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Conservation tillage to effectively reduce interrill erodibility of highly-weathered Ultisols

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Abstract: Highly weathered Southeastern soils traditionally cropped under conventional tillage systems are drought-prone and susceptible to runoff and soil loss. We quantified differences in infiltration, runoff, soil loss, and interrill erodibilities (K_i) for three soils: Compass loamy sand, Decatur silt loam, and Tifton loamy sand managed under conventional- (CT), strip- (ST), and/or no-till (NT) systems with and without a residue cover (rye [*Secale cerale* L.]) (+C/–C) and with and without paratilling (+P/–P). Duplicate plots (1 m^2 [~10 ft^2]) on each tillage treatment received simulated rainfall (50 mm h^{-1} [2 in hr^{-1}] for two hours). Runoff and sediment yields were continuously measured, and K_i values were calculated from measured data. The Water Erosion Prediction Project (WEPP) model was used to extend experimental data to long-term annual trends. For the Compass soil, NT–C plots increased runoff by as much as 43% and sediment yields by as much as 10-fold compared to NT+C plots. The NT+P+C plots decreased runoff by as much as 70% and sediment yields by 24-fold compared to CT–P–C. For the Decatur soil, NT+P plots decreased runoff by as much as 71% and sediment yields by as much as 2.7-fold compared to NT–P plots. The NT+P+C plots decreased runoff by as much as 73% and sediment yields by as much as 11.8-fold compared to CT–P–C. For the Tifton soil, ST+P+C plots decreased runoff by as much as 44% and sediment yields by as much as 2.7-fold compared to CT–P–C plots. Calculated K_i values for the Compass, Decatur, and Tifton soils were 0.37, 0.40, and 0.24, respectively. Residue cover decreased effective interrill erodibilities (K_{ieff}) values by 11%, 2-fold, and 2.6-fold for the Decatur, Tifton, and Compass soils, respectively; Paratilling decreased K_{ieff} values by 3-fold for the Compass and Decatur soils. The NT and/or ST systems had lower K_{ieff} values than K_i values from corresponding CT–P–C treatments (Compass = 4- to 37-fold; Decatur = 4- to 13-fold; Tifton = 2-fold). Converting from a CT to a NT or ST system reduced predicted runoff (Compass = 1.7-fold; Decatur = 10% to 17%; Tifton = 1.6- to 2.3-fold) and sediment yields (Compass = 10- to 12-fold; Decatur = 6- to 33-fold; Tifton = 7.3- to 12.1-fold). The most benefit of NT or ST, as quantified by the maximum difference in 100-year predicted runoff and sediment yields, was for the Compass (78%) and Tifton (75%) soils for runoff and for the Compass (10.3-fold) and Decatur soils (9.7-fold) for sediment. Conservation tillage systems (NT, ST) coupled with surface residue cover and/or paratilling are effective in reducing runoff and sediment yields from highly-weathered soils by lowering effective K_i values.

Key words: best management practices—modeling—runoff—simulated rainfall—soil erosion—WEPP

Highly-weathered Southeastern soils traditionally cropped under conventional tillage systems often have sandy surfaces, are drought-prone, and are susceptible to consolidation and soil loss. Conservation tillage systems coupled with surface residue management and paratilling are effective in reducing runoff and soil loss (Yoo and Touchton 1988; West et al. 1991; Truman et al. 2003, 2005, 2007). These systems accumulate residue and organic carbon at the soil surface with time, which helps dissipate raindrop impact and flowing water energies. Also, increased organics at the soil surface increases aggregate stability and soil resistance; improves infiltration; and decreases soil detachment, sediment transport, and water dispersible clay (Reeves 1997; Shaw et al. 2002; Truman et al. 2005).

Conversely, other studies have shown that less runoff (more infiltration) occurs from conventional-till (CT) systems than from reduced-till systems (Heard et al. 1988; Soileau et al. 1994; Cassel and Wagger 1996), especially one to three years after reduced tillage adoption, mainly due to increased consolidation (NeSmith et al. 1987; Radcliffe et al. 1988). As a result, deep tillage is needed to disrupt dense, water-restrictive subsurface horizons/zones. Paratilling, a non-inversion, deep tillage operation, is often used to reduce consolidation without incorporating surface residues, resulting in increased infiltration and decreased runoff (Clark et al. 1993; Rawitz et al. 1994; Schwab et al. 2002; Truman et al. 2003, 2005).

Because Southeastern soils are susceptible to runoff and soil loss from a wide range of climatic, especially rainfall, and soil surface conditions, management practices such as conservation tillage need to be evaluated on an event and annual basis. We used the Water Erosion Prediction Project (WEPP) model to extend experimental, event-based data to long-term annual trends/observations for three commonly cultivated soils in the Southeast. Using this approach allows us to answer questions such as (1) Do we see the same reduction trends in runoff and erosion experimentally between CT and strip-till/no-till as we do using modeling (WEPP)? (2) Given relative differences in measured runoff and erosion values for CT and strip-till/no-till, what long-term benefits do we obtain via model output with strip-till/no-till?

The WEPP model is a physically based tool designed to simulate/estimate runoff and sediment yields from slope profiles, fields, and small farm-sized watersheds (Flanagan et

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al. 2001). The WEPP model separates interrill and rill detachment (Foster et al. 1995). For short profiles, low slope gradients, and high surface cover conditions, like those quantified in this study, interrill erosion processes will dominate due to low or no excess flow shear stress acting on the soil. Thus, interrill detachment is always greater than or equal to zero and is a function of runoff rate, rainfall intensity, and interrill erodibility (K_i). The WEPP model has been extensively tested and validated, especially for the hillslope version hydrology and erosion components (Zhang et al. 1996; Bjorneberg et al. 1999; Tiwari et al. 2000; Laflen et al. 2004; Zhang 2004).

Understanding the role of maximizing surface residue cover and density reduction by paratillling as part of conservation tillage system management in the Southeast is essential if one is to quantify tillage effects on runoff, soil loss, and interrill erodibilities. Our objectives were to (1) quantify differences in runoff, soil loss, and K_i for three Ultisols managed under CT, strip- (ST), and no-till (NT) systems with and without surface residue cover (+C, –C) and with and without paratilling (+P, –P); and (2) use the WEPP model to extend experimental, event-based data to long-term annual trends/observations. Runoff and sediment yields were measured from 1 m^2 (~10 ft^2) field plots exposed to two hours of simulated rainfall (50 mm h^{-1} [2 in hr^{-1}]); K_i values were calculated for each treatment from measured data.

Materials and Methods

Experimental Sites. The Compass loamy sand (coarse-loamy, siliceous, subactive, thermic, Plinthic Paleudult; slope = 1%) was located at the Alabama Agricultural Experiment Station (AAES) E.V. Smith Research Center near Shorter, Alabama (32°N, 85°W). Details regarding this site have been presented (Reeves et al. 1992, 2000; Truman et al. 2005). The Ap horizon (0 to 20 cm [0 to 8 in]) had a sand (2 to 0.05 mm [0.08 to 0.02 in]) content of 805 g kg^{-1} (~80%) and clay (<0.002 mm [<0.00008 in]) content of 42 g kg^{-1} (~4%). For this study, tillage-residue treatments (established in 1998) evaluated included conventional tillage (CT) without paratilling (P) and without residue cover (CT–P–C), no-till (NT) without paratilling and without cover (NT–P–C), no-till without paratilling and with cover (NT–P+C), and no-till with paratill and cover (NT+P+C). Conventional till consisted of (1) disk, (2) chisel plow, (3) in-row subsoiling, (4) disk, and (5) field cultivate in the spring. The chisel plow was operated at a depth of 15 to 18 cm (6 to 7 in). The paratill (Bigham Brothers, Inc., Lubbock, Texas, USA) had six shanks (61 cm [24 in] spacings), disrupted soil to ~40 cm (~16 in), and had a smooth roller. Residue cover consisted of black oat (*Avena strigosa Schreb.*). For rainfall simulations, black oat residue was mowed and distributed evenly on four plots and was removed from four plots prior to simulating rainfall to simulate a grower baling oat straw after harvest.

