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Effects of biomass harvest on soil erosion

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Effects of biomass harvest on soil erosion

Abstract
The Water Erosion Prediction Project (WEPP) model was used to estimate the effects that harvesting corn residue would have on soil erosion. The erosion at different crop residue removal rates was compared on different soils and on different slopes.

Keywords
Bioeconomy and energy

Disciplines
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What rates of corn stover can be harvested from Iowa soils without excess erosion?

High rates of stover removal are possible on gentle slopes with no-till management or extended crop rotations that include perennial crops. On steep slopes, more intensive tillage systems (moldboard plow or even minimum tillage) are not sustainable in corn-bean rotations regardless of biomass removal rates.

Background

Harvesting crop residues (corn stalks and stover) as a co-product with grain provides additional income for the producer, while providing raw material for bio-based manufacturing. However, harvesting several tons per acre of crop residue from millions of acres carries certain environmental risks. Left in place, crop residue is effective in reducing erosion, and contributes to organic matter recycling and carbon sequestration in the soil. Removing excessive amounts of residue will increase both erosion and carbon loss. Farmers need to know how to harvest crop residue in a sustainable manner and identify a balance to lessen negative impacts and maintain soil quality.

The researchers used a simulation modeling approach to investigate the effects of biomass harvest on erosion under typical Iowa conditions. The Water Erosion Prediction Project (WEPP) model, developed by John Laflen, is used to predict soil erosion in the United States. Several cropping system scenarios and soil types were investigated, as were biomass harvest rates ranging from 10 to 90 percent. Soil erosion rates related to biomass harvest rates will provide important guidance to policy makers and producers as they consider sustainable strategies for bio-based development. One of the essential steps to developing appropriate cropping strategies and appropriate residue removal rates is to clearly define the amount and types of residue needed to maintain the soil resource base.

Approach and methods

Because such a large number of factors affect soil erosion, this comparative analysis focuses on four key variables:

1. Amount of biomass removed (from 0 to 100 percent in 20 percent increments)
2. Slope (100-meter, straight-line slopes at three levels)
3. Type of soil (four types, representative of major Midwest soils, were used)
4. Crop management plan (Two different crop rotations were used: conventional
two-year corn and soybean rotation and a six-year rotation of corn, soybean, oat, and alfalfa. Three different tillage regimens were examined for the two-year rotation; no-till, minimum tillage, and intensive tillage.)

Combinations of these factors were analyzed using Water Erosion Prediction Project (WEPP) v.2002.700 for a simulation period of 150 years. This time frame was needed to minimize the effect of single storm events on the overall simulation result.

Results and discussion

Only two management plans were evaluated with all four soil types. No-till and fall-moldboard tillage plans were selected because it was hypothesized that these management plans would be the extreme values for minimum and maximum soil erosion.

The basic trend of the amount of erosion per amount of biomass removed varied similarly for each of the four soil types. Analysis indicated that the model was not strongly affected by soil type, while it was considerably more sensitive to each of the other variables investigated. For a detailed look at these other variables, both crop rotations and the three tillage options were evaluated for 2.5, 7, and 11.5 percent slopes on a Marshall silty clay loam soil.

Increasing slope had less impact on increasing soil erosion for the six-year rotation and the two-year corn and soybean no-till rotation. The two-year minimum till corn and soybean rotation was affected most by slope, in terms of percent increase in soil erosion. On a percentage basis, the corn soybean rotation with fall moldboard plowing was affected less by slope than the minimum-till rotation because soil erosion for the baseline slope of 2.5 percent for fall moldboard plowing was already much larger than the baseline soil loss under minimum-till management.
Management had a significant effect on soil erosion for most slopes. As expected, the management with the most tillage, the fall-moldboard tillage, had the greatest amount of erosion, while the no-till experienced the least soil erosion. The six-year crop rotation demonstrated results similar to no-till, but was more effective at preventing soil erosion at higher residue removal rates. Even though the amount of biomass removal causes a larger increase in soil erosion from the minimum till rotation when compared to the rotation with the greatest amount of tillage, the greatest amount of soil erosion that occurs during the minimum till rotation is still less than the smallest amount that occurs during the rotation with the fall moldboard plowing.

**Conclusions**

The simulation modeling effect indicates that the amount of biomass removed can have significant effect on soil erosion. However, the magnitude of the effect differs by soil type, management plan and slope.

Even for rapidly regenerating soils with the maximum soil loss tolerance value of 11.2 tons/ha/yr, the corn-soybean rotation under intensive tillage cannot meet the tolerance standard for any biomass removal rate on slopes of 2.5 percent or above. On a 2.5 percent slope, the six-year rotation and no-till rotation could be used for all biomass removal rates and still would not exceed the highest T value. The minimum till rotation could use up to a 40 percent biomass removal rate on the 2.5 percent slope. On the 7 percent slope, minimum tillage practices would not be acceptable, while the six-year rotation would be acceptable only if no biomass was removed. The no-till management plan could be used for biomass removal up to about 40 percent biomass removal. On a slope of 11.5 percent or greater, this land erodes too rapidly to allow any residue removal.

For more slowly regenerating soils, at the low end of the soil loss tolerance range of 2.4 tons/ha/year, on a 2.5 percent slope only a no-till rotation with up to 20 percent biomass removal would be acceptable. On steeper slopes or with more intensive cropping or tillage, biomass removal would lead to excessive levels of soil erosion and threaten the long-term productivity of the soil resource. The project results show that sustainable crop and tillage management practices for biomass harvesting will depend on soil type and slope, and that acceptable biomass removal rates will often be limited by the regenerative capacity of the soil

**Impact of results**

This study provided critical early evidence that the sustainable removal of crop residues for biomass energy depends on both site and management factors, and that these factors dominate the analysis far more than the fractional residue removal rate. This has led to development of stover harvest equipment that allows variable rates of residue removal depending on local conditions. The study also demonstrated that extended crop rotations were comparable to no-till management in minimizing erosion for a wide range of soil and slope conditions.
Education and outreach
A paper on the project was presented at the American Society of Agricultural Engineers meeting.

Leveraged funds
This project providing important preliminary data for a USDA-DOE Joint Biomass Research and Development grant titled “Integrated Feedstock Supply Systems for Corn Stover Biomass.” The total award was $1,999,724, including support for integrating erosion models and soil sustainability criteria in the I-FARM whole farm planning and decision tool.

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