Impact of Conservation Practices on Soil Erosion in Central Iowa (Region 2)

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Introduction

The impact of soil erosion on water quality can be reduced by the adoption of erosion control measures, such as conservation tillage, residue management, vegetative filter strips, and grassed waterways. The purpose of this study was to investigate the impact of conservation practices on soil erosion for a farm in Central Iowa by using the Water Erosion Prediction Project (WEPP) model, which is a process-based erosion prediction model used to predict soil loss and sediment deposition for small watersheds and hillslopes.

Materials and Methods

A local farm in Webster County, Central Iowa, was selected to simulate soil erosion process. The simulation area is within the Upper Buttrick Creek Watershed (HUC 12). Slope ranges from 0.1% to 2.0% with mean slope about 0.4%. Predominant soil of the site consisted of Nicollet loam (*Fine-loamy, mixed, superactive, mesic Aquic Hapludolls*). Other soils were also present at the site including Clarion loam, Webster silty clay loam, and Harps clay loam. Four conservation tillage systems (no-till, strip-till, disk-till, and chisel-till) were simulated and compared with conventional-till. 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. 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.

The topographic inputs for WEPP 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 climate input was generated by the CLIGEN weather generator in the WEPP based on weather data from Fort Dodge in Webster County. A corn-soybean rotation was simulated for a 30-year period to obtain the average annual sediment yield for the entire study area.

Results and Discussion

Due to the relatively flat surface, soil erosion was not the major concern in Central Iowa in comparison with other regions in Iowa, as illustrated from the WEPP simulation results. In conventional-till, the average annual sediment yield of the entire 30-year simulation period was 0.61 tons/acre area. A reduced tillage system could further reduce the soil erosion. Sediment yield was 0.16, 0.18, 0.30, and 0.45 tons/acre/year for no-till, strip-till, disk-till, and chisel-till, respectively, based on the WEPP simulation results. Figure 2 shows the spatial distribution of the on-site annual soil loss for conventional-till and no-till systems. The on-site soil loss was clearly reduced with no-till system.

The total amount of phosphorus loss that was bound to sediment, was 0.33 pounds/acre/year in no-till, about one fourth of the amount in conventional-till (1.27 pounds/acre/year). Surface runoff also decreased in reduced tillage systems in comparison with conventional-till, although not as significant as soil loss. Consequently, less soluble nutrients and pollutants (e.g. pesticides, herbicides) would be delivered out of the field under conservation managements.

As expected, the amount of biomass over soil had a significant impact on soil erosion. Higher biomass removal rates dramatically increased soil loss (Table 2). For tillage systems with less intense field operations, such as no-till and strip-till, a small biomass removal rate, e.g. 30%, only slightly increased soil loss. However, soil erosion showed a big increase when the biomass removal rate was greater than 70%. The other three more intense tillage systems showed an increase in soil erosion even at the 30% biomass removal rate.

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. Although soil erosion is relatively low in the study area compared with other regions in Iowa based on the simulation results, grassed waterways could further reduce sediment yield in each of the study tillage systems (Figure 3).

While conservation practices can help reduce surface runoff and the transport of sediment and nutrients, water quality of the subsurface runoff through tile drainage systems may be the major issue in Central Iowa.

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, soil 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)	3.25	3.63	3.62	4.00	4.22
Sediment yield (tons/acre/year)	0.16	0.18	0.30	0.45	0.61
P on sediment (pounds/acre/year)	0.33	0.37	0.62	0.92	1.27

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 sediment yield compared with the control (without any biomass removal) for each tillage type.

	Biomass Removal Rate				
	0	30%	50%	70%	100%
No-till	0.16	0.17 (4.6%)	0.18 (9.8%)	0.19 (19.6%)	0.24 (59.4%)
Strip-till	0.18	0.18 (3.6%)	0.19 (8.4%)	0.21 (16.8%)	0.24 (44.0%)
Disk-till	0.30	0.42 (40.7%)	0.47 (57.5%)	0.50 (66.8%)	0.65 (117.9%)
Chisel-till	0.45	0.54 (24.8%)	0.57 (30.6%)	0.60 (38.7%)	0.67 (50.6%)
Conventional-till	0.61	0.78 (27.9%)	0.80 (31.5%)	0.84 (37.3%)	0.90 (47.7%)