The Decatur silt loam (fine, kaolinitic, thermic Rhodic Paledudult; slope = 1%) was located at the AAES Tennessee Valley Research and Extension Center at Belle Mina, Alabama (35°N, 87°W). Details regarding this site have been presented (Schwab et al. 2002; Truman et al. 2003). The Ap horizon (0 to 19 cm [0 to 7.5 in]) had a sand content of 153 g kg^{-1} (~15%) and clay content of 305 g kg^{-1} (~30%). For this study, tillage-residue treatments (established in 1994) evaluated included CT–P–C, NT–P–C, NT–P+C, and NT+P+C. Conventional till consisted of fall disking and chisel plow, followed by spring disking and cultivator leveling. The same paratill described above was used at this site. Residue cover consisted of rye (*Secale cerale* L.), that was killed chemically four weeks prior.

The Tifton loamy sand (fine-loamy, kaolinitic, thermic Plinthic Kandiudult; slope = 3%) was located at the University of Georgia Gibbs Farm Research center near Tifton, Georgia (31°N, 83°W). Details regarding this site have been presented (Bosch et al. 2005; Potter et al. 2006; Truman et al. 2007). The Ap horizon (0 to 25 cm [0 to 10 in]) had a sand content of 820 g kg^{-1} (82%) and clay content of 70 g kg^{-1} (7%). Tillage-residue treatments (established in 1998) evaluated included CT–P–C and ST–P+C. The CT system consisted of fall disking, rye cover, followed by spring disking and cultivator leveling. Rye cover was incorporated about 10 to 15 cm (4 to 6 in) in CT plots. Strip-till consisted of planting a winter rye cover immediately after crop harvest and killing the rye with a chemical burn down treatment about 30 to 40 days before planting the next year's row crop. Residue cover on ST plots was not distributed evenly across the plots. With ST, only the ~15 cm (~6 in) area that the crop is planted into is tilled with the remaining area remaining un-tilled. Residue was distributed over the 55 to 60 cm (~22 to 24 in) wide row middles.

Soil Measurements. Soil samples were taken at selected depths from random locations within each tillage-residue treatment at each site just prior to simulating rainfall. When possible, samples were collected in the immediate vicinity of areas designated for simulated rainfall. Soil properties were determined with the following methods: particle size distribution was measured by the pipette method (Kilmer and Alexander 1949), soil organic carbon was measured by dry combustion (Yeomans and Bremmer 1991), and bulk density was measured by the core method (Blake and Hartge 1986). Soil organic carbon was determined from 10 composite samples (20 mm [0.8 in] diameter core) taken adjacent to rainfall simulation plots. Samples were divided into depth increments of 0 to 1, 1 to 3, 3 to 6, 6 to 12, and 12 to 18 cm (0 to 0.4, 0.4 to 1.2, 1.2 to 2.4, 2.4 to 4.7, and 4.7 to 7.1 in depth) for the Compass loamy sand and Decatur silt loam and increments of 0 to 2 and 2 to 8 cm (0 to 0.8 and 0.8 to 3 in) depths for the Tifton loamy sand. Samples were cleaned of recognizable organic debris, and sub-samples were finely ground on a roller mill (Kelly 1994). Sub-samples were analyzed for C by automated combustion using a NA 1500 NCS analyzer (Fisons Instruments Inc., Beverly, Massachusetts 01915). Bulk density was determined from samples (5.4 cm [2.1 in] diameter cores) taken from three locations within each treatment combination immediately adjacent to areas designated for rainfall simulations. Bulk densities were determined at 0 to 15 (0 to 6 in), 15 to 30 (6 to 12 in), and 30 to 45 (12 to 18 in) cm depth intervals for the Compass loamy sand and Decatur silt loam and 7.5 cm (3 in) increments down to a depth of 30 cm (12 in) for the Tifton loamy sand. Soil water content was determined gravimetrically (Gardner 1986) prior to each rainfall simulation event from samples taken from at least three locations in the immediate vicinity around each rainfall simulation plot and separated into 0 to 1, 1 to 3, 3 to 6, 6 to 12, and 12 to 18 cm (0 to 7 in) depth increments. Soil property data for each soil and tillage treatment are given in table 1.

Rainfall Simulations. For the Compass loamy sand and Decatur silt loam, duplicate 1 m^2 (~10 ft^2) plots were randomly established on one replicate of each tillage-residue treatment combination (July 1999 for the Compass loamy sand; June 2000 for the Decatur silt loam) prior to planting and were considered replicates. For the Tifton loamy sand, duplicate 1 m^2 plots were randomly established on each tillage-residue treatment (May 2002) prior to planting and were also considered replicates. Plots were 1 m (3.3 ft) wide by 1 m long by 10 cm (4 in) tall. Each 1 m^2 plot had an aluminum collection trough on the down-slope end of each plot. An area surrounding each plot was treated like the test area to allow soil material to be splashed in all directions. Simulated rainfall was applied to each 1 m^2 plot (target intensity = 50 mm h^{-1} [2 in hr^{-1}] for 1 hour). One hour after the end of the first 60-minute simulated rainfall event, each 1 m^2 plot received an additional simulated rainfall event (50 mm h^{-1} for 1 hour). Rainfall was applied with an oscillating nozzle rainfall simulator (Truman et al. 2007) that used 80100 Veejet nozzles (median drop size = 2.3 mm [0.09 in]). Rainfall volumes were measured for each 1-hour rainfall event on each plot. The simulator was placed 3 m (10 ft) above each 1 m^2 plot. Well water was used in all simulations at all sites (pH range = 7.4 to 7.7; EC range = 0.17 to 0.20 dS m^{-1}).

Runoff (*R*) and soil loss (*E*) from each 1 m^2 (~10 ft^2) plot were measured continuously at 5-minute intervals during each simulated rainfall event. Runoff and *E* were collected in tared, 1 L (0.27 gal) autoclaveable Nalgene bottles. Bottles were weighed (bottle + water + sediment), dried (105°C [221°F], 24 h), and then weighed again (bottle + sediment). Runoff and *E* were determined gravimetrically, and infiltration (*INF*) was calculated by difference (rainfall–runoff). After simulating rainfall (2 hours), all identifiable non-decomposed surface residue from each 1 m^2 plot was collected, dried at 80°C (176°F) for 72 hours, cleaned of soil particles, and weighed.

Interrill Erodibility. Interrill erodibility was calculated from two equations:

$$E = K_i \times I_2, \quad (1)$$

where *E* = interrill steady-state erosion rate, K_i = interrill erodibility, and *I* = rainfall intensity (Meyer and Harmon 1989; Truman and Bradford 1993, 1995); and

$$E = K_i \times I \times q, \quad (2)$$

where *q* = steady-state runoff discharge (Flanagan and Nearing 1995). In equation 1, the exponent on the intensity term generally is close to 2 (0.9 to 2.2) for most soils and relates to intrinsic soil properties and whether detachment- and/or transport-limiting conditions exist. Equation 2, currently used in the WEPP model, evolved from the need for a detachment (*I*) and transport (*q*) term to describe interrill erodibility. Effective interrill erodibility (K_{ieff}) and effective interrill erodibility for steady-state runoff discharge (K_{iqeff}) values were calculated for NT and ST treatments with appropriate soil loss and runoff values from those respective treatments.

