SOIL EROSION: HOW MUCH IS OCCURRING, WHEN, AND WHERE?

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Introduction

Soil erosion and water runoff drive water quality degradation and are liabilities to crop production, yet their magnitude is neither quantified nor inventoried for US agricultural areas. This project's goals are to: (1) estimate soil erosion and surface runoff across the Upper Midwest as contributors to soil and water degradation and (2) inventory these quantities for the next several years.

The newly released Daily Erosion Project (DEP) gives daily estimates of water runoff and sheet and rill erosion for each of Iowa's 1,647 HUC 12 agricultural watersheds (HUC 12 average area is approximately 35 square miles). For each watershed, water runoff and soil erosion is recorded over time, allowing for a spatial and temporal inventory of runoff and soil erosion for identification of soil degraded areas as well as water quality impairment source areas. These estimates are made publicly available on a daily basis from an open access interactive website. This data, as well as all input data, is publically available through this website. We are currently in the process of expanding the use of this tool from Iowa only to other states in the Midwest. This includes all or parts of Minnesota, Missouri, Kansas, Nebraska, and Wisconsin. Results for Iowa will be exemplified as work in Wisconsin is not yet complete.

Approach

The Daily Erosion Project is a next generation upgrade of the original Iowa Daily Erosion Project (Cruse et al., 2006). DEP provides statistically robust, daily estimates of hillslope water runoff, sheet and rill soil erosion and profiles soil water storage on agricultural fields in the covered area. DEP takes advantage of recent technological advancements that enable a field level modelling approach to produce estimates important for crop production, environmental evaluations and policy analysis. High temporal and spatial resolution precipitation data required to drive soil erosion and water runoff estimates came from a 2-minute, 1-kilometer square (about 0.4 square miles) NEXRAD rainfall product. Soil and crop management inputs were field-based and determined from Landsat satellite imagery of land cover, LiDAR surface elevations, the USDA NASS Cropland Data Layer, and the USDA Soil Survey Geographic database. These

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data, excluding tillage management practices, are available as the USDA ARS' Agricultural Conservation Planning Framework (ACPF; http://northcentralwater.org/acpf/) and are a critical component of DEP. Soil erosion, water runoff and soil water content are estimated using the process based WEPP model and publicly reported at the HUC 12 level, which coincides with existing watershed monitoring data and multiple federal and state projects addressing soil and water quality improvements. While daily public reporting is at the HUC 12 level, erosion, water runoff, and soil water storage estimates are made for each agricultural subcatchment within each HUC 12; these sub catchments average 200 acres in size. Depending on user needs and computer power available, these estimates could be made at a much finer scale. Within the current project structure, a statewide rainfall event resulted in over 200,000 hillslope water runoff and soil erosion estimates.

Results

To illustrate the utility of DEP, hill slope soil erosion and water runoff losses for Iowa were estimated for an eight year period beginning in 2007 based on archived input data (precipitation, crops and tillage in each field, hill slope steepness and slope length, soil types…). The statewide hill slope soil erosion estimates with DEP matched the USDA estimate published in the National Resources Inventory (NRI) (5.7 tons/acre/year for DEP and 5.8 tons/acre/year for NRI). NRI uses RUSLE, an empirically based model, as the basis for soil erosion estimates. However, DEP estimates illustrate the wide range of soil erosion that occurred spatially and temporally during this period, a critically important capability not offered by any other technology. DEP results indicate that average annual statewide soil erosion ranged from 10.6 tons/acre in 2010 to 1.6 ton/acre in 2012. Key findings show the greatest soil erosion rate estimates exceeded 50 tons/acre in multiple HUC 12 watersheds in 2010. A majority of Iowa experienced less than 1 ton/acre hill slope loss of soil in 2012, which was a drought year in the Midwest.

Soil erosion averages over large areas (a state) and over long time periods (such as occurs when long term average precipitation is used over a broad area) have value for land use planning and for trend analysis on a broad scale. The NRI (http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/nri/) is a current tool, and a well-respected tool. DEP adds to this value by not only identifying critical areas in need of elevated attention, but it also inventories soil loss through time for all HUC 12 watersheds in the state.

DEP results can be accessed at: https://dailyerosion.org/

References

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CONNECTING SOIL AND NUTRIENT LOSS TO CROP PRODUCTION

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The 4R concept (right source, right rate, right time and right place) provides a useful structure to achieve increased crop production, improved farm profitability, greater environmental protection and better sustainability. However, crop nutrient management should go beyond the 4Rs of fertilizer and manure stewardship. Other soil management factors that affect crop productivity, farm profitability, the environment, and sustainability should be considered when thinking about crop nutrient management. While fertilizer and manure applications affect nutrient availability to crops short-term (e.g., current growing season or following year), other soil management factors affect nutrient availability long-term. More specifically, factors that affect crop residues after harvest and soil structure/ aggregation affect the availability of nutrients in future years. One such soil property is soil organic matter content.

Organic matter in the soil has several important roles. One such role of organic matter is helping the formation of soil aggregates which are indispensable for well-functioning soil hydraulic properties. Greater levels of soil aggregation are associated with greater infiltration rates, plant water availability and drainage capacity (Hillel, 1998). However, organic matter also helps increase the cation exchange capacity of a soil. The cation exchange capacity of soil is often referred to as the store house of fertility. Soil particles have a small negative charge, which helps retain positively charged plant nutrient ions. Note that an ion is a chemical element or molecule with either a positive or negative charge; a positively charged ion is also called a cation. Most plant nutrients exist as ions in the water within the soil (Foth and Ellis, 1988). Plant roots uptake these ions that are dissolved in the soil water, or soil solution. As crop roots take up these nutrient ions from the soil solution, they are replaced by other ions that were stored near a soil particle thanks to the cation exchange capacity of soil. The cation exchange capacity also prevents plant nutrients in a cationic form from been lost out of the root zone by leaching.

As mentioned earlier, soil particles inherently have a negative charge. However, organic matter can contribute significantly to the cation exchange capacity of soil and boost the nutrient retention capacity of soil (Parfitt et al., 1995). In some soils it has been reported that organic matter contributes between 30 to 60% of the cation exchange capacity of the plough layer (Schnitzer, 1967). Therefore, avoiding reductions and increasing organic matter content in soil helps increase the nutrient retention capacity of a soil. Further, plant nutrients are released and made available for root uptake as organic matter decomposes in soil.

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There are several ways that organic matter content in soil can decrease, such as erosion, fast oxidation from excessive tillage, and reductions in additions of organic materials to soil (e.g., long-term reductions in crop residue inputs because of crop biomass harvest). The impacts and implications of crop/soil management practices such as tillage and crop residue handling from a crop nutrient perspective and fertilizer replacement value will be discussed during this presentation.

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