Conservation systems and soil and water quality symposium

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Environmental costs and benefits from erosion reduction

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Iowa farmers have made a significant improvement in the amount of erosion occurring throughout the state. In spite of this improvement, however, the annual rate of erosion is still five tons per cropland acre.

A frequently asked question concerns the value of a ton of soil lost. The cost associated with soil lost can be broken into two major components; on-site costs and off-site costs. Higher fertilization rates and other technologies have masked some of the on-site costs. But, they still exist. The farmer directly bears the on-site costs. Everyone bears the off-site costs.

The USDA/NRCS recently estimated the value of a ton of soil at $19 per ton. Almost one-third of the value of the ton of soil were on-site values and the other two-thirds were off-site. This estimate were broken down as:

On-site:		
- Nutrients and yield loss	$4.39	18%
- Water holding capacity	1.44	8
Off-site:		
- Water quality	$6.32	34%
- Air quality (health)	3.16	17
- Air quality (property)	3.31	17

This part of the session will examine the costs associated with soil erosion. The final product will be an estimation of the value of a ton of soil saved.

There will also be a discussion of the costs and benefits of the alternative tillage systems being explored in the Iowa Learning Farm project. This part discussion will focus on the amount of energy used as well as the environmental costs and returns.

Conservation systems and soil quality

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Conservation systems play significant role in improving soil quality by protecting soils and reducing sediments transport, which are the main contributor to the water quality problems in Iowa. Conservation systems demonstrated the benefits of improving soil organic matter and other soil physical and biological properties significantly over conventional systems that utilize extensive tillage mono-cropping systems. On average, research showed that no-tillage system with crop rotation of corn soybean can contribute annually close to 0.5 ton of total C to the soil organic matter. This improvement in soil organic matter is coming from two sources: 1) the stability of the system. The conservation system and no-tillage in particular keep the soil system intact enhancing soil structure, microbial populations, and reducing the loss of organic matter and nutrient to soil erosion. 2) The amount of residues that were left on the soil surface with no-till, which provide protection to soil surface and source of slow released of carbon and nutrient to the soil system.

One of the challenges with conservation system is the management of crop residues. The way residues are managed on the field after harvest is very critical to the success of providing a good soil seedbed environment for planting. Cutting residues at 12 inches or more will provide better residues orientation for trapping snow and uniform distribution of it across the field. Many farmers have gotten into the habit of chopping corn stalks after harvest. This can present a significant management problem as well as other potential production problems that are associated with low soil temperature early in the spring, potential soil diseases, and early germination problems just to name a few. Chopping residue also can reduce the effectiveness of it in protecting the soil surface from potential water erosion, especially during high intensity rainfall events, where residue will be washed away with the surface runoff. Chopped residue is no longer anchored into the soil and is more prone to plugging tillage implements or planters used in subsequent operations.

While cutting residue after harvest is one technique for managing crop residue, it is possible to avoid this step all together. This can be accomplished by calibrating the combine properly to ensure a uniform residue distribution on the soil surface. A few adjustments and fine tuning of a combine prior to harvest can pay off significantly in having uniform residue cover across the field.

The misconceptions about conservation systems and no-till are widely used to avoid the adoption of these systems. The success of farmers who have been using no-till for many years shows that such systems can pay off economically and environmentally. Studies show that tilling corn residue prior to soybean planting did not improve soybean yield. Removing residue for any purpose needs to be balanced with the potential impact that may take place--especially from water and soil quality perspectives. Although standing residue in the field is sometimes viewed negatively, it actually presents fewer problems for equipment or seedling establishment than chopped, detached residue.