WEPP Description and Application. The WEPP model simulates runoff and sediment yields from multiple sized areas (Flanagan et

Table 1
Selected soil property data for each soil and tillage treatment.

Treatment†	Properties* BD (g cm^{-3})	SOC_1 (g kg^{-1})	SOC_3 (g kg^{-1})	Residue cover (kg ha^{-1})
Compass loamy sand (Typic Hapludult)				
NT+P+C	1.29 (01)‡	0.82 (09)	0.52 (03)	8,500 (05)
NT–P+C	1.64 (03)	1.46 (03)	1.09 (02)	9,630 (09)
NT–P–C	1.60 (04)	1.09 (01)	0.69 (01)	2,910 (25)
CT–P–C	1.45 (02)	0.62 (09)	0.53 (10)	110 (13)
Decatur silt loam (Rhodic Paleudult)				
NT+P+C	1.31 (10)	1.37 (03)	1.25 (01)	3,999 (25)
NT–P+C	1.44 (04)	2.58 (03)	1.25 (06)	4,438 (14)
NT–P–C	1.43 (08)	1.71 (01)	1.05 (01)	2,393 (16)
CT–P–C	1.54 (05)	0.94 (03)	0.90 (01)	927 (05)
Tifton loamy sand (Plinthic Kandiudult)				
ST–P+C	1.58 (04)	0.84 (20)	0.54 (20)	4,000 (32)
CT–P–C	1.30 (02)	0.48 (14)	0.51 (17)	0§ (00)

* BD = bulk density (0 to 15 cm for Compass loamy sand; 0 to 15 cm for Decatur silt loam; 0 to 7.5 cm for Tifton loamy sand). SOC_1 = mean soil organic carbon values. For the Compass loamy sand and Decatur silt loam, SOC_1 refers to the 0 to 1 cm soil depth, but for Tifton loamy sand SOC_1 refers to the 0 to 2 cm depth. SOC_3 = mean soil organic carbon values. For the Compass loamy sand and Decatur silt loam, SOC_3 refers to the 1 to 3 cm soil depth, but for the Tifton loamy sand, SOC_3 refers to the 2 to 8 cm depth. Residue cover (dry weights) is from a 1 m^2 area after both rainfall simulation events.

† NT = no-till. ST = strip-till. CT = conventional-till. P = paratill. C = residue cover.

‡ Values in parentheses are coefficients of variation (%).

§ CT–P–C for Tifton loamy sand had no surface residue cover (clean tilled).

Table 2
Calculated baseline WEPP soil erodibility input parameters.

Soil	Tillage*	$K_i \times 10^{-6}$† (kg s m^{-4})	Slope adjusted $K_i \times 10^{-6}$ (kg s m^{-4})	K_r (s m^{-1})	T_c (Pa)
Compass loamy sand	CT–P–C	4.373	0.564	0.0088	2.66
(Plinthic Paleudult)	NT–P+C	4.373	0.564	0.0038	2.66
	NT+P+C	4.373	0.564	0.0063	2.66
Decatur silt loam	CT–P–C	3.650	0.471 to 0.712	0.0072	3.50
(Rhodic Paleudult)	NT–P+C	3.650	0.471 to 0.712	0.0072	3.50
	NT+P+C	3.650	0.471 to 0.712	0.0072	3.50
Tifton loamy sand	CT–P–C	5.513	0.711 to 1.075	0.0148	2.28
(Plinthic Kandiudult)	ST–P+C	5.513	0.711 to 1.075	0.0090	2.28
	ST+P+C	5.513	0.711 to 1.075	0.0111	2.28

* NT = no-till. CT = conventional-till. ST = strip-till. P = paratill. C = surface residue cover.

† K_i = interrill erodibility. K_r = rill erodibility. T_c = critical shear stress.

al. 2001) and includes precipitation, precipitation partitioning, soil detachment, sediment transport, and sediment deposition. In a continuous simulation mode, WEPP predicts plant growth, residue decomposition, tillage disturbance, and subsequent consolidation effects on soil properties, soil water balance, etc. (Flanagan and Nearing 1995; Flanagan et al. 2001). The WEPP model consists of the following major components: hydrology, erosion, cropland plant growth, and climate generator. A brief description of each component is given below.

The hydrology component computes infiltration, runoff, soil evaporation, plant transpiration, soil water percolation, plant and residue interception of rainfall, depressional storage, and soil profile drainage by subsurface tiles (Savabi and Williams 1995). The hydrology component of the WEPP model significantly affects erosion prediction because of hydraulic shear-erosion interactions (Laflen et al. 1991). WEPP uses a Green-Ampt Mein-Larson calculation (Mein and Larson 1973), modified for unsteady rainfall by Chu (1978) to compute infiltration and rainfall excess (Stone et al. 1995). An important input parameter for infiltration and runoff predictions is the effective hydraulic conductivity (Alberts et al. 1995; Flanagan and Livingston 1995). This baseline value for freshly tilled, bare soils is adjusted for soil consolidation, crusting, residue cover, canopy, etc. on a daily basis through the simulation period (Flanagan et al. 2001). Effective hydraulic conductivity can also be estimated via default parameterization equations within the WEPP model based on soil textural information (Alberts et al. 1995).

The erosion component predicts soil erosion with a steady-state sediment continuity equation, with separate source terms for interrill and rill detachment (Foster et al. 1995). Interrill detachment is a function of runoff, soil characteristics, rainfall intensity, and an interrill erodibility term (K_i). Erosion processes in a rill can be either positive (detachment when sediment load is less than sediment transport capacity and flow shear stress is greater than critical shear stress), negative (deposition when sediment load is greater than sediment transport capacity), or zero (transport only, for all other cases). Rill detachment is a function of excess flow shear stress, with two parameters, rill erodibility and a critical shear stress term. Baseline erodibility parameters and critical

Table 3
Crop and tillage management information for WEPP simulations.

Tillage	Date	Operation
Shorter, Alabama (Compass loamy sand)		
CT	March 27	Disk, tandem finishing
	March 28	Field cultivator
	April 1	Plant cotton, planter, double disk openers
	May 15	Row cultivate
	Sept. 20	Harvest cotton
	Sept. 21	Disk, offset
	Sept. 22	Chisel plow with coulters and straight points
NT-P	March 1	Kill oats cover crop
	April 1	Plant cotton, planter, no-till with smooth coulters
	Sept. 20	Harvest cotton
	Sept. 23	Plant oats, drill, no-till
NT+P	March 1	Kill oats cover crop
	April 1	Plant cotton, planter, no-till with smooth coulters
	Sept. 20	Harvest cotton
	Sept. 22	Paraplow
	Sept. 23	Plant oats, drill, no-till
Belle Mina, Alabama (Decatur silt loam)		
CT	March 27	Disk, tandem finishing
	March 28	Field cultivator
	April 1	Plant cotton, planter, double disk openers
	May 15	Row cultivate
	Sept. 20	Harvest cotton
	Sept. 21	Disk, offset
	Sept. 22	Chisel plow with coulters and straight points
NT-P	March 1	Kill rye cover crop
	April 1	Plant cotton, planter, no-till with smooth coulters
	Sept. 20	Harvest cotton
	Sept. 23	Plant rye cover crop, drill, no-till
NT+P	March 1	Kill rye cover crop
	April 1	Plant cotton, planter, no-till with smooth coulters
	Sept. 20	Harvest cotton
	Sept. 22	Paraplow
	Sept. 23	Plant rye cover crop, drill, no-till
Tifton, Georgia (Tifton loamy sand)		
CT	March 1	Kill rye cover crop
	March 28	Disk with 100% residue burial
	March 29	Field cultivate
	April 1	Plant cotton, planter, double disk openers
	May 15	Row cultivate
	Sept. 20	Harvest cotton
	Sept. 21	Disk, offset
	Sept. 23	Plant rye cover crop, drill, conventional
ST-P	March 1	Kill rye cover crop
	April 1	Plant cotton, planter, strip-till w/row cleaning disks
	Sept. 20	Harvest cotton
	Sept. 23	Plant rye cover crop, drill, no-till
ST+P	March 1	Kill rye cover crop
	April 1	Plant cotton, planter, strip-till w/row cleaning disks
	Sept. 20	Harvest cotton
	Sept. 22	Paraplow
	Sept. 23	Plant rye cover crop, drill, no-till

