Kansas State University
Department of Agronomy MF-2682 Soil Conservation

Effects of Conservation Practices on Water Quality: Sediment

Conservation Ethic

The Homestead Act of 1862 was signed into law by Abraham Lincoln, just 1 year after Kansas was granted statehood. These two legislative moves resulted in a wave of settlers coming to what had once been called the Great American Desert. Agriculture in those days meant a mule and a plow on 160 acres. The soils were deep and rich with nutrients.

Farming on the plains developed at a steady pace, and was originally quite diverse. The high organic matter levels of these prairie soils kept them stable from erosion for many years. As soil organic matter levels declined and with multiple passes of tillage equipment, soil erosion began to occur. In 1931, severe drought hit the Midwest and southern plains. As the crops failed, the soils began to blow, creating some of the worst dust storms of modern time. In 1932, there were 14 major dust storms. In 1933, there were 38.

In April of 1935, following "Black Sunday," which was the worst dust blizzard of the decade, Congress declared soil erosion "a national menace" and established the Soil Conservation Service. This marked the begining of a national effort in soil conservation. The results of this effort in the following 70 years were remarkable.

Water Quality Impacts from Nonpoint Sources

Soils are moved by wind and water. This linkage between these natural resources goes both ways. Water quality of the receiving water body is a function of the volume and quality of runoff water that comes from the watershed. This water quality is affected by diverse sources such as wastewater treatment plants, direct discharge from industry, and failing or improperly maintained septic systems. The Clean Water Act of 1972 began a long-range program of addressing point source pollution by requiring a legal permit for discharges of known point sources, and requiring a certain level of treatment of waste water prior to discharge. By 1990, it was apparent that point sources only accounted for a portion of the water quality problem. It was evident that large amounts of suspended solids, nutrients, and chemicals were being delivered from unknown sources. These diffuse sources, not assigned to any point were labeled "nonpoint" sources. The largest and most likely source for these pollutants was agriculture.

Efforts to reduce nonpoint source pollution from agriculture have been directed primarily by developing best management practices. These identify management techniques that reduce losses of agricultural chemicals/nutrients and reduce soil erosion. This publication will quantify the impact of these practices that have been implemented to reduce nonpoint source pollution. To do this, computer modeling technology was used to estimate pollutant load reductions from specific best management practices and erosion control structures.

Current Knowledge of the Effectiveness of Conservation Structures and Practices

In the northern Mississippi Valley, a study was conducted to determine if soil loss patterns had changed over the course of years from 1930 to 1992 (Argabright et al., 1996). The study area included counties from northeast Iowa, southeast Minnesota, southwest Wisconsin, and northwest Illinois, for a total of nearly 19,000 square miles. Many things have changed since the 1930s, including installation of many conservation structures, new tillage systems, and changes in cropping patterns. In spite of increased intensity of row crop production and more total acreage in production, gross erosion rates per acre were reduced between 42 and 58 percent over these years (See figures 1 and 2). In 1930, erosion rates were estimated to be about 15 tons per acre-year. By 1982, loss rates had been reduced to 7.8 tons per acre-year, and by 1992, the rate was reduced to 6.3 tons per acre-year.

The reductions in soil erosion in this region since the 1930s occurred even as farming practices intensified. The reductions in soil erosion from upland areas over this period are attributed to the increased acreage protected by terraces, strip-cropping, and reduced tillage.

In this region, the sum of reduced tillage and no-tillage acreage over the last decade of this study has increased to nearly equal the amount of acreage that is terraced (see Figure 3). No-tillage practices hold the promise of profitable agricultural production while maintaining a greater stable soil resource.

Kansas has seen similar changes in tillage in the last several years with a steady growth of no-tillage (see Figure 4). Not shown is double-crop soybeans that were at 63 percent no-till in 2004.

In a long-term study of sediment storage and movement in Coon Creek, a 139 square mile basin

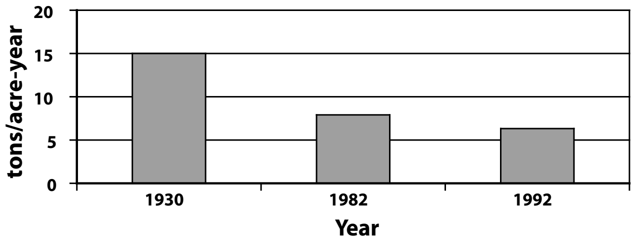


Figure 1. Cropland erosion rates in the Northern Mississippi Valley, 1930-1992.

