TOPOGRAPHIC POSITION AND LAND COVER EFFECTS ON SOIL ORGANIC CARBON DISTRIBUTION OF LOESS-VENEERED HILLSLOPES IN THE CENTRAL UNITED STATES

By

Thomas Rhanor

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A Thesis
Submitted in Partial Fulfillment of the Requirements for
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THESIS APPROVAL

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Approved by:

Dr. Brian Klubek, Chair

Dr. Samuel Indorante, Chair

Dr. Jon Schoonover

Dr. Brad Lee

Dr. Phillip Owens

Graduate School
Southern Illinois University Carbondale
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THOMAS RHANOR, for the Master of Science degree in PEDOLOGY, presented at Southern Illinois University Carbondale.

TITLE: TOPOGRAPHIC POSITION AND LAND COVER EFFECTS ON SOIL ORGANIC CARBON DISTRIBUTION OF LOESS-VENEERED HILLSLOPES IN THE CENTRAL UNITED STATES

MAJOR PROFESSOR: Dr. Brian Klubek

Soil organic carbon (SOC) is important both for its influence on agricultural productivity and for its role in the carbon cycle. The distribution of SOC is highly variable at the field scale both horizontally and vertically; a portion of SOC's variability can be attributed to differences in vegetative cover and to slope position. This study characterized and compared SOC concentration to a depth of 2 meters across 6 loess-veneered watersheds in the central United States. Data were collected as part of the Shawnee Hills Loess Catenas project, a collaboration between the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service, USDA Forest Service, Purdue University, University of Kentucky, Southern Illinois University at Carbondale, and Illinois State Geological Survey, among others. The study consists of pairs of sites, one under forest cover and one grass cover, located in southern Illinois, southern Indiana, and western Kentucky. Bulk density and SOC data were calculated from genetic horizon samples taken from soil pits laid out as transects along slopes at each site. SOC concentrations were significantly higher under forest cover. Footslopes and toeslopes had significantly higher SOC densities than summits, shoulders, and backslopes. A three-part exponential decay model was the best fit for the relationship between SOC density and depth from the surface. The comparisons and models may be used to more accurately predict SOC concentration and carbon pool size on similar loess-veneered landscapes in the central United States.

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INTRODUCTION

The pedosphere is a 1 to 2 meter deep layer that supports all terrestrial biotic activity and interacts with the atmosphere, lithosphere, biosphere, and hydrosphere. These interactions influence the biogeochemical cycling of nutrients and water, as well as gas and energy exchanges between soil and atmosphere (Lal et al., 1997). The soil serves as a medium for the accumulation of carbon initially captured by terrestrial biota, the transformation of carbon-containing compounds, and the outflow of carbon-containing greenhouse gases into the atmosphere (Konyushkov, 1997). When residues are decomposed in the soil, four basic reactions occur: (1) carbon leaves the soil as CO_2 to enter the atmosphere; (2) associated nutrient elements are mineralized; (3) a portion of the carbon is incorporated into microbial biomass; and (4) the remaining fraction of the carbon resides in stable humus. Concurrently, a fraction of humus may be mineralized (Stevenson, 1994).

Chemically, all organic material in the soil can be divided into two classes of substances: (1) the various organic compounds that belong to well-known groups in organic chemistry such as proteins, carbohydrates, and organic acids (10 to 15% of soil organic matter), and (2) a second class of compounds, making up about 85-90% of soil organic matter, are not related to any recognized groups in organic chemistry, and are termed humus (Kononova, 1966). Soil organic matter contains about 58% organic carbon, though this range is highly variable (Soil Survey Staff, 2004). Soil organic matter can be conceptualized as pools of material that differ in their susceptibility to microbial decomposition. Agronomically, organic matter is divided into so-called active and stable pools. The active pool includes surface litter, particulate organic matter (POM), microbial biomass, and nonhumic substances not bound by mineral particles (Stevenson, 1994). Paul and Clark (1996) define POM as that fraction of residues left in the 50 to 2000 micron fraction after sieving. Humus constitutes the stable pool of organic matter (Stevenson, 1994).

Humus may be divided into three components based on traditional fractionation techniques: (1) humic acids, which are extracted by alkaline solutions that precipitate upon acidification; (2) fulvic acids, which are extracted by alkaline solutions but do not precipitate upon acidification; and (3) humin, which is not soluble at any pH (Stevenson and Olsen, 1989). The molecular weights of these fractions are 1,000 to 30,000 for fulvic acids, 10,000 to 100,000 for humic acids, and over 100,000 for humin (Paul and Clark, 1996). The mean residence times of particular fractions of soil organic matter range from 0.01 to 10,000 years (Konyushkov, 1997). Although humus molecules are heterogeneous, various degradation methods suggest they share common components such as aromatic and side-chain carboxyl groups, aliphatic and phenolic hydroxyls, various amine groups, ketones, and quinones. Phenols and quinones readily combine with one another to form high molecular weight polymers (Stevenson, 1994). Humus is able to resist decomposition for two reasons: its inherent chemical resistance and its physical protection due to interaction with clay minerals (Stevenson, 1994).

The humus content in a given soil influences many of that soil's characteristics. According to Kononova (1966), humus participates in the weathering of minerals, provides a source of nutrients, aids in the formation of water-stable soil aggregates, and may directly promote plant growth and development under certain conditions. Stevenson (1994) gives a more complete outline by listing humus's properties and effects on soil: (1) color, which may help warm the soil; (2) water retention, which prevents soil drying and supplies water to plants; (3) combination with clay minerals, which stabilizes structure, thereby increasing aeration and permeability; (4) chelation, which enhances micronutrient availability to plants; (5) buffer action, which helps soil maintain a stable pH; (6) negative (pH-dependent) charge, which increases a soil's CEC; (7) mineralization, thereby offering a source of plant nutrients; and (8) combines with xenobiotics, which may alter the effective application rate of pesticides.

LITERATURE REVIEW

The two main fluxes in the global carbon pools are between atmosphere and land plants, which includes soil-related efflux, and between atmosphere and the ocean (Lal et al., 1997). The pedosphere is said to have played a significant role in influencing the composition of the atmosphere, especially since 1850; but, the magnitude of total contribution, as well as past and current rates of carbon flux to the atmosphere from the pedosphere are unknown (Lal et al., 1997). Increasing organic carbon accumulation in agricultural soils provides a way to reduce atmospheric CO_2 concentrations; however, the spatial variability of soil organic carbon (SOC) makes measurements of carbon accumulation difficult (Dell and Sharpley, 2006). Processes that enhance SOC content include plant biomass production, humification, soil aggregation, and sediment deposition; those that degrade SOC content include erosion, leaching, and organic matter decomposition. The balance between these factors determines the net SOC pool in the pedosphere (Lal et al., 1997).

One method of examining soil organic carbon distribution is analysis of existing data. In 2006, Guo et al. used State Soil Geographic (STATSGO) data to determine that the Midwest contains about 23-32% of SOC in the U.S.; the Southwest has 17-20%; the Northern Plains have 18-19%; the West has 15-16%; and the South Central region has 13-15%. Kern (1994) utilized the Soil Conservation Service (now NRCS) pedon database to rank SOC content down to the 1-meter depth by soil order: Aridisols <Entisols ~Ultisols =Alfisols <Vertisols <Oxisols <Inceptisols <Mollisols <Spodosols <<Histosols. Guo et al. (2006) found that Histosols have the highest SOC content at 140.1 kg m^{-3}, followed by Vertisols (14.7 kg m^{-3}) and Mollisols (13.5 kg m^{-3}), with Alfisols having 7.5 kg m^{-3} and Inceptisols 8.9 kg m^{-3}. However, Inceptisols and

Entisols had the greatest variability of SOC content among soil orders. Kern (1994) also found that the influence of soil moisture regimes varied among soil orders, but generally wet and cold groupings had greater SOC contents.

Soil organic carbon distribution varies not only horizontally, but also vertically with soil depth. Guo et al. (2006) in an examination of STATSGO data for the contiguous U.S., indicates that the relative spatial variability of SOC increases greatly as soil depth increases; the coefficient of variance (CV) increased from 115% to 209% to 321% for the 0-20 cm, 20-100 cm, and the 100-200 cm fractions respectively. It was also determined that of the upper 200 cm of soil, approximately 30% of SOC is located in the 0-20 cm surface layer and approximately 80% in the upper 100 cm (Guo et al., 2006). Kern (1994) also found that, for most soils, greater heterogeneity of SOC content was observed below 30 cm. Syswerda et al. (2011) had similar results in a field plot study on Typic Hapludalfs in southwest Michigan, where soil carbon concentrations were higher at the surface than at lower horizons, and there was increasing variability with depth. Soil carbon concentrations were 3 times more variable in Bt2/C horizons than A horizons. The high variability, coupled with the lower concentrations, makes it difficult to detect statistically significant differences in subsurface soil carbon concentrations without intense sampling (Syswerda et al., 2011).

When examining hillslope landscapes, the variability in the distribution of soil organic carbon, both horizontal and vertical, is partly attributable to the effects of topography. Any hillslope can be defined by three components: gradient, slope length geometry, and slope width geometry. The geometry of width and length are defined for a given section of slope as linear, convex, or concave for a possible nine combinations, e.g. linear convex or concave concave (Ruhe, 1969). A hillslope, seen in two-dimensional profile, can be divided into summit, shoulder, backslope, footslope, and toeslope components according to the model by Ruhe and Walker (1968). Topography effects may be due to the combined effects of slope aspect, water dynamics, and/or erosion and deposition.

A point on a hillslope may also be defined by its slope aspect, or the direction it faces, e.g. north, south, east, or west. Slope aspect can affect soil temperature, evapotranspiration, and which winds act (Soil Survey Division Staff, 1993). Studying the effect of microclimate and vegetation on soil genesis in southeast Michigan, it was found that south-facing slopes had shallower solums and shallower A horizons than north-facing slopes. The south-facing slopes had relatively higher light intensities, higher maximum air temperatures, higher evaporation rates, and higher soil temperatures; the north-facing slopes had lower temperatures and higher soil moisture; these differences in microclimate appear to have led to differences in tree species present, moisture cycles, and freeze-thaw and wet-dry cycles (Cooper, 1960).

According to Norton and Smith (1930), based on samples collected in loess landscapes in southern Illinois, the most important effect of slope on soil profile development is its influence on soil moisture. The amount of runoff increases as the slope gradient increases; therefore, the amount of water infiltrating the soil profile in any given area decreases as the slope gradient increases. They found that as the slope gradient increases, the depth to the zone of clay accumulation decreases parabolically (Norton and Smith, 1930). However, Ruhe and Walker (1968), point out that the influence of topography on soil formation is not as simple as its effect on water infiltration. On loess hillslopes in Iowa, Ruhe and Walker (1968) found a particle size sorting effect. They postulate that prior to soil formation, differences in soil surface texture were created by slope wash, so that coarser particles were preferentially left on steeper slope segments and finer particles transported to lower slope segments (Ruhe and Walker, 1968). Kleiss (1970) and Malo et al. (1974) also recognized this trend, noting an increase in the fine-to-coarse particle size ratio of the A horizon when moving from summit to shoulder and from backslope to toeslope. It was likewise found that organic matter content of A-horizons followed the trend of particle size sorting, indicating that the same sedimentary processes may have caused both trends. The differences in organic matter content may also relate to the different moisture regimes present at different slope positions (Kleiss, 1970; Malo et al., 1974).

Soil organic matter distribution on hillslopes may be affected both directly and indirectly by erosion. Soil erosion affects soil carbon content in two ways: first, it degrades the soil's productivity and thus the amount of carbon returning to soil as plant residues; second, it redistributes soil carbon by removing the surface soil (typically high in organic matter) from one site and depositing it in another (Gregorich et al., 1998). On a study site on a hillslope in western Iowa, the summit position was found to have the most developed soils; this is due to the lack of erosion from this relatively flat surface, leading to maximum time for pedogenesis (Huddleston and Riecken, 1973). Similarly, Malo et al. (1974) found that at the summit, vertical translocation of organic matter is maximized due to the lack of significant erosion. This contrasts with the shoulder and backslope positions, where only shallow vertical organic matter translocation is apparent, indicating erosion of surface accumulations. Analysis using ^{137}Cs methodology on a hillslope in Ontario, Canada indicated that topsoil is eroded from upslope positions, mainly the shoulder, and deposited in downslope positions, mainly the footslope (Van den Bygaart, 2001). As the slope gradient increases, moving from summit to shoulder to backslope, the depth to horizon of maximum clay content decreases exponentially and the A-horizon gets thinner (Ruhe and Walker, 1968). Malo et al. (1974), on the other hand, found that the organic carbon content in the A horizon increased logarithmically from shoulder to toeslope positions, and the depth to

<1% organic carbon was quadratic from summit to toeslope. The minima of both curves are at the shoulder, where there is maximum erosion (Malo et al., 1974).

Soils at the footslope and toeslope positions are relatively more moist and receive material from upslope positions via both run-off and leaching (Walker et al., 1968). There is also an abrupt decrease in bulk density values at the footslope and toeslope positions caused by increased amounts of organic matter and fine particles (Malo et al., 1974). It is important to note that although erosion and deposition redistribute soil carbon, there is not a net loss of carbon until mineralization of organic carbon occurs (Gregorich et al., 1998). The burial of soil in the depositional position may result in a relative gain in SOC, because there would be less carbon mineralization than when exposed to the higher oxygen conditions at the surface (Van den Bygaart, 2001).

RESEARCH OBJECTIVES

1. Compare the levels of soil organic carbon density between slope positions on loess-veneered landscapes.
2. Compare the levels of soil organic carbon density between previously-cultivated grass and forest land covers on loess-veneered landscapes.
3. Fit mathematical models to the relationship between soil organic carbon density and depth from the soil surfaces of research sites.
4. Calculate and compare carbon pools for research sites and then apply to similar loess-veneered landscapes.

MATERIALS AND METHODS

This research is part of a collaborative tri-state soil systems study, sometimes referred to as the Shawnee Hills Loess Catenas Project, involving the United States Department of Agriculture Natural Resources Conservation Service (USDA-NRCS), the USDA Forest Service, Southern Illinois University at Carbondale, Purdue University, and the University of Kentucky. The study aims to better understand soil-forming processes in the loess-veneered hillslope region stretching across southern Illinois, western Kentucky, and southern Indiana. Paired sites are located in each state, one with forest cover, the other with grass cover, for a total of 6 sites (Figure 1). Each site encompasses a small watershed, ranging from 1-8 ha, leading into a first-order stream.

The sites were selected to encompass the variety of land uses and the predominant land covers typical in the region. Those with grass cover are assumed to have been under agricultural production for over 100 years prior to the study; based on historic aerial photographs, the land use has varied between row-cropping, pasture, hay land, and fallow periods and is not the same across sites. The sites with forest cover are not mature forests, but are assumed to have been wooded for at least 50 years prior to the study. The tree species present are not uniform across sites.

All six sites fall within ecological subregion 223, Central Interior Broadleaf Forest Province. The climate is continental, and summers are hot with soil moisture deficits common (McNab et al., 2005). The USDA-NRCS system for classifying land resources places both Kentucky sites, and the Illinois grassland site, within Major Land Resource Area (MLRA) 120A, Kentucky and Indiana Sandstone and Shale Hills and Valleys, Southern Part; the average annual

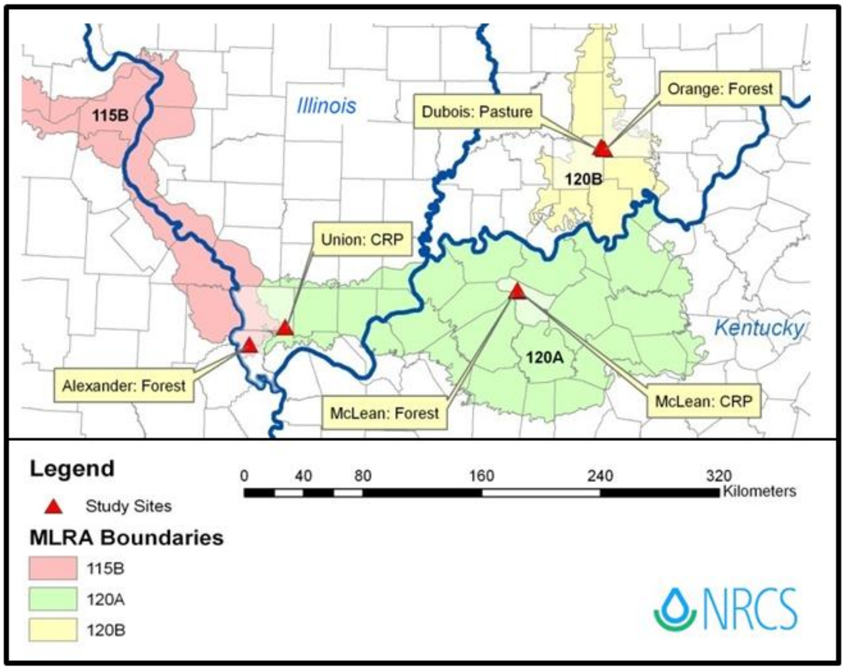

Figure 1. Map of Research Sites.

