Impact of Conservation Practices on Soil Erosion in Southern Iowa Plains (Region 4)

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Introduction

In southern Iowa, many upland soils have limited rooting depth potential and low permeability. Consequently, excessive erosion could lead to a significant reduction in crop yield. Many erosion control measures can be adopted to reduce soil erosion and maintain soil fertility. The purpose of this study was to investigate the impact of conservation practices on soil erosion for a farm in Southern Iowa Plains by using the Water Erosion Prediction Project (WEPP) model.

Materials and Methods

The study farm was located within the Rock Creek-South Skunk River Watershed (HUC 12) in Keokuk County. The mean slope of this 210-acre area was about 2.6%, ranging between 0.8% and 4.6%. Predominant soil consisted of Lagoda silty loam (Fine, smectitic, mesic Mollic Hapludalfs). Hedrick silty clay loam and Mahaska silty clay loam were also present in this field.

Conventional-till and four reduced tillage systems (no-till, strip-till, disk-till, and chisel-till) were simulated. No-till had no soil or crop residue disturbance except for that occurring during planting. Strip-till prepared narrow rows for seed bed after soybean harvest in the fall, while no-till was used after corn harvest. Disk-till included a disking after corn harvest in the fall and field cultivating for both corn and soybean in the spring. Chisel-till consisted of stalk shredding and chisel operation after corn harvest in the fall and field cultivating for both corn and soybean in the spring before planting. Conventional-till consisted of shredding stalks and subsoiling after corn harvest, and disking and cultivating for corn and soybean in the spring.

Two crop rotations under no-till and conventional-till were simulated: a 2-year corn-soybean (C-S) rotation, and a 5-year corn-soybean-oat-alfalfa-alfalfa (C-S-O-A-A) rotation. The impact of biomass removal rates after corn harvest on soil erosion was also investigated.

Total phosphorus (P_{sed}) bound to sediment was estimated by (Frere et al., 1980):

$$P_{sed} = P_{soil} \times W_{sed} \times W_{er}$$

Where P_{soil} is the total P content in 0-6 inch soil depth (530 ppm was used in this study, as estimated by Mallarino et al. (2002) for Iowa soil), W_{sed} is the sediment yield estimated from WEPP, and W_{er} is the enrichment ratio in WEPP.

Topography and slope of the study farm were derived from the 30 m digital elevation data. Subwatersheds were delineated using the GeoWEPP (Figure 1), which has a geospatial interface for the WEPP. The weather data from the City of Sigourney in Keokuk County was used to create the climate input file by the CLIGEN weather generator in the WEPP.

Results and Discussion

The simulation result showed that the mean annual surface runoff was around 4.1 inches, and displayed little difference between the conventional tillage and reduced tillage systems (Table 1). In contrast, the annual sediment yield of the entire study area in reduced tillage was markedly lower than that in conventional tillage. No-till and strip-till had much lower sediment yield than others. The on-site annual soil loss rate was also much lower under no-till system than conventional-till system (Figure 2).

The tillage type showed a similar impact on the total amount of phosphorus loss in topsoil, which was bound and lost with sediment (Table 1).

The amount of biomass remaining on soils after harvest had a significant impact on the soil erosion rate. For tillage systems with relatively more field operations, such as disk-till, chisel-till and conventional-till, even a small biomass removal rate could dramatically increase soil erosion (Table 2). On the other hand, No-till and strip-till showed a big increase in sediment yield at higher biomass removal rates, especially when the removal rate was greater than 70%.

Under no-till, little difference was observed on soil erosion between the 2-year C-S rotation and the 5-year C-S-O-A-A rotation. Under conventional-till, however, the soil loss with C-S-O-A-A rotation was lower than C-S rotation (Table 3).

Grassed waterways are strips of grass seeded in areas of cropland where water concentrates. They are often graded and shaped to form a smooth, bowl-shaped channel. In comparison with the tilled waterways which generally had the same tillage operations as other row-crop areas, grassed waterways reduced sediment yield in all tillage systems with the most significant effect in conventional tillage (Figure 3).