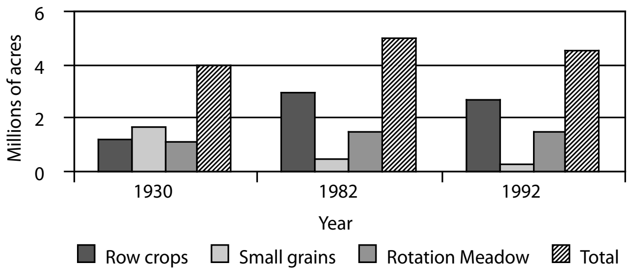


Figure 2. Cropland usage in the Northern Mississippi Valley, 1930-1992.

in southwest Wisconsin, sediment contribution from upland gullies and sheet and rill erosion have varied greatly over the years (Trimble, 1999). The greatest contribution from upland sources was between 1853 and 1938. Conservation practices and changes in management resulted in a reduction of sediment load from 1938 to 1975. Large changes in sediment movement occurred after 1975 when stream bank stabilization structures were installed, and floodplains were allowed to develop, which improved sediment trapping efficiency within the river system. Interestingly though, contributions of sediment to the Mississippi river over the entire period did not significantly change. Delivery of sediment is a function of water flow and climate. Climate has not changed during this 150 year period, and thus the energy to deliver sediment is still present. The river delivers this sediment either from upland sources, as in the early period, or it delivers it from stream banks and sand bars from within the basin

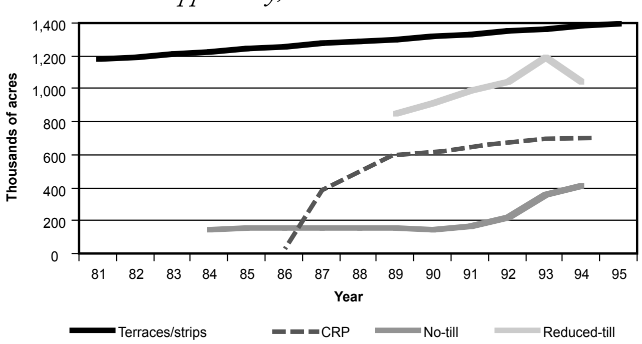


Figure 3. Adoption of conservation structures and practices in the Northern Mississippi Valley, 1981-1994.

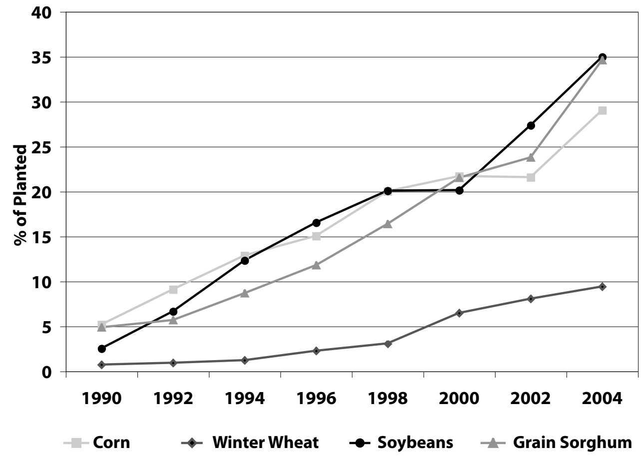


Figure 4. Change in no-tillage acreage for various crops in Kansas over a 15-year period as measured by the Conservation Tillage Information Center (CTIC).

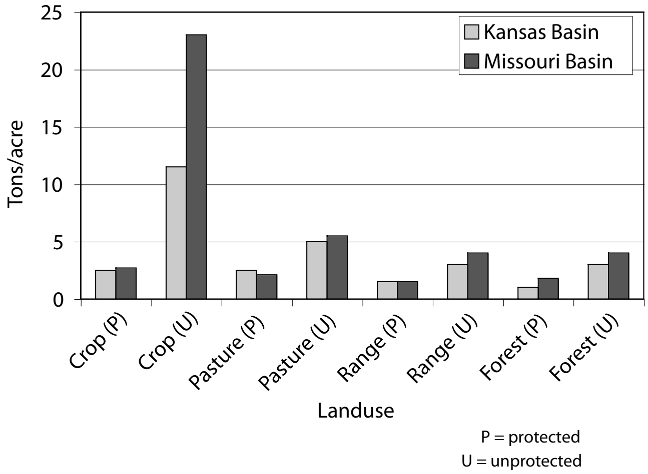
when input loads from upland sources are reduced, as in the later periods.