Yellow boxes point to each study site and indicate county name and current land use. CRP refers to land set aside from cultivation through enrollment in Conservation Reserve Program administered by USDA-NRCS. Modified from map by Bathgate (2011).

precipitation in this MLRA is 1145-1370 mm, and the annual average temperature is 13-14 degrees C. The Illinois forested site is in MLRA 115A, Central Mississippi Valley Wooded Slopes, Eastern Part; the average annual precipitation in this MLRA is 965-1220 mm, and the annual average temperature is 12-14 degrees C. Both Indiana sites are in MLRA 120B, Kentucky and Indiana Sandstone and Shale Hills and Valleys, Northwestern Part; the average annual precipitation in this MLRA is 1090-1220 mm, and the annual average temperature is 11-13 degrees C (USDA-NRCS, 2006). Table 1 summarizes the MLRA and climate data.

The parent material at all six sites is loess derived from the Wisconsinan glaciation. The sites represent a loess-thinning sequence, with Illinois sites ranging from 3.0-5.0 m of loess, Kentucky sites from 2.0-3.0 m, and Indiana sites from 1.5-2.0 m. The stratigraphy of materials present at the sites is as follows: loess over karst for the Illinois grass site; loess over cherty limestone for the Illinois forest site; loess over sandstone residuum for both Kentucky sites; and loess over loamy residuum, over shale and sandstone for both Indiana sites. Table 2 summarizes the parent material stratigraphy. The object of the study design is to allow for manipulation of a single state factor in soil formation while holding the others constant. Given that climate and time of soil formation are similar across sites, four of the five soil-forming factors defined by Jenny (1941) are relatively constant during individual analyses. When comparing similar land covers between states, the depth of parent material is meant to be the variable. When comparing sites within a pair, vegetation is meant to be the variable. When comparing sample points within a site, topography is meant to be the variable.

USDA-NRCS staff and cooperators conducted field investigation and GIS analysis of the study areas to delineate landforms. Hillslopes were divided into summit, shoulder, backslope, footslope, and toeslope positions as described by Schoeneberger et al. (2002), adapted from Ruhe

Table 1. Land covers, Major Land Resource Areas, and Climate of study sites.

State	MLRA	Land Cover	Average Annual Precipitation		Average Annual Temperature	
			inches	millimeters	° F	° C
Illinois	120A	Cultivated	45-54	1145-1370	55-58	13-14
Illinois	115B	Forested	38-48	965-1220	53-57	12-14
Kentucky	120A	Cultivated	45-54	1145-1370	55-58	13-14
Kentucky	120A	Forested	45-54	1145-1370	55-58	13-14
Indiana	120B	Cultivated	43-48	1090-1220	53-56	11-13
Indiana	120B	Forested	43-48	1090-1220	53-56	11-13

Table 2. Stratigraphy of Parent Material and Bedrock of Illinois, Kentucky, and Indiana sites.

State	County	Land Cover	Loess Thickness	Stratigraphy of Parent Material and Bedrock
Illinois	Union	Grass	3.0 - 5.0 m	Loess over karst
Illinois	Alexander	Forest	4.0 - 5.0 m	Loess over cherty limestone
Kentucky	McLean	Grass	2.0 - 3.0 m	Loess over residuum from sandstone
Kentucky	McLean	Forest	2.0 - 3.0 m	Loess over residuum from sandstone
Indiana	Orange	Grass	1.5 - 2.0 m	Loess over loamy residuum over shale and sandstone
Indiana	Dubois	Forest	1.5 - 2.0 m	Loess over loamy residuum over shale and sandstone

and Walker (1968). Figures 2, 3, and 4 illustrate hillslope landform concepts. Pits were excavated at points along slope transects at each site (see Figure 4) by regional NRCS personnel and university cooperators. Soil pits were dug to 2 meters depth or to bedrock. A total of 40 pits were dug across the 6 sites: 2 transects totaling 9 pits were dug at the Illinois grassland site; 2 transects totaling 8 pits at the Illinois forest site; 2 transects totaling 8 pits at the Indiana grassland site; 1 transect was dug at each of the Indiana forest, Kentucky grassland, and Kentucky forest sites (5 pits per site). The soil pits were sampled at both Illinois sites in 2005, the Indiana grassland site in 2006, the Indiana forest site in 2009, the Kentucky grassland site in 2010, and the Kentucky forest site in 2011. Different crews of NRCS soil survey staff performed the soil sampling and profile description, but all followed the methods described in Soil Survey Division Staff (2004).

A first-order soil survey was performed at each site by NRCS soil scientists. The Illinois grass site had Alford, Hosmer, Homen, Bunkum, Wilbur, and Wilbur taxadjunct soils present. The Illinois forest site had Menfro, Winfield, Hosmer, Hosmer taxadjunct, and Drury taxadjunct. The Kentucky grass site had Alford, Hosmer, and Zanesville. The Kentucky forest site had Alford, Wellston, Lenberg, and Stendal. The Indiana grass site had Apalona, Deuchars, Wellston, and Gilpin. The Indiana forest site had Zanesville, Deuchars, Wellston, and Ebal. Table 3 gives the taxonomic classifications and landscape positions for the soils identified during first-order surveys.

Samples taken from the soil pits were sent to the Kellogg Soil Survey Laboratory in Lincoln, Nebraska for analysis. The following methods were used for data referenced in this study: for soil texture, method 3A1a1a, air-dry pipet analysis with standard pretreatments and dispersion; for bulk-density, method 3B1c, oven-dry saran-coated natural clods; for pH, method

Position	Code
summit	SU
shoulder	SH
backslope	BS
footslope	FS
toeslope	TS

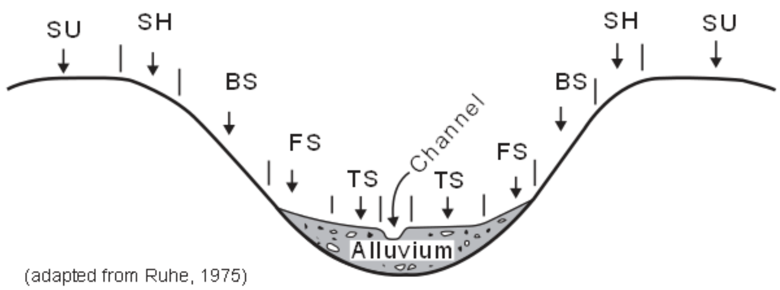

Figure 2. Diagram of hillslope profile positions

Taken from Schoeneberger et al. (2002).

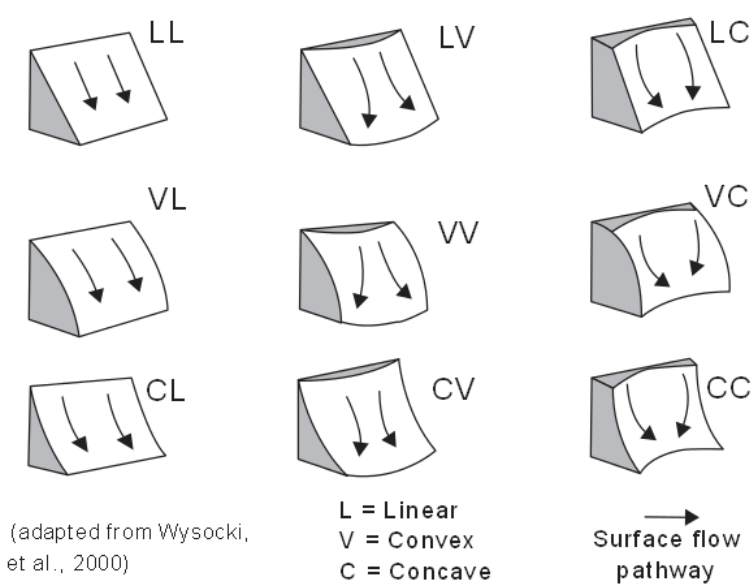

Figure 3. Diagram of up slope and across slope shapes.

Taken from Schoeneberger et al. (2002).

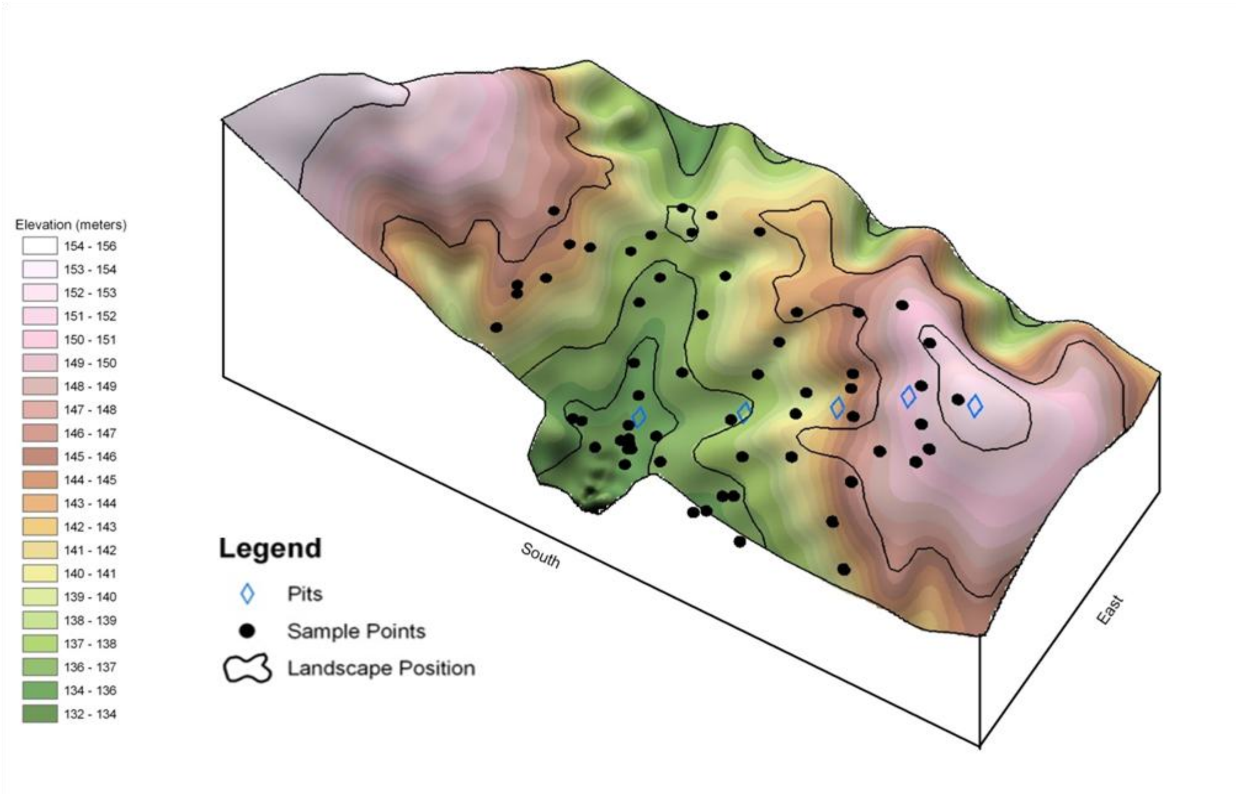

Figure 4. Example layout of soil pit transects and surface core samples.

3-dimensional model of the Kentucky grass cover site. The soil pits form a transect of the hillslope profile, from summit to toeslope. Sample points represent locations of surface core samples, which will be utilized in a later study. Modified from model by Jon Bathgate, USDA-NRCS Geographic Information Systems Specialist.

Table 3. Taxonomic classification of soils found in first-order survey of research sites.

Sites	Slope Position	Series	Particle Size	Activity	Subgroup
IL, KY	SU	Alford	Fine-silty	Superactive	Ultic Hapludalfs
IL	SU	Menfro	Fine-silty	Superactive	Typic Hapludalfs
IN	SU, SH, BS	Apalona	Fine-silty	Active	Oxyaquic Fragiudalfs
KY, IN	SU, BS	Zanesville	Fine-silty	Active	Oxyaquic Fragiudalfs
IL	SH	Winfield	Fine-silty	Superactive	Oxyaquic Hapludalfs
IL, KY	SH, BS	Hosmer	Fine-silty	Active	Oxyaquic Fragiudalfs
IN	SH, BS	Deuchars	Fine-silty	Active	Oxyaquic Hapludalfs
KY, IN	SH, BS, FT, TO	Wellston	Fine-silty	Active	Ultic Hapludalfs
IL	BS	Homen	Fine-silty	Superactive	Oxyaquic Hapludalfs
IL	BS	Bunkum	Fine-silty	Superactive	Aquic Hapludalfs
KY	BS	Lenberg	Fine	Semiactive	Ultic Hapludalfs
IN	BS	Ebal	Fine	Active	Oxyaquic Hapludalfs
IL	FT	Drury taxadjunct	Fine-silty	Superactive	Dystric Eutrudepts
IL	FT, TO	Wilbur taxadjunct	Coarse-silty	Superactive	Fluvaquentic Eutrudepts
KY	TO	Stendal	Fine-silty	Active	Fluventic Endoaquepts
IN	TO	Gilpin	Fine-loamy	Active	Typic Hapludults

USDA soil taxonomic classification from NRCS Official Series Descriptions (Soil Survey Staff, 2013). For all soils, the Mineralology class was Mixed and the Temperature class was Mesic. SU = summit, SH = shoulder, BS = backslope, FT = footslope, TO = toeslope.

4C1a2a2, 1:2 air-dry soil 0.01 M $CaCl_2$ via combination pH-reference electrode; for calcium carbonates, method 4E1a1a1a1, < 2mm fraction air-dry soil with 3 N HCl treatment; for total carbon, nitrogen, and sulfur, method 4H2a1-3, thermal conductivity detection of dry combusted air-dry soil. All laboratory methods listed above reference Soil Survey Division Staff (2004) and were performed by Kellogg Soil Survey Laboratory personnel.

The carbon data from the dry combustion analysis was given in % total carbon present in the < 2mm fraction of air-dry soil. This includes both inorganic ($CaCO_3$) and organic forms of carbon. Soil organic carbon (SOC) represents the organic matter present in the soil, including humus, whereas the inorganic carbon is related to soil pH. Since this study was interested in levels of organic matter in the soil, the % $CaCO_3$ in the < 2mm fraction must be subtracted from this total carbon to obtain the % organic carbon for each sample. Instead of using a percentage, which is unitless, the % organic carbon was then multiplied by the bulk-density to give the SOC density. SOC density is presented in units of kg m^{-3} throughout this study. When horizons lacked either bulk-density or SOC (mostly O horizons, some A horizons, and some deep subsoil horizons), SOC density values could not be calculated.

