Site Quality Classification for Mapping Forest Productivity Potential on Mine Soils in the Appalachian Coalfield Region

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ABSTRACT

Surface mining for coal in the Appalachian region destroys native forests and replaces them with reclaimed landscapes that are often revegetated as grasslands and are unacceptable for managed forest production without extensive remediation. Tree survival and growth are dependent on many reclaimed mine land properties. However, conventional mapping techniques using USDA soil series does not identify these critical soil property differences. This study was conducted to create a forest site quality classification system to be used to evaluate the potential productivity of specific tree species on mine soils. High soil bulk density is the most common limitation on mine soils and methods to efficiently measure this property were evaluated. No valid quantitative method of measuring mine soil bulk density was found due to the high rock fragment content in the soil profile, but a method for estimating relative soil density class was developed. Other soil chemical and physical properties were analyzed at abandoned mine sites in Virginia, West Virginia, and Ohio. Mine soil properties differed throughout the Appalachian region, with Ohio sites having finer textures and less rock fragments, West Virginia sites having coarser textures and a high quantity of dark-colored shale, and Virginia sites dominated by sandstone rock types. Selected field-measured soil and site properties were regressed with site index (SI) base age 50 at 52 sample locations in 10- to 18-year old white pine (*Pinus strobus* L.) stands on reclaimed mine lands. Sufficiency curves for nine soil and site properties were produced and a general productivity index (PI) calculated. Regression of the general PI and measured SI of white pine produced an R^2 of 0.61. The general PI was simplified to four soil properties (soil density, rooting depth, texture, and pH) most significantly related to the SI of

white pine, and the properties were weighted based on their importance to white pine growth on mine soils. The modified PI model produced an R^2 of 0.69 for a linear relationship between PI and measured SI. The SI values were divided into five classes of equal interval and the corresponding PI values were used to define five forest site quality classes that could be identified by measuring and mapping differences in the PI on older mine soils. The model may be modified for determination of hardwood productivity after validation sites are located. Soil and site properties that are correlated with seedling survival appear different than those properties important for tree productivity. The forest site quality classification system proposed here proved practical for mapping a selected mine site, and the maps may be used as a validation test after future reforestation.

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CHAPTER I
INTRODUCTION

Surface mining for coal has occupied the Eastern United States since the late 1940's, and the Appalachian Plateau region of Virginia (VA), West Virginia (WV), Kentucky (KY), and Ohio (OH) contains a large reserve of coal that can be profitably extracted. The native forest vegetation and soils must be removed to get to the underlying coal, and after surface mining, the land does not resemble the previous landscape. Most surface mining before 1977 was known as contour mining and done by cutting into mountainsides on the contour and leaving a high-wall of exposed bedrock. The spoil (blasted bedrock and soil particles) was simply pushed down the hillside. Laws have been enacted as an attempt to reshape the land and return it to its original productivity and approximate topography. The Surface Mining Control and Reclamation Act (SMCRA) of 1977 requires coal companies to return the mined land to the "approximate original contour" (AOC), requires topsoil or an approved topsoil substitute to be replaced, and requires the land to be able to support vegetation at its original productivity level or better (Public Law 95-87). However, this law allows the coal companies to reseed the area to forages since they are considered more productive than native trees and does not provide incentives to replant native forest vegetation. Most land is designated as pasture, hayland, or wildlife habitat after reclamation and bond-release. In 2004, there were nearly one million hectares that had been permitted for coal mining (www.osmre.gov) in the eastern coalfields, with approximately 200,000 of those hectares within the three-state region of VA, WV, and OH.

Mining reconfigures the soil forming factors (Jenny, 1941) of topography and parent material, and resets the soil formation time clock. Due to these drastic changes, mine soil properties are different from those found in soils that have been formed by natural processes over long periods of time. Several meters of soil and rock above the coal seams (overburden) are loosened and removed during surface mining. The loosened rock volume is 1.2 to 1.5 times the volume of unloosened rock (Daniels and Zipper, 1988). Consequently, there is an excess volume of material after mining that must be handled because the coal seems are often thin. Due to the complications associated with stockpiling topsoil in this region (steep slopes, shallow soil), the spoil is placed on the surface of the reclaimed areas and serves as the medium for plant growth instead of replacing the original soil. The spoil placed on the surface (called topsoil substitute), ranges from well oxidized sandstone to calcareous siltstone to dark gray carbonaceous shale. These rock types are vastly different in their physical and chemical properties and they weather to form different mine soils once they are exposed and emplaced after mining.

Ashby (1984) stated that mined land should (and commonly does) improve tree growth because it has greater porosity, improved water movement, less rooting restrictions, higher pH, and greater nutrient availability than native soils. However, most of these improvements were found on land mined prior to the SMCRA of 1977, and these properties are not always observed on post-SMCRA land (Sharma and Carter, 1996) due to different reclamation practices.

The physical properties of any forest soil are responsible for water relations, gas relations, nutrient availability and ion movement, temperature profiles, and the accumulation of organic matter (OM) (Fisher and Binkley, 2000). Torbert et al. (1988a) concluded that physical soil properties were more influential than fertility on 8-year old white pines grown on reclaimed mine soil benches in southwest VA. However, soil properties that affect the survival and early growth of trees are different from factors that affect the later growth (Andrews, 1992). Some of the most important physical properties for successful reforestation of mine soils are stoniness, particle size, bulk density (D_b), slope angle and length, color, aspect, erodibility, and stability

(Vogel, 1981). Rock type is a major factor that influences all of these properties (Torbert et al., 1988a; Torbert et al., 1990; Ashby 1984). Porosity and structure are other factors that are important to forest growth on mine soils (Sharma and Carter, 1996; Bussler et al., 1984; Potter et al., 1988; Rodrique, 2001; Thomas and Jansen, 1985; McSweeney and Jansen, 1984). Topsoil depth as well as total soil depth is also noted as being of importance in the productivity potential of mine soils (Power et al., 1981; Chong et al., 1986; Halvorson et al., 1986).

Chemical properties of mine soils such as pH, soluble salts measured by electrical conductivity (EC), exchangeable cations, base saturation (BS), and nutrient availability all are important in the reestablishment of forest on surface mines (Andrews, 1992; Rodrique, 2001; Burger et al., 1994; Torbert et al., 1988b). Vogel (1981) recognizes pH, acid-induced toxicities, and nutrient deficiencies as the chemical properties of most concern in the revegetation process. Soil types most suitable for general plant growth have low exchangeable acidity, high BS, moderate pH, and a high cation exchange capacity (CEC) (Johnson and Skousen, 1995), but these soil chemical conditions that are considered optimal for herbaceous vegetation are not always as suitable for native tree growth.

Forest productivity is commonly measured as the volume or biomass production of a specific tree species on a given site. General physical, chemical, and climatic factors interacting within a particular biological framework influence a site's productive potential (Powers et al., 1990). Many methods have been used to measure the productive potential of a site (Carmean, 1975). Soil-site evaluations are used most effectively on sites in which no forest vegetation is present for direct site quality measurements such as on reclaimed mined land. However, the productivity of mined lands is not likely to follow patterns of traditional site quality distributions due to alterations of underground hydrology, particle size, and soil depth.

Productivity indexes (PI) and sufficiency curves provide a basis for forest site classifications, but lengthy laboratory procedures are needed before conclusions can be drawn. Sufficiency curves describe the rooting suitability of a soil and the PI models assume that the overall productivity of trees is proportional to its root growth.

Forest productivity on mine soils fits no existing classification scheme that can be practically determined in the field. This research was conducted to develop a soil-based field classification system to predict the potential forest productivity of post-SMCRA reclaimed surface mine soils.

CHAPTER II
LITERATURE REVIEW

MINE SOIL PROPERTIES

Physical Properties

Structure

The destruction of soil structure during mining and absence of structure in the spoil replaced during subsequent reclamation processes has proven to be one of the major deficiencies of young mine soils (Thomas and Jansen, 1985; McSweeney and Jansen, 1984). Younos and Shanholtz (1980) recognized the destruction of natural soil structure and its importance to hydraulic properties of the soil. The water holding capacity of the structureless spoil material that they studied was drastically lower than pre-mining topsoil. Thomas and Jansen (1985) studied eight pre-Surface Mining Control and Reclamation Act (SMCRA) sites from 5 to 64 years old and found weak genetic structure below the A horizon in all but the youngest site (5-years old), but no structure development was observed below 35 cm. Structure formation was determined by darkening by organic matter (OM), which indicated pedogenic processes had taken place at the given depth. The structure development provided for a better rooting medium for higher plants, because macro-pores were created between ped surfaces and reduced resistance for the extension of roots (Taylor, 1974; McSweeney and Jansen, 1984).

Porosity

Most forest soils have porosity values between 30 and 65 percent (Fisher and Binkley, 2000). However, the original network of soil pores is destroyed during mining and reclamation activities and consequently there is reduced water retention and aeration in mine soils. Bussler et al. (1984) found total porosity to be less in a mine soil compared to native Ava and Parke soils in

Indiana. Rodrique and Burger (2004) found the total porosity of the C horizon to be positively correlated with site index (SI, total tree height at age 50) of white oak (*Quercus alba* L.) for 14 mine soils throughout the Eastern and Midwestern coalfields. Total porosity for those sites ranged from 44 to 67%, which compares with the native soil. In their study, an increase in one standard deviation of the C horizon total porosity (s.d. = 7%) resulted in a 0.92 m increase in SI. Lower values of 25% to 49% were found in 10 different mine soil profiles in Kentucky (KY) (Wells et al., 1982). In a study of mine soil properties and root growth, Ammons (1979) found that bulk density (D_b) values of 1.7 g cm^{-3} or greater, and porosities of 35% or less in the soil matrix caused roots to follow only structural macro-pores.

Micro-pores (<0.08 mm) are much smaller than macro-pores (>0.08 mm) and they are the dominant pore size found in most mine soils, due to compaction. Mechanical mining operations create an abundance of inter-aggregate pores (Sharma and Carter, 1996). Even when not filled with water most micro-pores are too small to permit much air movement (Brady and Weil, 1999). Water movement is slow through micro-pores and much of it is not readily available to plants because micro-pores are often too small even for roots to penetrate them to extract the water.

Reclamation operations with heavy equipment reduce macro-porosity (Sharma and Carter, 1996). High rock fragment (RF, rock fragments larger than 2 mm) content may be responsible for large air gaps in the subsurface of mine soils, and large cracks at the surface. However, these air gaps, if not connected by macro-pores, may have insignificant affects on the aeration properties of the soil. A macro-porosity value of 10 % has been reported as the lower limit before forest trees are adversely affected by oxygen availability (Childs et al. 1989; Fisher and Binkley, 2000; Wells and Morris, 1982). Macro-porosity for the sites studied by Rodrique and Burger (2004) ranged from 13 to 42 % across all mined sites, indicating adequate oxygen availability.

Reduced porosity near the surface restricts water infiltration and percolation, often causing ponding at the surface after periods of high precipitation (Bussler et al., 1984). Surface cracks between rock fragments allow for increased infiltration but may later become sealed due to sediment flow across the surface during precipitation events (Wells et al., 1982; Pedersen et al., 1980). Weak structure and low aggregate stability caused by reclamation activities is largely responsible for this surface crusting, and it is especially prevalent with finer textured mine soils. In most mine soils, percolation is restricted due to the discontinuity, increased tortuosity, and reduced number of pores (Sharma and Carter, 1996). The percolation rate of different mine soils and spoils from KY has been reviewed by Wells et al. (1982), and by Chong and Moore (1982) in Illinois. Wells et al. (1982) determined that percolation in spoil profiles occurred as a uniform wetting front but would be disrupted directly below RFs. Since mine soils typically contain high amounts of large RFs, pockets of dry soil will be frequently encountered by tree roots.

Bulk Density

The negative effects of compaction on the growth of vegetation have been reviewed by many authors (Ruark et al., 1982; Greacen and Sands, 1980; Zimmerman and Kardos, 1961). Compaction is common in mine soils due to trafficking by heavy machinery during reclamation on post-SMCRA sites. This compaction results in higher D_b, reduced macro-porosity, increased resistance to roots, impeded infiltration and drainage, reduced aeration, and other factors that are detrimental to tree survival and growth (Ruark et al., 1982). Higher D_b than native soils are commonly found on mine soils (Thurman and Scencindiver, 1986), and Daniels and Amos (1981) report high density as being the major mine soil factor limiting long term revegetation success in the Appalachian region. Torbert and Burger (1990) reported tree survival data on a rough-graded versus a leveled and smoothed slope as being 70% and 42% respectively and blamed the increase in traffic and subsequent compaction on the smoothed slope as the cause of mortality. Leveled and smoothed slopes encounter numerous passes by bulldozers and other large equipment that cause compaction. Thurman (1983) reported that compaction effects due to machinery may extend 60 cm or more in the profile.

Soil texture and moisture levels influence soil susceptibility to compaction. Sandy soils will have higher D_b than clayey soils because the sandy soils have less total pore space. Wet soils are more susceptible to compaction than dry soils (Brady and Weil, 1999). High D_b values have been reported as root limiting for trees, but the critical values are dependent upon the soil texture. Zisa et al. (1980) reported restrictions of pine root growth on a silt loam soil at 1.4 g cm^{-3}, and at 1.6 g cm^{-3} on a sandy loam soil. A sufficiency curve developed by Neill (1979) for agronomic crops designated a sufficiency value of 1.0 for D_b <1.3 g cm^{-3}, regardless of soil texture, to indicate that as the optimum D_b for root growth. The curve sharply declined at D_b > 1.55 g cm^{-3} indicating that root growth was adversely effected. No root growth was expected above D_b = 1.8 g cm^{-3} and the sufficiency value was zero (0.0). Pierce et al. (1983) reported non-limiting, critical, and root-limiting D_b values for different textural classes, and Andrews (1992) produced a sufficiency curve using those values (Figure II-1).

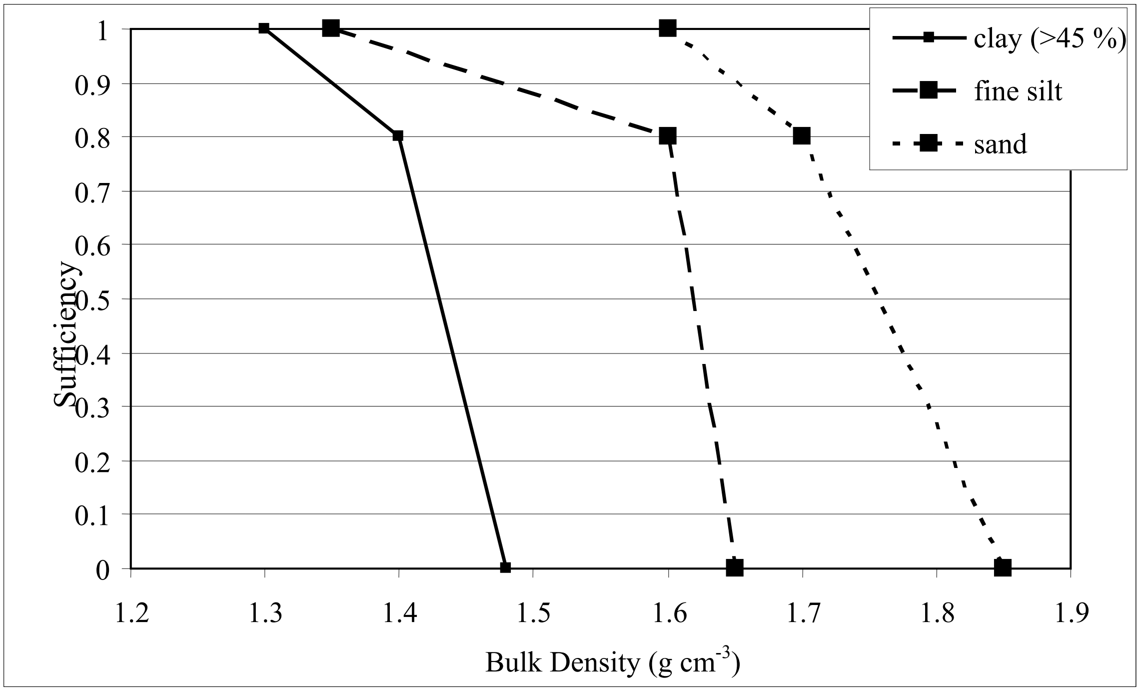

Figure II-1. A root growth sufficiency curve for bulk density for three texture classes used on mine soils of the Appalachian region. (reproduced from Andrews, 1992).

Grading spoils with a predominance of silt and clay particles has been reported to be detrimental to the survival and growth of planted trees (Vogel, 1981). On 14 reclaimed sites in Virginia (VA) and West Virginia (WV), Andrews et al. (1998) found fine earth D_b (D_b values that are corrected for RF content) ranging from 0.64 to 1.94 g cm^{-3} with an average of 1.02 g cm^{-3}, and in general found no roots in horizons with a D_b >1.7 g cm^{-3}. These values however, were believed to be insignificant as compared to natural soils, due to the high RF content (up to 88%).

Compaction resulting in high D_b can be ameliorated after the reclamation activities. Deep ripping and tillage of compacted mine soils has been proven to enhance root growth and vegetation productivity (Dunker et al., 1995; Philo et al., 1982). Wilson (1969 *as cited in* Philo et al., 1982) suggests that ripping loosens the soil enough to increase free drainage and aeration, create channels to collect runoff, increase moisture available to plants, and allow a larger deeper root system to develop, all of which enhance tree survival. In a study in Illinois with black walnut (*Juglans nigra* L.) seedlings, survival in the ripped and unripped plots was 88% and 66% respectively. Rooting depth was 81% greater in the first growing season on the ripped plots (Philo et al., 1982). The D_b of these ripped soils were about half that of the unripped soils in the 15-30 cm depth.

Dunker et al. (1995) concluded that the effects of deep tillage were influenced by initial soil strength as determined with a penetrometer, and were not correlated to D_b values. Based on their results, the greater the initial soil strength, the deeper the ripping treatment needed to be. Thompson et al. (1987) reported that D_b may be a better predictor of an effective rooting depth than soil strength determined with a penetrometer. In their study, penetrometer resistance was poorly correlated with D_b in the surface of mine soils but highly correlated in the lower root zone. Torbert et al. (1988b) used a penetrometer in an attempt to determine total soil depth, but found it to have no value in mine soils due to the large number of RFs.

Rock Type

The bedrock in the Appalachian region consists of various types of sedimentary rocks that are very different in their physical and chemical properties depending on their origin (Evangelou, 1995). Many meters of this hard rock is blasted and removed in order to retrieve the coal through surface mining. The resulting spoil material is then often used as a topsoil substitute during reclamation, and this is important to tree growth (Torbert et al., 1988a; Preve et al., 1984; Andrews, 1992). Spoil type affects properties such as texture, color, and subsurface pH (Indorante et al., 1992; Sencindiver and Ammons, 2000; Haering et al., 2005).

Bedrock located close to the original surface is oxidized and chemically weathered to some degree. This pre-weathered rock makes a much better topsoil substitute than reduced (unoxidized) spoil material (Hearing et al., 1993). The weathering of this material occurs in two distinct phases: 1) weathering of rocks both chemically and physically into soil-sized particles; and 2) weathering of soil minerals to release ions into the soil solution (Kingsbury, 1993).

Oxidized sandstone is considered to be the best parent material for the production of forest trees due to its resistance to compaction, increased macro-porosity, lower pH, lower levels of soluble salts, and its quick response to physical weathering processes (Hearing et al., 1993; Torbert et al. 1990). A sandy loam texture soil often results from weathering of sandstone. A depth of 1.2 m or more of uncompacted sandstone material is needed to produce a mine soil of high quality and productivity for native trees (Burger and Zipper, 2002). In a study by Torbert et al. (1988a) of hybrid pine growth on different rock mixtures, four-year-old trees had an average height, diameter, and volume of 146.2 cm, 40.4 mm, and 685 cm^3 respectively on oxidized sandstone spoil. On siltstone spoil the values reported were 84.8 cm, 21.8 mm, and 123 cm^3. After five years on this site it was concluded that overall survival was not significantly affected by rock type, but tree volume was (Torbert et al., 1990).

Siltstone and shale rock types weather into finer particles than sandstone and soils derived from them are more susceptible to compaction, have fewer macro-pores, higher pH, and higher levels of soluble salts. These rock types do not weather as quickly due to the more compact and less aerated structure that prevents water from being able to penetrate their interior. Hearing et al. (1993) reported only a 1 % decrease in RF content after 5 years of weathering of a pure siltstone spoil, as opposed to a 10 % decrease of a pure sandstone spoil. Due to the higher RF content in siltstone spoils (72 % vs. 52 % for sandstone) the whole soil available water holding capacity can be nearly half that of sandstone spoils (24 vs. 43 g kg^{-1}) (Torbert et al., 1990). The increase in RFs overrides the effect that an increase in silt sized soil material has on water holding capacity. However, germination of white pine has been reported as three times greater on siltstone than sandstone spoils due to higher moisture retention, but survival was 1.5 times better on sandstone spoils (Preve et al., 1984).

Unoxidized sandstone, siltstone, and shale in the Appalachian region that are grey, black, or white (for some sandstones) in color tend to be more cemented and take a longer time to weather into soil material than oxidized rocks of the same type (Burger and Zipper, 2002). The unoxidized rocks usually have a higher pH, and higher level of soluble salts than the oxidized rocks.

Rock fragments

The RF content of most reclaimed surface mines in the eastern coalfield region ranges between 40 - 80% (Plass and Vogel, 1973; Schoenholtz et al., 1992; Rodrique and Burger, 2004; Hearing et al., 1993). This high RF content is a potential growth limiting problem because of the reduced total soil volume, lower water holding capacity, rapid drainage, and potentially droughty conditions due to water being held at low tensions (Schoenholtz et al., 1992; Sobek et al., 2000; Pedersen et al., 1978). Plass and Vogel (1973) reported an average of 37 % of fine-earth (< 2 mm) material for 39 surface mine spoils in southern WV. This was apparently sufficient to retain adequate amounts of water during normal weather conditions. Bramble (1952) reported that mine soils must have at least 20 % soil-sized particles for trees to survive. Rodrique and Burger (2004) found RF content to be negatively correlated with SI of white oak with a decrease in RF percentage resulting in an increase in SI.

However, the RFs may also reduce the impact of compaction during grading by creating voids in which soils fines are protected from the force of heavy equipment. The increased rooting depth on loose, stony mine soils appears to compensate for the loss of soil volume (Ashby et al., 1984). Some RFs may also hold moisture that may be available to plants. Hanson and Blevins (1979) reported 11 % and 23 % available water for sandstone and shale fragments, respectively. The water in RFs was held at low tensions and was available for plant extraction.

Soil Depth

The concept of a “rooting volume index” (RVI) has been used in some studies and found to be a significant variable related to tree growth (Torbert et al., 1988b). The RVI is calculated by multiplying rooting depth and the percent fine soil (<2 mm) fraction. Torbert et al. (1988b) found that the RVI accounted for almost 50% of the variation in tree height for 8-year-old white pines. Andrews et al. (1998) found that rooting depth (not corrected for RFs) was the mine soil property most strongly related to height growth for 78 white pine plantations growing on reclaimed mine soils. The rooting depth can be defined by the depth to a root-limiting layer such as a densic layer that impedes root growth and water movement (Soil Survey Division Staff, 1999) or bedrock layer. Layers with “bridging voids” (large air gaps between rocks), greater than 90% RFs, and essentially no soil may also be considered root limiting (John Sencindiver, personal communication).

Topsoil

In some cases the original topsoil (O + A + E horizons) is stockpiled and then replaced on the surface after reclamation. This topsoil has proven to be beneficial by preserving the species diversity, biological integrity, nutrients, seed pools, and organic matter (OM) of the original forest, which is invaluable to the revegetation process (Daniels and Zipper, 1988; Vogel, 1981; Rodrique, 2001).

The value of topsoil placement on surface mined lands has been recognized mainly when reclaiming agricultural lands (Halvorson et al., 1986; Chong et al., 1986; Power et al., 1981). Topsoil thickness is especially important when the underlying spoil is a poor medium for root growth. In North Dakota the yield of alfalfa, wheat, crested wheatgrass, and native grasses were all found to respond to increased soil thickness up to 75 to 120 cm (Power et al., 1981). The greatest yield of all crops studied occurred when 20 cm of topsoil was placed over 55 cm to 110 cm of subsoil, but similar yields were obtained (except for wheat) where the topsoil and subsoil was mixed during reclamation.

Schoenholtz et al. (1992) found that the survival of pitch x loblolly pine hybrids on plots where topsoil was replaced was much lower than on control plots (60% vs. 83%), but height and diameter growth for the first two years was greater. However, none of these differences were statistically significant at the 0.05 level. The topsoil plots did have significantly higher total and mineralizable soil nitrogen (N) levels.

Chong et al. (1986) reported that the average OM content of topsoil was 1.9 % as opposed to 0.1 % for mixed B and C horizon materials. Reduction in OM content has been recognized as a primary reason for declines in forest productivity (Powers et al., 1990).

Color

Mine soils often consist of many different colors inherited from the parent material rocks (lithochromic colors). These colors may be used to determine the degree of oxidation, and generally describe weathering potential, nutrient release, and acidity reactions in the spoil material. The oxidized overburden can generally be identified by soil color chroma ≥ 3 due to precipitation of secondary Fe-oxides (Hearing et al., 2004; Sobek et al., 2000). Materials with a color value ≤ 3 contain high amounts of carbon (C) and often contain high amounts of sulfur that may be a source of extreme acidity (Sobek et al., 2000).

Texture

The texture of mine soils is likely to change within a few years of exposure to weathering. Haering et al. (1993) reported an increase in silt and decrease in sand after only one year of weathering in a siltstone spoil. Sandstone spoils showed little change in texture over the same time period. Silt particles are known to have the greatest water holding capacity and the presence of silt may lead to lower mortality rates in planted seedlings. However, silty soils are more easily compacted and less aerated than soils dominated by sand-sized particles, and therefore considered to be less productive for forest trees. A sandy loam-textured soil is considered to be optimum for tree growth by Burger and Zipper (2002). Fine texture soils along with the weak structure of mine soils may present aeration limitations for trees due to few macropores.

Slope and Aspect

Slope and aspect are factors associated with the successful establishment of trees on post-SMCRA mine soils (Vogel, 1981; Burger et al., 2002). Although the surface is returned to a similar topography, the subsurface hydrology that commonly is related to surface topography is altered often beyond simple explanation.

Steeper slopes on reclaimed surface mines are correlated with lower compaction and increased rooting depth due to the reduced amount of traffic by heavy equipment (Andrews et al., 1998). The aspect of the slope also has an influence on the temperature and water relations (evaporation and transpiration) of the soil. Southwest slopes receive the most direct sunlight during the growing season which increases photosynthesis and growth potential in steep areas (Miller et al., 2004). Whittaker (1966) also found south-facing forest stands to be more productive at high elevations (>1400 m) in the Great Smoky Mountains of Tennessee and North

Carolina. However, the southwest aspects also have higher evaporation and soil temperatures, causing reduced arthropod activity, and dry conditions on mine soils that are potentially droughty already. The northeast aspects are considered to be the best sites for tree growth due to their mesic site conditions (Burger et al., 2002). Furthermore, more complete litter decomposition and more rapid nutrient cycling have been noted on north and east aspects of native forests and associated soils in WV and VA (Hicks and Frank, 1984; Miller et al., 2004).

Chemical Properties

Soil Reaction (pH)

The pH of a soil is also known as the active acidity of the soil and is a measure of the hydrogen ions in the soil solution (Brady and Weil, 1999). The pH affects nutrient availability in the soil and the ionic form of some nutrients. Most native trees in the Appalachian Mountains generally compete better with herbaceous vegetation found on mine soils where pH is 5.5 or less (Skousen et al., 1994) but other species can grow well at more neutral pH values. A lower pH negatively affects the herbaceous ground cover growth, which positively affects tree growth due to less competition (Johnson and Skousen, 1995).

In recently reclaimed mine soils in regions with high carbonates in spoils the pH is often high (> 7) due to the lack of weathering processes on the spoil material. Bussler et al. (1984) reported pH values of 7.1 - 7.6 on Indiana mine soils. These values may be high enough to reduce the availability of boron (B), copper (Cu), zinc (Zn), iron (Fe), and manganese (Mn) (Brady and Weil, 1999).

With previously unweathered material being brought to the surface, there is always a possibility that weathering may cause toxic materials to be released or formed from the geologic material. The most notable problem occurs from the oxidation of pyritic minerals (FeS_2) to sulfuric acid that lowers the pH of the soil to a level detrimental to plant growth (Daniels and Zipper, 1997). The SMCRA provides requirements for the burial of this material well beneath the surface and it should not be a problem on post-SMCRA sites.

Torbert et al. (1990) found an inverse relationship ($R^2 = 0.86$) between tree volume and mine soil pH when studying pine growth on different spoil types. The pH values in this study ranged from 5.7 in the pure sandstone plots, to 7.1 in pure siltstone. Plass and Vogel (1973) found that a majority of the spoil material from 10 coal seams in southern WV ranged in pH from 4.0 - 6.0. In their review of eastern KY acid forming spoil materials, Barnhisel and Massey (1969) found pH's ranging from 2.16 - 6.20. Possible toxic levels of Mn, Cu, Fe, and Zn were found in the samples at the low end of this range. Schuster (1983) found that pH was one of only three factors significantly correlated to tree survival on strip mines in Pennsylvania. Davidson (1986) also found pH to be a major factor related to the survival of different tree species but notes that using other factors such as electrical conductivity (EC), exchangeable hydrogen (H), aluminum (Al), and nutrient levels in conjunction with pH increases the ability to predict survival.

Soluble Salts

Electrical conductivity (EC) is a measure of the level of soluble salts, or "the concentration of ionized constituents" in a soil (Sobek et al., 2000), and has been recognized as a factor that affects reforestation success on mine soils (Andrews et al., 1998; Torbert et al., 1988b; Burger et al., 1994; Rodrique and Burger, 2004). High levels of soluble salts result from the rapid weathering of newly exposed rock material. The salts often include the sulfates of sodium (Na), calcium (Ca), magnesium (Mg), and potassium (K) (Daniels and Zipper, 1997). Over time the level usually decreases due to leaching. The high salt level creates a high osmotic potential in the soil, and water absorption by plants is reduced. Ion toxicities and nutrient imbalances may also result from high EC values. Andrews et al. (1998) found total soluble salts to be the most important chemical property to affect white pine growth on mine soils, with a decrease in height growth with increasing EC. In that study EC values ranged from 0.02 to 1.97 dS m^{-1}.

Plant response to soluble salt levels becomes more dramatic as EC levels increase. An EC level of 3 dS m^{-1} was recognized as being toxic to plants, and at 2 dS m^{-1} plants are somewhat adversely affected (Cummins et al., 1965 *as cited in* Torbert et al., 1988b). However, in a study on 10-year-old white pines by Torbert et al. (1988b), the highest EC level recorded was 1.7 dS m^{-1} and it corresponded to a tree size of only 1.18 m. This suggests that a critical value lower than 2 dS m^{-1} is associated with forest tree productivity or that some other property associated with high EC is affecting growth. Rodrique and Burger (2004) found EC values ranging from 0.37 to 1.59 dS m^{-1}, which is below defined critical limits but it was a significant variable in their final model of factors influencing tree growth.

Ciolkosz et al. (1985) found salt concentrations increasing with depth on mine soils. Torbert et al. (1988a) found increasing soluble salt levels with an increase in siltstone percentage of the mine spoil material. This supports the findings that EC levels tend to be higher in fine textured mine soils (Torbert et al., 1988b; Rodrique and Burger, 2004). Torbert et al. (1988b) found a significant relationship between the clay fraction and EC, with mine soils containing higher amounts of clay resulting in higher EC values. Rodrique and Burger (2004) recognized finely textured C horizons with textures of silty clay and silty clay loam to have the highest EC readings, while horizons with textures of sandy loam and loam had the lowest values. These data suggests that siltstone spoil materials are likely to produce toxic EC levels, and that mine soils from sandstone spoils are better for tree growth (Preve et al., 1984).

Aluminum and Manganese

Aluminum (Al) and Manganese (Mn) are discussed together because the mobility, availability, and toxicity of both elements increase with a decreasing pH. Acid related toxicities, particularly due to Al and Mn, have been recognized as properties limiting the revegetation of mine soils (Thurman, 1983; Vogel, 1981; Barnhisel and Massey, 1969).

Aluminum is responsible for most of the acidity in natural soils and Al-hydrolysis reactions strongly buffer the soil between pH 4.5 to 5.0 (McBride, 1994). Below this pH range Al tends to convert to the soluble free cation form, Al^{3+}, which can be toxic to plants. Above this range Al tends to form the precipitated solid, $Al(OH)_3$. For a majority of mine soils, exchangeable Al is quite low because it has not been released from the relatively unweathered spoil material. McCormick and Steiner (1978) tested the Al tolerance of tree species commonly used in the reforestation of acidic spoils. Hybrid poplar was the least tolerant and was sensitive to very low concentrations of Al (<10 mg kg^{-1}). Pin oak (*Quercus palustris* Muenchh.) and red oak (*Quercus rubra* L.) were the most tolerant, and the pines (*Pinus spp.*) and birches (*Betula spp.*) were intermediate.

Manganese is also an element that becomes more soluble and available to plants at low pH values, and is unavailable at high pH values. Mn toxicity to plants is most likely found in waterlogged or acid soils with low humus content, and deficiency is most often observed in saline, alkaline, calcareous, peaty, and coarse-textured soils (McBride, 1994). Daniels et al. (1984) indicate that Mn toxicity may be a problem even at high pH for some Southwest VA mine soils due to levels of easily reducible Mn in relatively unweathered overburden materials that could possibly transform to soluble Mn over time. McFee et al. (1981) noted that Mn toxicity symptoms were most severe on spoils with a pH less than 5.0. Manganese has been important in forest productivity studies due to its toxicity and its deficiency. Andrews et al. (1998) found that height growth of white pine generally declined when exchangeable Mn levels exceeded 20 mg kg^{-1}. However, Torbert et al. (1990) found an increase in foliar Mn concentrations was associated with increased tree volume in pitch x loblolly pine hybrids.

Nitrogen and Phosphorus

N and P are two of the most important elements for optimum tree growth, and are also considered to be the most deficient on mine soils in the eastern coalfield region due to the lack of OM for N mineralization, and the high levels of insoluble Fe-, Al-, and Ca-bound phosphates (Vogel, 1981; Daniels and Zipper, 1997; Howard et al., 1988; Daniels et al., 1986; Howard, 1979; Barnhisel and Massey, 1969). Daniels and Zipper (1988) recognized the accumulation of OM and N, the establishment of an organic-P pool, and the avoidance of P-fixation as being the major factors for the long-term productivity of mine soils.

Burger et al. (1994), Torbert et al. (1988b), and Andrews et al. (1998) all found extractable soil P to be significantly correlated to tree growth. P will likely become unavailable in mine soils with an abundance of Fe, Al, and Ca, due to reactions with these elements to form insoluble compounds. At low pH, Fe and Al bind with P, and at high pH Ca controls solubility of P. A pH of 6.5 is optimum for P availability to plants (Stevenson, 1986). Howard (1979) recognized that most spoil material found in Southwest VA is high in Fe, and that P-fixation by Fe-oxides could present a problem in revegetation. The brownish-red oxidized spoil materials that are often preferred for topsoil substitutes usually contain a high amount of these Fe-oxides (Daniels and Zipper, 1988). Calcareous spoil material may have a significant amount of Ca-phosphates that causes P to be unavailable to plants at first, but will be slowly released as weathering takes place and pH decreases.

Andrews et al. (1998) used a $NaHCO_3$ extraction and found soil P levels ranging from 1.3 to 22.0 mg kg^{-1} for 78 reclaimed mined sites in VA and WV. The association between height growth of white pine and soil P levels was significant in their model even though P deficiencies were not a common problem. Torbert et al. (1988b) found soil P levels ranging from 0.2 to 28.5 mg kg^{-1} for 34 reclaimed mined sites in southwest VA.

When a topsoil substitute is used in place of the original topsoil, the surface layer contains very small (if any) amounts of OM, or C and N in plant-available forms (Faulconer et al., 1996; Power et al., 1981). Symbiotic fixation, mineralization of organic N, and fertilizer additions are the main mechanisms relied upon for an increase in available N (Daniels and Zipper, 1988). The addition of native topsoil and organic amendments have been shown to increase N availability to plants by increasing microbial activity and organic N pools in the soil (Faulconer et al., 1996; Rodrique, 2001; Roberts et al., 1988b; Schoenholtz et al., 1992). Seeding of herbaceous and woody leguminous species has also been used as a method to return N to mine soils (Faulconer et al., 1996; Jencks et al., 1982). Jencks et al. (1982) found that N accumulation on mine soils under black locust increased with age. An average N content of 2,974 kg ha^{-1} after 16 to 18 years was reported, and exceeds 2,808 kg ha^{-1} that was found in an adjacent native soil. A mine soil from Southwest VA was found to have an in-situ N mineralization rate of at least 59 kg N ha^{-1} year^{-1} (Faulconer et al., 1996), which easily meets the 5 to 25 kg N ha^{-1} year^{-1} that would be found in an undisturbed forest soil (Keeney, 1980).

Rock type also influences soil N on reclaimed mined land. Total N has been shown to increase with an increase in siltstone in the parent material. Roberts et al. (1988a) reported values of 601 mg kg^{-1} for sandstone and 1,220 mg kg^{-1} for siltstone. However, there was a smaller portion of fine earth material in siltstone spoils that lead to higher concentrations, and a higher proportion of 2:1 clays that fix more NH_4-N. Therefore, plant available N may not be greater for siltstone than for sandstone mine soils.

Macro- and Micro-Nutrients

The amount of nutrients in a mine soil is largely dependent on the original material used in reclamation and its degree of weathering. Most nutrients occur in adequate amounts for plant growth due to the rapid release of these elements from the newly exposed geologic material. The importance of Fe and Ca on P availability, sulfur (S) on acidification, and possible toxicities and deficiencies of elements such as B, Zn, Mn, and Cu have previously been discussed. K may become limiting due to fixation within inter-layers of 2:1 clay minerals if they are abundant. Howard et al. (1988) found this to be of little concern in southwestern VA mine spoils.

Cation Exchange Capacity and Base Saturation

The cation exchange capacity (CEC) of soils is largely dictated by the type and content of clay, and OM in soils. In mine soils, clay and OM content are usually very low in a majority of the eastern coalfield region. This leads to soils with low CEC values, which has been noted as the overall limitation to the nutrient potential of mine spoils (Howard et al., 1988). CEC values are commonly between 1 and 11 $cmol_c\ kg^{-1}$ (Evangelou, 1995). Skousen et al. (1994) found CEC values ranging from 6 to 47 $cmol_c\ kg^{-1}$ for 15 mined sites in northern WV. The CEC of recently-formed A horizons in mine soils are usually slightly higher than subsurface horizons due to the accumulation of OM (Roberts et al., 1988a). Three years after reclamation at Roberts' (1988a) sites, CEC values ranged from 3.7 to 7.1 $cmol_c\ kg^{-1}$ for different spoil materials, with the highest value associated with siltstone spoils and the lowest values with sandstone spoils.

Base saturation (BS) is the percent of the cation exchange sites that are occupied by base cations. At pH values less than 4 it is implied that BS percent approaches zero (Evangelou, 1995). High BS levels (>50 %) indicates that there is high base cation availability and low levels of exchangeable acidity (Rodrique and Burger, 2004). Base saturation ranged from 13 to 100 % in Rodrigue and Burger's (2004) model, and they found it to be the most significant mine soil property that affected tree growth. Base saturation is often high in young, unweathered mine soils because aluminum has not yet been released into solution and base cations dominate the soil solution (Daniels and Amos, 1982).

FOREST PRODUCTIVITY AND SITE CLASSIFICATION

Forest Productivity

Forest site productivity is most commonly defined as volume or biomass production of a given species over time (Powers et al., 1990), and is a function of both biotic and abiotic factors and their interaction (Van Lear, 1990). Forest site productivity potential is primarily determined by soil and site characteristics, and on actual tree growth and yield data (Hagglund, 1981). Many methods have been used to measure productivity (Carmean 1975). Direct methods are those in which actual tree growth data is used to determine productivity. Indirect methods require an evaluation of soils, topography, vegetation, physiography, or a combination of properties. Productivity indices (PI) based on sufficiency curves is an example of an indirect method used to determine site quality.

Site Index

SI is the most common and widely accepted method of expressing forest site quality (Carmean, 1975; Johnson et al., 2002). It is based on the height of dominant and co-dominant trees at a certain age. Often an index age of 50 years is used and expressed as SI_{50}. SI curves have been developed to predict the growth potential of trees less than 50 years of age. Curves that convert SI values of one species to another species have also been developed (Doolittle, 1958)

Growth Intercept

Growth intercept models may be useful for SI estimation for tree species such as white pine (*Pinus strobus* L.) and red pine (*Pinus resinosa* Ait.) that have distinct one-year internode growth. This method of determining SI can be used when trees are too young for traditional SI curves to be used. Beck (1971) developed a growth intercept model to predict the SI of white pine using internode length within a selected period of early height growth. Measurements of the first five internodes above breast-height (1.4 meters) were used to obtain a SI value (Equation 1):

$$SI = 26 + 6.6\ (\text{5-year internode length}) \qquad \textbf{(1)}$$

Where SI = white pine site index (predicted tree height in feet at age 50); 26 and 6.6 are coefficients; and 5-year internode = total length in feet of the first five internodes beginning at breast height. This growth intercept method reduces the effects of slow early growth on SI values but may also overestimate the growth during later years (Carmean, 1975).

Soil-Site Evaluations

Soil-site studies are most efficiently used where conditions are extremely variable, or there are no established trees present for direct estimations of SI (Carmean, 1975). Soil properties must be measurable in the field and they must correlate well with tree growth. In most all of the soil-site evaluations the important factors are related to available soil moisture and the growing space for tree roots (Aydelott, 1978).

Huddleston (1984) provided a good review of soil productivity ratings in the United States and suggested that soil productivity ratings can be expressed either qualitatively or quantitatively. Quantitative ratings may be assigned inductively or deductively. Inductive ratings are based on the inferred affects of soil properties on yields while deductive ratings are based on actual yield data. Most productivity evaluations combine inductive and deductive reasoning.

Within the realm of inductive ratings there are multiplicative and additive systems, and a combination of the two. Multiplicative systems separate the ratings and then take the product of all of them. Huddleston (1984) warned against this system in that the overall rating may be lower than the ratings of each individual factor. However, this system follows scientific laws, and acknowledges a single factor as being a dominant limitation to productivity. Only four or five factors should be used with multiplicative systems (Huddleston, 1984).

Additive systems are able to incorporate multiple factors into a soil rating. As the name implies each soil factor is given a rating and all factors are summed, or subtracted from a maximum rating (100), in order to get a PI. This system may generate negative numbers and could be difficult to interpret for plant yields. A combination of these systems allows the incorporation of information from many factors without generating unrealistic or negative numbers, or minimizing the effect of one or two major limitations (Huddleston, 1984). Weighting factors for each soil horizon or for each soil property based on its importance to productivity may be multiplied into an otherwise additive system.

Carmean (1979) summarized soil and site properties that are often correlated with SI. These include surface soil depth, depth to mottling, depth to impermeable layer, effective soil depth, texture, stone content, structure, drainage, and subsoil color. Topographic and climatic features such as aspect, slope position, slope steepness, slope shape, elevation, latitude, rainfall, and temperature were also recognized. Topographic features are most important in mountainous areas.

Some of the first soil-site quality evaluations and ratings for forests were developed by Storie and Wieslander (1948). Storie and Wieslander (1948) rated soils in California based on: (1) soil depth, texture characteristics; (2) soil permeability; (3) chemical properties; (4) drainage, runoff; (5) climate. A multiplicative system was used to divide sites into five site ratings for different conifer species. Coile (1952) provided a good review of other pioneer research.

Some site classifications and evaluations are based solely on landform and topographic variables. However, geology and nutrient levels associated with these landforms are the basis of most of these studies. Smalley (1984) developed guides using this type of classification for much of the Cumberland Plateau, Cumberland Mountains, Highland Rim, and Pennyroyal. Each region was divided into sub-regions and landform associations based on the geology, topography, climate, soils, and vegetation. When the system was adopted, land types became the basic mapping unit used for management. Climate, soils, and vegetation were not directly measured after the system was initially developed, but inferred from the knowledge of landforms in the region. Mader (1976) found topographic variables alone to be a poor predictor of white pine SI in Massachusetts. Important variables in his final regression were texture, pH, drainage class, total N in profile, and BS in the B horizon. A higher SI was correlated with a poorer drainage class, higher pH, and finer soil textures. Auchmoody and Smith (1979) developed an equation was to predict the SI of oaks in northwestern WV. The variables within the equation were slope shape, thickness of A horizon, slope gradient, aspect, precipitation, and position on slope.

Coile (1952) found soil properties such as depth, texture, and drainage to be the most important for southern pine growth. Baker and Broadfoot (1978) recognized four major soil factors as being important to the growth of hardwoods in the south: 1 = soil physical condition, 2 = moisture availability during the growing season, 3 = nutrient availability, 4 = aeration. They used easily measurable properties such as texture, structure, color, topographic position, A horizon depth, present cover, and depth to root- and water-restrictive horizons to estimate the site condition. Points or site quality ratings were given to different levels of each property observed and added in order to obtain a total that represented the predicted SI.

Jones and Saviello (1991) also used an additive system in an attempt to develop a simple model to predict site quality for the Alleghany hardwood region. Various point amounts were given to sites based on texture, aspect, stoniness, slope position, slope shape, shade angle, and soil depth. The total points were used to divide the area into three site quality classes and identify the sites meriting financial investment. The three broad classes were different from other models that estimate absolute values as an expression of site quality but were simple, flexible, and economical in their use.

Productivity Indexes

The underlying concept of the PI is that the overall productivity of a plant is proportional to root growth (Henderson et al., 1990) and thus describes tree growth. A tree whose root growth is not restricted by soil properties will reach its maximum genetic potential for a climatic region. The index is based on sufficiency curves that describe the suitability of the soil for root growth. Sufficiency curves have been developed for soil properties such as pH, D_b, aeration, and available water content, although Burley (1996) criticizes the approach of using sufficiency curves in order to determine productivity. Burley claims that sufficiency curves are heuristically derived and not statistically validated.

The PI model was first introduced by Neill (1979) and Kiniry et al. (1983) for agronomic crops. Five soil properties were identified that were thought to influence root growth and subsequently above-ground biomass production of annual crops. These properties were potential available water storage capacity (PAWC), aeration, D_b, soil pH, and EC. Gale (1987) suggested that measurements of plant-available N, P, and possibly other nutrients would be an appropriate addition to the model when used for forested sites. However, the PI model that was originally described may not explain variations in the productivity of deep-rooted trees (Udawatta, 1994). Kiniry et al. (1983) provides a conceptual model relating the original five soil properties to other growth factors (Figure II-2).

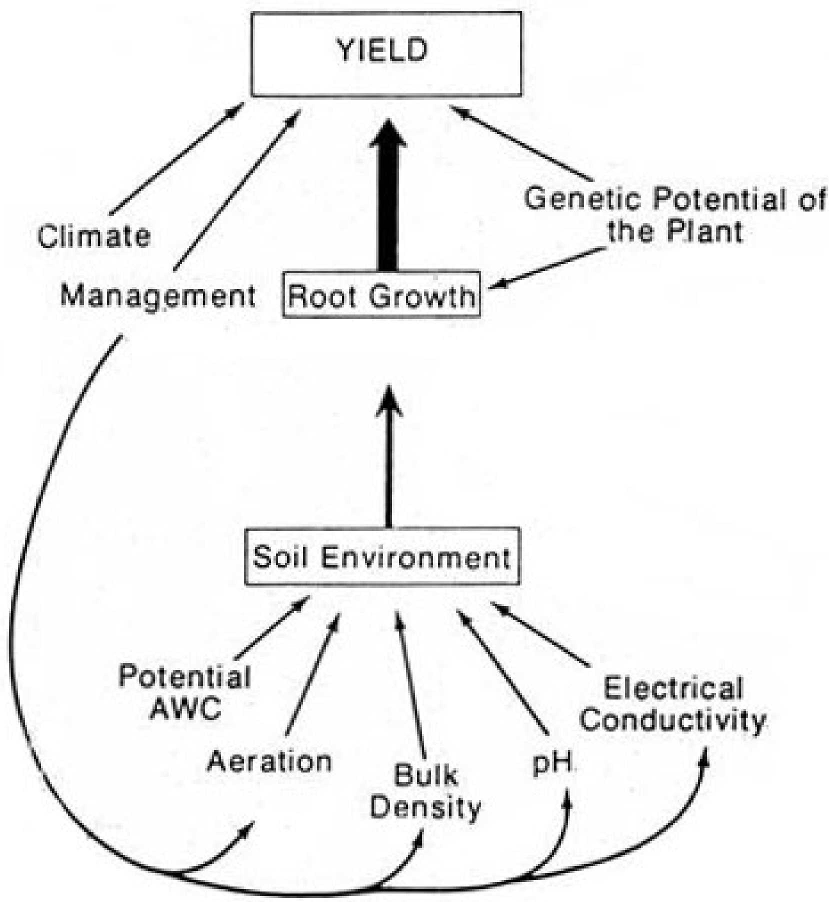

Figure II-2. Factors that affect the potential yield of plants (from Kiniry et al., 1983).

The use of the PI model results in a unitless number with a PI of 1.00 being the best. Any value below 1.00 represents the percentage of maximum root growth possible that can be expected. The original equation by Neill (Equation 2) used the product of the sufficiency of the five soil properties, and a weighting factor which also ranged from 0 to 1 and was based on the proportion of roots at a certain depth. This value is then summed over *r*, the number of 10 cm thick soil horizons within the rooting depth.

$$PI = \sum_{i=1}^{r} (A * B * C * D * E * WF)_i \tag{2}$$

where A = the sufficiency of PAWC
B = the sufficiency of aeration
C = the sufficiency of D_b
D = the sufficiency of pH
E = the sufficiency of EC
WF = the weighting factor
PI = the productivity index of the soil environment
r = depth of rooting under ideal soil conditions in units of 10 cm
i = the number of 10 cm increments (i = 1,2,3…r)

Pierce et al. (1983) reduced the equation by eliminating the sufficiency for aeration and EC (Equation 3). The number of pedogenic horizons is represented by *r*.

$$PI = \sum_{i=1}^{r} (A * C * D * WF)_i \tag{3}$$

Gale (1987) modified the original equation by eliminating the sufficiency of EC, and adding the sufficiency of topography (percent slope) and climate (Equation 4).

$$PI = \sum_{i=1}^{r} ([A * B * C * D]^{1/4} * WF)_i * [S * Cl]^{1/2} \tag{4}$$

where S = the sufficiency of topography (percent slope)
Cl = the sufficiency of climate

Gale used the geometric mean of the sufficiency values in order to give equal weight to differences in factor ratings. Therefore, if sufficiency's of 0.9, 0.9, and 0.9 were recorded then the PI would equal 0.9. With a simple multiplicative equation the same sufficiency values would result in a PI of 0.73 (Gale et al., 1991). Gale and Grigal (1987) developed curves that represent the vertical root distribution for intolerant, mid tolerant, and tolerant species. The equation used to develop the curves simply illustrates the decreasing root proportion with an increase in depth. The equation with β=0.96 (Equation 5) was used to obtain a weighting factor for use in a productivity equation for white spruce as well as for white pine (Gale et al., 1991; Torbert et al., 1994).

$$Y = 1 - \beta^{d} \tag{5}$$

where Y = cumulative root fraction from the surface to soil depth d
d = soil depth in centimeters
β = the estimated parameter

Torbert et al. (1994) used the PI model for white pine growth on mine soils. They developed sufficiency curves for P, Mn, slope, and pH. They also used a WF with the same equation as Gale. Many models were tested, but the final model resulted in using only pH, EC, and P, along with a WF that represented soil depth (Equation 6).

$$PI = (A * B * C)^{1/3} * WF \tag{6}$$

where A = sufficiency of pH
B = sufficiency of EC
C = sufficiency of soil P
WF = sufficiency of soil depth

Utilization of the geometric mean seemed to work best. A PI of 1.00 was decided to correspond with SI of 100 for white pines. Therefore, a SI of 80 would correspond to a PI of 0.80 if a linear relationship was assumed. Torbert et al. (1994) concluded that white pine height growth of an average of 45 cm yr^{-1} for two consecutive years would correspond to a SI of 80, and should be used as a productivity standard for reclaimed surface mines.

Classification

Site classification of soils and forests has been used to divide parcels of land into landscape units based on morphology, topography, or different management plans. Most classification schemes attempt to provide forest managers with a method to separate complex forest systems into homogeneous landscape units (Jones, 1994). The mapping and grouping of these landform units is primarily based on productivity (Van Lear, 1990). These systems attempt to relate a property of interest to some measurable feature of the site (Fox, 1991). Fox (1991) also concluded that land classification systems must address the potential to affect site productivity through silvicultural manipulations along with the inherent productivity. All classification systems should be practical, easy to use, and flexible in its application (Smalley, 1991; Jones and Saviello, 1991). The methods should also be easily communicated across professions such as forestry and soil science (Aydelott, 1978). Ecological classifications that incorporate soils, vegetation, physiography, and their interrelationships may be the best way to map and classify forest ecosystems (Corns and Pluth, 1984; Barnes et al., 1982)

The most widely-used soil classification in the world is USDA-NRCS Soil Taxonomy (Soil Survey Division Staff, 1999). Landscape units are delineated into map units that have a predictable composition and are named for the dominant soil series. Each soil series within each map unit is assigned a woodland suitability class and predicted SI values for certain tree species are given for each class as explained by Wiggins (1978). However, many foresters have found that these soil surveys are not adequate for the classification of forest sites due to large differences in SI within a soil series unit (Carmean, 1975; Van Lear, 1990; Smalley, 1991).

Soil Taxonomy has recently been used for classifying mine soils into soil series (Haering et al., 2005; Ammons and Scencindiver, 1990; Thurman and Scencindiver, 1986; Ciolkosz et al., 1985; Scencindiver and Ammons, 2000). Although over three dozen series for mine soils have been formally established, some soil scientists feel that current classes in Soil Taxonomy do not recognize the key features of mine soils and are not adequate for management interpretations (Schafer, 1979; Sencindiver, 1977; Indorante et al., 1992; Scencindiver and Ammons, 2000). Soil series in mined lands are usually based on particle size family, pH, and soil texture. Haering et al. (2005) proposed using rock type in classifying mine soils, and also recognized the importance of drainage class, densic layers, and cambic horizons (Soil Survey Division Staff, 1999). The addition of these criteria would greatly improve the Soil Taxonomy method of mine soil classification due to their importance to forest management. The extreme heterogeneity of mine soils prevents much of the standard USDA mapping techniques and soil criteria from being able to be used in a practical manner for mine soil mapping. Kotar (1986) claims that plant indicators suggest that soil series are broader than needed for optimal use in forest management.

Other classification schemes have been developed for specific regions and for specific purposes. Many of the large commercial forestry companies have developed their own schemes that are specific to their region and to the species being managed (Rayonier, 1993; Union Camp corporation (Broerman, 1978); Weyerhaeuser (Campbell, 1978); U.S. Forest Service (Aydelott, 1978); Cooperative Research in Forest Fertilization Program, University of Florida). Others have developed classification models for specific forest regions (Smalley, 1991; Jones and Saviello, 1991), or for certain tree species (Baker and Broadfoot, 1978; Coile, 1952).

Vegetation is often evaluated and used to predict soil type and corresponding forest site quality classes. Habitat types are said to be the basic ecologic units of landscapes, and natural vegetation is considered to be integrators of all possible combinations of environmental factors important to plants (Daubenmire, 1976; Jones, 1991). Jones (1991) recognizes that those plants with narrow ecological amplitude may be good diagnostic indicators of differences in site quality. McNab (1991) used vegetation to initially identify ecologically similar landscape units when classifying the Blue Ridge province. Because vegetation type simultaneously integrates many site factors, Barnes et al. (1982) claimed that vegetation is the most popular basis for site classification, but warned that herbs may only indicate upper soil conditions and be insufficient for forest growth predictions.

CHAPTER III

ASSESSMENT OF ALTERNATIVE BULK DENSITY MEASUREMENT METHODS ON MINE SOILS IN THE APPALACHIAN COALFIELD REGION

INTRODUCTION

High fine-earth bulk density (D_b) is the primary limitation for vegetation success on mine soils in the Appalachian coalfield region (Daniels and Amos, 1981). Compaction from repeated passes of heavy equipment often occurs when returning mined land to "approximate original contour" (AOC), which is required by the Surface Mining Control and Reclamation Act (SMCRA) of 1977. Compaction results in high fine earth D_b, along with reduced macroporosity, increased soil strength, impeded infiltration and drainage, reduced aeration, and other factors that are detrimental to tree survival and root growth (Ruark et al., 1982).

Measuring D_b in the field can be time-consuming and inaccurate in mine soils due to the high rock fragment (RF, particles >2 mm) content. Conventional coring tools cannot be used because they are impeded by too many RFs. Andrews et al. (1998) used an excavation method and found D_b ranging from 0.64 to 1.94 g cm^{-3} with an average of 1.02 g cm^{-3}, and in general found no roots in horizons with a D_b >1.7 g cm^{-3}. They concluded that the D_b values were inaccurate due to the high RF content (up to 88%). An attempt by Thompson et al. (1987) to correlate penetrometer resistance with D_b in the surface of mine soils was unsuccessful. Torbert et al. (1988b) used a penetrometer in an attempt to determine total soil depth, but found it to have no value in mine soils due to the large number of RFs. Pedersen et al. (1980) determined D_b using an excavation method, direct transmission gamma probe, and soil clods. No significant differences (alpha = 0.05) were found in the D_b measurements between the three methods and they are all too time consuming for field classifications. The excavation method of measuring D_b on mine soils is the most common but is too time consuming for field classifications of large land areas. Pedersen et al. (1980) suggests that when using the excavation method on rocky mine soils an excavation size of at least 1 m^3 is needed for accurate D_b estimation, which further disproves this method for efficient field classifications due to large equipment needed and time consuming procedures.

This study was conducted in an attempt to identify new tools and methods of assessing D_b of mine soils in the field. Three tests were conducted to correlate indicator tools with D_b measured by a small pit excavation and displacement method following that of Blake and Hartage (1986). The indicator tools included a sharp-shooter shovel, a screw auger, and a slide hammer device with a tapered tip (Figure III-1).

Figure III-1. Tools used to estimate bulk density measured by the excavation method on mine soils in the Appalachian region. From left to right: A slide hammer with a tapered tip (constructed by sharpening a carriage bolt), a sharpshooter, a meter stick for scale, and a screw auger.

MATERIALS AND METHODS

The study was conducted at sites in Lawrence County, Ohio (OH), Nicholas County, West Virginia (WV), and Wise County, Virginia (VA). A three by three plot matrix was replicated three times at each site and a D_b measurement was taken in each plot, giving 81 measurements, using the excavation procedure described by Blake and Hartage (1986), with an excavation surface area of approximately 900 cm^2 and a depth of 10 cm. The hole was lined with thin plastic, lightly pressed into the corners, and then filled with lead BB's as the displacement media to the original surface level. The volume of the BB's was measured in a graduated cylinder and recorded. The RFs were removed by sieving the whole sample through a 2-mm sieve and their weight was subtracted from the total sample weight to obtain RF content (%) on a weight basis. All RFs were assumed to have a specific gravity of 2.65 g cm^{-3}. The soil was corrected for moisture content in order to obtain fine earth D_b values in g cm^{-3} on an oven-dry soil basis. D_b and RF measurements were assumed to be constant throughout the thickness of the surface layer down to an abruptly different spoil layer. Particle-size distribution was determined by the pipet method (Gee and Bauder, 1986). ANOVA was also used to analyze the soil properties of RFs and D_b for site and sample differences as a 3x2 random complete block design with three sites and two sample depths. Only the topsoil sample data is reported in this study. The three test tools were used at each plot where the D_b was measured by the excavation method described above.

A standard 14-cm wide sharp-shooter (tapered shovel with rounded tip) with a 40-cm long blade was placed on the surface and stepped on using a steady force from the weight of a 70-kg person. The depth of penetration (cm) into the soil was recorded to the nearest centimeter. Three to five replications near the sample point were averaged for a final measurement.

A screw auger (round tip screw head 16 cm long and 5 cm wide with 3 complete turns and on a 97-cm long shaft) was twisted into the soil for 3 and 6 half-turns, or until a different layer of spoil was encountered. The depth of penetration (cm) that was reached at each interval was recorded, and the cm penetration per half-turn value was calculated. The depth to a different soil layer was determined by a dramatic change in color or apparent density of spoil material in shallow pit excavations. If a solid rock was encountered and prevented further penetration, the process was repeated in a nearby location.

An AMS slide hammer (AMS Inc., American Falls, Idaho) was used with a tapered tip (constructed by the sharpening of a carriage bolt) and the depth of penetration (cm) was recorded for 5 and 10 drops, or to an abrupt change in spoil type. The cm penetration per drop was calculated for each pre-determined drop interval. If a solid rock was encountered and prevented further penetration, the process was repeated in a nearby location.

RESULTS AND DISCUSSION

The OH site had a significantly lower ($p < 0.05$) RF content than the other two sites, likely due to topsoil (surface horizon down to bedrock) being stockpiled and replaced after mining (Table III-1). The VA and WV sites had topsoil substitutes on the surface that were significantly higher ($p < 0.05$) in RF weight percent than OH. The D_b measured by the excavation method was not significant across all sites (Table III-1). However, the D_b at OH may be root limiting because of its finer textures (Brady and Weil, 1999). Grading of the low RF, fine texture soils increases the detrimental affects of compaction on the fine earth material and observed roots were widely-spaced at the OH site. Air gaps (open pockets within the soil profile that contain no fine soil material) may result when spoil with high RFs is graded and fine earth D_b by the excavation method may be skewed, indicating lower D_b than the actual fine earth D_b.

Ashby et al. (1984) indicated that increased porosity, water infiltration, water availability, and rooting depth are found on stony mine soils. These properties can lead to increased weathering rates and may ameliorate some compaction over time. The shallow measurement zone that was subject to intense soil-forming processes such as freeze-thaw and shrink-swell and biological activity also explains the relatively lower than expected D_b values at all sites. Furthermore, extremely cemented, large RFs may support the weight of heavy equipment enough to decrease its force and prevent an increase in fine earth D_b, or may overlap and protect the fine earth from some compaction.

Table III-1. Rock fragment content (weight percent) and fine earth bulk density measured using the excavation method at each study site.

	Rock fragments		Fine Earth Bulk Density	
Site	Mean †	Std. Dev.	Mean †	Std. Dev.
	------------ % ------------		------------ g cm^{-3} ------------	
OH	14 b	6	1.4 a	0.1
VA	49 a	14	1.2 a	0.2
WV	55 a	10	1.1 a	0.2

† Means followed by different letters are significantly different at alpha = 0.05 as determined by Fisher's LSD mean separation procedure.

None of the three tools or methods was found to accurately predict D_b as measured by the excavation method that is used most commonly used for mine soils. Sharpshooter penetration depth did not correlate with measured D_b at any of the sites, with an R^2 of 0.085 at OH, 0.053 at VA, and 0.083 at WV (Figure III-3). We hypothesized that sharpshooter depth would decrease as D_b increased. The penetration depths were greater at the OH sites than all but four samples at VA because they had the fewest RFs ($p < 0.05$) (Table III-1). Furthermore, the soils were moist during testing and had finer field-estimated textures than the other two sites allowing for easier sharpshooter penetration (Table III-2). The OH soils had a higher D_b than the other soils (Table

III-1), and the same penetration test conducted during a drier period may have produced different results. The penetration depths at VA and WV were lower than those at OH because they had a higher content of large, hard RFs ($p < 0.05$).

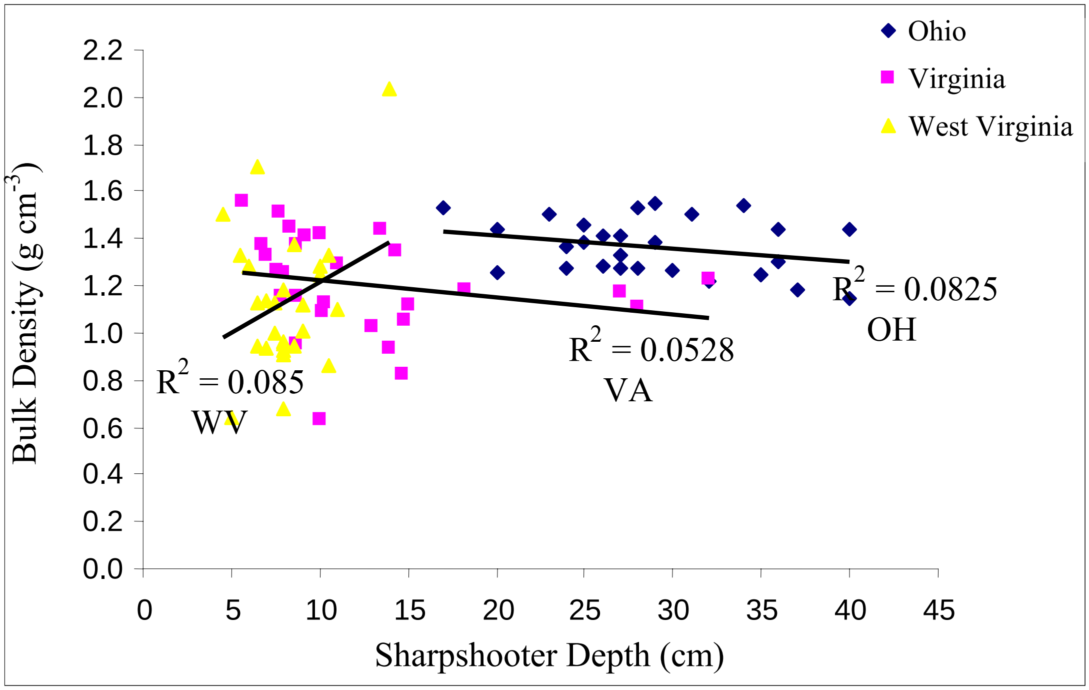

Figure III-2. The relationship between fine earth bulk density determined by the excavation method and sharpshooter penetration depth at each study site.

The screw auger cm penetration per three and six half-turns did not correlate with measured D_b, with an R^2 of 0.06 and 0.09, respectively. The cm penetration per half-turn was greater at OH than at VA and WV, and the increased soil contact and high soil moisture may have helped the screw auger pull itself down through the soil (Table III-1). Rock fragment content affected the depth and path of the screw auger as well and influenced the measurement, but most rocks were eventually bypassed with a few extra turns. The quantitative measure of cm per half-turn was insignificant in determining D_b, but the resistance to turning is likely a good relative indicator of soil density and may resemble the resistance that tree roots encounter.

Furthermore, total refusal (not from RF) to turning the screw auger may be used as a measure of total rooting depth.

Drop hammer cm penetration per 5 and 10 drops did not correlate with a measured D_b, with an R^2 of 0.03 and 0.07, respectively. The cm penetration per drop results was similar to those of the sharpshooter penetration depth data. The OH site had the highest measured D_b, along with the lowest RF weight percents that allowed the drop hammer to penetrate deeper into the soil, and consequently resulted in inaccurate data.

Table III-2. Whole and fine soil bulk density (D_b), rock fragment (RF) weight percent, moisture content, sand, silt, and clay determined for the 0-10 cm depth in nine plots within three blocks at three sites (Lawrence County, Ohio (OH); Wise County, Virginia (VA); Nicholas County, West Virginia (WV)).