A study by the NRCS in 1992 in northeast Kansas quantified sediment yields from different sources for two watersheds. In both the Missouri and Kansas basins, unprotected cropland contributed the majority of sediment load, amounting to more than 20 tons per acre-year in the Missouri basin (see Figure 5). Adding conservation structures and practices reduced their estimate of sediment contribution to less than 5 tons per acre-year. The second largest contributor was unprotected pasture with values near 5 tons per acre-year. When the sediment source is further identified, sheet and rill erosion is estimated to provide more than 60 percent of the total, with ephemeral gullies and classical gullies contributing around 15 to 20 percent each (Figure 6). The lowest contributing categories in this region are considered to be stream bank and flood plain scour, accounting for less than 5 percent.

Spatial Evaluation of BMPs

One of the problems with estimates of changes in erosion over time is that only the overall effect of the conservation effort and not the impact attributed to each individual practice is predicted. Evaluation of conservation practices on a watershed scale, in a spatial format is now possible with the use of watershed models. One model that has been used for the past several years is the Soil Water Assessment Tool (See the box on page 4). Water is the driving force for sediment movement, as well as for agricultural chemicals and bacteria. If a model can accurately predict where water moves following a rainfall, then with the right mathematical relationships, movement of pollutants with that water can provide a tool to determine the effect of different management practices.

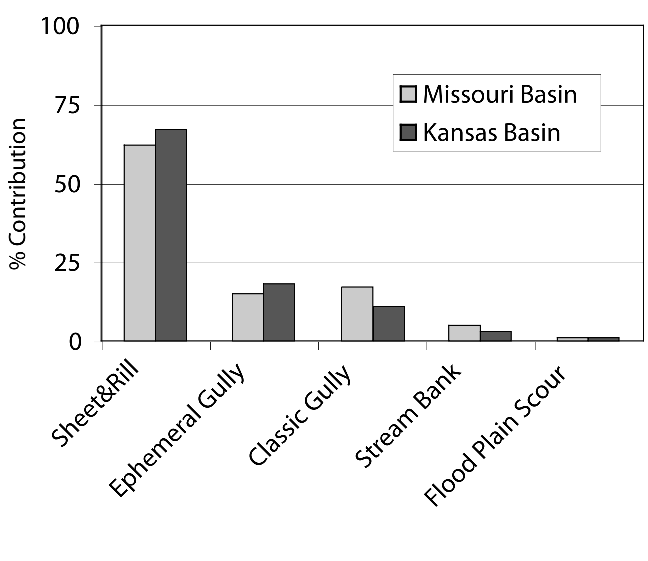
Figure 5. Estimates of sheet and rill erosion rates by land use in northeast Kansas.



Model Predictions for Little Blue Watershed

The SWAT model was used to evaluate the effect of conservation structures and best management practices on water and sediment yield from agricultural fields in the lower Little Blue River watershed located in northeast Kansas and south central Nebraska. This watershed covers approximately 1,300 square miles. Land use is 54 percent range and 41 percent cropland with dominant crops of corn, wheat, and soybeans. The base scenario was a conventional tillage system (chisel-disk) on cropland without conservation structures or use of best management practices. Multiple runs of the model were conducted to evaluate the influence of structures such as terraces, waterways, and field buffers. Scenarios that evaluated management practices like contour farming, minimum tillage and no-tillage systems were also included. No spatial information was available for management choices of herbicides, or fertilizer placement and rates, so a survey of area producers was consulted for inputs of appropriate chemical usage.

Figure 6. Estimates of different sediment source contributions from selected watershed in northeast Kansas.



The base scenario with no conservation structures or best management practices yielded more than 19 tons per acre-year averaged across the entire watershed. Sediment is being delivered from all land use within a sub-basin, but it comes primarily from cropland. Because cropland is less than half of the total acreage, sediment yield from cropland without conservation practices could be as much as twice this estimate.

Water discharge and sediment loss reductions from the base scenario because of conservation practices are listed in Table 1. Terraces are effective in removing sediment from the water that exits the watershed. Little change in water yield is noted for conventional till scenarios, yet sediment reduction ranges from 50 to nearly 90 percent depending on additional conservation practice.

Mulch tillage is less effective as an erosion control practice than either no-till or conventional till with structures. A majority of acreage in Kansas is managed as mulch tillage, or as reduced tillage, yet estimates for sediment reduction for this set of practices is only 50 percent of that from the base scenario. No-till management on the other hand, reduces water runoff by more than 12 percent and sediment yield by 77 percent without any other conservation structures in place. Adding contour farming, or any other conservation practice or structure increases the reduction to more than 90 percent from the base scenario.