Notes: NT = no-till. CT = conventional-till. ST = strip-till. P = paratill. C = surface residue cover.

shear stress are for a freshly tilled soil condition with no residue cover. Daily adjustments are then made to each parameter as a function of soil, residue, and plant conditions (Alberts et al. 1995).

The cropland plant growth component is based on that of the EPIC model (Williams et al. 1989) and uses daily accumulated heat units and photosynthetic active radiation for estimating biomass production and a harvest index for dividing biomass at harvest between grain and residue. Crop growth parameters (canopy height/cover, leaf area index) are all functions of above ground live biomass (Arnold et al. 1995).

Input files needed to run the WEPP model include climate, soil, slope, crop and land management, and irrigation. Simulated climates (100 y) were generated with CLIGEN v. 5.2 at each of the three locations. WEPP simulates irrigation based on soil water depletion. In all simulations, irrigation was scheduled to keep crops growing. Irrigation amounts ranged from 12 to 50 mm (0.5 to 2 in) (rate = 5 mm h^{-1} [0.2 in hr^{-1}]) between May 10th and August 20th of each year. Irrigation application depth ratio was 1.3 (ratio of application depth to amount of water needed to fill soil profile to field capacity); maximum depletion ratio was 0.5 (maximum value for the ratio of available soil water depletion to available water holding capacity or the depletion ratio at which irrigation will occur). Nozzle impact energy was 0.25 (compared to natural rainfall). Baseline erodibilities and critical shear stress were calculated using site-measured soil properties for each treatment and appropriate WEPP model equations (Flanagan and Nearing 1995) (table 2). Baseline hydraulic conductivity was computed within the WEPP model based on input soil textural information.

Crop rotation/management systems utilized for the three sites are shown in table 3. Model simulations (100 y) with WEPP v. 2006.5 were conducted for each site and each management system. Slope gradient and length combinations simulated included 2% gradient and 35, 50, and 200 m (115, 164, 656 ft) lengths for the Compass loamy sand; 2% and 5% gradients and 50, 60, and 300 m (164, 197, 984 ft) lengths for the Decatur silt loam; and 2% and 5% gradients and 40, 50, and 175 m (131, 164, 574 ft) lengths for the Tifton loamy sand. These combinations

Figure 1

Mean runoff rates (mm h^{-1}) for each soil and tillage treatment during the two hours of simulated rainfall (I = 50 mm h^{-1}). Bars represent standard error values associated with each corresponding mean.

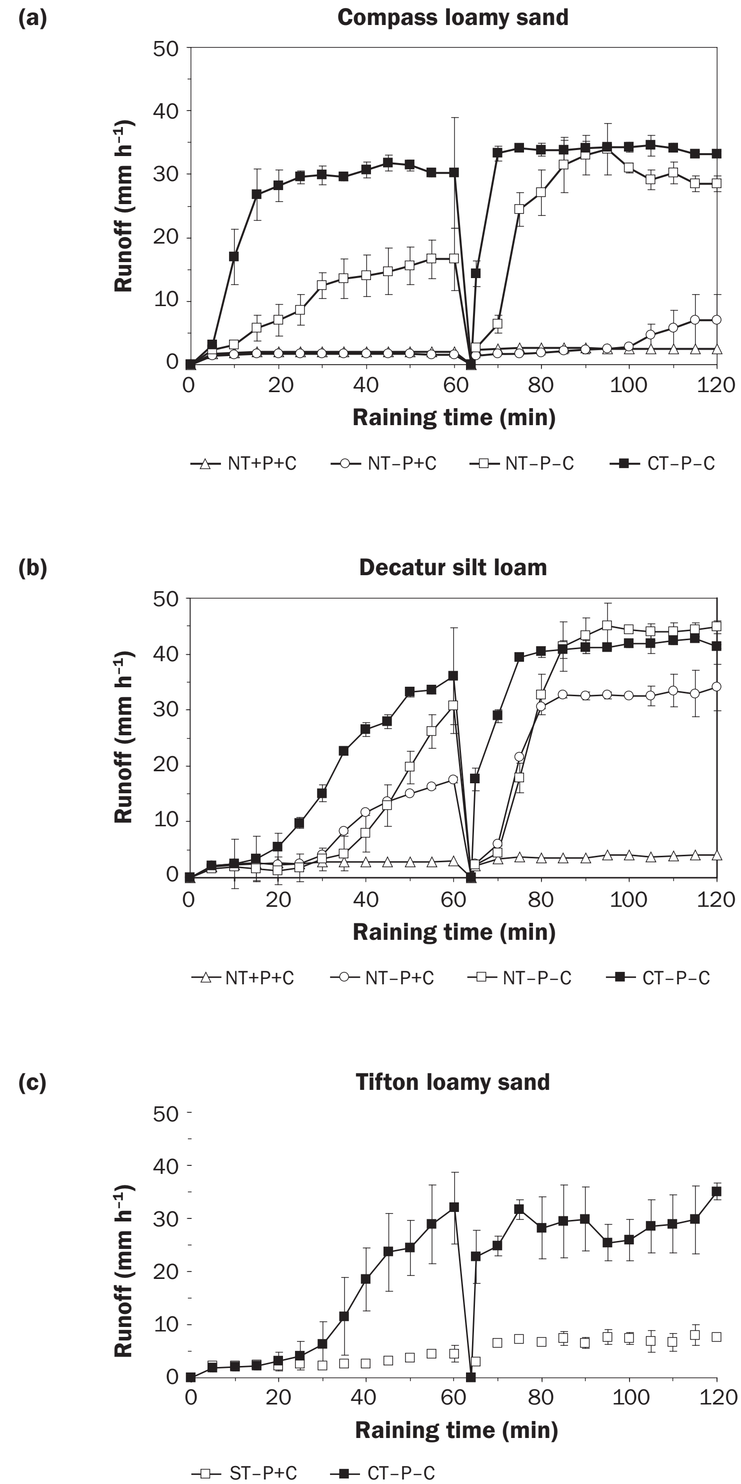
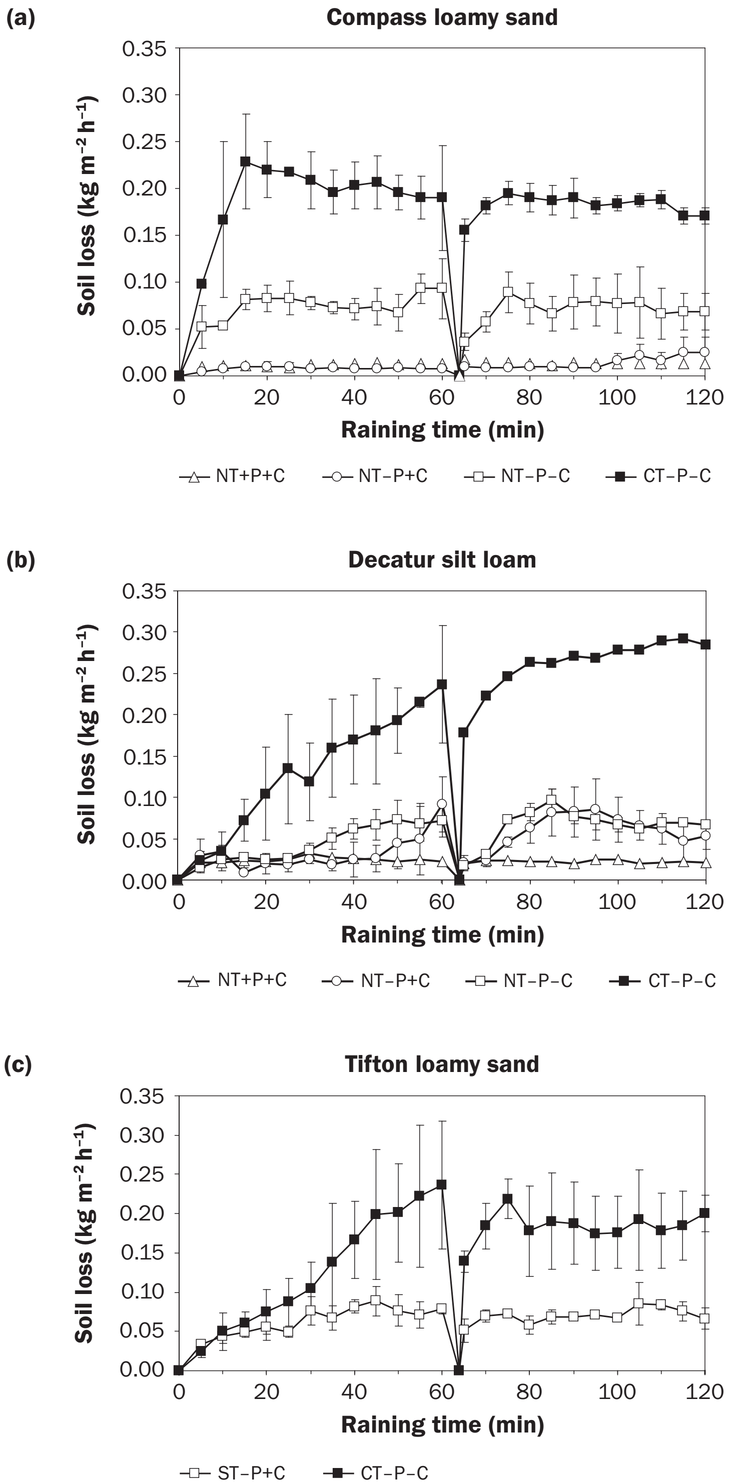


