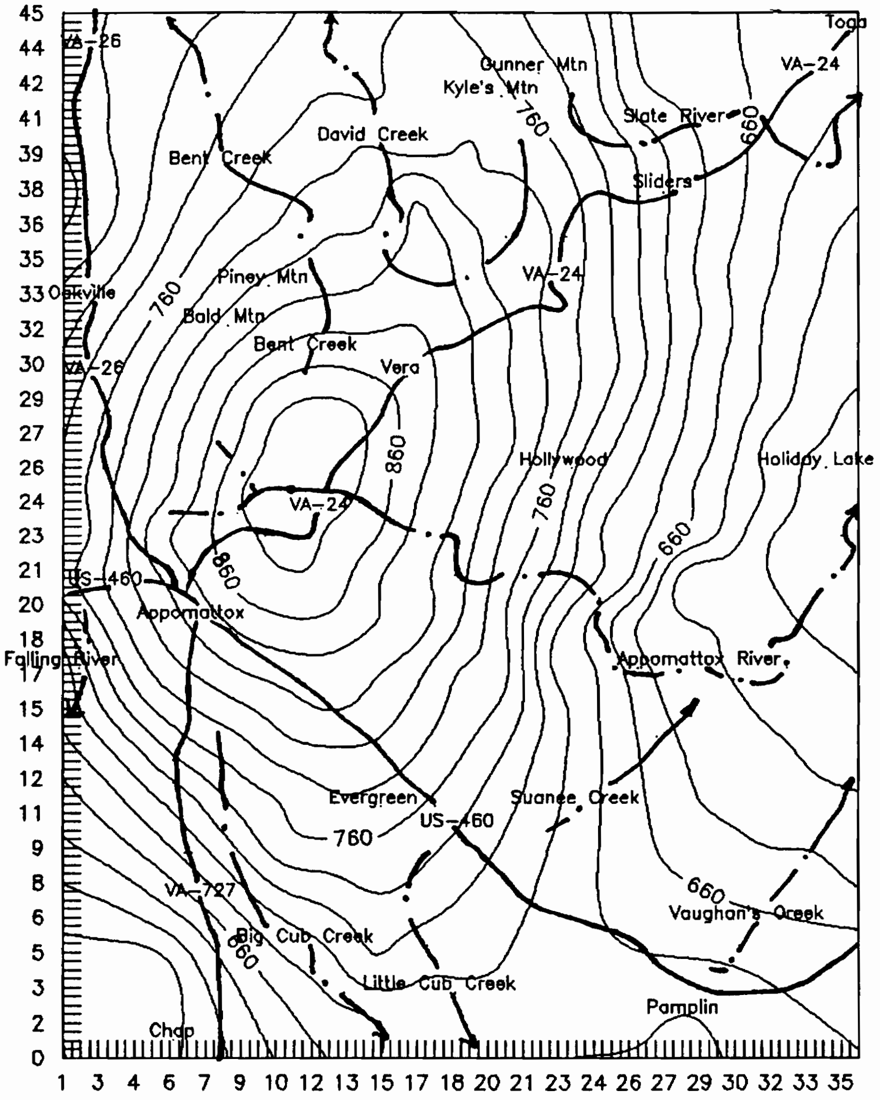
First–degree trend surface of non–red soils.

Figure B41. First-degree trend surface of non-red soils.