References

Frere, M.H., J.D. Ross, and L.J. Lane. 1980. The nutrient submodel. P.65-87. *In* W.Knisel (ed.) CREAMS: a field scale model for chemicals, runoff, and erosion from agricultural management systems. Vol.I Model documentation. USDA Conservation Research. Report 26. U.S. Gov. Print. Office, Washington, D.C.

Mallarino, A.P., B.M. Stewart, J.L. Baker, J.A. Downing, and J.E. Sawyer. 2002. Phosphorus indexing for cropland: overview and basic concepts of the Iowa phosphorus index. J. Soil Water Conserv. 57: 440-447.

Table 1. Simulation results of surface runoff, sediment yield, and phosphorus bound to sediment for different tillage systems in C-S system.

	No-till	Strip-till	Disk-till	Chisel-till	Conventional-till
Runoff (inch/year)	4.18	4.15	4.02	4.08	4.15
Sediment yield (tons/acre/year)	0.42	0.65	1.46	2.07	4.02
P on sediment (pounds/acre/year)	0.47	0.74	1.68	2.36	4.59

Table 2. Impact of biomass removal rate after corn harvest on sediment yield (tons/acre/year) for different tillage systems. Values in the bracket are the percentages of increase in soil loss compared with the control (without any biomass removal) for each tillage type.

	Biomass Removal Rate				
	0	30%	50%	70%	100%
No-till	0.42	0.45 (7.7%)	0.50 (18.1%)	0.60 (44.3%)	1.35 (223.0%)
Strip-till	0.65	0.70 (7.9%)	0.76 (16.2%)	0.85 (30.9%)	1.57 (141.9%)
Disk-till	1.46	2.15 (46.9%)	2.39 (63.1%)	2.75 (88.1%)	4.06 (177.2%)
Chisel-till	2.07	2.87 (38.9%)	3.10 (49.9%)	3.46 (67.3%)	4.48 (117.2%)
Conventional-till	4.02	4.76 (18.4%)	5.01 (24.6%)	5.34 (32.8%)	6.38 (58.7%)

Table 3. Impact of crop rotations on sediment yield (tons/acre/year) under no-till and conventional-till: a 2-year corn-soybean rotation (C-S), and a 5-year corn-soybean-oat-alfalfa-alfalfa (C-S-O-A-A),

	C-S	C-S-O-A-A
No-till	0.42	0.40
Conventional-till	4.02	2.65

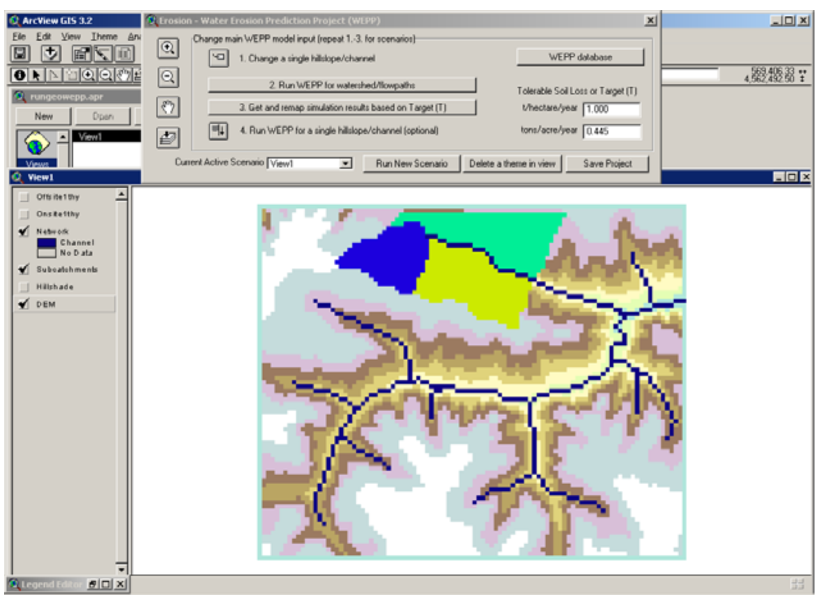
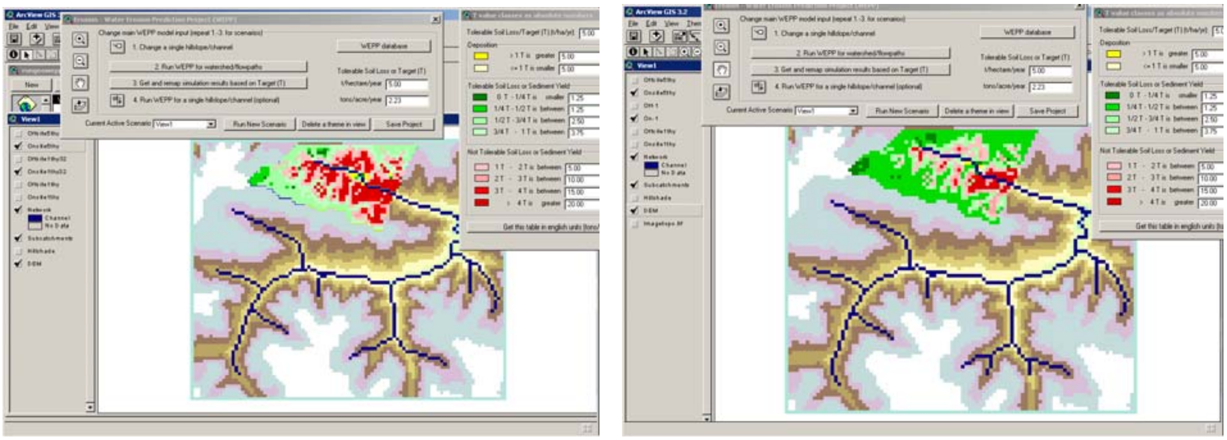