Block	Plot	whole soil D_b	fine soil D_b	RF	Moisture content	sand	silt	clay
		-----------g cm^{-3}-----------		-------------------------------%--------------------------------				
OH1	1	1.6	1.6	6	18	30	40	30
OH1	2	1.5	1.4	17	23	35	38	27
OH1	3	1.6	1.5	16	22	31	42	27
OH1	4	1.3	1.3	4	30	26	46	28
OH1	5	1.6	1.5	14	26	34	41	25
OH1	6	1.5	1.5	6	24	27	47	26
OH1	7	1.5	1.4	10	23	31	46	23
OH1	8	1.6	1.4	18	23	29	46	24
OH1	9	1.6	1.5	11	24	24	47	29
OH2	1	1.5	1.5	6	22	42	39	19
OH2	2	1.4	1.4	8	22	47	35	17
OH2	3	1.5	1.4	13	24	36	41	23
OH2	4	1.4	1.2	23	29	36	41	23
OH2	5	1.3	1.1	17	25	39	42	19
OH2	6	1.3	1.3	6	19	54	33	13
OH2	7	1.5	1.4	3	26	33	46	21
OH2	8	1.5	1.4	7	22	40	38	22
OH2	9	1.5	1.5	2	22	42	38	20
OH3	1	1.4	1.3	15	25	31	45	24
OH3	2	1.4	1.2	18	28	38	41	22
OH3	3	1.3	1.2	17	26	39	40	21
OH3	4	1.4	1.3	18	23	33	43	24
OH3	5	1.5	1.3	21	17	35	43	22
OH3	6	1.5	1.3	24	19	33	42	25

Table III-2 (continued)

Block	Plot	whole soil D_b	fine soil D_b	RF	Moisture content	sand	silt	clay
		-----------g cm^{-3}-----------		---------------------------------%---------------------------------				
OH3	7	1.4	1.3	16	20	30	43	27
OH3	8	1.3	1.3	9	21	30	41	29
OH3	9	1.5	1.4	15	22	35	42	23
VA1	1	1.3	1.1	24	18	46	40	14
VA1	2	1.2	0.8	43	29	62	28	10
VA1	3	1.4	0.9	50	25	56	32	11
VA1	4	1.4	1.1	38	22	49	38	13
VA1	5	1.7	1.3	40	11	51	36	12
VA1	6	1.5	1.3	30	15	45	44	11
VA1	7	1.8	1.2	61	18	57	33	11
VA1	8	1.5	1.2	41	16	49	38	13
VA1	9	1.5	1.0	53	18	56	32	12
VA2	1	1.9	1.6	45	10	52	33	15
VA2	2	2.0	1.4	63	11	49	37	14
VA2	3	2.0	1.2	73	12	58	31	11
VA2	4	1.8	1.2	65	16	44	43	13
VA2	5	2.0	1.3	72	14	47	39	14
VA2	6	1.8	1.4	49	9	45	42	13
VA2	7	1.9	0.6	88	13	50	37	13
VA2	8	1.6	1.1	54	14	54	34	11
VA2	9	1.8	1.1	66	14	42	42	16
VA3	1	1.8	1.3	51	13	58	30	11
VA3	2	1.8	1.0	71	16	57	30	13
VA3	3	1.4	1.1	35	15	49	39	13
VA3	4	1.6	1.2	50	12	55	33	12
VA3	5	2.0	1.4	62	11	51	37	12
VA3	6	1.8	1.4	45	11	47	37	15
VA3	7	2.0	1.5	55	10	52	34	14
VA3	8	1.8	1.3	56	13	54	33	13
VA3	9	1.8	1.4	48	15	47	44	10
WV1	1	1.5	1.1	47	5	58	35	7
WV1	2	1.5	0.9	62	10	63	30	7
WV1	3	1.7	1.3	49	14	56	36	8
WV1	4	1.7	1.3	48	10	64	29	6
WV1	5	1.7	1.7	0	11	58	35	7
WV1	6	1.7	1.1	61	12	54	39	7
WV1	7	1.6	0.9	63	15	56	35	9
WV1	8	1.8	1.0	71	14	59	34	7
WV1	9	1.6	1.0	65	15	63	29	8
WV2	1	1.7	0.6	81	7	63	28	9
WV2	2	1.7	0.9	67	8	60	33	7
WV2	3	2.0	2.0	0	12	60	32	8

Table III-2 (continued)

Block	Plot	whole soil D_b	fine soil D_b	RF	Moisture content	sand	silt	clay
		-----------g cm^{-3}---------		-------------------------------%---------------------------------				
WV2	4	1.6	0.9	66	10	63	28	9
WV2	5	1.7	1.3	47	12	66	25	8
WV2	6	1.8	1.2	65	12	65	25	10
WV2	7	1.7	1.1	56	10	66	27	7
WV2	8	1.6	0.7	76	8	66	29	5
WV2	9	1.7	0.9	67	10	61	31	8
WV3	1	1.9	1.1	69	9	58	32	10
WV3	2	1.9	1.5	52	11	62	30	7
WV3	3	1.5	0.9	60	13	62	30	8
WV3	4	1.6	1.0	64	19	56	34	10
WV3	5	1.5	1.0	54	11	59	31	10
WV3	6	1.7	1.4	43	14	63	29	8
WV3	7	1.7	1.3	43	10	59	35	6
WV3	8	1.8	1.3	52	11	54	35	11
WV3	9	1.5	1.1	42	20	58	35	8

No completely quantitative method was found to accurately predict mine soil D_b because of the high volume of RFs. Conventional D_b measurements using the excavation method require laboratory calculations of RF volume and moisture content, and are too time consuming for field practical measurements. Therefore, the “density class” of the upper 20 cm may be estimated based on the average penetration depth of the sharpshooter along with observations of soil rupture resistance and RF type and volume. The depth and ease in which the sharpshooter penetrated the soil was noted along with the associated soil properties listed above. The following guides can be used to estimate five general density classes: if the sharpshooter penetrates easily to 25 cm or more, then a density class of “very low” is assigned; if penetration is 16 to 25 cm with slight resistance, then a density class of “low” is assigned; if penetration is less than 15 cm with moderate resistance, then a density class of “moderate” is assigned; if penetration is less than 5 cm with strong resistance, then a density class of “high” is assigned; and if penetration is less than 2 cm then a density class of “very high” is assigned. The density class is decreased one class in soils with an estimated RF content greater than 50%, provided that the moist rupture resistance (a.k.a. moist consistence class) at the depth of maximum sharpshooter penetration is not very firm or extremely firm (Soil Survey Division Staff, 1993) as confirmed by shallow pit excavations. In moist soils with low RF content and textures finer than sandy loam, the density is increased one class because those soil conditions allow sharpshooter penetration into soil that has moist rupture resistance of very firm or extremely firm as confirmed by shallow pit excavations. In extremely dry soils, no adjustment was made. Along with the rupture resistance, fine root growth widely-spaced or matted between aggregates and large aggregate size are used to confirm that the soil is dense.

SUMMARY AND CONCLUSIONS

Fine earth D_b is often high enough in mine soils to restrict root growth and alter hydrologic properties, but measuring this limitation has proven to be very difficult in mine soils. Common measures of soil density and soil strength have been found to be inaccurate and inefficient in field studies, and the need for better measurement methods exist. None of the three tools tested in this study represent a good measure of D_b. Even though sharpshooter penetration depths do not appear to be a reliable estimate for D_b in mine soils, they may have use as an indicator of a relative soil density class. The resistance and refusal of the screw auger may indicate root limitations in mine soils, but no quantitative measurement of D_b is useful. The drop hammer was not useful for D_b estimation. A relative estimate of soil density may be best in mine soil mapping since actual D_b values are often inaccurate and difficult to obtain, and the knowledge and experience of a field scientist is invaluable in making such a qualitative assessment. Further research is needed to develop a rapid, simple, on-site measurement or estimate of D_b in high RF mine soils in the Appalachian region.

CHAPTER IV

MINE SOIL PROPERTY ASSESSMENT AND THEIR AFFECT ON SURVIVAL AND GROWTH OF FOREST TREES ON THREE SITES IN THE APPALACHIAN COALFIELD REGION

INTRODUCTION

Surface mining for coal in the Appalachian plateau region of the Eastern U.S. is a widespread industry. In order to improve upon safety and environmental hazards that are commonly associated with surface mining, the Surface Mining Control and Reclamation Act (SMCRA) of 1977 was enacted. The SMCRA requires coal companies to return mined lands to their "approximate original contour" (AOC), replace the topsoil or apply an approved topsoil substitute, and the land must be revegetated and able to support vegetation at its original productivity level or better (Public Law 95-87). SMCRA reclamation activities have been blamed for unsuccessful reforestation attempts on surface mines because of their negative impact on soil properties and revegetation with competitive, non-native herbaceous vegetation that competes with native tree seedlings.

Soil properties of post-SMCRA mine sites have been evaluated by a number of authors (Andrews et al., 1998; Bussler et al., 1984; Haering et al., 2004; Johnson and Skousen, 1995; McFee et al., 1981; Rodrique and Burger, 2004; Sobek et al., 2000; Torbert et al., 1988a). Post-SMCRA sites are commonly highly compacted due to a high amount of heavy equipment traffic. The reclamation process involves multiple trips across the land to shape it and prepare a smooth seedbed. The spoil material often has higher pH and soluble salt content (as measured by electrical conductivity) because deeply buried, non-weathered material is brought to and placed at the surface as a topsoil substitute. Oxidized sandstone topsoil substitutes are considered better material for tree growth (Haering et al., 1993; Torbert et al., 1990) and will likely improve survival and growth rates of native trees. The depth of the oxidized topsoil substitute is often thin and tree roots will encounter the unoxidized spoil within the first growing season. Therefore, it is important to characterize surface and subsurface soil properties because of their affect on future forest productivity.

Adverse chemical and physical properties of mine soils, along with competitive ground cover vegetation decrease survival of tree seedlings (Torbert and Burger, 1990; Philo et al., 1982; Preve, 1984; Davidson, 1986; Schuster, 1983). Since grasses and leguminous herbs are not as adversely affected by the reclaimed mine soil properties as native tree seedlings, they are often planted instead and accepted as a "more productive" post-mining vegetation type.

A recent movement towards planting more native hardwoods and managing forest on reclaimed surface mines in the Appalachian region has increased the need for research of mine soil properties that affect reforestation. However, few sites have been replanted to native hardwoods, and most reforestation in this region is done with white pine (*Pinus strobus* L.), black locust (*Robinia pseudoacacia* L.), and non-native shrubs.

Three sites were located in the Appalachian coalfield region in an attempt to create a long-term study that could be used to evaluate the effects of soil properties, silvicultural treatments, and species selection on the survival and growth of managed forest stands. Comparison of mine soil properties may explain differences in survival of planted seedlings. A better understanding of the effects of mine soil properties on seedling survival and growth may lead to improved planting recommendations on reclaimed mine land. The objectives of this study were (1) to analyze mine soil properties on three selected sites, and (2) relate soil properties to first year survival and height growth of planted hybrid poplar (*Populus trichocarpa*

L. (Torr. & Gray ex Hook) x *Populus deltoides* (Bartr. ex Marsh.) hybrid 52-225), white pine, and native hardwood seedlings after one growing season.

MATERIALS AND METHODS

Study Areas and Design

Research sites were chosen in Lawrence County, Ohio (OH); Nicolas County, West Virginia (WV); and Wise County, Virginia (VA) (Figure IV-1). The experiment was replicated three times to represent a range of pH values and rock type. The design was replicated with three blocks at each of the three study sites with nine 0.25 ha plots in each block. The study used a 3x3 factorial combination of treatments across the three sites in a randomized complete block design (Figure IV-2). The three treatments were weed control only, weed control plus tillage, and weed control plus tillage plus fertilization. The three species used were hybrid poplar, white pine, and native hardwoods. Areas with a slope of greater than 15% were avoided if possible in order to reduce slope and aspect effects on site quality. A 20 m x 20 m measurement plot was established in the center of each 0.25 ha treatment plots, within which all trees were assessed for survival and height growth.

The OH site was approximately 12 years past reclamation, the WV site approximately 15 years past reclamation, and the VA site was less than 5 years past reclamation. All blocks except for VA3 had a thick cover of herbaceous vegetation. VA3 was less than one year old when soil samples were taken and trees were planted, and very little vegetation had been established. The WV site had been grazed by cattle for several years and managed as pastureland.

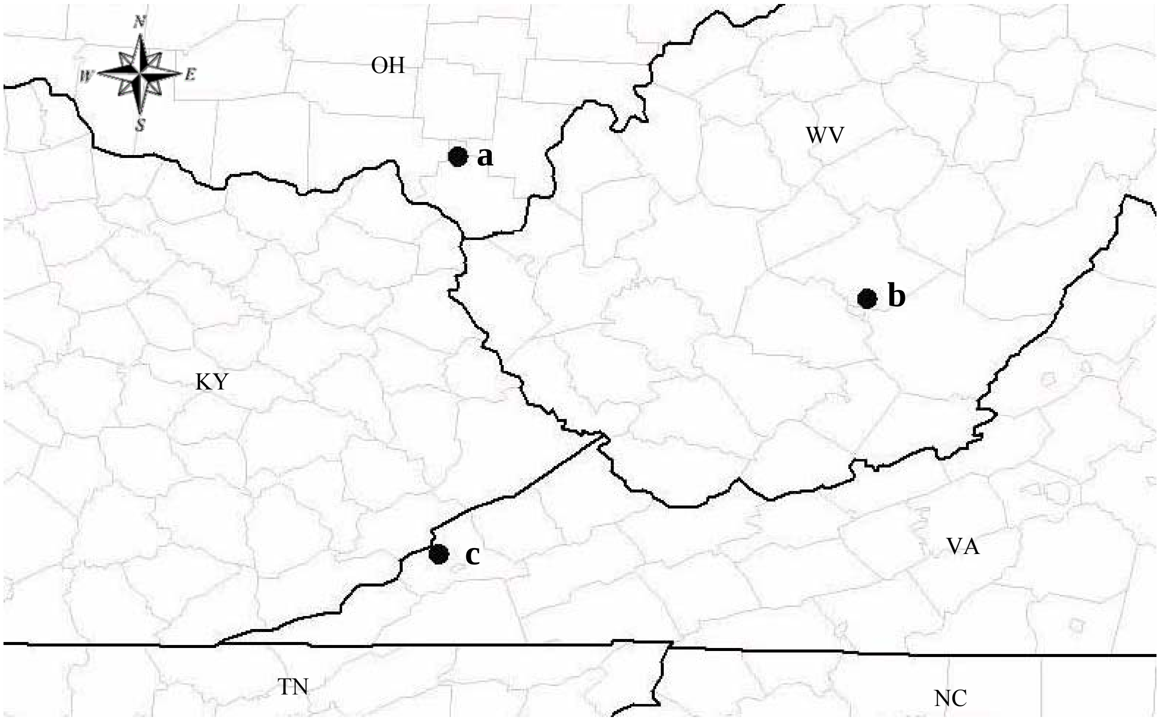

Figure IV-1. Research sites located in (a) Lawrence County, Ohio (OH); (b) Nicolas County, West Virginia (WV); and (c) Wise County, Virginia (VA).

Data Analysis

Analysis of variance (ANOVA) was used with a 0.05 level of significance for survival and height growth as a 3x3 random complete block design with three sites and three species (Table IV-1). Only the weed control only plots were used to obtain survival and height growth of the three species. If the species by site interaction was significant then the ANOVA was done by site and species separately to perform mean separation procedures. Tree survival was expressed as a percentage of the trees planted and these data were transformed using the arcsine transformation.

ANOVA was also used to analyze soil properties for site and sample differences as a split-plot design with three blocks, three sites, and two sample depths (Tables IV-2, IV-3, IV-4, IV-5). If the site by sample interaction term was significant then site and sample were analyzed separately to perform mean separation procedures. All values recorded in percent were arcsine transformed.

Means were separated using Fisher's LSD with a significance level of $P < 0.05$. If interaction terms were not significant, only main effect means were compared. All statistical analysis was done using SAS 9.1 (2003).

Table IV-1. The ANOVA summary for first year survival and height growth of three species (hybrid poplar, white pine, hardwoods) and sites (Lawrence County, Ohio; Wise County, Virginia; Nicholas County, West Virginia).

	Degree of Freedom	Variable (Pr>F)	
		Survival	Height Growth
Block	2	0.3425	0.0266
Site	2	0.011	0.0053
Species	2	0.0045	<0.0001
Site x Species	4	0.1658	0.0222
Model	10	0.0095	<0.0001
Error	16		
Total	26		

Table IV-2. The ANOVA summary for pH, electrical conductivity (EC), sand, silt, clay, rock fragments (RF), and sandstone (SS) content for three sites (Lawrence County, Ohio; Wise County, Virginia; Nicholas County, West Virginia) and two samples (topsoil and subsoil).

	Degrees of Freedom	Variable (Pr>F)						
		pH	EC	Sand	Silt	Clay	CF	SS
Block	2	0.7766	0.0742	0.0130	0.0271	0.0146	0.4509	0.0815
Site	2	0.6581	0.0905	0.0007	0.0025	0.0014	0.0023	0.0320
Block x Site	4	0.1915	0.3950	0.0508	0.0884	0.0097	0.0768	0.0379
Sample	1	0.0089	0.0499	0.0132	0.0237	0.0115	0.0017	0.6645
Site x Sample	2	0.4635	0.0020	0.0006	0.0012	0.0023	0.2651	0.8314
Model	11	0.1371	0.0158	<0.0001	0.0002	<0.0001	0.0002	0.0038
Error	6							
Total	17							

Table IV-3. The ANOVA summary for Magnesium (Mg), Potassium (K), Calcium (Ca), Manganese (Mn), Nitrogen (N), cation exchanged capacity (CEC), and base saturation (BS) for three sites (Lawrence County, Ohio; Wise County, Virginia; Nicholas County, West Virginia) and two samples (topsoil and subsoil).

	Degrees of Freedom	Variable (Pr>F)						
		Mg	K	Ca	Mn	N	CEC	BS
Block	2	0.1765	0.5361	0.2528	0.5292	0.3353	0.0603	0.5497
Site	2	0.0047	0.0115	0.0049	0.7083	0.0008	0.0051	0.8538
Block x Site	4	0.2974	0.1325	0.1437	0.4576	0.0205	0.0230	0.2711
Sample	1	0.0476	<0.0001	0.0037	0.0191	<0.0001	0.0032	0.0418
Site x Sample	2	0.0100	0.0017	0.0009	0.9912	<0.0001	<0.0001	0.4525
Model	11	0.0038	0.0005	0.0007	0.3212	<0.0001	<0.0001	0.3057
Error	6							
Total	17							

Table IV-4. The ANOVA summary for Aluminum (Al) and Phosphorus (P) for three sites (Lawrence County, Ohio; Wise County, Virginia; Nicholas County, West Virginia) and two samples (topsoil and subsoil).

	Degrees of Freedom	Variable (Pr>F)	
		Al	P
Block	2	0.2835	0.0670
Site	2	0.4091	0.0299
Block x Site	4	0.4522	0.0078
Sample	1	0.0720	<0.0001
Site x Sample	2	0.4553	0.0002
Model	11	0.3698	<0.0001
Error	5		
Total	16		

Table IV-5. The ANOVA summary for topsoil depth and bulk density (D_b) for three sites (Lawrence County, Ohio; Wise County, Virginia; Nicholas County, West Virginia).

	Degrees of Freedom	Variable (Pr>F) Top Soil Depth	D_b
Block	2	0.4982	0.8507
Site	2	0.1489	0.0615
Model	4	0.258	0.1484
Error	4		
Total	8		

Geology and Soils

Modern USDA Soil Surveys have been produced for Lawrence County, OH (1998), and Nicholas County, WV (1992). No recent survey has been published for Wise County, VA.

Pennsylvanian aged bedrock underlies all of the sites. In OH the Pottsville, Allegheny, and Conemaugh formations underlies a majority of Lawrence County. Pre-mine soils surrounding the study area were predominantly Lily loam on the ridge tops, and Shelocta-Latham association on the sideslopes. Soils on nearby mined lands were all identified as Bethesda channery silty clay loam. Full descriptions of all established soil series are found at (http://soils.usda.gov/). Native soils near the WV site consist of Buchanan channery fine sandy loam, very stony; Fenwick silt loam; and Gilpin silt loam, stony. The New River and Pocahontas formations from the Pottsville group dominate this coal producing area. The soils on the mined site were identified as Kaymine channery loam. The Wise formation underlies the study area in VA and consists of approximately 70% sandstone, 20% siltstone, and 10% shale (Howard, 1979). The dominant native soils in this area are the Jefferson and Dekalb series. Mined areas nearby the sites have been previously mapped as Sewell and Fiveblock series (Haering et al. 2005).

Sampling Procedures

Soils in each of nine plots were sampled in five different locations. Oxidized and unoxidized spoil layers were sampled separately, depending upon thickness of each layer. The plots were sampled approximately 11-m diagonally inside each corner and in the plot center. Exclusion criteria were developed prior to the sampling of plots (Table IV-6).

Table IV-6. Exclusion criteria used when sampling mine soils within plots.

Exclusion Criteria
The sampling point will be moved to an adjacent site if any of the following occur at the sampling point:

1. A boulder is encountered that is large enough to prevent the pit from being dug in the correct location or to the proper depth,
2. severely eroded land, determined by ditches or gullies, is present directly within the sampling location,
3. disturbed areas such as roads, rock piles, etc. are directly within the sampling location, or
4. poor drainage areas that occupy less than 1 % (25 m^2) of the total plot area. Poor drainage was indicated by standing water, dominance of hydrophytic vegetation, or lack of vegetation due to ponding.

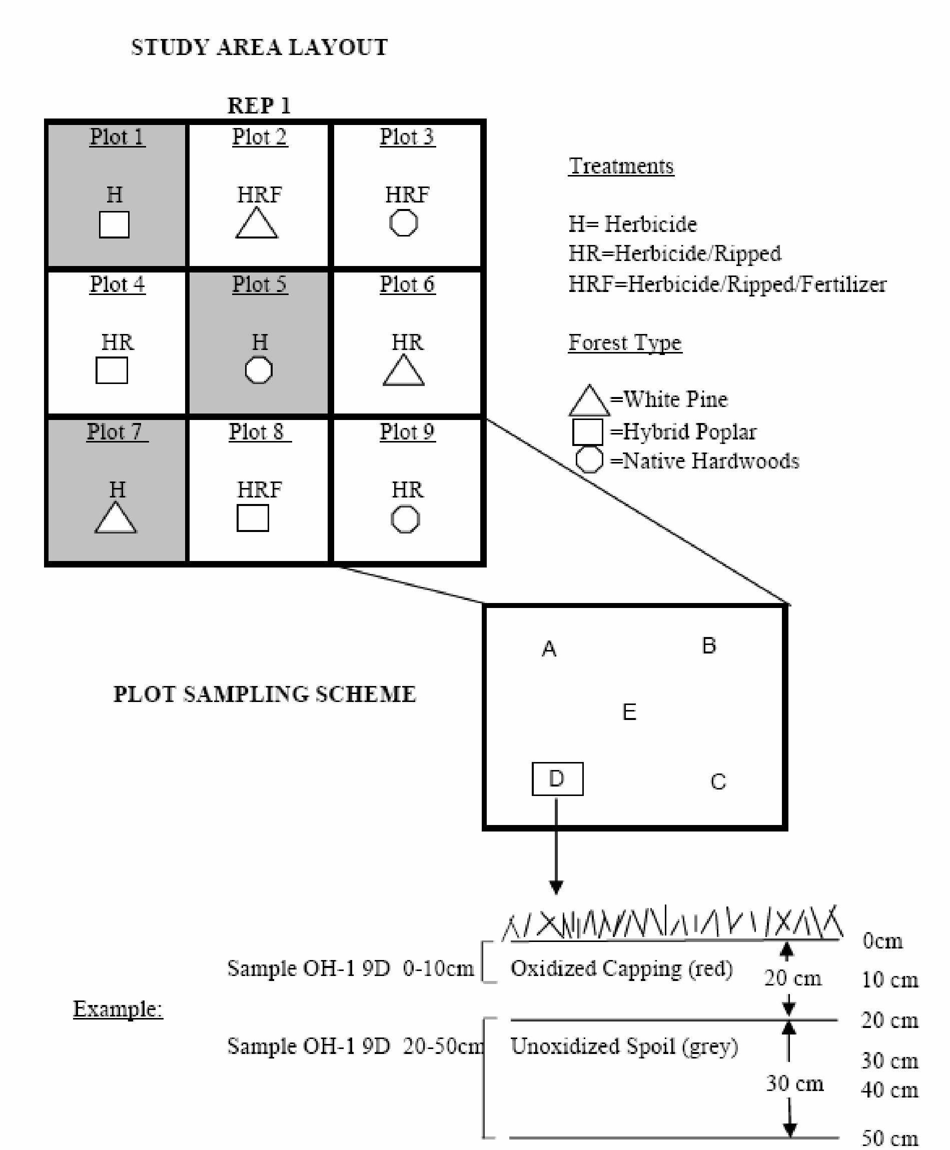

Figure IV-2. Schematic of one treatment block with nine plots. One plot is expanded to show the distribution of sample locations. An example of the sampling depths is shown at one sample location.

A shallow pit was dug to approximately 50-cm at each accepted sample site. There was often an abrupt boundary between the oxidized topsoil and a much greyer, unoxidized subsoil material at the VA and OH sites. A composite sample was taken from the 0- to 10-cm depth. Composite samples were also taken of all layers between the 10- to 30-cm depth unless the unoxidized subsoil was observed within 50-cm. The different materials were never mixed for laboratory analysis because they were suspected to have dramatically different chemical properties. If the unoxidized subsoil occurred at less than 50-cm, a composite sample of all layers within the subsoil was taken to the 50-cm depth. Three of the five shallow pits per plot were randomly chosen and described in order to characterize the soil variability at the site.

Multiple deep pits were excavated with a backhoe to approximately 2-m in representative locations at each site. Each horizon was described and sampled. Three to five bulk density (D_b) samples were collected in each horizon using a modified version of the excavation method of Blake and Hartage (1986). A metal cylinder approximately 5-cm in diameter was driven vertically into the soil and then extracted. The soil within the cylinder and any loose pieces in the hole were placed in labeled sample bags. The hole was lined with thin plastic, lightly pressed into the corners, and then filled with lead BB's to the original surface level. The volume of the BB's was measured in a graduated cylinder and recorded. The extracted soil was air dried and weighed, and the weights were corrected for rock fragment (RF) percent by dry sieving through a 2-mm sieve and corrected for moisture content in order to report the fine earth D_b in g cm^{-3} on an oven-dry soil basis. All RFs >2 mm were assumed to have a specific gravity of 2.65 g cm^{-3}.

Sample Preparation

Bulk samples from the deep pits were air dried while samples from the shallow pits were dried in a room heated at 50 ºC for one week. The heated room was used in order to speed drying time and space requirements for the large number of shallow pit samples (> 1000). Bulk samples (deep pits and shallow pits) were weighed and sieved through a 2-mm sieve. The fine earth was saved for laboratory analysis.

Measurements of pH, electrical conductivity (EC), carbon (C), and nitrogen (N) were taken on all samples. Equal sub-samples from the 0- to 10-cm samples from all five shallow pits in each plot were then combined to save time and cost of analysis. The same was true for the 10- to 30-cm depth, and subsoil samples if they occurred.

RF type and volume were visually estimated in each field descriptions. The RFs of the bulk samples were washed in order to remove all soil material and then dried in the 50 º Celsius drying room. RF percentage was then determined on a weight difference basis and proportions of each rock type visually estimated.

D_b of the topsoil and subsoil (if within 30-cm) was also taken within each plot. The excavation hole size was approximately 900-cm^2 and 10-cm deep. Otherwise, the same procedure with a plastic lining and lead BB's as outlined above was used. Porosity was calculated using these D_b measurements and assuming a particle density of 2.65 g cm^{-3}.

Lab Analysis

Samples were analyzed for pH and EC using an AGRI-METER (MYRON L Company) on a 20 g soil to 40 g H_2O mixture. The mixture equilibrated for one hour before readings were taken. Particle-size distribution was determined by the pipet method (Gee and Bauder, 1986). Surface samples were treated with H_2O_2 and heated in order to destroy organic matter present. Exchangeable cations (potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), and manganese (Mn)) were extracted with a 1M NH_4OAc (ammonium acetate) solution buffered at pH 7 (USDA, 1996). A modification of the exchangeable cation procedure was made in that only 100 ml of NH_4OAc leachate was used. Even though Ca and Mg are reported as exchangeable cations, carbonate cements that are often present in unweathered mine soils may be soluble in the NH_4OAc extract and consequently release cations that may not be truly exchangeable (Roberts et al., 1988a). Phosphorus was extracted with 0.5M $NaHCO_3$ (sodium bicarbonate) (Olsen and Sommers, 1982) as recommended for mine soils (Daniels and Amos, 1982). A modification was made from Olsen and Sommers (1982) in that only 1g of soil and 20 ml of $NaHCO_3$ were used. Also, "Reagent B" was not added to the bicarbonate extract because the measurements were made with the Inductively Coupled Plasma Spectrometry (ICP) instrument (SpectroFlame Modula Tabletop ICP with autosampler; Type: FTMOA85D; Spectro Analytical Instruments, Inc.). The resulting data includes both organic and inorganic phosphorus (P) (Kuo, 1996). All cations were measured with the ICP instrument. Total C (%) and N (%) were measured by combustion with a carbon-nitrogen auto-analyzer (Vario Max CNS analyzer, Elementar, Hanau, Germany). Exchangeable Aluminum (Al) was extracted with a 1N KCl solution and quantified by titration (McLean, 1965). The effective cation exchange capacity (CEC) of the samples was calculated by summing the NH_4OAc-extracted K, Ca, Mg, and Na and the KCl-extracted Al (Sumner and Miller, 1996). Base saturation (BS) values were calculated by dividing the sum of K, Ca, Mg, and Na by the CEC and converting to a percentage. Mehlich I-extracted zinc (Zn), copper (Cu), iron (Fe), and boron (B) was performed by the Virginia Tech Soil Testing Laboratory (Donohue and Heckendorn, 1996) and measured by ICP.

RESULTS AND DISCUSSION

Pit Descriptions

West Virginia

The shallow pit descriptions for all WV blocks indicated that A horizons had developed but were only approximately five cm thick (Appendix 4). A 10YR 3/2 color was the most common surface color and loam was the most common texture. Particle size analysis indicated that most of the textures described as loams in the field were actually sandy loams. C horizons were described directly below the A horizon and separated mainly on a color change, lack of structure, and decreased root growth. Colors of the C horizon were most commonly 10YR 4/2 or

4/1, and there was no structure present. Moist consistence was usually friable, but may not resemble the true soil density condition due to high RF contents that caused most extracted clods to easily rupture. Shale was the dominant rock type, and gravel and channers were the most common rock sizes.

Deep pits indicated that a Bw horizon was present in all pits down to 15-cm as determined by weak, coarse subangular blocky structure (Appendix 5). This was likely overlooked in the shallow pits because of less viewing area of the pit face and more destructive excavation techniques. Fragmental layers with ≥ 90% RF and bridging voids were present in all three pits, and began at a depth of 60- to 125-cm. This will likely cause reductions in forest productivity because of less rooting volume and excessively-rapid drainage of soil water.

Virginia

All VA blocks were young and genetic processes were just beginning to transform the spoil material (Appendix 4). No A horizon was described at VA1 because no darkening by organic matter was present. However, Haering et al. (1993) describe spoil loosening and aggregation for A horizons on two-year-old mine soils in the same region. These conditions were present at VA1 suggesting that a thin A horizon should have been described. The depth of the topsoil material was identified as A horizon material in the deep pits (Appendix 5). Any organic matter translocation into the soil was likely masked by the red colors (10YR 5/6, 5/4, and 5/3). The subsoil at VA1 was most commonly a 2.5Y 4/1 color, was structureless, had a higher RF content, and was often firm in consistence. Both deep pits at VA1 had densic layers within 35 cm of the surface and confirm that the subsoil was significantly compacted and impedes root growth (Appendix 5). Although densic layers were not described in the shallow pits, it is likely that they were overlooked due to small pit size.

The VA2 block had 5- to 10-cm thick A horizons as determined by weak subangular blocky structure. The surface color was most commonly 2.5Y 4/2 or 4/3 and the surface soil extended deeper than all other blocks. No dense layers were described in the shallow pit or deep pit descriptions and the moist consistence was most often friable (Appendix 4 and 5). The subsoil color was usually 2.5Y 3/1, and sandy loam and loam textures were found throughout the profile.

Thin A horizons were described for VA3 due to loosening of the spoil material on the surface. Colors were widely variable due to mixed rock types, and some dense horizons were described close to the surface. Moist consistence was often firm directly below the A horizon. No obviously different spoil type was found in the subsurface layers.

Ohio

All OH blocks consisted of lower RF contents and finer textures than all other blocks (Appendix 4 and 5). A 1- to 4-cm thick A horizon was recognized on all blocks and often had a color of 10YR 3/2 or 2/2. The structureless appearance and finer textures prevent much translocation of organic matter deep into the soil profile. However, weak structure was beginning to develop below the A horizon and Bw horizons had formed at all blocks. Thomas and Jansen (1985) also found weak genetic structure below the A horizon in all but the youngest site (5-years old) on pre-SMCRA mines, but no structure development was observed below 35 cm. Haering et al. (1993) describe transitional AC horizons in mine soils instead of Bw horizons. Colors of the topsoil were commonly 10YR 5/4 and 5/6 except for OH3 where topsoil colors were more commonly 2.5Y 5/3 and 5/4. Subsoil colors were usually of the 2.5Y or 5Y hue with values of 4 or 5 and chromas of 1 or 2. Loams and clay loams were the most common texture classes described, but lab data suggests that silt loams and silty clay loams were also prevalent. Moist consistence was most often friable, but may have been skewed due to high moisture contents, weak structure, and fine textures that allowed most soil clods to easily be deformed. Some dense horizons were described in the deep pits at OH2 and OH3 but both were below 50 cm. The dense layers are expected to be present at shallower depths in certain locations and should probably be described more often in the mini-pit descriptions. The ponding of water on the surface, especially at OH2, confirms suspicion that dense layers underlie the topsoil. D_b measurements for the deep pit horizons suggests that the Bw and BC horizons are often the most dense and will restrict root growth and aeration in fine textured soils (Appendix 5) (Brady and Weil, 1999).

Lab Results

Lab results for all of the composite samples and deep pits are given in Appendix 1 and 2. Statistics and means of the topsoil and subsoil properties by block are given in Appendix 3.

Physical Properties

The WV site did not have any oxidized topsoil substitute replaced on the surface. However, the topsoil depth was insignificant across all three sites likely due to the large variation within the other sites (Table IV-7). VA1 and VA2 had oxidized topsoil substitutes spread on the surface, while VA3 had no obvious pattern of topsoil deposition. There was oxidized topsoil at all OH blocks.

An evaluation of all rock types is given in Appendix 1. Significant differences only of total estimated volume percentages of sandstone were determined (Table IV-7). The WV blocks were all dominated by a dark-colored shale rock type. The OH blocks had a more oxidized spoil type on the surface and were dominated by siltstone rock types. The VA blocks had a mixture of spoil types on the surface. Sandstone content was significantly higher at VA than the other two sites and there were no significant differences of sandstone content between WV and OH (Table IV-7). The Wise formation underlying the VA site consists of 70 % sandstone and is expected to dominate spoil types in the surrounding region (Howard, 1979). No significant differences of sandstone content by sample was found.

Total RF content was significantly higher in the subsoil samples than topsoil samples (Table IV-7), likely due to increased weathering at the surface. Unoxidized subsoil layers have not been pre-weathered like the oxidized topsoil substitutes at the VA and WV sites, and are expected to have higher RF contents and require more time to weather into soil fines. The OH site had significantly less RFs than the WV or VA sites.

The topsoil and subsoil material at the OH site had significantly higher clay percentage than the VA or WV sites (Table IV-7). The spoil material used in reclamation was dominated by siltstone rock types and native soils that had higher clay contents, and is likely responsible for the high clay contents in the mine soils. The WV site was the only site in which significantly higher clay content was found in the subsoil than the topsoil. The topsoil and subsoil material at WV was the same spoil type, and the clay increase may indicate some translocation of clay down through the mine soil profile. Thomas and Jansen (1985) found no translocation of clay in their study of 5 – 64 year old mine soils in southern Illinois, and Haering et al. (1993) found similar results in 8-year-old Appalachian mine soils. Sand percentages in the topsoil were significantly higher at the WV site (Table IV-7), but this is likely due to sand-sized shale particles and not resistant quartz sand as observed in sieved soil samples. The OH site had significantly lower sand content in both the topsoil and subsoil samples (Table IV-7). The OH site had significantly higher silt content than WV and VA (Table IV-7), most likely due to the high siltstone content.

Higher silt and clay content at the OH site confirms our theory that aeration will likely limit tree growth.

No significant differences in D_b were observed across sites (Table IV-7). However, the D_b value for OH has been noted as being root restricting for fine-textured soils (Brady and Weil, 1999; Zisa et al., 1980).

Table IV-7. Physical property means by site (Lawrence County, Ohio (OH); Wise County, Virginia (VA); Nicholas County, West Virginia (WV)) and sample (0 = topsoil, 2 = subsoil) for topsoil depth; total sandstone (SS); sand, silt, and clay; rock fragments (RF); and bulk density (D_b).

		OH	VA	WV	sample means
topsoil depth (cm)	0	21 a†	20 a	0 a	**13**
	2	.	.	.	.
	site means	.	.	.	
SS (%)	0	23	61	9	**31** A
	2	16	58	10	**28** A
	site means	**20** b	**60** a	**9** b	
RF (%)	0	8	42	52	**34** B
	2	20	57	58	**45** A
	site means	**14** b	**49** a	**55** a	
sand (%)	0	35 cA‡	51 bA	61 aA	**49**
	2	24 bB	58 aA	54 aA	**45**
	site means	**29**	**55**	**57**	
silt (%)	0	42 aB	36 bA	31 bB	**36**
	2	48aA	32 bA	36 bA	**38**
	site means	**45**	**34**	**34**	
clay (%)	0	23 aA	13 bA	8 bB	**15**
	2	28 aA	10 bA	11 bA	**16**
	site means	**26**	**11**	**9**	
D_b (g cm^{-3})	0	1.4 a	1.2 a	1.1 a	**1.2**
	2	.	.	.	.
	site means	.	.	.	

† Across rows, means that are significantly different determined by Fischer's LSD at alpha=0.05 are followed by different lower case letters.
‡ Within columns, means that are significantly different determined by Fischer's LSD at alpha=0.05 are followed by different upper case letters.

Chemical Properties

The pH values were similar to ranges found in previous studies by Torbert et al. (1990), and Plass and Vogel (1973) (Table IV-8). There were no significant differences for sites, but the subsoil sample was significantly higher than the topsoil. The differences in degree of oxidation and weathering of the subsoil material at VA and OH is likely responsible for this increase. The pH of VA is expected to decrease over time due to rapid leaching of carbonates and basic cations associated with young mine soils (Roberts et al., 1988a).

Exchangeable Al was not significantly different for sites or samples (Table IV-8). The pH values are not low enough to expect conversion of Al to its soluble form (Al^{3+}) that is toxic to plants and Haering et al. (1993) reported that decades of weathering may be necessary before Al occupies a significant portion of the mine soil exchange complex. The EC levels at OH were significantly lower in the topsoil and significantly higher in the subsoil than the other two sites (Table IV-8). The higher EC in the topsoil at VA is likely due to those sites being the youngest and having little time to leach the salts that are released from the rapid weathering of newly-exposed, crushed bedrock. The WV site was previously in a managed pasture land use and the application of inorganic fertilizers and cattle manure are likely responsible for higher EC levels. Fine textures such as those found in the OH subsoils have been reported to have higher EC levels than coarse textures (Rodrigue and Burger, 2004), and the same pattern is observed in this study. However, no EC levels were higher than the value of 0.5 dS m^{-1} that Andrews (1992) reports to have a negative effect on tree growth (Table IV-8).

All BS values were high and are not expected to be limiting to tree survival or growth at such high levels (Rodrique and Burger, 2004). No significant differences between sites were found but the subsoil was significantly higher than the topsoil (Table IV-8). All CEC values were less than 14 $cmol_c\ kg^{-1}$ (Table IV-8), which agrees with reports by Evangelou (1995). No significant differences across sites were found in the topsoil samples, and the OH site was significantly higher than VA or WV for the subsoil samples (Table IV-8). This may be due to higher clay contents or a different clay mineralogy (not studied) in the OH subsoils compared to the other sites. The OH subsoil was also significantly higher than the OH topsoil and may be due to the same reasons described for site differences. However, Roberts et al. (1988a) reported CEC to be higher in the surface of mine soils than in the subsurface of mine soils due to the higher organic matter in the surface. The WV site follows this pattern, likely due to the same reasons.

Andrews et al. (1998) reported that height growth of white pine generally declined when exchangeable Mn levels exceeded 20 mg kg^{-1}. No Mn levels exceeded that critical limit in this study but the topsoils of VA and WV were very close (Table IV-8). There were no significant differences between sites, but the topsoil was significantly higher than the subsoil sample (Table IV-8). Mn deficiency is most often observed in saline, alkaline, calcareous, and coarse textured soils (McBride, 1994). In this study the significantly lower Mn levels were found in the subsoils which had pH > 6.0 and may inhibit tree production once roots enter that layer.

Phosphorus was significantly higher for the topsoil at the WV site than at VA and OH (Table IV-8). This is possibly due to fertilization used for the managed pasture land use and possibly from supplemental feed and manure. Only the OH site tested below 9 mg kg^{-1} P in the topsoil which is considered the critical level for tree response (Andrews, 1992). The P levels at VA and WV significantly decreased from the topsoil to subsoil samples (Table IV-8). The pasture fertilization at WV, residual fertilization from hydro-seeding the young VA sites, and the immobility of P are likely responsible for the higher topsoil levels. The P levels in this study were similar to those found by Andrews et al. (1998), but were slightly higher than reported by Roberts et al. (1988a), and Daniels and Amos (1982). The N content was also significantly higher at WV (Table IV-8), again possibly due to previous fertilization with the past land use and through the addition of cattle manure. The VA site had the lowest N content. The age factor and less time for herbaceous legumes to fix N in the soil are likely reasons, along with higher sandstone percent that has been shown to be associated with lower total N (Roberts et al., 1988a). A significant decrease in N content from the topsoil to subsoil at the OH and WV blocks (Table IV-8) is likely due to the shallow rooting of legumes that fix N in the topsoil but do not reach the subsoil. The younger VA site does not yet demonstrate this pattern.

There were no significant differences for Ca in the topsoils across all sites (Table IV-8). The subsoil at the OH site was significantly higher than the other subsoils and higher than the OH topsoil. The Conemaugh formation that underlies this site contains more limestone bedrock layers than the geologic formations that are found at the other sites and a limestone quarry was nearby. Furthermore, some limestone rock fragments were observed in pit descriptions and are likely responsible for the high Ca levels. These high levels may be responsible for forming insoluble P compounds as well. Mg and K were significantly higher in the topsoil at the WV site than VA and OH (Table IV-8). WV was the only site with dominantly unoxidized topsoil substitutes present on the surface, and that may explain the higher amount of exchangeable cations (Haering et al., 1993). The Mg, K, and Ca values at all sites were similar to those reported by Roberts et al. (1988a), and Torbert et al., (1990) who studied similar mine soils.

Table IV-8. Chemical property means by site (Lawrence County, Ohio (OH); Wise County, Virginia (VA); Nicholas County, West Virginia (WV)) and sample (0 = topsoil, 2 = subsoil)for pH; exchangeable aluminum (Al); electrical conductivity (EC); base saturation (BS); cation exchange capacity (CEC); exchangeable manganese (Mn); extractable phosphorus (P); nitrogen (N); exchangeable calcium (Ca), magensium (Mg), and potassium (K) by block and site.

		OH	VA	WV	sample means
pH	0	5.4	5.8	5.7	**5.6** B
	2	6.6	6.9	6.2	**6.6** A
	site means	**6.0** a†	**6.4** a	**6.0** a	
Al ($cmol_c\ kg^{-1}$)	0	0.6	0.3	0.2	**0.4** A
	2	0.1	0.0	0.1	**0.1** A
	site means	**0.3** a	**0.2** a	**0.1** a	
EC ($dS\ m^{-1}$)	0	0.1 bA‡	0.3 aA	0.2 aA	**0.2**
	2	0.5 aA	0.3 bA	0.1 bB	**0.3**
	site means	**0.3**	**0.3**	**0.2**	
BS (%)	0	94	95	98	**95** B
	2	100	100	99	**99** A
	site means	**97** a	**97** a	**98** a	
CEC ($cmol_c\ kg^{-1}$)	0	9 aB	6 aA	8 aA	**8**
	2	14 aA	6 bA	6 bB	**9**
	site means	**12**	**6**	**7**	
Mn ($mg\ kg^{-1}$)	0	15	19	19	**18** A
	2	4	6	7	**6** B
	site means	**9** a	**13** a	**13** a	
P ($mg\ kg^{-1}$)	0	8 bA	11 bA	20 aA	**13**
	2	3 aA	5 aB	6 aB	**5**
	site means	**6**	**8**	**13**	
N ($mg\ kg^{-1}$)	0	1196 bA	752 cA	2719 aA	**1556**
	2	482 bB	643 bA	1082 aB	**735**
	site means	**839**	**698**	**1900**	
Mg ($mg\ kg^{-1}$)	0	237 bA	243 bA	383 aA	**288**
	2	278 aA	203 aA	301 bB	**261**
	site means	**258**	**223**	**342**	
K ($mg\ kg^{-1}$)	0	131 bA	84 cA	162 aA	**126**
	2	97 aB	70 aA	82 aB	**83**
	site means	**114**	**77**	**122**	
Ca ($mg\ kg^{-1}$)	0	1169 aB	646 aA	925 aA	**913**
	2	2385 aA	811 bA	673 bB	**1290**
	site means	**1777**	**729**	**799**	

† Across rows, means that are significantly different determined by Fischer's LSD at alpha=0.05 are followed by different lower case letters.

‡ Within columns, means that are significantly different determined by Fischer's LSD at alpha=0.05 are followed by different upper case letters.

Seedling Survival and Growth

Seedling survival across all species was significantly higher at VA than at WV and OH (Table IV-9). This is most likely explained by the significantly higher sandstone content at VA (Table IV-7) which has been recognized as the best medium for tree survival and growth (Hearing et al., 1993; Torbert et al. 1990). The sandstone content influences soil properties that positively affect water and aeration relations and may out-weigh chemical property differences in this study. The N content in the topsoil at VA is significantly lower than the other two sites (Table IV-8) and may actually have a positive affect on seedling survival, in that the herbaceous vegetation is not stimulated at VA as much as at the other sites. The young age of the VA site as compared to the others has not allowed the seed pool of competing vegetation to become as well established and the weed control treatment was more effective. The survival rate of hardwoods was significantly higher than white pine or hybrid poplar across all sites (Table IV-9). The hardwoods planted are adapted to a wider range of soil properties than the white pine or hybrid poplars as shown by survival rates.

Table IV-9. First year survival rates (%) by site (Lawrence County, Ohio (OH); Wise County, Virginia (VA); Nicholas County, West Virginia (WV)) and species type (HP = hybrid poplar; WP = white pine; HW = hardwoods).

	OH	VA	WV	species means
HP	49	79	32	53 B‡
WP	45	54	41	47 B
HW	60	81	78	73 A
site means	51 b†	71 a	50 b	

† Across rows, means that are significantly different determined by Fischer's LSD at alpha=0.05 are followed by different lower case letters.
‡ Within columns, means that are significantly different determined by Fischer's LSD at alpha=0.05 are followed by different upper case letters.

First year height growth of hybrid poplar was significantly higher than white pine and hardwoods across all sites (Table IV-10). Only at WV were hardwoods significantly different (lower) than white pine. Hybrid poplar growth was the highest at VA and was significantly higher than WV (Table IV-10). There were no significant differences of hybrid poplar height growth between OH and the other two sites. Again, the high sandstone content at VA and the fact that an oxidized material was on the surface at VA and OH explain the higher growth rates at these two sites. The WV site had a high RF content and low silt and clay contents that likely resulted in lower available water and decreased growth of the hybrid poplars. Hardwood height growth was significantly higher at VA than at WV and OH (Table IV-10). The high sandstone content at VA continues to create a growing medium for tree roots with a proper balance of air and water and it affects height growth as well. Available water is likely to be limiting at WV and aeration is likely to be limiting at OH. No significant differences across sites were found for height growth of white pine (Table IV-10). White pine seedlings have a very slow early growth stage for two to three years before more rapid growth begins (Wendel and Smith, 1990). The effects of soil properties on white pine growth will not likely be observed until the initial stage of slow early growth is surpassed.

Table IV-10. First year height growth (cm) by site (Lawrence County, Ohio (OH); Wise County, Virginia (VA); Nicholas County, West Virginia (WV)) and species type (HP = hybrid poplar; WP = white pine; HW = hardwoods).

	OH	VA	WV
HP	36 ab†A‡	41 aA	22 bA
WP	5 aB	6 aB	6 aB
HW	-1 bB	4 aB	-1 bC

† Across rows, means that are significantly different determined by Fischer's LSD at alpha=0.05 are followed by different lower case letters.
‡ Within columns, means that are significantly different determined by Fischer's LSD at alpha=0.05 are followed by different upper case letters.

SUMMARY AND CONCLUSIONS

Mine soil properties are highly variable throughout the Appalachian region due to differences in site geology and reclamation activities. The topsoil substitute will likely change in soil composition the quickest through pedo-genesis at the soil surface. Horizon formation in mine soil profiles became more pronounced with increased weathering time, and soil properties will likely change as weathering, leaching and biological activity continues. The three sites were dominated by different rock types that affected the physical and chemical soil properties. Only the WV site did not have an oxidized topsoil substitute replaced on the surface.

The OH site was dominated by siltstone rock types, WV was dominated by shale, and VA was dominated by sandstone. Finer textures and fewer rock fragments were found at the OH site compared to VA and WV. The soil at OH likely presents aeration problems for optimal tree growth due to reduced macro-porosity associated with fine textures and the destruction of natural soil structure. The soil at WV has a high rock fragment content and bridging voids are present lower in the profile, which may increase drainage rates and create a droughty soil with low water-holding capacity. The VA site allowed for a good balance of water and air in the soil due to the high sandstone content, and will likely create fewer limitations for tree growth.

Mine soil properties were used to explain tree seedling survival and growth differences for site and species. The VA site had the best survival rates likely due to the soil properties created from weathering the sandstone based topsoil substitute. Hybrid poplars and hardwoods had the greatest height growth at VA and white pine growth was statistically the same across all sites due to its slow initial growth habit. The sandstone content continues to be the overwhelming soil property affecting tree growth on Appalachian mine soils. Future growth measurements may indicate other physical and chemical soil properties as significant to overall forest productivity.

CHAPTER V

DEVELOPMENT OF A FOREST SITE QUALITY CLASSIFICATION FOR MINE SOILS IN THE APPALACHIAN COALFIELD REGION

INTRODUCTION

Surface mining for coal has been taking place in the Eastern U.S. since the late 1940's. The Appalachian Plateau region of Virginia (VA), Kentucky (KY), and West Virginia (WV) contain a large source of coal that can be profitably extracted with surface mining techniques. Many regulations have been emplaced to ensure the stability and productivity of post mining landscapes due to safety and environmental concerns. The Surface Mining Control and Reclamation Act (SMCRA) of 1977 requires coal miners to return mined land to its "approximate original contour" (AOC), requires topsoil or an approved topsoil substitute to be replaced, and requires the land to be able to support vegetation at its original productivity level or better (Public Law 95-87). However, since hayland and pasture are considered higher order land uses than forest, the law allows coal companies to seed the area to herbaceous forages leading to a decline in the native forests that historically occupied the landscape.

There is no forest productivity standard currently enforced for mined land reclaimed under a regular forestland permit. Only a stocking standard or a minimum number of trees surviving for the five-year bond period is required (commonly 1,000 trees/ha). In addition to the stocking standard, mined land reclaimed to forestry should meet a minimum productivity standard in order to satisfy the intent of the SMCRA to return mined land to its original capability level. Research shows that forest land productivity can be fully restored. Ashby (1984) stated that tree growth on mined land could be greater than on non-mined land when mine soils have greater porosity, improved water movement, fewer rooting restrictions, better pH levels, and greater nutrient availability than some native soils. Recent research by Rodrigue and

Burger (2004) corroborates Ashby's observations. Therefore, if mined lands are reclaimed to create the right combination of soil physical and chemical properties, forest site productivity could be restored.

Soil and site conditions that are known to affect tree growth might be used to predict a site's forest productivity potential because it is difficult to evaluate forest productivity with only five years of growth obtained during the normal bond period. Soil and site conditions are commonly used to judge forest productivity where there are no trees present for direct estimations of forest growth rates or productivity (Carmean, 1975). The same approach could be used to estimate the productivity of recently-reclaimed mined sites given that soil and site conditions that influence tree survival and growth have been extensively studied and described. Many foresters have found that current classifications using USDA soil series are not adequate for forest sites due to large differences in SI within a soil series unit (Carmean, 1975; Van Lear, 1990; Smalley, 1991), and the heterogeneity of mine soils prevents much of the standard USDA mapping techniques and soil criteria from being able to be used in a practical manner for mine soil mapping and management interpretations (Schafer, 1979; Sencindiver, 1977; Indorante et al., 1992; Scencindiver and Ammons, 2000).

Important physical properties that affect successful reforestation of mine soils are rock fragment content, particle size, bulk density (D_b), and color (Vogel, 1981). The most important factors related to forest productivity in soil-site evaluations are available soil moisture and the growing space for tree roots (Aydelott, 1978; Sharma and Carter, 1996; Bussler et al., 1984; Potter et al., 1988; Rodrique, 2001). Torbert et al. (1988a) concluded that physical soil properties were more influential than fertility on 8-year old white pine (*Pinus strobus* L.) grown on reclaimed mine soil benches in southwest VA

Mine soils commonly have higher D_b and lower porosities than native soils due to heavy traffic associated with grading (Thurman and Sencindiver, 1986). This compaction due to traffic also results in increased resistance to roots, impeded infiltration and drainage, reduced aeration, and other factors that are detrimental to tree survival and growth (Ruark et al., 1982). Slope is often used as a surrogate for D_b because steep slopes are difficult to traverse with large equipment and the soils are consequently less compacted than soils on flat areas (Andrews et al., 1998). Torbert and Burger (1990) reported tree survival data on a rough-graded area, and a leveled, smooth-graded area as being 70 % and 42 %, respectively. The aspect of the slope has an influence on the temperature and water relations (evaporation and transpiration) of the soil. Southwest slopes receive the most direct sunlight during the growing season which increases evaporation and soil temperatures, causing even drier conditions on mine soils that are potentially droughty already. The northeast aspects are considered to be the best sites for tree growth on mine soils and native soils due to mesic site conditions (Burger et al., 2002; Hicks and Frank, 1984).

High rock fragment (RF, fragments > 2 mm diameter) contents are characteristic of the eastern coalfield region and are often a potential growth-limiting problem because of the reduced total soil volume, lower water holding capacity, rapid drainage, and potentially droughty conditions due to water being held at low water potentials (Pedersen et al., 1978; Schoenholtz et al., 1992; Sobek et al., 2000). Rock type is a major factor that influences many other soil properties and is largely responsible for forest productivity (Andrews, 1992; Ashby, 1984; Preve et al., 1984; Torbert et al., 1988a; Torbert et al., 1990). Oxidized sandstone spoil is considered to be the best parent material for the production of forest trees due to its resistance to compaction, increased macroporosity, acidity, low soluble salt level, and its rapid response to physical weathering (Torbert et al. 1990; Haering et al., 1993). A sandy loam texture is optimum for tree growth on mine soils (Burger and Zipper, 2002).

Rooting depth positively influences the productivity of mine soils through increased nutrient availability and available water holding capacity (Torbert et al., 1994; Andrews et al., 1998). Andrews et al. (1998) found that rooting depth was the mine soil property most strongly related to height growth for 78 white pine plantations growing on reclaimed mine soils.

Mine soil color (Munsell Color Charts, Kollmorgen Instruments Corporation, Newburgh, NY) may indicate the oxidation and weathering stage of different rock types. A soil chroma of $\geq$ 3 is a good indication that oxidation and chemical weathering processes that release nutrients from the hard rock have taken place (Sobek et al., 2000; Haering et al., 2004). In recently reclaimed mine soils formed from non-oxidized rock, the pH is often high (>7) due to the lack of weathering. Torbert et al. (1990) found a strong inverse relationship ($R^2 = 0.86$) between tree volume and mine soil pH when studying pine growth on different spoil types. The optimum pH range for most native trees in the Appalachian region to be competitive is 5.5 or less (Skousen et al., 1994).

Soluble salt concentration (as measured by electrical conductivity, EC) has been recognized as a factor that is often an issue in the reforestation of mine soils (Torbert et al., 1988b; Burger et al., 1994; Andrews et al., 1998; Rodrique and Burger, 2004). Tree growth decreases as EC levels increase.

Phosphorus (P) has been recognized as important to tree productivity in numerous soil-site evaluations (Andrews, 1992; Torbert et al., 1994). Mn has also been reported by previous studies to affect tree growth on mine soils in this region (Andrews et al., 1998; Torbert et al., 1990). Rodrique and Burger (2004) found base saturation of mine soils to be the most important soil property affecting forest productivity on pre- and post-SMCRA mined lands. Howard et al. (1988) indicated that low cation exchange capacity (CEC) was the greatest limitation to the nutrient potential of mine spoils.

Previous research demonstrates known relationships between tree growth and a number of measurable site and soil properties. Agronomic researchers have successfully combined soil properties in models to estimate crop production potential (Neill, 1979; Kiniry, 1983; Pierce et al., 1983):

$$PI = \sum_{i=1}^{r} (A \times B \times C \times D \times WF)_i \tag{1}$$

where PI is a productivity index scaled from 0 to 1; A, B, C, and D are sufficiency levels (scaled from 0 to 1) of soil properties known to influence crop production; and WF is a weighting factor that adjusts the relative importance of different soil layers through the profile. The product was summed over *r*, the number of soil layers within the total rooting depth.

Foresters have modified this model to estimate tree species production potential on forest land (Gale, 1987; Henderson et al., 1990):

$$PI = \sum_{i=1}^{r} (A \times B \times C \times D)^{1/4} \times WF)_i \times (S \times Cl)^{1/2} \tag{2}$$

where the first part of the equation is the same as Equation 1 except that the geometric mean (1/4 in the exponent) of the product is taken to assure equal weighting of the four soil properties; the product is summed over r, the number of soil layers (as in Equation 1); and S and Cl are sufficiency levels for slope and climate site factors, and the geometric mean (1/2 in the exponent) of the product is taken to assure equal weighting of those two site properties.

The underlying concept of PI models is that the overall productivity of a plant is proportional to root growth (Henderson et al., 1990). Therefore, a tree whose root growth is not restricted is expected to grow at its genetic potential for a given climatic region. These soils would have a PI value of 1.0. A soil where root growth is completely prevented would receive a PI value of 0.0 and a tree would not survive.

A PI model that incorporates key soil properties most influencing forest growth on mine soils might be used by reclamation personnel to identify optimum soil and site conditions for production of specific forest trees. Foresters and reclamation managers can use important soil and site properties to classify mine soils into a set of forest site quality class (FSQC) for predicting site index by tree species. The FSQC can be used to make silvicultural recommendations such as whether a site should be planted to trees, species selection if planted, and necessary remediation or management for mine land that is to be managed for optimal forest production. The objectives were to: (1) develop a general soil-based PI model for predicting site index and FSQC for specified tree species on reclaimed surface mined land in the Appalachian coalfield region; (2) improve the accuracy of the PI model for white pine by measuring growth and soil and site properties on previously established stands; and (3) demonstrate the practicality of using the model by mapping a selected site.

MATERIALS AND METHODS

General Productivity Index Model Development and Validation

Based on previous research, nine soil and site properties were selected for inclusion in a general forest PI model. Sufficiency curves defining the relationship between tree or root growth and levels of the soil and site properties were developed based on past and current research. The general PI model was developed based on the mathematical format of Equation 2, except that only one soil layer (0 – 20 cm) was analyzed, different properties were measured, and site properties were included together with soil layer properties.

Nine soil and site properties were measured or estimated to validate the general PI model for white pine growth on post-SMCRA reclaimed mine lands. Fifty-two white pine stands ranging from 10- to 18- years old were sampled at sites in Wise County, VA, and Nicholas, Mercer, and Wyoming Counties, WV, for soil and site variables and for site index (SI = dominant tree height at age 50) of white pine (Appendix 6), as explained below.

Field-Measured Soil and Site Properties

The pH, EC, texture, color, sandstone %, RF volume percent, soil density class, potential rooting depth, slope, and aspect were estimated at several (3 to 5) locations in a sample area and averaged for a representative result due to the extreme heterogeneity of mine soils. The color data was not included in the model but was used as ancillary data. The sample area varied from 9 to 36 m^2 depending on tree and stand diversity and the uniformity of soil types.

The dominant soil material in the upper 20 cm was evaluated at each sample site. The pH and EC were measured with a Hanna HI 9812 field meter (Hanna Instruments Inc., Woonsocket, RI) in pH units and $\mu S\ cm^{-1}$, respectively. The soil hue, value, and chroma were recorded using Munsell Color Charts. On sites where an A horizon had formed on the surface, the Munsell color was read below the zone of apparent organic matter (OM) accumulation. Soil texture class was estimated by rubbing moistened soil. Sandstone % was estimated as the proportion of sandstone fragments compared to the total volume of all rock fragments (the RF volume) in the sample area.

No completely quantitative method was found to accurately predict mine soil D_b because of the high volume of RFs. Conventional D_b measurements require laboratory calculations of RF volume and moisture content, and are too time consuming for field practical measurements. Therefore, the "density class" of the upper 20 cm was estimated based on the average penetration depth of a sharpshooter (tapered shovel with rounded tip blade 14 cm wide and 40 cm long) along with observations of soil rupture resistance and RF type and volume. The sharpshooter was stepped on using a steady force from the weight of a 70 kg person, and the depth and ease in which it penetrated the soil was noted along with the associated soil properties listed above. The following guides were used to estimate five general density classes: if the sharpshooter penetrated easily to 25 cm or more, then a density class of "very low" was assigned; if penetration was 16 to 25 cm with slight resistance, then a density class of "low" was assigned; if penetration was less than 15 cm with moderate resistance, then a density class of "moderate" was assigned; if penetration was less than 5 cm with strong resistance, then a density class of "high" was assigned; and if penetration was less than 2 cm then a density class of "very high" was assigned. The density class was decreased one class in soils with an estimated RF content greater than 50%, provided that the moist rupture resistance (a.k.a. moist consistence class) at the depth of maximum sharpshooter penetration was not very firm or extremely firm (Soil Survey Division Staff, 1993) as confirmed by shallow pit excavations. In moist soils with low RF content and textures finer than sandy loam, the density was increased one class because those soil conditions allow sharpshooter penetration into soil that has moist rupture resistance of very firm or extremely firm as confirmed by shallow pit excavations. In extremely dry soils, no adjustment was made. Along with the rupture resistance, fine root growth widely-spaced or matted between aggregates and large aggregate size were used to confirm that the soil was dense.

The potential rooting depth (cm) was determined by using a screw auger (round tip screw head 16-cm long and 5-cm wide with 3 complete turns and on a 97-cm long shaft) and turning it into the ground until significant resistance (more than upper body strength was required) was felt or complete refusal was reached. Layers with "bridging voids" (large air gaps between rocks), greater than 90% rock fragments, and essentially no soil were considered root limiting, along with dense, compacted layers.

Site factors were measured at each sample location. Percent slope was measured using a standard clinometer. Aspect was measured as an azimuth on slopes greater than 15% using a standard compass.

At each sample point the nearest two to four trees were measured using the growth intercept model developed by Beck (1971), in which the length of the first five internodes (distance between whorls of branches) beginning at breast height (1.4 m) is measured and converted to a site index (Equation 3). Waiting until the tree reaches breast height minimizes the effects of strong competition by ground cover on tree seedlings.

$$SI = 26 + 6.6 \text{ (5-year intercept length)} \qquad \textbf{(3)}$$

where SI=white pine site index (predicted tree height in feet at age 50); 26 and 6.6 are coefficients; and 5-year intercept = total length in feet of the first five internodes beginning at breast height.

Statistical Analysis

Multiple linear regression techniques were used in SAS 9.1 (2003) to identify the soil and site properties from the soil and site variables at each sample site that were the most significantly related to white pine SI calculated in Equation 3. Transformations of the independent variables were used to linearize the data based on known relationships. Multi-collinearity assessments were made using variance inflation factors (VIF's) (Montgomery et al., 2001). Data points with large influence or leverage on the model were identified using various influence statistics (Montgomery et al., 2001). Distributions, normality, and homogeneity of variance of the data were all analyzed using residual plots, stem-leaf plots, and normal probability plots (SAS 9.1,

2003) (Appendix 7). Mallows' C(p) statistic was used as a selection procedure to derive a list of the best models (Montgomery et al., 2001). Importance factors (IF) for each variable were calculated using the absolute value of standardized coefficients (Montgomery et al., 2001), and normalizing the values from 0 to 1. The PI model was developed and modified from Gale (1987), and regressed with SI using Microsoft Excel.

Sufficiency curves were developed for nine soil and site properties that were reported in the literature to have had significant effects on tree growth, and could be analyzed in the field. Many of these curves have previously been adapted for use on mine soils and for tree growth as opposed to agricultural crops. Sufficiency curves for pH, EC, D_b, rooting depth, and slope have been previously established for white pine productivity measurements of mine soils in the study region (Andrews, 1992; Torbert et al., 1994). Sufficiency curves for RF, texture, aspect, and sandstone % were developed based on previous research.

Mapping

A mountain top removal mine was selected as a mapping demonstration area to test the practicality of the classification system developed. It was located in Dickenson County, VA and is known as the Flint Gap site. This site was reclaimed in 1994, and herbaceous vegetation along with some planted white pine and Virginia pine (*Pinus virginiana* Mill.) dominated the site. Some volunteer seedlings had become established as well, but very little growth was evident.

Data were collected in selected locations using standard soil mapping techniques, and the model developed was used to delineate polygons that represented different FSQC. Ordination symbols of p, r, t, and c were designated to map units if one of the selected properties of pH, RF, texture, or density respectively had a sufficiency value of 0.6 or less. A rooting depth of less than 50 cm was given the ordination symbol of d. Spot symbols were used to indicate wet spots on the landscape.

RESULTS AND DISCUSSION

General Productivity Index Model Assessment

A sufficiency curve was developed for pH (Figure V-1), similar to the one used by Andrews (1992), and was adjusted using research results from Gale et al. (1991) and Torbert et al. (1990). A pH between 4.5 and 5.8 was considered optimal for white pine and was assigned a sufficiency level of 1.0, while a linear decline on each side of the optimal plateau results in a pH of 3.0 and 8.0, having a sufficiency level of 0.2. High pH values (>7) may be enough to reduce the availability of boron (B), copper (Cu), zinc (Zn), iron (Fe), and manganese (Mn) (Brady and Weil, 1999). A lower pH negatively affects the growth of herbaceous ground cover seeded during reclamation, reducing the competition with trees.

A sufficiency curve for EC developed by Andrews (1992) was used in this study (Figure V-2). An EC value less than 0.5 dS m^{-1} was not suspected to have an affect on white pine productivity, and the curve declines linearly to an EC of 2 dS m^{-1} and a sufficiency level of 0.2. Andrews et al. (1998) found that total soluble salts ranged from 0.02 and 1.97 dS m^{-1} across 78 mined sites. When values exceeded 1.00 dS m^{-1}, total salts became one of the most important chemical properties affecting white pine growth on mine soils.

Neill (1979) and Andrews (1992) produced sufficiency curves for D_b, both of which decline in sufficiency level above a critical D_b. The sufficiency curve developed in this study follows the same pattern but is shifted slightly to the left to correlate it with our sharpshooter penetration method of soil density class assessment (Figure V-3). A point along the soil density continuum is chosen to determine a sufficiency value. Mine soils typically have less structure and porosity and fewer interconnected pores than native soils, which leads to lower soil moisture availability and aeration. The densities that were considered limiting were adjusted downward based on the D_b measurements in Chapter III and to account for inherently lower porosity in mine soils than in native soils. The D_b sufficiency curve was modified by Andrews (1992) using data from Pierce et al. (1983) to account for three different general particle size classes. Our method for determining soil density class in the field accounts for soil texture and allows the use of only one sufficiency curve.

With the requirement of returning the land to AOC, reclaimed mine spoil is graded with large equipment. Slopes > 25 % are difficult to traverse with large equipment and the soils on steep slopes are consequently less compacted and have a deeper rooting depth than soils on flat areas (Andrews et al., 1998). Therefore, the slope of a site may be used as a surrogate for the degree of compaction. The sufficiency curve for slope developed by Andrews (1992) assigns a sufficiency of 1.0 to all slopes greater than 35% (Figure V-4).

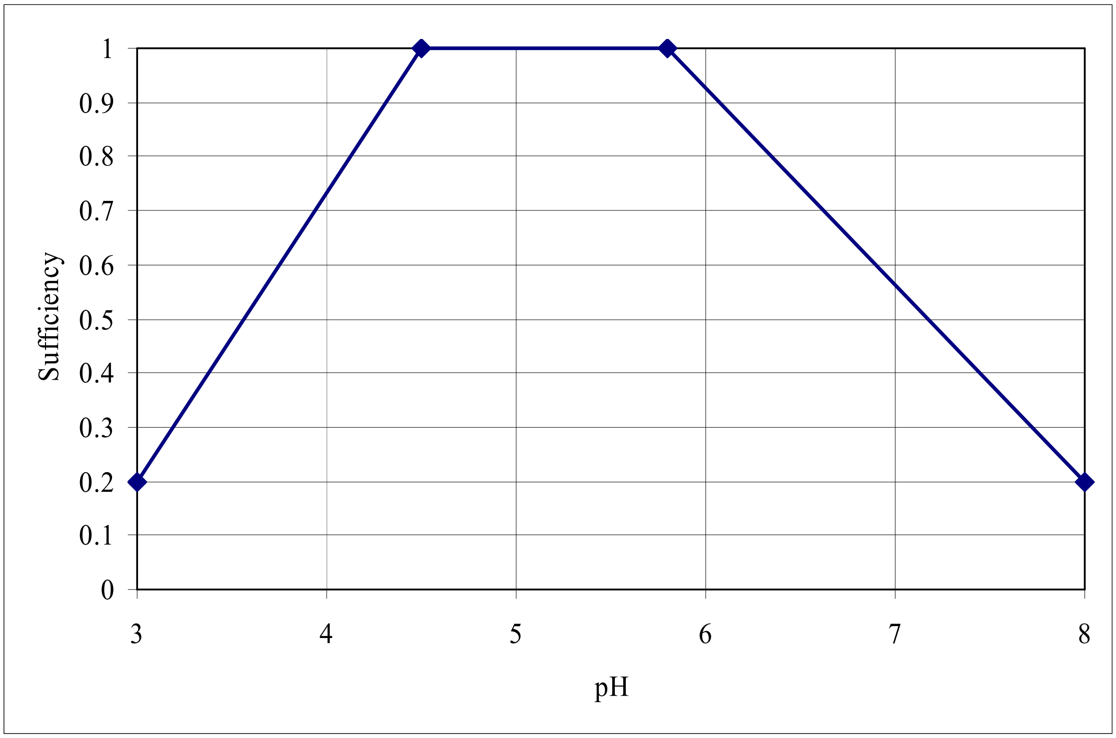

Figure V-1. A sufficiency curve for pH was developed based on research by Andrews (1992), Gale et al. (1991), and Torbert et al. (1990).