Soil pits were sampled by genetic horizon, so that sampling depths were not uniform. To test for statistically significant differences in the levels of SOC density between topographic position and land cover, standard sampling intervals were necessary. Spline Tool 2.0 allows the conversion of genetic horizon data to standard interval data. It does so by fitting a spline to the horizon values, so that values between sample points can be estimated (Jacquier and Seaton, 2013). SOC values for 0-5, 5-15, 15-30, 30-60, 60-100, and 100-200 cm depth intervals were generated for all soil pits using Spline Tool 2.0. Figure 5 is the graphical output from a spline fit. Values were also generated at 1 cm intervals, so that area under the curve could be calculated as

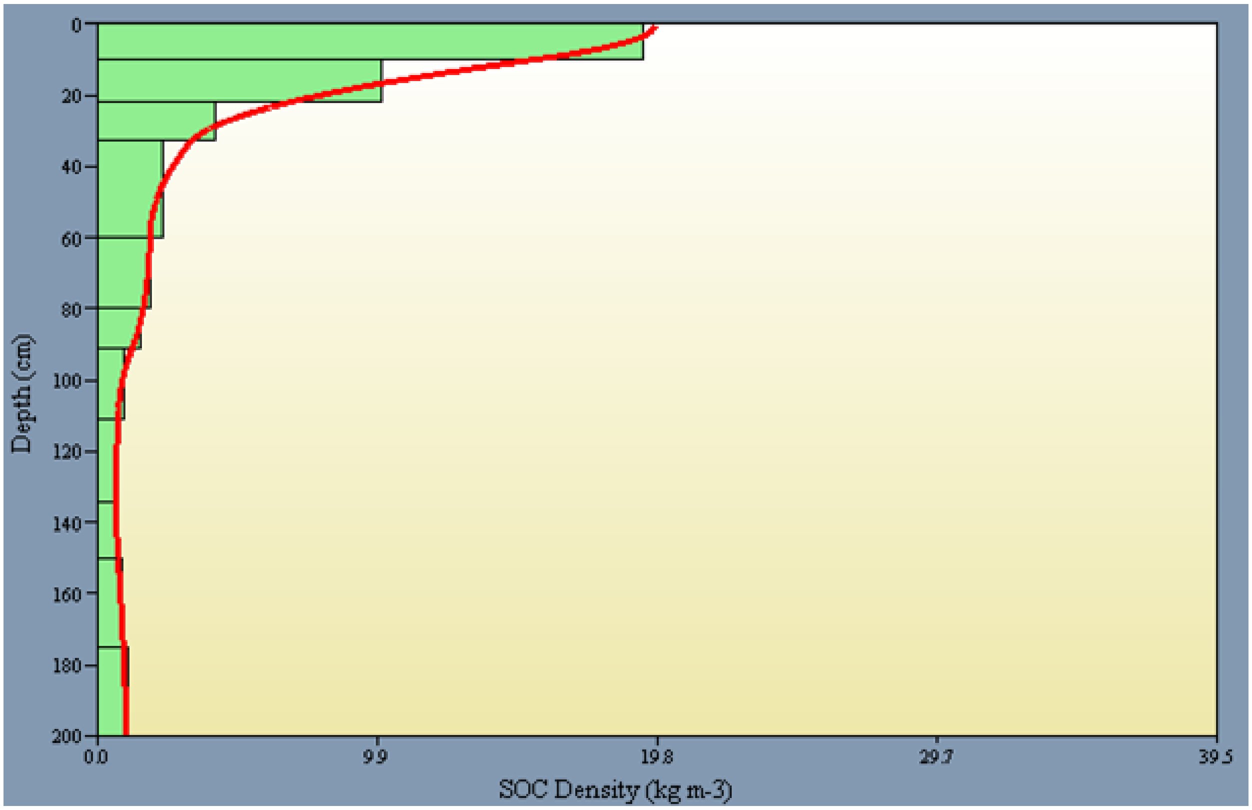

Figure 5. Example of a spline fit to genetic horizon data from a soil pit.

Green bars represent genetic horizon values. Red line indicates 1 cm interval values calculated by spline fit.

an estimate of the carbon pool represented by each pedon. Values were exported to a spreadsheet and organized for statistical analysis.

Statistical analysis was performed using JMP, version 10 (1989-2013). Distribution, descriptive statistics, and graphs were generated using the Analyze Distribution function. SOC density per pedon, total depth of sample pedon, mean horizon size, number of horizons per soil pit, and SOC density by standard depth interval were analyzed for distribution patterns that might affect SOC comparisons. The center depth of each horizon or subsample was used when analyzing total depth of sample pedon; the center depth of each sampled horizon or horizon subsample was used when analyzing mean horizon size and number of horizons. Most O horizons were excluded from these analyses since they lacked bulk-density data. SOC density and natural log transformed SOC density were analyzed for normality.

Comparisons were executed with the Analyze, Fit Y by X function. Comparisons between land covers and between topographic positions were run for SOC density per pedon, total depth of sample pedon, mean horizon depth, mean horizon size, number of horizons per soil pit, and SOC density by standard depth interval. When data was normally distributed, student's t-tests or Tukey-Kramer HSD were performed; when data was non-normal, Wilcoxon Rank Sum tests were used. The Wilcoxon Rank Sum test ranks all data together from smallest to largest values, and then compares mean rank value between sampling groups.

Model fitting of the relationship between SOC density and the soil depth of horizon initiation was performed on the genetic horizon data using the Analyze Modeling, Nonlinear function. Linear, quadratic, cubic, 2-part exponential, and 3-part exponential models were compared. Bi-exponential 4-part, bi-exponential 5-part, and 3-part exponential models were then compared. SOC density data were divided by land cover class and fitted to models separately.

Equations were generated for the best fitting models. The 3-part exponential equation contains parameters for asymptote, the value that is approached as decay occurs, scale, which is the starting value, and decay rate.

Carbon pools were estimated using two different approaches. In the simpler approach, the mean SOC density was put into an equation modified from Smith (2001): SOC density (g cm^{-3}) x Sample Depth x 100 = SOC pool (t ha^{-1}). This equation multiplies SOC density across sampling depths uniformly, and was used to calculate carbon pools for combined data and for data grouped by depth interval, land cover, or slope position. SOC density was calculated in kg m^{-3} throughout statistical analysis, so values had to be divided by 1000 before being input to the above equation as g cm^{-3}. A second approach used the equations from the best-fitting models of SOC vs. depth to calculate carbon pools. This calculation adjusts the SOC density continuously with depth. For each group of data, the estimated parameters were input to the best-fit model equation and then integrated to find the area under the curve. The minimum value used for the integration was 0 cm, and the maximum was 200 cm. Converting from kg m^{-3} to g cm^{-3}, and multiplying by 100 to get t ha^{-1}, requires that the output from integration be divided by 10.

RESULTS

The selected physical and chemical properties of all of the sampled soil pits are summarized in the Appendix. Of the 336 horizon samples, one half had horizon centers in the 0-70 cm range and the other half from 70-200 cm. Only 25% of samples represent the 120-200 cm range. Distribution of non-transformed SOC data was non-normal. Combined data ranged from 0.500 to 64.2 kg m^{-3}, with the center 50% of values between 0 and 2.80 kg m^{-3}. Twenty-five percent of values were greater than 7.20 kg m^{-3}. The mean SOC density was 6.90 kg m^{-3}, and the median was 2.80 kg m^{-3}. When the SOC density data was natural log transformed, referred to herein as ln(SOC) data, the mean became 3.53 kg m^{-3} and the median 2.80 kg m^{-3} (when values were back-transformed). Distribution of ln(SOC) did not pass the Shapiro-Wilk goodness-of-fit test for normality, but did come closer to being normal, as indicated by the smaller distance between mean and median. There was a long tail of high SOC density values, with the bulk of the distribution centered over low values.

When data was divided into standard depth intervals, ln(SOC) was found to decrease with increasing depth. When back-transformed, the median values for the non-normal distributions at 0-5, 5-15, 15-30, 30-60, 60-100, and 100-200 cm intervals were 25.7 kg m^{-3}, 21.9 kg m^{-3}, 9.68 kg m^{-3}, 3.58 kg m^{-3} , 2.24 kg m^{-3}, and 1.46 kg m^{-3} respectively. The variation increased with depth after the 15-30 cm interval; CV's, from shallowest to deepest interval, were 13, 12, 14, 36, 61, and 101.

Distributions of ln(SOC density) grouped by land cover were non-normal; both the grass and forest cover distributions were skewed towards high values, and had the greater mass of their data centered over low values. Forest sites had a smaller sample size, but lower variation (Table

4). Distributions on a per site basis were non-normal. Across all sites, median and mean SOC were higher under forest than grass (Table 5). Indiana sites had the highest mean SOC for both forest and grass covered sites, 5.78 kg m^{-3} and 3.87 kg m^{-3} respectively. Illinois sites had the lowest mean SOC levels, 3.80 kg m^{-3} under forest and 2.68 kg m^{-3} under grass cover, while Kentucky sites were intermediate at 4.80 kg m^{-3} under forest and 3.05 kg m^{-3} under grass.

Wilcoxon Rank Sum tests were used to compare SOC densities between land covers. Overall, grass sites had significantly lower SOC density than forest sites (p=0.0029). Median SOC was 78% higher under forest than grass, 4.15 kg m^{-3} vs. 2.33 kg m^{-3}. Mean SOC was 46% higher under forest, 4.47 kg m^{-3} vs. 3.06 kg m^{-3}. Kentucky sites had significantly higher SOC density under forest than under grass ($p = 0.0327$), as did the Indiana sites ($p = 0.0422$). There was no significant difference in SOC level between the Illinois sites. Table 6 summarizes the land cover comparisons. Differences in SOC densities between grass and forest cover at 0-5, 5-15, 15-30, 30-60, 60-100, and 100-200 cm intervals were all non-significant, although mean and median values were higher under forest at all intervals (see Table 7).

The ln(SOC) by slope position was distributed non-normally at summit, shoulder, and backslope positions, but normally distributed at the footslope and toeslope positions. Both median and mean SOC densities were highest at the footslopes, followed by the toeslopes, backslopes, shoulders, then summits. Variation was lowest at the footslope and toeslope (Table 8). According to Wilcoxon Rank Sum tests, SOC density was significantly higher at the footslopes than at the summits ($p = 0.0002$), shoulders ($p = 0.0009$), and backslopes ($p = 0.0039$). SOC density was also significantly higher at the toeslopes than at the summits ($p = 0.0014$), shoulders ($p = 0.0070$), and backslopes ($p = 0.0203$). Differences between footslopes and toeslopes were not significant, nor were differences among summit, shoulder, and backslope

Table 4. SOC density statistics of grass sites and forest sites†.

Statistic	Grass Cover	Forest Cover
	---------------------- kg m^{-3} ----------------------	
Maximum	51.3	64.2
75% Quartile	6.00	10.9
Median	2.33	4.15
25% Quartile	1.43	1.67
Minimum	0.600	0.500
Mean	3.06	4.47
Std Dev	2.83	3.09
CV	93	75
n	208	128

†Values were back-transformed from ln(SOC) data.

Table 5. SOC density statistics of each study site†.

Statistic	IL Grass	IL Forest	KY Grass	KY Forest	IN Grass	IN Forest
	---------------------------------- kg m^{-3} ----------------------------------					
Maximum	34.6	52.0	25.3	64.2	51.3	40.3
75% Quartile	5.87	10.9	6.00	9.45	5.79	15.0
Median	1.93	2.81	2.44	4.56	2.72	4.32
25% Quartile	1.22	1.37	1.47	1.93	1.60	2.87
Minimum	0.600	0.459	1.07	1.14	0.880	1.04
Mean	2.68	3.80	3.02	4.80	3.87	5.78
Std Dev	2.86	3.39	2.48	2.69	3.02	2.88
CV	107	91	82	63	82	60
n	100	63	51	35	57	30

†Values were back-transformed from ln(SOC) data.

Table 6. Comparison of SOC density between grass and forest covers.

Factor 1		Factor 2	Score Mean Difference	Std Err Diff	Z	p-value
Grass	<	Forest	32.5	10.9	2.98	0.0029*
KY Grass	<	KY Forest	11.7	5.48	2.13	0.0327*
IN Grass	<	IN Forest	11.6	5.70	2.03	0.0422*
IL Grass	<	IL Forest	12.6	7.59	1.66	0.0977

*Significant at α = 0.05.

Table 7. SOC density statistics at standard depth intervals of grass sites and forest sites†.

	0-5 cm	5-15 cm	15-30 cm	30-60 cm	60-100 cm	100-200 cm
	kg m^{-3}					
Mean _Grass	25.0	19.7	9.03	3.39	2.14	1.45
Mean_Forest	30.0	24.3	10.7	4.22	2.58	1.62
% Difference	20	23	18	24	21	12

†Values were back-transformed from ln(SOC). Median values given for 100-200 cm.

Table 8. SOC density at hillslope profile positions†.

Statistic	Summits	Shoulders	Backslopes	Footslopes	Toeslopes
	kg m^{-3}				
Maximum	52.0	50.0	47.8	64.2	51.3
75% Quartile	4.78	5.11	7.08	9.71	10.7
Median	2.16	2.21	2.50	5.25	4.23
25% Quartile	1.25	1.30	1.48	2.41	2.34
Minimum	0.600	0.616	0.459	0.790	1.24
Mean	2.86	3.01	3.37	5.26	5.22
Std Dev	2.90	3.22	3.05	2.47	2.86
CV	101	101	92	54	64
n	80	74	98	47	37

†Values were back-transformed from ln(SOC).

positions. Table 9 summarizes the results of comparisons between slope positions. Sampling characteristic data were distributed non-normally. Wilcoxon Rank Sum tests indicated no significant differences in mean horizon size, number of horizons per pit, and pedon depths between slope positions.

Median SOC densities for each slope position by standard depth interval are summarized in Table 10. SOC densities were highest at toeslopes and shoulders in 0-5, 5-15, and 15-30 cm intervals. Footslopes had the highest median SOC densities at 30-60, 60-100, and 100-200 cm. No significant differences in SOC were determined among slope positions at the 0-5, 5-15, and 15-30 cm intervals. Comparisons at the 30-60 cm interval, using Tukey's HSD test, indicated that footslopes had significantly higher SOC density than shoulders ($p = 0.0003$), backslopes ($p = 0.0002$), and summits ($p = 0.0078$); also, at this interval, toeslopes had significantly higher SOC than shoulders ($p = 0.0228$) and backslopes ($p = 0.0186$). Likewise, at the 60-100 cm interval, SOC density at footslopes was significantly higher than at shoulders ($p < 0.0001$), backslopes ($p < 0.0001$), and summits ($p < 0.0001$); and, SOC at toeslopes was significantly higher than at shoulders ($p = 0.0232$) and backslopes ($p = 0.0242$). Distribution of the 100-200 cm data was non-normal, prompting the use of Wilcoxon Rank Sum tests. At this interval, SOC density was significantly higher at toeslopes than at summits ($p = 0.0233$), and at footslopes compared to summits ($p = 0.0164$).

When data were divided between grass and forest sites, proportional differences in SOC at standard depth intervals were evident. SOC density patterns shifted in depth and degree (Figures 6 and 7). Under grass cover, there was a steep shift in proportion of SOC density from upper slope positions (SU, SH, BS) to lower slope positions (FT and TO) between the 15-30 and the 30-60 cm intervals. The shoulder and backslope positions decreased in SOC while the

Table 9. Comparisons of SOC density between hillslope profile positions.

Position 1		Position 2	Score Mean Difference	Std Err Diff	Z	p-value
Footslopes	>	Summits	25.5	6.76	3.76	0.0002*
Footslopes	>	Shoulders	21.8	6.54	3.33	0.0009*
Footslopes	>	Backslopes	21.5	7.45	2.88	0.0039*
Toeslopes	>	Summits	21.5	6.74	3.19	0.0014*
Toeslopes	>	Shoulders	17.5	7.55	2.70	0.0070*
Toeslopes	>	Backslopes	17.5	6.48	2.32	0.0203*
Summits		Backslopes	8.40	7.76	1.08	0.2793
Shoulders		Backslopes	5.11	7.67	0.666	0.5051
Summits		Shoulders	2.02	7.19	0.280	0.7793
Toeslopes		Footslopes	2.25	5.36	0.419	0.6752

*Significant at $\alpha = 0.05$.

Table 10. Median SOC densities between hillslope profile positions at standard depth intervals.†

	0-5 cm	5-15 cm	15-30 cm	30-60 cm	60-100 cm	100-200 cm
Summits	25.0	22.2	9.78	3.63	2.12	1.17
Shoulders	29.7	25.5	9.97	2.83	1.67	1.38
Backslopes	25.8	21.6	8.94	2.83	1.71	1.45
Footslopes	19.5	17.3	10.5	7.61	5.47	1.99
Toeslopes	31.5	25.8	12.1	6.11	3.22	1.95

†Values in units of kg m^{-3}.

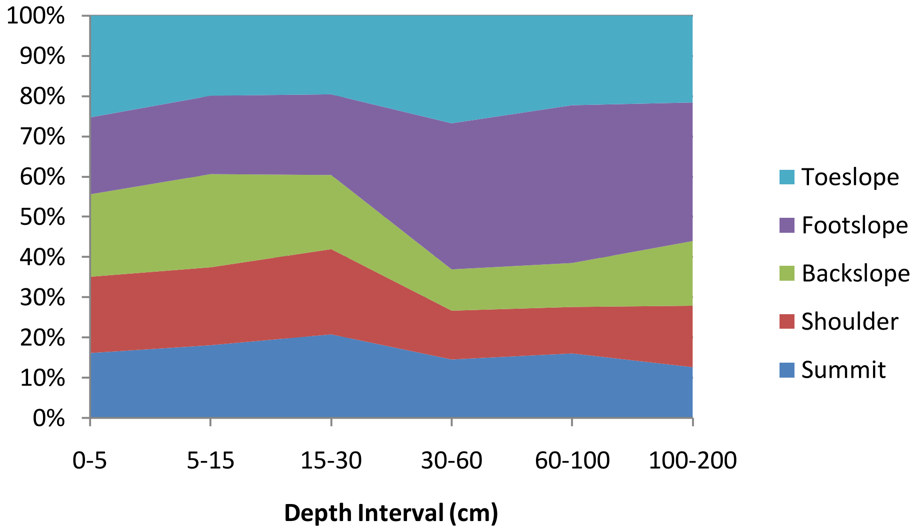

Figure 6. Proportional chart of SOC density by depth interval per hillslope position, grass cover.

