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Description of tne UŏDepartment of Agriculture water erosion prediction project (WEPP) model

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Abstract

The USDA Water Erosion Prediction Project (WEPP) was initiated in 1985 to develop new generation water erosion prediction technology for use in soil and water conservation and in environmental planning and assessment. The WEPP computer models represent erosion technology based on fundamentals of infiltration, surface runoff, plant growth, residue decomposition, hydraulics, tillage, management, soil consolidation and erosion mechanics. Process-based erosion models provide several major advantages over empirically based erosion prediction technology, including most notably: (a) capabilities for estimating spatial and temporal distributions of net soil loss; and (b) being process-based, the model can be extrapolated to a broad range of conditions which may not be practical or economical to field test. Soil detachment, transport and deposition processes are represented in the models using a steady-state sediment continuity equation which represents rill and interrill processes. Rill detachment rate is dependent upon the ratio of sediment load to transport capacity, rill erodibility, hydraulic shear stress, surface cover, below-ground residue and consolidation. Rill hydraulics are used to calculate shear stresses in rills. Net deposition is calculated when sediment load is greater than transport capacity. Interrill erosion is represented as a function of rainfall intensity, ground cover, canopy cover and interrill soil erodibility. The models are designed to accommodate spatial and temporal variability in topography, surface roughness, soil properties, hydrology and land-use conditions on hillslopes. A process-based erosion model used with a process-based hydrologic model, a daily water-balance model, a plant growth and residue-decomposition model, a climate generator and a soil-consolidation model represents a potentially powerful tool for estimating soil loss and selecting agricultural management practices for soil conservation.

Introduction

The United States Department of Agriculture (USDA) Water Erosion Prediction

Project (WEPP) was initiated in 1985 with the stated objective: "To develop new generation water erosion prediction technology for use by the USDA-Soil Conservation Service (SCS), USDA-Forest Service (FS), United States Department of Interior (USDI)-Bureau of Land Management (BLM), and other organizations involved in soil and water conservation and environmental planning and assessment." The new erosion prediction technology is based on modern hydrologic and erosion science and is process oriented. The first version of the technology was delivered to user agencies in August 1989. The technology will undergo extensive testing and evaluation by user groups while research continues to refine the relationships in the model. Delivery of the version intended for general use is expected in 1993. It is anticipated that the WEPP technology will eventually replace the Universal Soil Loss Equation for routine assessment of soil erosion and planning purposes in the United States.

The WEPP technology consists of three computer models: a profile version, a watershed version and a grid version. The profile version computes soil detachment and deposition on a hillslope profile and provides the basis for the other two versions. The profile version applies to hillslopes similar to those for the USLE, except that the WEPP model computes both detachment and deposition on the hillslope, as well as the net total soil loss from the end of the slope. The watershed and grid versions can estimate net soil loss or gain over a small watershed or field-sized area at all points including channels. The models are intended to incorporate the influence of climate, soils, topography, management and supporting practices on erosion, deposition, sediment yield and sediment size distributions over the area of interest. The models are based on continuous simulation, and output from the models include predictions of the net soil loss or gain at each point on the hillslope for all times of the year. Detailed goals for the project were formulated with specific input by expected users of the technology and those involved with the technical development of the model (Foster & Lane 1987). The objective of this chapter is to present a summary of the WEPP profile version erosion-prediction technology with emphasis on the erosion calculations within the model.

Model summary

The profile version of the WEPP model will be executed primarily as a continuous simulation model, although it can be run on a single-storm basis. Continuous simulation means that the processes that influence erosion, including management practices and climate, are modelled as a function of time. For example, surface residue may influence the amount of soil lost during a given rainfall event. A plant-growth and residue-decay model within

the WEPP model estimates the amount of crop residue on the soil surface for each day of the year. The model adjusts surface cover as a function of leaf drop during senescence and residue remaining after harvesting. The amount of residue buried during tilling is also used by the plant-growth and residue-decay model. Most calculations in the WEPP model are made on a daily time step. Soil parameters, residue amounts, crop growth, soil water content, surface roughness and other adjustments to model parameters are also made on the daily time step.