Combination of conservation tillage practices and crop rotation are proven to be very effective in improving soil environment and physical properties. Long-term studies in the Midwest show that corn-soybean rotation improved yield potential of no-till compared to continuous corn. The reduction in yield of continuous corn in no-till can be attributed to low soil temperature during seed germination. This was especially evident on poorly drained soils, where no-till often at a disadvantage with in row residue. Studies show that the poor performance of no-till corn following corn is more likely due to the previous crop rather than the surface residue conditions that prevented early season warming and drying soils. The use of crop rotation in conservation system is to achieve several benefits. These can include, but not limited to nutrient cycling, improvement of soil tilth and soil physical properties, and improve weed and pest control. However, understanding the relationship between nutrients cycling and crop rotation in achieving some of these benefits is very important in making nutrients management decision. The impact of crop rotation on nutrient status (i.e., N, P, K, etc.) in soil is one of many factors that influence nutrients need, but it is an important one. For example, the rate of N mineralization or the conversion of organic N to mineral N will be affected by soil moisture, soil temperature, pH, plant residue, tillage practices and host of other factors, which can be affected in one way or another by crop rotation.

Conservation systems are the right choice and offer significant services to the environment. Understanding conservation systems and the proper way of managing them is a key to successful outcome. Conservation systems should be managed in a system approach which includes diversified cropping system, balanced nutrient management program, use of the right equipment, and above all understanding the system.

Conservation systems and water quality: Estimating the impact of in-field management practices on surface water quality using the WEPP model

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The transport of sediment and its associated nutrients and pollutants from agricultural lands by soil erosion has been identified as a major contribution to the impairment of receiving waters in Iowa. While different tillage operations and management practices are generally adopted in different regions even in neighboring fields, their impacts on soil erosion and water quality are rather site-specific. Except for tillage operations, other factors also affect the extent and severity of soil erosion in agricultural lands, including soil texture and hydraulic properties, landscape and slope. As a result, the change of tillage system and management practices may reduce the sediment yield and nutrient loadings to a great extent in some areas, but may show little improvement in others. In addition, the compromise between the economic return and environmental protection, and the cost sharing between government agencies and local producers, stimulate the need of estimating the impact of a particular in-field management practice on water quality before it is implemented. Consequently, a site-specific identification of the most effective in-field management practice would greatly help reduce cost input and the sediment and nutrient loadings from agricultural lands in Iowa.

The impact of in-field management practices on surface water quality is investigated through modeling some selected farms that are part of the Iowa Learning Farm (ILF) project, which is a statewide partnership of agencies, local producers, researchers, extension personnel and general public, working together since 2005 to improve the soil and water quality in Iowa while maintaining profitability. Those selected farms represent each of five geographic regions in Iowa based on their soil formation and landscape difference: Northwest Iowa Plains, Des Moines Lobe, Northeast Iowan Surface, Southern Iowa Drift Plain, and Loess Hills. The sediment yield of each selected farm is simulated using the Water Erosion Prediction Project (WEPP) model, which is a process-based erosion prediction model for small watersheds and hillslopes. The WEPP model accommodates many processes related to soil erosion, including rill and interrill erosion, infiltration, percolation, sediment transport and deposition, climate, surface runoff, residue and canopy effects, tillage effects, and evapotranspiration; therefore, it can provide reasonably good estimates for water quality and other environmental assessments. Such a model is particularly useful when limited information on soil and water quality is available from local producers' fields as in our ILF project, and hence can be used to estimate the impacts of selected scenarios of in-field management practices on transport of sediments and nutrients from producer's fields.

The currently adopted practice of a demonstrated ILF farm (baseline scenario) and some other potential scenarios, e.g., different tillage systems, crop rotation, residue removal rates, and emplacement of grass buffer, are implemented to simulate the impact of various tillage systems and management practices on soil erosion and surface water quality for a 30-year period, and identify the best in-field management practices to reduce sediment yield and nutrient loadings for that specific farm. During the modeling process, the wisdom of local producers is integrated into the water quality model in simulating water quality response of selected in-field management scenarios.