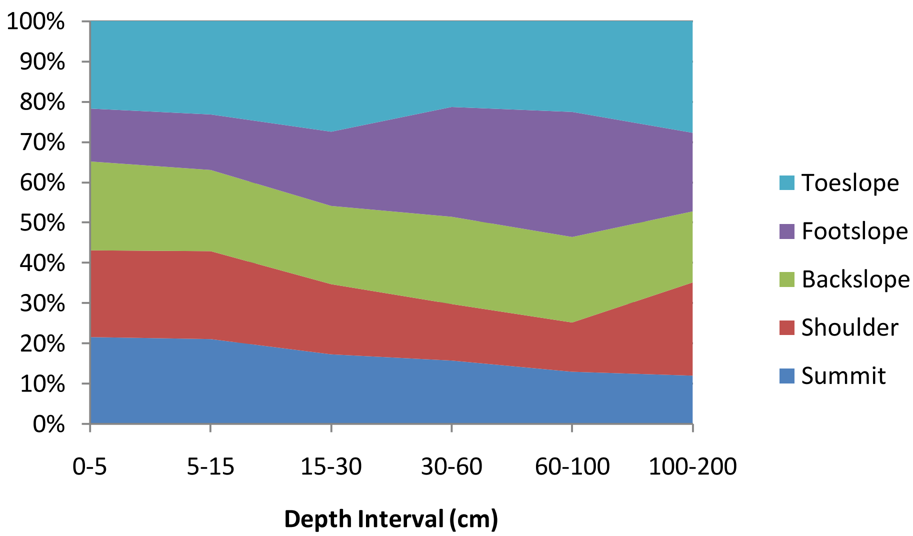

Figure 7. Proportional chart of SOC density by depth interval per hillslope position, forest cover.

footslopes and toeslopes increased. In contrast, a more gradual shift is seen under forest cover. This shift occurred between the 5-15 and 15-30 cm intervals, and continued down to the 60-100 cm interval. Mainly, SOC at shoulders decreased while the SOC at footslopes increased. The trend reversed from 60-100 to 100-200 cm.

Results of polynomial and exponential model fitting to the relationship of SOC density vs. depth indicated that exponential models fit the data better than polynomial models. For combined SOC density data, the 3-part exponential, 2-part exponential, and cubic models had r-squares of 0.81, 0.78, and 0.71 respectively. Quadratic and linear equations fit with r-squares of 0.59 and 0.36, respectively. The exponential models were also rated highest by the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC), which rank models according to goodness of fit with the least number of parameters. When several different exponential models were fit to SOC density vs. depth, they all had the same fit, r-square = 0.81, but different AIC and BIC rankings. AIC rated the 4-part bi-exponential model as best, whereas the BIC rated the 3-part exponential as best (Table 11). BIC penalizes model complexity more severely. The 3-part exponential model can be written as: a + b*exp(-c*depth), where a = asymptote, b = scale, and c = decay rate. The 4-part bi-exponential model can be written as: a*exp(-b*depth) + c*exp(-d*depth), where a = scale 1, b = decay rate 1, c = scale 2, and d = decay rate 2. Three-part exponential equations were used for remaining analyses, due to their high fit and more simple equations.

When data was divided by land cover class, the 3-part exponential model fit the SOC density by depth relationship at grass sites with an r-square of 0.85, and at forest sites with an r-square of 0.82. Estimates of the model parameters are given in Table 12. When data was grouped by hillslope position, 3-part exponential models fit with r-squares of 0.82, 0.83, 0.87,

Table 11. Fit ratings for exponential and bi-exponential models†.

Model	AIC	BIC	R-square
Biexponential, 4-part	1939	1958	0.81
Biexponential, 5-part	1941	1964	0.81
Exponential, 3-part	1942	1957	0.81

†A lower score is better for both AIC and BIC. AIC = 2k – 2*ln(L), where k is the number of parameters and L is the max value of the likelihood function for the model. BIC = -2*ln(L) + k*ln(n), where k and L are the same as in AIC, and n = sample size.

Table 12. Model parameter estimates for SOC density vs. depth by land cover†.

Parameter	Estimate		Lower 95%		Upper 95%	
	Grass	Forest	Grass	Forest	Grass	Forest
Asymptote	2.11	2.67	1.58	1.52	2.64	3.82
Scale	41.2	55.9	37.2	47.9	45.2	63.9
Decay Rate	0.0897	0.0913	0.102	0.110	0.0772	0.0731

†Units are kg m^{-3} for asymptote and scale, and kg m^{-3} per cm depth for decay rate.

0.64, and 0.89 for summit, shoulder, backslope, footslope, and toeslope positions respectively (Table 13). When grouped by both slope position and land cover, the models had higher asymptotes under forest covered sites at the summit, shoulder, and backslope positions, but lower at the footslope and toeslope positions (Table 14). Decay rates were higher under forest cover at summit and shoulder positions, but higher under grass cover at backslope, footslope, and toeslope positions. Scale was higher under forest covered sites at all positions other than toeslopes.

Estimates of SOC Pools

Multiplying median SOC density (g cm^{-3}) of combined data by average depth of 173 cm and then multiplying by 100, SOC was estimated at 48 t ha^{-1} overall. Using this method, total carbon pools were estimated at 41 t ha^{-1} at grass sites with average depth of 178 cm and 69 t ha^{-1} at forest sites with average depth of 167 cm. When grouped by slope position, the estimates were 38, 37, 41, 105, and 67 t ha^{-1} for summits, shoulders, backslopes, footslopes, and toeslopes, respectively, with average depths of 178, 168, 165, 200, and 158 cm. When data were grouped by state, estimates were 45 t ha^{-1} for Illinois, 48 t ha^{-1} for Kentucky, and 46 t ha^{-1} for Indiana, with average depths of 200, 173, and 138 cm.

Using similar calculations, carbon pools were calculated for depth intervals of 0-5, 5-15, 15-30, 30-60, 60-100, and 100-200 cm using median SOC densities. The carbon pools were 12.9, 21.9, 14.5, 10.7, 8.96, and 14.6 t ha^{-1} from the 0-5, 5-15, 15-30, 30-60, 60-100, and 100-200 cm depth, respectively. The total carbon pool estimate to 2 m depth was 84 t ha^{-1}. When calculated using median SOC densities at standard depth intervals, total carbon pools were estimated at 79 t ha^{-1} under grass and 95 t ha^{-1} under forest (Table 15). When slope position data was divided into standard depth intervals, the total SOC pools (t ha^{-1}) were 81 at summits, 84 at

Table 13. Model parameter estimates for SOC density vs. depth by hillslope position†.

Parameter	Summit	Shoulder	Backslope	Footslope	Toeslope
Asymptote	1.64	1.68	1.70	4.51	3.26
Scale	45.96	45.1	44.1	54.6	49.2
Decay Rate	0.0823	0.0873	0.0833	0.111	0.0824

†Units are kg m^{-3} for asymptote and scale and kg m^{-3} per cm depth for decay rate.

Table 14. Model parameter estimates for SOC density vs. depth by slope position and land cover†.

Parameter	Summit		Shoulder		Backslope		Footslope		Toeslope	
	Grass	For	Grass	For	Grass	For	Grass	For	Grass	For
Asymptote	1.31	1.85	1.41	2.26	1.55	2.15	4.95	4.57	3.31	3.21
Scale	31.0	61.5	34.0	64.6	43.1	46.1	58.6	81.7	55.3	47.6
Decay Rate	5.86×10^{-2}	10.1×10^{-2}	7.59×10^{-2}	10.7×10^{-2}	9.16×10^{-2}	7.58×10^{-2}	18.0×10^{-2}	13.5×10^{-2}	11.5×10^{-2}	6.04×10^{-2}

†Units are kg m^{-3} for asymptote and scale, and kg m^{-3} per cm depth for decay rate.

Table 15. SOC pools per depth interval under grass and forest covers†.

	0-5 cm	5-15 cm	15-30 cm	30-60 cm	60-100 cm	100-200 cm	TOTAL
Grass	12.5	19.7	13.5	10.2	8.56	14.5	79.0
Forest	15.0	24.3	16.1	12.7	10.3	16.2	94.6

†Units are t ha^{-1}.

shoulders, 78 at backslopes, 110 at footslopes, and 110 at toeslopes (Table 16).

In a second approach, SOC pools were calculated using parameter estimates for the 3-part exponential model. The estimate for combined data was 98.6 t ha^{-1}, 95% Confidence Intervals (77.0, 123). SOC pools by land cover were estimated using parameter estimates from Table 13. Estimates were 88 t ha^{-1} at grass sites, 95% CI (68.1, 111), and 120 t ha^{-1} at forest sites, 95% CI (73.9, 164). SOC pools by hillslope position were calculated using the parameter estimates summarized in Table 14. Estimates were as follows: for summits 88.7 t ha^{-1}, 95% CI (47.2, 144), for shoulders 85.2 t ha^{-1}, 95% CI (45.9 ,135), for backslopes 87.0 t ha^{-1}, 95% CI (54.4, 126), for footslopes 139 t ha^{-1}, 95% CI (65.6, 281), and for toeslopes 125 t ha^{-1}, 95% CI (70.1, 197).

When upslope positions (summit, shoulder, backslope) were grouped together, SOC was estimated at 86.9 t ha^{-1}, 95% CI (64.7, 112). When downslope positions (footslope, toeslope) were grouped, the estimate was 133 t ha^{-1}, 95% CI (84.7, 198). When further grouped into land cover category, SOC estimates were 77.2 t ha^{-1}, 95% CI (56.4, 101) for upslope grass, 123 t ha^{-1}, 95% CI (83.3, 176) for downslope grass, 102 t ha^{-1}, 95% CI (62.2, 150) for upslope forest, and 145 t ha^{-1}, 95% CI (54.1, 301) for downslope forest.

Table 16. SOC pools per depth interval grouped by slope position†.

	0-5 cm	5-15 cm	15-30 cm	30-60 cm	60-100 cm	100-200 cm	TOTAL
Summit	12.5	22.2	14.7	10.9	8.48	11.7	80.5
Shoulder	14.9	25.5	15.0	8.49	6.68	13.8	84.4
Backslope	12.9	21.6	13.4	8.49	6.84	14.5	77.7
Footslope	9.75	17.3	15.8	22.8	21.9	19.9	108
Toeslope	15.8	25.8	18.2	18.3	12.9	19.5	111

†Units are t ha^{-1}.

DISCUSSION

As with Kern (1994), Guo et al. (2006), Syswerda et al. (2011), Corre et al. (1999), and others, this study found that SOC density decreased with depth from the surface. The variation of SOC content tended to increase with increasing depth. Kern (1994) attributed the higher variability of SOC content below 30 cm depth to fewer samples having been taken at greater depths. In this study, distribution data indicated that only 25% of horizon samples came from the 120-200 cm range, even though that range accounts for 40% of the total sampling depth. The smaller number of subsoil samples may be related to shallow soil formation due to the presence of parent material or bedrock before 200 cm. It could also be due to a larger average size of subsoil horizons, due to a decrease in differentiating factors.

Mean SOC densities were significantly higher at the forest sites than the grass sites, even with O horizons excluded from analysis. This could be due to a difference in organic matter inputs between forest and grass vegetations. These inputs consist of above-ground inputs and below-ground inputs. Jenny (1941), in an analysis of studies in Europe and North America, stated that temperate zone forests produced more above-ground organic matter than prairies when the wood and leaf production were combined; he estimated that tree leaf inputs alone were equal to residue production in tall-grass prairies. Based on an analysis of existing data, Jackson et al. (1996) found that temperate grasslands had 83% of their root biomass within the top 30 cm of soil, a root to shoot ratio of 3.7, and root biomass of 1.4 kg m^{-2}. Temperate deciduous forests had 65% of root biomass in the top 30 cm, a root to shoot ratio of 0.23, and root biomass of 4.2 kg m^{-2}. It seems likely that the vegetative inputs were higher both above and below ground at the forest sites of this study.

There was also a difference in the chemical nature of the vegetative inputs. Melillo et al. (1981) measured lignin contents ranging from about 10-25% in leaves from deciduous tree species, whereas Sullivan (1955) recorded ranges of around 6-8% for common forage grasses. Swift et al. (1979) reports lignin contents of 21-30% in oak leaves, 14% in a grass leaf, 11% in a grass stem, and 17-26% in wood. Plant material at the grass sites would likely have been of lower lignin content than that at forest sites. Higher lignin content is negatively correlated with rate of decomposition (Melillo et al., 1982). The organic matter inputs at the grass sites may have decomposed more readily over the years, whereas the more resistant inputs at the forest sites may have accumulated.

The lower SOC content at the grass versus the forest sites may also be due to a difference in the length of time the soils were under cultivation. In an analysis of non-cultivated soils, Jobbagy and Jackson (2000) found that temperate forest soils had average SOC contents of 17.4 kg m^{-2} to 1 m depth, versus 11.7 kg m^{-2} under temperate grassland cover; the values from 1-2 m depth were 3.3 kg m^{-2} under forest and 4.2 kg m^{-2} under grass. In comparison, this study's analysis of SOC by standard depth interval indicates values of 7.83 kg m^{-2} to 1 m depth under forest and 6.45 kg m^{-2} under grass; from 1-2 m depth, forest had 1.62 kg m^{-2} and grass 1.45 kg m^{-2}. SOC values may be lower than the those in Jobbagy and Jackson (2000), because both forest and grass sites were previously cultivated. If the grass sites were cultivated for a longer period of time, this may account for the lower SOC content. Olson et al. (2011, 2012), in studies on adjacent sites with similar slope profiles and similar soil series in northern Illinois, found that cropped land had 13-48% lower SOC densities than forested land after 150 years of mostly row-crop production. In an analysis of existing data, Mann (1985) found that cultivated loess-derived soils had an average of 40% less carbon in the top 15 cm than non-cultivated ones; specifically, cultivated Udalfs had 28% lower carbon levels than non-cultivated Udalfs. However, Davidson and Ackerman (1993), among others, have determined that most soil C loss following cultivation occurs within the first few years.

Although the initial losses from cultivation may have been equal, the SOC gains following establishment of permanent cover may have been higher at the forest sites. The forest sites were converted from cultivation to permanent cover at an earlier date than the grass sites were. This means they had a time advantage in accumulating SOC. Corre et al. (1999) found that SOC was higher under forest than C_3 grass when the forest was at least 60 years old, but lower when the forest was about 30 years old. Forest cover possibly allows for a higher equilibrium level of SOC, which means a longer period of time since cultivation may result in higher levels. As discussed above, the amount and nature of the organic matter inputs under forest also appear to favor greater SOC accumulation.

SOC densities were significantly higher at downslope positions (footslopes and toeslopes) than at upslope positions (summits, shoulders, and backslopes). These differences may be attributable to the effects of topography on moisture content, depth of soil formation, and erosion and deposition. First, topography affects how much water flows to the different positions on the landscape. Yeakley et al. (1998) found that upslope positions had lower soil moisture during both drought and recharge conditions. Soils at the footslope and toeslope positions receive water from upslope positions via both run-off and through-flow.

The balance between plant organic matter production, decomposition of organic materials, and humus formation at each slope position may have been influenced by relative moisture contents. Based on water inputs, plant growth may have been greater at downslope positions, which may have translated into higher inputs of fresh organic matter to the soil each year. Decomposition rates of organic matter were found to generally increase with higher soil moisture content (Sequaris et al., 2010), although aerobic decomposition would be suppressed during times of saturation (Swift et al., 1979). Aerobic decomposition is generally highest at a soil water potential near -50 kPa (slightly drier than field capacity, -33 kPa in loam and clay loam soils), with decreased activity at water contents wetter or drier than this water potential value (Voroney, 2007). Readily-decomposed organic matter may have been more quickly decomposed at lower slope positions if moisture levels were closer to ideal. However, the rates of humus formation at upslope versus downslope positions may be more important than the decomposition rates of fresh organic matter. The microbial communities at upslope and downslope positions may be different. Fungi are more tolerant of dry soil conditions than bacteria (Voroney, 2007), so they may be more prevalent at upslope positions. Although some bacteria and actinomycetes can degrade lignin, fungi are the most successful and efficient at lignin decomposition (Horwath, 2007). Partial, rather than complete, degradation of lignin at the downslope positions may have led to greater levels of humus formation.