Because the model inputs are in terms that the general user understands: planting dates, tillage dates, harvest dates, yields, implement types, etc. the WEPP model is user friendly. Various sources are available to provide technical information that is required to run the WEPP model. Climatic information, for instance, can be generated by the CLIGEN model, which is a stochastic weather generator. Crop-specific information, such as growth parameters, will be provided to the model user by Agricultural Research Service (ARS) and SCS technical experts. Soils information required by the model is available from an SCS soil characterization database which contains information routinely collected for soil surveys. Required topographic information is compatible with current methods of measuring slope profiles in the field.

Model structure

The WEPP profile computer model includes six major components: climate, infiltration, water balance, plant growth and residue decomposition, surface runoff and erosion. A brief description of each major component is given below.

The climate component, CLIGEN (Nicks 1985), is run separately from WEPP. The CLIGEN model generates rainfall amount, duration, maximum intensity, time to peak intensity, maximum and minimum temperature, solar radiation and wind speed and direction for the on-site location. Output from CLIGEN is stored in a file which is read by the WEPP model. Temperature determines whether precipitation takes the form of rain or snow, and wind speed and direction are used to determine the redistribution of snow on the slope profile. Runoff and erosion caused by snowmelt are also calculated.

The number and distribution of precipitation events are generated using a two-state Markov chain model. Given the initial condition that the previous day was wet or dry, the model determines stochastically if precipitation occurs on the current day. A random number (0-1) is generated and compared with the appropriate wet-dry probability. If the random number is less than or equal

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to the wet–dry probability, precipitation occurs on that day. Random numbers greater than the wet–dry probability give no precipitation. When a precipitation event occurs, the amount of precipitation is determined from a skewed normal distribution function. The rainfall duration for individual events is generated from an exponential distribution using the monthly mean durations. The amount of daily precipitation is partitioned between rainfall and snowfall using daily air temperature. If the average daily air temperature is 0°C or below, precipitation is considered to be snowfall. Daily maximum and minimum temperatures and solar radiation are generated from normal distribution functions. A disaggregation model is included to generate time–rainfall intensity data or breakpoint data from daily rainfall amounts. Given a rainfall amount and rainfall duration, the disaggregation model derives a rainfall intensity pattern with properties similar to those obtained from analysis of breakpoint data. The breakpoint rainfall data are required by the infiltration component to compute rainfall excess rates and runoff.

The infiltration component of the hillslope model is based on the Green and Ampt equation, as modified by Mein & Larson (1973), with the ponding-time calculation for an unsteady rainfall (Chu 1978). The infiltration process is divided into two distinct stages: a stage in which the ground surface is ponded with water and a stage without surface ponding. During an unsteady rainfall the infiltration process may change from one stage to another. Under a ponded surface the infiltration process is independent of the effect of the time distribution of rainfall. When the infiltration rate reaches its maximum capacity it is referred to as the infiltration capacity. At this stage, rainfall excess is computed as the difference between rainfall rate and infiltration capacity. Without surface ponding, all the rainfall infiltrates into the soil. Under these conditions, infiltration rate equals the rainfall intensity, which is less than the infiltration capacity, and rainfall excess is zero.

The water-balance and percolation component of the profile model is based on the water-balance component of SWRRB (Simulator for Water Resources in Rural Basins) (Williams & Nicks 1985), with some modifications for improving estimation of percolation and soil-evaporation parameters. The water-balance component will estimate daily snowpack evaporation and melt, potential evapotranspiration, soil and plant evaporation, soil-water content in the root zone, and percolation throughout the simulation period. The water-balance component has been designed to use input from the climate (daily precipitation, temperature and solar radiation), infiltration (infiltrated water volume) and plant-growth (daily leaf-area index, root depth and residue cover) components.

