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# The USDA Water Erosion Prediction Project

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New generation water erosion prediction technology is being developed by the USDA Water Erosion Prediction Project (WEPP). The new technology is expected to replace the Universal Soil Loss Equation as the primary erosion prediction tool used by action agencies. The User Requirements, model structure, and experimental program for WEPP are described.

## Introduction

Traditional erosion prediction techniques have evolved as primarily data-based prediction equations or as simulation models incorporating modifications of the data-based prediction equations. Current erosion prediction technology, such as the Universal Soil Loss Equation (USLE) (Wischmeier and Smith, 1978), is useful for predicting average, long-term soil loss for many land use and management practices. Recent user requirements for erosion prediction include the traditional applications in conservation planning and resource conservation, but also, have called for increased sophistication. These include such applications as short-term soil loss estimates and erosion predictions for a wider variety of land use and management practices.

Recent technological advances in engineering hydrology, soil science, erosion mechanics, and microcomputers have provided the basis for development of process-based erosion prediction models. The U. S. Department of Agriculture (USDA) formed a team of scientists and engineers in 1985 and initiated a national project to develop an improved erosion prediction technology to replace the USLE. The objective of the USDA Water Erosion Prediction Project (WEPP) is to develop a new generation of water erosion prediction technology for use in soil and water conservation and environmental planning and assessment. This paper provides an overview of the user requirements, scope, model structure, and experimental program for the WEPP effort.

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## User Requirements

Previous experience in successful model development (such as the CREAMS model, Knisel, 1980) showed that communication between and among scientists and users would be essential to the success of WEPP. To accomplish this, the project developed and published User Requirements (Foster, 1987) which describe in detail the product of the project and how it is to function. These User Requirements serve as a guide or blueprint to model development and as the basis to judge performance of the final product--a suite of computer programs to predict soil erosion. The User Requirements were jointly developed by scientists and users in the Agricultural Research Service, the Soil Conservation Service, the Bureau of Land Management, and later, the Forest Service.

Major Applications. The major applications include conservation planning, project planning, and inventory and assessment. Other applications include special modeling studies and erosion predictions for design storm applications.

Technical Requirements. The technology is to apply to field-sized areas ranging in size from plots to individual hillslopes to areas of a few hundred hectares in size. The size of the areas depends upon their complexity with respect to topography, soils, and land use and management. To be appropriate for these applications, the WEPP models will be in three versions. The hillslope or representative overland flow profile version will consider variations along the landscape profile and is comparable in scale of application to the USLE. However, it will include nonuniform hillslope profiles and include sediment detachment, transport, and deposition. The watershed version will include a greater, but limited, degree of spatial variation and will include concentrated flow channels such as natural and constructed waterways. The grid version will apply to larger and more complex watersheds and will include more spatial variability. All versions will consider the major factors of climate, soil, topography, and land use and how they influence erosion. They will apply to cropland, rangeland, and disturbed forest areas. The erosion prediction technology will compute sheet and rill erosion and concentrated flow (ephemeral gully) erosion. The procedures will not consider classical gully erosion characterized by headcut migration and sidewall sloughing. Moreover, WEPP applications are intended for situations where overland flow and surface runoff dominate. WEPP is not intended for undisturbed forests or other areas where partial area runoff and subsurface flow dominate.

Initial Soils Data Base. The User Requirements include a list of 30 cropland, 20 rangeland, and 20 forest soils at various locations across the United States. These soils were selected to represent a broad range of properties and soil erodibility. Rainfall simulator studies are being conducted on these soils to obtain field estimates of infiltration parameters, interrill erodibility, and rill erodibility parameters. At the same time, a several field and laboratory procedures are being used to characterize the soils at the rainfall simulator sites toward the goal of relating basic soils properties to field-measured soil erodibility parameters. Future efforts will include soils beyond the initial data base.

Operational Requirements. The WEPP erosion prediction technology is being developed for use by action agencies dealing with soil erosion problems. Thus, the technology should apply to a broad range of conditions, be easy to use and explain, be valid for the intended applications, and be operational on personal and portable computers. Moreover, the computer programs should operate rather quickly (on the order of one minute run time for the hillslope version and two minutes for the watershed version) so as to be able to evaluate several alternatives in a rather short time.

Model Structure

The models are being designed on the basis of fundamental hydrologic and erosion processes. The models will include components for: climate, snow accumulation and melt, infiltration, runoff, hydraulics, erosion, soil moisture, plant growth, plant residue, tillage, and other practices disturbing the plant canopy and soil surface. These components are under development/testing and will be described in detail in the model documentation and elsewhere.

Briefly, the climate and snow components provide input to the model in terms of daily maximum and minimum temperatures, solar radiation, and precipitation. The rainfall events are described by a storm depth, a storm duration (< = 24 h), a relative time during the storm to the peak intensity, and the peak rainfall intensity. A double exponential function uses these data to disaggregate the storm rainfall into time-rainfall intensity data for the infiltration component. The snow routines accumulate and melt the pack and thus provide input to the infiltration routines.

The hydrologic component utilizes the Green-Ampt infiltration equation and its solution for unsteady rainfall (Chu, 1978). Infiltration parameters are obtained from soil properties (Rawls and Brakensiek, 1983, 1985) and incorporate land use and management effects (Brakensiek and Rawls, 1983). Runoff routing in overland flow and concentrated flow areas is based on the kinematic wave equations using roughness coefficients for various surface conditions and management practices (e.g. see Engman, 1986). The water balance component is based on ones developed by Williams et al. (1985) and provides status of the soil water for infiltration calculations and for the plant growth and residue decompositions components being developed.

The erosion component considers interrill sediment detachment and transport and rill detachment, transport, and deposition. Calculations are by sediment particle size classes (similar to the CREAMS model, see Knisel, 1980) and utilizes a modified Yalin Equation to compute sediment transport capacity (see Foster, 1982 for additional details). Overland flow is partitioned into sheet flow for interrill erosion calculations and into concentrated flow for rill erosion calculations.

## Field Experiments

Erosion plot studies are being conducted on about 70 soils in the initial soils data base. The studies are conducted using the Swanson (Swanson, 1965) rotating boom rainfall simulator using experimental procedures described by Simanton et al. (1986) and Laflen et al. (1987). These data will form the initial data base for the infiltration, runoff, and erosion components of the model. Complete soil pedon descriptions are being supplemented by detailed laboratory analyses to characterize soils at each of the experimental sites. In addition, supporting studies on cropping and management practices and their influence on erosion are being conducted at a number of other locations by cooperating individuals and organizations.

## Additional Information

Further information on WEPP is available from L. J. Lane, USDA-ARS, 2000 E. Allen Rd., Tucson, AZ 85719.

Copies of the WEPP User Requirements are available from Dr. J. M. Laflen, USDA-ARS, National Soil Erosion Research Laboratory, Purdue University, W. Lafayette, IN 47907.

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