Upslope soils at the study sites may have lower SOC than downslope soils because of the effect of topography on depth of soil formation. Malo et al. (1974) found that vertical translocation of organic matter is maximized at the summit. Depth to the zone of clay accumulation has been shown to decrease with increasing slope gradient on loess landscapes (Norton and Smith, 1930; Ruhe and Walker, 1968). Soils at the shoulder and backslope positions, where gradients are highest, should then have the lowest SOC densities deep in the profile, while summits, footslopes, and toeslopes should be higher. That is indeed the pattern seen in the SOC by standard depth interval data; median densities were lowest for shoulders and backslopes from 30-60 and 60-100 cm. Summits were slightly higher at those depths. Footslope and toeslope soils had the highest SOC densities at all intervals between 15-200 cm. Humus molecules may form organo-mineral complexes with clay particles (Stevenson, 1994). Since much of the SOC in the downslope positions is deep in the subsoil where clay content is high, this clay-SOC association may be protecting the organic matter from decomposition.

SOC differences between slope positions may also be caused by erosion and deposition. Soil erosion affects SOC content in two ways: by redistributing the surface soil, which is highest in C, and by degrading the soil's productivity at the erosional sites (Gregorich et al., 1998). Van den Bygaart (2001), using ^{137}Cs methodology, found that topsoil had been eroded from upslope positions, primarily from the shoulder, and deposited in downslope positions, mainly the footslope. Erosion that occurred prior to human disturbance likely would have followed this same pattern. Higher organic matter levels at footslope and toeslope positions lead to higher fertility, due to effects such as higher cation exchange capacity, increased water-holding capacity, lower bulk-density, and nutrient mineralization. The physical relocation of SOC from eroded positions to depositional positions, along with increased organic matter generation due to higher plant production, likely had a role in higher SOC contents found at the footslopes and toeslopes. Figure 6 indicates a proportional increase in SOC at the footslope and toeslope positions between the 15-30 cm and 30-60 cm intervals under grass cover; likewise, a similar increase is seen in Figure 7 between the 15-30 cm and 60-100 cm intervals under forest cover. These increases in SOC levels at the footslopes and toeslopes at the expense of the summits, shoulders, and backslopes may reflect a past erosion/deposition episode, such as may have occurred at the onset of cultivation at these sites.

Exponential decay models were the best fit for the relationship of SOC with depth from the surface. The 3-part exponential model with parameters for surface C value (scale), bottom pedon C value (asymptote), and decay rate, fit data best without being overly complicated. The r-square was 0.81. Bernoux et al. (1998) used a slightly more complicated exponential decay model in their study of SOC distribution with depth of Oxisols in the Brazilian Amazon. Hilinski (2001) also used an exponential decay equation for the updated CENTURY model used for estimated terrestrial carbon budgets. Equations for estimating C with depth allow for an estimation beyond the typical 1 or 2 m range, and also allows for calculation of C at any depth range (Bernoux et al., 1998). The exponential decay equations account for the sharp decrease seen in SOC concentration with increasing depth from the surface, which Bernoux et al. (1998) describe as a reflection of the rapid mineralization of labile C after incorporation.

When SOC density data were divided by land cover, model parameter estimates for asymptote, scale, and decay rate differed to varying degrees. The decay rates were fairly similar at 0.0897 for grass and 0.0913 for forest sites. The asymptote, the bottom value of SOC that the curve approaches with increasing depth, was higher under forest. The scale, or SOC value at the surface, was also higher under forest. The higher surface C values may reflect the influence of leaf litter, O horizons, on the A horizons of forest soils. The higher asymptote may also be due to the higher residence time of high-lignin material under forest cover. Similar exponential decay rates are possible since the grass and forest sites share very similar climates, parent materials, and topography.

When divided by hillslope position, estimates showed similar trends to those seen in earlier comparisons. The estimated decay rate parameters were similar at all positions, except for a greater rate at footslopes. Surface C values were similar for summits, shoulders, and backslopes at 45.95, 45.1, and 44.1, but higher at footslopes and toeslopes at 54.6 and 49.2. The asymptotes followed the same trend as the surface C values. The greater slope of the decay parameter at the footslope was higher than would be expected of simply starting at a higher surface value. Perhaps this rate reflects a wetter, more organic-carbon rich environment where decomposers thrive. Higher scales at the downslope positions may be due to deposited organic matter from upslope and higher plant inputs, while higher asymptotes at downslope positions may simply be due to higher inputs from the surface, and high water infiltration rates that leach organic materials down the profile.

When data were divided into combined classes of land cover by hillslope position, most results were the same as when models were fit individually. However, one new pattern did emerge. Decay rate parameters were higher under grass cover at backslopes, footslopes, and toeslopes, but higher under forest cover at summits and shoulders. The higher rates under forest at summits and shoulders may be due to higher surface SOC levels, which are double those found under grass. The higher rates under grass at footslopes and toeslopes may be due to lower infiltration rates at upslope positions under grass cover, and thus higher amounts of water reaching lower slope segments. If there were higher water inputs, this could lead to faster rates of labile C decomposition, and thus a sharper decline of SOC with depth. The footslope position especially seems to reflect a higher decomposition rate, because the scale is 58.6 under grass and 81.7 under forest, yet decay rates of SOC with depth are 0.180 under grass and 0.135 under forest. In order for SOC to decrease more quickly over such a short depth, there would have to be either a higher fraction of labile organic matter or more beneficial conditions for decomposition.

SOC was estimated at 48 t ha^{-1} using the median of combined data from all sites. When land cover data was divided, the estimate for grass sites was lower than this average, at 41 t ha^{-1}, and the estimate for forest sites was much higher, at 69 t ha^{-1}. The higher SOC density at forest sites overcame the slightly shallower average pedon depth. When grouped by slope position, estimates for summits, shoulders, and backslopes were similar and low, whereas estimates for footslopes and toeslopes were much higher. Footslopes had carbon pools more than double those at upslope positions, due to the combination of higher SOC density and deeper soils. Carbon pools by state resulted in only slight differences between states, because higher densities at Kentucky and Indiana sites were offset by shallower soil formation (depth to C horizon or to bedrock).

The sum of the carbon pools from standard depth intervals yielded a higher estimate of the overall pool. This may have been due to the capturing of surface SOC within the 0-5 cm interval, whereas using the overall median value likely discounts the higher, more extreme, values near the surface. The overall estimate by standard interval also extended the sample depth to 200 cm, instead of the average depth of 173 cm. However, the first 30 cm of soil was shown to contain about 49 t ha^{-1} versus only 34 t ha^{-1} in the remaining 170 cm of the sampling depth. Since 35 of the 40 soil pits sampled were classified as Udalfs, data can be compared to a previous analysis. Kern (1994) reported that Udalfs, to 1 m depth, contained 63 t ha^{-1} of SOC. The values, in t ha^{-1}, were distributed as follows: 15.8, 11.6, 13, 16, and 7.5 from 0-8, 8-15, 15-30, 30-70, and 70-100 cm, respectively. Estimates reported in this study are comparable, although the depths were slightly different. Total SOC to 1 m depth was 69 t ha^{-1}, distributed as: 12.9, 21.9, 14.5, 10.7, and 8.96 t ha^{-1} from 0-5, 5-15, 15-30, 30-60, and 60-100 cm, respectively.

Carbon pools calculated using parameter estimates for the exponential decay model generated higher values, because all pedons were adjusted to 200 cm depth. This allowed for comparisons to be made based on SOC distribution factors rather than factors controlling solum depth. Overall, the estimated carbon pool was 99 t ha^{-1}, more than double the 48 t ha^{-1} found using the median value and average depth. Soils at forest sites still contained a larger SOC pool than those at grass sites, but estimates were again much higher. Values for slope position carbon pools held the same relationship seen with the previous calculations. When parameters were used for groupings of upslope or downslope by grass or forest, carbon pools seemed to be well separated, but the confidence intervals indicate that all of these groupings overlap. A much higher sample size would likely be needed to overcome the level of variation within groups.

CONCLUSION

This study found that SOC density decreased with depth from the surface. Mean SOC densities were significantly higher at the forest sites than the grass sites. Vegetative inputs were likely higher from both above- and below-ground at the forest sites. Differences in the chemical nature of the organic matter inputs at the grass cover sites may have lead to more complete decomposition over time, whereas the inputs at forest cover sites were more resistant and thus accumulated. SOC differences at grass cover versus forest cover sites may have also been due to the length of time the soils were under cultivation. Although initial losses from cultivation may have been equal, the total loss from cultivation and the SOC gains following establishment of permanent cover may have been higher at the forest sites.

SOC densities were significantly higher at downslope positions (footslopes and toeslopes) than upslope positions (summits, shoulders, and backslopes). This may be because of topography's effect on moisture content, depth of soil formation, and erosion and deposition. Plant growth was likely higher at the downslope positions, in part due to higher water inputs. Soils at footslopes and toeslopes would have received greater amounts of organic material, although potentially experiencing faster rates of decomposition, assuming a moisture content at or near field capacity. Upslope soils had higher slope gradients, which likely decreased the rate of water infiltration, thereby limiting the depth of soil formation. High clay content in the deeply-formed subsoils of downslope soils may have protected organic matter from decomposition through formation of organo-mineral complexes. SOC differences between slope positions were also likely influenced by erosion and deposition. Erosion events may have resulted in the physical relocation of SOC from eroded positions to depositional positions. This may have then resulted in increased organic matter generation at footslopes and toeslopes due to higher fertility from erosional deposition, which may have resulted in greater humus formation. The erosion and deposition effects were likely the main reason for the significant SOC differences found between upslope and downslope positions at these sites.

Exponential decay models were the best fit for the relationship of SOC with depth from the surface. When SOC density data were divided by land cover, model parameters gave insight into causes for the differences seen between grass and forest covers. Higher surface C estimates may reflect the influence of leaf litter on the A horizons of forest soils. The higher asymptote could be due to higher average residence time of organic matter produced by trees. Similar decay rates may be explained by the fact that grass and forest sites shared similar climates, parent materials, and topography. When divided by hillslope position, parameter estimates showed similar trends to those seen in comparisons of median values. The exponential decay parameter was greater at footslopes than would be expected, perhaps indicating a higher rate of organic matter decomposition. When data were divided into combined classes of land cover by hillslope position, results were the same as when models were fit individually, except for one new pattern: exponential decay parameters were determined to be greater under grass cover at backslopes, footslopes, and toeslopes, but greater under forest cover at summits and shoulders.

SOC pools were estimated at 48 t ha^{-1} overall, 41 t ha^{-1} under grass cover, and 69 t ha^{-1} under forest. When grouped by slope position, upslope pools were similar to each other and low, whereas estimates for footslopes and toeslopes were much higher. Carbon pools across the study sites in all three states were similar, because higher densities at Kentucky and Indiana sites were offset by their shallow soil formation. The overall carbon pool calculated by the addition of standard depth intervals yielded a higher estimate. This may have been because the 0-5 cm interval better captured high surface SOC levels which were discounted using the overall median value. Carbon pools calculated using parameter estimates for the exponential decay model generated much higher values. When data were grouped by slope class (upslope or downslope) and land cover, carbon pools appeared to be more specific, yet confidence intervals indicated that all of the groupings overlapped. A higher sample size was likely necessary to overcome the level of variation within groups.

Detailed accounting of SOC levels is necessary to establish baseline data if the effects of land uses or conservation measures are to be assessed. Also, analysis of topography and land cover may help efforts at mapping similar soils, by defining significant and nonsignificant groupings with regard to their effects on SOC. New technology enables more complex, data-rich soil maps to be produced that no longer need to conform to 2-dimensional sheets of paper. Detailed break-downs of how key soil properties vary across the landscape and down the soil profile can be incorporated into digital geographic information systems, where users can see as much or as little information as they choose at any time.

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APPENDIX

Table 1A. Selected physical and chemical properties of Soil Pit #1, Illinois grass cover site, summit slope position.

Horizon	Depth	Color Moist	Structure:	% Clay	% Silt	% Sand	SOC	pH_{CaCl}
	- cm -		grade, size, type †				- kg m^{-3} -	
Ap1	0-10	10YR 4/3	2, F, GR	13.5	84.3	2.2	20.0	6.6
Ap2	10-24	10YR 4/3	2, M, GR	12.8	85.3	1.9	9.49	7.2
E	24-36	10YR 4/4	2, TN, PL	26.1	73.3	0.6	4.65	7.0
Bt11	36-49	7.5YR 4/6	2, M, PR to 2, M, SBK	33.9	65.6	0.5	3.28	6.9
Bt12	49-61	7.5YR 4/6	2, M, PR to 2, M, SBK	31.8	67.5	0.7	2.59	6.8
Bt21	61-75	7.5YR 4/6	2, M, PR to 2, F, SBK and 2, M, PR to 2, M, SBK	30.5	68.9	0.6	1.99	6.7
Bt22	75-89	7.5YR 4/6	2, M, PR to 2, M, SBK and 2, M, PR to 2, F, SBK	27.8	71.2	1.0	1.94	6.2
Bt3	89-105	7.5YR 4/4	2, M, PR to 2, M, SBK	26.9	72.1	1.0	1.53	4.3
Bt4	105-128	7.5YR 4/4	2, M, PR to 2, M, SBK	22.8	75.8	1.4	1.37	4.2
Bt5	128-151	7.5YR 5/6	2, M, PR to 2, M, SBK	18.8	80.0	1.2	0.906	4.2
Bt6	151-170	7.5YR 5/6	2, M, PR	19.2	79.9	0.9	0.720	4.2
Bt7	170-182	7.5YR 5/6	2, M, PR	18.2	81.1	0.7	0.745	4.4
Bt8	182-200	7.5YR 5/6	2, M, PR	17.7	81.3	1.0	0.600	4.7

† 2 = moderate, F = fine, GR = granular, M = medium, TN = thin, PL = platy, PR = prismatic, SBK = subangular blocky

Table 2A. Selected physical and chemical properties of Soil Pit #2, Illinois grass cover site, shoulder slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Ap	0-12	10YR 4/4	2, F, SBK to 2, M, GR	27.6	71.3	1.1	11.9	4.4
Bt1	12-22	7.5YR 4/6	2, M, SBK	29.1	70.1	0.8	5.54	4.2
Bt2	22-37	7.5YR 5/6	3, M, ABK	29.2	70.1	0.7	2.24	4.1
Bt3	37-55	7.5YR 5/6	2, M, ABK to 2, F, SBK	27.8	71.2	1	1.88	4.0
Btx1	55-78	7.5YR 4/6	2, F, PR to 2, M, SBK	23.7	74.9	1.4	1.56	4.0
Btx2	78-93	7.5YR 4/6	2, M, PR	23.1	75.7	1.2	1.05	4.0
Btx31	93-122	7.5YR 4/4	3, VC, PR	21.2	77.7	1.1	0.755	4.0
Btx32	122-140	7.5YR 4/4	3, VC, PR	18.1	81.1	0.8	0.616	4.3
2Btx4	140-166	7.5YR 4/4	3, VC, PR	16.6	82.7	0.7	0.745	4.6
2Btx5	166-200	7.5YR 4/4	3, VC, PR	15.3	83.3	1.4	0.745	4.9

† 2 = moderate, F = fine, SBK = subangular blocky, M = medium, GR = granular, 3 = strong, ABK = angular blocky, PR = prismatic, VC = very coarse

Table 3A. Selected physical and chemical properties of Soil Pit #3, Illinois grass cover site, backslope slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Ap	0-10	10YR 4/3	2, F, GR and 2, M, GR	23	75.9	1.1	19.3	5.2
Bt1	10-22	10YR 4/4	2, M, SBK	29.3	69.7	1	10.0	5.9
Bt2	22-33	7.5 YR 4/4	2, M, SBK to 2, CO, SBK and 1, F, SBK	31	67.9	1.1	4.18	6.3
Bt3	33-60	7.5 YR 4/4	3, M, SBK to 2, CO, SBK and 1, F, SBK	28.1	70.9	1	2.28	5.4
Bt4	60-80	7.5 YR 4/4	3, M, PR to 2, CO, ABK	25	73.6	1.4	1.85	5.0
Bt5	80-91	7.5 YR 4/4	3, M, PR to 3, CO, SBK	23.6	75	1.4	1.52	5.0
Bt6	91-111	7.5 YR 4/4	2, M, PR	24.4	74.4	1.2	0.912	4.9
2Btx1	111-134	7.5 YR 4/4	2, M, PR	22.1	76.8	1.1	0.740	4.9
2Btx2	134-150	7.5 YR 4/4	2, CO, PR	19.8	79.4	0.8	0.740	5.1
2Btx3	150-175	7.5 YR 4/4	2, CO, PR	17.2	82.1	0.7	0.888	5.3
2Btx4	175-200	7.5 YR 4/4	2, VC, PR	15.1	84	0.9	1.05	5.5

† 2 = moderate, F = fine, GR = granular, M = medium, SBK = subangular blocky, CO = coarse, 1 = weak, 3 = strong, ABK = angular blocky, PR = prismatic, VC = very coarse

Table 4A. Selected physical and chemical properties of Soil Pit #4, Illinois grass cover site, backslope slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Ap	0-10	10YR 4/2	2, F, GR and 2, M, GR	20.8	77.7	1.5	24.6	4.6
Bt1	10-18	7.5YR 5/4	2, F, SBK and 2, M, SBK	23.7	74.5	1.8	12.4	4.8
Bt2	18-25	10YR 5/6	2, M, SBK	24.3	73.6	2.1	7.59	5.2
Bt3	25-33	10YR 5/4	2, M, ABK	23.3	74.5	2.2	7.01	5.6
Btg1	33-49	10YR 5/2	2, M, SBK	25.4	72.4	2.2	2.51	6.5
Btg2	49-70	10YR 5/2	2, M, PR to 2, M, SBK	22.7	74.5	2.8	2.45	7.6
Btg3	70-93	10YR 5/2	2, CO, PR	22	76.2	1.8	1.78	7.7
Btg4	93-108	10YR 5/2	2, CO, PR	19.5	79	1.5	1.91	7.5
2BC1	108-128	10YR 4/4	2, CO, PR	16.8	82.1	1.1	1.38	7.2
2BC2	128-147	10YR 4/4	2, CO, PR	15.4	83.7	0.9	0.980	7.2
2BC3	147-175	10YR 4/4	2, CO, PR	15.2	83.8	1	1.57	7.4
2BC4	175-200	10YR 4/4	2, CO, PR	14.6	84.3	1.1	1.57	7.3

† 2 = moderate, F = fine, GR = granular, M = medium, SBK = subangular blocky, ABK = angular blocky, PR = prismatic, CO = coarse

Table 5A. Selected physical and chemical properties of Soil Pit #5, Illinois grass cover site, toeslope slope position.