The plant-growth component of the WEPP model simulates plant growth and residue decomposition for cropland and rangeland conditions. The purpose of

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this component is to simulate temporal changes in plant variables that influence the runoff and erosion processes. Crop-growth variables computed in the cropland model include growing degree-days, mass of vegetative dry matter, canopy cover and height, root growth, leaf-area index, plant basal area, etc. (Alberts et al. 1989). The effect of tillage on residue and soil properties is also included in the model. The rangeland plant-growth model estimates the initiation and growth of above- and below-ground biomass for range plant communities by using a unimodal or a bimodal potential growth curve. Range plant variables computed in the rangeland model include plant height, litter cover, foliar canopy cover, ground surface cover, exposed bare soil and leaf-area index (Weltz & Arslan 1990). The cropland plant-growth and decomposition models will accommodate mono-, double, rotation and strip cropping practices. The user is asked to select the desired cropping practice option. In the current model, crop choices in double cropping, rotation and strip cropping systems are limited to annual crops specified in the WEPP User Requirements (Foster & Lane 1987) plus perennial crops of alfalfa and grasses. A challenge for the next few years is to develop a method that would allow parameterization of any crop for the WEPP model using standard reproducible techniques.

Many of the soil parameters that are used in the hydrology and erosion calculations change with time as a result of crop growth stage, tillage operations, soil freezing and thawing, compaction, weathering or past history of precipitation. The soils component makes adjustments to soil properties on a daily time step. Examples of temporally varying factors include soil bulk density, saturated conductivity, surface roughness and erodibility parameters.

Erosion from areas irrigated using stationary sprinkler or furrow irrigation systems can be estimated using the irrigation component of the WEPP model. The stationary sprinkler systems include solid set, sideroll, and handmove systems. Stationary irrigation systems provide water to all locations within an area simultaneously and thus simulate natural rainfall of uniform intensity. Furrow irrigation systems supply water to the upper end of a furrow with channel hydraulics determining advance and infiltration along the length of the furrow. Either natural precipitation or irrigation events may cause erosion. The relative contribution of these processes to runoff and soil loss from an irrigated area can be identified by the irrigation component of the profile model. If irrigation is available, the user can choose one of three scheduling options. The first option uses available soil moisture depletion criteria. This option requires a data file of irrigation periods when irrigation is allowed. The model determines when the irrigation will occur and the depth applied. A second option uses a database of irrigation dates and depths. The final option allows a combination of the first two options.

Surface runoff is represented in two ways in the WEPP model:

(a)   broad, uniform sheet flow is assumed for the overland-flow routing to calculate the overland flow hydrograph, with hydraulic roughness terms being weighted averages of the rill and interrill areas;

(b)   flow is partitioned into broad sheet-flow for interrill erosion calculations and concentrated flow for rill erosion calculations.

The proportion of the area in rills is represented by a rill density statistic (equivalent to a mean number of rills per unit area) and an estimated rill width. Representative rill cross sections are based on the channel calculations derived from extensive field experimentation. Depth of flow, velocity, and shear stress in the rills are calculated assuming rectangular channel cross sections. The erosion calculations are then made for a constant rate over a characteristic time to produce estimates of erosion for the entire runoff event.

The erosion component of the model uses a steady-state sediment continuity equation which calculates net values of detachment or deposition rates along the hillslope profile. The erosion process is divided into interrill and rill components, with the interrill areas supplying sediment to the rills or small channels. Within the rills, the sediment may be carried down slope or deposited in the rill. Scour by rill flow is calculated for the case when flow shear exceeds critical shear of the soil and when sediment load is less than calculated sediment capacity. The erosion component of the model is discussed in more detail in a later section.

Model inputs and outputs

Four input data files are required to execute the WEPP profile model: (a) a climate file; (b) a slope profile file; (c) a soil file; and (d) a management file. For the case of irrigation, additional input files are required.