Two neighboring small row-cropped watersheds (5.1-ha watersheds 1 and 6.4-ha watershed 2) within the Four Mile Creek watershed (about 3.5 km wide and 15 km long) in northwestern Tama County were used as a case study for evaluating the WEPP model performance on simulating surface runoff and soil erosion since water quality monitoring data is available (Figure 1). Numerous data (Meteorological data, surface runoff data, nutrient and sediment data, tillage operation, and soil samples) were collected at these two watersheds and other sites within the Four Mile Creek watershed for a 5-year (1976 – 1980) research project conducted by Iowa State University and the United States Environmental Protection Agency (Johnson and Baker, 1982 and 1984). Those observed data were used for assessing the model simulation results. In both watersheds 1 and 2, the Tama silty clay loam soil (fine-silty, mixed, mesic Typic Argiudolls) was present on the steep hillslopes and the Colo silty clay loam soil (fine-silty, mixed, mesic Cumulic Endoaquolls) was present at lower flat areas along waterways. Hillslope delineation and input profiles were derived from the 30 m digital elevation data using the GeoWEPP model, which has a geospatial interface for the WEPP model. Slopes ranged from 1 to 9 percent in watershed 1, and 2 to 12 percent in watershed 2. The climate breakpoint input file was generated by the WEPP model using the observed precipitation and temperature data at the experiment watersheds, and other weather data from the nearby weather station located in Grundy Center (Perez-Bidegain, 2007). Both watersheds were in corn-soybean rotation with soybean in watershed 1 and corn in watershed 2 in 1976. Conventional tillage was implemented in both watersheds: cornstalks were plowed with a moldboard plow in the spring before planting soybean, and soybean stubble was disked in the spring in preparation for corn planting. The results showed that the simulated surface runoff depth and sediment yield matched reasonably well with the measured values at the watershed outlets for both watersheds (Figure 2). The simulated and measured runoff had a better agreement while the sediment yields were somewhat overestimated especially for watershed 1.

Four commonly-used conservation tillage systems (no-till, strip-till, disk-till, and chisel-till) were simulated for watersheds 1 and 2 in the same period (1976 - 1980) to investigate the impact of conservation tillage practices on reducing soil loss from agricultural lands. The same WEPP model input files as used in the conventional tillage simulation were used in all simulations except the management inputs. No-till had no soil or crop residue disturbance except for that occurring during planting. Strip tillage prepared narrow rows for seed bed in the fall while keeping row middles untilled and covered with undisturbed crop residue. Disk-till included a disking in the fall and field cultivating in the spring. Chisel-till consisted of stalk shredding and chisel operation after corn harvest in the fall and field cultivating in the spring before planting. The simulation results showed that the selected conservation tillage practices could significantly reduce the annual sediment yield in both watersheds, in comparison with the conventional tillage that was performed in the Four Mile Creek watershed (Table 1). No-till and strip-till had the best performance on controlling soil loss from the two watersheds.

References

Johnson, H. P., and J. L. Baker. 1982. Field-to-stream transport of agricultural chemicals and sediments in an Iowa watershed: Part I. Database for model testing (1976-1980). Report USEPA-600/S3-84-055, Athens, GA.

Johnson, H. P., and J. L. Baker. 1984. Field-to-stream transport of agricultural chemicals and sediments in an Iowa watershed: Part II. Database for model testing (1979-1980). Report USEPA-600/S3-84-055, Athens, GA.

Perez-Bidegain, M. 2007. Modeling phosphorus transport using the WEPP model. Ph.D. dissertation, Iowa State University, Ames, Iowa.