Horizon	Depth	Color Moist	Structure:	% Clay	% Silt	% Sand	SOC	pH_{CaCl}
	- cm -		grade, size, type †				- kg m^{-3} -	
Ap	0-6	10YR 4/3	2, VF, GR	18.1	80.3	1.6	33.1	4.6
Bw1	6-16	10YR 5/3	2, M, SBK	19.6	78.7	1.7	12.7	5.1
Bw2	16-36	10YR 5/3	1, M, SBK	21.5	76.5	2	8.53	6.4
Bw3	36-60	10YR 5/3	1, M, ABK	22	75.3	2.7	8.45	7.2
Bw4	60-85	10YR 5/6	1, CO, SBK and 1, M, SBK	24.8	73.9	1.3	3.02	7.3
2Bg1	85-108	10YR 5/2	1, CO, PR	18.1	81.1	0.8	1.47	7.5
3Bg21	108-130	10YR 5/2	1, CO, PR	17.3	81.9	0.8	1.33	7.2
3Bg22	130-150	10YR 5/2	1, CO, PR	15.2	83.9	0.9	1.32	7.2
3Bg3	150-160	10YR 6/2	1, VC, PR	15.3	83.8	0.9	1.45	7.2
3Bw11	160-180	10YR 4/4	1, VC, PR	16.4	80.4	3.2	4.23	7.6
3Bw12	180-200	10YR 4/4	1, VC, PR	16.2	82.6	1.2	1.51	7.2

† 2 = moderate, VF = very fine, GR = granular, M = medium, SBK = subangular blocky, 1 = weak, ABK = angular blocky, CO = coarse, PR = prismatic, VC = very coarse

Table 6A. Selected physical and chemical properties of Soil Pit #6, Illinois grass cover site, summit slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Ap1	0-14	10YR 4/3	2, M, GR and 2, F, GR	15.6	83.1	1.3	14.3	4.9
Ap2	14-28	10YR4/4	2, F, SBK	18	81	1	7.22	5.0
Bt1	28-38	7.5YR 4/6	3, F, PR to 3, F, SBK	27.9	71.5	0.6	4.70	5.2
Bt21	38-49	7.5YR 5/6	3, M, PR to 3, M, SBK	33	66.3	0.7	3.47	5.2
Bt22	49-59	7.5YR 5/6	3, M, PR to 3, M, SBK	33	66.5	0.5	2.81	5.0
Bt31	59-75	7.5YR 5/6	3, M, PR to 3, M, SBK	31.4	68	0.6	2.82	4.5
Bt32	75-90	7.5YR 5/6	3, M, PR to 3, M, SBK	28.6	70.5	0.9	2.25	4.2
Bt4	90-107	7.5YR 5/6	2, M, PR to 2, M, SBK	27.6	71.4	1	1.57	4.2
Bt5	107-121	7.5YR 5/6	2, M, PR to 2, M, SBK	25.1	73.9	1	1.65	4.2
Bt6	121-145	7.5YR 5/6	1, M, PR to 1, M, SBK	22.2	77.2	0.6	1.22	4.1
Bt7	145-179	7.5YR 5/6	1, M, PR to 1, M, SBK	20.7	78.5	0.8	0.900	4.2
Bt8	179-200	7.5YR 4/4	1, CO, PR	19.7	79.7	0.6	0.858	4.3

† 2 = moderate, M = medium, GR = granular, F = fine, 3 = strong, PR = prismatic, SBK = subangular blocky, 1 = weak, CO = coarse

Table 7A. Selected physical and chemical properties of Soil Pit #7, Illinois grass cover site, shoulder slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Ap	0-8	10YR 5/4	2, F, GR	23.3	75.6	1.1	24.0	4.7
Bt1	8-16	7.5YR 4/6	2, M, PR to 2, M, SBK	27.3	71.8	0.9	12.1	2.1
Bt21	16-25	7.5YR 5/6	2, M, PR to 2, M, SBK	29.6	69.6	0.8	7.91	5.2
Bt22	25-33	7.5YR 5/6	2, M, PR to 2, M, SBK	30.2	69.2	0.6	3.34	4.6
Bt31	33-44	7.5YR 4/6	2, M, PR to 2, M, SBK	28.2	71.2	0.6	2.33	4.3
Bt32	44-61	7.5YR 4/6	2, M, PR to 2, M, SBK	26.8	72.3	0.9	1.88	4.2
Bt41	61-76	7.5YR 4/6	2, M, PR to 2, M, SBK	24.3	74.8	0.9	1.52	4.2
Bt42	76-96	7.5YR 4/6	2, M, PR to 2, M, SBK	23.5	75	1.5	1.18	4.2
Btx11	96-118	7.5YR 5/4	1, CO, PR	23.7	75.4	0.9	0.780	4.1
Btx12	118-143	7.5YR 5/4	1, CO, PR	19.9	79.4	0.7	0.740	4.4
Btx2	143-180	7.5YR 4/4	1, VC, PR	16.9	82.3	0.8	0.700	4.8
2Btx3	180-200	7.5YR 4/4	1, VC, PR	15.8	83.3	0.9	0.720	5.0

† 2 = moderate, F = fine, GR = granular, M = medium, PR = prismatic, SBK = subangular blocky, 1 = weak, CO = coarse

Table 8A. Selected physical and chemical properties of Soil Pit #8, Illinois grass cover site, backslope slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Ap	0-12	10YR 5/4	2, F, GR and 2, M, GR	26.1	73.1	0.8	22.8	4.9
Bt1	12-23	10YR 5/6	2, F, GR and 2, M, GR	26.8	72.7	0.5	5.41	4.6
Bt2	23-51	10YR 5/6	1, M, SBK	25.3	74.1	0.6	1.71	4.2
Btx1	51-77	10YR 4/6	1, M, ABK	22.8	76.6	0.6	1.26	4.2
2Btx2	77-96	7.5YR 4/6	1, CO, SBK and 1, M, SBK	24.7	74.3	1	1.22	4.2
2Btx31	96-120	7.5YR 4/6	1, CO, PR	18.9	79.5	1.6	1.10	4.5
2Btx32	120-135	7.5YR 4/6	1, CO, PR	15.9	82.7	1.4	0.966	4.9
2Btx4	135-171	7.5YR 4/6	1, CO, PR	18.8	79.6	1.6	1.42	5.3
2Bx1	171-200	7.5YR 4/6	1, VC, PR	22.4	75.7	1.9	1.71	5.5

† 2 = moderate, F = fine, GR = granular, M = medium, 1 = weak, SBK = subangular blocky, ABK = angular blocky, CO = coarse, PR = prismatic, VC = very coarse

Table 9A. Selected physical and chemical properties of Soil Pit #9, Illinois grass cover site, footslope slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Ap	0-8	10YR 5/4	3, F, GR	17.3	80.8	1.9	34.6	4.5
Bw1	8-22	10YR 4/4	1, M, SBK	18.2	80.7	1.1	10.8	4.9
Bw2	22-43	10YR 5/3	1, CO, SBK and 1, M, SBK	17.7	81.1	1.2	7.94	5.5
Bw31	43-58	10YR 5/3	1, CO, ABK	16.8	82.3	0.9	7.45	5.6
Bw32	58-81	10YR 5/3	1, CO, ABK	15.9	83.1	1	6.29	5.8
Bg1	81-107	10YR 5/1	1, CO, SBK	17	81.9	1.1	5.22	6.0
Bg21	107-132	10YR 6/1	1, CO, SBK	19	79.8	1.2	4.88	6.2
Bg22	132-148	10YR 6/1	1, CO, SBK	19.4	79.4	1.2	5.08	6.2
Bg31	148-183	10YR 5/2	1, CO, SBK	17.6	81	1.4	5.25	6.2
Bg32	183-200	10YR 5/2	1, CO, SBK	16.3	82.3	1.4	5.99	6.7

† 3 = strong, F = fine, GR = granular, 1 = weak, M = medium, SBK = subangular blocky, CO = coarse, ABK = angular blocky

Table 10A. Selected physical and chemical properties of Soil Pit #10, Illinois forest cover site, summit slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Oe	0-1	-	-	-	-	-	-	-
A1	1-7	7.5YR 3/2	2, F, GR	11.0	87.4	1.6	40.1	6.1
A2	7-19	10YR 4/3	1, F, SBK to 1, F, GR	11.9	87.0	1.1	26.2	5.8
E	19-32	7.5YR 4/4	1, M, SBK	18.3	80.4	1.3	7.74	4.6
Bt1	32-63	7.5YR 4/6	2, M, PR to 2, M, SBK	27.7	71.3	1.0	3.52	4.4
Bt2	63-98	7.5YR 5/6	2, M, PR to 2, M, SBK	26.2	73.2	0.6	2.07	4.2
Bt3	98-131	7.5YR 5/6	2, M, PR to 2, M, SBK	23.1	76.3	0.6	1.40	4.2
Bt4	131-170	7.5YR 4/4	1, M, PR to 1, M, SBK	23.0	76.5	0.5	1.38	4.2
Bt5	170-200	7.5YR 4/6	1, CO, PR	22.2	77.4	0.4	1.37	4.2

† 2 = moderate, F = fine, GR = granular, 1 = weak, SBK = subangular blocky, M = medium, PR = prismatic, CO = coarse

Table 11A. Selected physical and chemical properties of Soil Pit #11, Illinois forest cover site, shoulder slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Oe	0-1	-	-	-	-	-	-	-
A1	1-7	10YR 3/3	2, M, GR	16.1	82.1	1.8	50.0	6.0
A2	7-18	10YR 4/3	2, M, SBK to 2, F, SBK	20.3	78.0	1.7	14.7	5.0
Bt1	18-37	7.5YR 5/4	1, M, SBK	28.1	71.0	0.9	4.64	4.3
Bt2	37-67	7.5YR 5/6	2, M, PR to 2, M, SBK	24.8	74.4	0.8	2.37	4.1
Bt3	67-121	7.5YR 6/4	2, M, PR to 2, M, SBK	22.5	76.9	0.6	1.24	4.0
Btx1	121-159	7.5YR 5/4	2, M, PR	21.9	77.5	0.6	1.06	4.0
Btx2	159-200	7.5YR 5/4	3, VC, PR	22.4	76.9	0.7	1.04	4.0

† 2 = moderate, M = medium, GR = granular, SBK = subangular blocky, F = fine, 1 = weak, PR = prismatic, 3 = strong, VC = very coarse

Table 12A. Selected physical and chemical properties of Soil Pit #12, Illinois forest cover site, backslope slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Oe	0-1	-	-	-	-	-	-	-
A	1-14	10YR 3/3	2, M, GR	19.5	78.8	1.7	47.8	6.0
Bt1	14-23	7.5YR 4/4	2, M, SBK	21.5	77.4	1.1	17.4	4.6
Bt2	23-39	7.5YR 4/4	2, M, SBK	26.0	73.2	0.8	3.95	4.0
Btx1	39-63	7.5YR 5/4	2, CO, PR to 2, M, SBK	25.6	73.6	0.8	1.44	4.0
Btx2	63-106	7.5YR 4/6	1, CO, PR	20.8	78.5	0.7	1.32	4.1
Btx3	106-151	7.5YR 5/6	1, CO, PR	17.4	82.2	0.4	1.00	4.3
B't	151-200	7.5YR 6/6	1, CO, PR	14.4	85.1	0.5	1.01	4.6

† 2 = moderate, M = medium, GR = granular, SBK = subangular blocky, CO = coarse, PR = prismatic

Table 13A. Selected physical and chemical properties of Soil Pit #13, Illinois forest cover site, footslope slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Oe	0-1	-	-	-	-	-	-	-
A11	1-8	10YR 4/3	2, M, GR	14.1	84.4	1.5	-	5.9
A12	8-20	10YR 4/3	2, M, GR	15.0	83.4	1.6	17.1	5.2
Bw11	20-39	10YR 4/3	1, M, SBK	16.0	82.6	1.4	9.72	4.6
Bw12	39-54	10YR 4/3	1, M, SBK	16.0	82.7	1.3	10.9	4.5
Bw2	54-75	10YR 4/4	1, M, SBK	16.7	82.5	0.8	13.5	4.5
Bw31	75-102	10YR 4/4	2, M, ABK	15.3	83.6	1.1	5.81	4.6
Bw32	102-125	10YR 4/4	2, M, ABK	21.7	76.8	1.5	2.81	4.5
2Btb11	125-161	10YR 4/6	2, CO, PR to 2, M, ABK	24.2	74.5	1.3	1.55	4.0
2Btb12	161-200	10YR 4/6	2, CO, PR to 2, M, ABK	18.3	80.6	1.1	0.790	4.1

† 2 = moderate, M = medium, GR = granular, 1 = weak, SBK = subangular blocky, ABK = angular blocky, CO = coarse, PR = prismatic

Table 14A. Selected physical and chemical properties of Soil Pit #14, Illinois forest cover site, summit slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Oe	0-2	-	-	-	-	-	-	-
A1	2-10	10YR 3/3	2, M, GR	12.6	86.5	0.9	52.0	6.6
A2	10-20	10YR 5/4	2, M, SBK to 2, M, GR	12.6	86.4	1.0	12.7	5.2
Bt1	20-38	7.5YR 5/6	2, M, SBK	25.6	73.5	0.9	5.53	4.6
Bt2	38-62	7.5YR 5/6	2, M, PR to 2, M, ABK	30.4	69.0	0.6	3.04	4.6
Bt3	62-90	7.5YR 5/4	3, M, ABK	26.8	72.7	0.5	2.33	4.1
Bt41	90-130	7.5YR 4/4	2, M, PR to 2, M, ABK	23.8	75.6	0.6	1.40	3.9
Bt42	130-175	7.5YR 4/4	2, M, PR to 2, M, ABK	18.6	81.0	0.4	1.09	3.9
Bt5	175-200	7.5YR 4/6	2, CO, PR	22.5	77.0	0.5	1.08	4.0

† 2 = moderate, M = medium, GR = granular, SBK = subangular blocky, PR = prismatic, ABK = angular blocky, 3 = strong, CO = coarse

Table 15A. Selected physical and chemical properties of Soil Pit #15, Illinois forest cover site, shoulder slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Oe	0-1	-	-	-	-	-	-	-
A	1-8	10YR 3/2	2, F, GR	22.0	77.2	0.8	-	7.0
Bt11	8-14	10YR 5/6	2, M, SBK	19.0	79.4	1.6	30.0	5.8
Bt12	14-28	10YR 5/6	2, M, SBK	24.2	74.9	0.9	13.2	5.2
Bt2	28-56	10YR 5/4	3, F, ABK and 3, M, ABK	24.2	74.9	0.9	4.50	5.0
Bt3	56-70	7.5YR 4/6	2, M, ABK and 2, CO, ABK	24.0	75.5	0.5	1.75	4.9
Bt4	70-102	7.5YR 4/6	2, M, ABK and 2, CO, ABK	20.8	78.5	0.7	1.33	5.1
Bt51	102-130	7.5YR 4/6	2, M, PR to 2, M, ABK	19.8	79.5	0.7	1.30	5.2
Bt52	130-160	7.5YR 4/6	2, M, PR to 2, M, ABK	18.4	81.0	0.6	1.43	5.3
Bt6	160-200	7.5YR 5/4	2, CO, PR	14.9	84.7	0.4	1.15	5.5