Figure 2
Mean soil loss rates (kg m⁻² h⁻¹) for each soil and tillage treatment during the two hours of simulated rainfall (*I* = 50 mm h⁻¹). Bars represent standard error values associated with each corresponding mean.



represent typical field lengths and slopes on which these soils occur.

Statistics. Means, coefficient of variations (CV), and standard error bars (figures 1 and 2) are given for measured data. Unpaired *t*-tests were performed (two-tailed distribution) to determine significance among treatment means. The probability level used in evaluating the test statistics was p = 0.05. Regression analysis was used to determine relationships between dependent and independent variables. Data analysis was conducted with corresponding functions in Microsoft Office Excel 2003.

Results and Discussion

We quantified K_i values calculated from measured runoff and sediment losses and the decrease in effective interrill erodibility (K_{ieff}) values associated with each imposed conservation tillage system. We then used the WEPP model to extend experimental, event-based data to long-term annual trends/observations for three soils. Using this approach, we answered the questions: (1) Do we see the same reduction trends in runoff and erosion experimentally between CT and ST/NT as we simulate using a modeling approach (WEPP)? (2) Given relative differences in measured runoff and erosion values for CT and ST/NT, what long-term benefits do we obtain via model simulation with ST/NT?

Compass Loamy Sand and Decatur Silt Loam. Infiltration (*INF*), runoff (*R*), and sediment yields (*E*) for the Compass and Decatur soils have been presented by Truman et al. (2005) and Truman et al. (2003), respectively. Briefly, for the Compass loamy sand, NT–C plots increased *R* and decreased *INF* by as much as 43% (table 4, figure 1a) and increased *E* by as much as 10-fold compared to NT+C plots (table 5, figure 2a). The NT+P+C plots decreased *R* and increased *INF* by as much as 70% and decreased *E* by 24-fold compared to CT–P–C. Also, *R* decreased with increased surface residue cover (r^2 = 0.97); *E* subsequently increased with increased *R* (r^2 = 0.89). Thus, sediment was mostly controlled by runoff transportability (transport-limiting).

For the Decatur silt loam, NT+P plots decreased *R* and increased *INF* by as much as 71% (table 4, figure 1b) and decreased *E* by as much as 2.7-fold compared to NT–P plots (table 5, figure 2b). The NT+P+C plots decreased *R* and increased *INF* by as much as 73% and decreased *E* by as much

Table 4
Infiltration and runoff values from each soil and tillage treatment.

Treatment†	Parameter* w (%)	INF_{60} (mm h^{-1})	INF_{120} (mm h^{-1})	R_{60} (mm h^{-1})	R_{120} (mm h^{-1})	R_{max} (mm h^{-1})
Compass loamy sand (Plinthic Paleudult)						
NT+P+C	13	54 (01) [96]‡	56 (01) [97]	2 (06) [04]	2 (06) [03]	3 (15)
NT–P+C	14	47 (01) [96]	46 (02) [94]	2 (13) [04]	3 (33) [06]	7 (56)
NT–P–C	14	46 (03) [81]	31 (03) [54]	11 (11) [19]	26 (04) [46]	35 (09)
CT–P–C	8	17 (09) [39]	12 (07) [27]	27 (06) [61]	32 (03) [73]	35 (03)
Decatur silt loam (Rhodic Paleudult)						
NT+P+C	7	47 (03) [94]	47 (02) [92]	3 (28) [06]	4 (25) [08]	4 (13)
NT–P+C	10	31 (17) [78]	16 (27) [32]	9 (13) [22]	34 (01) [68]	45 (03)
NT–P–C	10	21 (18) [72]	7 (33) [21]	8 (28) [28]	27 (11) [79]	34 (13)
CT–P–C	1	14 (05) [44]	9 (01) [19]	18 (02) [56]	38 (01) [81]	43 (01)
Tifton loamy sand (Plinthic Kandiudult)						
ST–P+C	2	46 (01) [94]	43 (03) [86]	3 (01) [06]	7 (08) [14]	9 (09)
CT–P–C	2	42 (14) [76]	20 (24) [42]	13 (32) [24]	28 (13) [58]	36 (07)

* w = gravimetric water content (0 to 1 cm); INF_{60} and INF_{120} are infiltration rates for the 55- to 60- and 115- to 120-minute time periods, respectively. R_{60} and R_{120} are runoff rates for the 55- to 60- and 115- to 120-minute time periods, respectively. R_{max} values are the maximum 5-minute runoff rate obtained during each 120-minute rainfall simulation.

† NT = no-till. CT = conventional-till. ST = strip-till. P = paratill. C = residue cover.