Table 1. Estimated reductions in water flow and sediment loss from agricultural sub-basins due to installation of conservation structures and adoption of best management practices as compared to a conventional till scenario.

Management		% Reduction in*	
		Runoff	Sediment
Conventional	10-m buffer	0	72.2
	20-m buffer	0	88.6
	Contour	0.9	49.9
	Terraces	0.9	89.4
No-Tillage		12.5	76.9
	10-m buffer	12.5	93.2
	20-m buffer	12.5	96.9
	Contour	20.1	90.4
	Terraces	20.1	97.5
Mulch Tillage	20% residue	0.4	46.9
	50% residue	0.8	63.4

** Based on SWAT model results in the Little Blue River Basin, averaged over 22 years.*

Summary

Sediment yield from a watershed will vary depending on total precipitation, frequency, and intensity. It will vary across soil type with silt loam soils such as those in the Little Blue watershed being more prone to movement than either sandy or clayey soils. Results from the Little Blue River watershed were used to illustrate the potential reduction in sediment yield that could be expected by various conservation structures and management scenarios. The combination of two or more conservation practices resulted in a compound effect that further reduced sediment loss. These results are quite applicable to most locations in Kansas outside of the claypan soils of southeast Kansas. The erosion rates in western Kansas would be less given the reduced total rainfall and lower intensity of storms, but the percent reductions by practice and structure are expected to be similar.

The quality of water that is delivered downstream depends on the management of non-point sources within the watershed. Nearly everyone lives downstream from someone, and is connected to neighbors through the hydrologic cycle. It is important for land managers to do their part to farm in a stable system. In this way the local soil resource is maintained, providing for continued productivity. At the same time, the water that flows downstream is clean, preserving another resource for those people depending on it.

References:

Anonymous, Northeast Kansas Erosion and Sediment Yield Report. 1992. USDA-SCS, Salina, KS

Argabright, M.S., R.G. Cronshey, J.D. Helms, G.A. Pavelis, and H.R. Sinclair, Jr. Historical Changes in Soil Erosion, 1930-1992: The Northern Mississippi Valley Loess Hills. 1996. Natural Resources Conservation Service, USDA, Washington D.C.

Trimble, S.W. Decreased Rates of Alluvia Sediment Storage in the Coon Creek Basin, Wisconsin, 1975-93. 1999. Science 285: 1244-1246.

Web site for Public Broadcasting *www.pbs.org/wgbh/amex/dustbowl/timeline/index.html*

Neitsch, S.L., J.G. Arnold, J.R. Kiniry, J.R. Williams. Soil and Water Assessment Tool: Theoretical Documentation, Version 2000. 2002. TWRI Report TR-191, Texas Water Resources Institute, College Station, TX.

The SWAT Model

Simulation models are used by watershed planners to predict runoff as it occurs in the real world. If all of the governing physical laws were known, and could be described by mathematical equations, a model using these would be considered entirely physically based. However, in common practice, models generally simplify the physical system and use physical and empirical components to describe natural processes and relationships.

The Soil and Water Assessment Tool, or SWAT, is a watershed scale model developed by Jeff Arnold for the USDA Agricultural Research Service. SWAT has been designed to predict the yield of water, sediment, and agricultural chemicals transported from watersheds. Larger watersheds have diverse soils, land use and management practices. For the most part, SWAT is physically based and requires specific spatial information about weather, soils, topography, vegetative cover, and land management practices for the watershed (Neitsch et al., 2001).

The physical processes associated with water movement, soil detachment, crop growth, and nutrient cycling are directly modeled by SWAT using digital inputs of this data. Daily records of precipitation coupled with the use of historical weather records allow for an accurate simulation of weather cycles over a long period of time. Planners can use model predictions to evaluate nonpoint source issues in watersheds by determining the effects of different BMPs and land use practices on yields of water, sediment, nutrients, and chemicals. This information can then be used to help watershed planners reduce pollutants to reach water quality standards such as the Total Maximum Daily Load goals established by Kansas Department of Health and Environment.

Kent. A. McVay
Soil and Water Conservation Specialist
Kansas State University

Daniel L. Devlin
Environmental Quality Specialist
Kansas State University

Jeffery Neel
Natural Resources Specialist
Kansas State University

Publications from Kansas State University are available on the World Wide Web at: *www.oznet.ksu.edu*

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

MF-2682 July 2005

K-State Research and Extension is an equal opportunity provider and employer. Issued in furtherance of Cooperative Extension Work, Acts of May 8 and June 30, 1914, as amended. Kansas State University, County Extension Councils, Extension Districts, and United States Department of Agriculture Cooperating, Fred A. Cholick, Director.