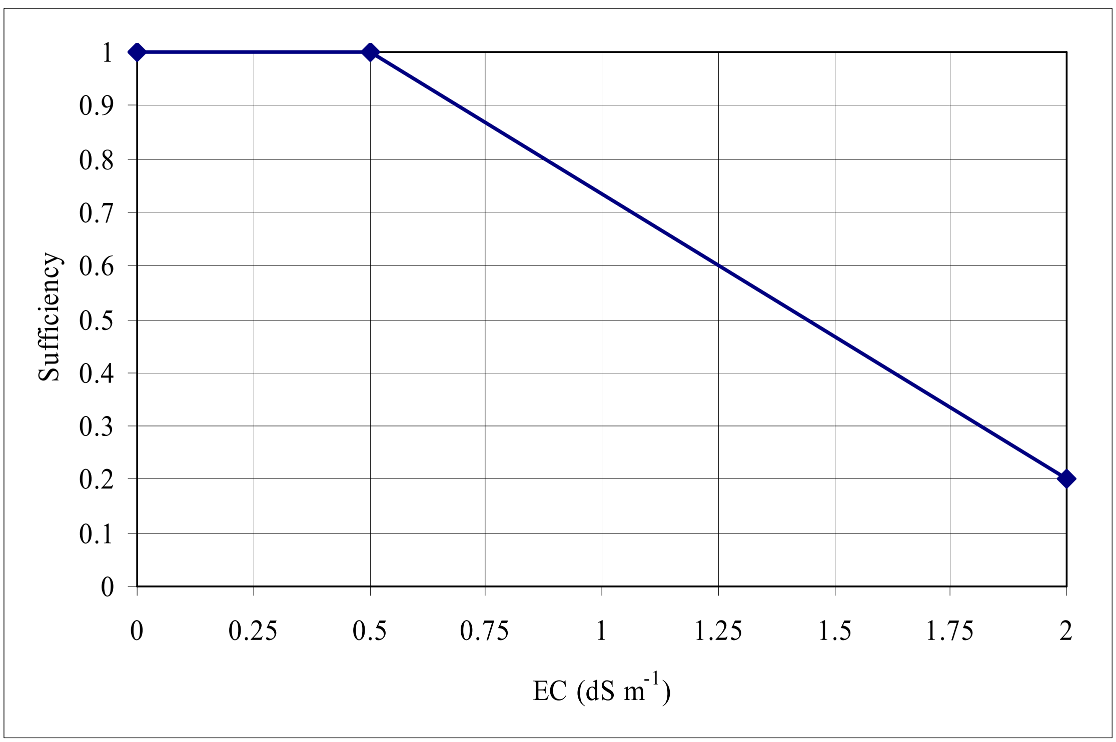

Figure V-2. Sufficiency curve for electrical conductivity (EC) on mine soils in the Appalachian region (reproduced from Andrews, 1992).

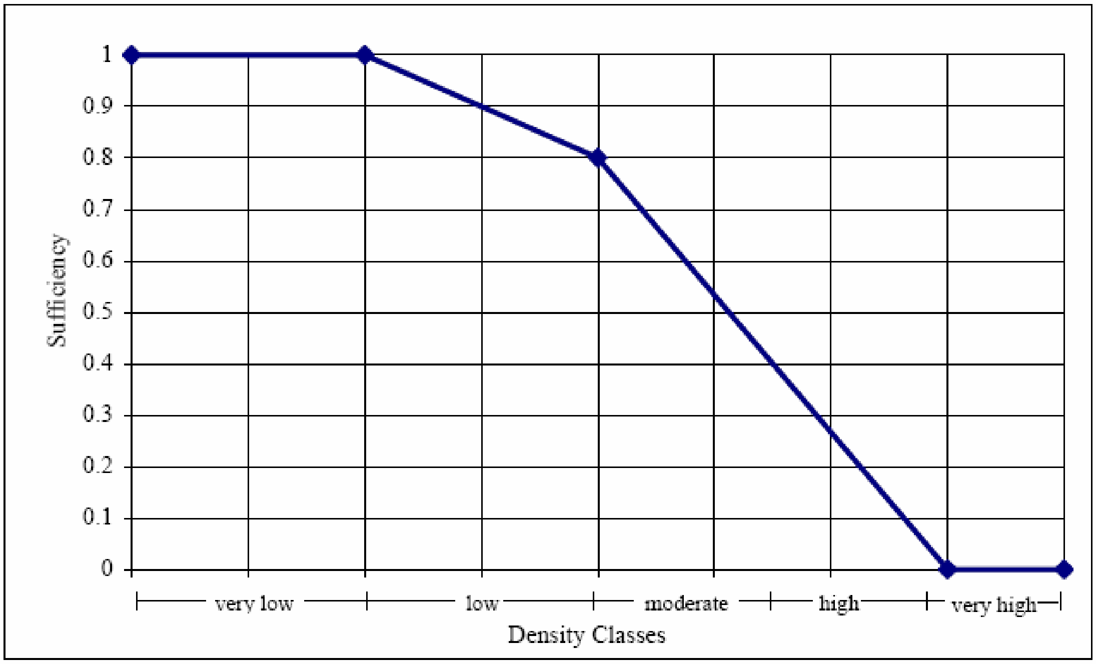

Figure V-3. Bulk density sufficiency curve developed by Andrews (1992) and Neill (1979) and modified to accommodate the sharpshooter penetration density classes adjusted for porosity differences in mine soils compared to native soils.

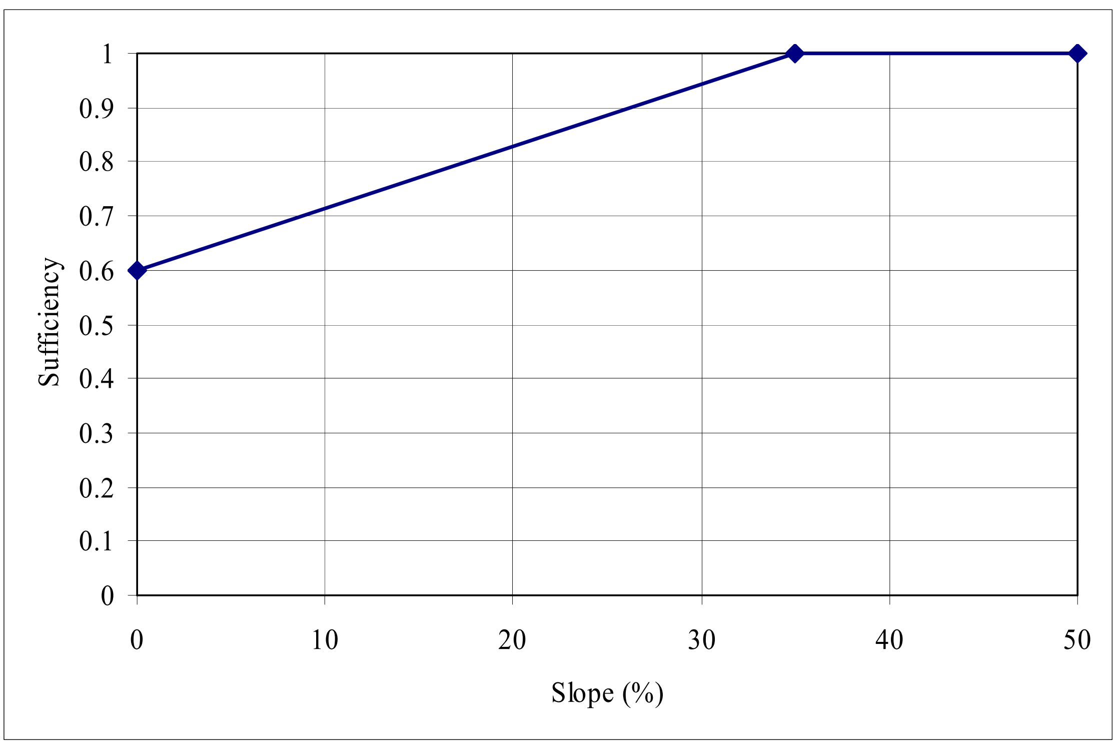

Figure V-4. Sufficiency curve for slope on mine soils in the Appalachian region (reproduced from Andrews, 1992).

No sufficiency curves for soil texture have been published. A first approximation of a soil texture sufficiency curve (Figure V-5) was based on mine soil research by Burger and Zipper (2002), and on white pine growth on native soils by Lancaster and Leak (1978). High clay soils are known to be unproductive for white pines, and extremely sandy soils have low water holding capacity. Sandy loam textures are optimal for pine growth (Burger and Zipper, 2002); this textural class falls within the range of silt + clay % that has a sufficiency of 1.0. Silt + clay % overlap texture class boundaries. Some growth is expected at 0 and 100 % silt + clay. Silty soils and soils with high clay content are also more easily compacted and less aerated than soils dominated by sand-sized particles. Poor aeration and drainage are chief causes of poor tree survival and growth.

The RF sufficiency curve is based on research by Rodrigue and Burger (2004). A linear relationship with increasing RF contents and decreasing sufficiency levels is expected at RF content greater than 35 % (Figure V-6). Bramble (1952) reported that at least 20 % of soil-sized particles must be present for trees to survive. Others have recognized 90 % rock fragments as being totally root limiting (John Sencindiver personal communication, 2005).

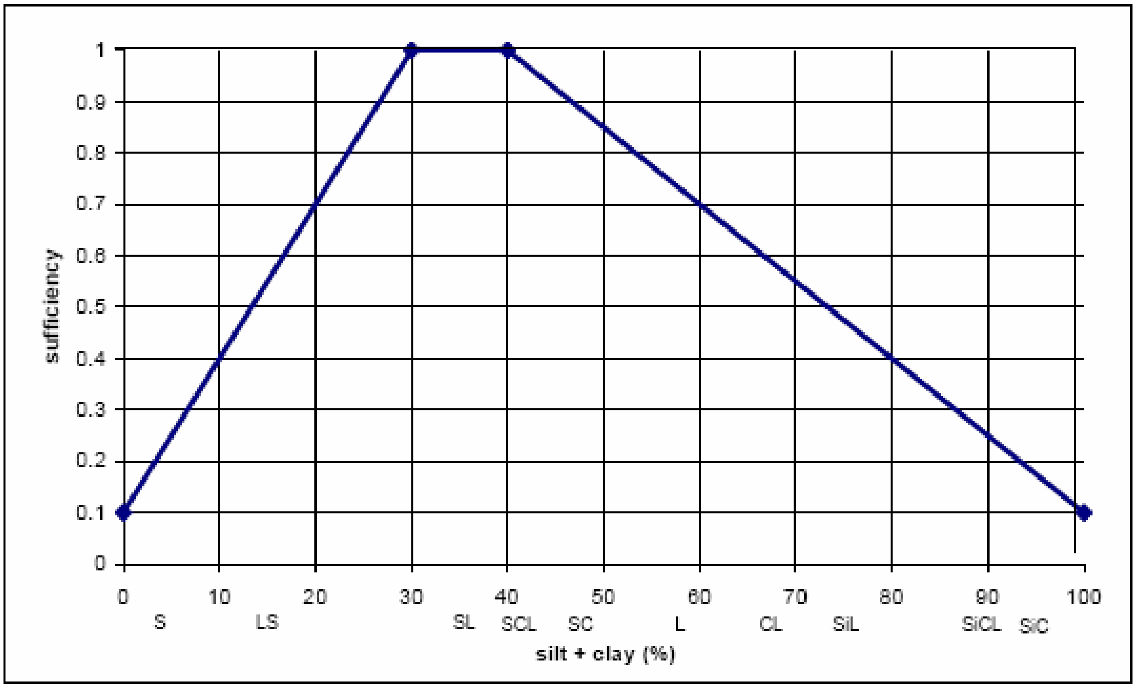

Figure V-5. A sufficiency curve for texture and its influence on white pine growth on mine soils in the Appalachian region was developed based on research from Burger and Zipper (2002) and Lancaster and Leak (1978). Silt + clay % overlap texture class boundaries.

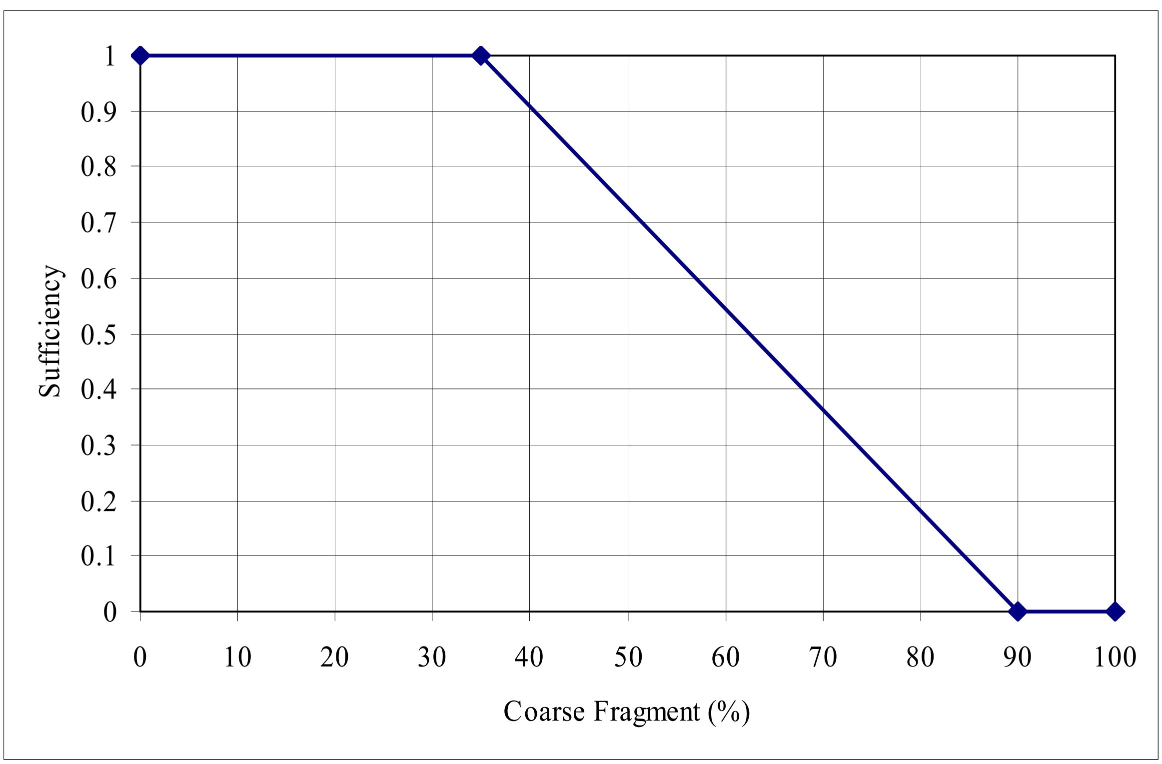

Figure V-6. Rock fragment sufficiency as a function of rock fragment volume.

The sufficiency of potential rooting depth was defined by Equation 4 (Gale, 1987):

$$Y = 1 - \beta^{d} \qquad \textbf{(4)}$$

Where Y = cumulative root fraction from the soil surface to soil depth ^{d} (cm); and β = 0.96, an estimated parameter used by Torbert et al. (1994) for white pine.

The sufficiency curve for rooting depth attributes greatest importance to the thickness of the surface soil layer, with the relative importance of rooting in subsoil layers decreasing exponentially with depth (Figure V-7) (Gale, 1987). Torbert et al. (1988b) found that the rooting volume index (RVI = rooting depth x percent fraction <2 mm) accounted for almost 50% of the variation in tree height for eight-year-old white pines.

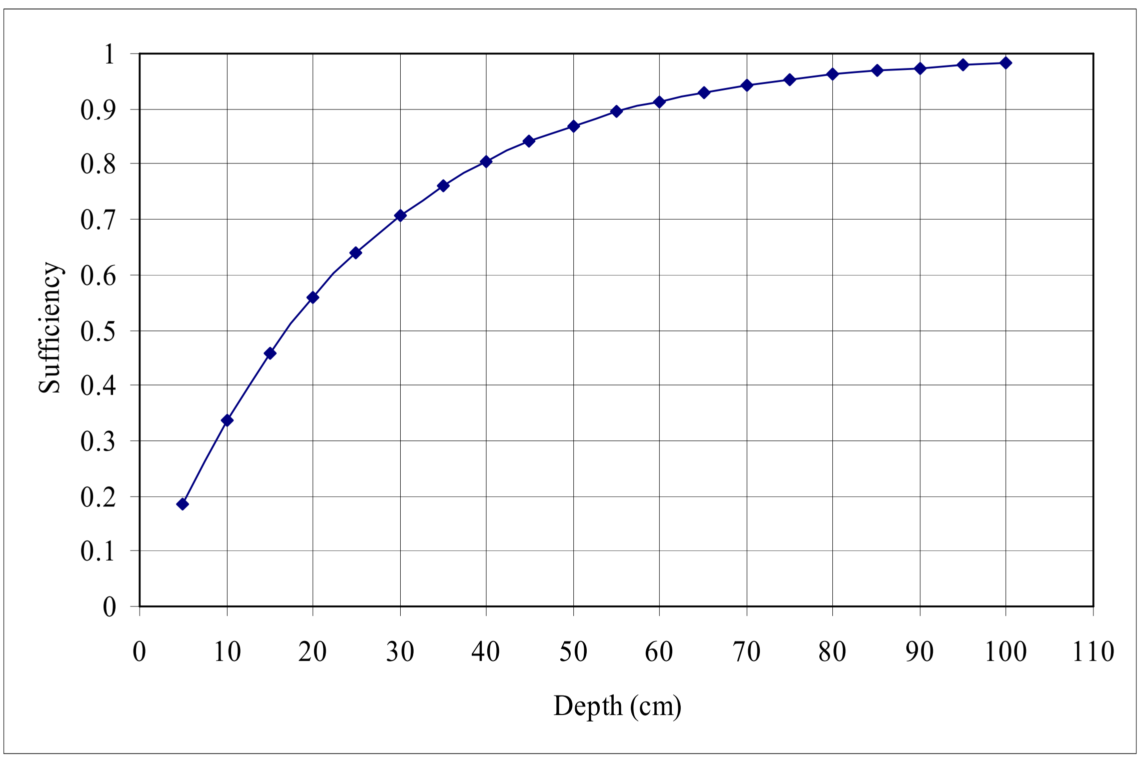

Figure V-7. Sufficiency of rooting depth potential declines exponentially with decreasing depth (Gale and Grigal, 1987).

No sufficiency curves have been previously developed for sandstone %, so a linear sufficiency curve was developed based on research from Torbert et al. (1990) (Figure V-8). A sufficiency of 0.4 is given for 0 % sandstone because lack of sandstone is not expected to totally limit tree growth. Siltstone and shale weather into finer particles and are generally more susceptible to compaction, have fewer macro-pores, a higher pH, and higher levels of soluble salts than most sandstone spoils. In a study by Torbert et al. (1988a) of hybrid pine growth on different rock mixtures, four-year-old trees had an average height, diameter, and volume of 146.2 cm, 40.4 mm, and 685 cm^3 respectively on oxidized sandstone spoil. On siltstone spoil the values reported were 84.8 cm, 21.8 mm, and 123 cm^3. After five years, Torbert et al. (1990) concluded that overall survival was not significantly affected by rock type, but tree volume was. About 1.2 m of uncompacted sandstone material is needed to produce a mine soil of high quality and productivity for native trees (Burger and Zipper, 2002).

A sufficiency curve was developed indicating northeast aspects being the best and southwest aspects being the worst sites for tree growth (Figure V-9), based on research by Hicks and Frank (1984) and Burger et al. (2002). The sufficiency levels may not be true on high-elevation mine sites, where sunlight may become limiting on steep northeast-facing aspects (Miller et al., 2004; Whittaker, 1966).

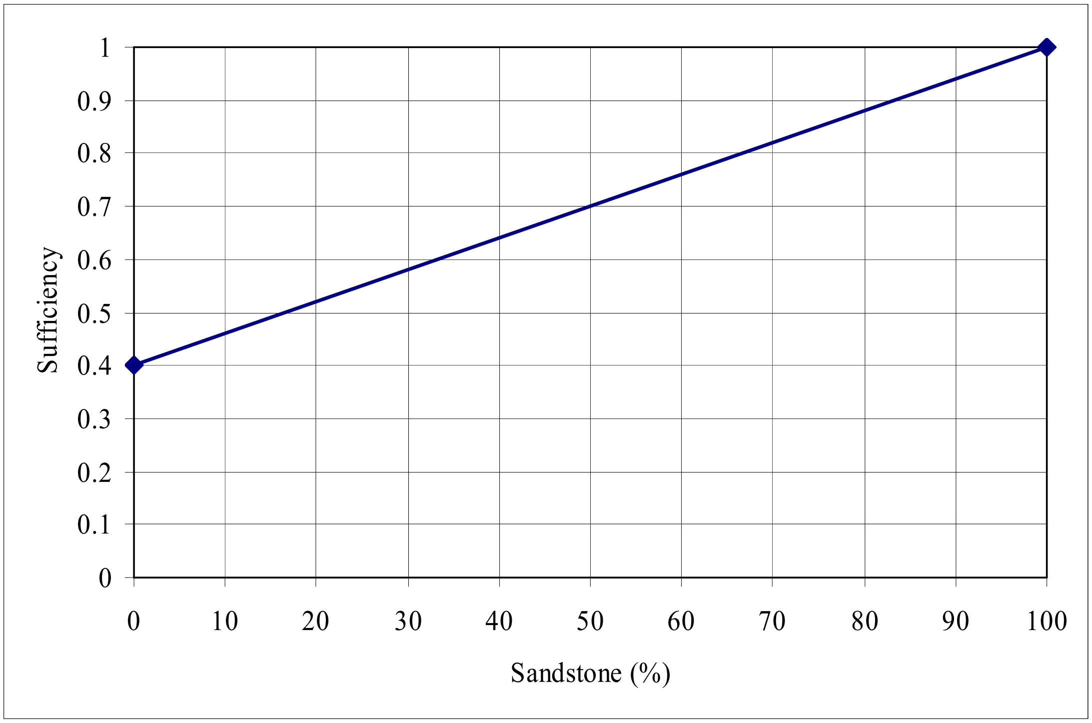

Figure V-8. Sufficiency curve for sandstone % used on mine soils in the Appalachian region was developed based on research from Torbert et al. (1990).

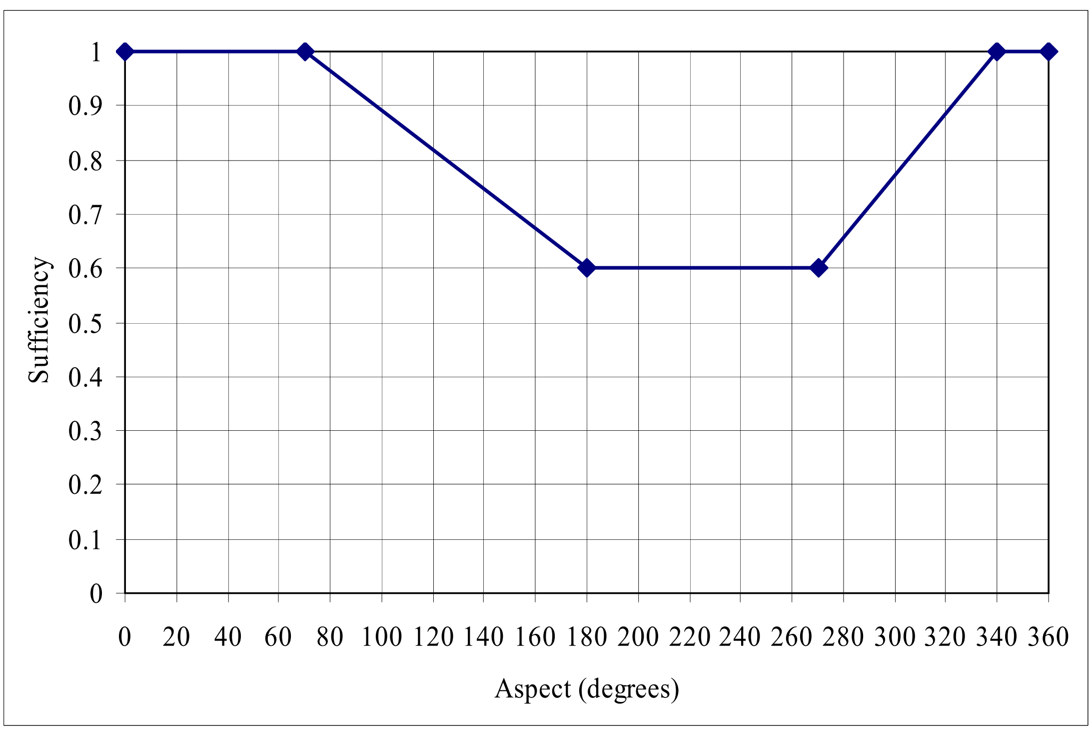

Figure V-9. Sufficiency curve for aspect used on mine soils in the Appalachian region, based on research by Hicks and Frank, 1984 and Burger et al., 2002.

The general PI model incorporating the soil and site properties that affect forest productivity on mine soils is:

$$PI = (pH \times EC \times density \times slope \times texture \times RF \times sandstone\ \% \times aspect)^{1/8} \times depth \quad \textbf{(5)}$$

where PI = Productivity Index; pH = sufficiency of pH; EC = sufficiency of electrical conductivity; density = sufficiency of density class; slope = sufficiency of slope; texture = sufficiency of texture determined by silt + clay %; RF = sufficiency of rock fragment volume; sandstone % = sufficiency of sandstone %; aspect = sufficiency of aspect; depth = sufficiency of potential rooting depth (equivalent to the WF variable in Equation 2).

PI was calculated for each of the 52 white pine sites using Equation 5 (Appendix 6). PI values were regressed with white pine SI to determine the extent to which the general PI model correlated with SI. The fit of the general PI model to SI of the validation sites resulted in an R^2 value of 0.61 (Figure V-10). This shows that the general soil-based PI model could be used in lieu of SI to estimate the productivity of white pine on post-SMCRA mined land.

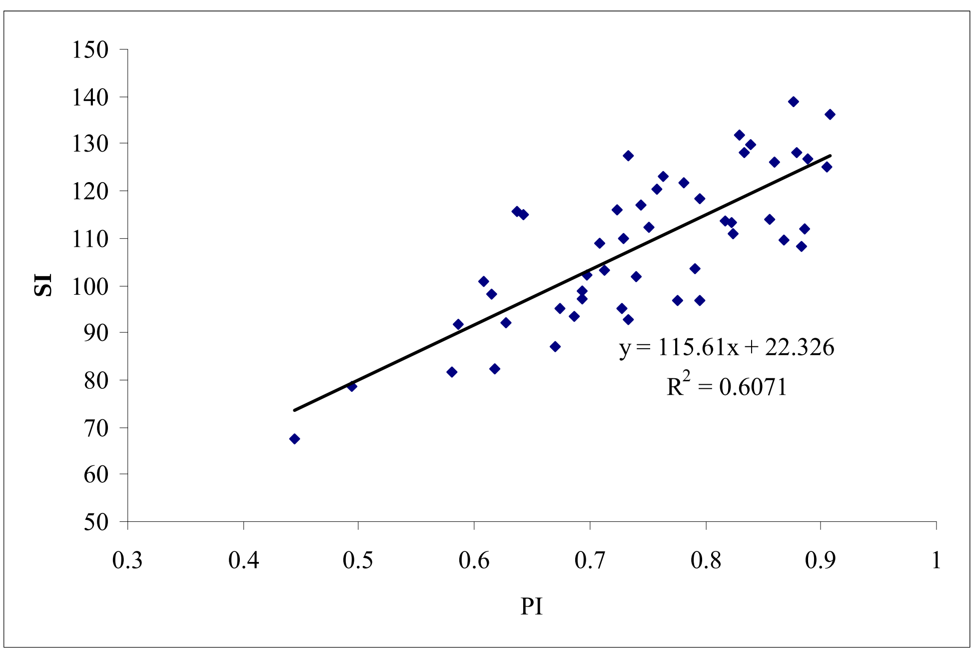

Figure V-10. The general productivity index (PI = x) regressed with site index (SI = y, tree height at age 50) of white pine growing on mine soils in the Appalachian region.

White Pine-Specific Productivity Index Model

The general PI model (Equation 5) calculated a geometric mean for all soil property sufficiency levels, assuming that each had the same level of importance on the PI. Soil and site properties have varying influence on productivity dependent upon the tree species. The general PI model could be improved if each property was weighted based on the extent to which it influenced growth of a particular tree species. A white pine-specific PI model was developed using regression relationships between white pine SI and soil and site properties found on the 52 measured sites.

Data from three of the original 52 sampling points were discarded because the SI values were extreme outliers, or had large influence and leverage on the model determined by influence statistics. Site index was regressed with all soil and site properties after the raw soil and site data were transformed to linearize them and reduce the variability. The pH variable was squared, an arcsine transformation was used on all data that was recorded in percent, and the RF and slope variables were log transformed.

The C(p) selection procedure indicated that the best white pine PI model included only the variables of texture, density, and rooting depth ($R^2 = 0.695$ and adjusted $R^2 = 0.675$). The VIF's indicated that no significant multi-collinearity problems existed. Statistical results and checks for normality are found in Appendix 7.

Soil density was the most significant variable ($p < 0.0001$) affecting tree growth (Table V-1), as predicted by the work of Daniels and Amos (1981) and Torbert and Burger (1990). A regression of SI and soil density class alone resulted in a R^2 of 0.53, with higher densities having lower SI values. Rooting depth was the second most influential significant variable ($p = 0.0002$), which agrees with the results reported by Andrews et al. (1998) and Torbert et al. (1988b).

Rooting depth is not expected to be as important in seedling survival and early growth when the root system is not yet fully developed. Sandy loam and loam were the only textures recorded across all of the validation sites. This may have led to a biased evaluation of the texture variable, but the variable was significant ($p = 0.0051$) (Table V-1) and has been reported as an influential property by Burger and Zipper (2002).

Table V-1. Standardized coefficients, importance factors, and significance values for the independent variables used in the final model (Equation 6).

Variable	Standardized Coefficient	Importance Factor	*p*-value
density	-0.54219	0.47	<0.0001
rooting depth	0.36684	0.32	0.0002
texture	-0.24362	0.21	0.0051

The pH variable was insignificant ($p > 0.10$). The soil reaction ranged from pH 4.3 – 8.0 with the distribution of values skewed to values lower than the median value (Table V-2). Most native trees in the Appalachian Mountains grow where pH is approximately 5.5 (Skousen et al., 1994) but some species can also grow well at more neutral pH values. A more diverse range of observed pH values would have likely increased the importance of pH on the model.

RF volume % ranged from 10 to 43 % (Table V-2), which was lower than reported in Chapter IV, possibly due to the increased age and weathering time of the white pine validation sites. RF volume % was negatively correlated with SI and was an insignificant variable ($p > 0.10$). Rodrigue and Burger (2004) found RF volume % to be negatively correlated with SI of white oak, and the same was expected in this study. However, the low levels of RF volume % in this study may not be in the range in which limitations to growth occur, but they do affect water holding capacity and total rooting volume, both of which are extremely important to forest productivity (Aydelott, 1978). RF volume % may be more important on younger sites for seedling survival when trees have not yet developed an extensive root system, available soil moisture is limiting, and most RFs have not undergone physical weathering into finer soil material (Haering et al., 1993).

EC was not significantly ($p > 0.10$) correlated with white pine in the white pine PI model, contrary to the results of Andrews et al. (1998) and Rodrigue and Burger (2004). In a study on 10-year-old white pines by Torbert et al. (1988b), the highest EC level recorded was 1.7 dS m^{-1} and it corresponded to a tree size of only 1.18 m. This suggests that a critical value of 1 dS m^{-1} is associated with white pine productivity and all EC values in this study were lower than 1 dS m^{-1} (Table V-2). All textures were sandy loam, loam, and silt loam (Table V-2), which have been reported to have low EC values, while finer textures are more commonly associated with higher EC levels (Rodrique and Burger, 2004). The ages of the sites were all between 10 and 18 years, allowing any initially high salt levels to leach over time. However, the use of the EC variable for younger sites (< 5 years) may be beneficial for predicting tree survival.

In this study slope was insignificant ($p > 0.10$), but it could serve as an indicator of probable soil density, as flatter slopes tend to be more compacted on post-SMCRA mine lands (Andrews et al., 1998). Aspect was also insignificant ($p > 0.10$) in this model. Aspect becomes more important as slope angle increases and steep, southwest-facing slopes should be the driest and thus have the lowest SI values for white pine. However, soil density decreases as slope angle increases, and therefore the lack of compaction and increased rooting depth may offset the effect of aspect on steep, post-SMCRA reclaimed mine soil slopes. The proportion of sandstone was not significant ($p > 0.10$) in this PI model. However, the proportion of different rock types in the topsoil substitute affect SI to some degree because they control the mine soil color, texture, and pH properties that occur after years of exposure and weathering.

A relative IF was calculated for each soil property in the regression model. IFs were calculated by normalizing the standardized coefficients from 0 to 1. Density was the most important soil property that affected white pine growth in this data set, followed by rooting depth, and soil texture (Table V-1). The sufficiency level of each soil property was weighted by its relative importance (IF) as shown in the following additive PI model:

$$PI_{wp} = (texture*IF_{txt}) + (density*IF_{Db}) + (depth*IF_d) \qquad \textbf{(6)}$$

where PI_{wp} = white pine-specific Productivity Index; texture = sufficiency of texture; density = sufficiency of soil density class or D_b; depth = sufficiency of rooting depth; and IF = importance factor for each soil property (Table V-1).

A regression of PI_{wp} with SI (Figure V-11) shows that weighting the sufficiency values based on the relative importance of each soil property improved the mine soil productivity estimation. The R^2 of the PI_{wp} versus SI relationship was 0.68, better than the R^2 of 0.61 for the general PI model (Figure V-10).

Table V-2. Ranges of measured values and sufficiency values for pH, electrical conductivity (EC), aspect, texture, rock fragment (RF) content, sandstone (SS) content, slope, soil density, and soil depth at 52 sites in southern West Virginia and southwest Virginia.

Property	pH	EC	Aspect	Texture	RF	SS	Slope	Density	Depth
		dS m^{-1}	degrees	USDA class	----------------%----------------				cm
Range of values	4.3 - 8.0	0.01 - 0.25	1 - 355	SL, L, SiL	10 - 43	10 - 90	1 - 50	very low - high	28 - 100
Range of sufficiencies	0.2 - 1.0	1.0 - 1.0	0.6 - 1.0	0.55 - 1.0	0.86 - 1.0	0.45 - 0.94	0.6 - 1.0	0.2 - 1.0	0.68 - 0.98

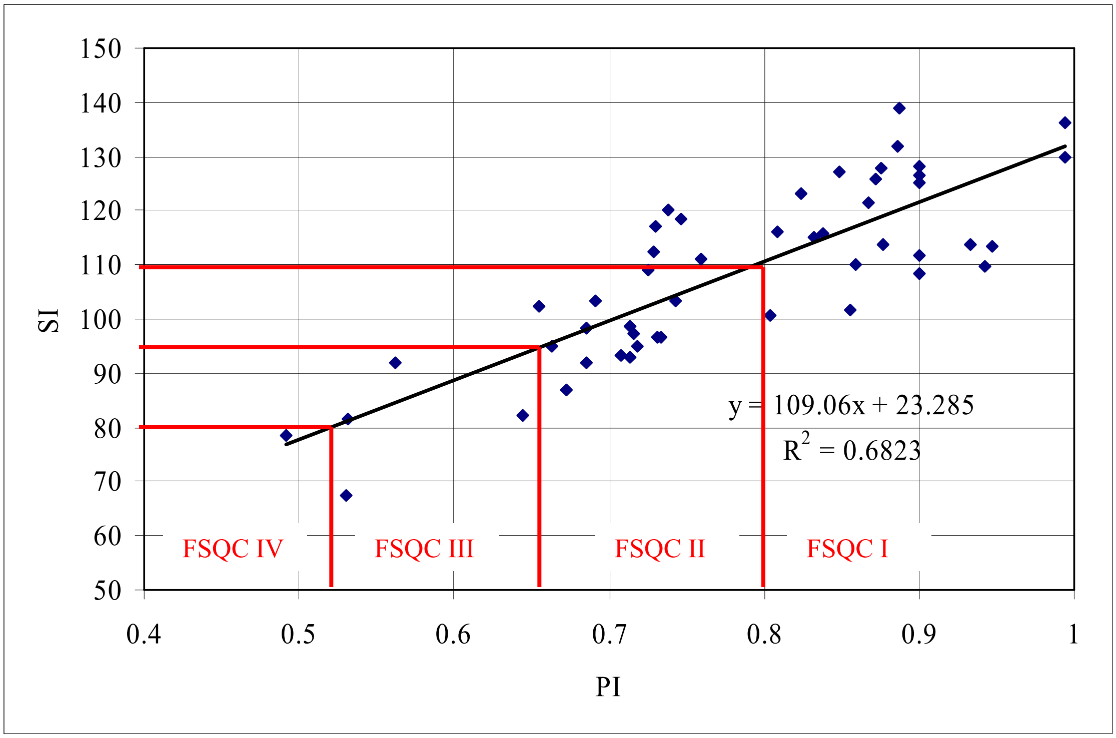

Figure V-11. A regression of the white pine-specific productivity index (PI_{wp} = x) with site index (SI = y, tree height at age 50) of white pine (*Pinus strobus* L.).

Forest Site Quality Class Development

For management purposes, foresters commonly divide the site quality gradient found across the landscape into site quality classes. The PI_{wp} was used to separate five categories of FSQC for white pine, with FSQC (I) being the most productive and FSQC (V) being the least productive (Table V-3). No white pines were found in this study that survived in soil-site conditions of FSQC (V). The SI breakpoints for white pine were based on the research of Doolittle (1958), who found the average SI for white pine on natural soils in the southern Appalachians to be 24 m (80 ft). His study showed an SI range from 20-30 m (66 - 98 ft).

Table V-3. Productivity index (PI) is associated with forest site quality classes (FSQC) and predicted site index (SI, tree height at age 50) for white pine growing on mine soils in the Appalachian coalfield region.

PI	FSQC	SI	SI
		---- ft ----	---- m ----
≤0.38	V	< 65	< 20
0.39 - 0.52	IV	65-79	20-24
0.53 - 0.66	III	80-94	24.4-28.7
0.67 - 0.80	II	95-110	29-33.5
>0.80	I	> 110	>33.5

The following example data can be used to demonstrate the use of the FSQC to predict white pine SI: silt + clay % = 60 %, density level = midrange moderate, and rooting depth = 57 cm. $SI_{wp} = (0.7*0.21) + (0.5*0.47) + (0.9*0.32) = 0.67$. According to Table V-3, this value falls on the high end of the range for FSQC III, and white pines growing on this site will likely have a SI in the high end of the 80 – 94 ft range.

Hardwood Productivity Index Model Development

The PI_{wp} model appears to be a good estimator of FSQC for white pine on older surface mines. However, some reclamationists may want to plant trees immediately following final reclamation grading or before bond release. We believe that the addition of the RF volume %, EC, sandstone %, and color variables would be beneficial for sites less than five years old. Sites older than this have already been through the initial weathering stages during which salts are leached and easily weathered rocks have broken down into soil fines, and the PI model similar to that discussed above may be more appropriate.

Native hardwood tree species may be preferred on some reclaimed mined sites. Hardwood species may respond differently to mine soil properties compared to white pine (Burns and Honkala, 1990). Therefore, it would be important to calibrate sufficiency curves for hardwoods, to the extent possible, based on published species/mine soil relationships.

Hardwoods have only recently been used for post-SMCRA reforestation in the Appalachian region, and very few sites exist for model validation. However, based on the success of this initial FSQC model developed for white pine, it appears that an adequate general model could be developed for hardwoods as well. Furthermore, hardwood SI can be estimated with site index comparison curves developed for several Appalachian species (Doolittle, 1958).

Hypothesized sufficiency curves have been developed for hardwood species based on known silvicultural characteristics of species native to the Appalachian region (Burns and Honkala, 1990). The EC, density class, slope, and rooting depth sufficiency curves developed for white pine are considered adequate for hardwoods. The pH curve is shifted toward higher pH values since most hardwoods are not as acid-loving as white pine and other conifers (Figure V-12). The texture curve shifts toward higher silt + clay % and has a wider optimal range (Figure V-13). Hardwoods are not adversely affected by heavy clay soils (Lancaster and Leak, 1978), but structureless mine soils will likely continue to present aeration problems when sand percent is very low. The RF curve indicates that RF volume % will become a limiting factor for hardwood productivity at lower levels than for white pine (Figure V-14). White pine is more tolerable of stony, droughty soils and can be productive on sites where moisture limits optimal hardwood growth (Lancaster and Leak, 1978). Sandstone rock types are more acidic, weather into sandy loam soil textures, and have higher nutrient levels than siltstone rock types (Torbert et al., 1990; Burger and Zipper, 2002; Haering et al., 1993). Due to a higher acceptable pH range and increased tolerance of fine textured soils, the hardwood sufficiency curve for sandstone % indicates that optimal sandstone percents may be lower than for white pine (Figure V-15). The hardwood sufficiency curve for aspect designates a lower sufficiency rating for southwest aspect in order to capture differences in drought tolerance from white pine (Figure V-16).

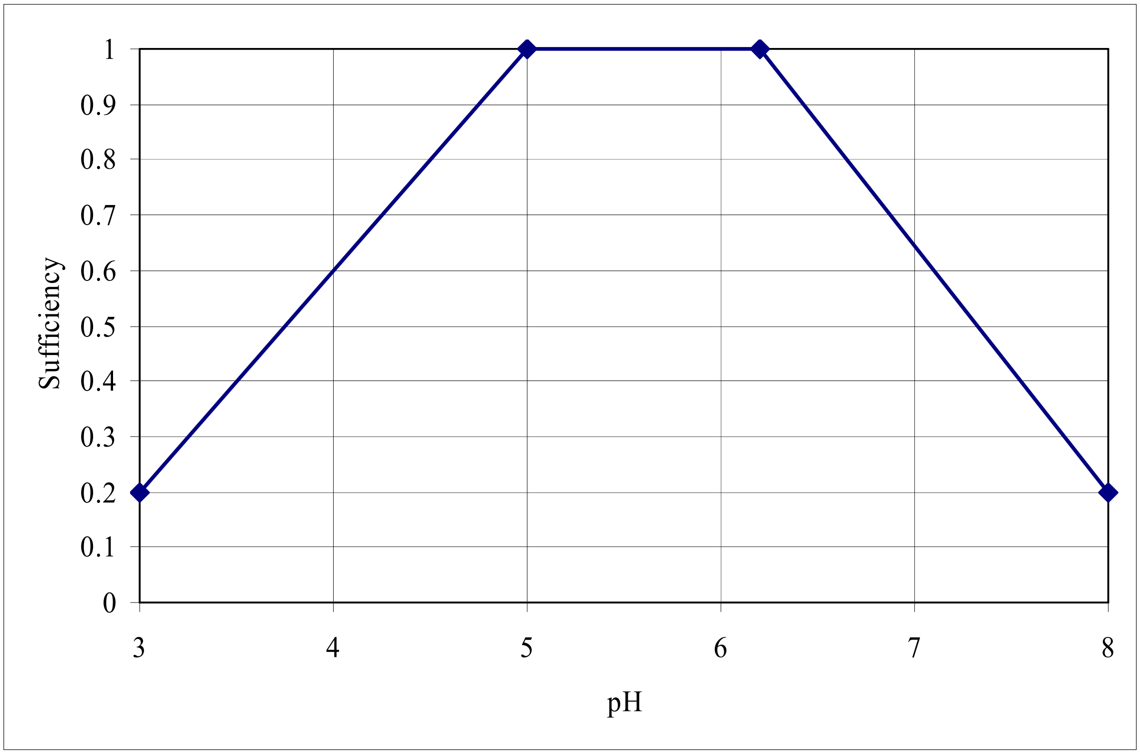

Figure V-12. Sufficiency curve for pH used for hardwoods on mine soils in the Appalachian region.

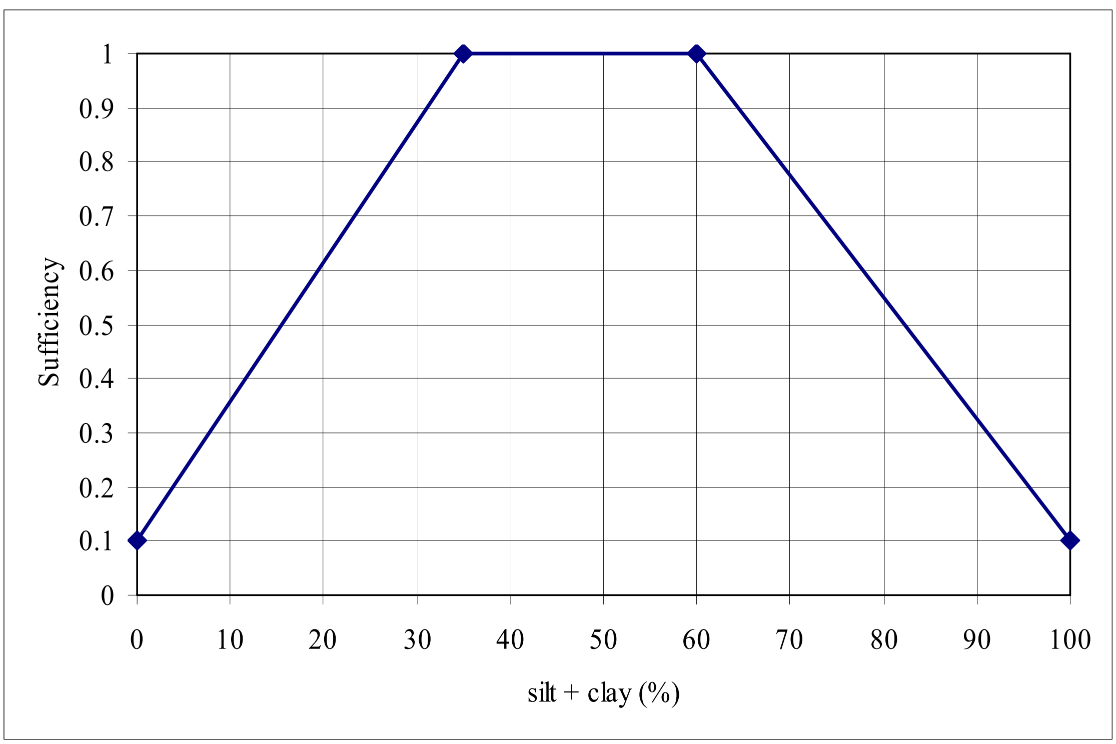

Figure V-13. Sufficiency curve for texture used for hardwoods on mine soils in the Appalachian region.

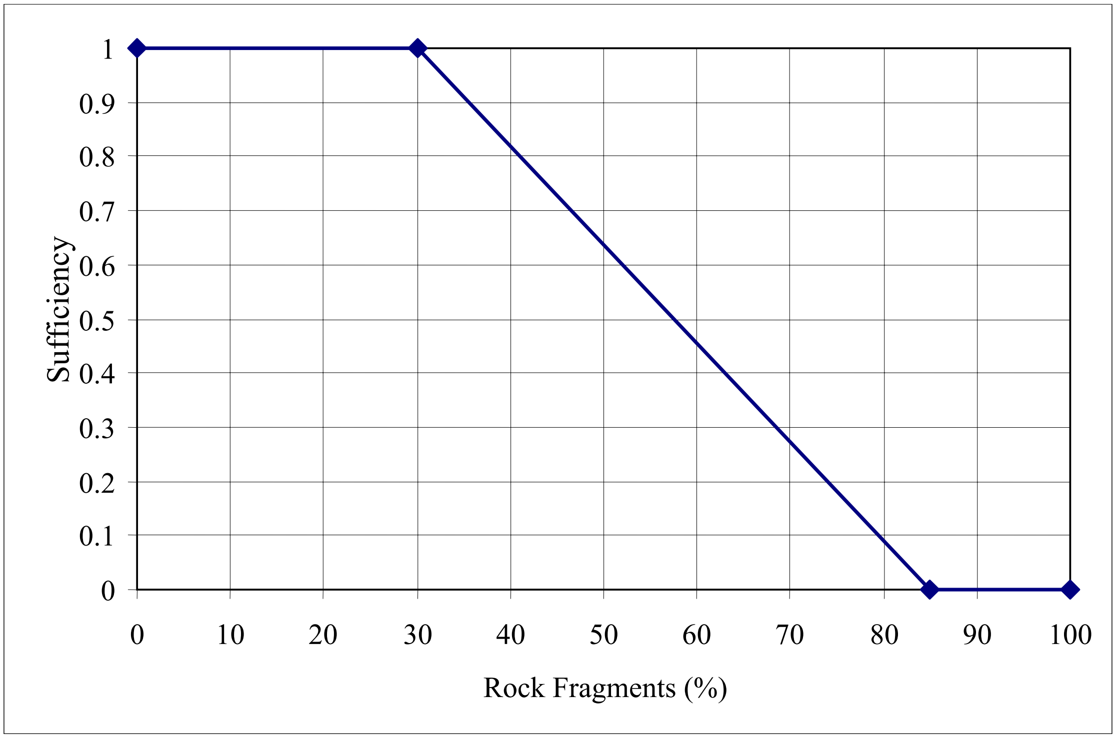

Figure V-14. Sufficiency curve for rock fragments used for hardwoods on mine soils in the Appalachian region.

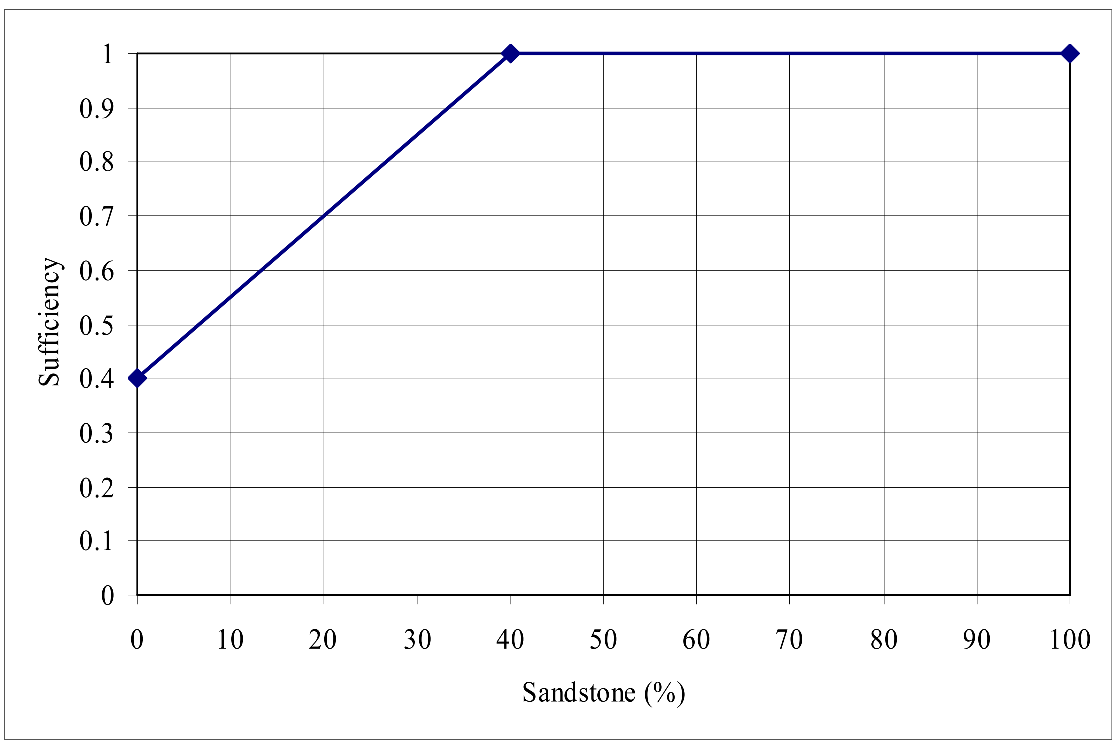

Figure V-15. Sufficiency curve for sandstone % used for hardwoods on mine soils in the Appalachian region.

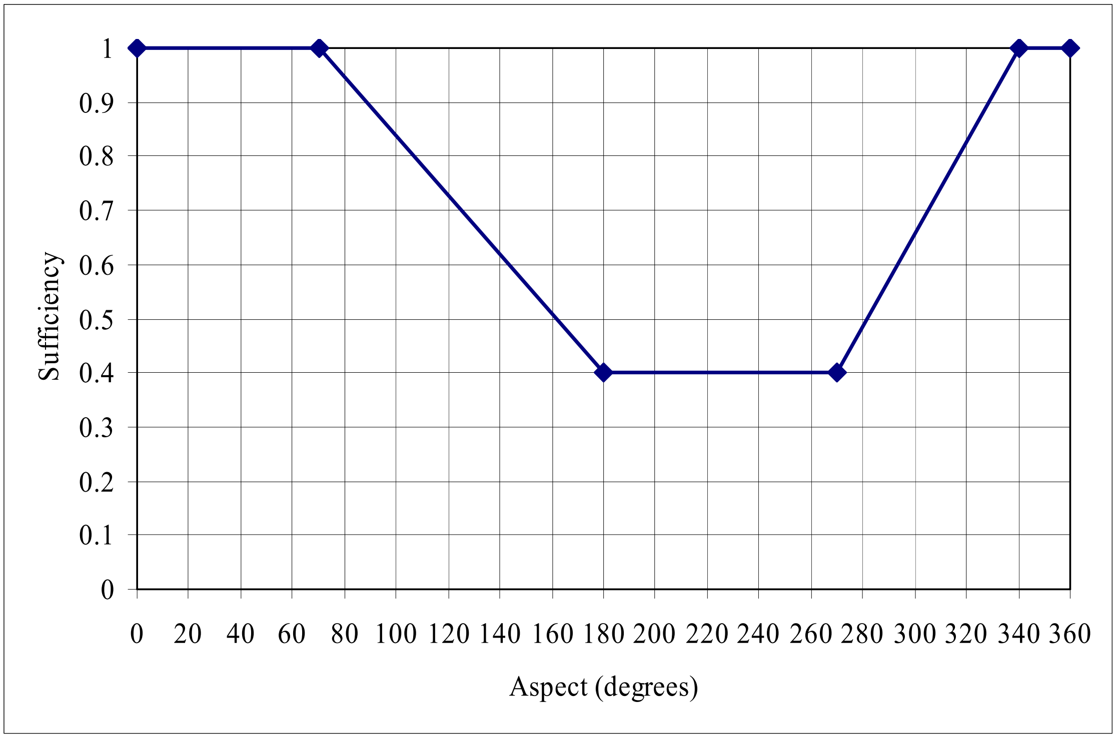

Figure V-16. Sufficiency curve for aspect used for hardwoods on mine soils in the Appalachian region.

Rapoca Study Site

In order to assess the influence of mine soil properties on different hardwood species, a selected site in Buchanan County, VA known as "Rapoca" was evaluated for the original nine soil and site properties used in the general PI model and the soil color variable. The ten properties were correlated with height growth of planted hardwood species in their third growing season (Table V-4). Multiple linear regressions was performed with the properties with the highest correlation coefficients and used to select the most influential independent variables, and recognize any multi-colinearity problems. All results are interpreted with caution due to the juvenility of the tree seedlings, competition from herbaceous ground covers during the first two growing seasons, and the differences that may occur in later growth.

Chestnut oak (*Quercus prinus* L.), red oak (*Quercus rubra* L.), and white oak (*Quercus alba* L.) are all desirable species for mast production and saw-timber production on reclaimed mines in the Appalachian region. A loam texture appears to be better than sandy loam for height growth of these species, confirming that the increased water retention of the heavier soils is likely beneficial for hardwood production. A higher pH is also correlated with red oak height growth and represents the need for better nutrient availability with this species as compared to others. Density was the only variable with any correlation to white oak height growth.

Density was the common variable found to be influential in the height and diameter growth of all other species (red maple, sugar maple, white ash, sycamore). This confirms that increased soil density continues to be the major limitation and most influential soil property on tree productivity on mined lands in the Appalachian region.

An approximate PI model for hardwood productivity in the Appalachian region follows the same form as Equation 5. A more specific model is not able to be produced due to the lack of data, but a first approximation is found in Equation 7:

$$PI_{HW} = (\text{density x texture x RF x aspect})^{1/4} \text{ x depth} \qquad \textbf{(7)}$$

Where PI_{HW} = the hardwood seedling Productivity Index, the geometric mean is taken of the product of the sufficiency of density class or D_b, texture, RF volume %, and aspect, and then multiplied by the sufficiency of depth. Soil density is expected to be the most important factor. With further research and location of more mature stands of hardwoods to measure, IFs should improve the hardwood model and develop it into a PI specific to a particular hardwood species.

Table V-4. Correlation coefficients for height growth of selected hardwood species correlated with pH; electrical conductivity (EC); rock fragments (RF); color; sandstone (SS); density; slope; aspect; and rooting depth.

	pH	EC	Texture	RF	Color	SS	Density	Slope	Aspect	Rooting Depth
Red Oak	0.40655	-0.28236	0.42348	0.53704	-0.13406	-0.1112	-0.54789	0.41411	-0.3186	-0.62112†
	0.2775	0.4616	0.256	0.136	0.731	0.7758	0.1267	0.2678	0.6013	0.0742‡
	9	9	9	9	9	9	9	9	5	9§
White Oak	-0.00739	-0.25754	0.19592	0.32633	-0.30309	0.25952	-0.52352	0.24346	-0.51659	-0.50097
	0.9849	0.5035	0.6134	0.3914	0.4279	0.5001	0.148	0.5279	0.3728	0.1695
	9	9	9	9	9	9	9	9	5	9
Chestnut Oak	0.24977	0.10518	0.40077	-0.16447	0.14514	-0.29733	0.1139	-0.12344	0.2861	0.27942
	0.5169	0.7877	0.2851	0.6724	0.7095	0.4372	0.7705	0.7517	0.6408	0.4665
	9	9	9	9	9	9	9	9	5	9
Sugar Maple	0.27775	-0.34992	-0.38906	0.22541	0.38705	0.40901	-0.48467	0.60187	-0.78635	0.04976
	0.5054	0.3955	0.3408	0.5915	0.3435	0.3143	0.2235	0.1144	0.1147	0.9069
	8	8	8	8	8	8	8	8	5	8
Red Maple	0.19192	-0.22954	0.15438	0.49422	-0.36728	-0.32169	-0.84423	0.763	-0.5919	0.23102
	0.6489	0.5845	0.7151	0.2132	0.3708	0.4372	0.0084	0.0276	0.293	0.582
	8	8	8	8	8	8	8	8	5	8
White Ash	0.45624	-0.27841	-0.08335	0.14753	0.52744	0.14847	-0.32749	0.48932	-0.16258	-0.21862
	0.2171	0.4682	0.8312	0.7049	0.1445	0.703	0.3896	0.1813	0.7939	0.572
	9	9	9	9	9	9	9	9	5	9
Sycamore	0.00166	-0.25819	0.01858	0.68024	-0.13859	0.1898	-0.84826	0.78623	-0.72763	-0.22918
	0.9966	0.5024	0.9622	0.0438	0.7221	0.6248	0.0039	0.012	0.1635	0.5531
	9	9	9	9	9	9	9	9	5	9

† Correlation coefficient.
‡ Probability |>|r.
§ Number of observations.

Mapping Project Demonstration Area

The mapping of the Flint Gap site proved the usability of the developed classification system. The system appears to adequately delineate map units based on forest productivity potential, and improves on inaccuracies associated with mine soil mapping using the current USDA soil series. Approximately 78 acres were mapped with a majority of the map units being a FSQC II or III, and rooting depth along with soil density were the most commonly recognized limitations (Table V-5). This site was a post-SMCRA mountain-top removal site, was not reclaimed to original contours, and was predominantly flat. Soil density levels were low to moderate with only very few areas having very low or high levels. RF volume % and pH were highly variable and the texture was most often loam or sandy loam.

Table V-5. Sample point data from the Flint Gap mountain top removal site in Dickenson County, Virginia. pH; electrical conductivity (EC); aspect; slope; texture; color; rock fragments (RF); sandstone (SS); density; and rooting depth were recorded and selected properties were used to calculate a white pine productivity index (PIwp), and forest site quality class (FSQC) to delineate map units. Ordination symbols are used to indicate the most limiting properties.

Point #	pH	EC	Aspect	Slope	Texture	Color	RF	SS	Density	Rooting Depth	PI_{wp}†	FSQC	Symbol‡
		dS m^{-1}	degrees	%			%	%		cm			
1	5.6	0.09	flat	§	SiL	2.5Y 4/2	20	10	low	45	0.75	II	t,d
2	7.2	0.08	flat	§	SiL	2.5Y 4/2	36	10	low	46	0.75	II	p+,t,d
3	5.5	0.08	22	18	SiL	2.5Y 4/2	30	10	low	63	0.78	II	t
4	4.9	0.08	flat	§	L	10YR 4/2	25	10	moderate	>90	0.71	II	c
5	5.4	0.06	flat	8	L	10YR 4/3	20	10	low	68	0.82	I	
6	4.5	0.03	flat	§	L	10YR 4/3	20	10	low	>75	0.85	I	
7	4.6	0.01	flat	5	L	10YR 4/4	15	10	low	>75	0.85	I	
8	6.3	0.07	flat	§	L	10YR 4/2	40	10	moderate	37	0.65	III	c,d
9	6	0.03	flat	§	SL	10YR 4/4	36	50	low	33	0.81	I	d
10	6.9	0.06	flat	9	L	2.5Y 4/3	30	10	low	45	0.79	II	p+,d
11	6.7	0.03	flat	2	SL	10YR 4/4	30	22	low	60	0.87	I	
12	5.1	0.06	flat	2	L	10YR 4/2	20	10	low	40	0.79	II	d
13	4.9	0.02	flat	§	L	10YR 4/6	10	10	very low	>75	0.95	I	
14	4.9	0.02	flat	§	L	10YR 4/6	10	10	low	40	0.79	II	d
15	5	0.02	flat	3	L	10YR 5/6	10	25	low	45	0.79	II	d
16	5.5	0.02	flat	2	L	10YR 4/4	20	10	low	72	0.82	I	
17	6	0.03	flat	§	SL	10YR 4/4	34	50	moderate	50	0.73	II	c
18	5.4	0.02	flat	3	SL	10YR 5/6	25	75	moderate	32	0.67	II	c,d
19	6	0.03	flat	5	SL	10YR 4/4	34	50	moderate	52	0.73	II	c
20	6	0.03	flat	7	SL	10YR 4/3	34	50	low	90	0.91	I	
21	5.3	0.02	flat	6	L	10YR 4/4	25	10	low	68	0.82	I	
22	5.1	0.03	flat	§	L	10YR 4/3	25	15	low	52	0.82	I	
23	5.1	0.03	flat	4	L	10YR 3/2	30	50	moderate	35	0.65	III	c,d
24	5.1	0.03	flat	8	L	10YR 4/3	30	15	low	61	0.82	I	
25	4.2	0.01	flat	4	L	10YR 4/3	30	25	moderate	36	0.65	III	c,d
26	6.2	0.07	flat	2	L	10YR 4/2	30	15	moderate	40	0.65	III	c,d
27	4.6	0.02	flat	§	L	10YR 4/4	15	15	very low	80	0.95	I	
28	5.6	0.04	flat	§	SL	10YR 4/2	40	15	low	40	0.84	I	d
29	3.6	0.01	flat	4	L	10YR 5/6	15	10	low	>100	0.85	I	p-

Table V-5. (continued)

Point #	pH	EC	Aspect	Slope	Texture	Color	RF	SS	Density	Rooting Depth	PI_{wp}†	FSQC	Symbol‡
		dS m-1	degrees	%			%	%		cm			
30	4.9	0.01	flat	§	L	10YR 4/4	30	15	low	40	0.79	II	d
31	5.5	0.03	76	20	SL	10YR 4/3	30	25	low	60	0.87	I	
32	6.4	0.03	flat	§	SL	10YR 5/4	65	90	high	10	0.43	IV	r,c,d
33	6.5	0.06	flat	§	SL	10YR 4/2	40	50	moderate	45	0.70	II	c,d
34	6.5	0.04	flat	§	SL	10YR 4/2	30	25	low	>75	0.91	I	
35	4.9	0.03	flat	§	SL	10YR 4/3	15	50	low	44	0.84	I	d
36	5.9	0.04	flat	§	SL	2.5Y 4/3	30	50	moderate	41	0.70	II	c,d
37	6	0.04	flat	§	SL	2.5Y 4/3	55	85	moderate	37	0.70	II	c,d
38	4.4	0.04	210	16	SL	10YR 4/6	30	90	low	45	0.84	I	d
39	5.9	0.03	flat	§	SL	10YR 4/4	30	75	low	>100	0.91	I	
40	6.2	0.03	flat	8	SL	10YR 4/3	60	90	moderate	21	0.64	III	r,c,d
41	4.7	0.03	flat	5	SL	10YR 5/6	30	95	low	38	0.84	I	d
42	6.7	0.06	flat	8	SL	10YR 4/4	70	90	low	17	0.75	II	r,d
43	5.7	0.01	4	16	SL	10YR 5/6	45	95	low	42	0.84	I	d
44	6.1	0.03	flat	8	SL	10YR 4/3	60	95	moderate	24	0.64	III	r,c,d
45	4.4	0.04	flat	§	L	10YR 4/4	30	30	low	>100	0.85	I	
46	6.5	0.03	flat	7	SL	10YR 4/4	40	75	moderate	34	0.67	II	c,d
47	4.7	0.02	flat	§	L	10YR 5/6	25	50	low	37	0.79	II	d

† PI_{wp}= (texture x 0.21) + (rooting depth x 0.32) + (density x 0.47); sufficiency values used for soil properties.
‡ Ordination symbol given if sufficiency of soil property was ≤0.6; c=density, d=depth, p=pH, r=rock fragments, t=texture.
§ 0-1%, nearly level.

The use of established vegetation on the site proved to be invaluable for determining map unit boundaries (Figure V-17 and V-18). This follows patterns of previous research in which vegetation was found to be a good indicator of soil properties and site quality (Daubenmire, 1976; Jones, 1991). Absence of vegetation or scattered broadleaf weeds often indicated extreme acidity, while thick, pure stands of fescue, orchard grass, and/or sweet clover indicated high pH values. Stunted, chlorotic vegetation was visible in compacted areas. A site's natural vegetation distribution begins to become naturalized and more representative of soil properties after about five years. Before this amount of time the use of vegetation as soil indicators should be done with caution.

There were areas of ponded water scattered throughout the site (Figure V-17 and V-18). The ponded water usually indicates high density, impermeable mine soil at some depth, and was not always associated with footslopes and depressional areas. Landscape position commonly used to delineate soil map unit boundaries on native soils did not work on this site and is not suspected to work on other reclaimed mined lands due to different mine reclamation strategies and drastically altered hydrology.

The ordination symbols designated to map unit boundaries can be used for management decisions on mined land (Table V-6). Symbols are given to a map unit if the sufficiency of the property is 0.6 or less. If the ordination symbol for density (c) is used, the land would benefit from a ripping or tillage treatment. The depth (d) symbol indicates the same, given that the ripping treatment used will reach the depth of the root limiting layer. A high RF content is represented by the ordination symbol (r), and may influence species selection decisions. More drought tolerant species should be planted in these map units. Ripping or tillage treatments may also improve these sites by bringing more soil fines to the surface and improving the planting bed. The ordination symbol for pH (p) is given a + or – to indicate which side of the optimal level the pH falls on. This will give experienced scientists an indication of nutrient availability in the soil, and may affect species selection for planting. The ordination symbol for texture (t) indicates that a soil is high in silt + clay content and will likely be limited by aeration. Different species are adapted to these sites and should be used in reclamation planting. An ordination symbol (s) (for sandstone) is suggested to be used on young sites for interpretations of rock type on a site. The ordination symbol (s) should be followed by a number 1 – 5; with 1 = < 20 % sandstone, 2 = 20 – 39 % sandstone, 3 = 40 – 59 % sandstone, 4 = 60 – 79 % sandstone, and 5 = 80 – 100 % sandstone. This will guide a land manager in making decisions on species selection and fertilization treatments based on known properties of different rock types and optimal soil properties for different tree species.

Table V-6. Suggested management practices for ordination symbols associated with high soil density (c), shallow rooting depth (d), high rock fragment content (r), high pH (p+), low pH (p-), and high silt + clay contents (t) to optimize forest productivity.

Ordination symbols	Management practices
c	ripping and/or tillage
d	deep ripping
r	plant drought tolerant species; ripping or tillage may improve planting bed by bringing more soil fines to the surface
p+	plant hardwoods or hybrid poplars
p-	plant acid loving pines; liming may improve the site for hardwoods
t	plant FSQC II, III, and IV hardwoods; bedding may improve aeration for pines

A variety of species may be used in reclamation planting in the Appalachian region, and selecting the proper species may have dramatic consequences on reforestation success (Burns and Honkala, 1990). The FSQC and mapping techniques can be used to determine which species should be planted in selected map units (Table V-7). Map units with an FSQC of I and sometimes II suggest that white pine, red oak, and sugar maple (*Acer saccharum* Marsh.) may be the best species to plant. Tulip poplar (*Liriodendron tulipifera* L.) has been observed to have low survival rates on mine soils and should be planted only on the very best FSQC I sites. White oak, chestnut oak, and hickory (*Carya spp.*) are more tolerant of adverse soil conditions and should be used on FSQC II and some III. Green ash (*Fraxinus pennsyvlvanica* Marsh.), white ash (*Fraxinus americana* L.), American sycamore (*Platanus occidentalis* L.), and red maple (*Acer rubrum* L.) are species that grow on a broad range of soil types and will likely grow better on all mined sites. These may be the only species that will grow on FSQC III and IV sites. Very little, if any, tree seedling survival and growth is expected on FSQC V and tree planting is not recommended. Any FSQC of II or higher will likely be improved with silvicultural treatments.