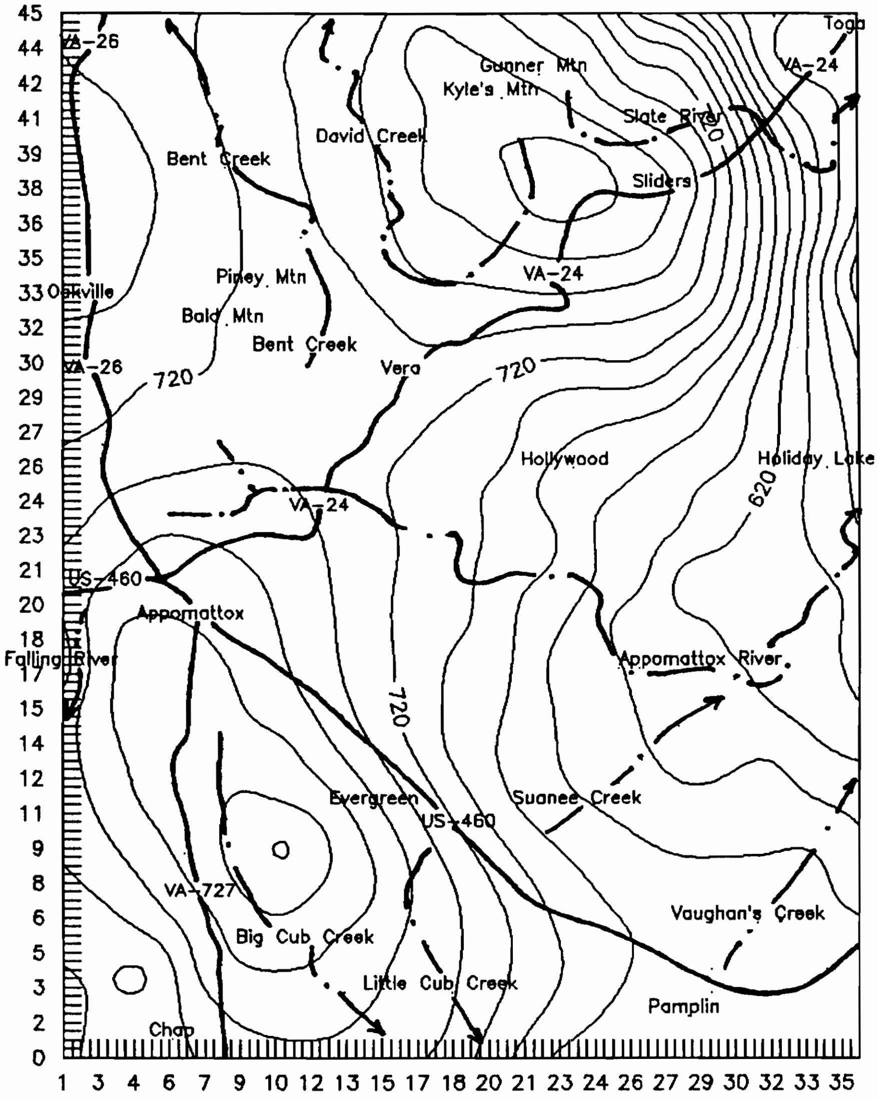
Second–degree trend surface of non–red soils.

Figure B42. Second-degree trend surface of non-red soils.



Third–degree trend surface of non–red soils.

Figure B43. Third-degree trend surface of non-red soils.



Fourth–degree trend surface of non–red soils.

Figure B44. Fourth-degree trend surface of non-red soils.