‡ Values in parentheses are coefficients of variation (%). Values in brackets are the percent of rainfall that was runoff or infiltration.

as 11.8-fold compared to CT–P–C. Also, R and E were more correlated to paratilling (r^2 = 0.82; r^2 = 0.94) than the negative correlation for R and E versus residue cover (r^2 = 0.40; r^2 = 0.55). Residue cover and paratilling (dominant) reduced R and E, albeit in differing amounts, by reducing soil detachment and sediment transport via dissipating raindrop impact energy, limiting surface seal development, and consolidation reduction.

Tifton Loamy Sand. The ST–P+C plots decreased R and increased INF as much as 44% compared to CT–P–C plots (p = 0.05 to 0.003) (table 4, figure 1c). Runoff maximum values were 4-fold greater for CT–P–C plots than for ST–P+C plots (p = 0.009). Runoff rates for CT–P–C plots increased sharply to steady-state rates; conversely, runoff rates for ST–P+C plots gradually increased throughout the first 60 minutes then reached steady-state rates during the second 60 minutes of simulated rainfall.

Soil loss from the Tifton loamy sand was affected by the presence of surface cover (table 5, figure 2c). The ST–P+C plots decreased total soil loss amounts for the 0 to 60 minute and 60 to 120 minute rainfall simulations as much as 2.7-fold compared to CT plots (p = 0.06). Maximum and steady-state soil loss rates for CT–P–C plots were 2.3-fold greater than for ST–P+C plots (p = 0.01). Soil loss rates for CT–P–C plots increased sharply for the first 60 minutes, and then reached steady-state rates; conversely, E rates for ST–P+C plots increased during first 30 minutes, and then reached steady-state rates.

Residue cover protects part of the soil surface, reduces this soil's susceptibility to surface sealing, maintains INF, and limits R and E (transport). Unlike the Compass loamy sand, residue cover on ST plots of the Tifton loamy sand was not distributed evenly across plots. With ST, only the 15 to 20 cm (6 to 8 in) area that the crop is planted into is tilled, with the remaining area remaining un-tilled (residue distributed over a 55 to 60 cm [22 to 24 in] wide area). Similar to the Compass soil, R and E were inversely proportional to residue cover; E increased with R. Also, sediment yields were controlled mostly by the transport capacity of R and the transportability of the sand fraction of the Ap horizon. About 45% of the sand fraction in the Ap horizon (top 30 cm [12 in]) of the Tifton loamy sand was either medium, coarse, or very coarse sand (Perkins 1987). These materials are easily detached, yet require energy to be transported. Small changes in transport capacity (runoff) enhance sediment deposition, impacting overall sediment lost.

Interrill Erodibility. Differences in INF, R, and E as a result of different tillage systems affected interrill erodibility (K_i) and interrill erodibility of steady-state runoff discharge (K_{iq}) and effective interrill erodibility (K_{ieff}, K_{iqeff}) values (table 5). Calculated K_i values are given to describe experimental soil loss values and support model results. Calculated K_{iq} and K_{iqeff} values ($E = K_i \times I \times q$, currently used in WEPP model) would theoretically be superior to calculated K_i and K_{ieff} values ($E = K_i \times I^2$) in highly-weathered, sandy soils because of the separate transport term that would more accurately describe the sand fraction transport from these soils. However, this was not the case as K_{iq} and K_{iqeff} values were numerically greater than K_i and K_{ieff} values; yet K_i and K_{ieff} values clearly did a better job representing trends (decrease) in measured soil loss ($E_{s/s}$) values among CT and NT or ST tillage systems and soils than did K_{iq} and K_{iqeff} values. Differences or discrepancies in trends for K_{iq} and K_{iqeff} values were due to simultaneous rate of change in steady-state runoff discharge and soil loss values among CT and NT or ST tillage systems and soils. This is evident in all treatments for all soils, and especially for the Tifton loamy sand (K_{iq} = 0.43, K_{iqeff} = 0.72. Note that soil loss decreased in the ST treatments. The remaining discussion on interrill erodibility will focus on K_i and K_{ieff} values.

Calculated K_i values ($E = K_i \times I^2$) from measured E values (CT–P–C treatment) for the Compass, Decatur, and Tifton soils were 0.37, 0.40, and 0.24 (table 5). These values are relatively low compared to other published K_i values (1 to 4.25) (Elliot et al. 1989; Liebenow et al. 1990). In Elliot and Liebenow's database, the Tifton loamy sand

Table 5
Soil loss and interrill erodibility values from each soil and tillage treatment.

	Parameter*					$K_i \times 10^{-6}$			
Treatment†	w (%)	E_{60} (g)	E_{120} (g)	E_{max} (kg m^{-2} h^{-1})	$E_{s/s}$ (kg m^{-2} h^{-1})	K_i (kg s m^{-4})	K_{ieff} (kg s m^{-4})	K_{iq} (kg s m^{-4})	K_{iqeff} (kg s m^{-4})
Compass loamy sand (Plinthic Paleudult)									
NT+P+C	13	12 (22)‡	14 (01)	0.02 (03)	0.01		0.01		0.26
NT–P+C	14	8 (04)	11 (39)	0.03 (56)	0.02		0.03		0.27
NT–P–C	14	78 (12)	71 (30)	0.11 (15)	0.07		0.08		0.15
CT–P–C	8	194 (14)	181 (06)	0.25 (13)	0.20	0.37		0.49	
Decatur silt loam (Rhodic Paleudult)									
NT+P+C	7	24 (18)	22 (11)	0.03 (17)	0.02		0.03		0.35
NT–P+C	10	39 (48)	59 (35)	0.09 (36)	0.07		0.09		0.11
NT–P–C	10	45 (24)	65 (07)	0.09 (15)	0.07		0.1		0.15
CT–P–C	1	137 (29)	261 (01)	0.31 (01)	0.28	0.4		0.48	
Tifton loamy sand (Plinthic Kandiudult)									
ST–P+C	2	64 (18)	70 (04)	0.11 (02)	0.08		0.12		0.72
CT–P–C	2	130 (37)	191(15)	0.25 (28)	0.18	0.24		0.43	

* w = gravimetric water content (0 to 1 cm). E_{60} and E_{120} are total soil loss amounts for the 0- to 60-minute and 60- to 120-minute rainfall simulations. E_{max} and $E_{s/s}$ are maximum and steady-state soil loss rates for each 120-minute rainfall simulation. K_i and K_{iq} values are interrill erodibilities (CT treatments only). K_{ieff} and K_{iqeff} values are effective interrill erodibilities (NT/ST treatments). K_i and K_{ieff} values calculated from measured data with the equation $E = K_i \times I^2$. K_{iq} and K_{iqeff} values calculated from measured data with the equation $E = K_i \times I \times q$.

† NT = no-till. CT = conventional-till. ST = strip-till. P = paratill. C = residue cover.

‡ Values in parentheses are coefficients of variation (%).

and Bonifay sand had K_i values of 0.77 and 0.87, respectively—about 2-fold larger than those calculated for the Compass and Tifton loamy sands in this study. However, K_i values reported by Elliot et al. (1989) and Liebenow et al. (1990) were for furrowed/ridged interrill plots, whereas plots in this study were relatively flat, level-sloping seedbed-type plots. Truman and Bradford (1993) reported a 3-fold difference in K_i values for the Cecil soil when comparing flat (K_i = 0.35) to ridged (K_i = 1.01) plots. Baseline and slope adjusted (plot configuration) K_i values for the three soils evaluated in this study are given in table 2.