Table V-7. Suggested species selection for each forest site quality class (FSQC).

FSQC I	FSQC II	FSQC III	FSQC IV	FSQC V
t. poplar, w. pine, r. oak, s. maple				
	w. oak, c. oak, hickory			
		r. maple, sycamore, w. ash, g. ash		
				none

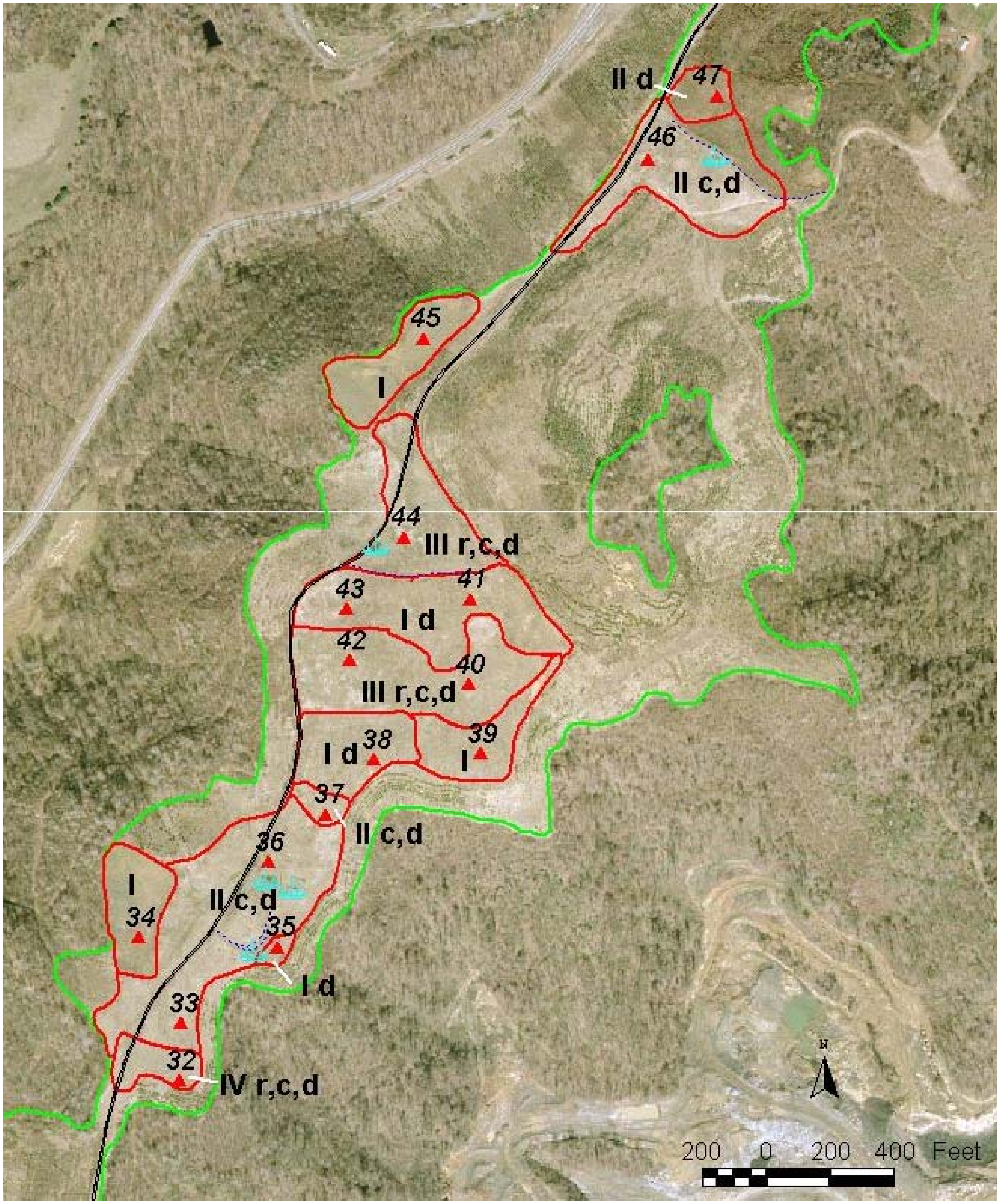

Figure V-17. Data points taken and used along with vegetation differences to delineate map units at the north end of the Flint Gap mountain top removal site.

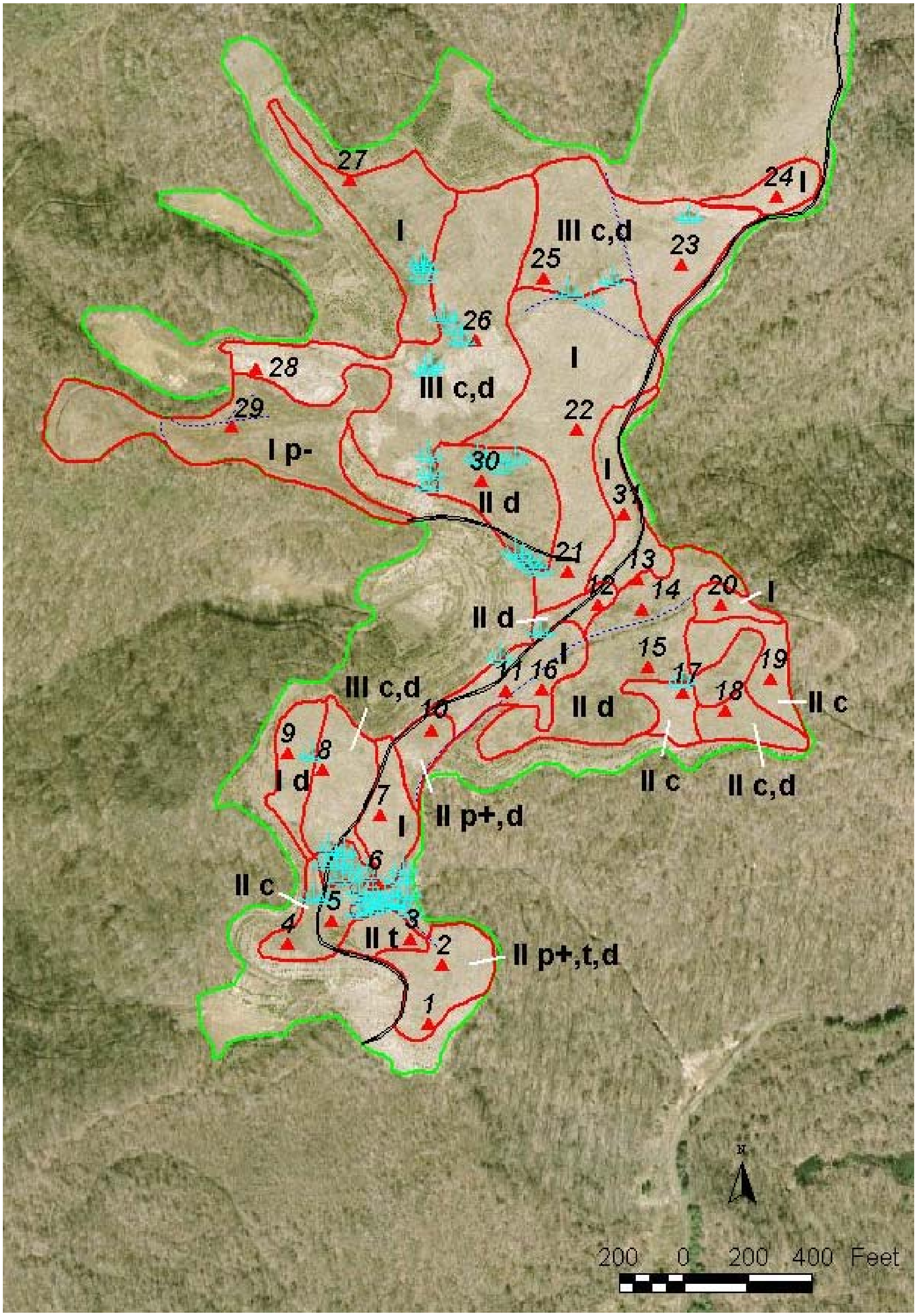

Figure V-18. Data points taken and used along with vegetation differences to delineate map units at the south end of the Flint Gap mountain top removal site.

Department of Energy Project: Site Quality

The FSQC for white pine was used to predict white pine productivity at each study site. These predictions will be evaluated later in the rotation and used to improve upon the FSQC. Only relationships between seedling survival percent and FSQC can be discussed at this time.

West Virginia

All three WV blocks were fairly uniform and resulted in a FSQC of III (Table V-8). The PI values were in the lower portion of the acceptable range for FSQC III and white pine SI will likely be near 80. However, WV3 had a white pine survival percentage of nearly twice that of WV1 and WV2 (Table IV-9). WV3 had a slightly lower pH and slightly lower RF content (Table V-8). Lower RF volume % may have improved water availability to the young seedlings and been responsible for the increased survival rates, but RF volume % are not accounted for in the FSQC model. Slightly higher sandstone percents in WV3 may have resulted in a greater portion of the total porosity being macro-pores and consequently improved aeration. Hardwood survival rates were fairly uniform across all blocks and were much higher than white pine (Table IV-9). A high density level suggests that ripping and/or tillage treatments will likely improve survival for all species. Along with high density, the high RF volume % is likely to be a limiting factor to tree growth.

Virginia

The VA blocks have more variation among blocks than do the other sites. VA1 and VA2 are identified as FSQC II, and VA3 is FSQC III (Table V-8). White pine survival percents of VA2 are much lower than the other two VA blocks (Table IV-9), likely due to high RF volume %, low sandstone percent, and high pH. Higher pH was advantageous to herbaceous vegetation growth and the competition likely increased mortality. VA3 also had high pH but was recently reclaimed and had little established competitive vegetation. Hardwood survival followed the same pattern as white pine with VA2 being the lowest, but overall hardwood survival was greater at all blocks with VA1 and VA3 having 96% and 88% survival respectively (Table IV-9). It appears that increased competition at VA2 affected survival of all species. FSQC may prove to be inaccurate for predicting forest productivity on young sites such as VA3, because most of the measured properties will quickly change within a few years of weathering.

Ohio

The OH blocks consisted of clayier textures than the other sites, and various topsoil depths. All three blocks resulted in FSQC II (Table V-8), but OH3 had a much lower survival percent for white pine and hardwoods (Table IV-9). The high pH of this block (>6) is likely responsible for tree mortality since most native species are not adapted to this range (Skousen et al., 1994). Most competitive grasses and legumes do thrive at this pH range and cause tremendous competition that likely resulted in elevated mortality levels.

White pine can compete on most soil types except for heavy clay soils (Lancaster and Leak, 1978). The OH blocks had from 20% to 27% clay in the topsoil material, which are only medium levels of clay contents for natural soils in the white pine range. However, the lack of structure in these mine soils result in reduced macro-porosity and aeration, which resembles the native soils referred to by Lancaster and Leak that have higher clay contents. Hardwoods are expected to outgrow white pine on clayey soil (Lancaster and Leak, 1978).

The compacted subsoils of all OH blocks will also affect white pine survival and growth, not only in physical root resistance, but in impeded drainage. Compacted subsoils are likely to perch water and temporarily raise the water table into the root zone. Subsurface drainage is difficult to predict in mine soils but is of extreme importance. The topography of OH1 is more undulating and will likely have better drainage than the other blocks, while OH2 is flat and has features indicating restricted surface drainage and slow percolation. White pine prefers well drained soils and cannot withstand anaerobic conditions in its root zone. Some native hardwoods are more adapted to surviving under saturated conditions and may be better adapted to these sites (Burns and Honkala, 1990). With no measure of subsurface drainage, FSQC may prove to be inappropriate for SI predictions of white pine on these OH blocks. Silvicultural operations such as deep ripping may improve drainage, and bedding can be used to raise seedlings above the local water table.

Table V-8. Measured soil properties resulted in forest site quality classes (FSQC) of II and III for white pine growth at three blocks each in Nicholas County, West Virginia (WV), Lawrence County, Ohio (OH), and Wise County, Virginia (VA). pH; electrical conductivity (EC); texture; color; rock fragments (RF); sandstone (SS); density; and rooting depth were recorded and selected properties were used to calculate a white pine productivity index (PIwp), and forest site quality class (FSQC). Ordination symbols are used to indicate the most limiting properties.

Block	pH	EC	Texture	Color	RF	SS	Density	Rooting Depth	PI_{wp}†	FSQC	symbol‡
		dS m^{-1}			weight %	%		cm			
WV-1	5.9	0.2	SL	10YR 4/2	55	10	high	36	0.55	III	c,d
WV-2	5.7	0.2	SL	10YR 4/2	55	10	high	32	0.54	III	c,d
WV-3	5.5	0.2	SL	10YR 4/2	45	15	high	34	0.54	III	c,d
OH-1	4.8	0.07	CL	10YR 5/4	10	20	low	45	0.76	II	t,d
OH-2	5.1	0.1	L	10YR 5/6	10	25	low	48	0.78	II	d
OH-3	6.1	0.2	L	2.5Y 5/3	10	25	low	42	0.77	II	d
VA-1	4.8	0.2	SL	10YR 5/3	30	80	low	32	0.80	II	d
VA-2	6.3	0.3	L	2.5Y 4/3	55	50	moderate	60	0.70	II	c
VA-3	6.5	0.4	SL	10YR 4/2	55	65	moderate	34	0.66	III	c,d

† PI_{wp}= (texture x 0.21) + (rooting depth x 0.32) + (density x 0.47); sufficiency values used for soil properties.

‡ Ordination symbol given if sufficiency of soil property was ≤0.6; c=density, d=depth, p=pH, r=rock fragments, t=texture.

SUMMARY AND CONCLUSIONS

Many chemical and physical soil properties, as well as site factors, influence tree growth and forest productivity on mined land. Successful establishment of a productive forest on reclaimed mined land can provide economic benefits through wood production, wildlife habitat, watershed protection, and carbon sequestration. The SMCRA of 1977 requires that reclaimed land be equally as, or more productive than pre-mined conditions. However, since the passage of this law, few productive forests have been established due to poor mine soil conditions, lack of incentives for mine operators to plant trees, and inability to estimate mine soil quality for forests.

FSQC ratings based on field-measured soil properties can be used to predict potential forest productivity, which will aid in forest management prescriptions. Soil texture, density, and rooting depth were the most influential properties for white pine growth on post-SMCRA reclaimed surface mines, with soil density being the most important. Other factors may be more influential on younger sites or on sites for which native hardwoods are the intended forest type. Soil pH and rock fragment content are known to be important for forest productivity on mine soils but were not found to be significant in this study. The EC and sandstone content variables will likely be useful for recently reclaimed (<5 years) mined sites. An evaluation of all soil properties in the general PI model is highly suggested.

Furthermore, the model developed is useable for mapping mined landscapes and making management decisions. Ordination symbols can be used to recognize the most limiting properties and offer suggestions of species selection and silvicultural prescriptions for land managers. Observations of vegetation type and vigor will lend much insight into determining map unit boundaries.

The PI model developed can only be validated where trees are present and therefore may not recognize soil properties that completely limit tree survival. Furthermore, Beck's growth intercept model may overestimate white pine SI, as extremely high SI estimations were observed in this study. Extrapolation of data beyond the ranges of soil properties, geographic regions, and PI values using this model may not be accurate.

Our FSQC model should aid mine operators, foresters, and landowners in determining the productive capability of mined land, in making management decisions, and in reducing the risk associated with planting trees on mined land.

CHAPTER VI
SUMMARY AND CONCLUSIONS

High energy prices and improvements in technology will continue to make surface mining in the Appalachian region a profitable industry. However, the devastating affects of mining operations are becoming more of an issue through increased environmental awareness and public concern. Treeless landscapes replace what once was a mixed hardwood forest and create watershed concerns for local communities, decrease timber production, and create unsightly, unnatural landforms. Reforestation of surface mines will return the land to its native vegetation type, increase timber and mast production, provide watershed protection, and aid in carbon sequestration.

Reclamation of surface mines in the Appalachian region often results in compacted and rocky soils that are detrimental to tree survival and growth. Reduced porosity and physical resistance to root elongation are results of compaction on mine soils. High rock fragment content will decrease rooting volume and may produce droughty conditions due to rapid drainage.

With surface mining being conducted to great depths, non-weathered material is brought to the surface and creates soil chemical properties that are foreign to native vegetation. A high pH and soluble salt level are two of the primary differences that result from weathering of these unoxidized rock types. Macro- and micro-nutrient cations are often abundant due to rapid release from the mineral structures and toxicities may occur. The decline of organic matter in mine soils often results in low phosphorus and nitrogen levels, both of which are extremely important to forest productivity.

High soil bulk density due to compaction is the major limitation in all mine soils within the Appalachian region, but measuring it is difficult. Our attempt to create field practical methods for determining mine soil bulk density was unsuccessful due to interference with rock fragments. A method separating relative classes of mine soil density is the best way to assess density levels for site quality evaluations.

Different mining techniques and underlying geology will create different mine soils throughout the Appalachian region. In our characterization of mine soils from three different sites throughout the region, we found southeast Ohio (OH) to be significantly different from the other two sites in many of its properties. The rock fragment content was much lower there, and the texture was finer. Aeration deficiencies are likely to be the main limitation to tree growth. The Southwest Virginia (VA) mine soils had higher sandstone contents than the other two sites, and based on previous research should be the most productive site. The West Virginia (WV) mine soils were composed of dark colored shale throughout the soil profile and were fragmental at various depths across the site. Droughty conditions are expected to be the major limitation to forest productivity at the WV site.

A classification system specific to mined lands in the Appalachian region will provide landowners with information needed to make forest management decisions. In our study, the forest site quality classes (FSQC) developed are a good predictor of white pine productivity on abandoned post-SMCRA surface mines in southern WV and southwest VA. Further modifications of the model are needed for sites less than five years-old, and for different hardwood species. However, soil density level is the most important soil property for forest productivity regardless of site age and species.

The usability of the FSQC system is of extreme importance so that it can be applied by a variety of users and interpreted correctly. In this study the Flint Gap site was mapped with ease and confirmed that the model was adequate for producing site quality maps. Ordination symbols will allow land managers to identify the most limiting property within a map unit and prescribe optimal silvicultural treatments. The productivity index (PI) was not found to be a good predictor of seedling survival because competing vegetation is more important than the soil properties measured in the model.

Overall, this study provides an analysis of soil properties on three different mined sites throughout the Appalachian region. These properties will be used in later studies to explain differences in tree survival and growth. The PI model developed for white pine was used to designate a FSQC to each block in the study, and will be used to improve the model at a later date. Sufficiency curves were developed for all properties used in the final PI model, and for others of known importance to tree growth on mine soils. The curves were modified for hardwood species and a PI model specific to hardwoods was hypothesized. The FSQC model produced in this study and further modifications of it will provide land managers with a much needed classification system for forest productivity on mined lands in the Appalachian region.

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VITA

Andy Thomas Jones was born February 10, 1981 to Mike and Pat Jones of Greensville County, VA. He is the younger brother of Kelly Jones and older brother of Casey and Travis Jones. Andy grew up in Purdy, VA and attended Greensville County High School. He continued his education at Virginia Tech where he received a B.S. degree in Crop and Soil Environmental Sciences and a minor in Forestry. He remained at Virginia Tech to complete a M.S. degree in the Crop and Soil Environmental Sciences department while working closely with the Forestry department on research with surface mine reclamation, mine soil classification, and reforestation of surface mines.

APPENDICES

for

Site Quality Classification for Mapping Forest Productivity Potential on Mine Soils in the Appalachian Coalfield Region

Appendices

Appendix 1a. pH, electrical conductivity (EC), carbon (C), and nitrogen (N) analysis for composite samples by plot, block, and site.

Site	Block	Plot	Sample	pH	EC	C	N	C:N
			†		dS m^{-1}	-------%------		
WV	1	1	0	5.6	0.3	38785	3191	12
WV	1	1	1	6.3	0.1	18400	1125	15
WV	1	2	0	5.9	0.2	46732	2904	16
WV	1	2	1	6.7	0.1	28572	1608	16
WV	1	3	0	5.9	0.2	34000	2741	12
WV	1	3	1	6.9	0.1	18831	1202	15
WV	1	4	0	5.8	0.3	50359	3803	13
WV	1	4	1	6.9	0.1	23103	1268	18
WV	1	5	0	5.8	0.2	41595	2867	14
WV	1	5	1	6.6	0.1	15820	1065	15
WV	1	6	0	6.0	0.2	27439	2267	12
WV	1	6	1	6.5	0.1	13764	1038	13
WV	1	7	0	6.0	0.1	29097	2635	12
WV	1	7	1	6.7	0.1	18198	1225	15
WV	1	8	0	6.1	0.2	27749	2081	13
WV	1	8	1	7.0	0.1	15256	1076	14
WV	1	9	0	6.1	0.2	33632	2537	13
WV	1	9	1	7.0	0.1	18087	1230	15
WV	2	1	0	5.7	0.2	27387	2202	13
WV	2	1	1	5.0	0.2	11505	934	12
WV	2	2	0	5.6	0.2	26368	2144	12
WV	2	2	1	6.2	0.1	14704	1039	14
WV	2	3	0	5.6	0.2	25875	2108	12
WV	2	3	1	6.2	0.1	12433	959	13
WV	2	4	0	5.9	0.3	33758	2806	12
WV	2	4	1	6.8	0.1	13120	998	13
WV	2	5	0	5.7	0.3	26345	2432	9
WV	2	5	1	5.9	0.1	13189	996	13
WV	2	6	0	5.8	0.2	26410	2203	12
WV	2	6	1	6.2	0.1	13203	1074	12
WV	2	7	0	5.7	0.3	38347	3366	11
WV	2	7	1	5.9	0.1	11123	853	13
WV	2	8	0	5.7	0.2	38527	3182	12
WV	2	8	1	5.6	0.1	15119	1161	13
WV	2	9	0	5.8	0.2	32353	2737	12
WV	2	9	1	6.4	0.1	14260	1063	13

Appendix 1a. (continued)

Site	Block	Plot	Sample †	pH	EC dS m^{-1}	C ----------mg kg^{-1}	N --------	C:N
WV	3	1	0	5.2	0.3	30200	2413	13
WV	3	1	1	5.1	0.1	12946	1058	12
WV	3	2	0	5.7	0.2	41768	3288	13
WV	3	2	1	5.9	0.1	16497	1095	15
WV	3	3	0	5.5	0.2	37908	3105	13
WV	3	3	1	5.8	0.1	14743	954	15
WV	3	4	0	5.8	0.3	34861	2980	12
WV	3	4	1	5.4	0.1	10237	885	12
WV	3	5	0	5.7	0.2	32934	2776	12
WV	3	5	1	5.9	0.1	12025	1017	12
WV	3	6	0	5.5	0.2	27631	2376	12
WV	3	6	1	6.0	0.1	11812	977	12
WV	3	7	0	5.5	0.1	38803	2821	14
WV	3	7	1	6.6	0.1	17518	1164	15
WV	3	8	0	5.3	0.2	36164	2827	13
WV	3	8	1	6.0	0.1	13606	962	14
WV	3	9	0	5.5	0.2	33811	2664	13
WV	3	9	1	6.1	0.1	12409	893	14
OH	1	1	0	5.1	0.1	15967	1204	13
OH	1	1	2	7.5	0.2	5502	518	11
OH	1	2	0	5.0	0.0	15320	1157	13
OH	1	2	2	5.5	0.1	3298	365	9
OH	1	3	0	5.0	0.0	15951	1303	12
OH	1	3	2	6.6	0.2	3008	404	7
OH	1	4	0	4.7	0.1	17233	1293	13
OH	1	4	2	6.2	0.7	5307	439	12
OH	1	5	0	4.7	0.0	12696	1030	12
OH	1	5	2	7.3	0.2	8200	471	18
OH	1	6	0	4.8	0.1	16693	1431	12
OH	1	6	2	7.2	0.4	25695	595	42
OH	1	7	0	5.2	0.2	12804	1104	12
OH	1	7	2	7.8	0.2	9420	499	19
OH	1	8	0	4.8	0.0	17608	1426	12
OH	1	8	2	6.8	0.4	14790	569	24
OH	1	9	0	4.7	0.0	18286	1442	13
OH	1	9	2	7.0	0.1	4868	458	10
OH	2	1	0	5.2	0.1	15715	1213	13
OH	2	1	2	6.0	0.4	4871	427	11

Appendix 1a. (continued)

Site	Block	Plot	Sample	pH	EC	C	N	C:N
			†		dS m^{-1}	-------%------		
OH	2	2	0	5.0	0.1	13918	1167	12
OH	2	2	2	6.6	0.4	7350	443	15
OH	2	3	0	4.9	0.2	20712	1654	12
OH	2	3	2	5.6	1.0	4058	395	10
OH	2	4	0	5.0	0.1	16318	1272	13
OH	2	4	2	6.0	1.1	4413	415	11
OH	2	5	0	5.2	0.1	12515	1046	12
OH	2	5	2	5.5	0.6	4499	458	10
OH	2	6	0	5.9	0.1	11715	936	13
OH	2	6	2	6.0	0.3	5019	474	10
OH	2	7	0	5.2	0.1	12092	1059	11
OH	2	7	2	7.0	0.5	8957	570	15
OH	2	8	0	5.0	0.1	12830	1090	12
OH	2	8	2	6.4	0.5	32421	950	21
OH	2	9	0	5.3	0.1	12110	1013	12
OH	2	9	2	6.4	0.6	5948	492	11
OH	3	1	0	6.4	0.1	16285	1313	12
OH	3	1	2	6.8	0.4	5016	471	11
OH	3	2	0	5.8	0.1	16160	1240	13
OH	3	2	2	7.0	0.5	6631	476	14
OH	3	3	0	6.5	0.1	18702	1352	14
OH	3	3	2	7.1	1.0	7087	461	15
OH	3	4	0	6.0	0.3	12870	1043	12
OH	3	4	1	6.2	0.2	‡	‡	‡
OH	3	4	2	7.4	0.2	5069	444	12
OH	3	5	0	6.1	0.1	13802	1162	12
OH	3	5	1	6.4	0.5	‡	‡	‡
OH	3	5	2	7.0	0.5	3797	363	10
OH	3	6	0	6.5	0.1	16811	1421	12
OH	3	6	2	6.5	0.3	3488	384	9
OH	3	7	0	6.3	0.1	12719	1088	12
OH	3	7	2	6.2	1.2	5469	436	12
OH	3	8	0	5.5	0.1	12162	1009	12
OH	3	8	2	6.6	0.2	4592	438	10
OH	3	9	0	5.4	0.1	12133	947	13
OH	3	9	1	7.0	0.3	‡	‡	‡
OH	3	9	2	7.5	0.5	3369	415	8

Appendix 1a. (continued)

Site	Block	Plot	Sample	pH	EC	C	N	C:N
			†		dS m^{-1}	-------%------		
VA	1	1	0	4.4	0.3	14237	755	19
VA	1	1	1	4.9	0.4	12985	622	22
VA	1	2	0	4.6	0.1	9454	431	21
VA	1	2	2	7.1	0.2	18917	495	39
VA	1	3	0	4.6	0.1	6567	458	14
VA	1	3	2	7.4	0.2	27189	621	42
VA	1	4	0	4.8	0.1	7671	539	14
VA	1	4	2	7.3	0.2	19886	615	32
VA	1	5	0	4.8	0.2	13472	638	21
VA	1	5	1	5.1	0.3	‡	‡	‡
VA	1	5	2	5.9	0.2	19896	651	29
VA	1	6	0	4.5	0.2	11499	574	19
VA	1	6	1	4.4	0.2	‡	‡	‡
VA	1	6	2	5.8	0.3	12992	545	24
VA	1	7	0	5.2	0.1	10769	600	18
VA	1	7	2	7.0	0.2	17683	583	31
VA	1	8	0	4.9	0.2	15481	667	23
VA	1	8	2	6.8	0.1	15012	612	24
VA	1	9	0	5.0	0.2	14539	632	23
VA	1	9	1	5.4	0.4	13681	543	25
						0	0	
VA	2	1	0	6.1	0.3	18421	783	24
VA	2	1	1	6.0	0.5	‡	‡	‡
VA	2	1	2	7.4	0.3	23146	703	32
VA	2	2	0	6.1	0.3	30330	1236	24
VA	2	2	2	7.7	0.3	35501	948	36
VA	2	3	0	6.4	0.3	27103	1102	25
VA	2	3	1	7.1	0.3	‡	‡	‡
VA	2	3	2	7.5	0.3	35794	901	38
VA	2	4	0	6.2	0.6	27236	1222	22
VA	2	4	2	7.6	0.3	27704	973	28
VA	2	5	0	6.3	0.2	25351	978	26
VA	2	5	2	7.8	0.2	27856	727	39
VA	2	6	0	6.1	0.2	23286	982	24
VA	2	6	2	7.7	0.2	25306	712	35
VA	2	7	0	6.8	0.2	21844	796	28
VA	2	7	2	7.6	0.3	31943	826	38
VA	2	8	0	7.0	0.3	19679	762	26
VA	2	8	1	7.2	0.6	‡	‡	‡
VA	2	8	2	7.3	0.6	21162	622	32

Appendix 1a. (continued)

Site	Block	Plot	Sample	pH	EC	C	N	C:N
			†		dS m⁻¹	-------%------		
VA	2	9	0	5.8	0.2	25191	1096	23
VA	2	9	2	7.5	0.2	32944	782	42
VA	3	1	0	5.3	0.3	9956	399	25
VA	3	1	1	5.2	0.2	7028	325	22
VA	3	2	0	5.9	0.3	9714	426	22
VA	3	2	3	5.9	0.2	8092	356	21
VA	3	3	0	6.5	0.3	18551	682	27
VA	3	3	1	6.2	0.3	14459	608	23
VA	3	4	0	6.6	0.4	20846	634	33
VA	3	4	1	6.6	0.3	18797	572	32
VA	3	5	0	7.0	0.4	27196	899	30
VA	3	5	1	7.0	0.3	19920	708	28
VA	3	6	0	6.6	0.5	22872	748	29
VA	3	6	3	6.8	0.3	16256	576	28
VA	3	7	0	6.8	0.4	26143	851	29
VA	3	7	1	6.4	0.4	22457	742	29
VA	3	8	0	7.0	0.4	23773	726	33
VA	3	8	3	6.9	0.2	23271	644	35
VA	3	9	0	6.3	0.4	27116	745	35
VA	3	9	3	5.9	0.3	17097	511	33

† 0 = 0 - 10 cm, 1 = 10 - 30 cm, 2 = subsoil, 3 = 10 - 30 cm + subsoil.

‡ No data available.

Appendix 1b. Exchangeable magnesium (Mg), potassium (P), calcium (Ca), manganese (Mn), sodium (Na), aluminum (Al), cation exchange capacity (CEC), and base saturation (BS) analysis for composite samples by plot, block, and site.

Site	Block	Plot	Sample	Mg	K	Ca	Mn	Na	Al	CEC	BS
			†	-----------------------mg kg^{-1}				----------------------	------$cmol_c$ kg^{-1}------		%
WV	1	1	0	423	242	1054	23	‡	0.1	9	99
WV	1	1	1	290	81	715	5	‡	0.0	6	100
WV	1	2	0	355	133	953	11	‡	0.1	8	99
WV	1	2	1	295	91	801	5	‡	0.0	7	100
WV	1	3	0	417	155	1075	16	‡	0.1	9	99
WV	1	3	1	350	86	1009	2	‡	0.0	8	100
WV	1	4	0	448	194	1327	29	‡	0.1	11	99
WV	1	4	1	291	78	877	4	‡	0.0	7	100
WV	1	5	0	389	155	1063	22	‡	0.1	9	99
WV	1	5	1	251	76	681	5	‡	0.0	6	100
WV	1	6	0	397	148	960	16	‡	0.1	9	99
WV	1	6	1	284	73	637	4	‡	0.0	6	100
WV	1	7	0	376	133	922	21	‡	0.2	8	98
WV	1	7	1	295	81	764	3	‡	0.1	6	99
WV	1	8	0	357	170	949	17	‡	0.1	8	99
WV	1	8	1	255	71	924	3	‡	§	7	100
WV	1	9	0	333	143	927	23	‡	0.1	8	99
WV	1	9	1	257	73	927	4	‡	§	7	100
WV	2	1	0	416	164	915	12	‡	0.2	9	98
WV	2	1	1	326	84	554	12	‡	0.4	6	94
WV	2	2	0	395	151	878	19	‡	0.2	8	98
WV	2	2	1	344	110	641	6	‡	0.1	6	99

Appendix 1b. (continued)

Site	Block	Plot	Sample	Mg	K	Ca	Mn	Na	Al	CEC	BS
			†	----------------------mg kg^{-1}---------------------					------$cmol_c$ kg^{-1}------		%
WV	2	3	0	384	120	824	21	‡	0.2	8	97
WV	2	3	1	314	89	613	5	‡	0.1	6	99
WV	2	4	0	439	191	993	11	‡	0.2	9	98
WV	2	4	1	313	111	692	4	‡	0.1	6	99
WV	2	5	0	417	153	1001	18	‡	0.2	9	98
WV	2	5	1	309	65	527	10	‡	0.2	5	97
WV	2	6	0	381	135	851	14	‡	0.1	8	99
WV	2	6	1	329	95	584	6	‡	0.0	6	100
WV	2	7	0	408	173	936	16	‡	0.2	9	98
WV	2	7	1	293	73	454	7	‡	0.0	5	100
WV	2	8	0	414	195	917	16	‡	0.2	9	98
WV	2	8	1	318	114	652	13	‡	0.1	6	99
WV	2	9	0	364	108	799	11	‡	0.2	7	98
WV	2	9	1	326	80	612	6	‡	0.0	6	100
WV	3	1	0	286	161	696	16	‡	0.3	6	96
WV	3	1	1	259	79	573	8	‡	0.7	6	89
WV	3	2	0	415	154	1021	18	‡	0.2	9	98
WV	3	2	1	307	83	625	9	‡	0.0	6	100
WV	3	3	0	387	143	843	24	‡	0.2	8	98
WV	3	3	1	329	70	531	10	‡	0.1	6	99
WV	3	4	0	437	206	939	28	‡	0.3	9	97
WV	3	4	1	271	62	414	16	‡	0.3	5	95
WV	3	5	0	366	126	857	14	‡	0.2	8	97
WV	3	5	1	322	74	622	8	‡	0.1	6	99

Appendix 1b. (continued)

Site	Block	Plot	Sample †	Mg	K	Ca	Mn	Na	Al	CEC	BS
				------------------------mg kg^{-1}				----------------------	------$cmol_c$ kg^{-1}	------	%
WV	3	6	0	330	175	792	27	‡	0.3	7	97
WV	3	6	1	317	88	625	8	‡	0.1	6	98
WV	3	7	0	313	191	857	20	‡	0.3	8	96
WV	3	7	1	297	93	931	4	‡	0.1	7	99
WV	3	8	0	346	182	866	26	‡	0.4	8	96
WV	3	8	1	309	80	656	17	‡	0.1	6	98
WV	3	9	0	336	176	749	25	‡	0.4	7	95
WV	3	9	1	277	70	533	7	‡	0.1	5	99
OH	1	1	0	234	125	1648	9	‡	0.6	11	95
OH	1	1	2	266	86	1802	2	‡	§	11	100
OH	1	2	0	241	133	1309	18	‡	1.1	10	89
OH	1	2	2	345	124	1839	4	‡	0.1	12	100
OH	1	3	0	284	132	1406	17	‡	0.9	11	91
OH	1	3	2	304	120	1521	2	‡	0.0	10	100
OH	1	4	0	222	132	1234	20	‡	1.5	10	85
OH	1	4	2	318	132	3006	6	‡	0.1	18	100
OH	1	5	0	172	123	841	17	‡	1.7	8	78
OH	1	5	2	252	101	3186	4	‡	§	18	100
OH	1	6	0	291	137	1154	16	‡	1.5	10	85
OH	1	6	2	210	90	3954	4	‡	§	22	100
OH	1	7	0	212	114	1138	13	‡	0.4	8	95
OH	1	7	2	226	99	3582	4	‡	§	20	100
OH	1	8	0	247	149	1069	29	‡	1.8	10	81
OH	1	8	2	236	102	3856	10	‡	0.3	22	99

Appendix 1b. (continued)

Site	Block	Plot	Sample	Mg	K	Ca	Mn	Na	Al	CEC	BS
			†	----------------------mg kg^{-1}				---------------------	------$cmol_c$ kg^{-1}	------	%
OH	1	9	0	272	148	824	17	‡	§	7	100
OH	1	9	2	260	99	1958	3	‡	§	12	100
OH	2	1	0	169	109	666	27	‡	0.9	6	85
OH	2	1	2	268	67	1359	11	‡	0.1	9	99
OH	2	2	0	187	126	699	29	‡	0.9	6	86
OH	2	2	2	228	64	1853	3	‡	0.2	11	99
OH	2	3	0	236	112	1046	24	‡	0.9	8	89
OH	2	3	2	226	60	1225	3	‡	0.0	8	100
OH	2	4	0	277	127	1096	25	‡	§	8	100
OH	2	4	2	322	63	1855	6	‡	0.0	12	100
OH	2	5	0	350	119	936	20	‡	0.5	8	95
OH	2	5	2	330	78	2097	5	‡	0.1	13	99
OH	2	6	0	201	124	904	6	‡	0.1	7	98
OH	2	6	2	185	93	2183	2	‡	0.1	13	99
OH	2	7	0	357	99	1241	22	‡	0.5	10	95
OH	2	7	2	312	110	2370	2	‡	§	15	100
OH	2	8	0	290	105	1041	31	‡	0.7	9	92
OH	2	8	2	226	101	4102	4	‡	0.1	23	100
OH	2	9	0	230	105	1017	16	‡	0.3	7	97
OH	2	9	2	236	101	4405	3	‡	0.2	14	99
OH	3	1	0	206	143	1781	5	‡	0.1	11	100
OH	3	1	2	234	104	1633	2	‡	§	10	100
OH	3	2	0	225	148	1437	7	‡	0.1	9	99

Appendix 1b. (continued)

Site	Block	Plot	Sample †	Mg	K	Ca	Mn	Na	Al	CEC	BS
				------------------------mg kg^{-1}				----------------------	------cmol$_c$ kg^{-1}	------	%
OH	3	2	2	297	114	2731	2	‡	§	16	100
OH	3	3	0	197	126	1657	5	‡	0.1	10	100
OH	3	3	2	334	123	3419	2	‡	§	20	100
OH	3	4	0	176	160	1126	6	‡	0.1	8	99
OH	3	4	1	192	98	1804	3	‡	0.1	11	100
OH	3	4	2	251	96	2628	2	‡	§	15	100
OH	3	5	0	212	126	1232	5	‡	0.0	8	100
OH	3	5	1	278	101	2095	6	‡	0.0	13	100
OH	3	5	2	405	108	2265	1	‡	§	15	100
OH	3	6	0	236	156	1496	4	‡	0.0	10	100
OH	3	6	2	232	100	1583	2	‡	0.0	10	100
OH	3	7	0	295	153	1557	5	‡	0.1	11	100
OH	3	7	2	334	94	2606	3	‡	0.1	16	100
OH	3	8	0	219	181	1103	12	‡	0.4	8	96
OH	3	8	2	252	86	1368	1	‡	0.1	9	99
OH	3	9	0	173	118	910	9	‡	0.2	6	98
OH	3	9	1	307	83	1484	1	‡	§	10	100
OH	3	9	2	404	100	2158	1	‡	§	14	100
VA	1	1	0	284	107	634	53	15	0.7	6	90
VA	1	1	1	304	77	822	32	15	0.2	7	97
VA	1	2	0	167	79	402	35	9	0.9	4	81
VA	1	2	2	121	65	1115	5	10	§	7	100
VA	1	3	0	168	110	322	41	7	1.5	5	69
VA	1	3	2	122	56	927	5	8	§	6	100

Appendix 1b. (continued)

Site	Block	Plot	Sample	Mg	K	Ca	Mn	Na	Al	CEC	BS
			†	-----------------------mg kg^{-1}-----------------------					------cmol$_c$ kg^{-1}------		%
VA	1	4	0	182	124	421	29	6	1.0	5	80
VA	1	4	2	172	63	888	3	7	§	6	100
VA	1	5	0	238	78	616	35	7	0.4	6	94
VA	1	5	1	265	67	778	18	8	0.4	7	95
VA	1	5	2	145	54	858	3	5	0.0	6	100
VA	1	6	0	234	77	451	54	5	1.7	6	73
VA	1	6	1	215	73	423	52	6	1.6	6	73
VA	1	6	2	215	65	855	14	7	0.1	6	99
VA	1	7	0	232	71	680	36	6	0.3	6	95
VA	1	7	2	136	53	947	4	8	§	6	100
VA	1	8	0	228	67	589	39	7	0.5	6	91
VA	1	8	2	129	52	867	3	6	0.1	6	99
VA	1	9	0	244	56	629	30	8	0.2	6	96
VA	1	9	1	336	55	917	13	14	0.1	8	99
VA	2	1	0	230	70	742	7	6	0.0	6	100
VA	2	1	1	272	70	1188	3	8	0.0	8	100
VA	2	1	2	208	88	952	4	10	§	7	100
VA	2	2	0	237	76	810	10	6	0.0	6	100
VA	2	2	2	204	72	1083	5	7	§	7	100
VA	2	3	0	249	116	880	13	4	0.1	7	99
VA	2	3	1	226	61	892	2	7	§	6	100
VA	2	3	2	233	95	933	4	9	§	7	100
VA	2	4	0	333	95	965	13	12	0.1	8	99
VA	2	4	2	271	106	965	4	10	§	7	100

Appendix 1b. (continued)

Site	Block	Plot	Sample	Mg	K	Ca	Mn	Na	Al	CEC	BS
			†	--------mg kg^{-1}--------					------$cmol_c$ kg^{-1}------		%
VA	2	5	0	240	84	737	10	10	0.1	6	99
VA	2	5	2	208	72	958	4	7	§	7	100
VA	2	6	0	250	78	802	10	7	0.0	6	100
VA	2	6	2	215	76	1169	5	9	§	8	100
VA	2	7	0	229	64	967	6	9	0.1	7	99
VA	2	7	2	247	82	1072	4	11	§	8	100
VA	2	8	0	198	70	901	4	8	§	6	100
VA	2	8	1	225	51	1241	1	13	§	8	100
VA	2	8	2	302	96	1458	5	16	§	10	100
VA	2	9	0	306	103	821	23	7	0.0	7	100
VA	2	9	2	207	69	957	4	9	§	7	100
VA	3	1	0	226	61	286	28	18	0.1	4	99
VA	3	1	1	188	54	184	22	14	0.2	3	93
VA	3	2	0	234	73	386	11	13	0.0	4	100
VA	3	2	3	218	59	349	12	16	0.0	4	100
VA	3	3	0	262	78	545	4	14	0.0	5	100
VA	3	3	1	239	75	463	11	14	0.0	5	100
VA	3	4	0	248	73	579	5	16	0.0	5	100
VA	3	4	1	224	70	529	2	16	0.0	5	100
VA	3	5	0	275	104	721	4	11	§	6	100
VA	3	5	1	227	76	497	2	11	§	5	100
VA	3	6	0	286	96	662	8	14	0.0	6	100
VA	3	6	3	237	69	506	3	10	0.0	5	100
VA	3	7	0	254	94	612	4	11	§	5	100

Appendix 1b. (continued)

Site	Block	Plot	Sample	Mg	K	Ca	Mn	Na	Al	CEC	BS
			†	-----------------------mg kg^{-1}				----------------------	------$cmol_c$ kg^{-1}	------	%
VA	3	7	1	269	79	584	9	14	0.0	5	100
VA	3	8	0	262	87	666	3	12	§	6	100
VA	3	8	3	233	65	537	3	14	§	5	100
VA	3	9	0	272	79	625	10	17	0.0	6	100
VA	3	9	3	222	66	412	23	14	0.0	4	100

† 0 = 0 - 10 cm, 1 = 10 - 30 cm, 2 = subsoil, 3 = 10 - 30 cm + subsoil.

‡ No measurements taken due site conditions.

§ No readings taken at pH levels > 6.5.

Appendix 1c. Extractable phosphorus (P), zinc (Zn), copper (Cu), iron (Fe), and boron (B) analysis for composite samples by plot, block, and site.

Site	Block	Plot	Sample	P	Zn	Cu	Fe	B
			†	-------------------	mg kg^{-1}	------------------		
WV	1	1	0	21.4	2.9	1.1	33.0	0.3
WV	1	1	1	6.5	2.6	2.1	39.2	0.2
WV	1	2	0	31.1	3.5	1.5	35.2	0.3
WV	1	2	1	7.8	2.9	2.5	42.9	0.2
WV	1	3	0	23.0	3.4	1.8	39.0	0.3
WV	1	3	1	3.6	2.6	1.9	44.3	0.2
WV	1	4	0	26.6	3.7	1.1	34.4	0.3
WV	1	4	1	18.2	4.1	2.0	40.7	0.2
WV	1	5	0	14.4	3.3	1.5	35.3	0.3
WV	1	5	1	6.0	1.9	1.6	37.8	0.2
WV	1	6	0	16.1	2.6	1.3	38.1	0.2
WV	1	6	1	4.0	2.6	1.9	42.8	0.2
WV	1	7	0	15.7	3.0	1.6	41.9	0.3
WV	1	7	1	7.1	2.2	1.7	46.7	0.2
WV	1	8	0	17.5	2.4	1.4	41.9	0.3
WV	1	8	1	7.0	1.9	1.7	43.1	0.2
WV	1	9	0	15.4	3.2	1.7	38.8	0.3
WV	1	9	1	3.9	2.9	2.0	42.6	0.2
WV	2	1	0	19.8	3.4	1.4	53.5	0.4
WV	2	1	1	7.0	2.6	1.7	68.8	0.2
WV	2	2	0	16.1	3.2	1.6	50.7	0.2
WV	2	2	1	7.0	2.7	1.8	49.7	0.2
WV	2	3	0	21.4	3.2	1.4	53.1	0.2
WV	2	3	1	4.6	2.7	1.5	54.9	0.2
WV	2	4	0	22.3	3.4	1.2	44.2	0.3
WV	2	4	1	6.3	2.6	1.9	48.9	0.2
WV	2	5	0	24.0	3.9	1.4	48.0	0.3
WV	2	5	1	11.4	3.0	2.0	56.1	0.2
WV	2	6	0	19.4	2.7	1.3	50.2	0.2
WV	2	6	1	6.9	2.6	1.6	48.3	0.2
WV	2	7	0	26.3	4.8	1.2	44.4	0.3
WV	2	7	1	‡	3.1	2.5	48.0	0.1
WV	2	8	0	25.4	3.9	1.2	53.6	0.2
WV	2	8	1	6.0	3.0	2.0	57.4	0.2
WV	2	9	0	12.5	3.1	1.5	48.6	0.2
WV	2	9	1	4.2	2.7	2.0	48.8	0.2

Appendix 1c. (continued)

Site	Block	Plot	Sample	P	Zn	Cu	Fe	B
			†	-------------------mg kg^{-1}	------------------			
WV	3	1	0	20.2	3.1	1.9	55.3	0.2
WV	3	1	1	‡	3.1	2.7	52.5	0.1
WV	3	2	0	20.9	4.1	1.2	34.7	0.3
WV	3	2	1	7.3	3.0	2.3	50.0	0.1
WV	3	3	0	3.5	4.2	1.3	36.2	0.2
WV	3	3	1	4.4	2.7	2.3	42.8	0.1
WV	3	4	0	27.2	4.7	1.8	37.6	0.2
WV	3	4	1	7.1	2.0	2.3	36.3	0.1
WV	3	6	0	16.6	3.0	1.3	40.7	0.2
WV	3	6	1	3.7	2.6	2.5	43.2	0.1
WV	3	7	0	18.9	3.3	1.6	43.7	0.2
WV	3	7	1	‡	2.9	2.3	45.1	0.2
WV	3	8	0	19.4	3.8	1.6	53.6	0.2
WV	3	8	1	5.0	2.1	2.1	42.4	0.1
WV	3	9	0	22.3	3.6	1.6	53.2	0.2
WV	3	9	1	2.9	2.2	2.0	41.8	0.1
OH	1	1	0	5.0	1.5	1.7	37.2	0.3
OH	1	1	2	‡	3.3	3.0	57.8	0.8
OH	1	2	0	10.3	1.4	1.5	26.5	0.2
OH	1	2	2	‡	3.3	3.2	68.3	0.9
OH	1	3	0	6.6	1.7	1.8	49.5	0.2
OH	1	3	2	‡	3.8	4.0	98.8	1.1
OH	1	4	0	6.9	1.3	1.4	49.7	0.2
OH	1	4	2	‡	4.3	3.0	71.3	1.0
OH	1	5	0	12.0	1.4	1.3	47.7	0.2
OH	1	5	2	‡	2.0	0.8	17.0	0.7
OH	1	6	0	10.2	1.8	1.1	40.7	0.2
OH	1	6	2	‡	0.2	0.1	1.5	0.4
OH	1	7	0	12.3	1.4	1.3	37.2	0.2
OH	1	7	2	‡	1.5	0.3	5.9	0.8
OH	1	8	0	13.4	1.7	1.8	44.7	0.2
OH	1	8	2	‡	1.6	0.2	6.5	0.6
OH	1	9	0	16.0	1.5	1.3	37.6	0.2
OH	1	9	2	‡	2.9	1.8	63.7	0.6
OH	2	1	0	8.6	1.3	0.9	28.0	0.2
OH	2	1	2	‡	2.4	2.2	58.1	0.4

Appendix 1c. (continued)

Site	Block	Plot	Sample	P	Zn	Cu	Fe	B
			†	--------------------mg kg^{-1}-------------------				
OH	2	2	0	10.4	1.5	0.9	34.1	0.2
OH	2	2	2	2.2	2.2	1.8	54.1	0.6
OH	2	3	0	10.0	2.1	2.1	30.9	0.2
OH	2	3	2	‡	2.3	2.2	62.2	0.3
OH	2	4	0	10.1	1.5	1.1	40.6	0.2
OH	2	4	2	‡	2.7	2.5	83.5	0.5
OH	2	5	0	9.1	1.2	1.1	36.4	0.2
OH	2	5	2	5.4	2.1	2.5	76.6	0.5
OH	2	6	0	5.2	1.1	1.0	34.2	0.3
OH	2	6	2	‡	2.4	3.1	83.6	0.7
OH	2	7	0	4.4	1.6	1.2	36.1	0.2
OH	2	7	2	‡	2.9	3.0	93.0	1.0
OH	2	8	0	5.2	1.5	1.1	41.0	0.2
OH	2	8	2	‡	2.5	2.0	88.5	0.7
OH	2	9	0	6.2	1.3	1.4	39.6	0.2
OH	2	9	2	‡	2.3	2.6	72.2	0.8
OH	3	1	0	9.4	2.3	1.6	49.0	0.5
OH	3	2	0	7.2	1.5	1.1	44.8	0.3
OH	3	2	2	‡	3.3	2.4	75.8	1.1
OH	3	3	0	5.3	1.8	1.6	61.5	0.4
OH	3	3	2	‡	2.5	2.2	74.9	1.0
OH	3	4	0	3.6	1.1	1.5	50.4	0.3
OH	3	4	1	2.4	1.9	2.7	57.1	0.5
OH	3	4	2	‡	1.8	3.4	25.9	0.7
OH	3	5	0	9.9	1.5	1.5	45.1	0.4
OH	3	5	1	‡	2.3	2.7	44.5	0.7
OH	3	5	2	‡	2.5	3.5	39.6	1.1
OH	3	6	0	2.8	1.6	1.4	34.5	0.4
OH	3	6	2	‡	2.5	2.3	69.2	0.7
OH	3	7	0	2.4	1.7	2.1	37.5	0.5
OH	3	7	2	‡	2.1	2.1	73.6	0.7
OH	3	8	0	2.9	1.0	1.3	39.6	0.2
OH	3	8	2	‡	2.4	3.0	51.3	0.9
OH	3	9	0	4.9	1.0	1.2	40.2	0.3
OH	3	9	1	2.6	1.7	2.8	29.8	0.7
OH	3	9	2	‡	2.0	3.6	48.2	1.0

Appendix 1c. (continued)

Site	Block	Plot	Sample	P	Zn	Cu	Fe	B
			†	--------------------mg kg^{-1}	-------------------			
VA	1	1	0	5.1	1.7	2.0	42.3	0.1
VA	1	1	1	‡	2.3	2.6	59.4	0.1
VA	1	2	0	3.3	1.5	1.6	40.2	0.1
VA	1	2	2	‡	4.7	2.8	109.7	0.1
VA	1	3	0	4.6	1.1	1.1	26.7	0.1
VA	1	3	2	5.0	5.5	2.8	118.8	0.1
VA	1	4	0	7.0	1.7	1.4	35.6	0.1
VA	1	4	2	‡	6.8	3.1	119.1	0.1
VA	1	5	0	37.4	1.9	2.3	58.1	0.1
VA	1	5	1	‡	2.8	3.1	73.1	0.1
VA	1	5	2	5.8	5.1	2.8	88.2	0.1
VA	1	6	0	5.4	2.1	2.7	43.3	0.1
VA	1	6	1	6.2	2.1	2.5	42.5	0.1
VA	1	6	2	3.0	3.6	2.9	78.1	0.1
VA	1	7	0	9.0	1.4	1.5	39.9	0.1
VA	1	7	2	4.7	4.7	2.9	108.0	0.1
VA	1	8	0	9.1	1.9	2.2	56.0	0.1
VA	1	8	2	5.2	5.1	3.0	97.4	0.1
VA	1	9	0	8.9	2.3	2.4	50.7	0.1
VA	1	9	1	4.4	2.9	2.9	49.7	0.1
VA	2	1	0	6.0	2.9	2.4	63.7	0.1
VA	2	1	1	‡	3.0	2.5	74.7	0.1
VA	2	1	2	2.2	9.0	5.3	145.7	0.2
VA	2	2	0	8.4	3.5	2.8	76.1	0.1
VA	2	2	2	2.6	6.6	4.0	201.5	0.1
VA	2	3	0	11.8	3.9	2.7	84.5	0.2
VA	2	3	1	3.5	4.6	3.5	106.8	0.1
VA	2	4	0	9.4	2.9	3.2	79.8	0.2
VA	2	4	2	4.2	7.4	5.8	151.8	0.2
VA	2	5	0	13.2	2.9	2.9	71.7	0.1
VA	2	5	2	4.7	7.3	5.0	224.3	0.2
VA	2	6	0	7.4	3.1	3.0	65.7	0.1
VA	2	6	2	4.9	7.8	4.6	237.0	0.1
VA	2	7	0	9.8	3.8	3.2	70.5	0.1
VA	2	7	2	‡	10.7	7.2	224.4	0.2
VA	2	8	0	11.6	3.9	3.1	75.4	0.1
VA	2	8	1	‡	4.2	3.7	84.3	0.1

Appendix 1c. (continued)

Site	Block	Plot	Sample	P	Zn	Cu	Fe	B
			†	-------------------mg kg^{-1}------------------				
VA	2	8	2	‡	6.7	5.1	153.0	0.2
VA	2	9	0	12.9	2.4	3.0	71.7	0.2
VA	2	9	2	7.8	6.2	4.9	191.6	0.1
VA	3	1	0	14.2	4.0	2.0	67.1	0.1
VA	3	1	1	7.8	3.9	1.8	38.8	0.1
VA	3	2	0	24.2	3.6	1.8	76.1	0.1
VA	3	2	3	6.6	3.3	1.9	104.9	0.1
VA	3	3	0	2.2	3.1	2.0	104.8	0.1
VA	3	3	1	4.4	3.2	2.0	133.1	0.1
VA	3	4	0	23.4	4.7	2.1	101.3	0.1
VA	3	4	1	5.4	4.3	2.1	100.6	0.1
VA	3	5	0	15.6	6.9	2.8	125.2	0.2
VA	3	5	1	7.5	6.5	2.8	152.3	0.2
VA	3	6	0	13.6	4.2	2.2	125.4	0.1
VA	3	6	3	4.6	3.0	2.0	116.6	0.1
VA	3	7	0	17.3	4.4	2.5	124.3	0.2
VA	3	7	1	‡	2.8	1.7	146.6	0.1
VA	3	8	0	7.8	5.0	2.8	122.3	0.2
VA	3	8	3	‡	3.8	2.0	169.5	0.2
VA	3	9	0	5.4	3.9	2.1	124.1	0.1
VA	3	9	3	‡	3.9	2.0	96.7	0.1

† 0 = 0 - 10 cm, 1 = 10 - 30 cm, 2 = subsoil, 3 = 10 - 30 cm + subsoil.

‡ Detection limit for P was 2.16 mg kg^{-1}.

Appendix 1d. Particle-size analysis for very coarse sand (VCS), coarse sand (CS), medium sand (MS), fine sand (FS), very fine sand (VFS), total sand, coarse silt (CSI), medium silt (MSI), fine silt (FSI), total silt, and total clay for composite samples by plot, block, and site.

Site	Block	Plot	Sample	USDA Textural Class	VCS	CS	MS	FS	VFS	Total Sand	CSI	MSI	FSI	Total Silt	Total Clay
			†	‡	--%--										
WV	1	1	0	SL	13	13	13	12	8	58	35	0	0	35	7
WV	1	1	1	L	13	10	8	9	10	50	39	1	0	40	10
WV	1	2	0	SL	16	13	12	13	9	63	29	0	1	30	7
WV	1	2	1	SL	14	13	11	11	9	57	36	0	0	36	7
WV	1	3	0	SL	16	12	10	10	7	56	36	0	0	36	8
WV	1	3	1	L	10	11	9	8	10	48	41	0	0	41	11
WV	1	4	0	SL	18	16	12	11	8	64	29	0	0	29	6
WV	1	4	1	SL	15	10	9	11	10	55	37	0	0	37	8
WV	1	5	0	SL	15	12	12	12	8	58	35	0	0	35	7
WV	1	5	1	SL	12	9	9	13	10	54	36	0	0	36	10
WV	1	6	0	SL	12	11	10	13	9	54	38	0	0	39	7
WV	1	6	1	L/SL	12	10	9	11	9	52	38	0	0	39	10
WV	1	7	0	SL	14	11	11	13	7	56	33	0	2	35	9
WV	1	7	1	L/SL	12	10	11	10	10	52	39	0	0	39	8
WV	1	8	0	SL	12	12	12	14	9	59	33	0	0	34	7
WV	1	8	1	SL	14	12	10	12	9	58	31	0	1	32	10
WV	1	9	0	SL	15	14	13	13	8	63	25	0	4	29	8
WV	1	9	1	SL	13	11	10	12	8	55	36	0	0	36	9
WV	2	1	0	SL	12	13	13	14	11	63	7	15	6	28	9
WV	2	1	1	L/SL	10	10	9	12	11	52	6	18	10	34	14
WV	2	2	0	SL	12	12	13	11	12	60	31	1	1	33	7
WV	2	2	1	SL	13	11	8	11	12	57	29	2	4	34	9
WV	2	3	0	SL	11	12	11	13	12	60	26	3	3	32	8

Appendix 1d. (continued)

Site	Block	Plot	Sample	USDA Textural Class	VCS	CS	MS	FS	VFS	Total Sand	CSI	MSI	FSI	Total Silt	Total Clay
			†	‡	-----------						%----------				
WV	2	3	1	SL	14	10	9	11	12	55	29	2	3	35	10
WV	2	4	0	SL	15	14	12	13	9	63	4	16	8	28	9
WV	2	4	1	SL	14	11	9	12	11	57	19	7	7	32	11
WV	2	5	0	SL	18	15	12	13	9	66	7	10	8	25	8
WV	2	5	1	SL	15	11	8	15	12	61	9	11	9	29	10
WV	2	6	0	SL	17	13	12	11	12	65	14	4	7	25	10
WV	2	6	1	SL	11	12	10	13	12	57	12	10	9	31	11
WV	2	7	0	SL	19	14	10	11	12	66	6	13	8	27	7
WV	2	7	1	SL	9	10	8	12	16	55	10	15	8	33	12
WV	2	8	0	SL	17	14	13	13	10	66	10	14	5	29	5
WV	2	8	1	SL	12	11	9	12	11	56	8	18	11	37	8
WV	2	9	0	SL	19	12	10	11	8	61	5	17	8	31	8
WV	2	9	1	SL	15	12	9	0	20	56	7	18	8	33	11
WV	3	1	0	SL	19	12	9	7	10	58	7	17	9	32	10
WV	3	1	1	L	13	10	6	7	10	47	7	21	10	38	15
WV	3	2	0	SL	17	13	11	11	11	62	7	16	7	30	7
WV	3	2	1	SL	14	11	8	9	11	55	9	17	8	34	12
WV	3	3	0	SL	16	13	10	11	11	62	7	17	6	30	8
WV	3	3	1	L/SL	11	10	8	10	13	52	10	18	8	36	12
WV	3	4	0	SL	16	12	9	4	15	56	7	18	9	34	10
WV	3	4	1	L	13	9	6	9	13	50	10	18	9	37	13
WV	3	5	0	SL	15	12	10	9	13	59	5	17	8	31	10
WV	3	5	1	L	14	10	9	11	5	49	8	20	10	38	13

Appendix 1d. (continued)

Site	Block	Plot	Sample	USDA Textural Class	VCS	CS	MS	FS	VFS	Total Sand	CSI	MSI	FSI	Total Silt	Total Clay
			†	‡	--						%				--
WV	3	6	0	SL	16	13	11	13	11	63	6	15	8	29	8
WV	3	6	1	L	13	9	7	10	10	50	6	19	11	35	15
WV	3	7	0	SL	13	12	10	13	11	59	12	15	8	35	6
WV	3	7	1	SL	15	12	8	10	10	54	10	18	9	37	10
WV	3	8	0	SL	14	10	8	10	12	54	9	20	6	35	11
WV	3	8	1	L/SL	11	9	8	11	12	52	9	20	7	36	12
WV	3	9	0	SL	14	11	9	9	14	58	10	18	7	35	8
WV	3	9	1	SL	12	10	7	10	15	53	9	19	8	36	11
OH	1	1	0	CL	4	4	7	10	5	30	3	22	15	40	30
OH	1	1	2	CL	3	3	3	6	6	21	4	36	9	49	30
OH	1	2	0	L	4	6	8	10	6	35	4	19	15	38	27
OH	1	2	2	SICL	2	1	2	5	5	16	29	9	15	53	31
OH	1	3	0	L	4	5	7	10	5	31	4	23	16	42	27
OH	1	3	2	SICL	1	2	2	4	6	14	3	28	23	53	33
OH	1	4	0	CL/L	3	3	4	9	7	26	6	26	15	46	28
OH	1	4	2	SICL	2	2	2	5	6	17	4	25	22	51	31
OH	1	5	0	L	3	4	7	13	7	34	4	23	13	41	25
OH	1	5	2	CL	4	3	3	6	7	22	3	26	19	47	30
OH	1	6	0	L	3	3	4	9	8	27	5	27	15	47	26
OH	1	6	2	L	7	5	4	6	8	29	5	22	18	45	26
OH	1	7	0	L	3	3	5	11	8	31	5	26	15	46	23
OH	1	7	2	SICL	3	2	2	5	6	19	4	30	17	51	31
OH	1	8	0	L	4	4	4	9	8	29	6	26	14	46	24
OH	1	8	2	SIL	4	3	3	6	6	23	8	25	16	50	27

Appendix 1d. (continued)

Site	Block	Plot	Sample †	USDA Textural Class ‡	VCS	CS	MS	FS	VFS	Total Sand	CSI	MSI	FSI	Total Silt	Total Clay
					%										
OH	1	9	0	CL	2	4	4	6	8	24	5	28	15	47	29
OH	1	9	2	SIL	1	2	2	7	7	20	7	29	18	54	26
OH	2	1	0	L	4	11	15	9	3	42	4	20	15	39	19
OH	2	1	2	L	2	4	11	13	9	40	6	18	15	39	21
OH	2	2	0	L	3	10	19	10	6	47	3	17	15	35	17
OH	2	2	2	L	3	5	14	11	9	42	6	17	15	39	19
OH	2	3	0	L	3	8	12	8	4	36	4	22	15	41	23
OH	2	3	2	L	3	4	14	8	12	41	6	19	13	38	21
OH	2	4	0	L	4	9	10	7	5	36	5	22	14	41	23
OH	2	4	2	L	4	5	13	10	8	39	5	20	11	37	24
OH	2	5	0	L	3	8	13	0	16	39	4	23	15	42	19
OH	2	5	2	L	3	4	9	8	8	31	5	24	17	45	24
OH	2	6	0	SL	3	5	21	16	8	54	4	18	10	33	13
OH	2	6	2	SIL	1	2	2	3	6	14	8	31	20	59	27
OH	2	7	0	L	3	8	9	8	5	33	5	26	16	46	21
OH	2	7	2	SIL	2	2	3	4	7	18	7	28	20	54	27
OH	2	8	0	L	3	10	12	10	5	40	3	21	15	38	22
OH	2	8	2	SIL/L	3	4	8	7	6	27	7	26	16	49	24
OH	2	9	0	L	2	8	15	12	5	42	4	21	13	38	20
OH	2	9	2	L	2	3	8	7	5	25	5	25	19	48	27
OH	3	1	0	L	5	5	8	8	5	31	0	30	14	45	24
OH	3	1	2	SICL	2	3	4	3	7	18	5	26	21	52	31
OH	3	2	0	L	3	6	9	12	7	38	6	22	13	41	22

Appendix 1d. (continued)

Site	Block	Plot	Sample	USDA Textural Class	VCS	CS	MS	FS	VFS	Total Sand	CSI	MSI	FSI	Total Silt	Total Clay
			†	‡	-------	-------	-------	-------	-------	-------	%	-------	-------	-------	-------
OH	3	2	2	SICL/CL	2	2	5	5	6	20	7	26	18	51	29
OH	3	3	0	L	5	6	9	11	7	39	7	21	12	40	21
OH	3	3	2	CL	2	3	4	6	7	22	5	26	17	48	30
OH	3	4	0	L	3	5	9	9	7	33	7	22	13	43	24
OH	3	4	1	CL	2	3	8	6	6	25	7	25	13	46	29
OH	3	4	2	SICL	2	3	4	4	4	16	6	23	18	47	36
OH	3	5	0	L	5	5	12	0	13	35	7	21	14	43	22
OH	3	5	1	CL	2	3	6	5	5	21	7	22	18	47	32
OH	3	5	2	CL	2	3	6	3	6	21	5	23	19	47	33
OH	3	6	0	L	6	5	9	7	6	33	7	21	14	42	25
OH	3	6	2	L	2	3	7	5	8	25	5	23	19	47	27
OH	3	7	0	L	5	5	8	6	6	30	6	23	14	43	27
OH	3	7	2	L	3	3	10	8	7	31	5	24	14	42	27
OH	3	8	0	CL	4	4	9	7	6	30	5	23	12	41	29
OH	3	8	2	CL	3	3	5	5	8	23	6	24	17	47	30
OH	3	9	0	L	3	5	12	8	6	35	6	22	13	42	23
OH	3	9	1	CL	3	3	10	6	5	28	3	21	14	39	33
OH	3	9	2	SICL	3	2	3	3	4	15	4	26	20	50	35
VA	1	1	0	L	6	7	11	13	8	46	8	21	11	40	14
VA	1	1	1	L	8	6	12	14	8	48	7	22	8	37	15
VA	1	2	0	SL	6	7	14	25	10	62	4	18	6	28	10
VA	1	2	2	SL	7	9	18	20	9	62	5	16	5	26	11
VA	1	3	0	SL	7	8	13	18	9	56	5	18	10	32	11
VA	1	3	2	SL	8	9	18	20	9	64	4	13	8	26	11

Appendix 1d. (continued)

Site	Block	Plot	Sample	USDA Textural Class	VCS	CS	MS	FS	VFS	Total Sand	CSI	MSI	FSI	Total Silt	Total Clay
			†	‡	---%--										
VA	1	4	0	L	5	7	10	15	12	49	6	21	12	38	13
VA	1	4	2	SL	10	9	14	15	9	58	5	16	10	31	11
VA	1	5	0	L	8	8	11	15	10	51	6	18	12	36	12
VA	1	5	1	L	8	7	11	12	8	46	5	23	11	40	14
VA	1	5	2	SL	10	10	18	17	8	62	8	14	8	31	7
VA	1	6	0	L	8	6	9	13	9	45	10	20	13	44	11
VA	1	6	1	L	7	6	11	12	8	45	6	23	9	39	17
VA	1	6	2	SL	9	7	14	16	8	53	5	19	10	34	13
VA	1	7	0	SL	8	7	14	19	9	57	6	18	8	33	11
VA	1	7	2	SL	7	8	17	18	9	59	7	16	8	31	9
VA	1	8	0	L	7	7	12	14	9	49	9	20	10	38	13
VA	1	8	2	SL	12	9	17	17	8	62	6	14	8	28	9
VA	1	9	0	SL	7	7	14	18	10	56	5	18	10	32	12
VA	1	9	1	L/SL	7	8	13	16	9	52	7	19	9	36	12
VA	2	1	0	L/SL	9	9	14	13	7	52	6	15	12	33	15
VA	2	1	1	L	10	8	14	12	7	51	7	13	14	33	16
VA	2	1	2	SL	11	12	13	10	10	57	5	16	11	31	12
VA	2	2	0	L	10	10	11	11	8	49	6	18	13	37	14
VA	2	2	2	SL	12	14	13	13	11	63	7	13	8	27	10
VA	2	3	0	SL	12	10	14	13	8	58	6	15	9	31	11
VA	2	3	1	SL	12	11	13	13	8	57	8	17	10	34	9
VA	2	3	2	SL	17	14	10	9	8	58	9	16	9	34	8
VA	2	4	0	L	8	7	9	11	9	44	8	23	12	43	13
VA	2	4	2	SL	17	13	10	8	6	54	5	19	10	34	12

Appendix 1d. (continued)

Site	Block	Plot	Sample	USDA Textural Class	VCS	CS	MS	FS	VFS	Total Sand	CSI	MSI	FSI	Total Silt	Total Clay
			†	‡	----------	----------	----------	----------	----------	----------%	----------	----------	----------	----------	----------
VA	2	5	0	L	8	8	11	9	11	47	7	22	10	39	14
VA	2	5	2	SL	16	16	12	10	8	62	7	17	5	30	8
VA	2	6	0	L	11	7	9	10	9	45	9	22	11	42	13
VA	2	6	2	SL	16	13	14	14	8	65	6	14	6	26	9
VA	2	7	0	L	8	9	11	13	9	50	6	20	12	37	13
VA	2	7	2	SL	19	16	11	10	7	63	7	15	7	29	8
VA	2	8	0	SL	10	8	13	0	23	54	7	17	10	34	11
VA	2	8	1	SL	9	8	12	16	8	53	7	18	10	35	12
VA	2	8	2	SL	14	12	11	9	10	56	4	18	10	32	12
VA	2	9	0	L	7	7	9	11	8	42	7	23	12	42	16
VA	2	9	2	SL	17	14	11	11	9	62	6	16	7	29	9
VA	3	1	0	SL	5	6	17	20	11	58	8	15	7	30	11
VA	3	1	1	SL	7	6	20	21	9	63	10	15	5	31	7
VA	3	2	0	SL	5	5	15	20	12	57	8	17	5	30	13
VA	3	2	3	SL	6	5	13	20	12	56	8	17	5	30	14
VA	3	3	0	L	5	5	11	16	11	49	9	24	6	39	13
VA	3	3	1	L	7	7	11	14	10	48	9	21	8	38	14
VA	3	4	0	SL	7	7	11	18	11	55	8	19	7	33	12
VA	3	4	1	SL	6	7	12	19	10	55	7	20	6	33	12
VA	3	5	0	L	8	8	10	15	10	51	6	23	8	37	12
VA	3	5	1	SL	8	8	12	17	10	55	5	22	7	34	11
VA	3	6	0	L	7	7	9	14	10	47	7	20	11	37	15
VA	3	6	3	L	8	7	11	14	10	50	8	20	11	39	11
VA	3	7	0	L/SL	7	7	11	13	13	52	7	19	8	34	14

Appendix 1d. (continued)

Site	Block	Plot	Sample	USDA Textural Class	VCS	CS	MS	FS	VFS	Total Sand	CSI	MSI	FSI	Total Silt	Total Clay
			†	‡	-----	-----	-----	-----	-----	-----	%	-----	-----	-----	-----
VA	3	7	1	L	6	8	12	13	11	50	7	19	11	37	13
VA	3	8	0	SL	8	8	11	16	12	54	7	17	10	33	13
VA	3	8	3	SL	10	9	12	16	11	58	7	17	8	32	9
VA	3	9	0	L	5	5	9	16	12	47	14	19	11	44	10
VA	3	9	3	SL	7	7	11	19	12	56	11	16	10	37	8

† 0 = 0 - 10 cm, 1 = 10 - 30 cm, 2 = subsoil, 3 = 10 - 30 cm + subsoil.

