Predicting Runoff and Erosion with WEPP

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A new model, the Water Erosion Prediction Project (WEPP), estimates runoff, soil erosion, and sediment delivery at hillslope and watershed scales for single-event design storms or as continuous simulations. The model was developed by scientists from USDA's Forest Service, Agricultural Research Service (ARS), and Natural Resources Conservation Service, and the Department of Interior's Bureau of Land Management and Geological Survey to replace the Universal Soil Loss Equation (USLE). Unlike the USLE, an empirical model developed using data from the Midwest, the process-based aspect of WEPP makes the model applicable to any condition where the input data are known.

WEPP is currently the most sophisticated erosion prediction technology available; appropriate input data files have been developed by the Forest Service to offset its intensive data requirements and support its application. Predictions for runoff and erosion are within 50 percent of the true value, and have been validated by 1,000 plot-years of data on water runoff and erosion from 12 sites and 15 watersheds across the United States, according to ARS. The model is currently used to predict runoff and erosion for croplands, rangelands, disturbed forests (roads, wildfires, prescribed burns, harvest activities), watershed assessments, total maximum daily loads, sediment detention basin design, and ski-run management practices.

Processes

WEPP is a distributed-parameter, continuous-simulation erosion prediction model. Continuous simulation means that the model simulates a number of years and the parameters are updated on a daily basis. For each day that has a precipitation event, WEPP determines whether the event is rain or snow and calculates the infiltration and runoff. WEPP routes the runoff over the surface and calculates the spatial erosion and deposition rates for the event, and the average sediment yield delivered from the surface. Soil loss, sediment deposition, and sediment delivery are calculated for each runoff event. Sediment characteristics (including composition, particle size distribution, and sediment enrichment ratio) are also determined, allowing water quality estimates to be made for absorbed constituents such as phosphorous and the pesticide diazinon.

Components

WEPP simulates eight interrelated components of the erosion process: climate generation, winter processes, hydrology, soils, plant growth, residue decomposition, hydraulics of overland flow, and erosion. Winter processes modeled in WEPP include soil frost and thaw development, snowfall, and snow melt. The hydrology component computes infiltration, runoff, soil evaporation, plant transpiration, soil water percolation, plant and residue interception of rainfall, and depressional storage. The plant growth component calculates above- and below-ground biomass production, based on the EPIC model approach (Williams et al., 1984), which predicts potential growth based upon daily heat-unit accumulation and the effects of water or temperature stress. Plant residue decomposition is based on a "decomposition day" approach, which is similar to the growing degree-day approach used in many plant growth models.

The impacts of soil roughness, residue cover, and living plant cover on the runoff rates, flow shear stress, and flow sediment transport capacity are computed in the WEPP model's section on hydraulics of overland flow. The erosion component uses a steady-state continuity equation to estimate the change in sediment load in the flow with distance downslope. The WEPP model categorizes erosion into rill and inter-rill processes. Soil erodibility parameters for WEPP include inter-rill erodibility, rill erodibility, and critical hydraulic shear. These parameters quantify the susceptibility of soil detachment by water, and predict soil loss resulting from rill and inter-rill erosion.

Input Files

Four primary input files are required to run WEPP: climate, slope, soils, and plant management. WEPP provides an interface to the CLIGEN model, which generates a climate data file that can be read directly by WEPP for a user-specified location. The slope file contains topographic information, such as slope length, gradient, and aspect. The soil file includes multiple parameters, including (but not limited to) soil texture, bulk density, hydraulic conductivity, and erodibility parameters. The plant management file has 50 parameters, and is the most complex. Due to the breadth and complexity of data requirements, WEPP researchers at the Forest Service's Rocky Mountain Research Station have developed appropriate plant management and soils files that have been validated by field research throughout the western United States using rainfall simulators. These files reduce the effort required to run WEPP, and can be modified with site-specific data where available.

The WEPP model is available for download at forest.moscowfsl.wsu.edu/. Contact Drea Traeumer at drea.em@gmail.com.

Reference

Williams, J.R., C.A. Jones, and P.T. Dyke, 1984. A modeling approach to determining the relationship between erosion and soil productivity. Trans. ASAE 27(1): 129-144.