Figure 1. Subwatersheds delineation in the GeoWEPP.



(a) (b)

Figure 2.On-site annual soil loss rate for (a) conventional-till and (b) no-till of the study area. Areas with red color indicated that the annual soil loss exceeded the target value, and areas with green color represented the areas with the annual soil loss below the target value. A target soil loss rate of 5 tons/ha/year was used for illustration in the figure.

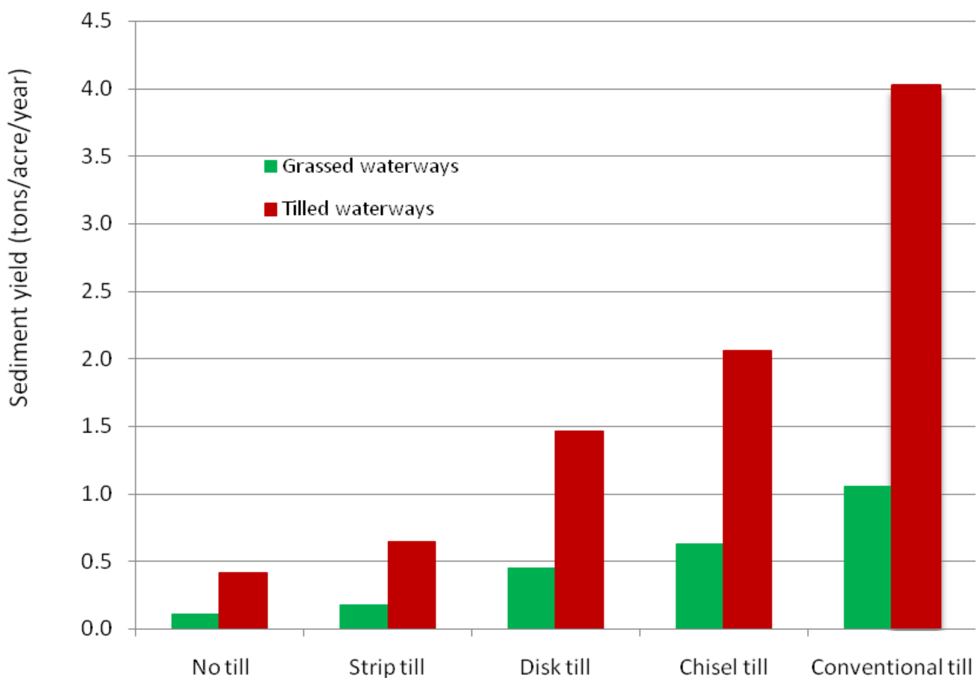


Figure 3. Comparison of grassed waterways and tilled waterways.