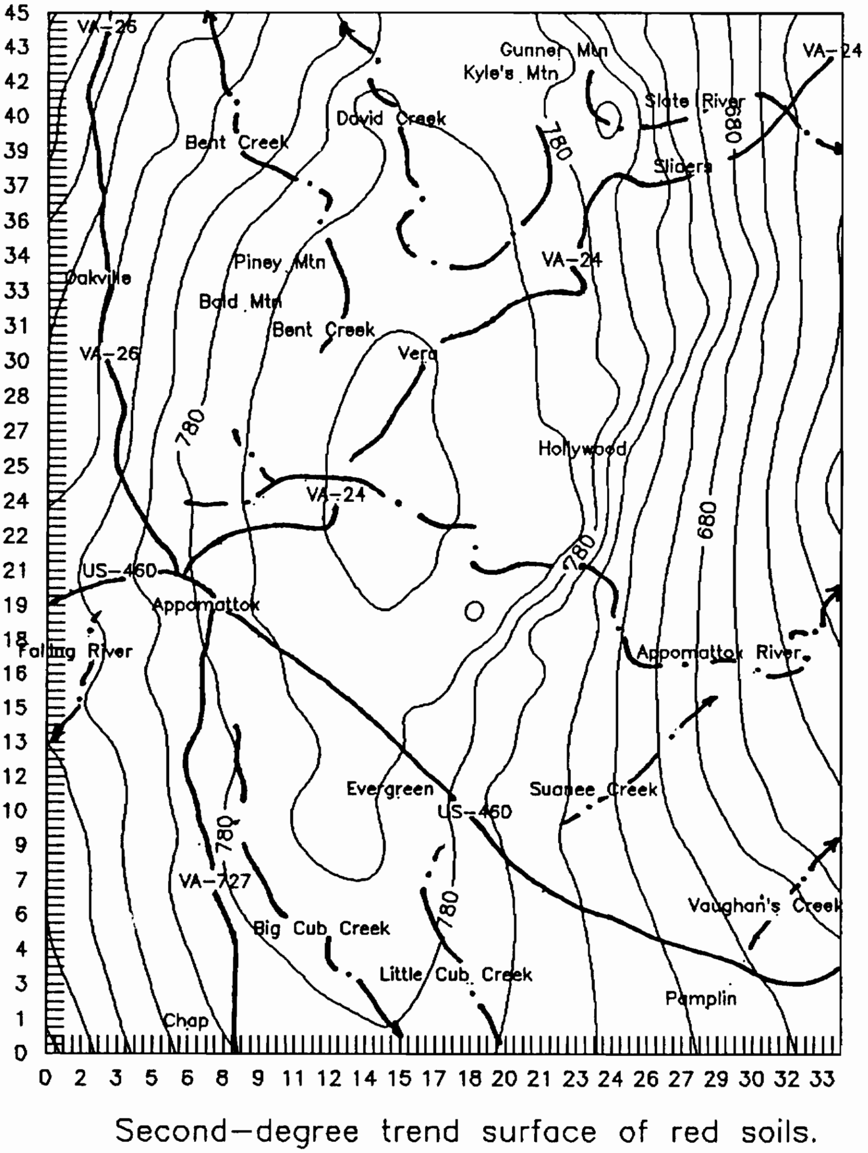
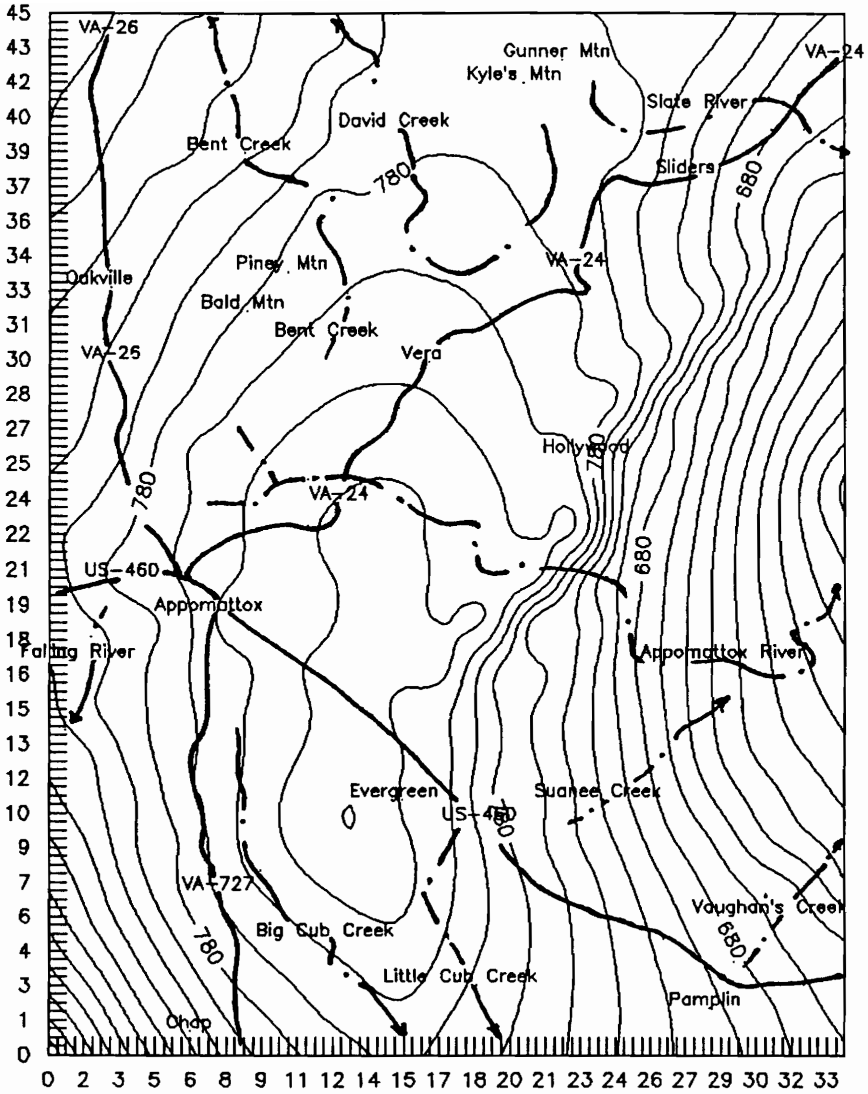


Figure B45. Second-degree trend surface of red soils.