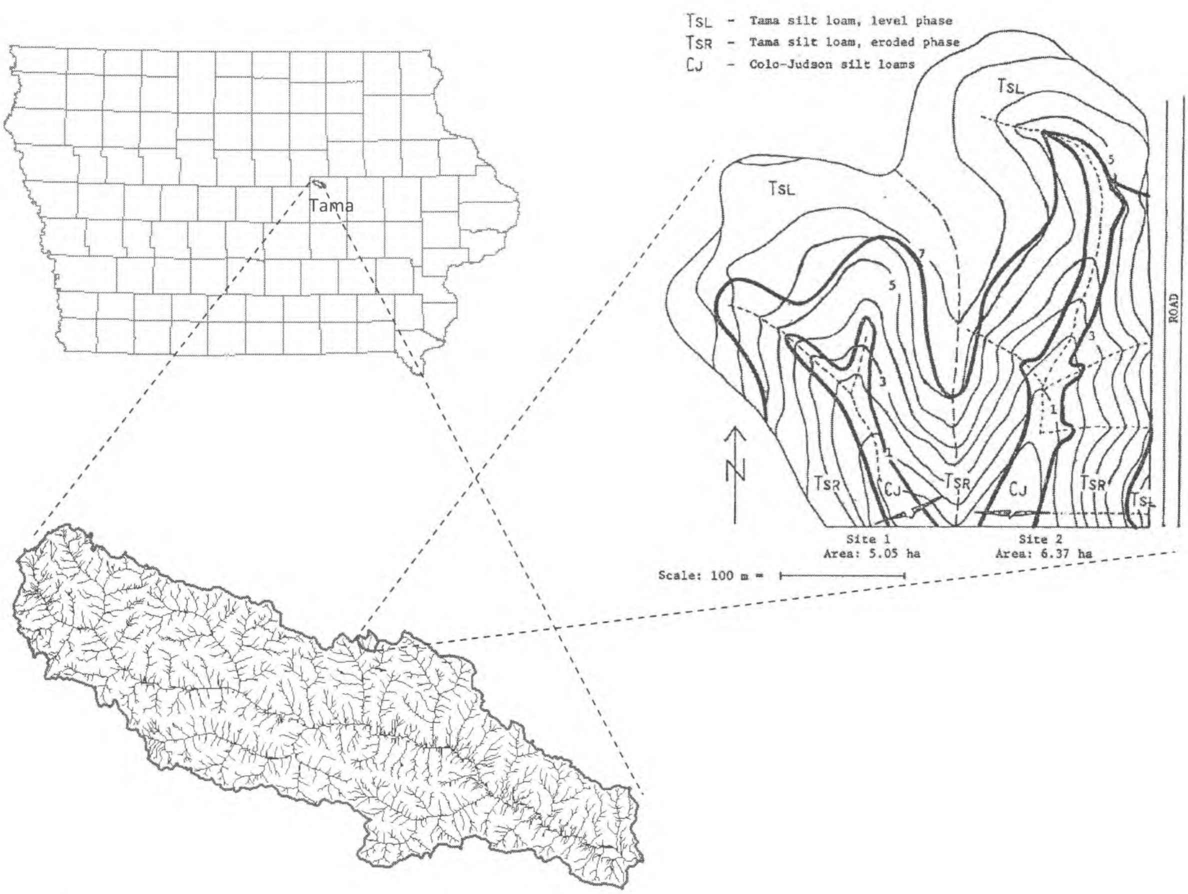

Figure 1. Location of the studying watersheds 1 and 2 within the Four Mile Creek watershed in Tama County, Iowa.