‡ SL, sandy loam; L, loam; CL, clay loam; SICL, silty clay loam; SIL, silt loam.

Appendix 1e. Rock fragment (CF) distribution of sandstone (SS), shale, siltstone (SiS), and coal for composite samples by plot, block, and site. CF values in each row sum to 100 percent.

Site	Block	Plot	Sample	CF	Red SS	Grey SS	White SS	Shale	Red SiS	Grey SiS	Coal
			†	weight %	-----------------% volume of all CF------------------						
WV	1	1	0	50	5			85		10	
WV	1	1	1	53		10		60	10	10	
WV	1	2	0	62		5		90		5	
WV	1	2	1	69				80		20	
WV	1	3	0	49				80	10	10	
WV	1	3	1	55		10	5	70	5	10	
WV	1	4	0	59		15		70		15	
WV	1	4	1	60	5			90		5	
WV	1	5	0	54		15		65	5	15	
WV	1	5	1	58	10	20		60		10	
WV	1	6	0	48				75	10	15	
WV	1	6	1	61							
WV	1	7	0	52	10	15		65		10	
WV	1	7	1	54		10		80		10	
WV	1	8	0	53		10		80		10	
WV	1	8	1	63	5			85		10	
WV	1	9	0	61		10		80		10	
WV	1	9	1	59	10	10		80			
WV	2	1	0	58		10		80		10	
WV	2	1	1	62		10		80		10	
WV	2	2	0	57		10		80		10	
WV	2	2	1	63		10		80		10	
WV	2	3	0	52		10		80		10	
WV	2	3	1	62		10		80		10	
WV	2	4	0	53				80		20	
WV	2	4	1	61	5			80		15	
WV	2	5	0	55				80		20	
WV	2	5	1	60				80		20	
WV	2	6	0	60		5		90		5	
WV	2	6	1	62		5		80		15	
WV	2	7	0	54		10		80		10	
WV	2	7	1	51		10		80		10	
WV	2	8	0	56		10		80		10	
WV	2	8	1	68		10		80		10	
WV	2	9	0	53		10		80		10	
WV	2	9	1	65				90		10	

Appendix 1e. (continued)

Site	Block	Plot	Sample	CF	Red SS	Grey SS	White SS	Shale	Red SiS	Grey SiS	Coal
			†	weight %	-----------------% volume of all CF------------------						
WV	3	1	0	47		10		70		10	10
WV	3	1	1	48							
WV	3	2	0	54		15		70		15	
WV	3	2	1	63		10		80		10	
WV	3	3	0	48		20		70		10	
WV	3	3	1	57		15		71		15	
WV	3	4	0	49		5		80	5	10	
WV	3	4	1	50	10	10		50	20	10	
WV	3	5	0	47		10		70	10	10	
WV	3	5	1	54		15		60	10	15	
WV	3	6	0	45		10		70	10	10	
WV	3	6	1	50	10	10		60	10	10	
WV	3	7	0	42	5	10		75		10	
WV	3	7	1	58	5	10		75		10	
WV	3	8	0	41		10		80		10	
WV	3	8	1	49			10	65	15	10	
WV	3	9	0	44				75	10	15	
WV	3	9	1	48	5			70	10	15	
OH	1	1	0	8	10				90		
OH	1	1	2	29	20				20	60	
OH	1	2	0	6	20				80		
OH	1	2	2	17	20					80	
OH	1	3	0	8	10				85	5	
OH	1	3	2	19					15	85	
OH	1	4	0	4					100		
OH	1	4	2	15				10		90	
OH	1	5	0	5	20				80		
OH	1	5	2	30		10			10	80	
OH	1	6	0	4	10				90		
OH	1	6	2	43		25			15	60	
OH	1	7	0	7	20				80	.	
OH	1	7	2	20		40				60	
OH	1	8	0	9	20				80	.	
OH	1	8	2	29	30				30	40	
OH	1	9	0	7	20				80		
OH	1	9	2	27	10		15			75	
OH	2	1	0	6	5		5		90		
OH	2	1	2	15	10	10			10	70	

Appendix 1e. (continued)

Site	Block	Plot	Sample	CF	Red SS	Grey SS	White SS	Shale	Red SiS	Grey SiS	Coal
			†	weight %	-----------------% volume of all CF------------------						
OH	2	2	0	6	20				80		
OH	2	2	2	23	10				20	70	
OH	2	3	0	7	25				75		
OH	2	3	2	19	15		15		20	50	
OH	2	4	0	12	5				95		
OH	2	4	2	12	15		15		20	50	
OH	2	5	0	10	10	5	5		80		
OH	2	5	2	23	30				30	40	
OH	2	6	0	5	60				30	10	
OH	2	6	2	19					5	95	
OH	2	7	0	8	5				85	10	
OH	2	7	2	21						100	
OH	2	8	0	5	100						
OH	2	8	2	18		50				10	40
OH	2	9	0	5							
OH	2	9	2	11	15	10			15	60	
OH	3	1	0	10	10				70	20	
OH	3	1	2	17					15	85	
OH	3	2	0	9	15				70	15	
OH	3	2	2	15	15	25			10	50	
OH	3	3	0	11	10				90		
OH	3	3	2	13					25	75	
OH	3	4	0	11	40				60		
OH	3	4	1	10		15 (LS)			75	10	
OH	3	4	2	12	30				70		
OH	3	5	0	10	30				70		
OH	3	5	1	14					90	10	
OH	3	5	2	15					60	40	
OH	3	6	0	10	10				90		
OH	3	6	2	20					90	10	
OH	3	7	0	7	50				50		
OH	3	7	2	17					10	90	
OH	3	8	0	9	30				70		
OH	3	8	2	25	10				20	70	
OH	3	9	0	12	50				50		
OH	3	9	1	12							
OH	3	9	2	13					50	50	

Appendix 1e. (continued)

Site	Block	Plot	Sample	CF	Red SS	Grey SS	White SS	Shale	Red SiS	Grey SiS	Coal
			†	weight %	-----------------% volume of all CF------------------						
VA	1	1	0	29	90		5			5	
VA	1	1	1	38	60	15	15			10	
VA	1	2	0	32							
VA	1	2	2	43			95			5	
VA	1	3	0	35	70		5		20	5	
VA	1	3	2	55	5	35	60				
VA	1	4	0	27	25	15	5		30	25	
VA	1	4	2	57	5	10	10			75	
VA	1	5	0	34	60	15	15			10	
VA	1	5	1	34	85		10			5	
VA	1	5	2	55	10		70			20	
VA	1	6	0	28	80		10			10	
VA	1	6	1	28	90					10	
VA	1	6	2	49	60		35			5	
VA	1	7	0	39	90		5			5	
VA	1	7	2	45	5		90			5	
VA	1	8	0	34	55	10	10			15	
VA	1	8	2	49	10		70			20	
VA	1	9	0	35	70		20			10	
VA	1	9	1	36	80	5	10			5	
VA	2	1	0	40	30		30			40	
VA	2	1	1	40	50		35			15	
VA	2	1	2	56	5		10			85	
VA	2	2	0	46	80		15			5	
VA	2	2	2	65							
VA	2	3	0	42							
VA	2	3	1	50	15	20	25			40	
VA	2	3	2	53			5			95	
VA	2	4	0	34	25		25			50	
VA	2	4	2	57	5		5			90	
VA	2	5	0	48	30		20			50	
VA	2	5	2	70		20				80	
VA	2	6	0	43	40		10			50	
VA	2	6	2	67	5		85			10	
VA	2	7	0	44	20	25	10			45	
VA	2	7	2	71			10			90	
VA	2	8	0	38	25	25	10			40	
VA	2	8	1	37	25	10	10			55	
VA	2	8	2	52	5		15			80	

Appendix 1e. (continued)

Site	Block	Plot	Sample	CF	Red SS	Grey SS	White SS	Shale	Red SiS	Grey SiS	Coal
			†	weight %	-----------------% volume of all CF------------------						
VA	2	9	0	35							
VA	2	9	2	79		10				90	
VA	3	1	0	51	45	10	40			5	
VA	3	1	1	54	65	10	25				
VA	3	2	0	52	35	10	50			5	
VA	3	2	3	59	35	25	35			5	
VA	3	3	0	51	15	5	60			20	
VA	3	3	1	52	40	10	35			15	
VA	3	4	0	55	10	10	40			40	
VA	3	4	1	60	10	20	60			10	
VA	3	5	0	57	5	5	15			75	
VA	3	5	1	59	20	5	40			35	
VA	3	6	0	49	15	5	40			40	
VA	3	6	3	52	10	10	20			60	
VA	3	7	0	50	15	15	15			55	
VA	3	7	1	62	15	15	25			45	
VA	3	8	0	54	10	5	15			70	
VA	3	8	3	60	5	15	15			65	
VA	3	9	0	45	20	5	70			5	
VA	3	9	3	55	15	20	60			5	

† 0 = 0 - 10 cm, 1 = 10 - 30 cm, 2 = subsoil, 3 = 10 - 30 cm + subsoil.

Appendix 2a. pH, electrical conductivity (EC), carbon (C), and nitrogen (N) analysis by horizon and deep pit.

Pit	Horizon	EC	pH	C	N	C:N
		dS m^{-1}		--------- %	---------	
OH1-1	A	0.3	5.0	107446	7172	15
OH1-1	Bw	0.1	4.7	8963	570	16
OH1-1	2BC	1.0	7.5	9994	499	20
OH1-1	3C1	0.3	7.7	3468	236	15
OH1-1	3C2	0.5	7.8	3050	316	10
OH1-2a	A	0.4	5.5	73621	5164	14
OH1-2a	Bw	0.1	5.7	7552	646	12
OH1-2a	2BC	0.2	7.4	6627	556	12
OH1-2a	3C1	0.2	7.5	4198	435	10
OH1-2a	4C2	0.2	7.7	4488	420	11
OH1-2b	A	0.4	5.9	127682	8467	15
OH1-2b	Bw1	0.1	5.3	9066	637	14
OH1-2b	Bw2	0.2	7.7	4996	476	11
OH1-2b	2BC	0.2	7.9	3467	392	9
OH1-2b	2C1	0.6	7.7	2985	389	8
OH1-2b	2C2	0.5	7.6	3160	447	7
OH1-3	A	0.5	5.6	98848	5903	17
OH1-3	Bw	0.1	4.8	3860	404	10
OH1-3	2BC	0.2	7.8	6729	412	16
OH1-3	2C1	0.6	7.6	6092	407	15
OH1-3	2C2	1.0	7.6	5029	449	11
OH2-1	A	0.5	5.5	183479	11242	16
OH2-1	Bw	0.1	5.2	1793	152	12
OH2-1	2BC	0.4	7.4	3541	380	9
OH2-1	2C1	1.0	7.0	3944	424	9
OH2-1	2C2	1.2	6.9	3949	424	9
OH2-1	2C3	1.3	7.2	15184	572	27
OH2-1	3C4	1.9	6.6	115370	2671	43
OH2-2	A	0.3	5.0	106966	6453	17
OH2-2	Bw1	0.1	4.6	5390	450	12
OH2-2	2Bw2	0.5	5.8	5177	357	14

Appendix 2a. (continued)

Pit	Horizon	EC	pH	C	N	C:N
		dS m^{-1}		--------- %---------		
OH2-2	2BC	1.5	6.9	5533	333	17
OH2-2	3C	2.3	7.4	69137	1314	53
OH2-2	3Cd	2.2	7.5	29859	622	48
OH3-1	A	0.7	7.1	95093	6788	14
OH3-1	Bw	0.4	7.4	9645	579	17
OH3-1	2BC	1.1	7.6	9862	464	21
OH3-1	2C1	1.6	7.6	9234	411	22
OH3-1	3C2	0.5	7.7	12826	40	317
OH3-1	4C3	2.3	7.5	32370	539	60
OH3-1	4C4	1.6	7.3	26589	428	62
OH3-2	A	0.8	6.6	121726	9176	13
OH3-2	Bw	0.7	6.9	4450	358	12
OH3-2	2BC	2.1	5.6	7116	405	18
OH3-2	2C	2.6	6.3	12991	553	23
OH3-2	2Cd	1.1	6.0	7620	424	18
VA1-1	A	0.1	4.8	2658	203	13
VA1-1	C	0.6	7.1	13194	401	33
VA1-1	Cd1	0.5	6.5	13832	578	24
VA1-1	Cd2	0.4	6.6	15187	576	26
VA1-1	C'	0.6	6.8	12923	481	27
VA1-2	A	0.3	6.7	11855	420	28
VA1-2	C1	0.3	7.8	44298	787	56
VA1-2	C2	0.4	7.6	17411	443	39
VA1-2	C3	0.4	7.7	20111	490	41
VA2-1	A	0.1	7.6	15417	539	29
VA2-1	C1	0.3	7.1	46076	930	50
VA2-1	C2	0.2	7.5	35699	766	47
VA2-2	A	0.4	6.2	22459	923	24
VA2-2	C1	0.4	5.3	17289	669	26
VA2-2	C2	0.2	7.3	25694	569	45
VA2-2	C3	0.3	6.8	40733	809	50

Appendix 2a. (continued)

Pit	Horizon	EC	pH	C	N	C:N
		dS m^{-1}		--------- %---------		
VA3-1	A	0.3	5.7	14219	589	24
VA3-1	C1	0.2	7.0	11660	404	29
VA3-1	C2	0.3	5.8	12609	424	30
VA3-2	A	0.4	7.1	29579	861	34
VA3-2	Cd	0.3	6.7	33948	995	34
VA3-2	C	0.3	6.9	10152	325	31
WV-1	A	0.5	5.9	48862	4013	12
WV-1	Bw	0.1	6.9	16530	1093	15
WV-1	BC	0.2	7.2	13469	807	17
WV-1	C1	0.2	7.6	15903	799	20
WV-1	C2	0.3	7.4	14747	634	23
WV-2	A	0.4	5.3	47815	3935	12
WV-2	Bw	0.1	5.6	10835	864	13
WV-2	BC	0.1	6.4	8636	659	13
WV-2	C1	0.2	7.0	9262	641	14
WV-2	C2	†	†	†	†	†
WV-3	A	0.5	5.6	50219	4316	12
WV-3	Bw	0.2	4.9	15672	1060	15
WV-3	BC	0.2	5.1	11892	962	12
WV-3	C1	0.2	6.0	9439	784	12
WV-3	C2	0.3	7.1	9954	730	14

† Insufficient fine earth fraction for analysis.

Appendix 2b. Exchangeable magnesium (Mg), potassium (P), calcium (Ca), manganese (Mn), sodium (Na), aluminum (Al), cation exchange capacity (CEC), and base saturation (BS) analysis by horizon and deep pit.

Pit	Horizon	Mg	K	Ca	Mn	Na	Al	CEC	BS
		----------------------mg kg^{-1}-----------------------					----$cmol_c$ kg^{-1}-----		%
OH1-1	A	288	437	1273	55	18	1.0	11	91
OH1-1	Bw	172	133	883	9	6	1.8	8	78
OH1-1	2BC	228	106	3365	3	9	†	19	100
OH1-1	3C1	526	86	2796	6	18	†	19	100
OH1-1	3C2	576	94	2568	5	28	†	18	100
OH1-2a	A	290	334	1857	18	9	0.3	13	98
OH1-2a	Bw	232	119	1387	6	8	0.1	9	99
OH1-2a	2BC	219	102	1704	3	17	†	11	100
OH1-2a	3C1	219	90	1892	1	9	†	12	100
OH1-2a	4C2	279	118	1932	2	14	†	12	100
OH1-2b	A	421	402	3072	28	8	0.3	20	99
OH1-2b	Bw1	208	128	1394	4	5	0.3	9	97
OH1-2b	Bw2	252	111	2135	2	8	†	13	100
OH1-2b	2BC	290	115	1814	2	8	†	12	100
OH1-2b	2C1	354	126	2064	2	24	†	14	100
OH1-2b	2C2	392	113	1999	2	50	†	14	100
OH1-3	A	384	345	2972	46	12	0.4	19	98
OH1-3	Bw	187	87	945	6	9	2.0	8	77
OH1-3	2BC	307	109	3339	4	10	†	20	100
OH1-3	2C1	407	105	2925	5	24	†	18	100
OH1-3	2C2	461	127	3236	5	50	†	20	100
OH2-1	A	721	405	3377	128	19	0.8	25	97
OH2-1	Bw	180	31	450	12	10	0.3	4	93
OH2-1	2BC	393	119	1641	2	20	†	12	100
OH2-1	2C1	487	118	2081	2	30	†	15	100
OH2-1	2C2	431	97	2070	2	33	†	14	100
OH2-1	2C3	331	153	2596	3	29	†	16	100
OH2-1	3C4	378	211	9610	14	33	0.4	52	99
OH2-2	A	281	291	1185	52	14	0.7	10	93
OH2-2	Bw1	190	78	514	3	5	2.15	6	67
OH2-2	2Bw2	283	64	1076	4	11	0.0	8	100
OH2-2	2BC	263	71	2462	3	14	†	15	100

Appendix 2b. (continued)

Pit	Horizon	Mg	K	Ca	Mn	Na	Al	CEC	BS
		----------------------mg kg^{-1}				-----------------------	----cmol$_c$ kg^{-1}	-----	%
OH2-2	3C	411	158	14410	2	25	†	76	100
OH2-2	3Cd	365	133	5520	4	23	†	31	100
OH3-1	A	285	241	4299	13	15	†	24	100
OH3-1	Bw	170	91	2277	2	13	†	13	100
OH3-1	2BC	287	112	3976	2	20	†	23	100
OH3-1	2C1	445	148	4756	2	36	†	28	100
OH3-1	3C2	78	25	2613	8	18	†	14	100
OH3-1	4C3	334	133	8430	2	32	†	45	100
OH3-1	4C4	253	115	5130	4	24	†	28	100
OH3-2	A	555	420	3880	37	17	0.3	25	99
OH3-2	Bw	348	99	2016	2	15	†	13	100
OH3-2	2BC	360	89	3642	4	19	0.0	21	100
OH3-2	2C	437	117	6080	2	23	0.0	34	100
OH3-2	2Cd	410	161	2637	11	30	0.0	17	100
VA1-1	A	159	73	370	48	15	1.0	4	78
VA1-1	C	205	88	1064	6	19	†	7	100
VA1-1	Cd1	240	88	1167	18	17	0.0	8	100
VA1-1	Cd2	213	76	1130	18	15	0.0	8	100
VA1-1	C'	188	62	1211	4	17	0.0	8	100
VA1-2	A	224	49	982	3	19	0.0	7	100
VA1-2	C1	135	50	1245	6	11	†	7	100
VA1-2	C2	180	54	1160	4	15	†	7	100
VA1-2	C3	136	60	881	4	14	†	6	100
VA2-1	A	188	51	842	1	6	†	6	100
VA2-1	C1	142	62	1294	9	7	†	8	100
VA2-1	C2	150	58	1284	7	10	†	8	100
VA2-2	A	250	102	925	9	11	0.0	7	100
VA2-2	C1	287	82	782	4	10	0.1	7	99
VA2-2	C2	184	77	880	5	8	†	6	100
VA2-2	C3	159	61	813	5	8	†	6	100
VA3-1	A	299	83	557	42	10	0.1	6	98
VA3-1	C1	246	65	423	2	9	†	4	100
VA3-1	C2	243	57	331	14	10	0.1	4	99

Appendix 2b. (continued)

Pit	Horizon	Mg	K	Ca	Mn	Na	Al	CEC	BS
		----------------------mg kg^{-1}				-----------------------	----cmol$_c$ kg^{-1}	-----	%
VA3-2	A	258	95	713	3	10	†	6	100
VA3-2	Cd	280	100	716	3	13	0.1	6	99
VA3-2	C	172	44	303	7	6	†	3	100
WV-1	A	425	209	1335	19	9	0.1	11	99
WV-1	Bw	247	69	1062	3	8	†	8	100
WV-1	BC	289	75	839	1	8	†	7	100
WV-1	C1	275	87	1462	0	8	†	10	100
WV-1	C2	422	97	2682	0	9	†	17	100
WV-2	A	453	173	1060	29	6	0.2	10	98
WV-2	Bw	290	69	445	16	6	0.1	5	98
WV-2	BC	314	71	579	4	7	0.0	6	100
WV-2	C1	271	79	1196	1	6	†	8	100
WV-2	C2	‡	‡	‡	‡	‡	†‡	‡	‡
WV-3	A	554	322	1458	19	6	0.1	13	99
WV-3	Bw	264	74	541	19	8	1.2	6	81
WV-3	BC	354	121	752	15	10	0.4	7	95
WV-3	C1	380	145	951	3	11	0.1	8	99
WV-3	C2	450	161	1651	1	11	†	12	100

† Not analyzed at pH levels > 6.5.
‡ Insufficient fine earth fraction for analysis.

Appendix 2c. Extractable phosphorus (P), zinc (Zn), copper (Cu), iron (Fe), and boron (B) analysis by horizon and pit.

Pit	Horizon	P	Zn	Cu	Fe	B
		--------------------mg kg^{-1}--------------------				
OH1-1	A	81.7	2.5	0.5	23.40	0.3
OH1-1	Bw	7.4	1.0	1.6	68.60	0.2
OH1-1	2BC	†	3.0	1.6	22.30	1.4
OH1-1	3C1	†	1.2	0.7	9.00	0.9
OH1-1	3C2	†	1.9	1.5	12.40	1.1
OH1-2a	A	25.2	2.9	0.9	20.90	0.4
OH1-2a	Bw	5.4	2.2	2.6	69.10	0.2
OH1-2a	2BC	†	5.4	2.8	75.20	0.6
OH1-2a	3C1	†	2.4	2.0	41.90	0.5
OH1-2a	4C2	†	2.1	1.7	50.00	0.9
OH1-2b	A	43.8	3.2	0.3	13.40	0.4
OH1-2b	Bw1	6.1	1.3	1.6	42.60	0.2
OH1-2b	Bw2	†	2.7	2.4	54.20	0.7
OH1-2b	2BC	2.6	2.8	2.3	85.90	1.0
OH1-2b	2C1	†	2.9	2.5	82.40	1.2
OH1-2b	2C2	†	2.6	1.8	104.00	1.0
OH1-3	A	35.0	2.3	0.4	12.40	0.5
OH1-3	Bw	5.1	0.9	1.6	47.70	0.1
OH1-3	2BC	†	1.8	0.8	17.60	0.9
OH1-3	2C1	†	3.6	2.9	28.10	1.2
OH1-3	2C2	†	1.8	1.6	61.10	1.1
OH2-1	A	45.0	5.3	0.2	7.20	0.5
OH2-1	Bw	†	0.7	0.6	20.10	0.1
OH2-1	2BC	†	2.3	2.6	67.90	1.0
OH2-1	2C1	†	2.6	2.8	87.00	1.0
OH2-1	2C2	†	3.1	2.5	68.00	1.2
OH2-1	2C3	†	2.6	4.2	137.00	1.1
OH2-1	3C4	4.6	5.4	0.8	13.20	1.1
OH2-2	A	35.5	2.5	0.2	12.00	0.3
OH2-2	Bw1	†	0.8	0.9	16.90	0.1

Appendix 2c. (continued)

Pit	Horizon	P	Zn	Cu	Fe	B
			--------------------mg kg^{-1}--------------------			
OH2-2	2Bw2	2.2	1.7	2.0	48.10	0.3
OH2-2	2BC	†	4.1	5.2	59.10	0.6
OH2-2	3C	†	0.3	0.1	0.90	1.3
OH2-2	3Cd	†	0.6	0.1	5.70	1.0
OH3-1	A	41.2	3.0	0.4	12.70	1.2
OH3-1	Bw	†	1.6	2.1	59.00	0.5
OH3-1	2BC	4.8	1.8	1.6	48.60	0.8
OH3-1	2C1	†	1.3	0.3	27.40	1.1
OH3-1	3C2	4.5	0.6	0.1	1.10	0.3
OH3-1	4C3	†	0.1	0.1	0.10	0.4
OH3-1	4C4	†	0.2	0.1	0.40	0.4
OH3-2	A	36.5	4.6	0.7	4.60	1.1
OH3-2	Bw	†	1.7	3.4	23.70	0.8
OH3-2	2BC	†	2.6	2.1	94.30	0.7
OH3-2	2C	†	3.8	3.1	103.30	0.9
OH3-2	2Cd	†	2.7	6.4	112.60	1.0
VA1-1	A	4.1	1.0	0.8	25.20	0.1
VA1-1	C	†	3.8	3.3	103.20	0.1
VA1-1	Cd1	†	4.0	5.2	79.50	0.1
VA1-1	Cd2	†	1.9	2.2	87.20	0.1
VA1-1	C'	†	3.6	2.1	73.50	0.1
VA1-2	A	5.4	2.3	1.9	56.40	0.1
VA1-2	C1	6.9	6.9	2.8	122.10	0.1
VA1-2	C2	3.7	4.9	2.7	92.70	0.2
VA1-2	C3	5.5	8.5	5.0	134.10	0.1
VA2-1	A	2.2	4.2	2.9	73.00	0.1
VA2-1	C1	4.1	7.3	4.2	367.60	0.2
VA2-1	C2	3.7	8.7	3.7	288.30	0.2
VA2-2	A	8.6	3.5	2.8	79.00	0.2
VA2-2	C1	4.7	3.1	3.5	85.30	0.1
VA2-2	C2	†	9.0	4.8	364.60	0.1
VA2-2	C3	†	10.3	5.5	371.50	0.2

Appendix 2c. (continued)

Pit	Horizon	P	Zn	Cu	Fe	B
			--------------------mg kg^{-1}--------------------			
VA3-1	A	9.4	2.3	2.5	84.90	0.1
VA3-1	C1	4.3	3.0	2.3	112.50	0.1
VA3-1	C2	2.9	4.3	3.9	96.50	0.1
VA3-2	A	11.4	6.9	3.5	156.60	0.2
VA3-2	Cd	†	6.8	3.8	198.90	0.2
VA3-2	C	2.7	3.7	1.5	113.50	0.1
WV-1	A	20.7	3.5	0.8	34.40	0.4
WV-1	Bw	2.9	2.4	1.8	42.80	0.2
WV-1	BC	†	2.5	1.4	45.40	0.2
WV-1	C1	†	2.4	1.7	39.90	0.2
WV-1	C2	2.2	0.2	0.1	1.00	0.2
WV-2	A	29.4	5.7	0.8	24.50	0.3
WV-2	Bw	7.5	3.0	3.3	55.50	0.1
WV-2	BC	3.8	2.8	2.1	46.90	0.2
WV-2	C1	†	3.4	2.4	45.20	0.2
WV-2	C2	‡	‡	‡	‡	‡
WV-3	A	19.7	5.0	0.5	31.20	0.4
WV-3	Bw	15.8	1.9	1.9	82.70	0.2
WV-3	BC	15.8	2.7	0.8	63.00	0.2
WV-3	C1	9.0	1.5	0.3	59.30	0.3
WV-3	C2	†	3.4	0.8	27.00	0.5

† Detection limit for P was 2.16 mg kg^{-1}.

‡ Insufficient fine earth fraction for analysis.

Appendix 2d. Particle size analysis for very coarse sand (VCS), coarse sand (CS), medium sand (MS), fine sand (FS), very fine sand (VFS), total sand, coarse silt (CSI), medium silt (MSI), fine silt (FSI), total silt, total clay, and rock fragments (CF) by horizon and deep pit.

Pit	Horizon	USDA Textural Class	VCS	CS	MS	FS	VFS	Total Sand	CSI	MSI	FSI	Total Silt	Total Clay	CF
		†	----------	----------	----------	----------	----------	%	----------	----------	----------	----------	----------	weight %
OH1-1	A	CL	0	2	7	2	14	25	12	25	8	44	31	§
OH1-1	Bw	SiCL	2	3	3	6	7	22	11	31	9	51	28	6
OH1-1	2BC	SiL	2	3	2	3	4	13	8	32	19	59	27	17
OH1-1	3C1	SiL/L	6	4	3	6	11	30	12	28	10	49	21	45
OH1-1	3C2	L	4	3	2	6	12	28	7	27	12	45	27	30
OH1-2a	A	CL	1	3	6	8	4	22	13	23	12	47	31	§
OH1-2a	Bw	CL	3	3	5	0	14	24	4	27	14	45	31	§
OH1-2a	2BC	SiCL	3	2	2	4	5	16	5	32	15	52	32	§
OH1-2a	3C1	SiCL/CL/SiL	3	2	2	5	7	20	5	32	15	52	28	§
OH1-2a	4C2	SiCL	3	2	2	3	5	14	6	32	19	57	29	§
OH1-2b	A	SiL	1	2	5	7	3	19	19	23	13	55	26	§
OH1-2b	Bw1	CL/L	4	4	5	9	5	26	5	26	15	46	28	13
OH1-2b	Bw2	SiL	3	3	2	5	8	21	6	30	16	53	27	37
OH1-2b	2BC	SiL	2	2	2	4	6	16	9	32	17	58	26	40
OH1-2b	2C1	SiL	3	2	2	4	6	16	8	32	18	58	25	39
OH1-2b	2C2	SiL	3	2	1	3	7	16	7	36	17	60	25	45
OH1-3	A	L	10	13	9	8	6	47	12	22	7	41	12	§
OH1-3	Bw	SiL	3	3	2	6	10	24	11	31	11	52	24	7
OH1-3	2BC	CL	3	2	2	6	9	22	7	27	15	49	29	24
OH1-3	2C1	SiL/CL	3	2	2	5	8	21	9	27	16	51	28	37
OH1-3	2C2	SiCL	2	2	2	5	7	19	6	30	17	53	29	31

Appendix 2d. (continued)

Pit	Horizon	USDA Textural Class	VCS	CS	MS	FS	VFS	Total Sand	CSI	MSI	FSI	Total Silt	Total Clay	CF
		†	--------------------					%					--------------------	weight %
OH2-1	A	SiL	2	8	8	1	6	25	22	19	9	51	24	§
OH2-1	Bw	SL	2	20	20	12	6	60	4	14	6	24	16	10
OH2-1	2BC	SiL	2	2	2	3	6	15	6	34	19	58	26	24
OH2-1	2C1	SiL	1	1	1	2	4	9	7	40	20	67	24	24
OH2-1	2C2	SiL	3	3	2	4	6	17	7	35	16	58	24	40
OH2-1	2C3	SiCL	2	2	2	3	6	16	2	32	20	54	30	17
OH2-1	3C4	L	10	10	8	7	5	40	2	22	13	38	22	46
OH2-2	A	L	2	12	12	6	3	35	12	19	8	39	26	§
OH2-2	Bw1	L	3	12	11	6	4	36	4	22	12	38	26	6
OH2-2	2Bw2	L	2	4	11	0	22	40	6	22	10	38	22	22
OH2-2	2BC	L	3	4	14	13	8	42	6	21	11	38	20	36
OH2-2	3C	L	9	7	6	5	5	32	4	23	15	42	26	51
OH2-2	3Cd	SiL	6	4	4	4	5	22	6	27	18	52	26	38
OH3-1	A	L	2	6	11	7	6	33	15	18	8	41	26	§
OH3-1	Bw	L	3	5	8	10	7	32	8	25	12	44	23	27
OH3-1	2BC	CL	3	3	5	5	5	21	8	28	14	50	29	22
OH3-1	2C1	SiCL	2	3	4	5	5	18	5	28	17	51	31	27
OH3-1	3C2	LS	3	16	37	21	7	84	4	6	2	12	5	§
OH3-1	4C3	L	6	6	7	7	7	32	9	22	11	42	26	§
OH3-1	4C4	CL	4	5	13	9	6	37	8	19	6	33	30	50
OH3-2	A	SiL	4	5	7	5	4	26	19	20	11	50	24	§
OH3-2	Bw	SiCL	3	3	3	2	5	16	8	23	16	47	37	27
OH3-2	2BC	L	3	4	8	8	9	33	8	23	12	43	24	15
OH3-2	2C	L	5	6	6	6	7	29	11	24	11	45	26	23
OH3-2	2Cd	SiCL	1	2	4	4	4	16	8	26	20	55	29	21

Appendix 2d. (continued)

Pit	Horizon	USDA Textural Class	VCS	CS	MS	FS	VFS	Total Sand	CSI	MSI	FSI	Total Silt	Total Clay	CF
		†	--					%					--	weight %
VA1-1	A	SL	4	6	13	27	11	61	9	13	5	27	12	32
VA1-1	C	L	8	8	12	12	8	48	11	16	4	31	21	52
VA1-1	Cd1	L	9	7	9	11	8	43	11	20	8	39	18	52
VA1-1	Cd2	L	10	8	11	12	8	48	9	19	9	37	15	56
VA1-1	C'	L/SL	8	9	14	12	9	52	10	19	6	34	13	46
VA1-2	A	SL	7	8	15	17	9	56	9	17	6	33	12	44
VA1-2	C1	SL	9	10	21	20	9	68	7	13	3	23	8	63
VA1-2	C2	SL	9	11	19	15	8	61	10	16	5	31	8	60
VA1-2	C3	SL	11	13	21	18	8	71	7	12	3	21	8	73
VA2-1	A	SL	10	8	13	16	8	54	9	18	6	33	13	46
VA2-1	C1	SL	20	15	11	13	9	68	9	12	1	22	10	73
VA2-1	C2	SL	28	18	12	11	6	75	7	10	0	17	8	85
VA2-2	A	L	9	8	11	12	9	49	10	17	8	35	16	25
VA2-2	C1	L	7	7	8	10	10	43	9	20	11	40	17	31
VA2-2	C2	SL	18	13	11	12	10	64	10	14	3	27	9	68
VA2-2	C3	SL	20	18	13	12	8	71	8	13	1	21	8	81
VA3-1	A	L	6	5	4	11	13	38	9	25	10	44	17	21
VA3-1	C1	SL	6	5	15	18	9	54	7	17	7	32	15	60
VA3-1	C2	L/SL	6	4	16	13	12	52	8	17	10	35	13	54
VA3-2	A	SL	13	11	10	11	9	54	8	19	9	36	10	58
VA3-2	Cd	L	13	9	8	8	7	47	9	23	8	40	13	60
VA3-2	C	SL	9	9	18	23	9	68	8	12	4	25	7	68

Appendix 2d. (continued)

Pit	Horizon	USDA Textural Class	VCS	CS	MS	FS	VFS	Total Sand	CSI	MSI	FSI	Total Silt	Total Clay	CF
		†	------------------------					%					------------------------	weight %
WV-1	A	L	14	13	9	7	5	47	10	18	7	35	17	51
WV-1	Bw	SL	15	12	10	10	7	55	7	18	7	32	13	73
WV-1	BC	SL	19	16	9	8	6	58	8	16	8	32	10	20
WV-1	C1	SL	21	13	9	8	6	58	8	16	5	29	12	§
WV-1	C2	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	98
WV-2	A	L	14	11	8	8	8	49	16	16	5	37	14	56
WV-2	Bw	L	14	8	7	10	13	51	10	17	8	35	13	57
WV-2	BC	SL	17	10	7	6	14	54	12	17	4	33	13	71
WV-2	C1	SL	15	11	7	7	13	53	10	19	7	36	11	70
WV-2	C2	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡§
WV-3	A	SL	19	14	9	10	7	59	9	15	4	28	13	42
WV-3	Bw	SL	15	12	10	11	9	57	10	16	7	32	11	66
WV-3	BC	SL	32	20	11	7	4	75	4	10	2	15	10	90
WV-3	C1	SL	24	21	12	8	5	70	4	12	5	20	10	76
WV-3	C2	SL	22	21	10	12	7	72	6	9	4	19	9	86

† SL, sandy loam; L, loam; CL, clay loam; SICL, silty clay loam; SIL, silt loam; LS, loamy sand.

‡ Insufficient fine earth fraction for analysis.

§ Measurements not taken.

Appendix 3. Statistical summary for pH; electrical conductivity (EC); sand, silt, and clay; exchangleable magnesium (Mg), potassium (K), calcium (Ca), and manganese (Mn); aluminum (Al), zinc (Zn), copper (Cu), iron (Fe), and boron (B); cation exchange capacity (CEC); base saturation (BS); extractable phosphorus (P); rock fragments (CF); nitrogen (N); carbon (C); topsoil depth; bulk density (D_b); and total sandstone (SS) for composite samples by block, site, and sample depth.

Site	Block	Sample†	Variable	Units	Mean	Std Dev	Std Error	N
OH	1	0	pH		4.9	0.2	0.1	9
			EC	dS m^{-1}	0.1	0.1	0.0	9
			sand	%	30	3	1	9
			silt	%	44	3	1	9
			clay	%	27	2	1	9
			Mg	mg kg^{-1}	242	38	13	9
			K	mg kg^{-1}	133	11	4	9
			Ca	mg kg^{-1}	1180	261	87	9
			Mn	mg kg^{-1}	17	5	2	9
			Al	$cmol_c$ kg^{-1}	1.2	0.5	0.2	8
			Zn	mg kg^{-1}	1.5	0.2	0.1	9
			Cu	mg kg^{-1}	1.5	0.3	0.1	9
			Fe	mg kg^{-1}	41.2	7.6	2.5	9
			B	mg kg^{-1}	0.2	0.0	0.0	9
			CEC	$cmol_c$ kg^{-1}	9	1	0	9
			BS	%	89	7	2	9
			P	mg kg^{-1}	10.3	3.6	1.2	9
			CF	weight %	6	2	1	9
			N	%	1256	142	47	9
			C	%	15844	1974	658	9
			C:N		13	1	0	9
			Topsoil depth	cm	26	6	2	9
			D_b	g cm^{-3}	1.5	0.1	0.0	9
			Total SS	%	14.4	7.3	2.4	9
OH	1	2	pH		6.9	0.7	0.2	9.0
			EC	dS m^{-1}	0.3	0.2	0.1	9.0
			sand	%	20	4	1	9
			silt	%	50	3	1	9
			clay	%	29	2	1	9
			Mg	mg kg^{-1}	268	45	15	9
			K	mg kg^{-1}	106	16	5	9
			Ca	mg kg^{-1}	2745	967	322	9
			Mn	mg kg^{-1}	4	3	1	9
			Al	$cmol_c$ kg^{-1}	0.1	0.1	0.1	4
			Zn	mg kg^{-1}	2.5	1.3	0.4	9
			Cu	mg kg^{-1}	1.8	1.5	0.5	9
			Fe	mg kg^{-1}	43.4	35.9	12.0	9
			B	mg kg^{-1}	0.8	0.2	0.1	9
			CEC	$cmol_c$ kg^{-1}	16	5	2	9
			BS	%	100	0	0	9
			P	mg kg^{-1}	†	†	†	0
			CF	weight %	25	9	3	9
			N	%	489	78	26	9
			C	%	8900	7284	2428	9
			C:N		17	11	4	9
			D_b	g cm^{-3}	2	0	0	5
			Total SS	%	19	13	4	9

Appendix 3. (continued)

Site	Block	Sample†	Variable		Mean	Std Dev	Std Error	N
OH	2	0	pH		5.2	0.3	0.1	9
			EC	dS m^{-1}	0.1	0.0	0.0	9
			sand	%	41	6	2	9
			silt	%	39	4	1	9
			clay	%	20	3	1	9
			Mg	mg kg^{-1}	255	68	23	9
			K	mg kg^{-1}	114	10	3	9
			Ca	mg kg^{-1}	961	185	62	9
			Mn	mg kg^{-1}	22	8	3	9
			Al	$cmol_c$ kg^{-1}	0.6	0.3	0.1	8
			Zn	mg kg^{-1}	1.5	0.3	0.1	9
			Cu	mg kg^{-1}	1.2	0.4	0.1	9
			Fe	mg kg^{-1}	35.7	4.4	1.5	9
			B	mg kg^{-1}	0.2	0.0	0.0	9
			CEC	$cmol_c$ kg^{-1}	8	1	0	9
			BS	%	93	5	2	9
			P	mg kg^{-1}	7.7	2.4	0.8	9
			CF	weight %	7	3	1	9
			N	%	1167	235	78	9
			C	%	14200	2935	978	9
			C:N		12	1	0	9
			Topsoil depth	cm	16	2	1	9
			D_b	g cm^{-3}	1.4	0.1	0.0	9
			Total SS	%	27.2	32.6	10.9	9
OH	2	2	pH		6.1	0.5	0.2	9
			EC	dS m^{-1}	0.6	0.3	0.1	9
			sand	%	31	10	3	9
			silt	%	45	8	3	9
			clay	%	24	3	1	9
			Mg	mg kg^{-1}	260	51	17	9
			K	mg kg^{-1}	82	20	7	9
			Ca	mg kg^{-1}	2145	832	277	9
			Mn	mg kg^{-1}	5	3	1	9
			Al	$cmol_c$ kg^{-1}	0.1	0.1	0.0	8
			Zn	mg kg^{-1}	2.4	0.2	0.1	9
			Cu	mg kg^{-1}	2.4	0.4	0.1	9
			Fe	mg kg^{-1}	74.6	13.9	4.6	9
			B	mg kg^{-1}	0.6	0.2	0.1	9
			CEC	$cmol_c$ kg^{-1}	13	4	1	9
			BS	%	99	0	0	9
			P	mg kg^{-1}	3.8	2.3	1.6	2
			CF	weight %	18	4	1	9
			N	%	522	192	64	9
			C	%	8622	9060	3020	9
			C:N		13	4	1	9
			D_b	g cm^{-3}	1.6	0.2	0.1	8
			Total SS	%	21.7	16.2	5.4	9

Appendix 3. (continued)

Site	Block	Sample†	Variable		Mean	Std Dev	Std Error	N
OH	3	0	pH		6.1	0.4	0.1	9
			EC	dS m^{-1}	0.1	0.1	0.0	9
			sand	%	34	3	1	9
			silt	%	42	1	0	9
			clay	%	24	2	1	9
			Mg	mg kg^{-1}	215	37	12	9
			K	mg kg^{-1}	146	20	7	9
			Ca	mg kg^{-1}	1367	289	96	9
			Mn	mg kg^{-1}	6	3	1	9
			Al	$cmol_c$ kg^{-1}	0.1	0.1	0.0	9
			Zn	mg kg^{-1}	1.5	0.4	0.1	9
			Cu	mg kg^{-1}	1.5	0.3	0.1	9
			Fe	mg kg^{-1}	44.7	8.2	2.7	9
			B	mg kg^{-1}	0.4	0.1	0.0	9
			CEC	$cmol_c$ kg^{-1}	9	2	1	9
			BS	%	99	1	0	9
			P	mg kg^{-1}	5.4	2.9	1.0	9
			CF	weight %	10	1	0	9
			N	%	1167	180	60	9
			C	%	14633	2404	801	9
			C:N		12	1	0	9
			Topsoil depth	cm	20	6	2	9
			D_b	g cm^{-3}	1.3	0.0	0.0	9
			Total SS	%	27.2	16.8	5.6	9
OH	3	1	pH		6.5	0.4	0.2	3
			EC	dS m^{-1}	0.3	0.2	0.1	3
			sand	%	25	3	2	3
			silt	%	44	4	3	3
			clay	%	31	2	1	3
			Mg	mg kg^{-1}	259	60	35	3
			K	mg kg^{-1}	94	10	6	3
			Ca	mg kg^{-1}	1794	306	176	3
			Mn	mg kg^{-1}	3	2	1	3
			Al	$cmol_c$ kg^{-1}	0.0	0.0	0.0	2
			Zn	mg kg^{-1}	2.0	0.3	0.2	3
			Cu	mg kg^{-1}	2.7	0.1	0.0	3
			Fe	mg kg^{-1}	43.8	13.7	7.9	3
			B	mg kg^{-1}	0.6	0.1	0.1	3
			CEC	$cmol_c$ kg^{-1}	11	1	1	3
			BS	%	100	0	0	3
			P	mg kg^{-1}	2.5	0.1	0.1	2
			CF	weight %	12	2	1	3
			N	%	‡	‡	‡	0
			C	%	‡	‡	‡	0
			C:N		‡	‡	‡	0
			D_b	g cm^{-3}	‡	‡	‡	0
			Total SS	%	5.0	8.7	5.0	3

Appendix 3. (continued)

Site	Block	Sample†	Variable		Mean	Std Dev	Std Error	N
OH	3	2	pH		6.9	0.4	0.1	9
			EC	dS m^{-1}	0.5	0.3	0.1	9
			sand	%	21	5	2	9
			silt	%	48	3	1	9
			clay	%	31	3	1	9
			Mg	mg kg^{-1}	305	69	23	9
			K	mg kg^{-1}	103	11	4	9
			Ca	mg kg^{-1}	2266	659	220	9
			Mn	mg kg^{-1}	2	1	0	9
			Al	$cmol_c$ kg^{-1}	0.0	0.0	0.0	3
			Zn	mg kg^{-1}	2.5	0.5	0.2	9
			Cu	mg kg^{-1}	2.8	0.6	0.2	9
			Fe	mg kg^{-1}	59.7	19.0	6.3	9
			B	mg kg^{-1}	0.9	0.2	0.1	9
			CEC	$cmol_c$ kg^{-1}	14	4	1	9
			BS	%	100	0	0	9
			P	mg kg^{-1}	2.9	.	.	1
			CF	weight %	16	4	1	9
			N	%	433	50	17	9
			C	%	4956	1305	435	9
			C:N		11	2	1	9
			D_b	g cm^{-3}	1.5	0.2	0.1	4
			Total SS	%	8.9	15.4	5.1	9
VA	1	0	pH		4.7	0.3	0.1	9
			EC	dS m^{-1}	0.2	0.1	0.0	9
			sand	%	52	5	2	9
			silt	%	36	5	2	9
			clay	%	12	1	0	9
			Mg	mg kg^{-1}	220	39	13	9
			K	mg kg^{-1}	85	23	8	9
			Ca	mg kg^{-1}	527	128	43	9
			Mn	mg kg^{-1}	39	9	3	9
			Al	$cmol_c$ kg^{-1}	0.8	0.5	0.2	9
			Zn	mg kg^{-1}	1.7	0.4	0.1	9
			Cu	mg kg^{-1}	1.9	0.5	0.2	9
			Fe	mg kg^{-1}	43.6	9.9	3.3	9
			B	mg kg^{-1}	0.1	0.0	0.0	9
			CEC	$cmol_c$ kg^{-1}	5	1	0	9
			BS	%	85	10	3	9
			P	mg kg^{-1}	10.0	10.5	3.5	9
			CF	weight %	32	4	1	9
			N	%	589	117	39	9
			C	%	11533	3147	1049	9
			C:N		19	3	1	9
			Topsoil depth	cm	23	7	2	9
			D_b	g cm^{-3}	1.1	0.2	0.1	9
			Total SS	%	72.8	31.5	10.5	9

Appendix 3. (continued)

Site	Block	Sample†	Variable		Mean	Std Dev	Std Error	N
VA	1	1	pH		4.9	0.4	0.2	4
			EC	dS m^{-1}	0.3	0.1	0.1	4
			sand	%	48	3	2	4
			silt	%	38	2	1	4
			clay	%	15	2	1	4
			Mg	mg kg^{-1}	280	52	26	4
			K	mg kg^{-1}	68	10	5	4
			Ca	mg kg^{-1}	735	216	108	4
			Mn	mg kg^{-1}	29	17	9	4
			Al	$cmol_c$ kg^{-1}	0.5	0.7	0.3	4
			Zn	mg kg^{-1}	2.5	0.4	0.2	4
			Cu	mg kg^{-1}	2.8	0.3	0.1	4
			Fe	mg kg^{-1}	56.2	13.2	6.6	4
			B	mg kg^{-1}	0.1	0.0	0.0	4
			CEC	$cmol_c$ kg^{-1}	6.7	0.8	0.4	4
			BS	%	90.9	12.4	6.2	4
			P	mg kg^{-1}	5.3	1.3	0.9	2
			CF	weight %	34	4	2	4
			N	%	550	71	50	2
			C	%	13350	495	350	2
			C:N		23	2	2	2
			D_b	g cm^{-3}	1.4	.	.	1
			Total SS	%	92.5	2.9	1.4	4
VA	1	2	pH		6.8	0.7	0.2	7
			EC	dS m^{-1}	0.2	0.0	0.0	7
			sand	%	60	4	1	7
			silt	%	30	3	1	7
			clay	%	10	2	1	7
			Mg	mg kg^{-1}	149	34	13	7
			K	mg kg^{-1}	58	6	2	7
			Ca	mg kg^{-1}	922	92	35	7
			Mn	mg kg^{-1}	5	4	1	7
			Al	$cmol_c$ kg^{-1}	0.0	0.0	0.0	3
			Zn	mg kg^{-1}	5.1	1.0	0.4	7
			Cu	mg kg^{-1}	2.9	0.1	0.0	7
			Fe	mg kg^{-1}	102.8	15.5	5.9	7
			B	mg kg^{-1}	0.1	0.0	0.0	7
			CEC	$cmol_c$ kg^{-1}	6	0	0	7
			BS	%	100	0	0	7
			P	mg kg^{-1}	4.7	1.0	0.5	5
			CF	weight %	50	5	2	7
			N	%	586	69	26	7
			C	%	18800	4514	1706	7
			C:N		32	7	3	7
			D_b	g cm^{-3}	1.4	0.2	0.1	4
			Total SS	%	81.4	26.1	9.9	7

Appendix 3. (continued)

Site	Block	Sample†	Variable		Mean	Std Dev	Std Error	N
VA	2	0	pH		6.3	0.4	0.1	9
			EC	dS m^{-1}	0.3	0.1	0.0	9
			sand	%	49	5	2	9
			silt	%	38	4	1	9
			clay	%	13	2	1	9
			Mg	mg kg^{-1}	252	42	14	9
			K	mg kg^{-1}	84	17	6	9
			Ca	mg kg^{-1}	847	86	29	9
			Mn	mg kg^{-1}	11	6	2	9
			Al	$cmol_c$ kg^{-1}	0.0	0.0	0.0	8
			Zn	mg kg^{-1}	3.3	0.5	0.2	9
			Cu	mg kg^{-1}	2.9	0.3	0.1	9
			Fe	mg kg^{-1}	73.2	6.5	2.2	9
			B	mg kg^{-1}	0.1	0.1	0.0	9
			CEC	$cmol_c$ kg^{-1}	7	1	0	9
			BS	%	100	0	0	9
			P	mg kg^{-1}	10.1	2.5	0.8	9
			CF	weight %	64	13	4	9
			N	%	1000	166	55	9
			C	%	24267	3832	1277	9
			C:N		25	2	1	9
			Topsoil depth	cm	36	7	2	9
			D_b	g cm^{-3}	1.2	0.3	0.1	9
			Total SS	%	46.7	29.9	10.0	9
VA	2	1	pH		6.7	0.7	0.4	3
			EC	dS m^{-1}	0.5	0.1	0.1	3
			sand	%	54	3	2	3
			silt	%	34	1	1	3
			clay	%	12	4	2	3
			Mg	mg kg^{-1}	241	27	16	3
			K	mg kg^{-1}	61	9	5	3
			Ca	mg kg^{-1}	1107	188	109	3
			Mn	mg kg^{-1}	2	1	1	3
			Al	$cmol_c$ kg^{-1}	0.0	.	.	1
			Zn	mg kg^{-1}	3.9	0.8	0.5	3
			Cu	mg kg^{-1}	3.2	0.6	0.4	3
			Fe	mg kg^{-1}	88.6	16.5	9.5	3
			B	mg kg^{-1}	0.1	0.0	0.0	3
			CEC	$cmol_c$ kg^{-1}	8	1	1	3
			BS	%	100	0	0	3
			P	mg kg^{-1}	3.5	.	.	1
			CF	weight %	42	7	4	3
			N	%	‡	‡	‡	0
			C	%	‡	‡	‡	0
			C:N		‡	‡	‡	0
			D_b	g cm^{-3}	‡	‡	‡	0
			Total SS	%	63	20	12	3

Appendix 3. (continued)

Site	Block	Sample†	Variable		Mean	Std Dev	Std Error	N
VA	2	2	pH		7.6	0.2	0.1	9
			EC	dS m^{-1}	0.3	0.1	0.0	9
			sand	%	60	4	1	9
			silt	%	30	3	1	9
			clay	%	10	2	1	9
			Mg	mg kg^{-1}	233	35	12	9
			K	mg kg^{-1}	84	13	4	9
			Ca	mg kg^{-1}	1061	169	56	9
			Mn	mg kg^{-1}	4	0	0	9
			Al	$cmol_c$ kg^{-1}	‡	‡	‡	0
			Zn	mg kg^{-1}	7.7	1.4	0.5	9
			Cu	mg kg^{-1}	5.2	0.9	0.3	9
			Fe	mg kg^{-1}	194.1	35.6	11.9	9
			B	mg kg^{-1}	0.2	0.1	0.0	9
			CEC	$cmol_c$ kg^{-1}	7	1	0	9
			BS	%	100	0	0	9
			P	mg kg^{-1}	4.4	2.0	0.8	6
			CF	weight %	63	9	3	9
			N	%	789	127	42	9
			C	%	29033	5296	1765	9
			C:N		36	4	1	9
			D_b	g cm^{-3}	‡	‡	‡	0
			Total SS	%	20.0	27.0	9.0	9
VA	3	0	pH		6.4	0.6	0.2	9
			EC	dS m^{-1}	0.4	0.1	0.0	9
			sand	%	52	4	1	9
			silt	%	35	4	1	9
			clay	%	12	2	1	9
			Mg	mg kg^{-1}	258	20	7	9
			K	mg kg^{-1}	83	14	5	9
			Ca	mg kg^{-1}	565	141	47	9
			Mn	mg kg^{-1}	8	8	3	9
			Al	$cmol_c$ kg^{-1}	0.0	0.0	0.0	6
			Zn	mg kg^{-1}	4.4	1.1	0.4	9
			Cu	mg kg^{-1}	2.3	0.4	0.1	9
			Fe	mg kg^{-1}	107.8	22.6	7.5	9
			B	mg kg^{-1}	0.1	0.1	0.0	9
			CEC	$cmol_c$ kg^{-1}	5	1	0	9
			BS	%	100	0	0	9
			P	mg kg^{-1}	13.8	7.5	2.5	9
			CF	weight %	52	4	1	9
			N	%	667	180	60	9
			C	%	20689	6771	2257	9
			C:N		29	4	1	9
			Topsoil depth	cm	‡	‡	‡	0
			D_b	g cm^{-3}	1.3	0.2	0.1	9
			Total SS	%	65.0	27.8	9.3	9

Appendix 3. (continued)

Site	Block	Sample†	Variable		Mean	Std Dev	Std Error	N
VA	3	3	pH		6.31	0.58	0.19	9
			EC	dS m^{-1}	0.27	0.06	0.02	9
			sand	%	54	5	2	9
			silt	%	35	3	1	9
			clay	%	11	3	1	9
			Mg	mg kg^{-1}	229	21	7	9
			K	mg kg^{-1}	68	8	3	9
			Ca	mg kg^{-1}	451	122	41	9
			Mn	mg kg^{-1}	10	8	3	9
			Al	$cmol_c$ kg^{-1}	0.0	0.1	0.0	7
			Zn	mg kg^{-1}	3.9	1.1	0.4	9
			Cu	mg kg^{-1}	2.0	0.3	0.1	9
			Fe	mg kg^{-1}	117.7	38.9	13.0	9
			B	mg kg^{-1}	0.1	0.0	0.0	9
			CEC	$cmol_c$ kg^{-1}	4	1	0	9
			BS	%	99	2	1	9
			P	mg kg^{-1}	6.1	1.5	0.6	6
			CF	weight %	57	4	1	9
			N	%	556	133	44	9
			C	%	16389	5747	1916	9
			C:N		28	5	2	9
			D_b	g cm^{-3}	‡	‡	‡	0
			Total SS	%	73.3	25.1	8.4	9
WV	1	0	pH		5.9	0.2	0.1	9
			EC	dS m^{-1}	0.2	0.1	0.0	9
			sand	%	59	4	1	9
			silt	%	33	3	1	9
			clay	%	7	1	0	9
			Mg	mg kg^{-1}	388	37	12	9
			K	mg kg^{-1}	164	35	12	9
			Ca	mg kg^{-1}	1026	128	43	9
			Mn	mg kg^{-1}	20	5	2	9
			Al	$cmol_c$ kg^{-1}	0.1	0.0	0.0	9
			Zn	mg kg^{-1}	3.1	0.4	0.1	9
			Cu	mg kg^{-1}	1.4	0.2	0.1	9
			Fe	mg kg^{-1}	37.5	3.2	1.1	9
			B	mg kg^{-1}	0.3	0.0	0.0	9
			CEC	$cmol_c$ kg^{-1}	9	1	0	9
			BS	%	99	0	0	9
			P	mg kg^{-1}	20.1	5.8	1.9	9
			CF	weight %	54	5	2	9
			N	%	2778	507	169	9
			C	%	36589	8353	2784	9
			C:N		13	1	0	9
			Topsoil depth	cm	0	0	0	9
			D_b	g cm^{-3}	1.1	0.1	0.0	9
			Total SS	%	9.4	8.1	2.7	9

Appendix 3. (continued)

Site	Block	Sample†	Variable		Mean	Std Dev	Std Error	N
WV	1	1	pH		6.7	0.2	0.1	9
			EC	dS m^{-1}	0.1	0.0	0.0	9
			sand	%	53	3	1	9
			silt	%	37	3	1	9
			clay	%	9	1	0	9
			Mg	mg kg^{-1}	285	30	10	9
			K	mg kg^{-1}	79	6	2	9
			Ca	mg kg^{-1}	815	127	42	9
			Mn	mg kg^{-1}	4	1	0	9
			Al	$cmol_c$ kg^{-1}	0.0	0.0	0.0	7
			Zn	mg kg^{-1}	2.6	0.7	0.2	9
			Cu	mg kg^{-1}	1.9	0.3	0.1	9
			Fe	mg kg^{-1}	42.2	2.7	0.9	9
			B	mg kg^{-1}	0.2	0.0	0.0	9
			CEC	$cmol_c$ kg^{-1}	7	1	0	9
			BS	%	100	0	0	9
			P	mg kg^{-1}	7.1	4.4	1.5	9
			CF	weight %	59	5	2	9
			N	%	1200	173	58	9
			C	%	18900	4496	1499	9
			C:N		15	1	0	9
			D_b	g cm^{-3}	‡	‡	‡	0
			Total SS	%	10.6	9.8	3.3	9
WV	2	0	pH		5.7	0.1	0.0	9
			EC	dS m^{-1}	0.2	0.0	0.0	9
			sand	%	63	3	1	9
			silt	%	28	3	1	9
			clay	%	8	2	1	9
			Mg	mg kg^{-1}	402	23	8	9
			K	mg kg^{-1}	154	30	10	9
			Ca	mg kg^{-1}	902	70	23	9
			Mn	mg kg^{-1}	16	4	1	9
			Al	$cmol_c$ kg^{-1}	0.2	0.0	0.0	9
			Zn	mg kg^{-1}	3.5	0.6	0.2	9
			Cu	mg kg^{-1}	1.4	0.1	0.0	9
			Fe	mg kg^{-1}	49.6	3.6	1.2	9
			B	mg kg^{-1}	0.3	0.1	0.0	9
			CEC	$cmol_c$ kg^{-1}	8	1	0	9
			BS	%	98	0	0	9
			P	mg kg^{-1}	20.8	4.5	1.5	9
			CF	weight %	55	3	1	9
			N	%	2567	487	162	9
			C	%	30600	5259	1753	9
			C:N		12	1	0	9
			Topsoil depth	cm	0	0	0	9
			D_b	g cm^{-3}	1.0	0.3	0.1	9
			Total SS	%	7.2	4.4	1.5	9

Appendix 3. (continued)

Site	Block	Sample†	Variable		Mean	Std Dev	Std Error	N
WV	2	1	pH		6.0	0.5	0.2	9
			EC	dS m^{-1}	0.1	0.0	0.0	9
			sand	%	56	2	1	9
			silt	%	33	2	1	9
			clay	%	11	2	1	9
			Mg	mg kg^{-1}	319	15	5	9
			K	mg kg^{-1}	91	18	6	9
			Ca	mg kg^{-1}	592	72	24	9
			Mn	mg kg^{-1}	8	3	1	9
			Al	$cmol_c$ kg^{-1}	0.1	0.1	0.0	9
			Zn	mg kg^{-1}	2.8	0.2	0.1	9
			Cu	mg kg^{-1}	1.9	0.3	0.1	9
			Fe	mg kg^{-1}	53.4	6.8	2.3	9
			B	mg kg^{-1}	0.2	0.0	0.0	9
			CEC	$cmol_c$ kg^{-1}	6	0	0	9
			BS	%	99	2	1	9
			P	mg kg^{-1}	6.7	2.2	0.8	8
			CF	weight %	62	5	2	9
			N	%	1022	97	32	9
			C	%	13178	1370	457	9
			C:N		13	1	0	9
			D_b	g cm^{-3}	‡	‡	‡	0
			Total SS	%	6.7	4.3	1.4	9
WV	3	0	pH		5.5	0.2	0.1	9
			EC	dS m^{-1}	0.2	0.1	0.0	9
			sand	%	59	3	1	9
			silt	%	32	2	1	9
			clay	%	9	2	1	9
			Mg	mg kg^{-1}	357	49	16	9
			K	mg kg^{-1}	168	25	8	9
			Ca	mg kg^{-1}	847	97	32	9
			Mn	mg kg^{-1}	22	5	2	9
			Al	$cmol_c$ kg^{-1}	0.3	0.1	0.0	9
			Zn	mg kg^{-1}	3.8	0.6	0.2	9
			Cu	mg kg^{-1}	1.6	0.2	0.1	9
			Fe	mg kg^{-1}	43.3	8.6	2.9	9
			B	mg kg^{-1}	0.2	0.0	0.0	9
			CEC	$cmol_c$ kg^{-1}	8	1	0	9
			BS	%	97	1	0	9
			P	mg kg^{-1}	18.0	6.6	2.2	9
			CF	weight %	46	4	1	9
			N	%	2811	298	99	9
			C	%	34900	4389	1463	9
			C:N		13	1	0	9
			Topsoil depth	cm	0	0	0	9
			D_b	g cm^{-3}	1.2	0.2	0.1	9
			Total SS	%	10.6	5.8	1.9	9

Appendix 3. (continued)

Site	Block	Sample†	Variable		Mean	Std Dev	Std Error	N
WV	3	1	pH		5.9	0.4	0.1	9
			EC	dS m^{-1}	0.1	0.0	0.0	9
			sand	%	51	2	1	9
			silt	%	36	1	0	9
			clay	%	12	2	1	9
			Mg	mg kg^{-1}	299	25	8	9
			K	mg kg^{-1}	78	10	3	9
			Ca	mg kg^{-1}	612	140	47	9
			Mn	mg kg^{-1}	10	4	1	9
			Al	$cmol_c$ kg^{-1}	0.1	0.2	0.1	9
			Zn	mg kg^{-1}	2.6	0.4	0.1	9
			Cu	mg kg^{-1}	2.3	0.2	0.1	9
			Fe	mg kg^{-1}	44.3	4.7	1.6	9
			B	mg kg^{-1}	0.1	0.0	0.0	9
			CEC	$cmol_c$ kg^{-1}	6	1	0	9
			BS	%	97	4	1	9
			P	mg kg^{-1}	4.7	1.9	0.7	7
			CF	weight %	53	5	2	9
			N	%	1022	97	32	9
			C	%	13511	2347	782	9
			C:N		13	2	1	9
			D_b	g cm^{-3}	‡	‡	‡	0
			Total SS	%	12.2	6.7	2.2	9

† 0 = 0 - 10 cm, 1 = 10 - 30 cm, 2 = suboil, 3 = 10 - 30 cm + subsoil.

‡ Insufficient observations recorded.

Appendix 4a. Shallow soil pit descriptions of horizon, depth, texture, color, structure, roots, moist consistence, vegetation, slope and aspect of mine sites in Ohio.