† 2 = moderate, F = fine, GR = granular, M = medium, SBK = subangular blocky, 3 = strong, ABK = angular blocky, CO = coarse, PR = prismatic

Table 16A. Selected physical and chemical properties of Soil Pit #16, Illinois forest cover site, backslope slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Oe	0-1	-	-	-	-	-	-	-
A11	1-5	10YR 3/2	2, F, GR	21.4	77.4	1.2	-	6.5
A12	5-10	10YR 3/2	2, F, GR	22.5	76.0	1.5	23.4	5.1
Bt1	10-26	10YR 4/4	2, M, PR to 2, M, SBK	24.3	74.7	1.0	9.03	4.2
Bt2	26-46	10YR 4/4	2, M, PR to 2, M, SBK	22.1	77.5	0.4	4.00	4.2
Btx1	46-72	10YR 5/4	2, M, PR to 2, M, SBK	15.9	83.5	0.6	1.99	4.2
Btx2	72-96	10YR 5/4	2, M, PR to 2, M, SBK	16.8	82.9	0.3	0.459	4.4
Btx3	96-126	10YR 6/4	2, CO, PR to 2, CO, SBK	15.4	84.2	0.4	1.14	4.6
Btx4	126-162	10YR 5/4	1, CO, PR	13.8	85.7	0.5	1.53	4.9
B't1	162-200	10YR 5/4	1, VC, PR	12.1	87.4	0.5	1.27	5.3

† 2 = moderate, F = fine, GR = granular, M = medium, PR = prismatic, SBK = subangular blocky, CO = coarse, VC = very coarse

Table 17A. Selected physical and chemical properties of Soil Pit #17, Illinois forest cover site, footslope slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Oe	0-1	-	-	-	-	-	-	-
A11	1-3	10YR 2/2	2, F, GR	14.7	83.9	1.4	-	6.5
A12	3-9	10YR 2/2	2, F, GR	11.5	87.9	0.6	19.4	5.3
A2	9-16	10YR 4/3	1, F, SBK to 1, F, GR	13.2	86.0	0.8	12.5	4.9
Bw1	16-33	10YR 4/3	1, M, SBK	16.8	82.2	1.0	4.29	4.3
Bt1	33-57	10YR 5/6	1, M, SBK	18.7	80.2	1.1	4.95	4.2
Bt2	57-77	10YR 5/4	1, M, SBK	21.5	77.1	1.4	6.08	4.1
Btxb1	77-98	10YR 5/4	3, M, PR to 3, M, ABK	25.7	73.6	0.7	4.17	4.2
Btxb2	98-136	10YR 5/6	3, M, PR to 3, M, ABK	24.3	75.0	0.7	2.13	4.0
Btxb3	136-172	10YR 5/4	2, CO, PR	17.2	82.1	0.7	1.64	4.1
Btxb4	172-200	10YR 5/4	1, CO, PR	17.4	81.6	1.0	2.21	4.4

† 2 = moderate, F = fine, GR = granular, 1 = weak, SBK = subangular blocky, M = medium, 3 = strong, PR = prismatic, ABK = angular blocky, CO = coarse

Table 18A. Selected physical and chemical properties of Soil Pit #18, Kentucky grass cover site, summit slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Ap	0-19	10YR 4/3	2, F, GR	17.9	79.9	2.2	24.5	4.6
Bt1	19-38	7.5YR 5/6	3, F, PR to 3, F, SBK	30.5	68.5	1.0	6.44	4.5
Bt21	38-57	7.5YR 5/6	2, M, PR to 2, M, SBK	28.6	70.3	1.1	2.84	4.2
Bt22	57-76	7.5YR 5/6	2, M, PR to 2, M, SBK	19.5	79.5	1.0	1.68	4.2
Bt31	76-96	7.5YR 5/6	2, M, PR to 2, M, SBK	18.7	80.4	0.9	1.47	4.2
Bt32	96-116	7.5YR 5/6	2, M, PR to 2, M, SBK	15.2	83.8	1.0	1.18	4.2
2Bt4	116-140	7.5YR 5/6	2, M, PR to 2, M, SBK	15.5	80.7	3.8	1.07	4.3
2Bt5	140-155	7.5YR 5/4	2, CO, PR to 2, CO, ABK	16.4	70.1	13.5	1.11	4.4
3Bt61	155-179	7.5YR 5/4	2, CO, PR to 2, CO, ABK	15.6	52.4	32.0	1.14	4.5
3Bt62	179-200	7.5YR 5/4	2, CO, PR to 2, CO, ABK	17.0	62.4	20.6	1.18	4.6

† 2 = moderate, F = fine, GR = granular, 3 = strong, PR = prismatic, SBK = subangular blocky, M = medium, CO = coarse, ABK = angular blocky

Table 19A. Selected physical and chemical properties of Soil Pit #19, Kentucky grass cover site, shoulder slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Ap	0-19	10YR 6/3	2, M, PL to 2, F, GR	22.4	76.3	1.3	18.4	5.0
Bt1	19-42	10YR 5/6	2, M, PR to 2, M, SBK	23.1	76.1	0.8	4.71	5.0
Bt2	42-66	7.5YR 5/6	2, M, PR to 2, M, SBK	18.9	79.5	1.6	2.42	4.3
Bt3	66-85	10YR 5/4	2, M, PR to 2, M, SBK	17.9	79.2	2.9	1.80	4.2
Btx1	85-99	10YR 5/4	2, M, PR to 2, M, SBK	16.2	81.5	2.3	1.27	4.2
2Btx21	99-129	10YR 5/4	3, VC, PR to 2, CO, ABK	17.5	80.5	2.0	1.11	4.5
2Btx22	129-158	10YR 5/4	3, VC, PR to 2, CO, ABK	20.0	77.1	2.9	1.14	4.9
3Btx31	158-183	10YR 5/4	2, VC, PR to 2, M, ABK	21.3	70.7	8.0	1.49	5.5
3Btx32	183-200	10YR 5/4	2, VC, PR to 2, M, ABK	23.8	64.7	11.5	2.10	5.7

† 2 = moderate, M = medium, PL = platy, F = fine, GR = granular, PR = prismatic, SBK = subangular blocky, 3 = strong, VC = very coarse, CO = coarse, ABK = angular blocky

Table 20A. Selected physical and chemical properties of Soil Pit #20, Kentucky grass cover site, backslope slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Ap	0-12	10YR 4/3	1, TN, PL	23.9	75.2	0.9	25.3	4.5
Bt1	12-21	10YR 5/6	1, F, SBK	22.6	76.3	1.1	14.2	4.3
Bt2	21-33	10YR 5/4	2, M, SBK	18.2	80.0	1.8	3.34	4.1
Bt/E	33-43	10YR 5/4	3, M, PR to 3, M, ABK	17.2	80.6	2.2	2.48	4.1
2Btx1	43-61	10YR 5/4	2, VC, PR to 2, M, ABK	19.5	76.9	3.6	1.80	4.0
3Btx21	61-78	10YR 5/4	2, VC, PR to 2, M, ABK	18.3	76.0	5.7	1.67	4.2
3Btx22	78-95	10YR 5/4	2, VC, PR to 2, M, ABK	20.6	70.6	8.8	1.88	4.3
3Btx31	95-109	10YR 4/4	2, VC, PR to 2, M, ABK	23.3	62.9	13.8	2.44	4.8
3Btx32	109-124	10YR 4/4	2, VC, PR to 2, M, ABK	26.7	58.3	15.0	2.67	5.3
3Bt	124-147	10YR 4/4	1, CO, PR	33.9	51.6	14.5	2.72	5.7
4BC1	147-170	5Y 6/1	MASSIVE	63.2	33.7	3.1	2.67	6.2
4BC2	170-200	5Y 6/1	MASSIVE	65.7	31.5	2.8	2.93	6.4

† 1 = weak, TN = thin, PL = platy, F = fine, SBK = subangular blocky, 2 = moderate, M = medium, , 3 = strong, PR = prismatic, ABK = angular blocky, VC = very coarse, CO = coarse

Table 21A. Selected physical and chemical properties of Soil Pit #21, Kentucky grass cover site, footslope slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Ap	0-16	10YR 4/3	2, F, GR	13.7	84.7	1.6	15.7	4.6
Bw1	16-28	10YR 4/4	1, F, SBK	12.4	85.5	2.1	9.73	4.9
Bw2	28-56	10YR 4/4	1, M, SBK	13.8	83.4	2.8	9.37	4.8
Ab	56-66	10YR 3/3	1, F, SBK	17.5	78.6	3.9	7.78	4.6
Btb1	66-84	10YR 5/6	2, M, SBK	17.9	77.9	4.2	6.00	4.5
Btb2	84-103	10YR 5/6	2, M, PR to 2, M, ABK	20.7	74.3	5.0	3.80	4.4
Btb3	103-117	10YR 5/6	2, M, PR to 2, M, ABK	21.1	71.5	7.4	2.79	4.2
Btb4	117-135	10YR 5/4	2, M, PR to 2, M, SBK	19.5	67.4	13.1	2.00	4.1
2Btb5	135-151	10YR 5/4	2, M, PR to 2, M, SBK	20.9	61.6	17.5	1.54	4.0
2Btb61	151-166	10YR 5/4	1, CO, PR	25.9	57.4	16.7	1.38	4.0
2Btb62	166-182	10YR 5/4	1, CO, PR	30.6	52.0	17.4	1.46	4.2
2BC	182-200	10YR 5/4	1, CO, PR	30.8	51.3	17.9	1.63	4.3

† 2 = moderate, F = fine, GR = granular, 1 = weak, SBK = subangular blocky, M = medium, PR = prismatic, ABK = angular blocky, CO = coarse

Table 22A. Selected physical and chemical properties of Soil Pit #22, Kentucky grass cover site, toeslope slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Ap	0-22	10YR 4/3	1, F, GR	14.5	80.7	4.8	18.0	4.6
Bg1	22-42	10YR 5/2	1, F, SBK	13.2	81.6	5.2	6.67	5.2
Bg2	42-54	10YR 6/2	1, F, SBK	16.1	78.6	5.3	6.00	4.7
Bg3	54-73	10YR 6/2	1, F, SBK	18.0	76.0	6.0	6.44	4.6
2Bt11	73-91	10YR 5/6	3, M, PR to 3, M, ABK	21.9	62.9	15.2	3.40	4.3
2Bt12	91-109	10YR 5/6	3, M, PR to 3, M, ABK	19.5	62.1	18.4	1.88	4.3
2Bt2	109-134	10YR 5/6	2, CO, PR to 2, M, ABK	24.2	56.3	19.5	1.27	4.2
2Bt3	134-160	10YR 5/6	3, CO, PR to 3, M, ABK	24.9	55.3	19.8	1.24	4.5

† 1 = weak, F = fine, GR = granular, SBK = subangular blocky, 3 = strong, M = medium, PR = prismatic, ABK = angular blocky, 2 = moderate, CO = coarse

Table 23A. Selected physical and chemical properties of Soil Pit #23, Kentucky forest cover site, summit slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Oi	0-1	10YR 3/2	-	12.7	75.2	12.1	-	-
A	1-3	10YR 3/2	1, F, GR	20.7	75.5	3.8	-	6.8
E	3-18	10YR 4/4	1, F, GR	14.7	81.0	4.3	10.9	4.1
Bt1	18-34	7.5YR 4/6	1, M, SBK	34.0	64.5	1.5	9.24	4.3
Bt2	34-53	7.5YR 4/4	2, M, SBK	33.6	65.6	0.8	4.21	4.4
Bt3	53-83	7.5YR 4/4	2, M, SBK	27.3	72.0	0.7	1.44	4.5
Bt4	83-105	7.5YR 4/4	1, F, SBK	21.2	78.1	0.7	1.26	4.4
Bt5	105-131	7.5YR 4/4	1, F, SBK	18.0	81.3	0.7	1.42	4.4
Bt6	131-152	7.5YR 4/4	1, F, SBK	16.5	81.3	2.2	1.25	4.4
2Bt7	152-167	7.5YR 4/4	1, F, SBK	16.2	77.6	6.2	1.14	4.4
2Btx	167-190	7.5YR 4/6	1, CO, PR to 2, F, SBK	15.3	69.6	15.1	1.22	4.4
3C	190-200	10YR 5/4	MASSIVE	12.8	38.3	48.9	-	4.5

† 1 = weak, F = fine, GR = granular, M = medium, SBK = subangular blocky, 2 = moderate, CO = coarse, PR = prismatic

Table 24A. Selected physical and chemical properties of Soil Pit #24, Kentucky forest cover site, shoulder slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Oi	0-1	10YR 3/2	-	10.7	80.8	8.5	-	-
A	1-3	10YR 3/2	1, F, GR	16.5	79.8	3.7	-	5.6
E	3-19	10YR 4/4	2, F, GR	20.4	76.9	2.7	13.2	4.0
Bt1	19-34	7.5YR 4/4	2, F, SBK	24.8	72.0	3.2	6.42	4.3
Bt2	34-51	7.5YR 4/4	2, M, SBK	22.1	67.4	10.5	1.93	4.4
Bt3	51-62	7.5YR 4/4	2, M, SBK	21.1	65.3	13.6	1.80	4.4
Bt4	62-81	7.5YR 4/6	2, M, SBK	21.6	58.4	20.0	1.85	4.6
2Bt5	81-102	5YR 4/6	2, M, SBK	20.5	57.8	21.7	4.56	4.5

† 1 = weak, F = fine, GR = granular, 2 = moderate, SBK = subangular blocky, M = medium

Table 25A. Selected physical and chemical properties of Soil Pit #25, Kentucky forest cover site, backslope slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Oi	0-1	10YR 3/2	-	19.3	47.3	33.4	-	-
A1	1-2	10YR 3/2	2, F, GR	14.8	62.9	22.3	-	5.7
A2	2-9	10YR 4/3	2, F, GR	16.8	57.9	25.3	22.4	4.3
Bt1	9-18	10YR 4/4	3, M, PR to 3, M, ABK	19.8	54.6	25.6	14.5	4.0
2Bt2	18-36	5YR 4/6	3, M, PR to 3, M, ABK	55.3	39.9	4.8	7.28	4.2
2Bt3	36-51	5YR 4/6	2, M, PR	53.1	44.6	2.3	5.05	4.6
2Bt4	51-75	7.5YR 4/6	2, M, PR	47.9	47.3	4.8	4.33	5.5
2BC	75-89	2.5Y 5/2	2, TN, PL	35.3	55.5	9.2	2.56	6.6

† 2 = moderate, F = fine, GR = granular, 3 = strong, M = medium, PR = prismatic, ABK = angular blocky, TN = thin, PL = platy

Table 26A. Selected physical and chemical properties of Soil Pit #26, Kentucky forest cover site, footslope slope position.

