Impact of Conservation Practices on Soil Erosion in Iowa's Loess Hills (Region 5)

Bob Zhou, postdoctoral research associate
Matt Helmers, assistant professor
Mark Hanna, Extension agricultural engineer

Department of Agricultural and Biosystems Engineering, Iowa State University

Introduction

The Loess Hills are unique and extremely susceptible to gully erosion in the absence of good farming systems. The area has one of the highest erosion rates in the U.S. In this study, the Water Erosion Prediction Project (WEPP) model was used to simulate the impact of conservation practices on soil erosion for a farm in the Loess Hills of Western Iowa.

Materials and Methods

The study site was located within the West High Creek Watershed (HUC 12) in Fremont County, Iowa. The total size of the site was approximately 108 acres. The mean slope was about 2.9%, ranging between 1.5% and 10.9%. Note that the slope range of the study area may not be truly representative of more steeply sloping areas. Napier silt loam (*Fine-silty, mixed, superactive, mesic Cumulic Hapludolls*) was the predominant soil of the study area. Marshall silty clay loam and IDA silt loam were also present at the site.

Soil erosion was simulated for four reduced tillage systems (no-till, strip-till, disk-till, and chisel-till) and conventional-till with a corn-soybean rotation. No-till had no soil or crop residue disturbance except for that occurring during planting. Strip tillage 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 various biomass removal rates (0, 30%, 50%, 70%, and 100%) 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.

Soil erosion was simulated by the WEPP model for a 30-year period to obtain the mean annual surface runoff and sediment yield for the entire study area. The topographic inputs 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.

Results and Discussion

As expected, the Loess Hills region had higher soil erosion rates than other regions in Iowa, due to its highly erodible soil. Simulation results showed that reduced tillage systems could greatly reduce soil loss caused by erosion. For more intense tillage practices such as conventional-till, chisel-till and disk-till, the mean annual soil loss all exceeded the tolerable soil loss rate (5 tons/acre/year), while sediment yield was only 1.14 and 1.73 tons/acre/year for no-till and strip-till, respectively (Table 1).

Figure 2 compares the on-site soil loss for conventional-till and no-till systems. Most of the areas with an annual soil loss rate greater than the target value under conventional-till would meet the target under a no-till system.

However, simulation results showed that tillage had little impact on surface runoff amount in this study site. In field conditions, tillage operations often destroy soil structure and macropore connectivity of the near-surface soil layers, and therefore decrease infiltration and increase surface runoff.

The total amount of phosphorus loss with sediment was lowest in no-till, and increased as more field operations occurred. The P loss was 1.31 pounds/acre/year in no-till, about one-tenth of the amount in conventional-till (13.88 pounds/acre/year).

Soil erosion showed a quick and significant response to the amount of biomass remaining on soil. Higher biomass removal rates dramatically increased sediment yield regardless of tillage types (Table 2). All tillage systems showed a big increase of soil erosion when the biomass removal rate exceeded 70%, especially for no-till and strip-tillage. However, even a 100% biomass removal in no-till and strip-till had a lower sediment yield than the other three more intense tillage types (disk-till, chisel-till and conventional-till) without any biomass removal.

Grassed waterways are strips of grass seeded in areas of cropland where water concentrates. Grassed waterways greatly reduced sediment yield in each tillage system (Figure 3), compared with the tilled waterways, which had the same field operations as other row-crop areas. With the implementation of grass waterways, the simulated annual sediment yield was below the commonly-used tolerable soil loss rate even under conventional-tillage at the study site.

Soil erosion is a severe problem in the Loess Hills region. More no-till or strip-till and good residue management would greatly help reduce sediment yield and nutrient loadings in this region.