Site: OH 1 Describer: CNC

Plot # and Hole ID: 1 C

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	20	ss/sis	fg/mg	20	g	L	2.5Y	6	4	wk	sbk	f	m	fr
	C	28	ss/sis	fg/mg/cg	40	vg	L	2.5Y	5	4	sl	ma	-	c	fr
	2C	44+	ss/sis	fg/mg	15	g	SiCL	2.5Y	5	2	sl	ma	-	f	fr

Comments:

Vegetation: lespadeza

Slope and Aspect: 2% and 56

Site: OH 1 Describer: ATJ

Plot # and Hole ID: 1 D

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	37	ss/sis	fg/mg	15	g	SCL	2.5Y	5	4	wk	sbk	m	m	fr
	2C	43+	ss/sis	mg/cg	30	g	L	2.5Y	4	2	sl	ma	-	c	fr

Comments:

Vegetation: lespadeza, fescue, red clover

Slope and Aspect: 2% and 2

Site: OH 1 Describer: ATJ

Plot # and Hole ID: 1 E

Date: 29 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	-	10YR	3	2	wk	gr	f	m	vfr
	Bw	18	sis/ss	fg/mg	15	g	L	2.5Y	5	4	wk	sbk	c	m	fr
	2C	50+	sis/ss	mg/cg	15	g	L	2.5Y	4	2	sl	ma	-	c	fr

Comments:

Vegetation: goldenrod, lespadeza, fescue, clover

Slope and Aspect: 5% and 32

Appendix 4a. (continued)

Site: OH 1 Describer: CNC

Plot # and Hole ID: 2 B

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	4	2	wk	gr	f	m	vfr
	Bw	26	ss/sis	fg/mg/cg	25	g	L	2.5Y	5	4	wk	sbk	m	m	fr
	C	51	sis/ss	fg/mg	20	g	L	2.5Y	5	6	sl	ma	-	f	fr
	2C	59+	ss/sis	fg/mg	15	g	L	2.5Y	4	2	sl	ma	-	none	fr

Comments:

Vegetation: lespadeza, goldenrod, white clover

Slope and Aspect: 7% and 56

Site: OH 1 Describer: ATJ

Plot # and Hole ID: 2 C

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	23	ss	fg/mg	10	-	L	10YR	5	4	wk	sbk	m	c	fr
	2C	35+	ss/sis	cg	50	vg	L	2.5Y	7	2	sl	ma	-	c	fr

Comments:

Vegetation: lespadeza, fescue, red clover, broomstraw, goldenrod

Slope and Aspect: 8% and 302

Site: OH 1 Describer: ATJ

Plot # and Hole ID: 2 D

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	18	ss	fg/mg	10	-	SCL	10YR	6	4	wk	sbk	c	m	fr
	C	36	ss/sis	fg/mg	20	g	L	2.5Y	6	4	sl	ma	-	c	fr
	2C	44+	ss/sis	fg/mg	20	g	L	2.5Y	6	1	sl	ma	-	c	fr

Comments:

Vegetation: goldenrod, orchard grass, clover

Slope and Aspect: 10% and 287

Appendix 4a. (continued)

Site: OH 1 Describer: ATJ

Plot # and Hole ID: 3 A

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	24	ss	fg/mg	10	-	L	10YR	5	6	wk	sbk	c	m	fr
	2C	41+	sis	mg/cg	25	g	SCL	2.5Y	5	2	sl	ma	-	c	fr

Comments:

Vegetation: lespadeza, goldenrod, clover, fescue

Slope and Aspect: 6% and 319

Site: OH 1 Describer: ATJ

Plot # and Hole ID: 3 C

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	26	ss/sis	fg/mg	10	-	SCL	2.5Y	5	4	wk	sbk	m	m - c	fr
	C	41	ss	fg/mg	10	-	CL	10YR	5	6	sl	ma	-	c	fr
	2C	52+	ss/sis	mg/cg	30	g	L	2.5Y	5	1	sl	ma	-	c	fr

Comments: Bw texture is of fine sand
C horizon has few clay films and slickensides

Vegetation: lespadeza, fescue, goldenrod, bull rush

Slope and Aspect: 6% and 22

Site: OH 1 Describer: ATJ

Plot # and Hole ID: 3 D

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	1	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	28	ss/sis	fg/mg	15	g	L	2.5Y	5	4	wk	sbk	c	m	fr
	2C	39+	sis	mg	30	g	L	2.5Y	5	1	sl	ma	-	f	fr

Comments:

Vegetation: goldenrod, clover, red maple, fescue, timothy

Slope and Aspect: 5% and 353

Appendix 4a. (continued)

Site: OH 1 Describer: CNC

Plot # and Hole ID: 4 A

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	13	ss	fg	5	-	L	10YR	5	4	wk	sbk	m	m	fr
	2C	30+	sis/ss	fg/mg	25	g	L	2.5Y	5	2	sl	ma	-	c	fr

Comments:

Vegetation:

Slope and Aspect:

Site: OH 1 Describer: BA

Plot # and Hole ID: 4 B

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	20	ss/sis	fg/mg/ch	10	-	L	10YR	5	6	wk	sbk	f	c	vfr
	2C	34+	ss/sis	fg/mg/ch	70	eg	CL	5Y	5	1	sl	ma	-	none	fr

Comments:

Vegetation: fescue, goldenrod, broomstraw, clover

Slope and Aspect: flat

Site: OH 1 Describer: BA

Plot # and Hole ID: 4 E

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	18	ss	fg/mg	5	-	CL	10YR	6	6	wk	sbk	m	f	fr
	2C	30+	sis	fg/mg/cg	30	g	SiL	2.5Y	5	2	sl	ma	-	none	fi

Comments:

Vegetation: goldenrod, clover, orchard grass, fescue, bull rush, broomstraw

Slope and Aspect: flat

Appendix 4a. (continued)

Site: OH 1 Describer: CNC

Plot # and Hole ID: 5 B

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	28	ss/sis	mg/cg	30	g	L	2.5Y	5	3	wk	sbk	m	c	fr
	2C	42+	ss/sis	fg/mg/cg	50	vg	L	2.5Y	5	2	sl	ma	-	f	fr

Comments:

Vegetation: fescue, orchard grass, clover, goldenrod

Slope and Aspect:

Site: OH 1 Describer: CNC

Plot # and Hole ID: 5 C

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	13	sis	fg/mg	5	-	L	10YR	5	6	mo	sbk	m	m	fr
	2C	16+	sis/lis	cb	85	ecb	L	2.5Y	5	2	sl	ma	-	c	fr

Comments:

Vegetation: fescue, goldenrod, lespadeza

Slope and Aspect: 4% and 16

Site: OH 1 Describer: ATJ

Plot # and Hole ID: 5 E

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	24	ss/sis	mg	10	-	L	10YR	5	6	wk	sbk	m	m	fr
	2C	42+	sis/ss	fg/mg	25	g	SiL	2.5Y	5	2	sl	ma	-	f	fr

Comments: 4 m towards plot 4

Vegetation: goldenrod, clover, fescue, blackberry

Slope and Aspect: flat

Appendix 4a. (continued)

Site: OH 1 Describer: CNC

Plot # and Hole ID: 6 B

Date: 29 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	-	-	-	-	L	10YR	3	2	mo	gr	f	m	vfr
	Bw	13	sis	fg	5	-	CL	10YR	5	4	wk	sbk	f	m	fr
	2C	33+	sis	fg/mg/cg	60	vg	L	2.5Y	5	2	sl	ma	-	c	fr

Comments:

Vegetation: fescue, orchard grass, clover, timothy, cinquefoil

Slope and Aspect: 3% and 29

Site: OH 1 Describer: CNC

Plot # and Hole ID: 6 C

Date: 29 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	1	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	17	ss/sis	fg/mg	15	g	L	2.5Y	6	4	mo	sbk	m	c	fr
	2C	24+	lis	fg/mg/cg	85	eg	L	5Y	4	1	sl	ma	-	f	fr

Comments:

Vegetation: fescue, goldenrod, lespadeza, red clover

Slope and Aspect: flat

Site: OH 1 Describer: CNC

Plot # and Hole ID: 6 D

Date: 29 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	21	sis	fg/mg	15	g	L	10YR	5	4	mo	sbk	f	m	fr
	2C	31+	lis	mg/cg/cb	75	eg	L	5Y	5	2	sl	ma	-	c	fr

Comments:

Vegetation: clover, fescue, orchard grass

Slope and Aspect: flat

Appendix 4a. (continued)

Site: OH 1 Describer: CNC

Plot # and Hole ID: 7 A

Date: 29 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	mo	gr	f	m	vfr
	Bw	24	ss/sis	mg	15	g	L	10YR	5	4	wk	sbk	c	m	fr
	2C	38+	ss	mg	30	g	L	5Y	5	2	sl	ma	-	f	fr

Comments:

Vegetation: fescue, orchard grass, clover, lespadeza

Slope and Aspect: 4% and 26

Site: OH 1 Describer: CNC

Plot # and Hole ID: 7 B

Date: 29 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	mo	gr	f	m	vfr
	Bw	25	ss/sis	fg/mg	20	g	L	2.5Y	5	4	wk	sbk	c	m - c	fr
	2C	40+	ss/sis	fg/mg	20	g	L	5Y	5	1	sl	ma	-	f	fr

Comments:

Vegetation: fescue, goldenrod, lespadeza, red clover, orchard grass

Slope and Aspect: flat

Site: OH 1 Describer: CNC

Plot # and Hole ID: 7 D

Date: 29 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	21	ss	fg/mg/cg	20	g	CL	10YR	5	4	wk	sbk	m	m	fr
	2C	37+	sis/ss	fg/mg/cg	70	eg	L	2.5Y	5	2	sl	ma	-	f	fr

Comments:

Vegetation: fescue, lespadeza, goldenrod

Slope and Aspect: 4% and 62

Appendix 4a. (continued)

Site: OH 1 Describer: ATJ

Plot # and Hole ID: 8 A

Date: 29 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	19	ss/sis	fg/mg	5	-	SiCL	10YR	5	6	mo	sbk	m	m	fr
	BC	40	ss/sis	fg/mg	15	g	L	2.5Y	5	4	wk	sbk	c	c	fr
	2C	50+	ss/sis	fg/mg	20	g	L	2.5Y	5	2	sl	ma	-	f	fr

Comments:

Vegetation: lespadeza, goldenrod, downy brome

Slope and Aspect:

Site: OH 1 Describer: ATJ

Plot # and Hole ID: 8 D

Date: 29 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	mo	gr	f	m	vfr
	Bw	24	sis/ss	mg	10	-	L	2.5Y	5	3	wk	sbk	c	c	fr
	2C	33+	ss	mg/cg	60	vg	L	2.5Y	4	2	sl	ma	-	f	fr

Comments: Bw has many roots at top but few at bottom of horizon

Vegetation: fescue, lespadeza, white clover

Slope and Aspect: flat

Site: OH 1 Describer: ATJ

Plot # and Hole ID: 8 E

Date: 29 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	mo	gr	f	m	vfr
	Bw	19	ss	mg	10	-	SCL	2.5Y	5	6	wk	sbk	m	c	fr
	2C	37+	ss	mg/cg	35	vg	SCL	5Y	5	2	sl	ma	-	f	fr

Comments:

Vegetation: fescue, cinquefoil, white clover, timothy, orchard grass

Slope and Aspect:

Appendix 4a. (continued)

Site: OH 1 Describer: ATJ

Plot # and Hole ID: 9 B

Date: 29 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L				mo	gr	f	m	vfr
	Bw	12	ss	mg	2	-	L				wk	sbk	c	m	fr
	C1	27	ss	cg	2	-	CL				sl	ma	-	c	fi
	C2	40+	ss	cb	2	-	C				sl	ma	-	f	fi

Comments: rock at 40 cm

Vegetation: lespadeza, goldenrod, fescue, cinquefoil, white clover

Slope and Aspect: 4% and 232

Site: OH 1 Describer: ATJ

Plot # and Hole ID: 9 C

Date: 29 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	4	2	wk	gr	f	m	vfr
	Bw	20	sis	mg	5	-	L	10YR	5	4	wk	sbk	m	m	fr
	2C	40+	sis/ss	mg	15	g	L	2.5Y	5	2	sl	ma	-	c	fr

Comments: SS in C horizon is white

Vegetation: white clover, red clover, goldenrod

Slope and Aspect: 4% and 232

Site: OH 1 Describer: ATJ

Plot # and Hole ID: 9 D

Date: 29 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	mo	gr	f	m	vfr
	Bw	22	ss	mg	10	-	L	10YR	5	4	mo	sbk/pr	c	m	fr
	C1	36	ss	mg	5	-	L	2.5Y	5	3	sl	ma	-	c	fr
	2C	50+	ss/sis	mg	15	g	L	5Y	5	1	sl	ma	-	c	fr

Comments:

Vegetation: fescue, red maple, lespedeza, broomstraw

Slope and Aspect: 2% and 232

Appendix 4a. (continued)

Site: OH 2 Describer: ATJ

Plot # and Hole ID: 1 A

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	1	-	-	-	-	L	10YR	3	2	wk	gr	m	m	vfr
	Bw	11	ss	fg/mg	10	-	L	10YR	4	6	wk	sbk	f	m	fr
	2C	28	ss	mg/cg	20	g	L	2.5Y	5	1	sl	ma	-	c	fr

Comments:

Vegetation: lespadeza, fescue, orchardgrass

Slope and Aspect: flat

Site: OH 2 Describer: ATJ

Plot # and Hole ID: 1 B

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	1	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	16	ss	fg/mg	5	-	SL	10YR	5	6	wk	sbk	m	m	fr
	C	26	ss	mg	5	-	SCL	2.5Y	5	6	sl	ma	-	c	fr
	2C	38+	ss/sis	mg	20	g	L	2.5Y	5	4	sl	ma	-	c	fr

Comments:

Vegetation: goldenrod, blackberry, pin cherry, fescue

Slope and Aspect: 13% and 56

Site: OH 2 Describer: ATJ

Plot # and Hole ID: 1 D

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	15	ss	fg	2	-	SL	10YR	5	4	wk	sbk	f	m	fi
	C	27+	sis/ss	cg/cb	40	vg	L	2.5Y	5	2	sl	ma	-	f	fi

Comments:

Vegetation: fescue, blackberry, clover

Slope and Aspect: 2% and 254

Appendix 4a. (continued)

Site: OH 2 Describer: ATJ

Plot # and Hole ID: 2 A

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	1	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	12	ss	mg	2	-	SCL	10YR	5	8	wk	sbk	m	m	fr
	2C	39+	ss/sis	mg/cg	25	g	L	5Y	5	1	sl	ma	-	f	fr

Comments:

Vegetation: lespadeza, fescue

Slope and Aspect: flat

Site: OH 2 Describer: ATJ

Plot # and Hole ID: 2 D

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	1	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	13	ss	fg/mg	2	-	SL	10YR	5	6	wk	sbk	m	m	fr
	2C	29+	sis	mg/cg	40	g	L	2.5Y	5	1	sl	ma	-	m	fr

Comments:

Vegetation: fescue, orchardgrass, clover, timothy

Slope and Aspect: flat

Site: OH 2 Describer: ATJ

Plot # and Hole ID: 2 E

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	1	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	12	ss	mg/cg	10	-	SCL	10YR	5	4	wk	sbk	m	m	fr
	2C	26+	ss/sis	fg/mg/cg	30	g	f SL	5Y	5	1	sl	ma	-	c	fr

Comments:

Vegetation: fescue, lespedeza

Slope and Aspect: flat

Appendix 4a. (continued)

Site: OH 2 Describer: CNC

Plot # and Hole ID: 3 C

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	-	-	-	-	L	10YR	4	3	wk	gr	f	m	vfr
	Bw	10	-	-	-	-	SL	10YR	5	6	wk	sbk	m	m	fr
	C	24	ss	cb/cg	5	-	SL	10YR	5	4	sl	ma	-	c	fr

Comments:

Vegetation: lespadeza, fescue

Slope and Aspect: flat

Site: OH 2 Describer: CNC

Plot # and Hole ID: 3 D

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	4	3	wk	gr	f	m	vfr
	Bw	19	ss	fg/mg	10	-	SL	10YR	5	6	wk	sbk	c	m - c	fr
	2C	34+	ss/sis	fg/mg/cg	20	g	L	5Y	5	2	sl	ma	-	f	fr

Comments:

Vegetation: fescue, orchardgrass, bull rush

Slope and Aspect: flat

Site: OH 2 Describer: CNC

Plot # and Hole ID: 3 E

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	1	-	-	-	-	L	10YR	4	3	wk	gr	f	m	vfr
	Bw	17	ss	mg	5	-	L	10YR	5	6	wk	sbk	m	c	fi
	2C	36+	ss	mg/cg	20	g	L	2.5Y	5	3	sl	ma	-	f	fr

Comments:

Vegetation: lespedeza

Slope and Aspect: 1% and 242

Appendix 4a. (continued)

Site: OH 2 Describer: BA

Plot # and Hole ID: 4 A

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	Bw	14	ss	fg	5	-	SL	10YR	5	4	wk	sbk	c	m	fr
	2C	34+	sis/ss	fg/mg	40	g	L	2.5Y	5	2	sl	ma	-	c	fr

Comments:

Vegetation: lespadeza, fescue

Slope and Aspect: 2% and 290

Site: OH 2 Describer: BA

Plot # and Hole ID: 4 B

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	19	ss	fg/mg	5	-	CL	10YR	5	4	wk	sbk	m	m	fr
	2C	35+	ss/sis	fg/mg/cg	20	g	L	5Y	5	2	sl	ma	-	f	fr

Comments:

Vegetation: fescue, orchardgrass, lespedeza, blackberry

Slope and Aspect: 2% and 82

Site: OH 2 Describer: BA

Plot # and Hole ID: 4 C

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	16	ss/sis	fg/mg	10	-	CL	10YR	5	6	wk	sbk	f	m	fr
	C	26	ss/sis	fg/mg	10	-	CL	10YR	5	6	sl	ma	-	c	fr
	2C	45+	ss/sis	fg/mg/cg	50	vg	CL	2.5Y	5	2	sl	ma	-	f	fr

Comments: near wet area

Vegetation: lespedeza, fescue, orchardgrass, bull rush

Slope and Aspect: flat

Appendix 4a. (continued)

Site: OH 2 Describer: ATJ

Plot # and Hole ID: 5 B

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	4	2	wk	gr	f	m	vfr
	Bw	25	ss	fg/mg	15	g	SCL	10YR	5	6	wk	sbk	m	m	fr
	2C	35+	sis	mg/cg	40	vg	SiL	2.5Y	5	3	sl	ma	-	m	fr

Comments:

Vegetation: fescue, orchardgrass

Slope and Aspect: 2% and 85

Site: OH 2 Describer: ATJ

Plot # and Hole ID: 5 D

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	4	2	wk	gr	f	m	vfr
	Bw	18	ss	fg	2	-	L	10YR	5	6	wk	sbk	m	m	fr
	2C	35+	ss/sis	mg	10	-	L	2.5Y	5	2	sl	ma	-	m	fr

Comments:

Vegetation: fescue, orchardgrass, lespedeza

Slope and Aspect: 1% and 50

Site: OH 2 Describer: ATJ

Plot # and Hole ID: 5 E

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	1	-	-	-	-	L	10YR	4	2	wk	gr	f	m	vfr
	Bw	12	ss/sis	mg	10	-	SL	10YR	5	6	wk	sbk	c	m	fr
	2C	27+	ss/sis	fg/mg	20	-	L	2.5Y	5	2	sl	ma	-	m	fr

Comments:

Vegetation: lespedeza, fescue, orchardgrass, ragweed

Slope and Aspect: 1% and 300

Appendix 4a. (continued)

Site: OH 2   Describer: ATJ

Plot # and Hole ID: 6 A

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	-	-	-	-	L	10YR	4	2	wk	gr	f	m	vfr
	Bw	9	ss	mg/cg	10	-	SL	10YR	5	4	wk	sbk	m	m	fr
	2C	36+	sis	mg/cg	15	g	L	5Y	5	2	sl	ma	-	m	fi

Comments:

Vegetation: fescue, orchardgrass, lespedeza

Slope and Aspect: 2% and 266

Site: OH 2   Describer: ATJ

Plot # and Hole ID: 6 C

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	15	ss	fg	5	-	SL	10YR	5	6	wk	sbk	m	m	fr
	2C	38+	ss/sis	fg/mg	20	-	SiL	2.5Y	5	2	sl	ma	-	m	fr

Comments:

Vegetation: fescue, orchardgrass

Slope and Aspect: 2% and 85

Site: OH 2   Describer: ATJ

Plot # and Hole ID: 6 E

Date: 30 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	4	2	wk	gr	f	m	vfr
	Bw	13	ss/sis	fg/mg	15	g	L	2.5Y	5	4	wk	sbk	m	m	fr
	2C	33+	sis	mg/cg	30	g	SiL	5Y	5	1	sl	ma	-	c	fr

Comments:

Vegetation: lespedeza, fescue

Slope and Aspect:

Appendix 4a. (continued)

Site: OH 2 Describer: ATJ

Plot # and Hole ID: 7 A

Date: 31 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	4	2	wk	gr	f	m	vfr
	Bw	9	ss	fg/mg	10	-	L	2.5Y	5	4	wk	sbk	f	c	fr
	2C	37+	sis/ss	mg/cg	30	g	SiL	5Y	5	1	sl	ma	-	c	fi

Comments:

Vegetation: fescue, lespedeza

Slope and Aspect: 15% and 240

Site: OH 2 Describer: ATJ

Plot # and Hole ID: 7 D

Date: 31 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	1	-	-	-	-	L	10YR	4	2	wk	gr	f	m	vfr
	Bw	20	ss	fg/mg	5	-	SL	10YR	5	6	wk	sbk	m	c	fr
	2C	31+	ss/sis	fg/mg	15	g	L	5Y	5	1	sl	ma	-	c	fi

Comments:

Vegetation: fescue, lespedeza

Slope and Aspect: 2% and 240

Site: OH 2 Describer: ATJ

Plot # and Hole ID: 7 E

Date: 31 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	1	-	-	-	-	L	10YR	4	2	wk	gr	f	m	vfr
	Bw	16	ss	fg/mg	10	-	CL	10YR	5	4	wk	sbk	m	c	fr
	2C	33+	sis/ss	mg/cg	15	g	L	2.5Y	5	2	sl	ma	-	f	fr

Comments:

Vegetation: lespedeza, fescue

Slope and Aspect: 15% and 240

Appendix 4a. (continued)

Site: OH 2 Describer: BA

Plot # and Hole ID: 8 A

Date: 31 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	13	ss	fg/mg	10	-	L	10YR	5	6	mo	sbk	m	c	fr
	2C	23	ss	mg/cg	40	vg	CL	5Y	5	1	sl	ma	-	f	fr
	3C	36+	ss/coal	mg/cg/cb	60	vcb		5Y	2.5	1	sl	ma	-	f	

Comments: Horizon 3C is made of coal coarse fragments and fine particles
Bw and 2C horizons have pieces of coal as well

Vegetation: fescue, lespedeza

Slope and Aspect: 10% and 243

Site: OH 2 Describer: BA

Plot # and Hole ID: 8 C

Date: 31 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	-	-	-	-	L	10YR	4	2	wk	gr	f	m	vfr
	Bw	24	sis/ss	fg/mg	10	-	SL	2.5Y	5	2	wk	sbk	f	f	vfr
	2C	44+	ss/sis	fg/mg/cg	60	vg	CL	10YR	5	6	sl	ma	-	none	fr

Comments:

Vegetation: fescue, lespedeza

Slope and Aspect: 2% and 250

Site: OH 2 Describer: BA

Plot # and Hole ID: 8 D

Date: 31 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	22	sis	cn	5	-	CL	10YR	5	6	wk	sbk	f	c	fr
	2C	40+	sis	cn	30	ch	SiL	5Y	5	1	sl	ma	-	c	fr

Comments:

Vegetation: lespedeza, fescue

Slope and Aspect: 4% and 243

Appendix 4a. (continued)

Site: OH 2 Describer: CNC

Plot # and Hole ID: 9 A

Date: 31 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	4	2	wk	gr	f	m	vfr
	Bw	22	sis/ss	mg	10	-	L	10YR	5	6	wk	sbk	m	m	fr
	2C	43+	sis	fg/mg/cg	20	g	SiL	5Y	4	1	sl	ma	-	c	fi

Comments:

Vegetation: fescue, lespedeza, orchard grass

Slope and Aspect: 4% and 280

Site: OH 2 Describer: CNC

Plot # and Hole ID: 9 B

Date: 31 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	1	-	-	-	-	L	10YR	4	2	wk	gr	f	m	vfr
	Bw	14	ss	fg/mg	10	-	L	2.5Y	5	3	wk	sbk	m	m	fi
	2C	35+	ss	fg/mg	20	g	SL	5Y	5	1	sl	ma	-	c	fr

Comments:

Vegetation: fescue, lespedeza, orchard grass

Slope and Aspect: 5% and 254

Site: OH 2 Describer: CNC

Plot # and Hole ID: 9 E

Date: 31 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	4	2	wk	gr	f	m	vfr
	Bw	12	ss/sis	cn/mg	10	-	L	10YR	5	6	wk	sbk	m	m	fr
	2C	32+	sis	cb	65	ecb	SiL	5Y	5	1	sl	ma	-	c	fi

Comments:

Vegetation: lespedeza, fescue, orchard grass

Slope and Aspect: 8% and 260

Appendix 4a. (continued)

Site: OH 3 Describer: ATJ

Plot # and Hole ID: 1 A

Date: 31 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	C	30	sis/ss	fg/mg/cg	20	g	L	2.5Y	5	2	sl	ma	-	c	fi

Comments: C horizon is gray subsoil

Vegetation: fescue, alfalfa, red clover

Slope and Aspect: 20% and 63

Site: OH 3 Describer: ATJ

Plot # and Hole ID: 1 B

Date: 31 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	10	ss	fg/mg	10	-	SCL	2.5Y	5	3	wk	sbk	f	m	fi
	2C	28+	sis	cn	50	vcn	SiL	2.5Y	5	1	sl	ma	-	c	fi

Comments:

Vegetation: fescue, birdsfoot trefoil

Slope and Aspect: 19% and 66

Site: OH 3 Describer: ATJ

Plot # and Hole ID: 1 D

Date: 31 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	4	2	wk	gr	f	m	vfr
	Bw	9	ss/sis	fg/mg	10	-	SCL	2.5Y	5	3	wk	sbk	c	m	fr
	2C	32+	sis	fg/mg/cn	20	g	SCL	2.5Y	5	2	sl	ma	-	c	fi

Comments:

Vegetation: fescue, birdsfoot trefoil, wild garlic

Slope and Aspect: 15% and 60

Appendix 4a. (continued)

Site: OH 3 Describer: ATJ

Plot # and Hole ID: 2 A

Date: 31 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	13	ss	fg/mg	15	g	SCL	10YR	5	4	wk	sbk	m	m	fr
	2C	39+	sis	fg/mg	20	g	CL	2.5Y	5	2	sl	ma	-	f	fi

Comments:

Vegetation: fescue, wild garlic

Slope and Aspect: 16% and 67

Site: OH 3 Describer: ATJ

Plot # and Hole ID: 2 B

Date: 31 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	1	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	12	ss	fg/mg	10	-	L	10YR	5	6	mo	sbk	m	m	fr
	2C	34+	ss/sis	mg/cg	25	g	L	2.5Y	6	1	sl	ma	-	c	fr

Comments:

Vegetation: fescue, lespedeza, goldenrod

Slope and Aspect: 11% and 67

Site: OH 3 Describer: ATJ

Plot # and Hole ID: 2 D

Date: 31 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	21	ss/sis	fg	10	-	SCL	2.5Y	5	3	wk	sbk	m	m	fr
	2C	38+	ss/sis	fg/mg	15	g	SCL	2.5Y	5	2	sl	ma	-	f	fr

Comments:

Vegetation: fescue

Slope and Aspect: 14% and 67

Appendix 4a. (continued)

Site: OH 3 Describer: ATJ

Plot # and Hole ID: 3 A

Date: 31 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	18	ss/sis	fg/mg	10	-	SCL	2.5Y	5	4	wk	sbk	m	c	fr
	2C	40+	sis/ss	fg/mg	15	g	CL	2.5Y	5	2	sl	ma	-	f	fi

Comments: Bw horizon has fine sand material (within SCL)

Vegetation: fescue, wild garlic

Slope and Aspect: 8% and 68

Site: OH 3 Describer: ATJ

Plot # and Hole ID: 3 C

Date: 31 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	-	-	-	-	L	10YR	4	2	wk	gr	f	m	vfr
	Bw	24	ss	fg/mg	10	-	SCL	10YR	5	4	wk	sbk	m	m	fr
	C	38	ss	fg/mg	10	-	CL	10YR	5	4	sl	ma	-	c	fr
	2C	48+	sis	fg	10	-	L	2.5Y	5	2	sl	ma	-	f	fi

Comments: Bw horizon has fine sand material (within SCL)

Vegetation: fescue, timothy, wild garlic, orchard grass, thistle

Slope and Aspect: 5% and 60

Site: OH 3 Describer: ATJ

Plot # and Hole ID: 3 E

Date: 31 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	21	ss/sis	fg/mg/cg	15	g	CL	2.5Y	6	3	wk	sbk	c	c	fr
	2C	38+	sis	fg/mg	20	g	CL	5Y	5	1	sl	ma	-	c	fr

Comments:

Vegetation: fescue, timothy, wild garlic, orchard grass

Slope and Aspect: 5% and 60

Appendix 4a. (continued)

Site: OH 3 Describer: BA

Plot # and Hole ID: 4 A

Date: 31 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	17	ss/sis	fg/mg	10	-	CL	10YR	5	4	wk	sbk	c	c	fr
	2C	30+	sis/ss	fg/mg	10	-	L	2.5Y	5	2	sl	ma	-	f	fi

Comments:

Vegetation: fescue, goldenrod, orchard grass, red clover, birdsfoot trefoil

Slope and Aspect: 5% and 195

Site: OH 3 Describer: BA

Plot # and Hole ID: 4 D

Date: 31 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	1	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	9	ss	fg/mg	5	-	CL	2.5Y	5	3	wk	sbk	m	m	fi
	2C	16	ss/sis	cg	60	vg	CL	2.5Y	5	2	sl	ma	-	c	fi
	3C	29	ss/sis	cg	80	vg	CL	2.5Y	6	4	sl	ma	-	f	vfi

Comments:

Vegetation: fescue, wild garlic, goldenrod, red clover

Slope and Aspect: 12% and 248

Site: OH 3 Describer: BA

Plot # and Hole ID: 4 E

Date: 31 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	8	ss	fg/mg	5	-	CL	10YR	5	4	wk	sbk	c	m	fi
	C	23	ss	fg	5	-	SiL	10YR	5	6	sl	ma	-	m	fr
	2C	37+	sis	fg/mg	5	-	CL	2.5Y	5	2	sl	ma	-	c	fi

Comments:

Vegetation: fescue, lespedeza, birdsfoot trefoil

Slope and Aspect: 9% and 238

Appendix 4a. (continued)

Site: OH 3 Describer: CNC

Plot # and Hole ID: 5 B

Date: 31 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	1	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	18	ss	fg/mg/cb	25	g	L	2.5Y	5	4	wk	sbk	m	m	fi
	2C	37+	sis	cn	40	vcn	L	2.5Y	5	2	sl	ma	-	f	fr

Comments:

Vegetation: fescue, birdsfoot trefoil

Slope and Aspect: 13% and 250

Site: OH 3 Describer: CNC

Plot # and Hole ID: 5 C

Date: 31 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	1	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	18	ss/sis	fg/mg/cg	20	g	SCL	2.5Y	5	3	wk	sbk	m	m	fr
	C	45+	ss/sis	fg/mg/cg	20	g	CL	2.5Y	5	2	sl	ma	-	c	fr

Comments:

Vegetation: fescue, wild garlic, timothy, red clover

Slope and Aspect: 15% and 250

Site: OH 3 Describer: CNC

Plot # and Hole ID: 5 D

Date: 31 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	1	-	-	-	-	L	10YR	4	2	wk	gr	f	m	vfr
	Bw	15	ss	fg/mg/cg	15	g	L	2.5Y	5	3	wk	sbk	f	m	fr
	C	32+	ss/sis	fg/mg/cg	35	g	L	2.5Y	5	2	sl	ma	-	c	fr

Comments:

Vegetation: fescue, white clover, red clover

Slope and Aspect: 15% and 250

Appendix 4a. (continued)

Site: OH 3 Describer: CNC

Plot # and Hole ID: 6 A

Date: 24 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	4	3	mo	gr	f	m	vfr
	Bw	18	ss/sis	fg/mg	20	g	L	2.5Y	6	6	wk	sbk	c	m	fr
	C	30+	ss/sis	cb	75	ecb	CL	2.5Y	5	3	sl	ma	-	f	fi

Comments:

Vegetation: fescue, birdsfoot trefoil, red clover

Slope and Aspect: 6% and 255

Site: OH 3 Describer: ATJ

Plot # and Hole ID: 6 B

Date: 24 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	20	ss/sis	mg/cg	20	g	CL	2.5Y	5	3	wk	sbk	c	c	fr
	C	40+	ss/sis	mg/cg	15	g	L	5Y	6	1	sl	ma	-	f	fr

Comments:

Vegetation: fescue, sweet clover, alfalfa, red clover

Slope and Aspect: 12% and 260

Site: OH 3 Describer: ATJ

Plot # and Hole ID: 6 C

Date: 24 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	4	2	wk	gr	f	m	vfr
	Bw	20	ss/sis	mg/cg	15	g	CL	2.5Y	5	3	wk	sbk	c	m	fr
	C	43+	ss	cg/cb	30	cb	L	2.5Y	5	2	sl	ma	-	c	fr

Comments:

Vegetation: fescue, red clover

Slope and Aspect: 12% and 245

Appendix 4a. (continued)

Site: OH 3 Describer: CNC

Plot # and Hole ID: 7 A

Date: 24 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	4	3	mo	gr	f	m	vfr
	Bw	13	ss/sis	fg/mg	10	-	L	10YR	5	6	wk	sbk	c	m	fr
	C	36+	ss/sis	fg/mg/cg	30	g	L	2.5Y	5	2	sl	ma	-	c	fr

Comments:

Vegetation: fescue, timothy, red clover

Slope and Aspect: 4% and 270

Site: OH 3 Describer: CNC

Plot # and Hole ID: 7 B

Date: 24 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	4	3	mo	gr	f	m	vfr
	Bw	20	ss/sis	fg/mg	15	g	L	2.5Y	5	6	wk	sbk	c	m	fr
	C	40+	ss/sis	fg/mg	25	g	SL	2.5Y	6	3	sl	ma	-	c	fr

Comments:

Vegetation: fescue, red clover

Slope and Aspect: 5% and 270

Site: OH 3 Describer: ATJ

Plot # and Hole ID: 7 C

Date: 24 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	4	3	mo	gr	f	m	vfr
	Bw	15	sis/ss	fg/mg	15	g	CL	2.5Y	5	3	wk	sbk	c	m	fr
	2C	35+	sis/ss	fg/mg	15	g	CL	5Y	6	1	sl	ma	-	c	fi

Comments:

Vegetation: fescue, red clover, birdsfoot trefoil

Slope and Aspect: 8% and 250

Appendix 4a. (continued)

Site: OH 3 Describer: ATJ

Plot # and Hole ID: 8 A

Date: 24 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	1	-	-	-	-	-	10YR	4	3	mo	gr	f	m	vfr
	Bw	10	ss	fg/mg	5	-	CL	10YR	5	4	wk	sbk	m - c	m	fr
	2C1	23	ss/sis	mg/cn	15	g	L	2.5Y	5	2	sl	ma	-	m	fr
	2C2	35+	ss	cb	75	ecb	-	-	-	-	sl	ma	-	f	-

Comments: C2 = oxidized and unoxidized sandstone

Vegetation: fescue, orchard grass, birdsfoot trefoil, red clover

Slope and Aspect: flat

Site: OH 3 Describer: ATJ

Plot # and Hole ID: 8 B

Date: 24 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	4	3	mo	gr	f	m	vfr
	Bw1	10	sis/ss	fg	5	-	L	10YR	5	6	wk	sbk	c	m	fr
	Bw2	18	ss/sis	mg	10	-	L	2.5Y	5	4	wk	sbk	m	m	fr
	2C	40+	ss/sis	mg/cg	15	g	L	2.5Y	6	1	sl	ma	-	c	fi

Comments:

Vegetation: fescue, orchard grass

Slope and Aspect: flat

Site: OH 3 Describer: ATJ

Plot # and Hole ID: 8 C

Date: 24 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	4	3	mo	gr	f	m	vfr
	Bw	15	ss	fg	3	-	L	2.5Y	5	6	wk	sbk	c	m	fr
	2C	33+	ss/sis	mg/cg	15	g	L	2.5Y	6	3	sl	ma	-	c	fi

Comments:

Vegetation: fescue, birdsfoot trefoil, wild garlic

Slope and Aspect: 3% and 253

Appendix 4a. (continued)

Site: OH 3 Describer: ATJ

Plot # and Hole ID: 9 A

Date: 24 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	-	10YR	4	3	mo	gr	f	m	vfr
	C1	28	ss	mg/cg	20	g	SCL	2.5Y	5	4	sl	ma	-	m	fr
	2C2	36+	ss/sis	cg/cb	10	-	SCL	2.5Y	5	2	sl	ma	-	c	fi

Comments:

Vegetation: fescue, orchard grass, birdsfoot trefoil

Slope and Aspect: 4% and 160

Site: OH 3 Describer: ATJ

Plot # and Hole ID: 9 B

Date: 24 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	4	3	mo	gr	f	m	vfr
	Bw	18	ss/sis	fg/mg	5	-	CL	2.5Y	5	4	wk	sbk	m	m	fr
	C	35+	ss/sis	mg/cg	10	-	L	2.5Y	5	6	sl	ma	-	m	fr

Comments:

Vegetation: fescue, red clover

Slope and Aspect: 3% and 160

Site: OH 3 Describer: ATJ

Plot # and Hole ID: 9 C

Date: 24 July 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	-	-	-	-	L	10YR	4	3	mo	gr	f	m	vfr
	Bw	15	ss/sis	fg	5	-	L	2.5Y	4	4	wk	sbk	m	m	fr
	2C1	28	ss/sis	fg/mg	10	-	CL	2.5Y	5	2	sl	ma	-	c	fr
	2C2	33+	ss	cb	75	ecb	SL	-	-	-	sl	ma	-	f	-

Comments: C2 is partially weathered oxidized SS

Vegetation: fescue, birdsfoot trefoil, orchard grass, red clover

Slope and Aspect: 3% and 188

Appendix 4b. Shallow soil pit descriptions of horizon, depth, texture, color, structure, roots, moist consistence, vegetation, slope and aspect of mine sites in Virginia.

Site: VA 1 Describer: ATJ

Plot # and Hole ID: 1 A

Date: 19 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	C	33+	ss/sis	g/cb	30	g	L	2.5Y	4	2	sl	ma	-	m - c	fi

Comments:

Vegetation: red clover, timothy, birdsfoot trefoil, annual ryegrass

Slope and Aspect: flat

Site: VA 1 Describer: ATJ

Plot # and Hole ID: 1 B

Date: 19 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	C1	30	ss	g/cb	30	g	SL	10YR	4	3	sl	ma	-	c	fr
	2C2	40+	ss	g/cb/st	70	ec	L	2.5Y	4	2	sl	ma	-	f	fr

Comments:

Vegetation: red clover, birdsfoot trefoil

Slope and Aspect: 2% and 334

Site: VA 1 Describer: ATJ

Plot # and Hole ID: 1 C

Date: 19 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	Bw	10	ss	g	20	g	SL	10YR	4	3	wk	sbk	f	m	fr
	2C	30+	ss	g/cb/st	70	ecb	FSL	2.5Y	4	2	sl	ma	-	c	fi

Comments:

Vegetation: orchard grass, timothy, birdsfoot trefoil, red clover

Slope and Aspect: 2% and 157

Appendix 4b. (continued)

Site: VA 1 Describer: ATJ

Plot # and Hole ID: 2 A

Date: 19 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	C1	31	ss	g	25	g	SL	10YR	5	6	sl	ma	-	m - c	fr
	2C2	42+	ss	g	65	eg	SL	2.5Y	4	1	sl	ma	-	f	fr

Comments:

Vegetation: red clover, birdsfoot trefoil, annual ryegrass

Slope and Aspect: flat

Site: VA 1 Describer: ATJ

Plot # and Hole ID: 2 C

Date: 19 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	C1	41	ss/sis	g/cb	30	g	SL	10YR	5	3	sl	ma	-	c	fi
	2C2	50+	-	-	-	-	-	2.5Y	4	2	sl	ma	-	f	fi

Comments:

Vegetation: red clover, birdsfoot trefoil, annual ryegrass, timothy

Slope and Aspect: 3% and 185

Site: VA 1 Describer: ATJ

Plot # and Hole ID: 2 E

Date: 19 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	C1	9	ss	g	25	g	SL	10YR	5	6	sl	ma	-	m	fr
	2C2	29+	ss/sis	g/cb	80	eg	SL	5Y	4	1	sl	ma	-	c	-

Comments:

Vegetation: annual ryegrass, birdsfoot trefoil, red clover

Slope and Aspect: 4% and 220

Appendix 4b. (continued)

Site: VA 1 Describer: ATJ

Plot # and Hole ID: 3 C

Date: 19 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	C1	22	ss	g	20	g	SL	10YR	5	4	sl	ma	-	m	fr
	2C2	34+	ss	g/cb	65	eg	SL	2.5Y	4	1	sl	ma	-	c	fi

Comments:

Vegetation: red clover, birdsfoot trefoil, annual ryegrass

Slope and Aspect:

Site: VA 1 Describer: ATJ

Plot # and Hole ID: 3 D

Date: 19 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	C1	13	ss	g	15	g	SL	10YR	5	6	sl	ma	-	m	fr
	2C2	30+	ss	g/cb	80	eg	L	2.5Y	4	1	sl	ma	-	f	fi

Comments:

Vegetation: red clover, birdsfoot trefoil, annual ryegrass

Slope and Aspect:

Site: VA 1 Describer: ATJ

Plot # and Hole ID: 3 E

Date: 19 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	C1	14	ss/sis	g	20	g	SL	10YR	5	4	sl	ma	-	m	fr
	2C2	30+	ss	g/cb	75	eg	SL	2.5Y	4	1	sl	ma	-	f	fr

Comments:

Vegetation: annual ryegrass, birdsfoot trefoil, red clover

Slope and Aspect: 4% and 208

Appendix 4b. (continued)

Site: VA 1 Describer: ATJ

Plot # and Hole ID: 4 A

Date: 19 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	C1	5	ss/sis	g	25	g	L	10YR	5	4	sl	ma	-	c	fr
	2C2	32+	ss	g/cb	60	vg	SL	2.5Y	4	1	sl	ma	-	c	fr

Comments:

Vegetation: red clover, birdsfoot trefoil, annual ryegrass

Slope and Aspect: flat

Site: VA 1 Describer: ATJ

Plot # and Hole ID: 4 C

Date: 19 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	C1	13	ss/sis	g	25	g	L	10YR	5	6	sl	ma	-	m	fr
	2C2	32+	ss	g/cb	80	eg	-	2.5Y	4	1	sl	ma	-	m	fr

Comments:

Vegetation: red clover, birdsfoot trefoil, annual ryegrass

Slope and Aspect: flat

Site: VA 1 Describer: ATJ

Plot # and Hole ID: 4 D

Date: 19 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	C1	9	ss/sis	g	30	g	L	10YR	5	6	sl	ma	-	c	fr
	2C2	25+	ss	g/cb	70	eg	SL	2.5Y	4	1	sl	ma	-	f	fi

Comments:

Vegetation: annual ryegrass, birdsfoot trefoil, red clover

Slope and Aspect: flat

Appendix 4b. (continued)

Site: VA 1 Describer: CNC

Plot # and Hole ID: 5 A

Date: 19 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	C1	17	ss	g/cb	35	vg	SL	10YR	5	4	sl	ma	-	m	fr
	2C2	25+	ss	g/cb/st	65	ecb	SL	2.5Y	4	1	sl	ma	-	c	fr

Comments:

Vegetation: white clover, annual ryegrass

Slope and Aspect: flat

Site: VA 1 Describer: CNC

Plot # and Hole ID: 5 C

Date: 19 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	C1	24	ss	g/cb	40	vg	SL	10YR	5	3	sl	ma	-	m	fr
	2C2	29+	ss	g/cb/st	70	ecb	SL	5Y	3	1	sl	ma	-	f	fr

Comments:

Vegetation: birdsfoot trefoil

Slope and Aspect: 3% and 195

Site: VA 1 Describer: CNC

Plot # and Hole ID: 5 D

Date: 19 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	C	34+	ss	g/cb	40	vg	L	10YR	5	3	sl	ma	-	m - f	fr

Comments:

Vegetation: annual ryegrass, white clover

Slope and Aspect: 3% and 178

Appendix 4b. (continued)

Site: VA 1 Describer: CNC

Plot # and Hole ID: 6 C

Date: 19 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	C	32+	ss	g/cb/st	45	vg	L	10YR	4	3	sl	ma	-	m - f	fr

Comments:

Vegetation: white clover, annual ryegrass, red clover, timothy, 60% bare ground

Slope and Aspect: 2%

Site: VA 1 Describer: CNC

Plot # and Hole ID: 6 D

Date: 19 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	C1	35	ss	g/cb	40	vg	L	10YR	5	4	sl	ma	-	m - c	fr
	2C2	45+	ss	g/cb/st	70	ecb	L	2.5Y	4	1	sl	ma	-	f	fr

Comments:

Vegetation: birdsfoot trefoil, timothy, white clover

Slope and Aspect: 2% and 186

Site: VA 1 Describer: CNC

Plot # and Hole ID: 6 E

Date: 19 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	C1	31	ss	g/cb	35	vg	L	2.5Y	5	3	sl	ma	-	m - c	fi
	2C2	34+	ss	g/cb/st	75	ecb	SL	10YR	4	1	sl	ma	-	f	fr

Comments:

Vegetation: white clover, red clover, timothy, birdsfoot trefoil

Slope and Aspect: 4% and 186

Appendix 4b. (continued)

Site: VA 1 Describer: CNC

Plot # and Hole ID: 7 A

Date: 19 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	C1	25	ss	g	45	vg	SL	10YR	5	4	sl	ma	-	m - c	fr
	2C2	30+	ss	g/cb	65	eg	SL	2.5Y	4	1	sl	ma	-	f	fr

Comments:

Vegetation: white clover, annual ryegrass, red clover, timothy, birdsfoot trefoil

Slope and Aspect: 3% and 230

Site: VA 1 Describer: CNC

Plot # and Hole ID: 7 B

Date: 19 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	C1	25	ss	g	40	vg	SL	10YR	5	3	sl	ma	-	m	fr
	2C2	32+	ss	g/cb	70	eg	SL	2.5Y	4	1	sl	ma	-	f	fr

Comments:

Vegetation: birdsfoot trefoil, orchard grass, white clover

Slope and Aspect: 5% and 90

Site: VA 1 Describer: CNC

Plot # and Hole ID: 7 D

Date: 19 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	C1	34	ss	g	30	g	SL	10YR	5	3	sl	ma	-	m	fr
	2C2	39+	ss	g/cb	65	eg	SL	2.5Y	4	1	sl	ma	-	f	fr

Comments:

Vegetation: annual ryegrass, timothy, birdsfoot trefoil, 60% bare ground

Slope and Aspect: 3%

Appendix 4b. (continued)

Site: VA 1 Describer: ATJ

Plot # and Hole ID: 8 C

Date: 20 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	Bw	8	ss	g	20	g	SL	10YR	5	4	wk	sbk	f	m	fr
	C	38+	ss	g/cb	35	vg	SL	10YR	5	4	sl	ma	-	c	fr

Comments:

Vegetation: orchard grass

Slope and Aspect: 3% and 188

Site: VA 1 Describer: ATJ

Plot # and Hole ID: 8 D

Date: 20 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	C	33+	ss	g/cb/st	80	eg	FSL	10YR	5	4	sl	ma	-	m - c	fi - vfi

Comments: appears to get into grey subsoil at 35 cm but too rocky to get sample

Vegetation: birdsfoot trefoil, timothy, clover, 50% bare ground

Slope and Aspect: 8% and 188

Site: VA 1 Describer: ATJ

Plot # and Hole ID: 8 E

Date: 20 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	C1	14	ss	g	20	g	SL	10YR	4	4	sl	ma	-	m	fr
	2C2	29+	ss	g/cb/st	80	ecb	SL	2.5Y	4	1	sl	ma	-	f	-

Comments:

Vegetation: clover, orchard grass, birdsfoot trefoil

Slope and Aspect: 4% and 188

Appendix 4b. (continued)

Site: VA 1 Describer: ATJ

Plot # and Hole ID: 9 B

Date: 20 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	Bw	9	ss	g/cb	60	vg	FSL	2.5Y	4	4	wk	sbk	m	m	fi
	C	42+	ss	g/cb	60	vg	FSL	2.5Y	4	4	sl	ma	-	f	fi

Comments:

Vegetation: orchard grass, white clover, timothy

Slope and Aspect: 2% and 150

Site: VA 1 Describer: ATJ

Plot # and Hole ID: 9 C

Date: 20 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	Bw	6	ss	g	60	vg	FSL	10YR	5	3	wk	sbk	f	m	fr
	C	35+	ss	g/cb	70	eg	FSL	10YR	4	3	sl	ma	-	f	fi

Comments:

Vegetation: birdsfoot trefoil, timothy, clover, orchard grass, annual ryegrass

Slope and Aspect: 2% and 110

Site: VA 1 Describer: ATJ

Plot # and Hole ID: 9 D

Date: 20 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	C	33+	ss	g/cb	60	vg	FSL	2.5Y	4	3	sl	ma	-	c - f	fr

Comments:

Vegetation: clover, orchard grass

Slope and Aspect: 4% and 180

Appendix 4b. (continued)

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 1 A

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	6	ss	g	55	vg	SL	2.5Y	4	3	wk	sbk	f	m	fr
	C1	51	ss	g	70	eg	SL	10YR	4	2	sl	ma	-	c - f	fr
	2C2	62+													

Comments: Didn't describe 2C2 because it starts at bottom of pit.

Vegetation: orchard grass, clover, birdsfoot trefoil

Slope and Aspect: 8% and 167

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 1 C

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	ss/sis	g/cb	55	vg	SL	2.5Y	4	3	wk	sbk	f	m	fr
	C1	26	ss/sis	g/cb	65	eg	SL	2.5Y	4	3	sl	ma	-	c	fi
	2C2	50+	sis	g/cb	75	eg	SL	5Y	4	1	sl	ma	-	f	fr

Comments:

Vegetation: birdsfoot trefoil, timothy, clover

Slope and Aspect: 4% and 79

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 1 D

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	ss	g/cb	65	eg	SL	2.5Y	4	4	wk	sbk	m	m	fr
	C1	19	ss	g/cb/st	75	eg	SL	2.5Y	4	3	sl	ma	-	c	fi
	2C2	51+	sis	g/cb	75	ecb	SL	N	3	0	sl	ma	-	c - f	fr

Comments:

Vegetation: clover, orchard grass, birdsfoot trefoil

Slope and Aspect: 3% and 188

Appendix 4b. (continued)

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 2 A

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	8	ss/sis	g	55	vg	SL/L	2.5Y	4	2	wk	sbk	m	m	fr
	C1	28	ss	g/cb	70	eg	SL/L	2.5Y	4	3	sl	ma	-	c	fi
	2C2	50+	sis	g/cb	75	eg	SL	2.5Y	3	1	sl	ma	-	c - f	fr

Comments:

Vegetation: orchard grass, clover, birdsfoot trefoil

Slope and Aspect: 10% and 186

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 2 C

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	6	ss	g/cb	65	eg	L	2.5Y	4	3	wk	sbk	f	m	fr
	C	45+	ss	g/cb	65	eg	L	2.5Y	4	2	sl	ma	-	c	fr

Comments:

Vegetation: birdsfoot trefoil, orchard grass, clover

Slope and Aspect: 6% and 178

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 2 E

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	8	ss	g	50	vg	SL/L	2.5Y	4	3	wk	sbk	f	m	fr
	C1	37	ss	g/cb/st	65	eg	SL/L	2.5Y	4	2	sl	ma	-	c	fr
	2C2	55+	ss/sis	g/cb/st	75	eg	SL	2.5Y	3	1	sl	ma	-	f	fr

Comments:

Vegetation: clover, orchard grass

Slope and Aspect: 7% and 186

Appendix 4b. (continued)

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 3 A

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	9	ss	g	55	vg	L	10YR	4	2	wk	sbk	m	m	fr
	C1	27	ss	g/cb	55	vg	L	10YR	4	2&3	sl	ma	-	c	fi
	2C2	66+	sis	g/cb/st	80	ecb	SL	2.5Y	3	1	sl	ma	-	f	fr

Comments:

Vegetation: orchard grass, clover, birdsfoot trefoil

Slope and Aspect: 4%

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 3 C

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	10	ss	g/cb	60	vg	L/SL	2.5Y	4	3	wk	sbk	m	m	fr
	C	56+	ss	g/cb/st	60	vg	L/SL	2.5Y	4	3	sl	ma	-	c	fr

Comments:

Vegetation: birdsfoot trefoil, orchard grass, clover

Slope and Aspect: 4% and 160

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 3 E

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	6	ss	g/cb	60	vg	SL/L	10YR	4	2	wk	sbk	f	m	fr
	C	48+	ss	cb/st	75	ecb	SL/L	10YR	4	2	sl	ma	-	c	fr

Comments:

Vegetation: clover, orchard grass, birdsfoot trefoil

Slope and Aspect: 5% and 150

Appendix 4b. (continued)

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 4 A

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	ss	g/cb	60	vg	L	10YR	4	3	wk	sbk	c	m	fr
	C1	44	ss	g/cb/st	65	vg	L	2.5Y	4	3	sl	ma	-	c	fi
	2C2	65+	sis	cb/st	80	ecb	L	2.5Y	3	1	sl	ma	-	none	fr

Comments:

Vegetation: orchard grass, clover, birdsfoot trefoil

Slope and Aspect: 2% and 220

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 4 B

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	9	ss	g/cb	50	vg	L/SL	2.5Y	3	3	wk	sbk	c	m	fr
	C1	33	ss/sis	g/cb	55	vg	L/SL	2.5Y	4	3&2	sl	ma	-	c	fr
	2C2	62+	sis	g/cb/st	70	eg	L	2.5Y	3	1	sl	ma	-	f	fr

Comments:

Vegetation: birdsfoot trefoil, orchard grass, clover

Slope and Aspect: 1% and 180

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 4 C

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	6	ss	g	50	vg	L	2.5Y	4	3	wk	sbk	m	m	fr
	C1	35	ss	g/cb	60	vg	L	2.5Y	4	2	sl	ma	-	c	fr
	2C2	63+	sis	cb/st	70	ecb	L	2.5Y	3	1	sl	ma	-	f	fr

Comments:

Vegetation: clover, orchard grass, birdsfoot trefoil

Slope and Aspect: 1% and 255

Appendix 4b. (continued)

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 5 A

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	7	ss	g/cb	50	vg	L	2.5Y	4	3	wk	sbk	m	m	fr
	C1	42	ss/sis	g/cb/st	55	vg	L	2.5Y	4	2&3	sl	ma	-	c	fi
	2C2	52+													

Comments: No data for 2C2 because boundary was at bottom of pit.

Vegetation: orchard grass, clover, birdsfoot trefoil

Slope and Aspect: 3% and 200

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 5 B

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	8	ss	g/cb	50	vg	L	10YR	4	2	wk	sbk	m	m	fr
	C1	31	ss	g/cb	50	vg	L	10YR	4	3	sl	ma	-	c	fr
	2C2	51+	sis	g/cb/st	70	ecb	SL/L	2.5Y	3	1	sl	ma	-	f	fr

Comments:

Vegetation: orchard grass, clover

Slope and Aspect: 1% and 150

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 5 D

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	13	ss	g/cb	55	vg	L/SL	2.5Y	4	3	wk	sbk	m	m	fr
	2C2	54+	sis	g/cb/st	85	est	SL/L	5Y	4	1	sl	ma	-	c	fr

Comments:

Vegetation: clover, orchard grass, birdsfoot trefoil

Slope and Aspect: 1% and 245

Appendix 4b. (continued)

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 6 B

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	7	ss	g	55	vg	L/SL	10YR	4	3	wk	sbk	m	m	fr
	C1	37	sis	g/cb	55	vg	L/SL	10YR	4	2	sl	ma	-	c	fr
	2C2	52+	ss/sis	g/cb	70	eg	SL	2.5Y	4	1	sl	ma	-	f	fr

Comments:

Vegetation: orchard grass, clover

Slope and Aspect: 3% and 188

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 6 C

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	18	ss	g/cb	45	vg	SL/L	2.5Y	4	3	wk	sbk	m	m	fi
	2C2	48+	sis	cb/st	85	est	SL	2.5Y	4	2	sl	ma	-	f	fr

Comments:

Vegetation: orchard grass, clover, birdsfoot trefoil

Slope and Aspect: 2% and 200

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 6 D

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	9	ss	g	55	vg	SL	2.5Y	4	2	wk	sbk	m	m	fr
	C	56+	ss	g/cb/st	65	eg	SL	2.5Y	4	3	sl	ma	-	c	fi

Comments:

Vegetation: clover, orchard grass, birdsfoot trefoil

Slope and Aspect: 2% and 226

Appendix 4b. (continued)

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 7 A

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	8	ss	g	55	vg	SL	2.5Y	4	4	wk	sbk	f	m	fr
	C1	31	ss	g/cb/st	65	eg	SL	2.5Y	4	4	sl	ma	-	c	fr
	2C2	52+	sis	g/cb	75	ecb	SL/L	2.5Y	3	1	sl	ma	-	f	fr

Comments:

Vegetation: orchard grass, clover, birdsfoot trefoil

Slope and Aspect: 2% and 122

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 7 C

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	10	ss	g/cb	55	vg	SL	2.5Y	4	3	wk	sbk	m	m	fr
	C	58+	ss	g/cb/st	60	vg	SL	2.5Y	4	3	sl	ma	-	c	fr

Comments:

Vegetation: orchard grass

Slope and Aspect: flat

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 7 E

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	10	ss	g/cb	55	vg	SL	2.5Y	4	3	wk	sbk	m	m	fr
	C1	42	ss/sis	g/cb/st	65	ecb	SL	2.5Y	4	3	sl	ma	-	c	fr
	2C2	60+	sis	g/cb/st	85	ecb	SL	2.5Y	3	1	sl	ma	-	f	fr

Comments:

Vegetation: clover, orchard grass, birdsfoot trefoil

Slope and Aspect: 4% and 110

Appendix 4b. (continued)

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 8 B

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	9	ss	g/cb	50	vg	SL	2.5Y	4	2	wk	sbk	f	m	fr
	C1	32	ss	g/cb	50	vg	SL	2.5Y	4	3	sl	ma	-	c	fr
	2C2	62+	sis	g/cb/st	80	ecb	SL	2.5Y	3	1	sl	ma	-	f	fr

Comments:

Vegetation: orchard grass

Slope and Aspect: 2% and 217

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 8 C

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	6	ss	g	55	vg	L	2.5Y	4	3	wk	sbk	m	m	fr
	C	66+	ss	g/cb/st	55	vg	L	2.5Y	4	3	sl	ma	-	c - f	fi

Comments:

Vegetation: orchard grass, clover, birdsfoot trefoil

Slope and Aspect: flat

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 8 E

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	10	ss	g/cb	55	vg	SL	2.5Y	4	3	wk	sbk	m	m	fr
	C1	37	ss	g/cb	65	vg	SL	2.5Y	4	3	sl	ma	-	c	fi
	2C2	60+	sis	g/cb/st	75	eg	SL	2.5Y	3	1	sl	ma	-	none	fi

Comments:

Vegetation: clover, orchard grass, birdsfoot trefoil

Slope and Aspect: flat

Appendix 4b. (continued)

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 9 B

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	6	ss	g/cb	60	vg	L/SL	2.5Y	4	3	wk	sbk	c	m	fr
	C1	37	ss	g/cb	60	vg	L/SL	2.5Y	4	2	sl	ma	-	c	fi
	2C2	47+	sis	-	-	-	-	2.5Y	3	1	sl	ma	-	none	-

Comments: 2C2 is at bottom of pit. Unable to get full description.

Vegetation: orchard grass, clover, birdsfoot trefoil

Slope and Aspect: 8% and 205

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 9 D

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	6	ss	g/cb	50	vg	L	2.5Y	4	3	wk	sbk	f	m	fr
	C1	42	ss	g/cb	55	vg	L	10YR	4	3	sl	ma	-	c	fi
	2C2	54+	sis	g/cb/st	80	ecb	L/SL	2.5Y	4	1	sl	ma	-	none	fr

Comments:

Vegetation: orchard grass, clover, birdsfoot trefoil

Slope and Aspect: flat

Site: VA 2 Describer: ATJ

Plot # and Hole ID: 9 E

Date: 14 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	10	ss	g/cb	50	vg	L	2.5Y	4	3	wk	sbk	m	m	fr
	C1	47	ss	g/cb	55	vg	L	10YR	4	3	sl	ma	-	c	fr
	2C2	53+	sis	g/cb/st	70	eg	SL/L	2.5Y	3	1	sl	ma	-	f	fr

Comments:

Vegetation: clover, orchard grass

Slope and Aspect: 2% and 175

Appendix 4b. (continued)

Site: VA 3 Describer: ATJ

Plot # and Hole ID: 1 B

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	7	ss	g/cb	70	eg	SL	10YR	4	3	wk	sbk	m	m	fr
	C	55+	ss	g/cb/st	85	est	SL	10YR	5&4	6&4	sl	ma	-	c	vfi

Comments:

Vegetation: foxtail millet

Slope and Aspect: 2% and 27

Site: VA 3 Describer: ATJ

Plot # and Hole ID: 1 C

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	ss	g	60	vg	SL	10YR	4	2	wk	sbk	c	m	fi
	C	66+	ss	g/cb/st	80	eg	SL	10YR	4	4	sl	ma	-	f	fi

Comments:

Vegetation: foxtail millet, birdsfoot trefoil

Slope and Aspect: flat

Site: VA 3 Describer: ATJ

Plot # and Hole ID: 1 D

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	ss	g/cb	65	eg	SL	2.5Y	5	3	wk	sbk	c	m	fi
	C1	33	ss	g/cb	70	ecb	SL	10YR	5	4	sl	ma	-	c	fi
								2.5Y	5	2					
	2C2	60+	ss	g/cb	81	eg	L	2.5Y	4	2	sl	ma	-	f	fi

Comments:

Vegetation: foxtail millet, birdsfoot trefoil

Slope and Aspect: 3% and 330

Appendix 4b. (continued)

Site: VA 3 Describer: ATJ

Plot # and Hole ID: 2 A

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	ss/sis	g/cb	60	vg	SL	10YR	4	2	wk	sbk	c	m	fr
	C1	33	ss	g/cb	70	eg	SL	10YR	4	3	sl	ma	-	c	fr
	2C2	52+	sis	c/cb	85	eg	L	2.5Y	4	2	sl	ma	-	none	fi

Comments:

Vegetation: foxtail millet, birdsfoot trefoil

Slope and Aspect: flat

Site: VA 3 Describer: ATJ

Plot # and Hole ID: 2 B

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	7	ss	g/cb/st	70	eg	SL	10YR	5	6	wk	sbk	f	m	fr
	C	53+	ss	g/cb/st	70	ecb	SL	7.5YR	5	6	sl	ma	-	c	fr

Comments:

Vegetation: foxtail millet

Slope and Aspect: flat

Site: VA 3 Describer: ATJ

Plot # and Hole ID: 2 D

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	ss/sis	g/cb	60	vg	SL	10YR	4	2	wk	sbk	m	m	fi
	C	65+	ss	g/cb/st	75	eg	SL	10YR	4	3	sl	ma	-	f	fi

Comments:

Vegetation: foxtail millet, birdsfoot trefoil

Slope and Aspect: flat

Appendix 4b. (continued)

Site: VA 3 Describer: ATJ

Plot # and Hole ID: 3 B

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	ss	g	70	eg	L	10YR	4	2	wk	sbk	m	m	fi
	Cd	53+	ss	g/cb/st	70	ecb	SiCL	10YR	4	4	sl	ma	-	none	efi

Comments:

Vegetation: foxtail millet, birdsfoot trefoil

Slope and Aspect: 2% and 350

Site: VA 3 Describer: ATJ

Plot # and Hole ID: 3 C

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	ss	g/cb	65	eg	SL	10YR	4	2	wk	sbk	m	m	fr
	C	44+	ss	g/cb	75	eg	SL	10YR	4	3	sl	ma	-	f	fi

Comments:

Vegetation: foxtail millet, birdsfoot trefoil

Slope and Aspect: 3% and 281

Site: VA 3 Describer: ATJ

Plot # and Hole ID: 3 D

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	ss	g	70	eg	L/SL	10YR	4	2	wk	sbk	c	m	fr
	C	42+	ss	g/cb/st	75	est	SL	10YR	4	2	sl	ma	-	f	fi

Comments:

Vegetation: foxtail millet

Slope and Aspect: 1% and 281

Appendix 4b. (continued)

Site: VA 3 Describer: ATJ

Plot # and Hole ID: 4 C

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	6	ss	g/cb	70	eg	SL	2.5Y	4	3	wk	sbk	m	m	fr
	C	47+	ss	g/cb/st	70	ecb	SL	2.5Y	4	3	sl	ma	-	c - f	fr

Comments:

Vegetation: foxtail millet, birdsfoot trefoil

Slope and Aspect: 2% and 345

Site: VA 3 Describer: ATJ

Plot # and Hole ID: 4 D

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	ss	g/cb	60	vg	L/SL	10YR	4	3	wk	sbk	f	m	fr
	C1	25	ss	g/cb	70	eg	L/SL	10YR	4	3	sl	ma	-	c - f	fi
	C2	55+	ss	g/cb	75	eg	L/SL	10YR	4	2	sl	ma	-	none	fi

Comments:

Vegetation: foxtail millet, birdsfoot trefoil, clover

Slope and Aspect: 4% and 20

Site: VA 3 Describer: ATJ

Plot # and Hole ID: 4 E

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	ss	g	70	eg	SL	2.5Y	4	2	wk	sbk	f	m	fi
	C	55+	ss	g/cb	70	eg	SL	2.5Y	4	2	sl	ma	-	c	fi

Comments:

Vegetation: foxtail millet

Slope and Aspect: 6% and 345

Appendix 4b. (continued)

Site: VA 3 Describer: ATJ

Plot # and Hole ID: 5 A

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	sis	g	75	eg	L	10YR	4	2	wk	sbk	f	c	fi
	C	50+	sis	cb/st	80	ecb	L	10YR	4	2	sl	ma	-	f	fi - vfi

Comments: C horizon may be densic.

Vegetation: foxtail millet

Slope and Aspect: 4% and 330

Site: VA 3 Describer: ATJ

Plot # and Hole ID: 5 B

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	ss/sis	g/cb	65	eg	L	2.5Y	4	2	wk	sbk	f	c	fi
	C	55+	ss/sis	st/cb	75	est	L	2.5Y	4	2	sl	ma	-	f	fi

Comments:

Vegetation: foxtail millet

Slope and Aspect: 6% and 10

Site: VA 3 Describer: ATJ

Plot # and Hole ID: 5 C

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	ss	g	65	eg	SL	2.5Y	4	2	wk	sbk	f	m	fr
	C1	30	ss	g/cb	70	eg	SL	2.5Y	4	3	sl	ma	-	f	fi
	C2	53+	ss	cb/st	75	ecb	SL	2.5Y	4	1	sl	ma	-	f	fi

Comments:

Vegetation: foxtail millet

Slope and Aspect: 6% and 0

Appendix 4b. (continued)

Site: VA 3 Describer: CNC

Plot # and Hole ID: 6 B

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	6	ss	g	65	eg	L	2.5Y	4	2	wk	sbk	m	m	fr
	C1	15	sis	g	65	eg	L/SL	2.5Y	5	4	sl	ma	-	f	fi
	C2	55+	sis	g/cb	70	eg	SL/L	2.5Y	4	2	sl	ma	-	none	vfi

Comments: C2 horizon may be densic.

Vegetation: foxtail millet, birdsfoot trefoil

Slope and Aspect: 4% and 323

Site: VA 3 Describer: ATJ

Plot # and Hole ID: 6 C

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	6	sis/ss	g/cb	65	eg	L/SL	2.5Y	4	2	wk	sbk	m	m	fi
	C	23	ss/sis	g/cb	75	ecb	SL	10YR	4	3	sl	ma	-	f	vfi
	Cd	43+	ss/sis	st/cb	80	est	-	10YR	4	2	sl	ma	-	none	vfi

Comments:

Vegetation: foxtail millet

Slope and Aspect: 1% and 60

Site: VA 3 Describer: ATJ

Plot # and Hole ID: 6 E

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	ss	g/cb	70	eg	L	10YR	4	2	wk	sbk	c	c	fr
	C	68+	ss	cb/st	80	ecb	SL	10YR	4	2	sl	ma	-	none	fi - vfi

Comments: C horizon may be Cd.

Vegetation: foxtail millet

Slope and Aspect: 5% and 330

Appendix 4b. (continued)

Site: VA 3 Describer: CNC

Plot # and Hole ID: 7 B

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	6	ss/sis	g	65	eg	L	2.5Y	4	3	wk	sbk	f	m	fr
	Cd	46+	ss/sis	g/cb	75	eg	L	2.5Y	4	4	sl	ma	-	f - none	vfi

Comments:

Vegetation: foxtail millet

Slope and Aspect: 5% and 322

Site: VA 3 Describer: CNC

Plot # and Hole ID: 7 C

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	8	ss	g	60	vg	L	2.5Y	4	1	wk	sbk	m	m	fr
	C	54+	ss	g/cb/st	70	eg	SL	10YR	5	4	sl	ma	-	c - none	fr

Comments:

Vegetation: foxtail millet, birdsfoot trefoil

Slope and Aspect: 4% and 326

Site: VA 3 Describer: CNC

Plot # and Hole ID: 7 D

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	8	ss	g	60	vg	SL	2.5Y	4	2	wk	sbk	m	m	fr
	C	48+	ss/sis	g/cb/st	70	eg	SL	2.5Y	4	3	sl	ma	-	c - none	fr

Comments:

Vegetation: foxtail millet, birdsfoot trefoil, clover

Slope and Aspect: flat

Appendix 4b. (continued)

Site: VA 3 Describer: CNC

Plot # and Hole ID: 8 A

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	ss/sis	g	80	eg	L	2.5Y	4	2	wk	sbk	m	f	fi
	C	62+	sis	g/cb/st	75	eg	L	10YR	5	3	sl	ma	-	none	fi

Comments:

Vegetation: foxtail millet

Slope and Aspect: 6% and 305

Site: VA 3 Describer: ATJ

Plot # and Hole ID: 8 C

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	ss/sis	g	75	eg	SL	2.5Y	4	2	wk	sbk	m	c	fr
	C	55+	ss/sis	g/cb	85	eg	SL	2.5Y	4	2	sl	ma	-	f	fr

Comments:

Vegetation: foxtail millet

Slope and Aspect: 8% and 320

Site: VA 3 Describer: CNC

Plot # and Hole ID: 8 E

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	ss	g	75	eg	SL	2.5Y	4	2	wk	sbk	f	c	vfr
	C	45+	ss	g/cb	75	eg	SL/L	2.5Y	4	2	sl	ma	-	none	fi

Comments:

Vegetation: foxtail millet

Slope and Aspect: 6% and 310

Appendix 4b. (continued)

Site: VA 3 Describer: ATJ

Plot # and Hole ID: 9 C

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	ss	g/cb	70	eg	L	10YR	4	2	wk	sbk	f	m	fr
	C1	42	ss	cb/st	70	est	L	10YR	4	4	sl	ma	-	c	fr
	2C2	54+	-	-	-	-	L	5Y	4	1	sl	ma	-	f	fr

Comments:

Vegetation: foxtail millet

Slope and Aspect: 4% and 300

Site: VA 3 Describer: ATJ

Plot # and Hole ID: 9 D

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	10	ss	g/cb	70	eg	L/SL	10YR	4	3	wk	sbk	f	m	fr
	C	46+	ss/sis	st/cb	85	est	SL	10YR	4	4	sl	ma	-	f	fi

Comments:

Vegetation: foxtail millet

Slope and Aspect: 2% and 300

Site: VA 3 Describer: ATJ

Plot # and Hole ID: 9 E

Date: 13 September 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	ss	g	65	eg	SL	10YR	4	2	wk	sbk	f	f	fi
	Cd	50+	ss	cb	80	ecb	SL/L	10YR	4	2	sl	ma	-	none	vfi

Comments: Sparse vegetation.