Horizon	Depth	Color Moist	Structure:	% Clay	% Silt	% Sand	SOC	pH_{CaCl}
	- cm -		grade, size, type †				- kg m^{-3} -	
Oi	0-1	-	-	13.3	64.1	22.6	-	-
A1	1-3	10YR 3/2	1, VF, GR	16.6	56.6	26.8	-	5.1
A2	3-10	10YR 3/2	2, F, GR	14.6	52.1	33.3	64.2	4.7
E	10-26	10YR 4/4	1, F, SBK	12.9	48.4	38.7	14.0	4.2
Bt1	26-40	7.5YR 5/6	2, M, PR to 2, M, SBK	16.5	61.8	21.7	7.52	4.1
Bt2	40-56	7.5YR 5/6	2, M, PR to 2, M, SBK	21.2	62.2	16.6	6.07	4.3
Bt3	56-74	7.5YR 5/6	2, M, PR to 2, M, SBK	23.7	60.4	15.9	5.22	4.4
2Bt4	74-87	7.5YR 4/6	3, M, PR to 3, M, ABK	24.0	57.7	18.3	4.20	4.4
2Bt5	87-122	7.5YR 4/6	2, M, PR to 2, M, ABK	24.4	32.1	43.5	2.41	4.4
2Bt6	122-154	7.5YR 5/8	2, M, PR to 2, M, ABK	21.2	32.1	46.7	1.96	4.4
2Bt7	154-175	7.5YR 5/6	1, CO, PR to 2, M, SBK	17.6	29.2	53.2	-	5.5
2Bt8	175-200	7.5YR 5/6	1, CO, PR to 2, M, SBK	15.7	30.9	53.4	-	6.0

† 1 = weak, VF = very fine, GR = granular, 2 = moderate, F = fine, SBK = subangular blocky, M = medium, PR = prismatic, 3 = strong, ABK = angular blocky, CO = coarse

Table 27A. Selected physical and chemical properties of Soil Pit #27, Kentucky forest cover site, toeslope slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Oi	0-2	-	-	11.3	71.8	16.9	-	-
A1	2-5	10YR 3/2	1, F, GR	15.8	65.2	19.0	-	6.6
A2	5-19	10YR 4/3	1, F, GR	12.1	61.3	26.6	25.5	4.2
Bg1	19-31	10YR 5/2	1, M, SBK	12.6	62.7	24.7	12.1	4.2
Bg2	31-56	10YR 5/2	1, M, SBK	12.8	68.0	19.2	9.45	4.2
Bw	56-81	7.5YR 5/4	1, M, SBK	15.2	73.1	11.7	5.58	4.5
2Bt11	81-120	7.5YR 5/6	1, CO, SBK	17.1	72.7	10.2	4.10	5.3
2Bt12	120-160	7.5YR 5/6	1, CO, SBK	17.1	72.8	10.1	4.15	5.8
2Bt2	160-188	7.5YR 4/6	1, CO, ABK	33.9	44.4	21.7	-	6.9
Oa	188-200	N 2.5	MASSIVE	52.1	37.1	10.8	-	6.7

† 1 = weak, F = fine, GR = granular, M medium, SBK = subangular blocky, CO = coarse, ABK = angular blocky

Table 28A. Selected physical and chemical properties of Soil Pit #28, Indiana grass cover site, summit slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
A	0-20	10YR 4/3	2, M, GR	20.3	76.9	2.8	16.4	5.5
Bt1	20-45	10YR 5/6	2, F, SBK	25.7	72.6	1.7	4.71	4.6
Bt2	45-65	10YR 5/6	2, F, SBK	24.4	73.5	2.1	2.84	4.3
Btx1	65-92	10YR 4/4	1, CO, PR to 2, M, SBK	23.4	67.1	9.5	2.28	4.0
Btx2	92-134	-	-	-	-	-	-	-
2Btb	134-145	7.5YR 5/6	2, VF, SBK	61.0	33.6	5.4	2.42	5.2

† 2 = moderate, M = medium, GR = granular, F = fine, SBK = subangular blocky, 1 = weak, CO = coarse, PR = prismatic, VF = very fine

Table 29A. Selected physical and chemical properties of Soil Pit #29, Indiana grass cover site, shoulder slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH$_{CaCl}$
Ap	0-8	10YR 4/3	2, F, GR	23.9	74.3	1.8	33.9	5.4
BA	8-20	10YR 5/4	2, M, SBK	25.5	72.8	1.7	18.5	5.3
Bt1	20-51	7.5YR 5/6	2, M, SBK	27.6	71.1	1.3	4.97	4.4
Bt2	51-64	7.5YR 5/4	2, M, SBK	32.3	65.8	1.9	3.53	4.1
2Bt3	64-84	7.5YR 5/4	2, CO, SBK	32.3	57.6	10.1	2.34	4.1
2Bt4	84-114	10YR 4/6	1, CO, SBK	71.9	26.1	2.0	3.46	4.2
2BCt	114-170	2.5Y 6/4	1, CO, SBK	59.9	37.5	2.6	2.63	4.6

† 2 = moderate, F = fine, GR = granular, M = medium, SBK = subangular blocky, CO = coarse, 1 = weak

Table 30A. Selected physical and chemical properties of Soil Pit #30, Indiana grass cover site, backslope slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH$_{CaCl}$
Ap	0-12	10YR 4/4	2, M, SBK	23.9	68.5	7.6	31.2	5.3
Bt1	12-28	7.5YR 4/6	2, F, SBK and 2, M, SBK	28.2	64.2	7.6	10.0	5.2
Bt2	28-43	7.5YR 5/6	2, VF, SBK and 2, F, SBK	29.6	50.1	20.3	4.06	4.2
2Bt3	43-82	7.5YR 5/6	2, M, ABK to 2, M, SBK	50.5	15.8	33.7	2.70	4.1
2Bt4	82-110	7.5YR 5/6	2, M, SBK	38.8	14.6	46.6	1.99	4.2
2Bt5	110-140	7.5YR 5/8	2, M, SBK	37.4	16.3	46.3	1.76	4.5
C	140-172	-	MASSIVE	41.9	47.0	11.1	1.60	4.9

† 2 = moderate, M = medium, SBK = subangular blocky, F = fine, VF = very fine, ABK = angular blocky

Table 31A. Selected physical and chemical properties of Soil Pit #31, Indiana grass cover site, backslope slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH$_{CaCl}$
Ap	0-16	10YR 4/4	2, M, SBK to 2, M, GR	24.6	56.9	18.5	23.2	5.9
Bt1	16-33	7.5YR 5/6	2, M, SBK and 2, F, SBK	33.0	43.8	23.2	6.28	5.2
Bt2	33-63	10YR 5/6	2, F, SBK	26.4	45.3	28.3	2.12	3.9
Bt3	63-87	10YR 5/8	2, F, SBK	34.2	44.6	21.2	1.42	3.8
2BC1	87-120	10YR 5/8	1, TN, PL	26.2	43.6	30.2	1.16	3.9
2BC2	120-134	10YR 7/1	1, M, PL	26.2	46.4	27.4	0.935	4.4
2Cr	134-164	10YR 5/6	-	18.5	66.0	15.5	0.880	5.9

† 2 = moderate, M = medium, SBK = subangular blocky, GR = granular, F = fine, 1 = weak, TN = thin, PL = platy

Table 32A. Selected physical and chemical properties of Soil Pit #32, Indiana grass cover site, toeslope slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH$_{CaCl}$
Ap1	0-8	10YR 4/4	2, M, SBK	21.0	68.3	10.7	51.3	5.3
Ap2	8-17	7.5YR 4/4	2, F, SBK	23.4	64.8	11.8	17.1	6.1
2Bt1	17-50	10YR 5/6	2, M, SBK to 2, F, SBK	25.9	58.8	15.3	5.34	6.0
2Bt2	50-64	10YR 5/4	2, M, SBK to 2, F, SBK	29.7	58.7	11.6	3.43	4.3
2Bt3	64-90	10YR 6/1	1, M, SBK	34.9	55.9	9.2	2.94	4.0
2Cr	90-150	10YR 5/1	-	26.9	64.1	9.0	4.98	5.1
Ap1	0-8	10YR 4/4	2, M, SBK	21.0	68.3	10.7	51.3	5.3

† 2 = moderate, M = medium, SBK = subangular blocky, F = fine, 1 = weak

Table 33A. Selected physical and chemical properties of Soil Pit #33, Indiana grass cover site, summit slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Ap1	0-15	10YR 4/3	2, F, SBK and 2, M, SBK	21.7	75.7	2.6	33.0	6.1
Ap2	15-28	10YR 4/4	2, F, SBK	23.5	74.4	2.1	16.4	6.0
Bt1	28-56	7.5YR 4/6	2, M, SBK	28.0	70.1	1.9	5.1	4.9
Bt2	56-74	10YR 4/6	2, F, SBK	21.8	70.9	7.3	3.00	4.0
Bt3	74-88	10YR 5/6	2, M, SBK	18.5	63.7	17.8	-	3.9
2Btx	88-100	10YR 5/6	2, M, ABK	22.5	56.3	21.2	1.81	3.9
3Bt1	100-134	2.5YR 4/6	2, F, ABK	42.2	35.0	22.8	1.48	3.9
3Bt2	134-147	7.5YR 5/8	2, M, ABK and 2, F, ABK	38.7	34.1	27.2	1.87	4.0
4Bt	147-168	7.5YR 4/6	2, VF, ABK	32.3	41.2	26.5	1.18	4.2
4Cr	168-182	10YR 6/8	-	27.6	61.7	10.7	1.27	4.2

† 2 = moderate, F = fine, SBK = subangular blocky, M = medium, ABK = angular blocky, VF = very fine

Table 34A. Selected physical and chemical properties of Soil Pit #34, Indiana grass cover site, shoulder slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Ap	0-23	10YR 4/4	2, F, SBK to 2, M, GR	22.3	75.0	2.7	26.2	5.3
Bt1	23-49	10YR 5/6	1, F, SBK	25.0	72.8	2.2	4.92	4.1
Bt2	49-70	10YR 6/6	2, F, SBK	24.9	69.8	5.3	2.00	3.9
Btx1	70-92	10YR 5/6	1, M, PR	20.7	60.2	19.1	1.58	3.9
2Btx2	92-103	10YR 5/6	2, M, PR to 2, M, SBK	26.6	51.0	22.4	1.33	3.9
3Bt3	103-133	10YR 5/6	2, F, SBK to 2, F, ABK	55.4	28.6	16.0	2.18	4.0
3Bt4	133-150	10YR 5/6	2, M, SBK to 2, F, ABK	47.7	31.0	21.3	2.72	4.2
3BC	150-170	10YR 6/6	2, TK, PL	32.8	65.1	2.1	1.30	4.4

† 2 = moderate, F = fine, SBK = subangular blocky, M = medium, GR = granular, 1 = weak, PR = prismatic, ABK = angular blocky, TK = thick, PL = platy

Table 35A. Selected physical and chemical properties of Soil Pit #35, Indiana grass cover site, backslope slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Ap1	0-10	10YR 4/4	1, VC, PL to 2, M, SBK	20.9	75.0	4.1	42.0	5.6
Ap2	10-21	10YR 5/4	2, F, SBK to 2, VF, SBK	23.7	72.0	4.3	15.1	6.4
Bt1	21-39	10YR 4/6	2, M, SBK	22.6	67.7	9.7	3.74	4.6
Bt2	39-54	10YR 5/4	2, M, SBK	20.6	64.9	14.5	1.91	3.9
2Btx1	54-96	10YR 5/4	2, CO, PR to 2, M, SBK	27.9	58.7	13.4	1.49	4.3
2Btx2	96-114	10YR 5/6	1, CO, PR to 2, M, ABK	36.9	45.6	17.5	1.52	4.4
2Bt3	114-143	10YR 5/6	1, CO, PR to 1, M, ABK	31.5	50.4	18.1	1.30	3.9
2Cr	143-183	10YR 5/6	-	31.6	54.8	13.6	1.60	4.3

† 1 = weak, VC = very coarse, PL = platy, 2 = moderate, M = medium, SBK = subangular blocky, F = fine, VF = very fine, CO = coarse, PR = prismatic, ABK = angular blocky

Table 36A. Selected physical and chemical properties of Soil Pit #36, Indiana forest cover site, summit slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Ap	0-13	10YR 4/3	1, VF, SBK and 1, F, SBK	13.1	68.7	18.2	24.5	4.7
BE	13-19	10YR 4/4	1, F, SBK and 1, M, SBK	13.4	70.0	16.6	-	4.5
Bt1	19-44	7.5YR 5/8	2, F, SBK and 2, M, SBK	28.0	59.5	12.5	4.80	4.0
Bt2	44-62	10YR 5/6	2, F, SBK and 2, M, SBK	23.3	58.0	18.7	3.34	3.9
Btx	62-79	10YR 5/6	2, F, PR to 2, M, ABK	20.9	48.0	31.1	2.87	3.8
2Btx	79-95	10YR 5/4	1, M, PR	18.4	47.3	34.3	1.04	3.8
2Cr	95-130	10YR 6/8	MASSIVE	12.7	16.2	71.1	1.16	3.7

† 1 = weak, VF = very fine, SBK = subangular blocky, F = fine, M = medium, 2 = moderate, PR = prismatic, ABK = angular blocky

Table 37A. Selected physical and chemical properties of Soil Pit #37, Indiana forest cover site, shoulder slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Ap	0-10	10YR 3/3	2, F, GR	13.7	66.1	20.2	34.8	4.8
E	10-22	10YR 5/3	1, M, SBK	13.5	66.0	20.5	17.3	4.4
Bt1	22-42	7.5YR 5/6	2, M, SBK	25.8	43.5	30.7	6.97	4.3
2Bt2	42-61	10YR 5/6	2, CO, SBK and 2, M, SBK	18.4	23.2	58.4	2.49	4.1
2Bt3	61-79	10YR 5/6	2, CO, SBK and 2, M, SBK	19.8	21.8	58.4	1.93	4.0
3Bt4	79-102	2.5Y 5/6	2, CO, ABK and 2, M, ABK	54.3	32.2	13.5	3.11	4.0
3BCt	102-123	2.5Y 5/4	1, CO, ABK and 1, M, ABK	45.9	43.7	10.4	4.49	4.0
3Cr	123	5Y 5/2	MASSIVE	34.3	52.1	13.6		4.5

† 2 = moderate, F = fine, GR = granular, 1 = weak, M = medium, SBK = subangular blocky, CO = coarse, ABK = angular blocky

Table 38A. Selected physical and chemical properties of Soil Pit #38, Indiana forest cover site, backslope slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Ap	0-10	10YR 4/3	1, F, GR	13.7	76.8	9.5	31.2	5.1
EB	10-26	10YR 5/4	1, F, SBK and 1, M, SBK	14.5	76.8	8.7	14.3	4.5
Bt1	26-63	7.5YR 5/6	2, CO, SBK and 2, M, SBK	33.6	61.1	5.3	6.12	4.0
2Bt2	63-89	10YR 5/6	2, CO, SBK and 2, M, ABK	47.3	42.7	10.0	4.51	3.9
2BC	89-135	10YR 5/6	2, CO, ABK and 2, M, ABK	33.3	61.0	5.7	2.63	3.9

†1 = weak, F = fine, GR = granular, SBK = subangular blocky, M = medium, 2 = moderate, CO = coarse, ABK = angular blocky

Table 39A. Selected physical and chemical properties of Soil Pit #39, Indiana forest cover site, toeslope slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Ap	0-8	10YR 4/2	1, F, SBK and 1, M, SBK to 2, M, GR	12.2	47.4	40.4	40.3	5.2
E	8-23	10YR 5/3	1, F, SBK	11.5	47.0	41.5	24.2	4.9
Bt1	23-64	7.5YR 5/6	2, M, SBK and 1, F, SBK	23.6	32.4	44.0	3.42	4.0
Bt2	64-79	10YR 5/6	2, M, ABK and 2, F, SBK	27.3	30.4	42.3	2.93	4.0
Bt3	79-100	10YR 5/6	2, M, ABK	27.4	29.2	43.4	2.85	4.0
Bt4	100-142	10YR 5/8	2, CO, ABK and 2, M, ABK	22.1	30.0	47.9	1.92	4.0
Bt5	142	10YR 5/8	2, CO, ABK	22.8	33.3	43.9		4.1

†1 = weak, F = fine, SBK = subangular blocky, M = medium, 2 = moderate, GR = granular, ABK = angular blocky, CO = coarse

Table 40A. Selected physical and chemical properties of Soil Pit #40, Indiana forest cover site, backslope slope position.

Horizon	Depth - cm -	Color Moist	Structure: grade, size, type †	% Clay	% Silt	% Sand	SOC - kg m^{-3} -	pH_{CaCl}
Ap	0-13	10YR 4/4	2, F, SBK and 1, TN, PL	12.8	82.4	4.8	33.9	4.7
BE	13-25	10YR 5/4	2, M, SBK	17.5	78.0	4.5	12.9	4.2
Bt1	25-64	7.5YR 5/6	2, F, SBK and 2, M, SBK	28.9	68.8	2.3	5.21	4.0
2Bt2	64-88	7.5YR 5/6	2, M, ABK	44.1	39.3	16.6	3.04	4.0
2Bt3	88-106	10YR 6/6	2, CO, ABK and 2, M, ABK	58.9	36.7	4.4	4.16	4.0
2BC	106-141	10YR 6/6	2, CO, ABK and 2, M, ABK	55.7	41.7	2.6	3.74	4.1
2Cr	141-160			45.6	47.4	7.0		4.6

†2 = moderate, F = fine, SBK = subangular blocky, 1 = weak, TN = thin, PL = platy, M = medium, ABK = angular blocky, CO = coarse

VITA

Graduate School
Southern Illinois University

Thomas M. Rhanor

tomasverapaz@gmail.com

Southern Illinois University Carbondale
Bachelor of Science in Plant and Soil Science, May 2011

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