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)	4.64	4.58	4.48	4.60	4.79
Sediment yield (tons/acre/year)	1.14	1.73	5.83	7.45	12.15
P on sediment (pounds/acre/year)	1.31	1.99	6.66	8.51	13.88

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	1.14	1.23 (7.4%)	1.36 (18.8%)	1.62 (41.5%)	3.85 (236.3%)
Strip-till	1.74	1.87 (7.5%)	2.00 (15.0%)	2.28 (31.1%)	4.13 (137.4%)
Disk-till	5.83	7.62 (30.7%)	8.04 (38.0%)	9.23 (58.4%)	12.42 (113.1%)
Chisel-till	7.45	9.40 (26.2%)	9.69 (30.1%)	10.85 (45.7%)	13.33 (79.0%)
Conventional-till	12.15	12.90 (6.2%)	13.39 (10.2%)	14.40 (18.5%)	16.89 (39.0%)

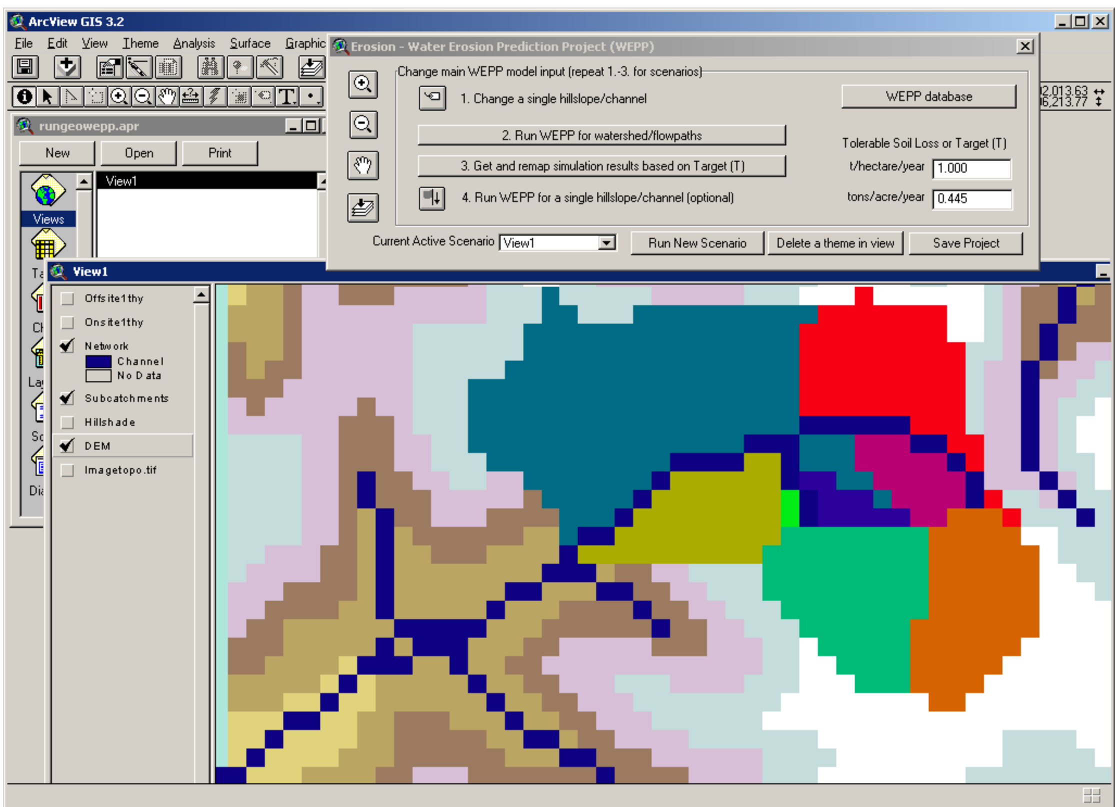
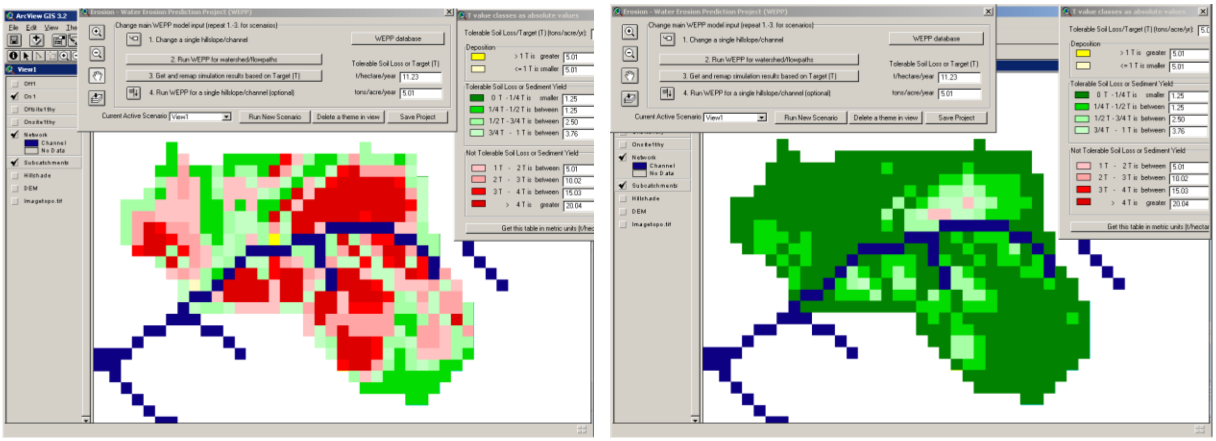