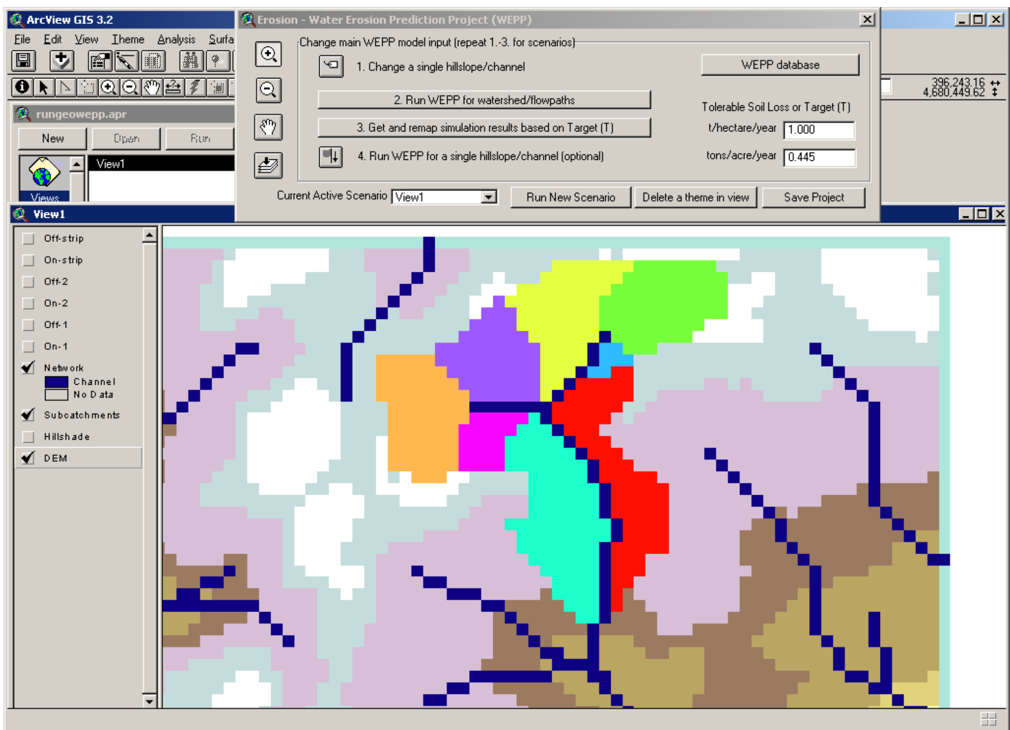
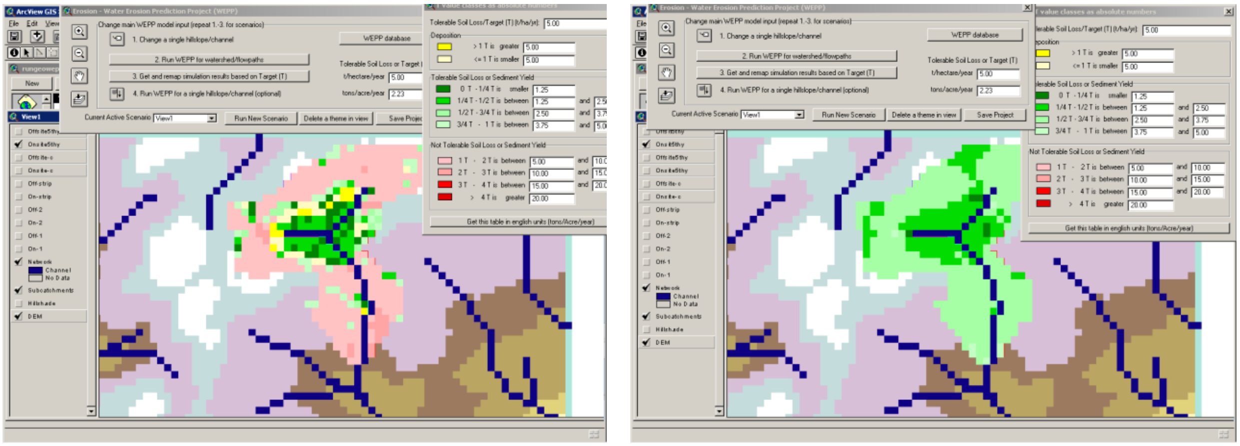


Figure 1. Subwatersheds delineation in the GeoWEPP.



(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.

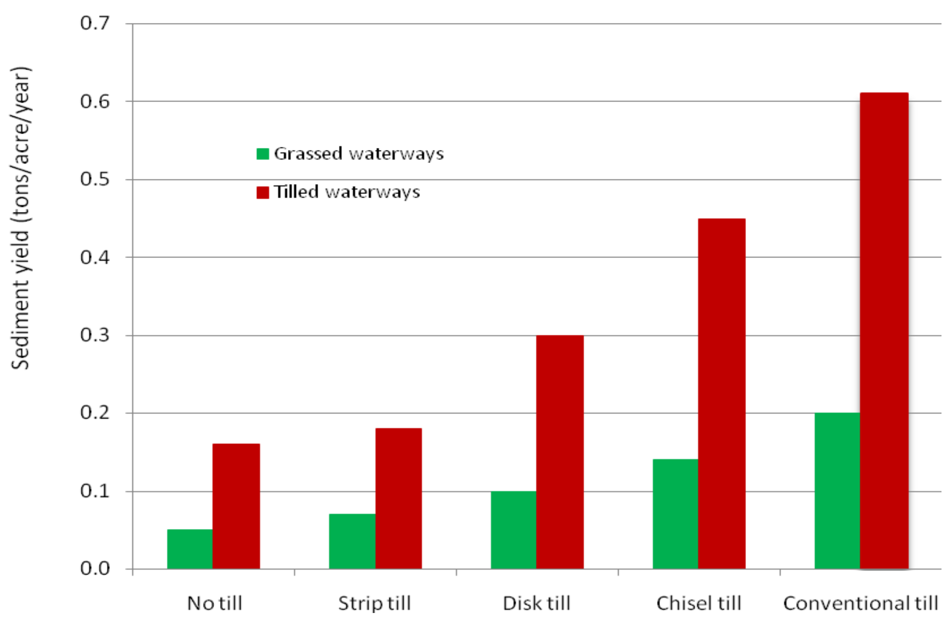


Figure 3. Comparison of grassed waterways and tilled waterways.