Third–degree trend surface of red soils.

Figure B46. Third-degree trend surface of red soils.

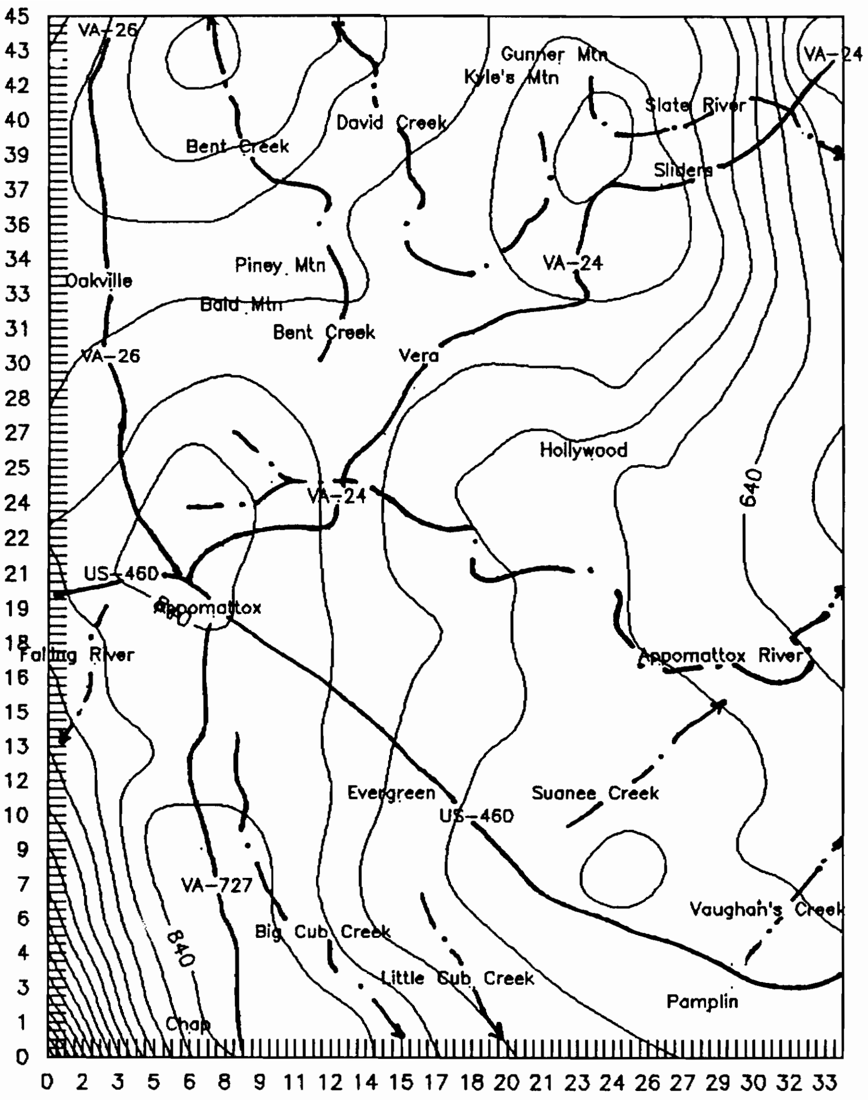


Figure B47. Fourth-degree trend surface of red soils.

Vita

Harry Thomas Saxton III was born on September 14, 1955 in Charlottesville, Virginia. His primary education was obtained in the Chesterfield County, Virginia school system. Secondary education and high school diploma were obtained from the Orange County, Virginia school system in June 1974. He attended Va Tech from 1974 to December 1978 when a Bachelor of Science degree in Agronomy was achieved.

In February 1979, Tom began mapping with the VA Tech Soil Survey in Isle of Wight County, Virginia. In the winter and spring of 1982 he mapped in Greensville County, Virginia. He began mapping in Appomattox County, Virginia in the summer of 1982. On the advice of T.B. Hutcheson Jr., he began Master of Science degree work in September 1985. This was achieved while mapping Appomattox County and through the beginning of Buckingham County in the fall of 1990. He is currently still mapping in Buckingham County.

Tom is a Virginia Certified Professional Soil Scientist and a life member of the Virginia Association of Professional Soil Scientists.