Figure 1. Subwatersheds delineation in the GeoWEPP.



(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/ac/year was used for illustration in the figure.

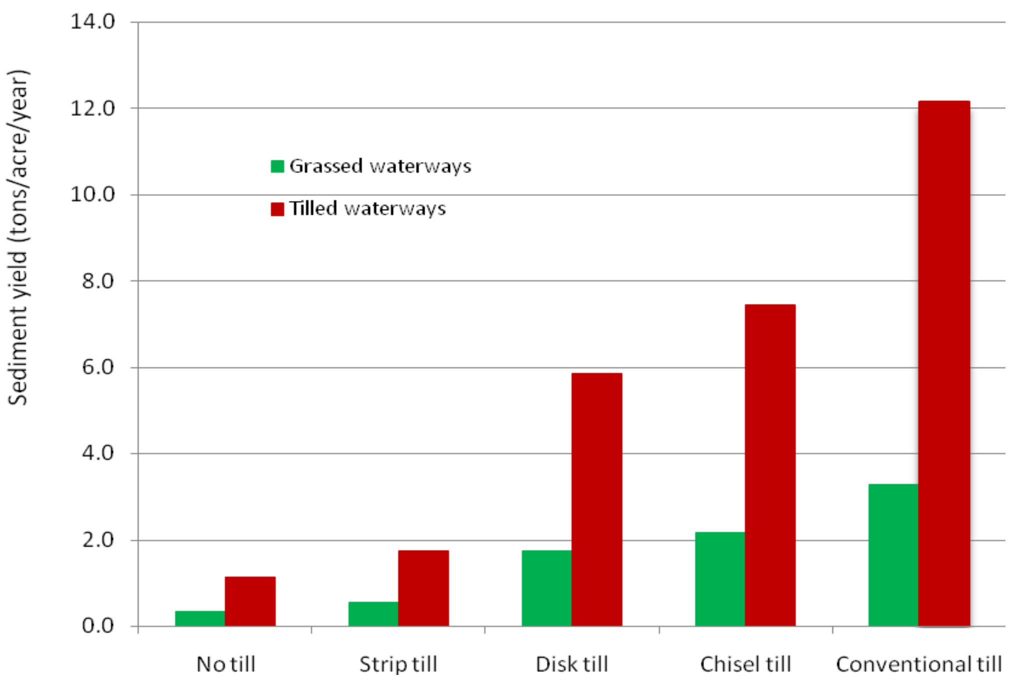


Figure 3. Comparison of grassed waterways and tilled waterways.