Vegetation: foxtail millet

Slope and Aspect: 1% and 300

Appendix 4c. Shallow soil pit descriptions of horizon, depth, texture, color, structure, roots, moist consistence, vegetation, slope and aspect of mine sites in West Virginia.

Site: WV 1 Describer: ATJ

Plot # and Hole ID: 1 A

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	sh	fg/mg	20	g	L	10YR	4	2	wk	gr	f	m	vfr
	C	30+	sh	g/cn	75	ecn	L	10YR	4	1	sl	ma	-	c	vfr

Comments:

Vegetation: fescue, red clover, wild carrot

Slope and Aspect: 3% and 324

Site: WV 1 Describer: ATJ

Plot # and Hole ID: 1 C

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	8	sh	fg/mg	35	vg	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	g/cn	65	ecn	L	10YR	4	3	sl	ma	-	c	fr

Comments:

Vegetation: fescue, red clover, timothy, wild carrot

Slope and Aspect: 2% and 2

Site: WV 1 Describer: ATJ

Plot # and Hole ID: 1 E

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	sh	fg/mg	25	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	ss/sh	g/cn	70	ecn	CL	10YR	4	6	sl	ma	-	f	fr

Comments:

Vegetation: goldenrod, fescue, clover, carrot

Slope and Aspect: 2% and 324

Appendix 4c. (continued)

Site: WV 1 Describer: BYA

Plot # and Hole ID: 2 A

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	sh	fg	20	g	L	10YR	3	2	wk	gr	f	m	fr
	C	30+	sh	cn	70	ecn	L	10YR	4	1	sl	ma	-	c	fr

Comments:

Vegetation: fescue, red clover, wild carrot, timothy, orchard grass, birdsfoot trefoil

Slope and Aspect: flat

Site: WV 1 Describer: BYA

Plot # and Hole ID: 2 B

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	sh	fg	50	vg	L	10YR	3	2	wk	gr	f	m	fr
	C	31+	sh	cn	90	ecn	L	10YR	4	1	sl	ma	-	c	fr

Comments:

Vegetation: fescue, red clover, wild carrot, orchard grass, birdsfoot trefoil

Slope and Aspect: flat

Site: WV 1 Describer: BYA

Plot # and Hole ID: 2 D

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	sh	fg	15	g	L	10YR	3	2	wk	gr	f	m	fr
	C	30+	sh	cn	95	ecn	L	10YR	4	1	sl	ma	-	f	fr

Comments:

Vegetation: fescue, red clover, wild carrot, orchard grass, timothy

Slope and Aspect: flat

Appendix 4c. (continued)

Site: WV 1 Describer: ATJ

Plot # and Hole ID: 3 A

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	sh	fg/mg	30	g	L	10YR	3	3	wk	gr	f	m	vfr
	C	30+	sh	g/cn	75	ecn	L	10YR	4	2	sl	ma	-	c	vfr

Comments:

Vegetation: fescue, white clover, wild carrot

Slope and Aspect: 3% and 8

Site: WV 1 Describer: ATJ

Plot # and Hole ID: 3 B

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	6	sh	fg/mg	35	vg	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	g/cn	80	ecn	L	10YR	4	1	sl	ma	-	c	vfr

Comments:

Vegetation: fescue, red clover, sweet clover, birdsfoot trefoil, wild carrot

Slope and Aspect: 4% and 356

Site: WV 1 Describer: ATJ

Plot # and Hole ID: 3 D

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	6	sh	fg/mg	25	g	L	10YR	4	2	wk	gr	f	m	vfr
	C	30+	sh	g/cn	70	ecn	L	10YR	4	2	sl	ma	-	f	vfr

Comments:

Vegetation: fescue, clover, carrot, birdsfoot trefoil

Slope and Aspect: 3% and 8

Appendix 4c. (continued)

Site: WV 1 Describer: ATJ

Plot # and Hole ID: 4 C

Date: 07 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	6	ss/sh	fg/mg	20	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	ss/sh	g/cn	60	vg	L	10YR	4	1	sl	ma	-	c	vfr

Comments:

Vegetation: fescue, red clover, wild carrot, rose bush

Slope and Aspect: 3% and 352

Site: WV 1 Describer: ATJ

Plot # and Hole ID: 4 D

Date: 07 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	ss/sh	fg/mg	20	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	ss/sh	g/cn	80	eg	L	10YR	4	1	sl	ma	-	c	vfr

Comments:

Vegetation: fescue, red clover, white clover, wild carrot

Slope and Aspect: 4% and 352

Site: WV 1 Describer: ATJ

Plot # and Hole ID: 4 E

Date: 07 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	ss/sh	fg/mg	20	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	ss/sh	g/cn	65	vg	L	10YR	4	1	sl	ma	-	f	vfr

Comments:

Vegetation: fescue, red clover, carrot, birdsfoot trefoil

Slope and Aspect: 2% and 352

Appendix 4c. (continued)

Site: WV 1 Describer: ATJ

Plot # and Hole ID: 5 A

Date: 07 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	ss/sh	fg/mg	25	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh/ss	g/cn	65	ecn	L	10YR	4	1	sl	ma	-	f	vfr

Comments:

Vegetation: fescue, white clover, wild carrot

Slope and Aspect: 2% and 338

Site: WV 1 Describer: ATJ

Plot # and Hole ID: 5 C

Date: 07 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	ss/sh	fg/mg	20	g	L	10YR	3	3	wk	gr	f	m	vfr
	C	30+	ss/sh	g/cn	65	eg	L	10YR	4	3	sl	ma	-	f	fr

Comments:

Vegetation: fescue, red clover, white clover, wild carrot

Slope and Aspect: 2% and 338

Site: WV 1 Describer: ATJ

Plot # and Hole ID: 5 E

Date: 07 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	sh	fg/mg	30	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	g/cn	70	eg	L	10YR	4	1	sl	ma	-	f	vfr

Comments:

Vegetation: fescue, white clover, carrot, sweet clover, orchard grass

Slope and Aspect: 3% and 338

Appendix 4c. (continued)

Site: WV 1 Describer: ATJ

Plot # and Hole ID: 6 A

Date: 07 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	6	ss/sh	fg/mg	25	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	ss/sh	g/cn	65	eg	L	10YR	3	2	sl	ma	-	f	vfr

Comments:

Vegetation: fescue, white clover, wild carrot, red clover, birdsfoot trefoil

Slope and Aspect: 4% and 338

Site: WV 1 Describer: ATJ

Plot # and Hole ID: 6 C

Date: 07 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	6	ss/sh	fg/mg	25	g	L	10YR	3	3	wk	gr	f	m	vfr
	C	30+	ss/sh	g/cn	65	eg	L	10YR	4	2	sl	ma	-	c	fr

Comments:

Vegetation: fescue, red clover, wild carrot, rose bush

Slope and Aspect: 3% and 338

Site: WV 1 Describer: ATJ

Plot # and Hole ID: 6 D

Date: 07 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	7	sh	fg/mg	25	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	g/cn	75	ecn	L	10YR	4	1	sl	ma	-	c	vfr

Comments:

Vegetation: fescue, white clover, carrot, red clover, birdsfoot trefoil

Slope and Aspect: 3% and 338

Appendix 4c. (continued)

Site: WV 1 Describer: BYA

Plot # and Hole ID: 7 B

Date: 07 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	sh	fg/mg	20	g	L	2.5Y	4	2	wk	gr	f	m	fr
	C	30+	sh	cn	60	vcn	L	5Y	5	1	sl	ma	-	c	fr

Comments:

Vegetation: fescue, red clover, wild carrot, orchard grass, birdsfoot trefoil

Slope and Aspect: flat

Site: WV 1 Describer: BYA

Plot # and Hole ID: 7 C

Date: 07 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	sh	fg/mg	20	g	L	10YR	3	2	wk	gr	f	m	fr
	C	30+	sh	cn	80	ecn	L	10YR	4	1	sl	ma	-	c	fr

Comments:

Vegetation: fescue, red clover, wild carrot, orchard grass, birdsfoot trefoil

Slope and Aspect: 3% and 300

Site: WV 1 Describer: BYA

Plot # and Hole ID: 7 D

Date: 07 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	sh	fg/mg	20	g	L	2.5Y	4	2	wk	gr	f	m	fr
	C	30+	sh	cn	90	ecn	L	5Y	4	1	sl	ma	-	c	fr

Comments:

Vegetation: fescue, red clover, wild carrot, orchard grass, birdsfoot trefoil

Slope and Aspect: flat

Appendix 4c. (continued)

Site: WV 1 Describer: CNC

Plot # and Hole ID: 8 B

Date: 07 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	ss/sh	fg	30	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	ss/sh	g/cn	70	ecn	L	10YR	4	2	sl	ma	-	c	vfr

Comments:

Vegetation: fescue, wild carrot, red clover, birdsfoot trefoil

Slope and Aspect: 3% and 338

Site: WV 1 Describer: CNC

Plot # and Hole ID: 8 C

Date: 07 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	ss/sh	fg/mg	35	vg	L	10YR	3	3	wk	gr	f	m	vfr
	C	30+	ss/sh	g/cn	70	ecn	L	10YR	4	2	sl	ma	-	c	fr

Comments:

Vegetation: fescue, red clover, wild carrot

Slope and Aspect: 2% and 355

Site: WV 1 Describer: CNC

Plot # and Hole ID: 8 D

Date: 07 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	ss/sh	fg	25	g	L	10YR	3	1	wk	gr	f	m	vfr
	C	30+	ss/sh	g/cn	70	ecn	L	10YR	4	2	sl	ma	-	c	fr

Comments:

Vegetation: fescue, orchard grass, wild carrot, red clover, birdsfoot trefoil

Slope and Aspect: 4% and 344

Appendix 4c. (continued)

Site: WV 1 Describer: ATJ

Plot # and Hole ID: 9 B

Date: 07 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	sh	mg/fg	60	vg	L	10YR	3	1	wk	gr	f	m	vfr
	C	30+	sh	g/cn	85	ecn	L	10YR	4	1	sl	ma	-	f	vfr

Comments:

Vegetation: fescue, wild carrot, birdsfoot trefoil

Slope and Aspect: 2% and 360

Site: WV 1 Describer: CNC

Plot # and Hole ID: 9 C

Date: 07 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	sh/ss	fg	20	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh/ss	g/cn	75	ecn	L	10YR	4	1	sl	ma	-	f	fr

Comments:

Vegetation: fescue, red clover, wild carrot, birdsfoot trefoil, orchard grass

Slope and Aspect: 4% and 18

Site: WV 1 Describer: ATJ

Plot # and Hole ID: 9 E

Date: 07 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	7	ss/sh	fg/mg	30	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	ss/sh	g/cn	70	eg	L	10YR	4	1	sl	ma	-	c	vfr

Comments:

Vegetation: fescue, wild carrot, white clover, sweet clover

Slope and Aspect: 3% and 360

Appendix 4c. (continued)

Site: WV 2 Describer: ATJ

Plot # and Hole ID: 1 C

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	sh	g/cn	30	cn	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	g/cn	75	ecn	L	10YR	4	2	sl	ma	-	c	fr

Comments:

Vegetation: fescue, wild carrot, orchard grass, red clover

Slope and Aspect: 1% and 84

Site: WV 2 Describer: ATJ

Plot # and Hole ID: 1 D

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	sh	fg/mg/cn	35	vg	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	cn	85	ecn	L	10YR	4	2	sl	ma	-	f	fr

Comments:

Vegetation: wild carrot, birdsfoot trefoil

Slope and Aspect: 3% and 52

Site: WV 2 Describer: ATJ

Plot # and Hole ID: 1 E

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	sh	g/cn	30	g	L	10YR	4	3	wk	gr	f	m	vfr
	C	30+	sh	g/cn	75	ecn	L	10YR	4	3	sl	ma	-	f	fr

Comments:

Vegetation: wild carrot, white clover

Slope and Aspect: 1% and 84

Appendix 4c. (continued)

Site: WV 2 Describer: ATJ

Plot # and Hole ID: 2 A

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	sh	g/cn	40	vcn	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	g/cn	75	ecn	L	10YR	4	1	sl	ma	-	f	fr

Comments:

Vegetation: fescue, wild carrot, birdsfoot trefoil, red clover

Slope and Aspect: 1% and 360

Site: WV 2 Describer: ATJ

Plot # and Hole ID: 2 B

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	sh	fg/mg	20	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	g/cn	70	ecn	L	10YR	4	2	sl	ma	-	f	fr

Comments:

Vegetation: wild carrot, fescue, white clover

Slope and Aspect: 1% and 360

Site: WV 2 Describer: ATJ

Plot # and Hole ID: 2 C

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	sh	g/cn	50	vcn	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	g/cn	75	ecn	L	10YR	4	1	sl	ma	-	c	fr

Comments:

Vegetation: wild carrot, white clover, fescue, red clover

Slope and Aspect: flat

Appendix 4c. (continued)

Site: WV 2 Describer: ATJ

Plot # and Hole ID: 3 B

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	ss/sh	fg/mg	30	g	SL	10YR	3	3	wk	gr	f	m	vfr
	C	30+	sh	g/cn	65	ecn	SL	10YR	4	2	sl	ma	-	f	fr

Comments:

Vegetation: fescue, wild carrot, timothy, white clover, red clover

Slope and Aspect: 1% and 360

Site: WV 2 Describer: ATJ

Plot # and Hole ID: 3 C

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	sh	fg/mg	25	vg	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	g/cn	80	ecn	L	10YR	4	1	sl	ma	-	c	fr

Comments:

Vegetation: fescue, red clover

Slope and Aspect: flat

Site: WV 2 Describer: ATJ

Plot # and Hole ID: 3 D

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	sh	fg/mg	30	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	g/cn	75	ecn	L	10YR	4	2	sl	ma	-	c	fr

Comments:

Vegetation: wild carrot, white clover, fescue, red clover

Slope and Aspect: flat

Appendix 4c. (continued)

Site: WV 2 Describer: ATJ

Plot # and Hole ID: 4 A

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	sh	fg/mg	30	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	g/cn	70	ecn	L	10YR	4	1	sl	ma	-	f	fr

Comments:

Vegetation: fescue, wild carrot, birdsfoot trefoil

Slope and Aspect: 3% and 14

Site: WV 2 Describer: CNC

Plot # and Hole ID: 4 D

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	ss/sh	fg/mg	25	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	25+	ss/sh	g/cn	80	ecn	L	10YR	4	2	sl	ma	-	c	vfr

Comments:

Vegetation: fescue, red clover, birdsfoot trefoil, wild carrot

Slope and Aspect: 2% and 28

Site: WV 2 Describer: CNC

Plot # and Hole ID: 4 E

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	ss	fg/mg	25	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	ss	cn	75	ecn	L	10YR	4	2	sl	ma	-	m	vfr

Comments:

Vegetation: wild carrot, birdsfoot trefoil, fescue, red clover

Slope and Aspect: 3% and 27

Appendix 4c. (continued)

Site: WV 2 Describer: CNC

Plot # and Hole ID: 5 B

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	sh	fg/mg	20	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	cn	75	ecn	L	10YR	4	2	sl	ma	-	c	vfr

Comments:

Vegetation: fescue, wild carrot, birdsfoot trefoil, timothy, red clover

Slope and Aspect: 3% and 32

Site: WV 2 Describer: CNC

Plot # and Hole ID: 5 D

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	ss/sh	fg/mg	25	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	ss/sh	g/cn	70	ecn	L	10YR	4	2	sl	ma	-	c	vfr

Comments:

Vegetation: fescue, red clover, birdsfoot trefoil, wild carrot, timothy

Slope and Aspect: 4% and 10

Site: WV 2 Describer: CNC

Plot # and Hole ID: 5 E

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	sh/ss	fg/mg	30	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh/ss	fg/cn	80	ecn	L	10YR	4	2	sl	ma	-	c	vfr

Comments:

Vegetation: wild carrot, timothy, fescue, red clover

Slope and Aspect: 3% and 11

Appendix 4c. (continued)

Site: WV 2 Describer: ATJ

Plot # and Hole ID: 6 C

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	sh	fg/mg	45	vg	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	g/cn	80	ecn	L	10YR	4	1	sl	ma	-	f	fr

Comments:

Vegetation: fescue, wild carrot, timothy, red clover

Slope and Aspect: 1% and 52

Site: WV 2 Describer: ATJ

Plot # and Hole ID: 6 D

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	sh	fg/mg	40	vg	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	g/cn	75	ecn	L	10YR	4	1	sl	ma	-	f	fr

Comments:

Vegetation: fescue, wild carrot

Slope and Aspect: 2% and 358

Site: WV 2 Describer: ATJ

Plot # and Hole ID: 6 E

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	sh	fg/mg	45	vg	L	10YR	3	2	wk	gr	f	m	vfr
	Bw	16	sh	g/cn	70	ecn	L	10YR	4	2	wk	sbk	f	m	vfr
	2C	30+	sh/ss	g/cn	70	ecn	SL	10YR	4	3	sl	ma	-	f	fr

Comments:

Vegetation: timothy, fescue, white clover, orchard grass, birdsfoot trefoil

Slope and Aspect: 1% and 50

Appendix 4c. (continued)

Site: WV 2 Describer: ATJ

Plot # and Hole ID: 7 B

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	sh	fg/mg	25	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	g/cn	70	ecn	L	10YR	4	1	sl	ma	-	c	vfr

Comments:

Vegetation: fescue, wild carrot, white clover, red clover

Slope and Aspect: 2% and 10

Site: WV 2 Describer: ATJ

Plot # and Hole ID: 7 C

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	sh	fg/mg	30	vg	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	g/cn	70	ecn	L	10YR	4	2	sl	ma	-	c	fr

Comments:

Vegetation: fescue, wild carrot, white clover

Slope and Aspect: 2% and 10

Site: WV 2 Describer: ATJ

Plot # and Hole ID: 7 D

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	6	sh/ss	fg/mg/cn	55	vg	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh/ss	g/cn	65	ecn	L	10YR	4	2	sl	ma	-	c	fr

Comments:

Vegetation: fescue, white clover, red clover, wild carrot

Slope and Aspect: 2% and 10

Appendix 4c. (continued)

Site: WV 2 Describer: ATJ

Plot # and Hole ID: 8 A

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	6	sh	fg/mg	25	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	g/cn	70	ecn	L	10YR	4	1	sl	ma	-	m	vfr

Comments:

Vegetation: fescue, timothy, red clover

Slope and Aspect: 2% and 44

Site: WV 2 Describer: ATJ

Plot # and Hole ID: 8 C

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	ss/sh	fg/mg	40	vg	SL	10YR	3	2	wk	gr	f	m	vfr
	C	30+	ss/sh	g/cn	65	eg	SL	10YR	4	1	sl	ma	-	c	fr

Comments:

Vegetation: fescue, wild carrot, red clover

Slope and Aspect: 3% and 348

Site: WV 2 Describer: ATJ

Plot # and Hole ID: 8 D

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	sh	fg/mg	50	vg	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	cn/g	80	ecn	L	10YR	4	1	sl	ma	-	m	vfr

Comments:

Vegetation: fescue, birdsfoot trefoil, red clover

Slope and Aspect: 2% and 44

Appendix 4c. (continued)

Site: WV 2 Describer: ATJ

Plot # and Hole ID: 9 B

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	sh	cn/g	50	vcn	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	cn/g	75	ecn	L	10YR	4	1	sl	ma	-	c	vfr

Comments:

Vegetation: fescue, wild carrot, red clover, birdsfoot trefoil

Slope and Aspect: 2% and 52

Site: WV 2 Describer: ATJ

Plot # and Hole ID: 9 C

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	ss/sh	fg/mg	40	vg	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	g/cn	80	ecn	L	10YR	4	1	sl	ma	-	c	vfr

Comments:

Vegetation: fescue, white clover, red clover, timothy

Slope and Aspect: 2% and 14

Site: WV 2 Describer: ATJ

Plot # and Hole ID: 9 D

Date: 05 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	sh	fg/mg	40	vg	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	cn/g	70	ecn	L	10YR	4	1	sl	ma	-	c	fr

Comments:

Vegetation: fescue, birdsfoot trefoil, red clover, wild carrot

Slope and Aspect: 2% and 40

Appendix 4c. (continued)

Site: WV 3 Describer: ATJ

Plot # and Hole ID: 1 B

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	6	sh	fg/mg	15	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	cn/g	65	ecn	L	10YR	4	2	sl	ma	-	c	vfr

Comments:

Vegetation: fescue, wild carrot, red clover

Slope and Aspect: 2% and 47

Site: WV 3 Describer: ATJ

Plot # and Hole ID: 1 C

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	sh	fg/mg	20	g	L	10YR	3	2	wk	gr	f	m	vfr
	C1	11	sh	fg/mg/cn	30	g	L	10YR	4	1	sl	ma	-	m	vfr
	2C2	30+	sh	g/cn	70	ecn	CL	10YR	4&5	2&6	sl	ma	-	f	fr

Comments:

Vegetation: fescue, white clover, timothy, orchard grass, wild carrot

Slope and Aspect: 2% and 47

Site: WV 3 Describer: ATJ

Plot # and Hole ID: 1 E

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	sh	fg/mg	30	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	cn/g	75	ecn	L	10YR	4	1	sl	ma	-	c	vfr

Comments:

Vegetation: fescue, birdsfoot trefoil, red clover, wild carrot, white clover

Slope and Aspect: 3% and 47

Appendix 4c. (continued)

Site: WV 3 Describer: BYA

Plot # and Hole ID: 2 A

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	ss/sh	fg/mg	20	g	L	10YR	3	2	wk	gr	f	m	fr
	C	30+	ss/sh	cn/g	90	ecn	L	10YR	4	1	sl	ma	-	f	fr

Comments:

Vegetation: fescue, red clover, orchard grass, timothy, birdsfoot trefoil, golden rod

Slope and Aspect: 8% and 100

Site: WV 3 Describer: BYA

Plot # and Hole ID: 2 C

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	sh	fg/mg	20	g	L	10YR	3	2	wk	gr	f	m	vfr
	C1	11	sh	fg/mg/cn	30	g	L	10YR	4	1	sl	ma	-	m	vfr
	2C2	30+	sh	g/cn	70	ecn	CL	10YR	4&5	2&6	sl	ma	-	f	fr

Comments:

Vegetation: fescue, red clover, timothy, orchard grass, wild carrot, golden rod

Slope and Aspect: 5% and 160

Site: WV 3 Describer: BYA

Plot # and Hole ID: 2 E

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	ss/sh	fg/mg	20	g	L	10YR	3	2	wk	gr	f	m	fr
	C	30+	ss/sh	cn/g	80	ecn	L	10YR	4	1	sl	ma	-	c	fr

Comments:

Vegetation: fescue, birdsfoot trefoil, red clover, wild carrot, orchard grass, timothy

Slope and Aspect: 5% and 80

Appendix 4c. (continued)

Site: WV 3 Describer: BYA

Plot # and Hole ID: 3 B

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	ss/sh	fg/mg	20	g	L	10YR	3	2	wk	gr	f	m	fr
	C	30+	ss/sh	cn/g	70	ecn	L	10YR	4	1	sl	ma	-	f	fr

Comments:

Vegetation: fescue, orchard grass, timothy, wild carrot, golden rod

Slope and Aspect: 2% and 100

Site: WV 3 Describer: BYA

Plot # and Hole ID: 3 C

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	ss/sh	fg	35	vg	L	10YR	3	2	wk	gr	f	m	fr
	C	30+	ss/sh	cg/cn	80	ecn	L	10YR	4	1	sl	ma	-	f	fr

Comments:

Vegetation: fescue, red clover, timothy, birdsfoot trefoil, wild carrot, golden rod

Slope and Aspect: flat

Site: WV 3 Describer: BYA

Plot # and Hole ID: 3 D

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	ss/sh	fg	20	g	L	10YR	3	2	wk	gr	f	m	fr
	C	30+	ss/sh	cn/g	70	ecn	L	10YR	4	1	sl	ma	-	f	fr

Comments:

Vegetation: fescue, birdsfoot trefoil, red clover, golden rod, orchard grass, timothy

Slope and Aspect: 5% and 100

Appendix 4c. (continued)

Site: WV 3 Describer: ATJ

Plot # and Hole ID: 4 A

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	ss/sh	fg/mg	30	g	L	10YR	3	3	wk	gr	f	m	vfr
	C	30+	ss/sh	cn/g	65	ecn	SL	10YR	4	3	sl	ma	-	c	fr

Comments:

Vegetation: fescue, birdsfoot trefoil, white clover, timothy, golden rod

Slope and Aspect: 4% and 70

Site: WV 3 Describer: ATJ

Plot # and Hole ID: 4 B

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	sh	fg/mg	40	vg	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	g/cn	80	ecn	L	10YR	4	3	sl	ma	-	c	fr

Comments:

Vegetation: fescue, red clover, golden rod

Slope and Aspect: 3% and 70

Site: WV 3 Describer: ATJ

Plot # and Hole ID: 4 E

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	6	sh	fg/mg	35	vg	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	cn/g	70	ecn	L	10YR	4	2	sl	ma	-	c	fr

Comments:

Vegetation: fescue, red clover, wild carrot, golden rod

Slope and Aspect: 3% and 70

Appendix 4c. (continued)

Site: WV 3 Describer: ATJ

Plot # and Hole ID: 5 A

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	6	sh	fg/mg	20	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	cn/g	75	ecn	L	10YR	4	1	sl	ma	-	m	vfr

Comments:

Vegetation: fescue, red clover, white clover, timothy, wild carrot

Slope and Aspect: 3% and 44

Site: WV 3 Describer: ATJ

Plot # and Hole ID: 5 C

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	sh	fg/mg	25	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	g/cn	75	ecn	L	10YR	4	2	sl	ma	-	c	vfr

Comments:

Vegetation: fescue, red clover, wild carrot, autumn olive

Slope and Aspect: 4% and 52

Site: WV 3 Describer: ATJ

Plot # and Hole ID: 5 E

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	6	sh	fg/mg	35	vg	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	cn/g	70	ecn	L	10YR	4	2	sl	ma	-	c	fr

Comments:

Vegetation: fescue, red clover, wild carrot, pokeberry

Slope and Aspect: 2% and 44

Appendix 4c. (continued)

Site: WV 3 Describer: BYA

Plot # and Hole ID: 6 A

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	ss/sh	fg/mg	40	vg	L	10YR	3	2	wk	gr	f	m	fr
	C	32+	sh	cn	90	ecn	L	10YR	4	2	sl	ma	-	f	fi

Comments:

Vegetation: fescue, orchard grass, timothy, wild carrot, birdsfoot trefoil, red clover

Slope and Aspect: flat

Site: WV 3 Describer: BYA

Plot # and Hole ID: 6 B

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	ss/sh	fg/mg	20	g	L	10YR	4	2	wk	gr	f	m	fr
	C	29+	ss/sh	g/cn	75	ecn	L	10YR	5	4	sl	ma	-	f	fi

Comments:

Vegetation: fescue, red clover, timothy, orchard grass, wild carrot, golden rod

Slope and Aspect: 5% and 30

Site: WV 3 Describer: BYA

Plot # and Hole ID: 6 D

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	ss/sh	mg/cn	20	g	L	10YR	3	2	wk	gr	f	m	fr
	C	30+	ss/sh	cn/g	75	eg	L	10YR	4	2	sl	ma	-	f	fi

Comments:

Vegetation: fescue, birdsfoot trefoil, red clover, golden rod, orchard grass, timothy, wild carrot

Slope and Aspect: 2% and 30

Appendix 4c. (continued)

Site: WV 3 Describer: ATJ

Plot # and Hole ID: 7 A

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	6	sh	fg/mg	30	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	g/cn/st	85	ecn	L	10YR	4	1	sl	ma	-	f	vfr

Comments:

Vegetation: fescue, wild carrot, white clover

Slope and Aspect: 4% and 50

Site: WV 3 Describer: BYA

Plot # and Hole ID: 7 B

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	ss/sh	fg	40	vg	L	10YR	3	2	wk	gr	f	m	fr
	C	31+	ss/sh	mg/cg/cn	60	vg	L	10YR	4	2	sl	ma	-	c	fr

Comments:

Vegetation: fescue, red clover, timothy, orchard grass, wild carrot, birdsfoot trefoil, multiflora rose

Slope and Aspect: 5% and 40

Site: WV 3 Describer: BYA

Plot # and Hole ID: 7 E

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	ss/sh	fg/mg	20	g	L	10YR	3	2	wk	gr	f	m	fr
	C	29+	ss/sh	cg/cn	70	ecn	L	10YR	4	1	sl	ma	-	f	fr

Comments:

Vegetation: fescue, red clover, golden rod, orchard grass, timothy, wild carrot, multiflora rose

Slope and Aspect: 8% and 50

Appendix 4c. (continued)

Site: WV 3 Describer: ATJ

Plot # and Hole ID: 8 B

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	2	ss/sh	fg/mg	20	g	L	10YR	4	2	wk	gr	f	m	vfr
	C	30+	ss/sh	cn/g	80	ecn	L	10YR	4	2	sl	ma	-	c	fr

Comments:

Vegetation: fescue, red clover, white clover, birdsfoot trefoil, wild carrot

Slope and Aspect: 3% and 86

Site: WV 3 Describer: ATJ

Plot # and Hole ID: 8 C

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	sh	fg/mg	30	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	g/cn	75	ecn	L	10YR	4	1	sl	ma	-	f	fr

Comments:

Vegetation: fescue, red clover, wild carrot, sweet clover, thistle

Slope and Aspect: 2% and 40

Site: WV 3 Describer: ATJ

Plot # and Hole ID: 8 E

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	3	ss/sh	fg/mg	35	vg	L	10YR	4	2	wk	gr	f	m	vfr
	C	30+	ss/sh	cn/g	70	ecn	L	10YR	4	2	sl	ma	-	f	fr

Comments:

Vegetation: fescue, white clover, wild carrot, orchard grass, golden rod, lespedeza

Slope and Aspect: 3% and 50

Appendix 4c. (continued)

Site: WV 3 Describer: CNC

Plot # and Hole ID: 9 A

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	6	sh	fg/mg	15	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	cn/g	70	ecn	L	10YR	4	2	sl	ma	-	f	fr

Comments:

Vegetation: fescue, red clover, timothy, birdsfoot trefoil, wild carrot

Slope and Aspect: 8% and 106

Site: WV 3 Describer: CNC

Plot # and Hole ID: 9 B

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	5	sh	fg	35	vg	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	sh	g/cn	75	ecn	L	10YR	5	3	sl	ma	-	c	fr

Comments:

Vegetation: fescue, red clover, wild carrot, golden rod

Slope and Aspect: 5% and 68

Site: WV 3 Describer: CNC

Plot # and Hole ID: 9 C

Date: 06 August 2003

Horizon		Bottom Depth	Rocks			Texture		Color			Structure			Roots	Moist
No.	Name	cm.	type	size	%	mod.	fine earth	Hue	Value	Chroma	Grade	Shape	Size	Abundance	Consistence
	A	4	sh	fg	25	g	L	10YR	3	2	wk	gr	f	m	vfr
	C	30+	ss/sh	cn/g	70	ecn	L	10YR	4	1	sl	ma	-	f	fr

Comments:

Vegetation: fescue, wild carrot, orchard grass, golden rod, timothy, red clover, birdsfoot trefoil

Slope and Aspect: 4% and 106

Appendix 5a. Soil and site descriptions of mine soils in Ohio.

SOIL AND SITE DESCRIPTION FORM

Persons Describing the Soil: __JG, AJ, CC________________________________ Pedon # __OH1-1_________

Date __8/13/03________ Lat.(5) ____ . _________ Lon.(5) _____ . ________ (decimal degrees)

County __Lawerence, Ohio____ USGS Quad Sheet(5)_____________________ MLRA(6) ________

Site Properties: (8-9)

Current land use and vegetation: __fescue, lespedeza, clover_________________________________

Elevation (m): __300____________ Aspect (slope direction) (0^o to 360^o):___40_____________

Slope gradient (%): ___2%________ Slope length: (m) _____65____________

Boulders on/in surface (%) __-__ Stones on/in surface (%) __-__

Physiography: (10) ___ Flood Plain ___ Stream terrace (level) ___ Stream terrace (dissected)
_x_ Upland ___ Closed Depression ___ Drainageway

Slope shape: (11) _x_ Summit ___ Shoulder ___ Backslope
___ Footslope ___ Toeslope ___ Not Appl. (on < 2% slopes in coastal plains)

Land surface shape: (12) (First letter is down-slope profile, second letter is cross-slope profile) L = linear V = convex C = concave

___ LL ___ LV ___ LC
___ VL ___ VV _x_ VC
___ CL ___ CV ___ CC

Hydrology: (13-15)

Saturation type: endo or epi? _____ Wetland indicator plants? y/n _n_ Artificial drainage: y/n _n_

Depth of observed water: (cm) ____ Flooding evidence? y/n _n__ Ponding evidence? y/n _n__

SOIL PROPERTIES		
Soil Drainage Class (19)	Depth Class: (20)	Parent Material(s): (20)
___ excessively drained	____ V. Shallow (< 25 cm)	_x_ Mine spoil
___ somewhat excessive	____ Shallow (25 – 50 cm)	___ Residuum (kind/s) ____________________________
_x_ well	____ Mod. Deep (50 – 100 cm)	___ Organic (not litter)
___ somewhat well	____ Deep (100 – 150 cm)	___ Alluvium
___ moderately well	_x__ Very Deep (> 150 cm)	___ Marine (recent)
___ somewhat poor		___ Unconsol. Coastal Plain
___ poorly drained		___ Beach
___ very poorly		___ Lacustrine
		___ Loess
	Root-restricting depth: (20) (cm) _____	___ Eolian sand (dune)
		___ Colluvium

ABBREVIATIONS

Texture:

Sand = S | Silt Loam = SiL
Loamy Sand = LS | Silty Clay Loam = SiCL
Sandy Loam = SL | Silty Clay = SiC
Loam = L | Sandy Clay Loam = SCL
Clay Loam = CL | Clay = C
Silt = SI | Sandy Clay= SC

Modifiers of Coarse Fragments:

Gravelly = GR ($\geq$ 15%) | Cobbly = CB ($\geq$ 15%)
Channery = CH ($\geq$ 15%) | Stony = ST ($\geq$ 15%)
Very (add V if $\geq$ 35%) | Extremely (add X if $\geq$ 65%)

Structure Grade:

Weak = WK | Strong = ST
Moderate = MO | Structureless = SLS

Structure Shape:

Granular = GR | Angular Blocky = ABK
Platy = PL | Subangular Blocky = SBK
Prismatic = PR | Massive = MA
Single Grain = SG

Consistence:

Loose = L | Firm = FI
Very Friable = VFR | Very Firm = VFI
Friable = FR | Extremely Firm = EFI

Abundance:

Few (< 2% vol) = F | Many ($\geq$ 20% vol) = M
Common (2 to < 20% vol) = C

Pore Linings or Masses:

L = pore linings | M = masses

Appendix 5a. (continued)

Soil Profile __OH1-1__________ **Description Worksheet** (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Depth	Texture		Color			Redoximorphic Features (1 or 2 of each)						Structure		Consis -tence	Roots
Hor #	Name	Bot- tom	Rock frag. Mod- ifier	Fine-earth Class	Moist Matrix			Fe Depletions		Fe Concentrations				Grade	Shape	Moist	Abund.
		cm			Hue	Val	Chr	% vol.	Full Color Hue V/C	% vol.	Full Color Hue V/C	Linings /masses	Abun dance				Fine + V. F.
1	A	3	-	SiL	10YR	2	2							wk	gr	vfr	M
2	Bw	27	G	CL	10YR	5	4							mo wk	sbk sbk	fi	M
3	2BC	47	Vg	CL	2.5Y	5	2							wk	sbk	fi	C
4	3C1	101	Vg	CL	2.5Y	5	3							sls	ma	fr	C
5	3C2	160+	Vg	CL	2.5Y	5	3							sls	ma	fr	F
6																	
7																	
8																	
Page																	

Additional Description Worksheet (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Rock fragments				Other Concentrations			Other Depletions	Rock-controlled structure?	Brittle?	Perching layer?	Root-limiting?	D_b
Hor #	Name	Gravel	Cobbles	Channers	Stones	Mn concr	Mn stains	Clay Films	Sandy or bleached pockets					
		%	%	%	%	%	y/n	y/n	% vol.	y/n	%	y/n	y/n	g/cm^3
1	A	5	-	-	-	0	N	N	0	N	0	N	N	-
2	Bw	25	5	-	-	0	N	N	0	N	5	N	N	1.4 – 1.5
3	2BC	35	10	-	5	0	N	N	0	N	5	N	N	1.46
4	3C1	35	10	-	10	0	N	N	0	N	0	N	N	1.08
5	3C2	35	10	-	5	0	N	N	0	N	0	N	N	1.20
6														
7														
8														
Page#														

Comments:	**hor**	grey SS	Sis + shale	white + red SS	carboliths	**hor**	grey SS	Sis + shale	white + red SS	carboliths	**hor**	grey SS	Sis + shale	white + red SS	carboliths
rock type	**1**	-	-	-	-	**3**	5	30	60	5	**5**	15	60	25	-
by horizon	**2**	-	50	50	-	**4**	5	35	60	-					

SOIL AND SITE DESCRIPTION FORM

Persons Describing the Soil: __JG, AJ, CC________________________________ Pedon # __OH1-2A_________

Date __8/13/03________ Lat.(5) ____ . _________ Lon.(5) _____ . ________ (decimal degrees)

County __Lawerence, Ohio____ USGS Quad Sheet(5)_____________________ MLRA(6) ________

Site Properties: (8-9)

Current land use and vegetation: __fescue, lespedeza, orchard grass, goldenrod, blackberry

Elevation (m): __300____________ Aspect (slope direction) (0^o to 360^o):___328_____________

Slope gradient (%): ___7%________ Slope length: (m) _____50____________

Boulders on/in surface (%) __-__ Stones on/in surface (%) __-__

Physiography: (10) ___ Flood Plain ___ Stream terrace (level) ___ Stream terrace (dissected)
_x_ Upland ___ Closed Depression ___ Drainageway

Slope shape: (11) ___ Summit ___ Shoulder _x_ Backslope
___ Footslope ___ Toeslope ___ Not Appl. (on < 2% slopes in coastal plains)

Land surface shape: (12) (First letter is down-slope profile, second letter is cross-slope profile) L = linear V = convex C = concave

_x_ LL ___ LV ___ LC
___ VL ___ VV ___ VC
___ CL ___ CV ___ CC

Hydrology: (13-15)

Saturation type: endo or epi? _____ Wetland indicator plants? y/n _n_ Artificial drainage: y/n _n_

Depth of observed water: (cm) ____ Flooding evidence? y/n _n__ Ponding evidence? y/n _n__

SOIL PROPERTIES

Soil Drainage Class (19)	Depth Class: (20)	Parent Material(s): (20)
		_x_ Mine spoil
___ excessively drained	____ V. Shallow (< 25 cm)	___ Residuum (kind/s) ___________
___ somewhat excessive	____ Shallow (25 – 50 cm)	___ Organic (not litter)
_x_ well	____ Mod. Deep (50 – 100 cm)	___ Alluvium
___ somewhat well	____ Deep (100 – 150 cm)	___ Marine (recent)
___ moderately well	_x__ Very Deep (> 150 cm)	___ Unconsol. Coastal Plain
___ somewhat poor		___ Beach
___ poorly drained		___ Lacustrine
___ very poorly		___ Loess
	Root-restricting depth: (20) (cm) _____	___ Eolian sand (dune)
		___ Colluvium

ABBREVIATIONS

Texture:

Sand = S	Silt Loam = SiL
Loamy Sand = LS	Silty Clay Loam = SiCL
Sandy Loam = SL	Silty Clay = SiC
Loam = L	Sandy Clay Loam = SCL
Clay Loam = CL	Clay = C
Silt = SI	Sandy Clay= SC

Modifiers of Coarse Fragments:

Gravelly = GR (≥ 15%)	Cobbly = CB (≥ 15%)
Channery = CH (≥ 15%)	Stony = ST (≥ 15%)
Very (add V if ≥ 35%)	Extremely (add X if ≥ 65%)

Structure Grade:

Weak = WK	Strong = ST
Moderate = MO	Structureless = SLS

Structure Shape:

Granular = GR	Angular Blocky = ABK
Platy = PL	Subangular Blocky = SBK
Prismatic = PR	Massive = MA
Single Grain = SG	

Consistence:

Loose = L	Firm = FI
Very Friable = VFR	Very Firm = VFI
Friable = FR	Extremely Firm = EFI

Abundance:

Few (< 2% vol) = F	Many (≥ 20% vol) = M
Common (2 to < 20% vol) = C	

Pore Linings or Masses:

L = pore linings	M = masses

Appendix 5a. (continued)

Soil Profile __OH1-2A__________ **Description Worksheet** (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Depth	Texture		Color			Redoximorphic Features (1 or 2 of each)						Structure		Consis -tence	Roots
Hor #	Name	Bot-tom	Rock frag. Mod-ifier	Fine-earth Class	Moist Matrix			Fe Depletions		Fe Concentrations				Grade	Shape	Moist	Abund.
		cm			Hue	Val	Chr	% vol.	Full Color Hue V/C	% vol.	Full Color Hue V/C	Linings /masses	Abun dance				Fine + V. F.
1	A	3		CL										wk	gr	vfr	M
2	Bw	11		CL										mo	sbk	fr	M
3	2BC	22		CL										wk	sbk	fr	C
4	3C1	62		CL										sls	ma	fi	F
5	4C2	200+		CL										sls	ma	fr	F
6																	
7																	
8																	
Page																	

Additional Description Worksheet (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Rock fragments				Other Concentrations			Other Depletions	Rock-controlled structure?	Brittle?	Perching layer?	Root-limiting?	Pores?
Hor #	Name	Gravel	Cobbles	Channers	Stones	Mn concr	Mn stains	Clay Films	Sandy or bleached pockets					
		%	%	%	%	%	y/n	y/n	% vol.	y/n	%	y/n	y/n	Abund
1														
2														
3														
4														
5														
6														
7														
8														
Page#														

Comments:

SOIL AND SITE DESCRIPTION FORM

Persons Describing the Soil: __JG, AJ, CC________________________________ Pedon # __OH1-2B_________

Date __8/13/03________ Lat.(5) ____ . _________ Lon.(5) _____ . ________ (decimal degrees)

County __Lawerence, Ohio____ USGS Quad Sheet(5)_____________________ MLRA(6) ________

Site Properties: (8-9)

Current land use and vegetation: __lespedeza, goldenrod_________________________________

Elevation (m): __300____________ Aspect (slope direction) (0^o to 360^o):___328______________

Slope gradient (%): ___8%________ Slope length: (m) _____45____________

Boulders on/in surface (%) __-__ Stones on/in surface (%) __-__

Physiography: (10) ___ Flood Plain ___ Stream terrace (level) ___ Stream terrace (dissected)
_x_ Upland ___ Closed Depression ___ Drainageway

Slope shape: (11) ___ Summit ___ Shoulder _x_ Backslope
___ Footslope ___ Toeslope ___ Not Appl. (on < 2% slopes in coastal plains)

Land surface shape: (12) (First letter is down-slope profile, second letter is cross-slope profile) L = linear V = convex C = concave

_x_ LL ___ LV ___ LC
___ VL ___ VV ___ VC
___ CL ___ CV ___ CC

Hydrology: (13-15)

Saturation type: endo or epi? _____ Wetland indicator plants? y/n _n_ Artificial drainage: y/n _n_

Depth of observed water: (cm) ____ Flooding evidence? y/n _n__ Ponding evidence? y/n _n__

SOIL PROPERTIES		
Soil Drainage Class (19)	Depth Class: (20)	Parent Material(s): (20)
		_x_ Mine spoil
___ excessively drained	____ V. Shallow (< 25 cm)	___ Residuum (kind/s) ___________________________
___ somewhat excessive	____ Shallow (25 – 50 cm)	___ Organic (not litter)
_x_ well	____ Mod. Deep (50 – 100 cm)	___ Alluvium
___ somewhat well	____ Deep (100 – 150 cm)	___ Marine (recent)
___ moderately well	_x__ Very Deep (> 150 cm)	___ Unconsol. Coastal Plain
___ somewhat poor		___ Beach
___ poorly drained		___ Lacustrine
___ very poorly		___ Loess
	Root-restricting depth: (20)	___ Eolian sand (dune)
	(cm) _____	___ Colluvium

ABBREVIATIONS

Texture:

Sand = S	Silt Loam = SiL
Loamy Sand = LS	Silty Clay Loam = SiCL
Sandy Loam = SL	Silty Clay = SiC
Loam = L	Sandy Clay Loam = SCL
Clay Loam = CL	Clay = C
Silt = SI	Sandy Clay= SC

Modifiers of Coarse Fragments:

Gravelly = GR (≥ 15%)	Cobbly = CB (≥ 15%)
Channery = CH (≥ 15%)	Stony = ST (≥ 15%)
Very (add V if ≥ 35%)	Extremely (add X if ≥ 65%)

Structure Grade:

Weak = WK	Strong = ST
Moderate = MO	Structureless = SLS

Structure Shape:

Granular = GR	Angular Blocky = ABK
Platy = PL	Subangular Blocky = SBK
Prismatic = PR	Massive = MA
Single Grain = SG	

Consistence:

Loose = L	Firm = FI
Very Friable = VFR	Very Firm = VFI
Friable = FR	Extremely Firm = EFI

Abundance:

Few (< 2% vol) = F	Many (≥ 20% vol) = M
Common (2 to < 20% vol) = C	

Pore Linings or Masses:

L = pore linings	M = masses

Soil Profile __OH1-2B__________ **Description Worksheet** (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Depth	Texture		Color			Redoximorphic Features (1 or 2 of each)						Structure		Consis-tence	Roots
Hor #	Name	Bot-tom	Rock frag. Mod-ifier	Fine-earth Class	Moist Matrix			Fe Depletions		Fe Concentrations				Grade	Shape	Moist	Abund.
		cm			Hue	Val	Chr	% vol.	Full Color Hue V/C	% vol.	Full Color Hue V/C	Linings /masses	Abun dance				Fine + V. F.
1	A	3	-	L	10YR	2	2							wk	gr	vfr	M
2	Bw1	10	Gr	CL	10YR	5	4							mo	sbk	fr	M
3	Bw2	20	Vgr	CL	2.5Y	5	3							wk	sbk	fr	M
4	2BC	40	Vgr	CL	2.5Y	5	2							wk	sbk	fr	C
5	2C1	97	Vgr	CL	2.5Y	5	2							sls	ma	fr	F
6	2C2	200+	Vgr	CL	5Y	5	1							sls	ma	fr	F
7																	
8																	
Page																	

Additional Description Worksheet (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Rock fragments				Other Concentrations			Other Depletions	Rock-controlled structure?	Brittle?	Perching layer?	Root-limiting?	Pores?
Hor #	Name	Gravel	Cobbles	Channers	Stones	Mn concr	Mn stains	Clay Films	Sandy or bleached pockets					
		%	%	%	%	%	y/n	y/n	% vol.	y/n	%	y/n	y/n	Abund
1	A	10	-	-	-	0	N	N	0	N	0	N	N	-
2	Bw1	20	5	-	-	0	N	N	0	N	0	N	N	-
3	Bw2	45	5	-	-	0	N	N	0	N	0	N	N	-
4	2BC	45	10	-	5	0	N	N	0	N	0	N	N	-
5	2C1	35	10	-	5	0	N	N	0	N	0	N	N	-
6	2C2	40	10	-	10	0	N	N	0	N	0	N	N	-
7														
8														
Page#														

Comments:	**hor**	grey SS	Sis + shale	white + red SS	carboliths	**hor**	grey SS	Sis + shale	white + red SS	carboliths	**hor**	grey SS	Sis + shale	white + red SS	carboliths
rock type	**1**	-	-	-	-	**3**	10	40	50	-	**5**	-	70	30	-
by horizon	**2**	10	30	60	-	**4**	-	80	20	-	**6**	5	55	40	-

SOIL AND SITE DESCRIPTION FORM

Persons Describing the Soil: __JG, AJ, CC______ Pedon # __OH1-3________

Date __8/13/03________ Lat.(5) ____ . _________ Lon.(5) _____ . ________ (decimal degrees)

County __Lawerence, Ohio____ USGS Quad Sheet(5)_____________________ MLRA(6) ________

Site Properties: (8-9)

Current land use and vegetation: __fescue, lespedeza, orchard grass, goldenrod__________

Elevation (m): __300____________ Aspect (slope direction) (0^o to 360^o):___38_____________

Slope gradient (%): ___7%________ Slope length: (m) _____150____________

Boulders on/in surface (%) __-__ Stones on/in surface (%) __-__

Physiography: (10)
- ___ Flood Plain ___ Stream terrace (level) ___ Stream terrace (dissected)
- _x_ Upland ___ Closed Depression ___ Drainageway

Slope shape: (11)
- _ _ Summit ___ Shoulder _x_ Backslope
- ___ Footslope ___ Toeslope ___ Not Appl. (on < 2% slopes in coastal plains)

Land surface shape: (12) (First letter is down-slope profile, second letter is cross-slope profile) L = linear V = convex C = concave

_x_ LL	___ LV	___ LC
___ VL	___ VV	_ _ VC
___ CL	___ CV	___ CC

Hydrology: (13-15)

Saturation type: endo or epi? _____ Wetland indicator plants? y/n _n_ Artificial drainage: y/n _n_

Depth of observed water: (cm) ____ Flooding evidence? y/n _n__ Ponding evidence? y/n _n__

SOIL PROPERTIES

Soil Drainage Class (19)	Depth Class: (20)	Parent Material(s): (20)
		_x_ Mine spoil
___ excessively drained	____ V. Shallow (< 25 cm)	___ Residuum (kind/s) ___________
___ somewhat excessive	____ Shallow (25 – 50 cm)	___ Organic (not litter)
_x_ well	____ Mod. Deep (50 – 100 cm)	___ Alluvium
___ somewhat well	____ Deep (100 – 150 cm)	___ Marine (recent)
___ moderately well	_x__ Very Deep (> 150 cm)	___ Unconsol. Coastal Plain
___ somewhat poor		___ Beach
___ poorly drained		___ Lacustrine
___ very poorly		___ Loess
	Root-restricting depth: (20) (cm) _____	___ Eolian sand (dune)
		___ Colluvium

ABBREVIATIONS

Texture:

Sand = S	Silt Loam = SiL
Loamy Sand = LS	Silty Clay Loam = SiCL
Sandy Loam = SL	Silty Clay = SiC
Loam = L	Sandy Clay Loam = SCL
Clay Loam = CL	Clay = C
Silt = SI	Sandy Clay= SC

Modifiers of Coarse Fragments:

Gravelly = GR (≥ 15%)	Cobbly = CB (≥ 15%)
Channery = CH (≥ 15%)	Stony = ST (≥ 15%)
Very (add V if ≥ 35%)	Extremely (add X if ≥ 65%)

Structure Grade:

Weak = WK	Strong = ST
Moderate = MO	Structureless = SLS

Structure Shape:

Granular = GR	Angular Blocky = ABK
Platy = PL	Subangular Blocky = SBK
Prismatic = PR	Massive = MA
Single Grain = SG	

Consistence:

Loose = L	Firm = FI
Very Friable = VFR	Very Firm = VFI
Friable = FR	Extremely Firm = EFI

Abundance:

Few (< 2% vol) = F	Many (≥ 20% vol) = M
Common (2 to < 20% vol) = C	

Pore Linings or Masses:

L = pore linings	M = masses

Appendix 5a. (continued)

Soil Profile __OH1-3__________ **Description Worksheet** (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Depth	Texture		Color			Redoximorphic Features (1 or 2 of each)						Structure		Consis-tence	Roots
Hor #	Name	Bot-tom	Rock frag. Mod-ifier	Fine-earth Class	Moist Matrix			Fe Depletions		Fe Concentrations				Grade	Shape	Moist	Abund.
		cm			Hue	Val	Chr	% vol.	Full Color Hue V/C	% vol.	Full Color Hue V/C	Linings /masses	Abun dance				Fine + V. F.
1	A	2	-	L	10YR	2	2							mo	gr	vfr	M
2	Bw	22	Vgr	CL	10YR	5	6							mo wk	sbk sbk	fr	M
3	2BC	33	xgr	CL	5Y	4	2							wk	sbk	fi	F
4	2C1	106	xgr	CL	5Y	5	2							sls	ma	fr	F
5	2C2	150+	xgr	CL	5Y	5	2							sls	ma	fr	Vf
6																	
7																	
8																	
Page																	

Additional Description Worksheet (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Rock fragments				Other Concentrations			Other Depletions	Rock-controlled structure?	Brittle?	Perching layer?	Root-limiting?	Pores?
Hor #	Name	Gravel	Cobbles	Channers	Stones	Mn concr	Mn stains	Clay Films	Sandy or bleached pockets					
		%	%	%	%	%	y/n	y/n	% vol.	y/n	%	y/n	y/n	Abund
1	A	10	-	-	-	0	N	N	0	N	0	N	N	-
2	Bw	25	10	-	-	0	N	N	0	N	0	N	N	-
3	2BC	50	10	-	5	0	N	N	0	N	0	N	N	-
4	2C1	45	10	-	5	0	N	N	0	N	0	N	N	-
5	2C2	40	10	-	5	0	N	N	0	N	0	N	N	-
6														
7														
8														
Page#														

Comments:	**hor**	grey SS	Sis + shale	white + red SS	carboliths	**hor**	grey SS	Sis + shale	white + red SS	carboliths	**hor**	grey SS	Sis + shale	white + red SS	carboliths
rock type	**1**	-	50	50	-	**3**	10	70	20	-	**5**	10	80	10	-
by horizon	**2**	-	50	50	-	**4**	10	65	20	5	- 10% boulders in 2C1 and 2C2				

SOIL AND SITE DESCRIPTION FORM

Persons Describing the Soil: __JG, AJ, CC________________________________ Pedon # __OH1-4_________

Date __8/13/03________ Lat.(5) ____ . _________ Lon.(5) _____ . ________ (decimal degrees)

County __Lawerence, Ohio____ USGS Quad Sheet(5)_____________________ MLRA(6) ________

Site Properties: (8-9)

Current land use and vegetation: __fescue, lespedeza, orchard grass, goldenrod________________________________

Elevation (m): __300____________ Aspect (slope direction) (0° to 360°):___220_____________

Slope gradient (%): ___8%________ Slope length: (m) _____20____________

Boulders on/in surface (%) __-__ Stones on/in surface (%) __5__

Physiography: (10)
- ___ Flood Plain
- ___ Stream terrace (level)
- ___ Stream terrace (dissected)
- _x_ Upland
- ___ Closed Depression
- ___ Drainageway

Slope shape: (11)
- __ Summit
- _x_ Shoulder
- __ Backslope
- ___ Footslope
- ___ Toeslope
- ___ Not Appl. (on < 2% slopes in coastal plains)

Land surface shape: (12) (First letter is down-slope profile, second letter is cross-slope profile) L = linear V = convex C = concave

__ LL	___ LV	___ LC
_x_ VL	___ VV	__ VC
___ CL	___ CV	___ CC

Hydrology: (13-15)

Saturation type: endo or epi? _____ Wetland indicator plants? y/n _n_ Artificial drainage: y/n _n_

Depth of observed water: (cm) ____ Flooding evidence? y/n _n__ Ponding evidence? y/n _n__

SOIL PROPERTIES

Soil Drainage Class (19)	Depth Class: (20)	Parent Material(s): (20)
		_x_ Mine spoil
___ excessively drained	____ V. Shallow (< 25 cm)	___ Residuum (kind/s) ___________________________
_x_ somewhat excessive	____ Shallow (25 – 50 cm)	___ Organic (not litter)
__ well	____ Mod. Deep (50 – 100 cm)	___ Alluvium
___ somewhat well	____ Deep (100 – 150 cm)	___ Marine (recent)
___ moderately well	_x__ Very Deep (> 150 cm)	___ Unconsol. Coastal Plain
___ somewhat poor		___ Beach
___ poorly drained		___ Lacustrine
___ very poorly		___ Loess
	Root-restricting depth: (20)	___ Eolian sand (dune)
	(cm) _____	___ Colluvium

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Very (add V if ≥ 35%)	Extremely (add X if ≥ 65%)

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Moderate = MO	Structureless = SLS

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Granular = GR	Angular Blocky = ABK
Platy = PL	Subangular Blocky = SBK
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Single Grain = SG	

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Loose = L	Firm = FI
Very Friable = VFR	Very Firm = VFI
Friable = FR	Extremely Firm = EFI

Abundance:

Few (< 2% vol) = F	Many (≥ 20% vol) = M
Common (2 to < 20% vol) = C	

Pore Linings or Masses:

L = pore linings M = masses

Appendix 5a. (continued)

Soil Profile __OH1-4_________ **Description Worksheet** (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Depth	Texture		Color			Redoximorphic Features (1 or 2 of each)						Structure		Consis -tence	Roots
Hor #	Name	Bot-tom	Rock frag. Mod-ifier	Fine-earth Class	Moist Matrix			Fe Depletions		Fe Concentrations				Grade	Shape	Moist	Abund.
		cm			Hue	Val	Chr	% vol.	Full Color Hue V/C	% vol.	Full Color Hue V/C	Linings /masses	Abun dance				Fine + V. F.
1	A	2	-	L	10YR	2	2							mo	gr	vfr	M
2	Bw	26	gr	CL	10YR	5	4							mo wk	sbk sbk	fr	M
3	2C1	63	xgr	L	2.5Y	4	1							sls	ma	fr	C
4	2C2	88	xgr	SL	2.5Y	6	2							sls	ma	fr	F
5	2C3	150+	xcb	L	5Y	5	2							sls	ma	fr	F
6																	
7																	
8																	
Page																	

Additional Description Worksheet (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Rock fragments				Other Concentrations			Other Depletions	Rock-controlled structure?	Brittle?	Perching layer?	Root-limiting?	Pores?
Hor #	Name	Gravel	Cobbles	Channers	Stones	Mn concr	Mn stains	Clay Films	Sandy or bleached pockets					
		%	%	%	%	%	y/n	y/n	% vol.	y/n	%	y/n	y/n	Abund
1	A	10	-	-	-	0	N	N	0	N	0	N	N	-
2	Bw	10	5	-	-	0	N	N	0	N	0	N	N	-
3	2C1	45	30	-	5	0	N	N	0	N	0	N	N	-
4	2C2	50	25	-	5	0	N	N	0	N	0	N	N	-
5	2C3	40	35	-	10	0	N	N	0	N	0	N	N	-
6														
7														
8														
Page#														

Comments:	**hor**	grey SS	Sis + shale	white + red SS	carboliths	**hor**	grey SS	Sis + shale	white + red SS	carboliths	**hor**	grey SS	Sis + shale	white + red SS	carboliths
rock type	**1**	-	50	50	-	**3**	30	15	50	5	**5**	15	5	60	-
by horizon	**2**	-	10	90	-	**4**	45	10	45	-	- 5% boulders in 2C3				

SOIL AND SITE DESCRIPTION FORM

Persons Describing the Soil: __JG, AJ, CC________________________________ Pedon # __OH2-2_______

Date __8/13/03________ Lat.(5) ____ . _________ Lon.(5) _____ . ________ (decimal degrees)

County __Lawerence, Ohio____ USGS Quad Sheet(5)_____________________ MLRA(6) ________

Site Properties: (8-9)

Current land use and vegetation: __fescue, lespedeza, goldenrod, broomstraw___________________________________

Elevation (m): __300____________ Aspect (slope direction) (0^o to 360^o):___40_____________

Slope gradient (%): ___15%________ Slope length: (m) _____150____________

Boulders on/in surface (%) __-__ Stones on/in surface (%) __-__

Physiography: (10) ___ Flood Plain ___ Stream terrace (level) ___ Stream terrace (dissected)
_x_ Upland ___ Closed Depression ___ Drainageway

Slope shape: (11) __ Summit ___ Shoulder _x_ Backslope
___ Footslope ___ Toeslope ___ Not Appl. (on < 2% slopes in coastal plains)

Land surface shape: (12) (First letter is down-slope profile, second letter is cross-slope profile)
L = linear V = convex C = concave

_x_ LL ___ LV ___ LC
___ VL ___ VV __ VC
___ CL ___ CV ___ CC

Hydrology: (13-15)

Saturation type: endo or epi? _____ Wetland indicator plants? y/n _n_ Artificial drainage: y/n _n_

Depth of observed water: (cm) _160 Flooding evidence? y/n _n__ Ponding evidence? y/n _n__

SOIL PROPERTIES		
Soil Drainage Class (19)	Depth Class: (20)	Parent Material(s): (20)
		_x_ Mine spoil
___ excessively drained	____ V. Shallow (< 25 cm)	___ Residuum (kind/s) ___________________________
___ somewhat excessive	____ Shallow (25 – 50 cm)	___ Organic (not litter)
_x_ well	_x__ Mod. Deep (50 – 100 cm)	___ Alluvium
___ somewhat well	____ Deep (100 – 150 cm)	___ Marine (recent)
___ moderately well	____ Very Deep (> 150 cm)	___ Unconsol. Coastal Plain
___ somewhat poor		___ Beach
___ poorly drained		___ Lacustrine
___ very poorly		___ Loess
	Root-restricting depth: (20) (cm) _70	___ Eolian sand (dune)
		___ Colluvium

ABBREVIATIONS

Texture:

Sand = S	Silt Loam = SiL
Loamy Sand = LS	Silty Clay Loam = SiCL
Sandy Loam = SL	Silty Clay = SiC
Loam = L	Sandy Clay Loam = SCL
Clay Loam = CL	Clay = C
Silt = SI	Sandy Clay= SC

Modifiers of Coarse Fragments:

Gravelly = GR (≥ 15%)	Cobbly = CB (≥ 15%)
Channery = CH (≥ 15%)	Stony = ST (≥ 15%)
Very (add V if ≥ 35%)	Extremely (add X if ≥ 65%)

Structure Grade:

Weak = WK	Strong = ST
Moderate = MO	Structureless = SLS

Structure Shape:

Granular = GR	Angular Blocky = ABK
Platy = PL	Subangular Blocky = SBK
Prismatic = PR	Massive = MA
Single Grain = SG	

Consistence:

Loose = L	Firm = FI
Very Friable = VFR	Very Firm = VFI
Friable = FR	Extremely Firm = EFI

Abundance:

Few (< 2% vol) = F	Many (≥ 20% vol) = M
Common (2 to < 20% vol) = C	

Pore Linings or Masses:

L = pore linings	M = masses

Appendix 5a. (continued)

Soil Profile __OH2-2__________ **Description Worksheet** (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Depth	Texture		Color			Redoximorphic Features (1 or 2 of each)						Structure		Consis-tence	Roots
Hor #	Name	Bot-tom	Rock frag. Mod-ifier	Fine-earth Class	Moist Matrix			Fe Depletions		Fe Concentrations				Grade	Shape	Moist	Abund.
		cm			Hue	Val	Chr	% vol.	Full Color Hue V/C	% vol.	Full Color Hue V/C	Linings /masses	Abun dance				Fine + V. F.
1	A	2	-	L	10YR	2	2							mo	gr	vfr	M
2	Bw1	9	gr	SCL	10YR	4	6							mo	sbk	fr	M
3	2Bw2	25	Vgr	SCL	2.5Y	4	3							mo wk	sbk sbk	fr	M
4	2BC	53	Vgr	L	2.5Y	4	3							wk	sbk	fr	M
5	3C	70	xgr	L	2.5Y	3	1							sls	ma	fr	F
6	3Cd	160+	xgr	L	5Y	4	1							sls	ma	vfi	Vf
7																	
8																	
Page																	

Additional Description Worksheet (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Rock fragments				Other Concentrations			Other Depletions	Rock-controlled structure?	Brittle?	Perching layer?	Root-limiting?	D_b
Hor #	Name	Gravel	Cobbles	Channers	Stones	Mn concr	Mn stains	Clay Films	Sandy or bleached pockets					
		%	%	%	%	%	y/n	y/n	% vol.	y/n	%	y/n	y/n	g/cm^3
1	A	10	-	-	-	0	N	N	0	N	0	N	N	-
2	Bw1	20	5	-	-	0	N	N	0	N	0	N	N	-
3	2Bw2	40	10	-	5	0	N	N	0	N	0	N	N	-
4	2BC	35	15	-	5	0	N	N	0	N	0	N	N	-
5	3C	50	15	-	-	0	N	N	0	N	0	N	N	-
6	3Cd	45	25	-	5	0	N	N	0	N	0	N	N	1.47
7														
8														
Page#														

Comments:	**hor**	grey SS	Sis + shale	white + red SS	carboliths	**hor**	grey SS	Sis + shale	white + red SS	carboliths	**hor**	grey SS	Sis + shale	white + red SS	carboliths
rock type	**1**	-	50	50	-	**3**	5	30	50	5	**5**	5	45	40	10
by horizon	**2**	-	10	90	-	**4**	5	30	50	5	**6**	5	50	40	5

SOIL AND SITE DESCRIPTION FORM

Persons Describing the Soil: __JG, AJ, CC________________________________ Pedon # __OH3-1_________

Date __8/13/03________ Lat.(5) ____ . _________ Lon.(5) _____ . ________ (decimal degrees)

County __Lawerence, Ohio____ USGS Quad Sheet(5)_____________________ MLRA(6) ________

Site Properties: (8-9)

Current land use and vegetation: __fescue, wild garlic___________________________________

Elevation (m): __300____________ Aspect (slope direction) (0^o to 360^o):___70_____________

Slope gradient (%): ___2%________ Slope length: (m) _____15____________

Boulders on/in surface (%) __-__ Stones on/in surface (%) __-__

Physiography: (10) ___ Flood Plain ___ Stream terrace (level) ___ Stream terrace (dissected)
_x_ Upland ___ Closed Depression ___ Drainageway

Slope shape: (11) __ Summit __ Shoulder __ Backslope
_x_ Footslope ___ Toeslope ___ Not Appl. (on < 2% slopes in coastal plains)

Land surface shape: (12) (First letter is down-slope profile, second letter is cross-slope profile)
L = linear V = convex C = concave

_x_ LL ___ LV ___ LC
__ VL ___ VV __ VC
___ CL ___ CV ___ CC

Hydrology: (13-15)

Saturation type: endo or epi? _____ Wetland indicator plants? y/n _n_ Artificial drainage: y/n _n_

Depth of observed water: (cm) ____ Flooding evidence? y/n _n__ Ponding evidence? y/n _n__

SOIL PROPERTIES

Soil Drainage Class (19)	Depth Class: (20)	Parent Material(s): (20)
		_x_ Mine spoil
___ excessively drained	____ V. Shallow (< 25 cm)	___ Residuum (kind/s) ____________________
___ somewhat excessive	____ Shallow (25 – 50 cm)	___ Organic (not litter)
_x_ well	____ Mod. Deep (50 – 100 cm)	___ Alluvium
___ somewhat well	____ Deep (100 – 150 cm)	___ Marine (recent)
___ moderately well	_x__ Very Deep (> 150 cm)	___ Unconsol. Coastal Plain
___ somewhat poor		___ Beach
___ poorly drained		___ Lacustrine
___ very poorly		___ Loess
	Root-restricting depth: (20)	___ Eolian sand (dune)
	(cm) _____	___ Colluvium

ABBREVIATIONS

Texture:

Sand = S	Silt Loam = SiL
Loamy Sand = LS	Silty Clay Loam = SiCL
Sandy Loam = SL	Silty Clay = SiC
Loam = L	Sandy Clay Loam = SCL
Clay Loam = CL	Clay = C
Silt = SI	Sandy Clay= SC

Modifiers of Coarse Fragments:

Gravelly = GR (≥ 15%)	Cobbly = CB (≥ 15%)
Channery = CH (≥ 15%)	Stony = ST (≥ 15%)
Very (add V if ≥ 35%)	Extremely (add X if ≥ 65%)

Structure Grade:

Weak = WK	Strong = ST
Moderate = MO	Structureless = SLS

Structure Shape:

Granular = GR	Angular Blocky = ABK
Platy = PL	Subangular Blocky = SBK
Prismatic = PR	Massive = MA
Single Grain = SG	

Consistence:

Loose = L	Firm = FI
Very Friable = VFR	Very Firm = VFI
Friable = FR	Extremely Firm = EFI

Abundance:

Few (< 2% vol) = F	Many (≥ 20% vol) = M
Common (2 to < 20% vol) = C	

Pore Linings or Masses:

L = pore linings	M = masses

Appendix 5a. (continued)

Soil Profile __OH3-1__________ **Description Worksheet** (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Depth	Texture		Color			Redoximorphic Features (1 or 2 of each)						Structure		Consis -tence	Roots
Hor #	Name	Bot-tom	Rock frag. Mod-ifier	Fine-earth Class	Moist Matrix			Fe Depletions		Fe Concentrations				Grade	Shape	Moist	Abund.
		cm			Hue	Val	Chr	% vol.	Full Color Hue V/C	% vol.	Full Color Hue V/C	Linings /masses	Abun dance				Fine + V. F.
1	A	4	-	L	10YR	2	2							mo	gr	vfr	M
2	Bw	16	vgr	SCL	10YR	5	4							mo	sbk	fr	M
3	2BC	26	Vgr	CL	5Y	5	2							wk	sbk	fi	C
4	2C1	63	Vgr	CL	5Y	5	2							sls	ma	fi	F
5	3C2	67	-	S	10YR	5	4							sls	sg	l	F
6	4C3	125	xgr	CL	2.5Y	5	1							sls	ma	fi	F
7	4C4	180+	xgr	CL	5Y	4	2							sls	ma	fi	-
8																	
Page																	

Additional Description Worksheet (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Rock fragments				Other Concentrations			Other Depletions	Rock-controlled structure?	Brittle?	Perching layer?	Root-limiting?	Pores?
Hor #	Name	Gravel	Cobbles	Channers	Stones	Mn concr	Mn stains	Clay Films	Sandy or bleached pockets					
		%	%	%	%	%	y/n	y/n	% vol.	y/n	%	y/n	y/n	Abund
1	A	10	-	-	-	0	N	N	0	N	0	N	N	-
2	Bw	30	5	-	-	0	N	N	0	N	0	N	N	-
3	2BC	35	10	-	5	0	N	N	0	N	0	N	N	-
4	2C1	35	10	-	5	0	N	N	0	N	0	N	N	-
5	3C2	5	-	-	-	0	N	N	0	N	0	N	N	-
6	4C3	50	20	-	5	0	N	N	0	N	0	N	N	-
7	4C4	50	20	-	5	0	N	N	0	N	0	N	N	-
8														
Page#														

Comments:	**hor**	grey SS	Sis + shale	white + red SS	carboliths	**hor**	grey SS	Sis + shale	white + red SS	carboliths	**hor**	grey SS	Sis + shale	white + red SS	carboliths
rock type	**2**	10	35	55	-	**4**	-	25	70	5	**6**	5	30	60	5
by horizon	**3**	-	25	70	5	**5**	-		100	-	**7**	10	10	80	-

Appendix 5a. (continued)
SOIL AND SITE DESCRIPTION FORM

Persons Describing the Soil: __JG, AJ, CC________________________________ Pedon # __OH3-3_________
Date __8/13/03________ Lat.(5) ____ . _________ Lon.(5) _____ . ________ (decimal degrees)
County __Lawerence, Ohio____ USGS Quad Sheet(5)_____________________ MLRA(6) ________

Site Properties: (8-9)
Current land use and vegetation: __thick fescue___________________________________
Elevation (m): __300____________ Aspect (slope direction) (0° to 360°):___70_____________
Slope gradient (%): ___23%________ Slope length: (m) _____18____________
Boulders on/in surface (%) __-__ Stones on/in surface (%) __-__

Physiography: (10) ___ Flood Plain ___ Stream terrace (level) ___ Stream terrace (dissected)
_x_ Upland ___ Closed Depression ___ Drainageway

Slope shape: (11) ___ Summit ___ Shoulder _x_ Backslope
___ Footslope ___ Toeslope ___ Not Appl. (on < 2% slopes in coastal plains)

Land surface shape: (12) (First letter is down-slope profile, second letter is cross-slope profile) L = linear V = convex C = concave
___ LL ___ LV ___ LC
_x_ VL ___ VV ___ VC
___ CL ___ CV ___ CC

Hydrology: (13-15)
Saturation type: endo or epi? _____ Wetland indicator plants? y/n _n_ Artificial drainage: y/n _n_
Depth of observed water: (cm) ____ Flooding evidence? y/n _n__ Ponding evidence? y/n _n__

SOIL PROPERTIES		
Soil Drainage Class (19)	Depth Class: (20)	Parent Material(s): (20)
		_x_ Mine spoil
___ excessively drained	____ V. Shallow (< 25 cm)	___ Residuum (kind/s) ____________________________
___ somewhat excessive	____ Shallow (25 – 50 cm)	___ Organic (not litter)
_x_ well	____ Mod. Deep (50 – 100 cm)	___ Alluvium
___ somewhat well	____ Deep (100 – 150 cm)	___ Marine (recent)
___ moderately well	_x__ Very Deep (> 150 cm)	___ Unconsol. Coastal Plain
___ somewhat poor		___ Beach
___ poorly drained		___ Lacustrine
___ very poorly		___ Loess
	Root-restricting depth: (20)	___ Eolian sand (dune)
	(cm) ____	___ Colluvium

ABBREVIATIONS

Texture:

Sand = S	Silt Loam = SiL
Loamy Sand = LS	Silty Clay Loam = SiCL
Sandy Loam = SL	Silty Clay = SiC
Loam = L	Sandy Clay Loam = SCL
Clay Loam = CL	Clay = C
Silt = SI	Sandy Clay= SC

Modifiers of Coarse Fragments:

Gravelly = GR (≥ 15%)	Cobbly = CB (≥ 15%)
Channery = CH (≥ 15%)	Stony = ST (≥ 15%)
Very (add V if ≥ 35%)	Extremely (add X if ≥ 65%)

Structure Grade:

Weak = WK	Strong = ST
Moderate = MO	Structureless = SLS

Structure Shape:

Granular = GR	Angular Blocky = ABK
Platy = PL	Subangular Blocky = SBK
Prismatic = PR	Massive = MA
Single Grain = SG	

Consistence:

Loose = L	Firm = FI
Very Friable = VFR	Very Firm = VFI
Friable = FR	Extremely Firm = EFI

Abundance:

Few (< 2% vol) = F	Many (≥ 20% vol) = M
Common (2 to < 20% vol) = C	

Pore Linings or Masses:

L = pore linings	M = masses

Appendix 5a. (continued)

Soil Profile __OH3-3__________ **Description Worksheet** (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Depth	Texture		Color			Redoximorphic Features (1 or 2 of each)						Structure		Consis-tence	Roots
Hor #	Name	Bot-tom	Rock frag. Mod-ifier	Fine-earth Class	Moist Matrix			Fe Depletions		Fe Concentrations				Grade	Shape	Moist	Abund.
		cm			Hue	Val	Chr	% vol.	Full Color Hue V/C	% vol.	Full Color Hue V/C	Linings /masses	Abun dance				Fine + V. F.
1	A	4	gr											mo	gr	vfr	M
2	Bw	17	vgr											mo wk	sbk sbk	fr	M
3	2BC	30	vgr											wk	sbk	fi	F
4	2C1	81	xgr											sls	ma	fi	F
5	2C2	145+	xgr											sls	ma	fi	-
6																	
7																	
8																	
Page																	

Additional Description Worksheet (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Rock fragments				Other Concentrations			Other Depletions	Rock-controlled structure?	Brittle?	Perching layer?	Root-limiting?	Pores?
Hor #	Name	Gravel	Cobbles	Channers	Stones	Mn concr	Mn stains	Clay Films	Sandy or bleached pockets					
		%	%	%	%	%	y/n	y/n	% vol.	y/n	%	y/n	y/n	Abund
1														
2														
3														
4														
5														
6														
7														
8														
Page#														

Comments:

Appendix 5b. Soil and site descriptions of mine soils in Virginia.