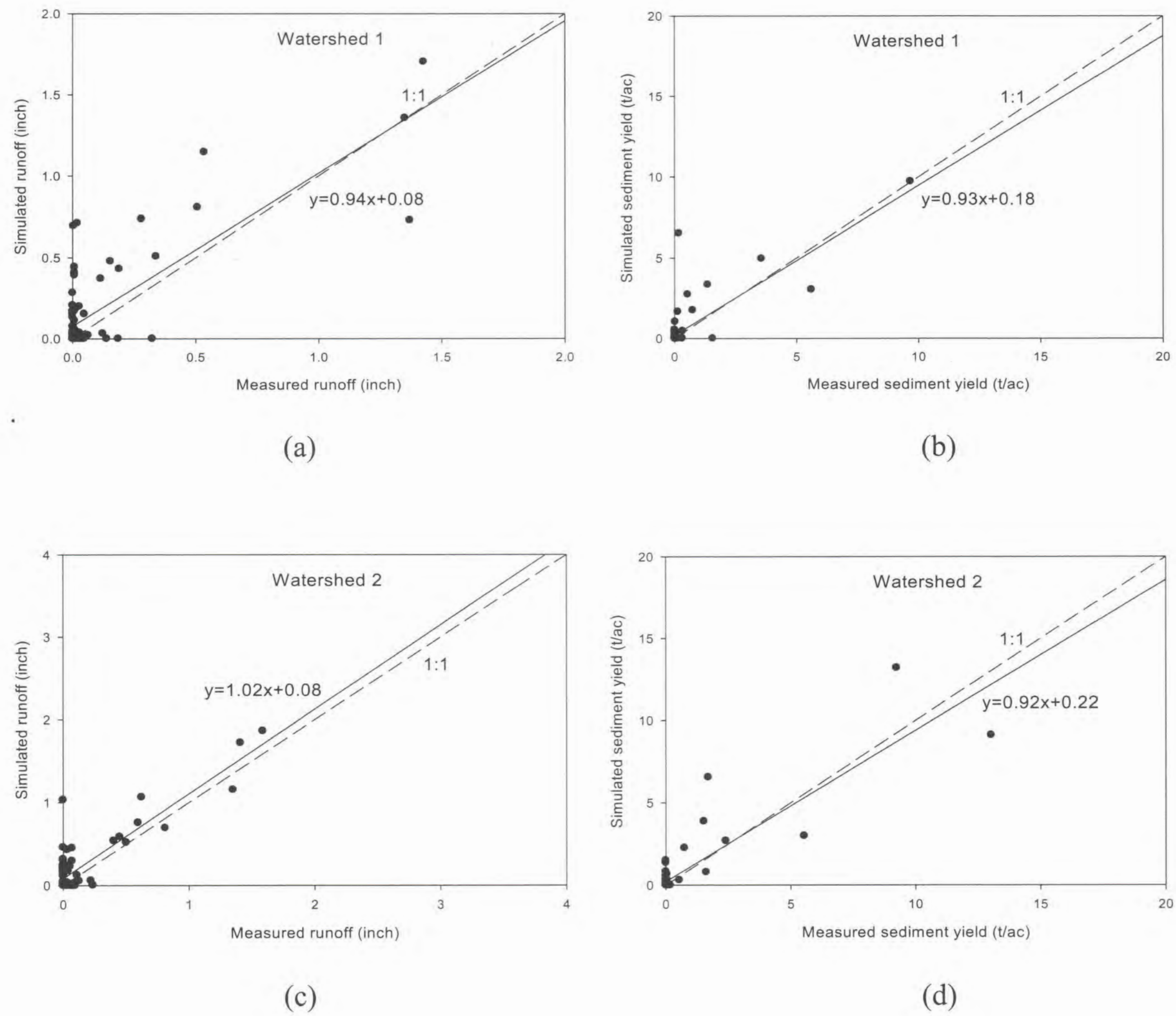

Figure 2. Measured vs WEPP-simulated runoff and sediment yield for storm events during 1976 to 1980 in the row-cropped watersheds 1 (a, b) and 2 (c, d) within the Four Mile Creek watershed in Tama County, Iowa.

Table 1. Simulation results of surface runoff and sediment yield for conventional tillage and four conservation tillage practices for watersheds 1 and 2 within the Four Mile Creek watershed in Tama County, Iowa.

	Sediment yield (t/ac/yr)	
Scenario	**Watershed 1**	**Watershed 2**
Conventional-till	6.4	9.8
No-till	0.4	0.5
Strip-till	1.1	1.2
Disk-till	1.9	3.3
Chisel-till	2.4	4.2