A purpose of this study was to quantify K_i values and the decrease in K_i values (expressed as K_{ieff} values) associated with each tillage system. For all soils, conservation tillage systems (NT and/or ST) had lower K_{ieff} values (range = 0.01 to 0.12) compared to K_i values from corresponding CT–P–C treatments (by at least 4.6 fold for the Compass loamy sand, 4 fold for the Decatur silt loam, and 2 fold for the Tifton loamy sand). Although the ST treatment (Tifton) has ~20% of its land area in a relatively bare (~80% of the land area has surface residue cover), tilled condition, this treatment still effectively reduced K_i values by 2 fold when compared to the CT treatment. The NT+P+C (Compass, Decatur) and ST–P+C (Tifton) treatments had the lowest K_{ieff} values. Residue cover decreased K_{ieff} values by 11%, 2-fold, and 2.6-fold for the Decatur, Tifton, and Compass soils, respectively. Paratilling decreased K_{ieff} values by 3-fold for the Compass and Decatur soils. Compared to CT plots, conservation tillage (NT, ST) was effective in reducing K_i values for the Compass (37-fold), Decatur (13-fold), and Tifton (2-fold) soils, indicating that conservation tillage was effective in all three soils and was most effective for the Compass loamy sand.

WEPP Model Simulation Results. The WEPP 100-year simulation results for selected soil tillage–slope gradient–slope length combinations are presented in table 6. Only the CT–P–C, NT+P+C, and/or ST+P+C are given (ST–P+C, ST+P+C, NT–P+C, NT+P+C treatments are not shown). Also, all paratilling treatments shown are for paratilling every other year. Simulations did not show any apparent benefit to paratilling. This is not surprising because effects of deep-loosening tools such as paratilling on *INF* (and *R*, *E*) are currently poorly represented in the model.

For the Compass loamy sand, switching from a CT to a NT system reduced predicted *R* by ~1.7-fold and *E* by 10- to 12-fold. Conventional till and NT treatment combinations simulated each had similar results for predicted *R* (63 to 83 mm [2.5 to 3.3 in] for CT–P–C; 36 49 mm [1.4 to 1.9 in] for NT+P+C) and *E* (3.8 to 4.2 t ha^{-1} [3,393 to 3,750 lb ac^{-1}] for CT–P–C; 0.3 to 0.4 t ha^{-1} [268 to 357 lb A^{-1}] for NT+P+C). Runoff and *E* losses tended to decline with increased slope length. It is likely that for this simulation scenario most soil detachment is occurring in interrill areas with some deposition in concentrated flow channels. Sediment transport capacity of the flow controls sediment yields (transport limited, not detachment limited). Values of K_i used in WEPP simulations were as follows: baseline K_i = 4.37 (table 2); slope adjusted K_i = 0.56 (table 2); minimum K_i used over the 100-year simulation = 0.11; and maximum K_i used over the 100-year simulation = 1.91 for CT–P–C and 0.13 for NT+P+C (14-fold difference between maximum adjusted K_i values for CT and NT treatments). These values are comparable to calculated K_i and K_{ieff} values from measured data in this study for CT–P–C and NT+P+C treatments (table 5) (37-fold difference).

For the Decatur silt loam, converting from a CT to a NT system reduced predicted *R* by 10% to 17% and *E* by 6- to 33-fold. Conventional till and NT treatment combinations simulated each had similar results for predicted *R* (288 to 332 mm [11 to 13 in] for CT–P–C, 263 to 284 mm [10 to 11 in] for NT+P+C). Predicted *E* for each CT and

Table 6
Average annual WEPP model results (runoff, sediment yields) from 100-year runs.

Parameter	Compass loamy sand			Decatur silt loam			Tifton loamy sand		
	CT–P–C	NT+P+C	Difference	CT–P–C	NT+P+C	Difference	CT–P–C	ST+P+C	Difference
	Slope: 2%; L = 35 m			**Slope: 2%; L = 50 m**			Slope: 2%; L = 40 m		
Runoff (mm)	83	49	1.7×	323	279	1.2×	110	66	1.7×
Sediment (t ha^{-1})	4.2	0.4	10×	18.5	1.9	9.7×	8.0	1.1	7.3×
	Slope: 2%; L = 50 m			Slope: 2%; L = 60 m			**Slope: 2%; L = 50 m**		
Runoff (mm)	80	45	1.8×	321	277	1.2×	107	61	1.8×
Sediment (t ha^{-1})	4.1	0.4	10×	19.2	1.9	10×	7.8	1.0	7.8×
	Slope: 2%; L = 200 m			Slope: 2%; L = 300 m			Slope: 2%; L = 175 m		
Runoff (mm)	63	36	1.8×	288	263	1.1×	76	33	2.3×
Sediment (t ha^{-1})	3.8	0.3	12×	48.5	1.6	30×	5.7	0.5	11×
				Slope: 5%; L = 60 m			Slope: 5%; L = 40 m		
Runoff (mm				332	284	1.2×	118	75	1.6×
Sediment (t ha^{-1})				66.1	2.0	33×	18.3	2.2	8.3×
				Slope: 5%; L = 300 m			Slope: 5%; L = 175 m		
Runoff (mm)				305	265	1.2×	93	43	2.2×
Sediment (t ha^{-1})				231.0	3.7	62×	17.0	1.4	12×

Notes: CT = conventional-till. P = paratill (All "P" designations are for paratilling every other year). C = residue cover. NT = no-till. ST = strip-till. L = length. Use of bold shows when the slopes and lengths are similar for all three soils.

NT treatment combination was more variable, especially as slope gradient and length changed. Predicted *R* and *E* from CT and NT treatments on the Decatur silt loam were greater than corresponding predicted values of the other two loamy sand soils, mainly due to a finer texture and decreased effective hydraulic conductivity. At 2% slope, predicted *R* from CT and NT treatments decreased by 11% and 6% when going to the longest (300 m [984 ft]) slope length evaluated. For CT, higher predicted *R* causes increased shear stress, rill soil detachment, and rill sediment transport—and subsequently, higher predicted *E* (2.6-fold) (slope length = 300 m [984 ft]). For NT, interrill erosion processes dominated. Thus, at 2% slope, predicted *R* decreased by 6% while predicted *E* decreased by 18% (slope length = 300 m [984 ft]). At 5% slope, predicted *R* from the CT treatment decreased by 9% while predicted *E* increased 3.5-fold. This simulation scenario is most likely due to the shear stress acting at the soil surface exceeding the critical shear at points throughout the profile, causing predicted rill soil detachment and sediment transport. Values of K_i used in WEPP simulations were as follows: baseline K_i = 3.65 (table 2); slope adjusted K_i = 0.47 to 0.71 (table 2); minimum K_i used over the 100 year simulation = 0.13; and maximum K_i used over the 100-year simulation = 2.72 for CT–P–C and 0.26 for NT+P+C (10-fold difference between maximum adjusted K_i values for CT and NT treatments). These values are comparable to calculated K_i and K_{ieff} values from measured data in this study for CT–P–C and NT+P+C treatments (table 5) (13.3-fold difference).

For the Tifton loamy sand, converting from a CT–P to a ST+P system reduced predicted *R* by 1.6- to 2.3-fold and *E* by 7.3- to 12.1-fold. Predicted *R* and *E* for each CT and ST treatment were variable, especially as slope gradient and length changed. Runoff and *E* losses tended to decline with increased slope length. Similar to the Compass loamy sand, runoff generation was relatively low—thus sediment transport capacity of the flow controls sediment yields (transport limited). Values of K_i used in WEPP simulations were as follows: baseline K_i = 5.51 (table 2); slope adjusted K_i = 0.71 to 1.07 (table 2); minimum K_i used over the 100-year simulation = 0.16; and maximum K_i used over the 100-year simulation = 2.76 for CT–P–C and 0.29 for ST+P+C (9-fold difference between maximum adjusted K_i values for CT and ST treatments). These values are comparable to calculated K_i and K_{ieff} values from measured data in this study for CT–P–C and ST–P+C treatments (table 5) (2-fold difference).