SOIL AND SITE DESCRIPTION FORM

Persons Describing the Soil: _AJ, JG, PD, KS________________________________ Pedon # _VA-1 (Pit 1)___

Date __9/12/03________ Lat.(5) _____ . _________ Lon.(5) _____ . ________ (decimal degrees)

County ___Wise, VA______ USGS Quad Sheet(5)_____________________ MLRA(6) ________

Site Properties: (8-9)

Current land use and vegetation: clover, fescue, orchard grass, birdsfoot trefoil, alfalfa

Elevation (m): __820_____ Aspect (slope direction) (0° to 360°):__180_____________

Slope gradient (%): ___4%________ Slope length: (m) ____30_

Boulders on/in surface (%) _1%__ Stones on/in surface (%) __1%_

Physiography: (10) ___ Flood Plain ___ Stream terrace (level) ___ Stream terrace (dissected)
_x_ Upland ___ Closed Depression ___ Drainageway

Slope shape: (11) _x_ Summit ___ Shoulder ___ Backslope
___ Footslope ___ Toeslope ___ Not Appl. (on < 2% slopes in coastal plains)

Land surface shape: (12) (First letter is down-slope profile, second letter is cross-slope profile) L = linear V = convex C = concave

__ LL ___ LV ___ LC
___ VL ___ VV ___ VC
_x_ CL ___ CV ___ CC

Hydrology: (13-15)

Saturation type: endo or epi? _____ Wetland indicator plants? y/n _n_ Artificial drainage: y/n _n_

Depth of observed water: (cm) ____ Flooding evidence? y/n _n__ Ponding evidence? y/n _n__

SOIL PROPERTIES

Soil Drainage Class (19)	Depth Class: (20)	Parent Material(s): (20)
		_x_ Mine spoil
__ excessively drained	____ V. Shallow (< 25 cm)	___ Residuum (kind/s) ___________________________
___ somewhat excessive	__x_ Shallow (25 – 50 cm)	___ Organic (not litter)
_x_ well	____ Mod. Deep (50 – 100 cm)	___ Alluvium
___ somewhat well	____ Deep (100 – 150 cm)	___ Marine (recent)
___ moderately well	____ Very Deep (> 150 cm)	___ Unconsol. Coastal Plain
___ somewhat poor		___ Beach
___ poorly drained		___ Lacustrine
___ very poorly		___ Loess
	Root-restricting depth: (20)	___ Eolian sand (dune)
	(cm) _26_	___ Colluvium

ABBREVIATIONS

Texture:

Sand = S | Silt Loam = SiL
Loamy Sand = LS | Silty Clay Loam = SiCL
Sandy Loam = SL | Silty Clay = SiC
Loam = L | Sandy Clay Loam = SCL
Clay Loam = CL | Clay = C
Silt = SI | Sandy Clay= SC

Modifiers of Coarse Fragments:

Gravelly = GR (≥ 15%) | Cobbly = CB (≥ 15%)
Channery = CH (≥ 15%) | Stony = ST (≥ 15%)
Very (add V if ≥ 35%) | Extremely (add X if ≥ 65%)

Structure Grade:

Weak = WK | Strong = ST
Moderate = MO | Structureless = SLS

Structure Shape:

Granular = GR | Angular Blocky = ABK
Platy = PL | Subangular Blocky = SBK
Prismatic = PR | Massive = MA
Single Grain = SG

Consistence:

Loose = L | Firm = FI
Very Friable = VFR | Very Firm = VFI
Friable = FR | Extremely Firm = EFI

Abundance:

Few (< 2% vol) = F | Many (≥ 20% vol) = M
Common (2 to < 20% vol) = C

Pore Linings or Masses:

L = pore linings | M = masses

Appendix 5b. (continued)

Soil Profile ___VA-1 (Pit 1)_ **Description Worksheet** (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Depth	Texture		Color			Redoximorphic Features (1 or 2 of each)						Structure		Consis-tence	Roots
Hor #	Name	Bot-tom	Rock frag. Mod-ifier	Fine-earth Class	Moist Matrix			Fe Depletions		Fe Concentrations				Grade	Shape	Moist	Abund.
		cm			Hue	Val	Chr	% vol.	Full Color Hue V/C	% vol.	Full Color Hue V/C	Linings /masses	Abun dance				Fine + V. F.
1	A	11	Vgr	SL	10YR	5	6							wk	gr	Vfr	Mf mvf
2	2C	26	Xgr	SL	10YR	4	1							sls	ma	vfi	f
3	2Cd1	63	Xgr	SL	10YR 10YR	4 5	2 6							sls	ma	xfi	vf
4	2Cd2	81	Xgr	SL	10YR 10YR	5 4	4 2							sls	ma	xfi	-
5	2Cd3	116	Xgr	SL	10YR 10YR	4 4	4 2							sls	ma	xfi	-
6	2C’	150+	Vgr	SL	2.5Y 10YR	4 6	3 6							sls	ma	fi	-
7																	
8																	
Page																	

Additional Description Worksheet (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Rock fragments				Other Concentrations			Other Depletions	Rock-controlled structure?	Brittle?	Perching layer?	Root-limiting?	D_b
Hor #	Name	Gravel	Cobbles	Channers	Stones	Mn concr	Mn stains	Clay Films	Sandy or bleached pockets					
		%	%	%	%	%	y/n	y/n	% vol.	y/n	%	y/n	y/n	g/cm^3
1	A	40	5	-	-	0	N	N	0	N	0	N	N	1.25
2	2C	45	5	-	10	0	N	N	0	N	0	N	N	1.41
3	2Cd1	50	10	-	15	0	N	N	0	N	0	Y	Y	-
4	2Cd2	50	20	-	15	0	N	N	0	N	0	Y	Y	-
5	2Cd3	45	20	-	10	0	N	N	0	N	0	Y	Y	-
6	2C’	30	15		15	0	N	N	0	N	0	N	N	-
7														
8														
Page#														

Comments: **hor**	grey SS	Sis + shale	white + red SS	carboliths	**hor**	grey SS	Sis + shale	white + red SS	carboliths	**hor**	grey SS	Sis + shale	white + red SS	carboliths
Rock type 1	0	20	80	0	**3**	5	25	65	5	**5**	10	15	70	5
by horizon 2	10	50	40	0	**4**	10	30	50	10	**6**	10	15	70	5

SOIL AND SITE DESCRIPTION FORM

Persons Describing the Soil: _AJ, JG, PD, KS________________________________ Pedon # _VA-1 (Pit 2)___
Date __9/12/03________ Lat.(5) ____ . _________ Lon.(5) _____ . ________ (decimal degrees)
County ___Wise, VA______ USGS Quad Sheet(5)_____________________ MLRA(6) ________

Site Properties: (8-9)
Current land use and vegetation: clover, fescue, orchard grass, birdsfoot trefoil, alfalfa
Elevation (m): __820_____ Aspect (slope direction) (0^o to 360^o):__180_____________
Slope gradient (%): ___6%________ Slope length: (m) ____20_
Boulders on/in surface (%) _1%__ Stones on/in surface (%) __1%_

Physiography: (10) ___ Flood Plain ___ Stream terrace (level) ___ Stream terrace (dissected)
_x_ Upland ___ Closed Depression ___ Drainageway

Slope shape: (11) _x_ Summit ___ Shoulder ___ Backslope
___ Footslope ___ Toeslope ___ Not Appl. (on < 2% slopes in coastal plains)

Land surface shape: (12) (First letter is down-slope profile, second letter is cross-slope profile) L = linear V = convex C = concave
_x_ LL ___ LV ___ LC
___ VL ___ VV ___ VC
___ CL ___ CV ___ CC

Hydrology: (13-15)
Saturation type: endo or epi? _____ Wetland indicator plants? y/n _n_ Artificial drainage: y/n _n_
Depth of observed water: (cm) ____ Flooding evidence? y/n _n__ Ponding evidence? y/n _n__

SOIL PROPERTIES

Soil Drainage Class (19)	Depth Class: (20)	Parent Material(s): (20)
		_x_ Mine spoil
__ excessively drained	____ V. Shallow (< 25 cm)	___ Residuum (kind/s) ___________________________
___ somewhat excessive	____ Shallow (25 – 50 cm)	___ Organic (not litter)
_x_ well	____ Mod. Deep (50 – 100 cm)	___ Alluvium
___ somewhat well	____ Deep (100 – 150 cm)	___ Marine (recent)
___ moderately well	_x_ Very Deep (> 150 cm)	___ Unconsol. Coastal Plain
___ somewhat poor		___ Beach
___ poorly drained		___ Lacustrine
___ very poorly		___ Loess
	Root-restricting depth: (20)	___ Eolian sand (dune)
	(cm) ___	___ Colluvium

ABBREVIATIONS

Texture:

Sand = S	Silt Loam = SiL
Loamy Sand = LS	Silty Clay Loam = SiCL
Sandy Loam = SL	Silty Clay = SiC
Loam = L	Sandy Clay Loam = SCL
Clay Loam = CL	Clay = C
Silt = SI	Sandy Clay= SC

Modifiers of Coarse Fragments:

Gravelly = GR (≥ 15%)	Cobbly = CB (≥ 15%)
Channery = CH (≥ 15%)	Stony = ST (≥ 15%)
Very (add V if ≥ 35%)	Extremely (add X if ≥ 65%)

Structure Grade:

Weak = WK	Strong = ST
Moderate = MO	Structureless = SLS

Structure Shape:

Granular = GR	Angular Blocky = ABK
Platy = PL	Subangular Blocky = SBK
Prismatic = PR	Massive = MA
Single Grain = SG	

Consistence:

Loose = L	Firm = FI
Very Friable = VFR	Very Firm = VFI
Friable = FR	Extremely Firm = EFI

Abundance:

Few (< 2% vol) = F	Many (≥ 20% vol) = M
Common (2 to < 20% vol) = C	

Pore Linings or Masses:

L = pore linings	M = masses

Appendix 5b. (continued)

Soil Profile ___VA-1 (Pit 2)_ **Description Worksheet** (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Depth	Texture		Color			Redoximorphic Features (1 or 2 of each)						Structure		Consis -tence	Roots
Hor #	Name	Bot-tom	Rock frag. Mod-ifier	Fine-earth Class	Moist Matrix			Fe Depletions		Fe Concentrations				Grade	Shape	Moist	Abund.
		cm			Hue	Val	Chr	% vol.	Full Color Hue V/C	% vol.	Full Color Hue V/C	Linings /masses	Abun dance				Fine + V. F.
1	A	21	Vgr	SL	2.5Y	5	4							wk wk	gr Sbk	fr	mf mvf
2	2C	35	Xgr	SL	2.5Y	3	1							sls	ma	fi	c
3	2Cd	120	Xgr	SL	2.5Y	4	1							sls	ma	vfi	-
4	2Cd2	140+	Xgr	SL	5Y	3	1							sls	ma	fi	-
5																	
6																	
7																	
8																	
Page																	

Additional Description Worksheet (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Rock fragments				Other Concentrations			Other Depletions	Rock-controlled structure?	Brittle?	Perching layer?	Root-limiting?	D_b
Hor #	Name	Gravel	Cobbles	Channers	Stones	Mn concr	Mn stains	Clay Films	Sandy or bleached pockets					
		%	%	%	%	%	y/n	y/n	% vol.	y/n	%	y/n	y/n	g/cm^3
1	A	40	5	-	-	0	N	N	0	N	0	N	N	1.21
2	2C1	55	10	-	5	0	N	N	0	N	0	N	N	-
3	2C2	45	20	-	15	0	N	N	0	N	0	N	N	-
4	2C3	55	10	-	10	0	N	N	0	N	0	N	N	-
5														
6														
7														
8														
Page#														

Comments:	**hor**	grey SS	Sis + shale	white + red SS	carboliths	**hor**	grey SS	Sis + shale	white + red SS	carboliths
Rock type	**1**	5	5	89	1	**3**	10	10	75	5
by horizon	**2**	10	10	79	1	**4**	10	10	75	5

SOIL AND SITE DESCRIPTION FORM

Persons Describing the Soil: _AJ, JG, PD, KS_______________________________ Pedon # _VA-2 (Pit 1)___
Date __9/12/03________ Lat.(5) ____ . _________ Lon.(5) _____ . ________ (decimal degrees)
County ___Wise, VA______ USGS Quad Sheet(5)_____________________ MLRA(6) ________

Site Properties: (8-9)
Current land use and vegetation: clover, fescue, orchard grass, birdsfoot trefoil, alfalfa, sweet clover
Elevation (m): __700_____ Aspect (slope direction) (0° to 360°):__165_____________
Slope gradient (%): ___5%________ Slope length: (m) ____50_
Boulders on/in surface (%) _1%__ Stones on/in surface (%) __10%_

Physiography: (10) ___ Flood Plain ___ Stream terrace (level) ___ Stream terrace (dissected)
_x_ Upland ___ Closed Depression ___ Drainageway

Slope shape: (11) ___ Summit ___ Shoulder _x_ Backslope
___ Footslope ___ Toeslope ___ Not Appl. (on < 2% slopes in coastal plains)

Land surface shape: (12) (First letter is down-slope profile, second letter is cross-slope profile)
L = linear V = convex C = concave
_x_ LL ___ LV ___ LC
___ VL ___ VV ___ VC
___ CL ___ CV ___ CC

Hydrology: (13-15)
Saturation type: endo or epi? _____ Wetland indicator plants? y/n _n_ Artificial drainage: y/n _n_
Depth of observed water: (cm) ____ Flooding evidence? y/n _n__ Ponding evidence? y/n _n__

SOIL PROPERTIES		
Soil Drainage Class (19)	Depth Class: (20)	Parent Material(s): (20)
		_x_ Mine spoil
___ excessively drained	____ V. Shallow (< 25 cm)	___ Residuum (kind/s) ___________________________
___ somewhat excessive	____ Shallow (25 – 50 cm)	___ Organic (not litter)
_x_ well	____ Mod. Deep (50 – 100 cm)	___ Alluvium
___ somewhat well	____ Deep (100 – 150 cm)	___ Marine (recent)
___ moderately well	_x_ Very Deep (> 150 cm)	___ Unconsol. Coastal Plain
___ somewhat poor		___ Beach
___ poorly drained		___ Lacustrine
___ very poorly		___ Loess
	Root-restricting depth: (20) (cm) ___	___ Eolian sand (dune)
		___ Colluvium

ABBREVIATIONS

Texture:

Sand = S | Silt Loam = SiL
Loamy Sand = LS | Silty Clay Loam = SiCL
Sandy Loam = SL | Silty Clay = SiC
Loam = L | Sandy Clay Loam = SCL
Clay Loam = CL | Clay = C
Silt = SI | Sandy Clay= SC

Modifiers of Coarse Fragments:

Gravelly = GR (≥ 15%) | Cobbly = CB (≥ 15%)
Channery = CH (≥ 15%) | Stony = ST (≥ 15%)
Very (add V if ≥ 35%) | Extremely (add X if ≥ 65%)

Structure Grade:

Weak = WK | Strong = ST
Moderate = MO | Structureless = SLS

Structure Shape:

Granular = GR | Angular Blocky = ABK
Platy = PL | Subangular Blocky = SBK
Prismatic = PR | Massive = MA
Single Grain = SG

Consistence:

Loose = L | Firm = FI
Very Friable = VFR | Very Firm = VFI
Friable = FR | Extremely Firm = EFI

Abundance:

Few (< 2% vol) = F | Many (≥ 20% vol) = M
Common (2 to < 20% vol) = C

Pore Linings or Masses:

L = pore linings | M = masses

Appendix 5b. (continued)

Soil Profile ___VA-2 (Pit 1)_ **Description Worksheet** (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Depth	Texture		Color			Redoximorphic Features (1 or 2 of each)						Structure		Consis -tence	Roots
Hor #	Name	Bot- tom	Rock frag. Mod- ifier	Fine-earth Class	Moist Matrix			Fe Depletions		Fe Concentrations				Grade	Shape	Moist	Abund.
		cm			Hue	Val	Chr	% vol.	Full Color Hue V/C	% vol.	Full Color Hue V/C	Linings /masses	Abun dance				Fine + V. F.
1	A	20	Vgr	SL	2.5Y	5	3							wk	Sbk	fr	mf mvf
2	2C1	40	Xgr	L	N	3	0							sls	ma	fi	f
3	2C2	115+	Xst	L	10YR	3	1							sls	ma	fr	-
4																	
5																	
6																	
7																	
8																	
Page																	

Additional Description Worksheet (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Rock fragments				Other Concentrations			Other Depletions	Rock- controlled structure?	Brittle?	Perching layer?	Root- limiting?	D_b
Hor #	Name	Gravel	Cobbles	Channers	Stones	Mn concr	Mn stains	Clay Films	Sandy or bleached pockets					
		%	%	%	%	%	y/n	y/n	% vol.	y/n	%	y/n	y/n	g/cm^3
1	A	40	10	-	5	0	N	N	0	N	0	N	N	0.85
2	2C1	50	15	-	10	0	N	N	0	N	0	N	N	1.19
3	2C2	50	15	-	20	0	N	N	0	N	0	N	N	-
4														
5														
6														
7														
8														
Page#														

Comments:	**hor**	grey SS	Sis + shale	white + red SS	carboliths	**hor**	grey SS	Sis + shale	white + red SS	carboliths
Rock type	**1**	5	5	89	1	**3**	5	83	10	2
by horizon	**2**	5	78	15	2					

- 5% boulders in C1 and C2
- 5-10% bridging voids in C2
- 2% jarosite mottles in C2

Appendix 5b. (continued)

SOIL AND SITE DESCRIPTION FORM

Persons Describing the Soil: _AJ, JG, PD, KS_______________________________ Pedon # _VA-2 (Pit 2)___

Date __9/12/03________ Lat.(5) ____ . _________ Lon.(5) _____ . ________ (decimal degrees)

County ___Wise, VA______ USGS Quad Sheet(5)_____________________ MLRA(6) ________

Site Properties: (8-9)

Current land use and vegetation: clover, fescue, orchard grass, birdsfoot trefoil, alfalfa, sweet clover

Elevation (m): __700_____ Aspect (slope direction) (0^o to 360^o):__140_____________

Slope gradient (%): ___3%________ Slope length: (m) ____50_

Boulders on/in surface (%) _1%__ Stones on/in surface (%) __5%_

Physiography: (10) ___ Flood Plain ___ Stream terrace (level) ___ Stream terrace (dissected)
_x_ Upland ___ Closed Depression ___ Drainageway

Slope shape: (11) __ Summit ___ Shoulder _x_ Backslope
___ Footslope ___ Toeslope ___ Not Appl. (on < 2% slopes in coastal plains)

Land surface shape: (12) (First letter is down-slope profile, second letter is cross-slope profile) L = linear V = convex C = concave

__ LL ___ LV ___ LC
_x_ VL ___ VV ___ VC
__ CL ___ CV ___ CC

Hydrology: (13-15)

Saturation type: endo or epi? _____ Wetland indicator plants? y/n _n_ Artificial drainage: y/n _n_

Depth of observed water: (cm) ____ Flooding evidence? y/n _n__ Ponding evidence? y/n _n__

SOIL PROPERTIES		
Soil Drainage Class (19)	Depth Class: (20)	Parent Material(s): (20)
		_x_ Mine spoil
__ excessively drained	____ V. Shallow (< 25 cm)	___ Residuum (kind/s) ________________
___ somewhat excessive	___ Shallow (25 – 50 cm)	___ Organic (not litter)
_x_ well	____ Mod. Deep (50 – 100 cm)	___ Alluvium
___ somewhat well	____ Deep (100 – 150 cm)	___ Marine (recent)
___ moderately well	_x_ Very Deep (> 150 cm)	___ Unconsol. Coastal Plain
___ somewhat poor		___ Beach
___ poorly drained		___ Lacustrine
___ very poorly		___ Loess
	Root-restricting depth: (20)	___ Eolian sand (dune)
	(cm) ___	___ Colluvium

ABBREVIATIONS

Texture:

Sand = S	Silt Loam = SiL
Loamy Sand = LS	Silty Clay Loam = SiCL
Sandy Loam = SL	Silty Clay = SiC
Loam = L	Sandy Clay Loam = SCL
Clay Loam = CL	Clay = C
Silt = SI	Sandy Clay= SC

Modifiers of Coarse Fragments:

Gravelly = GR (≥ 15%)	Cobbly = CB (≥ 15%)
Channery = CH (≥ 15%)	Stony = ST (≥ 15%)
Very (add V if ≥ 35%)	Extremely (add X if ≥ 65%)

Structure Grade:

Weak = WK	Strong = ST
Moderate = MO	Structureless = SLS

Structure Shape:

Granular = GR	Angular Blocky = ABK
Platy = PL	Subangular Blocky = SBK
Prismatic = PR	Massive = MA
Single Grain = SG	

Consistence:

Loose = L	Firm = FI
Very Friable = VFR	Very Firm = VFI
Friable = FR	Extremely Firm = EFI

Abundance:

Few (< 2% vol) = F	Many (≥ 20% vol) = M
Common (2 to < 20% vol) = C	

Pore Linings or Masses:

L = pore linings M = masses

Appendix 5b. (continued)

Soil Profile ___VA-2 (Pit 2)_ **Description Worksheet** (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Depth	Texture		Color			Redoximorphic Features (1 or 2 of each)						Structure		Consis -tence	Roots
Hor #	Name	Bot-tom	Rock frag. Mod-ifier	Fine-earth Class	Moist Matrix			Fe Depletions		Fe Concentrations				Grade	Shape	Moist	Abund.
		cm			Hue	Val	Chr	% vol.	Full Color Hue V/C	% vol.	Full Color Hue V/C	Linings /masses	Abun dance				Fine + V. F.
1	A	8	Vgr	L	10YR	4	2							mo	sbk	fr	m
2	C1	28	vgr	L	10YR 2.5Y	4 4	4 2							sls wk	ma sbk	Fr	c
3	2C2	51	Xgr	L	N	3	0							sls	Ma	Fr	c
4	2C3	130+	Xgr Xst	L	N	3	0							sls	Ma	fr	f
5																	
6																	
7																	
8																	
Page																	

Additional Description Worksheet (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Rock fragments				Other Concentrations			Other Depletions	Rock-controlled structure?	Brittle?	Perching layer?	Root-limiting?	D_b
Hor #	Name	Gravel	Cobbles	Channers	Stones	Mn concr	Mn stains	Clay Films	Sandy or bleached pockets					
		%	%	%	%	%	y/n	y/n	% vol.	y/n	%	y/n	y/n	g/cm^3
1	A	40	10	-	5	0	N	N	0	N	0	N	N	0.92
2	C1	40	10	-	5	0	N	N	0	N	0	N	N	0.87
3	2C2	50	15	-	10	0	N	N	0	N	0	N	N	0.96
4	2C3	50	15	-	20	0	N	N	0	N	0	N	N	-
5														
6														
7														
8														
Page#														

Comments:	**hor**	grey SS	Sis + shale	white + red SS	carboliths	**hor**	grey SS	Sis + shale	white + red SS	carboliths	
Rock type	**1**	5	10	84	1	**3**	5	79	15	1	- 5% boulders in C2 and C3
by horizon	**2**	5	10	84	1	**4**	5	84	10	1	- 5% bridging voids in C3

Appendix 5b. (continued)

SOIL AND SITE DESCRIPTION FORMS

Persons Describing the Soil: _AJ, JG, PD, KS________________________________ Pedon # _VA-3 (Pit 1)___

Date __9/12/03________ Lat.(5) ____ . _________ Lon.(5) _____ . ________ (decimal degrees)

County ___Wise, VA______ USGS Quad Sheet(5)_____________________ MLRA(6) ________

Site Properties: (8-9)

Current land use and vegetation: foxtail millet

Elevation (m): __820_____ Aspect (slope direction) (0° to 360°):__90_____________

Slope gradient (%): ___3%________ Slope length: (m) ____100_

Boulders on/in surface (%) _1%__ Stones on/in surface (%) __10%_

Physiography: (10) ___ Flood Plain ___ Stream terrace (level) ___ Stream terrace (dissected)
_x_ Upland ___ Closed Depression ___ Drainageway

Slope shape: (11) _x_ Summit ___ Shoulder ___ Backslope
___ Footslope ___ Toeslope ___ Not Appl. (on < 2% slopes in coastal plains)

Land surface shape: (12) (First letter is down-slope profile, second letter is cross-slope profile)
L = linear V = convex C = concave

__ LL ___ LV ___ LC
__ VL ___ VV ___ VC
_x_ CL ___ CV ___ CC

Hydrology: (13-15)

Saturation type: endo or epi? _____ Wetland indicator plants? y/n _n_ Artificial drainage: y/n _n_

Depth of observed water: (cm) ____ Flooding evidence? y/n _n__ Ponding evidence? y/n _n__

SOIL PROPERTIES

Soil Drainage Class (19)	Depth Class: (20)	Parent Material(s): (20)
		_x_ Mine spoil
__ excessively drained	____ V. Shallow (< 25 cm)	___ Residuum (kind/s) ___________________________
___ somewhat excessive	____ Shallow (25 – 50 cm)	___ Organic (not litter)
_x_ well	____ Mod. Deep (50 – 100 cm)	___ Alluvium
___ somewhat well	____ Deep (100 – 150 cm)	___ Marine (recent)
___ moderately well	_x_ Very Deep (> 150 cm)	___ Unconsol. Coastal Plain
___ somewhat poor		___ Beach
___ poorly drained		___ Lacustrine
___ very poorly		___ Loess
	Root-restricting depth: (20)	___ Eolian sand (dune)
	(cm) ___	___ Colluvium

ABBREVIATIONS

Texture:

Sand = S	Silt Loam = SiL
Loamy Sand = LS	Silty Clay Loam = SiCL
Sandy Loam = SL	Silty Clay = SiC
Loam = L	Sandy Clay Loam = SCL
Clay Loam = CL	Clay = C
Silt = SI	Sandy Clay= SC

Modifiers of Coarse Fragments:

Gravelly = GR (≥ 15%)	Cobbly = CB (≥ 15%)
Channery = CH (≥ 15%)	Stony = ST (≥ 15%)
Very (add V if ≥ 35%)	Extremely (add X if ≥ 65%)

Structure Grade:

Weak = WK	Strong = ST
Moderate = MO	Structureless = SLS

Structure Shape:

Granular = GR	Angular Blocky = ABK
Platy = PL	Subangular Blocky = SBK
Prismatic = PR	Massive = MA
Single Grain = SG	

Consistence:

Loose = L	Firm = FI
Very Friable = VFR	Very Firm = VFI
Friable = FR	Extremely Firm = EFI

Abundance:

Few (< 2% vol) = F	Many (≥ 20% vol) = M
Common (2 to < 20% vol) = C	

Pore Linings or Masses:

L = pore linings	M = masses

Appendix 5b. (continued)

Soil Profile ___VA-3 (Pit 1)_ **Description Worksheet** (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Depth	Texture		Color			Redoximorphic Features (1 or 2 of each)						Structure		Consis -tence	Roots
Hor #	Name	Bot- tom	Rock frag. Mod- ifier	Fine-earth Class	Moist Matrix			Fe Depletions		Fe Concentrations				Grade	Shape	Moist	Abund.
		cm			Hue	Val	Chr	% vol.	Full Color Hue V/C	% vol.	Full Color Hue V/C	Linings /masses	Abun dance				Fine + V. F.
1	A	9	xcb	SL	10YR	4	4							wk	sbk	fi	c
2	C1	72	xst	SL	10YR 2.5Y	4 4	3 3							sls	ma	vfi	f
3	C2	130+	xgr	SL	2.5Y 2.5Y	4 4	1 2							sls	ma	fi	-
4																	
5																	
6																	
7																	
8																	
Page																	

Additional Description Worksheet (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Rock fragments				Other Concentrations			Other Depletions	Rock-controlled structure?	Brittle?	Perching layer?	Root-limiting?	D_b
Hor #	Name	Gravel	Cobbles	Channers	Stones	Mn concr	Mn stains	Clay Films	Sandy or bleached pockets					
		%	%	%	%	%	y/n	y/n	% vol.	y/n	%	y/n	y/n	g/cm^3
1	A	45	15	-	10	0	N	N	0	N	0	N	N	1.02
2	C1	45	15	-	20	0	N	N	0	N	0	N	N	1.06
3	C2	50	10	-	10	0	N	N	0	N	0	N	N	-
4														
5														
6														
7														
8														
Page#														

Comments: **hor**	grey SS	Sis + shale	white + red SS	carboliths	**hor**	grey SS	Sis + shale	white + red SS	carboliths	- 5% boulders in C1 and C2
Rock type 1	5	10	84	1	**3**	5	10	84	1	
by horizon 2	5	10	84	1						

Appendix 5c. Soil and site descriptions of mine soils in West Virginia.
SOIL AND SITE DESCRIPTION FORM

Persons Describing the Soil: _AJ, JG, KS________________________________ Pedon # _WV-1 (Rep 1)___
Date __8/12/03________ Lat.(5) ____ . _________ Lon.(5) _____ . ________ (decimal degrees)
County ___Nicholas, WV______ USGS Quad Sheet(5)_____________________ MLRA(6) ________

Site Properties: (8-9)
Current land use and vegetation: grazed pasture, clover, fescue, orchard grass, wild carrot, birdsfoot trefoil, autumn olive
Elevation (m): __820_____ Aspect (slope direction) (0^o to 360^o):____280________
Slope gradient (%): ___5%________ Slope length: (m) __450 – 500______
Boulders on/in surface (%) _1%__ Stones on/in surface (%) __1%_

Physiography: (10) ___ Flood Plain ___ Stream terrace (level) ___ Stream terrace (dissected)
_x_ Upland ___ Closed Depression ___ Drainageway

Slope shape: (11) _x_ Summit ___ Shoulder ___ Backslope
___ Footslope ___ Toeslope ___ Not Appl. (on < 2% slopes in coastal plains)

Land surface shape: (12) (First letter is down-slope profile, second letter is cross-slope profile) L = linear V = convex C = concave
_x_ LL ___ LV ___ LC
___ VL ___ VV ___ VC
___ CL ___ CV ___CC

Hydrology: (13-15)
Saturation type: endo or epi? _____ Wetland indicator plants? y/n _n_ Artificial drainage: y/n _n_
Depth of observed water: (cm) ____ Flooding evidence? y/n _n__ Ponding evidence? y/n _n__

SOIL PROPERTIES

Soil Drainage Class (19)	Depth Class: (20)	Parent Material(s): (20)
		_x_ Mine spoil
_x_ excessively drained	____ V. Shallow (< 25 cm)	___ Residuum (kind/s) ____________________________
___ somewhat excessive	____ Shallow (25 – 50 cm)	___ Organic (not litter)
___ well	____ Mod. Deep (50 – 100 cm)	___ Alluvium
___ somewhat well	____ Deep (100 – 150 cm)	___ Marine (recent)
___ moderately well	_x__ Very Deep (> 150 cm)	___ Unconsol. Coastal Plain
___ somewhat poor		___ Beach
___ poorly drained		___ Lacustrine
___ very poorly		___ Loess
	Root-restricting depth: (20)	___ Eolian sand (dune)
	(cm) _____	___ Colluvium

ABBREVIATIONS

Texture:

Sand = S	Silt Loam = SiL
Loamy Sand = LS	Silty Clay Loam = SiCL
Sandy Loam = SL	Silty Clay = SiC
Loam = L	Sandy Clay Loam = SCL
Clay Loam = CL	Clay = C
Silt = SI	Sandy Clay= SC

Modifiers of Coarse Fragments:

Gravelly = GR (≥ 15%)	Cobbly = CB (≥ 15%)
Channery = CH (≥ 15%)	Stony = ST (≥ 15%)
Very (add V if ≥ 35%)	Extremely (add X if ≥ 65%)

Structure Grade:

Weak = WK	Strong = ST
Moderate = MO	Structureless = SLS

Structure Shape:

Granular = GR	Angular Blocky = ABK
Platy = PL	Subangular Blocky = SBK
Prismatic = PR	Massive = MA
Single Grain = SG	

Consistence:

Loose = L	Firm = FI
Very Friable = VFR	Very Firm = VFI
Friable = FR	Extremely Firm = EFI

Abundance:

Few (< 2% vol) = F	Many (≥ 20% vol) = M
Common (2 to < 20% vol) = C	

Pore Linings or Masses:

L = pore linings	M = masses

Appendix 5c. (continued)

Soil Profile ___WV-1 (Rep 1)_ **Description Worksheet** (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Depth	Texture		Color			Redoximorphic Features (1 or 2 of each)						Structure		Consis -tence	Roots
					Moist Matrix			Fe Depletions		Fe Concentrations							Abund.
Hor #	Name	Bot-tom cm	Rock frag. Mod-ifier	Fine-earth Class	Hue	Val	Chr	% vol.	Full Color Hue V/C	% vol.	Full Color Hue V/C	Linings /masses	Abun dance	Grade	Shape	Moist	Fine + V. F.
1	A	5	Vgr	L	10YR	3	3							M	Gr	Vfr	Mf mvf
2	Bw	13	Xgr	L	10YR	4	2							W	Sbk	Fr	Mf mvf
3	BC	36	Xgr	L	2.5Y	4	1							W	Sbk	Fr	c
4	C1	60	Xgr	L	2.5Y	3	1							Sls	M	Fr	f
5	C2	150+	Xcb	Fragmental	2.5/N									-	-	-	-
6																	
7																	
8																	
Page																	

Additional Description Worksheet (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Rock fragments				Other Concentrations			Other Depletions	Rock-controlled structure?	Brittle?	Perching layer?	Root-limiting?	D_b
Hor #	Name	Gravel	Cobbles	Channers	Stones	Mn concr	Mn stains	Clay Films	Sandy or bleached pockets					
		%	%	%	%	%	y/n	y/n	% vol.	y/n	%	y/n	y/n	g/cm^3
1	A	45	5	-	-	0	N	N	0	N	0	N	N	0.73
2	Bw	45	20	-	5	0	N	N	0	N	0	N	N	0.43
3	BC	35	25	-	20	0	N	N	0	N	0	N	N	0.71
4	C1	35	25	-	20	0	N	N	0	N	0	N	N	0.78
5	C2	20	60	-	10	0	N	N	0	N	0	N	N	-
6														
7														
8														
Page#														

Comments: 5% boulders in BC and C1. 10% boulders in C2
5% carboliths in C1 and C2
¼ of rock fragments are channer shaped

Appendix 5c. (continued)

SOIL AND SITE DESCRIPTION FORM

Persons Describing the Soil: _AJ, JG, KS_________________________________ Pedon # _WV-3 (Rep 2)___

Date __8/12/03________ Lat.(5) ____ . _________ Lon.(5) _____ . ________ (decimal degrees)

County ___Nicholas, WV______ USGS Quad Sheet(5)_____________________ MLRA(6) ________

Site Properties: (8-9)

Current land use and vegetation: grazed pasture, clover, fescue, orchard grass, wild carrot, birdsfoot trefoil, autumn olive

Elevation (m): __820_____ Aspect (slope direction) (0^o to 360^o):_______________

Slope gradient (%): ___4%________ Slope length: (m) _____

Boulders on/in surface (%) _1%__ Stones on/in surface (%) __1%_

Physiography: (10) ___ Flood Plain ___ Stream terrace (level) ___ Stream terrace (dissected)
_x_ Upland ___ Closed Depression ___ Drainageway

Slope shape: (11) _x_ Summit ___ Shoulder ___ Backslope
___ Footslope ___ Toeslope ___ Not Appl. (on < 2% slopes in coastal plains)

Land surface shape: (12) (First letter is down-slope profile, second letter is cross-slope profile)
L = linear V = convex C = concave

___ LL ___ LV ___ LC
___ VL ___ VV ___ VC
___ CL ___ CV _x_ CC

Hydrology: (13-15)

Saturation type: endo or epi? _____ Wetland indicator plants? y/n _n_ Artificial drainage: y/n _n_

Depth of observed water: (cm) ____ Flooding evidence? y/n _n__ Ponding evidence? y/n _n__

SOIL PROPERTIES		
Soil Drainage Class (19)	Depth Class: (20)	Parent Material(s): (20)
		_x_ Mine spoil
_x_ excessively drained	____ V. Shallow (< 25 cm)	___ Residuum (kind/s) ___________________________
___ somewhat excessive	____ Shallow (25 – 50 cm)	___ Organic (not litter)
___ well	____ Mod. Deep (50 – 100 cm)	___ Alluvium
___ somewhat well	____ Deep (100 – 150 cm)	___ Marine (recent)
___ moderately well	_x__ Very Deep (> 150 cm)	___ Unconsol. Coastal Plain
___ somewhat poor		___ Beach
___ poorly drained		___ Lacustrine
___ very poorly		___ Loess
	Root-restricting depth: (20)	___ Eolian sand (dune)
	(cm) _____	___ Colluvium

ABBREVIATIONS

Texture:

Sand = S	Silt Loam = SiL
Loamy Sand = LS	Silty Clay Loam = SiCL
Sandy Loam = SL	Silty Clay = SiC
Loam = L	Sandy Clay Loam = SCL
Clay Loam = CL	Clay = C
Silt = SI	Sandy Clay= SC

Modifiers of Coarse Fragments:

Gravelly = GR (≥ 15%)	Cobbly = CB (≥ 15%)
Channery = CH (≥ 15%)	Stony = ST (≥ 15%)
Very (add V if ≥ 35%)	Extremely (add X if ≥ 65%)

Structure Grade:

Weak = WK	Strong = ST
Moderate = MO	Structureless = SLS

Structure Shape:

Granular = GR	Angular Blocky = ABK
Platy = PL	Subangular Blocky = SBK
Prismatic = PR	Massive = MA
Single Grain = SG	

Consistence:

Loose = L	Firm = FI
Very Friable = VFR	Very Firm = VFI
Friable = FR	Extremely Firm = EFI

Abundance:

Few (< 2% vol) = F	Many (≥ 20% vol) = M
Common (2 to < 20% vol) = C	

Pore Linings or Masses:

L = pore linings	M = masses

Appendix 5c. (continued)

Soil Profile ___WV-3 (Rep 2)_ **Description Worksheet** (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Depth	Texture		Color			Redoximorphic Features (1 or 2 of each)						Structure		Consis -tence	Roots
Hor #	Name	Bot-tom	Rock frag. Mod-ifier	Fine-earth Class	Moist Matrix			Fe Depletions		Fe Concentrations				Grade	Shape	Moist	Abund.
		cm			Hue	Val	Chr	% vol.	Full Color Hue V/C	% vol.	Full Color Hue V/C	Linings /masses	Abun dance				Fine + V. F.
1	A	3	Vgr	L	10YR	3	2							M	Gr	Vfr	Mf mvf
2	Bw	15	Xgr	L	2.5Y	3	2							W	Sbk	VFr	Mf mvf
3	BC	46	Xgr	L	10YR	3	1							W	Sbk	Fr	m
4	C1	125	Xgr	L	2.5Y	3	1							Sls	M	Fr	f
5	C2	135+	Xcb	Fragmental	10YR	2	2							-	-	-	-
6																	
7																	
8																	
Page																	

Additional Description Worksheet (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Rock fragments				Other Concentrations			Other Depletions	Rock-controlled structure?	Brittle?	Perching layer?	Root-limiting?	Pores?
Hor #	Name	Gravel	Cobbles	Channers	Stones	Mn concr	Mn stains	Clay Films	Sandy or bleached pockets					
		%	%	%	%	%	y/n	y/n	% vol.	y/n	%	y/n	y/n	Abund
1	A	40	10	-	-	0	N	N	0	N	0	N	N	0
2	Bw	40	20	-	5	0	N	N	0	N	0	N	N	0
3	BC	55	20	-	10	0	N	N	0	N	0	N	N	0
4	C1	40	20	-	20	0	N	N	0	N	0	N	N	0
5	C2	40	25	-	25	0	N	N	0	N	0	N	N	0
6														
7														
8														
Page#														

Comments: 5% boulders in BW, BC, C1, and C2
Acid sulfate weathering – jarosite, yellow and white crystals, red colors
¼ of rock fragments are channer shaped

SOIL AND SITE DESCRIPTION FORM

Persons Describing the Soil: _AJ, JG, KS_________________________________ Pedon # _WV-2 (Rep 3)___

Date __8/12/03________ Lat.(5) ____ . _________ Lon.(5) _____ . ________ (decimal degrees)

County ___Nicholas, WV______ USGS Quad Sheet(5)_____________________ MLRA(6) ________

Site Properties: (8-9)

Current land use and vegetation: grazed pasture, clover, fescue, orchard grass, wild carrot, birdsfoot trefoil, autumn olive

Elevation (m): __820_____ Aspect (slope direction) (0^o to 360^o):_______________

Slope gradient (%): ___3%________ Slope length: (m) _____

Boulders on/in surface (%) _1%__ Stones on/in surface (%) __1%_

Physiography: (10) ___ Flood Plain ___ Stream terrace (level) ___ Stream terrace (dissected)
_x_ Upland ___ Closed Depression ___ Drainageway

Slope shape: (11) _x_ Summit ___ Shoulder ___ Backslope
___ Footslope ___ Toeslope ___ Not Appl. (on < 2% slopes in coastal plains)

Land surface shape: (12) (First letter is down-slope profile, second letter is cross-slope profile)
L = linear V = convex C = concave

___ LL ___ LV ___ LC
_x_ VL ___ VV ___ VC
___ CL ___ CV ___ CC

Hydrology: (13-15)

Saturation type: endo or epi? _____ Wetland indicator plants? y/n _n_ Artificial drainage: y/n _n_

Depth of observed water: (cm) ____ Flooding evidence? y/n _n__ Ponding evidence? y/n _n__

SOIL PROPERTIES

Soil Drainage Class (19)	Depth Class: (20)	Parent Material(s): (20)
		_x_ Mine spoil
_x_ excessively drained	____ V. Shallow (< 25 cm)	___ Residuum (kind/s) ___________________________
___ somewhat excessive	____ Shallow (25 – 50 cm)	___ Organic (not litter)
___ well	____ Mod. Deep (50 – 100 cm)	___ Alluvium
___ somewhat well	____ Deep (100 – 150 cm)	___ Marine (recent)
___ moderately well	_x__ Very Deep (> 150 cm)	___ Unconsol. Coastal Plain
___ somewhat poor		___ Beach
___ poorly drained		___ Lacustrine
___ very poorly		___ Loess
	Root-restricting depth: (20)	___ Eolian sand (dune)
	(cm) _____	___ Colluvium

ABBREVIATIONS

Texture:

Sand = S; Loamy Sand = LS; Sandy Loam = SL; Loam = L; Clay Loam = CL; Silt = SI
Silt Loam = SiL; Silty Clay Loam = SiCL; Silty Clay = SiC; Sandy Clay Loam = SCL; Clay = C; Sandy Clay= SC

Modifiers of Coarse Fragments:

Gravelly = GR (≥ 15%) Cobbly = CB (≥ 15%)
Channery = CH (≥ 15%) Stony = ST (≥ 15%)
Very (add V if ≥ 35%) Extremely (add X if ≥ 65%)

Structure Grade:

Weak = WK Strong = ST
Moderate = MO Structureless = SLS

Structure Shape:

Granular = GR Angular Blocky = ABK
Platy = PL Subangular Blocky = SBK
Prismatic = PR Massive = MA
Single Grain = SG

Consistence:

Loose = L Firm = FI
Very Friable = VFR Very Firm = VFI
Friable = FR Extremely Firm = EFI

Abundance:

Few (< 2% vol) = F Many (≥ 20% vol) = M
Common (2 to < 20% vol) = C

Pore Linings or Masses:

L = pore linings M = masses

Soil Profile ___WV-2 (Rep 3)_ **Description Worksheet** (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Depth	Texture		Color			Redoximorphic Features (1 or 2 of each)						Structure		Consis-tence	Roots
Hor #	Name	Bot-tom	Rock frag. Mod-ifier	Fine-earth Class	Moist Matrix			Fe Depletions		Fe Concentrations				Grade	Shape	Moist	Abund.
		cm			Hue	Val	Chr	% vol.	Full Color Hue V/C	% vol.	Full Color Hue V/C	Linings /masses	Abun dance				Fine + V. F.
1	A	5	Vgr	L	10YR	3	3							M	Gr	Vfr	Mf mvf
2	Bw	15	Xgr	SL	10YR	4	3							M	Sbk	Fr	Mf mvf
3	BC	45	Xgr	SL	2.5Y	3	2							W	Sbk	Fr	c
4	C1	90	Xgr	L	2.5Y	3	1							Sls	M	F 10%vf	f
5	C2	120+	Xcb	Fragmental	2.5/N									-	-	-	-
6																	
7																	
8																	
Page																	

Additional Description Worksheet (reference Field Book for Describing Soils or Soil Profile Desc. Manual)

Horizon		Rock fragments				Other Concentrations			Other Depletions	Rock-controlled structure?	Brittle?	Perching layer?	Root-limiting?	D_b
Hor #	Name	Gravel	Cobbles	Channers	Stones	Mn concr	Mn stains	Clay Films	Sandy or bleached pockets					
		%	%	%	%	%	y/n	y/n	% vol.	y/n	%	y/n	y/n	g/cm^3
1	A	40	10	-	-	0	N	N	0	N	0	N	N	-
2	Bw	50	10	-	5	0	N	N	0	N	0	N	N	-
3	BC	35	10	-	20	0	N	N	0	N	0	N	N	1.22
4	C1	40	20	-	10	0	N	N	0	N	0	N	10% Y	-
5	C2	15	45	-	25	0	N	N	0	N	0	N	N	-
6														
7														
8														
Page#														

Comments: 5% boulders in BC and C1
15% boulders in C2
¼ of rock fragments are channer shaped

Appendix 6. Validation records for the development of a forest site quality class model for White Pine (*Pinus strobus* L.). Site index (SI); pH; electrical conductivity (EC); aspect; texture; color; rock fragments (CF); sandstone (SS); density; rooting depth; and slope were used to calculate a preliminary productivity index (PI), and a white pine productivity index (PI_{wp}).

Obs.	SI	pH	EC	Aspect	Texture	Color	CF	SS	Density	Rooting Depth	Slope	PI†	PI_{wp}‡
	ft		dS m^{-1}	degrees			volume %	%		cm	%		
1	103.4	5.9	0.01	75	SL	10YR 4/3	30	30	Moderate	65	35	0.8	0.7
2	92.9	5.3	0.03	75	SL	10YR 4/3	30	50	Moderate	45	32	0.7	0.7
3	82.2	5.1	0.07	76	L	10YR 4/3	40	15	Moderate	38	23	0.6	0.6
4	95.1	5.7	0.02	48	L	10YR 3/3	43	15	Moderate	46	37	0.7	0.7
5	103.3	5.5	0.15	164	L	10YR 5/4	30	10	Moderate	67	47	0.7	0.7
6	120.3	6.2	0.21	185	SL	10YR 5/4	30	75	Moderate	61	33	0.8	0.7
7	112.4	5.5	0.12	flat	SL	10YR 4/3	37	85	Moderate	53	11	0.8	0.7
8	98.3	4.3	0.17	flat	SL	10YR 4/3	30	85	Moderate	34	2	0.6	0.7
9	117	5.4	0.25	flat	SL	10YR 4/3	30	85	Moderate	54	2	0.7	0.7
10	128.2	4.7	0.24	flat	SL	10YR 4/3	30	85	Low	100	2	0.9	0.9
11	92	4.8	0.3	flat	SL	10YR 4/3	30	85	Moderate	34	2	0.6	0.7
12	98.8	5	0.2	flat	SL	10YR 4/2	37	70	Moderate	45	4	0.7	0.7
13	121.6	4.4	0.11	168	SL	10YR 4/3	38	85	Low	52	28	0.8	0.9
14	102.2	5.5	0.02	115	L	10YR 4/3	37	85	Moderate	42	37	0.7	0.7
15	96.8	5.6	0.09	125	SL	10YR 5/4	30	85	Moderate	57	40	0.8	0.7
16	113.7	5.5	0.11	flat	SL	10YR 5/4	38	85	Low	59	7	0.8	0.9
17	111	5.7	0.04	152	SL	10YR 4/6	30	50	Moderate	100	40	0.8	0.8
18	96.7	5.1	0.07	85	SL	10YR 4/6	37	50	Moderate	55	43	0.8	0.7
19	87	7.1	0.1	100	L	10YR 4/2	38	50	Moderate	51	50	0.7	0.7
20	81.6	4.6	0.04	flat	L	10YR 4/2	37	40	High	51	1	0.6	0.5
21	97.2	6.7	0.07	110	SL	10YR 4/4	30	85	Moderate	46	15	0.7	0.7
22	91.9	4.4	0.11	flat	SL	10YR 5/4	25	85	High	40	2	0.6	0.6
23	93.3	4.5	0.06	flat	SL	10YR 5/6	25	85	Moderate	42	2	0.7	0.7
24	108.3	6.4	0.05	355	SL	10YR 4/4	37	50	Low	100	35	0.9	0.9
25	78.6	6.4	0.07	flat	L	10YR 3/2	40	70	High	34	1	0.5	0.5
26	67.6	7.2	0.11	flat	SL	10YR 3/2	40	50	High	30	1	0.4	0.5
27	100.6	8	0.11	flat	SiL	2.5Y 3/2	15	10	Very low	73	3	§	§

Appendix 6. (continued)

Obs.	SI	pH	EC	Aspect	Texture	Color	CF	SS	Density	Rooting Depth	Slope	PI†	PI_{wp}‡
	ft		dS m^{-1}	degrees			volume %	%		cm	%		
28	111.9	4.9	0.02	195	SL	10YR 5/4	15	85	Low	100	46	0.9	0.9
29	101.8	6.2	0.07	268	SL	10YR 4/4	30	85	Low	45	30	0.7	0.9
30	136.1	6.4	0.03	338	SL	10YR 5/4	10	50	Very low	100	33	0.9	1.0
31	113.3	5.4	0.02	338	SL	10YR 4/6	25	85	Very low	44	37	0.8	0.9
32	79.5	5	0.05	324	L	10YR 4/4	20	35	Very low	100	38	§	§
33	81.1	7.9	0.09	333	SL	10YR 4/3	40	85	Low	39	22	§	§
34	127.3	5.4	0.07	210	SL	10YR 4/2	30	75	Low	42	36	0.7	0.8
35	115	5	0.03	216	SL	10YR 4/3	30	15	Low	36	48	0.6	0.8
36	109	6.5	0.04	185	SL	10YR 3/2	40	85	Moderate	51	37	0.7	0.7
37	129.7	7.8	0.05	12	SL	10YR 5/4	10	90	Very low	100	44	0.8	1.0
38	100.8	6	0.05	1	SL	10YR 4/6	20	25	Low	28	34	0.6	0.8
39	115.7	7.4	0.09	17	SL	10YR 5/4	30	30	Low	38	28	0.6	0.8
40	113.9	4.8	0.09	188	L	10YR 5/6	25	90	Very low	75	42	0.9	0.9
41	109.6	4.3	0.02	188	L	10YR 5/4	25	90	Very low	100	43	0.9	0.9
42	95	5.6	0.13	250	SL	10YR 4/4	35	90	Moderate	47	40	0.7	0.7
43	123.1	5	0.08	244	L	10YR 5/6	35	50	Low	58	42	0.8	0.8
44	116	4.9	0.05	246	L	10YR 5/4	25	50	Low	48	36	0.7	0.8
45	126	4.8	0.07	35	SL	10YR 5/4	20	85	Low	55	45	0.9	0.9
46	138.8	4.7	0.08	337	SL	10YR 4/6	35	50	Low	70	45	0.9	0.9
47	125.1	4.4	0.07	140	SL	10YR 5/6	25	85	Low	100	46	0.9	0.9
48	118.4	4.6	0.04	235	SL	10YR 4/4	30	75	Moderate	70	48	0.8	0.7
49	131.8	4.4	0.02	330	SL	10YR 4/6	40	50	Low	68	18	0.8	0.9
50	128	6.6	0.04	348	SL	10YR 4/4	35	85	Low	58	36	0.8	0.9
51	110	6.1	0.03	284	SL	10YR 4/3	40	40	Low	47	44	0.7	0.9
52	126.6	4.3	0.01	288	SL	10YR 4/3	25	85	Low	100	47	0.9	0.9

† PI=(pH x EC x aspect x texture x CF x rock type x density x slope) $^{1/8}$ x rooting depth; sufficiency values used for soil properties.

‡ PI_{wp}=(pH x 0.08) + (texture x 0.2) + (rooting depth x 0.28) + (density x 0.44); sufficiency values used for soil properties.

§ Data points omitted following statistical analysis.

Appendix 7a. Statistical analysis of all model variables (pH; electrical conductivity (EC); aspect; textural class; color; sandstone percent; soil density class; rooting depth; and slope) before selection procedures were used to determine the best model. Three of the original 52 data points were previously discarded.

Number of Observations Read	49
Number of Observations Used	37
Number of Observations with Missing Values	12

Analysis of Variance

Sum of Source	DF	Sum of Squares	Mean Sqaure	F Value	Pr >F
Model	10	4295.179	429.518	4.00	0.0022
Error	26	2794.271	107.472		
Corrected Total	36	7089.45			
Root MSE	10.36687	R-Square	0.6059		
Dependent Mean	111.9162	Adj R-Sq	0.4543		
Coeff Var	9.26306				

Parameter Estimates

Variable	Parameter Estimate	Standard Error	t Value	Pr > |t|	Standardized Estimate	Variance Inflation
Intercept	113.0298	78.93112	1.43	0.1641	0	0
pH1	-0.18117	0.19445	-0.93	0.3601	-0.13509	1.38676
EC	51.75486	55.99289	0.92	0.3638	0.15549	1.86671
Aspect1	0.01922	0.02251	0.85	0.4011	0.14316	1.85536
Texture	-10.41253	4.52455	-2.3	0.0296	-0.32274	1.29734
color3	-2.89638	21.65982	-0.13	0.8947	-0.02822	2.93764
CF3	-1.72011	8.73755	-0.2	0.8455	-0.04253	3.07876
asinrock	-4.56217	5.85066	-0.78	0.4426	-0.11021	1.31777
Compaction	-10.67657	4.04617	-2.64	0.0139	-0.52737	2.63494
WF2	53.5739	31.22352	1.72	0.0981	0.2778	1.72916
slope3	0.34986	6.89761	0.05	0.9599	0.0068	1.18697

Appendix 7b. Textural class; soil density class; rooting depth (WF); pH; electrical conductivty (EC); rock fragments (CF); sandstone percent; slope; and color were transformed and regressed with the site index (SI) of white pine (*Pinus strobus* L.). The C(p) selection procedure using SAS developed a list of the best models.

Number in Model	C(p)	R-Square	Variables in Model
3	1.9753	0.6952	Texture Compaction WF2
4	2.494	0.7057	pH1 Texture Compaction WF2
4	3.0721	0.7016	EC Texture Compaction WF2
4	3.405	0.6992	Texture CF3 Compaction WF2
4	3.753	0.6967	Texture asinrock Compaction WF2
5	3.8393	0.7103	pH1 EC Texture Compaction WF2
4	3.8469	0.6961	Texture Compaction WF2 slope3
4	3.9662	0.6952	Texture color3 Compaction WF2
5	4.0252	0.709	pH1 Texture asinrock Compaction WF2
5	4.1213	0.7083	pH1 Texture CF3 Compaction WF2
5	4.1343	0.7082	pH1 Texture Compaction WF2 slope3
5	4.2777	0.7072	EC Texture Compaction WF2 slope3
5	4.4619	0.7059	pH1 Texture color3 Compaction WF2
5	4.4688	0.7059	EC Texture asinrock Compaction WF2
5	4.5559	0.7052	EC Texture CF3 Compaction WF2
6	4.6891	0.7185	pH1 EC Texture Compaction WF2 slope3
6	4.9545	0.7166	pH1 EC Texture asinrock Compaction WF2
5	5.0648	0.7016	EC Texture color3 Compaction WF2
5	5.2008	0.7007	Texture color3 CF3 Compaction WF2
5	5.2511	0.7003	Texture CF3 asinrock Compaction WF2
5	5.337	0.6997	Texture CF3 Compaction WF2 slope3
6	5.4904	0.7128	pH1 EC Texture CF3 Compaction WF2
5	5.7099	0.6971	Texture asinrock Compaction WF2 slope3
5	5.7345	0.6969	Texture color3 asinrock Compaction WF2
6	5.7376	0.711	pH1 EC Texture color3 Compaction WF2

Appendix 7c. Statistical analysis of all final model variables chosen (textural class; soil density class; and rooting depth).

Number of Observations Used 49

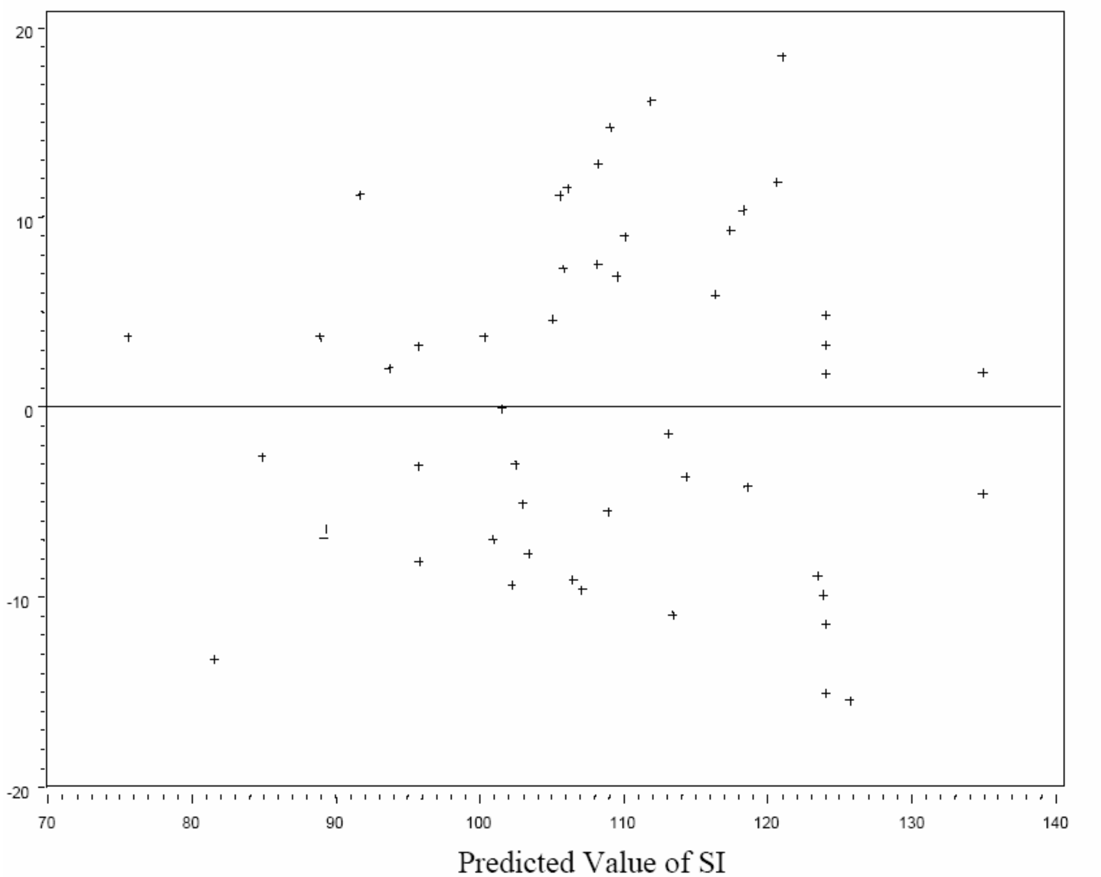
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	8544.448	2848.15	34.21	<.0001
Error	45	3746.732	83.2603		
Corrected Total	48	12291			
Root MSE	9.12471	R-Square	0.6952		
Dependent Mean	108.4551	Adj R-Sq	0.6748		
Coeff Var	8.41335				

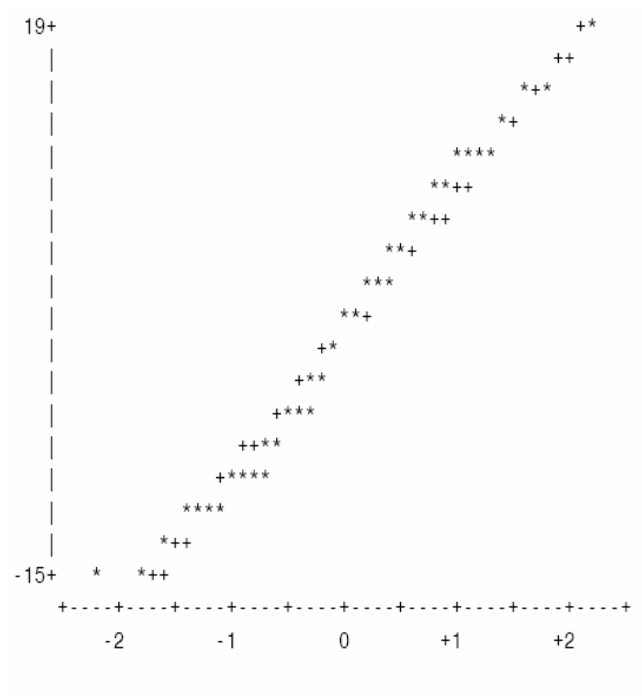
Parameter Estimates

Variable	Parameter Estimate	Standard Error	t Value	Pr > |t|	Type II SS	Standardized Estimate	Variance Inflation
Intercept	81.71586	19.10189	4.28	<.0001	<0.0001	0	0
Texture	-9.24748	3.14024	-2.94	0.0051	0.0051	-0.24362	1.01034
Compaction	-10.93012	1.8558	-5.89	<.0001	<0.0001	-0.54219	1.25106
WF2	74.44527	18.59737	4	0.0002	0.0002	0.36684	1.23979

Appendix 7d. Residual plot as an assessment for normality of the final forest site quality class model.



Appendix 7e. Stem leaf plot, box plot, and normal probability plot as an assessment for equal variance on the final forest site quality class model.

<table>
<tr><th>Stem</th><th>Leaf</th><th>#</th><th>Boxplot</th><th>Normal Probability Plot</th></tr>
<tr><td></td><td></td><td></td><td>|</td><td rowspan="19">
</td></tr>
<tr><td>18</td><td>0</td><td>1</td><td></td></tr>
<tr><td>16</td><td></td><td></td><td>|</td></tr>
<tr><td>14</td><td>37</td><td>2</td><td>|</td></tr>
<tr><td>12</td><td>3</td><td>1</td><td>|</td></tr>
<tr><td>10</td><td>7714</td><td>4</td><td>|</td></tr>
<tr><td>8</td><td>689</td><td>3</td><td>|</td></tr>
<tr><td>6</td><td>481</td><td>3</td><td>+-----+</td></tr>
<tr><td>4</td><td>245</td><td>3</td><td>| |</td></tr>
<tr><td>2</td><td>88233</td><td>5</td><td>| |</td></tr>
<tr><td>0</td><td>346</td><td>3</td><td>*--+--*</td></tr>
<tr><td>0</td><td>95</td><td>2</td><td>| |</td></tr>
<tr><td>-2</td><td>551</td><td>3</td><td>| |</td></tr>
<tr><td>-4</td><td>55071</td><td>5</td><td>| |</td></tr>
<tr><td>-6</td><td>49</td><td>2</td><td>+-----+</td></tr>
<tr><td>-8</td><td>54462</td><td>5</td><td>|</td></tr>
<tr><td>-10</td><td>9431</td><td>4</td><td>|</td></tr>
<tr><td>-12</td><td>7</td><td>1</td><td>|</td></tr>
<tr><td>-14</td><td>95</td><td>2</td><td>|</td></tr>
</table>