The greatest benefit of conservation tillage (NT, ST), based on the maximum difference in 100-year predicted *R* losses, was for the Compass (78%) and Tifton (75%) loamy sands (table 6). The greatest benefit of NT or ST based on the maximum difference in 100-year predicted *E* losses was for the Compass (10.3-fold) and Decatur (9.7-fold) soils. To further demonstrate long-term benefits of NT or ST systems using WEPP output, daily *R* and *E* values for selected return periods are given in table 7. Differences in values for selected return periods between CT–P–C and NT+P+C were greatest for *E* (6- to 35-fold difference), and as expected, support differences between soils as discussed above (table 6).

Summary and Conclusions

We evaluated infiltration, runoff, soil loss, and interrill erodibilities from three highly-weathered Ultisols managed under conventional- (CT), strip- (ST) and/or no-till (NT) systems with and without residue cover (+C, –C) and with and without paratilling (+P, –P). Each 1 m^2 (~10 ft^2) plot was exposed to 2 hours of simulated rainfall (I = 50 mm h^{-1} [2 in hr^{-1}]).

Surface residue cover and paratilling collectively and individually influenced infiltration, runoff, and sediment yields. The NT–P+C or NT+P+C plots for the Compass loamy sand, NT+P+C plots for the Decatur silt loam, and ST–P+C plots for the Tifton loamy sand had the lowest runoff and soil loss and highest infiltration; CT–P–C plots (all soils) had the highest runoff and soil loss and lowest infiltration.

For the Compass loamy sand, NT–C plots increased runoff and decreased infiltration

Table 7
Daily runoff and sediment values for selected return periods based on WEPP model simulation results from 100-year runs.

	Compass loamy sand				**Decatur silt loam**				**Tifton loamy sand**			
Return period (years)	**CT***	**NT**	**CT**	**NT**	**CT**	**NT**	**CT**	**NT**	**CT**	**ST**	**CT**	**ST**
	Slope: 2%; L = 50 m				**Slope: 2%; L = 50 m**				**Slope: 2%; L = 50 m**			
	R (mm)	*R* (mm)	*E* (t ha^{-1})	*E* (t ha^{-1})	*R* (mm)	*R* (mm)	*E* (t ha^{-1})	*E* (t ha^{-1})	*R* (mm)	*R* (mm)	*E* (t ha^{-1})	*E* (t ha^{-1})
2	34.0	25.2	2.0	0.2	62.5	63.4	6.8	0.7	33.1	22.1	3.3	0.4
5	52.5	49.1	3.3	0.4	74.2	79.3	9.6	1.0	49.1	35.4	5.2	0.6
10	70.7	67.8	4.6	0.5	84.7	91.3	13.7	1.1	56.5	48.7	7.7	0.8
20	85.4	80.0	6.3	0.8	93.1	102.8	17.6	1.3	66.0	58.9	9.9	1.0
25	86.8	83.3	6.7	0.9	93.6	106.8	17.9	1.4	71.9	60.0	10.1	1.2
50	106.2	94.5	7.7	0.9	108.3	110.3	23.3	1.6	110.4	96.0	14.1	2.2
					Slope: 5%; L = 60 m				Slope: 5%; L = 175 m			
					R (mm)	*R* (mm)	*E* (t ha^{-1})	*E* (t ha^{-1})	*R* (mm)	*R* (mm)	*E* (t ha^{-1})	*E* (t ha^{-1})
2					62.9	62.7	24.6	0.7	33.4	19.4	7.2	0.7
5					74.2	79.1	32.6	1.0	49.5	35.3	12.9	1.3
10					85.2	92.0	42.2	1.2	57.1	49.7	16.2	1.7
20					91.5	102.0	53.5	1.5	66.4	60.2	19.9	2.2
25					93.9	106.6	55.7	1.6	72.3	60.6	21.3	2.3
50					108.1	112.0	57.5	1.9	110.9	96.2	32.4	5.0

Note: Use of bold shows when the slopes and lengths are similar for all three soils.

* CT = CT–P–C. NT = NT+P+C. ST = ST+P+C. All "P" designations are for paratilling every other year.

by as much as 43% and increased sediment yields by as much as 10-fold compared to NT+C plots. The NT+P+C plots decreased runoff and increased infiltration by as much as 70% and decreased sediment yields by 24-fold compared to CT–P–C.

For the Decatur silt loam, NT+P plots decreased runoff and increased infiltration by as much as 71% and decreased sediment yields by as much as 2.7-fold compared to NT–P plots. The NT+P+C plots decreased runoff and increased infiltration by as much as 73% and decreased sediment yields by as much as 11.8-fold compared to CT–P–C.

For the Tifton loamy sand, ST+P+C plots decreased runoff and increased infiltration by as much as 44% and decreased sediment yields by as much as 2.7-fold compared to CT–P–C plots.

Calculated K_i values for the Compass, Decatur, and Tifton soils were 0.37, 0.40, and 0.24, respectively. The NT+P+C (Compass, Decatur) and ST–P+C (Tifton) plots had the lowest K_{ieff} values. Residue cover decreased K_{ieff} values by 11%, 2-fold, and 2.6-fold for the Decatur, Tifton, and Compass soils, respectively; Paratilling decreased K_{ieff} values by 3-fold for both the Compass and Decatur soils. The NT or ST systems had lower K_{ieff} values than K_i values from corresponding CT–P–C treatments by 4- to 37-fold for the Compass, 4-to 13-fold for the Decatur, and 2-fold for the Tifton soil.

Converting from a CT to a NT or ST system reduced predicted runoff (Compass = 1.7-fold; Decatur = 10% to 17%; Tifton = 1.6- to 2.3-fold) and sediment yields (Compass = 10- to 12-fold; Decatur = 6- to 33-fold; Tifton = 7.3- to 12.1-fold). Minimum adjusted K_i values used in 100-year simulations were 0.11, 0.13, and 0.16 for the Compass, Decatur, and Tifton soils, respectively. For the Compass loamy sand, maximum adjusted K_i values were 1.91 (CT–P–C) and 0.13 (NT+P+C), a 14-fold difference between CT and NT treatments. Calculated K_i and K_{ieff} values from measured data for CT–P–C and NT+P+C treatments were 0.37 and 0.01 (37-fold difference). For the Decatur silt loam, maximum adjusted K_i values were 2.72 (CT–P–C) and 0.26 (NT+P+C), a 10-fold difference between CT and NT treatments. Calculated K_i and K_{ieff} values from measured data for CT–P–C and NT+P+C treatments were 0.40 and 0.03 (13.3-fold difference). For the Tifton loamy sand, maximum adjusted K_i values were 2.76 (CT–P–C) and 0.29 (ST+P+C), a 9-fold difference between CT and ST treatments. Calculated K_i and K_{ieff} values from measured data for CT–P–C and ST–P+C treatments were 0.24 and 0.12 (2-fold difference). The most benefit of NT or ST, as quantified by the maximum difference in 100-year predicted runoff and sediment yields, was for the Compass (78%) and Tifton (75%) soils for runoff and for the Compass (10.3-fold) and Decatur (9.7-fold) soils for sediment. Also, for sediment yields, differences in predicted daily sediment values for selected return periods between CT and NT or ST treatments ranged from 6- to 35-fold and were greatest for the Decatur silt loam (9- to 35-fold). Conservation tillage systems (NT, ST) coupled with surface residue cover and/or paratilling are effective in reducing runoff and sediment yields from highly-weathered soils by lowering effective K_i values.

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