CLIGEN is used to generate the climate file for the continuous simulation option of the WEPP model. Model use and climate at the location where the model is to be applied determine the most appropriate number of years of simulated climatic data. Three years of simulation are normally adequate (given the current set-up of CLIGEN) for comparing various management practices for making soil-conservation decisions. More than 3 years will be required for climates which are semi-arid or arid, or if more accurate long-term predictions of soil loss are desired. The model will not run partial years of simulation. It will not normally be feasible for the user to generate climate

files without the aid of CLIGEN for the continuous simulation option of the model.

The slope profile is described by length-slope pairs starting at the upper end of the hillslope. Breakpoints for the end of input segments should be made at the locations on the hillslope of the most obvious changes in slope. A typical S-shaped profile, for instance, might best be described by three input segments: a relatively flat segment at the upper end of the hillslope, a steeper mid-segment and a flatter end-segment at the toe of the slope. Slope length does not end where deposition begins. The slope profile must be described to the end of the field, or to a concentrated flow channel, grass waterway or terrace. The point where detachment ends and deposition begins is calculated by the model and given as output. Representative slope profiles must be chosen by the user for building the slope input file for the field.

Downslope variability is accommodated in the model by dividing the slope profile into overland-flow elements. An overland-flow element is defined as a section of the hillslope which is homogeneous in terms of cropping, management and soil properties. Erosion on the slope profile is calculated for each of 100 increments on each overland-flow element. Each overland-flow element is described topographically by the user with one or more slope input segments, which are described below in the section on model inputs. The model can accommodate up to 10 overland-flow elements on the profile.

The soil profile may be represented by up to 10 layers. The first line of the soil file contains general information about the soil, including soil name, texture class, soil albedo, initial saturation, rill and interrill erodibilities (if available) and critical shear stress (if available). The remainder of the file contains information for each soil layer, including bulk density, saturated conductivity (if available), field capacity (if available), 15-bar water content (if available), percentage sand, silt and clay, organic matter content, cation exchange capacity and percentage rock fragments.

Differences in soil type down the slope profile may be described using the overland-flow element for each soil type. An overland-flow element is defined as a section of the hillslope which is homogeneous in terms of cropping, management and soil properties. The user should be aware, however, that each additional overland-flow element significantly increases computational time. If soil properties, for example, are not greatly different down the slope (i.e. if soils do not vary in texture classes), the improvement in erosion prediction on the hillslope may not be significant enough to warrant multiple overland-flow elements for the downslope soil-texture variation.

The structure of the management file will depend on the land use. At present, croplands and rangelands are the two land uses supported by the WEPP model. Disturbed forest lands will be added. The management file for croplands

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includes crop-growth and residue-decay parameters for the crop-growth model, tillage dates, tillage implements, information on contour farming (if any), planting, harvesting and grazing dates, data on weed cover and data on the size of equipment used. The rangeland management file contains plant information for the ecological range community, dates of grazing and number and type of animals grazed.

Up to three irrigation input files may be required to run the model for the case of irrigation, depending upon the irrigation scheduling option specified in the management data file. These files may be: (a) a depletion-level scheduling file; (b) a fixed-date scheduling file; and (c) a sprinkler irrigation control file. The control file includes a description of the irrigation system used and dates on which irrigation may be active. The depletion-level file is used if irrigation is to be based on water content of the soil as calculated by the water-balance component of the model. A combination of depletion-level and fixed-date scheduling may be chosen. Details of the input requirements for irrigation are presented in the WEPP Profile Model Documentation (Lane & Nearing 1989).

The output of the continuous simulation model represents time-integrated estimates of erosion. In nature, as well as in the model predictions, a large percentage of erosion occurs due to a small percentage of rainfall events. The model simulates yearly erosion and sums the total soil loss over those years for each point on the hillslope to obtain average annual values along the hillslope. The model calculates both detachment and deposition. It predicts where deposition begins and/or ends on a hillslope, which may vary from storm to storm. Certain points on the hillslope may experience detachment during some rainfall events and deposition during other events. The output of the continuous simulation model represents an average of the erosion events.

The model output includes two sections, one for onsite effects of erosion and one for offsite effects. These two sections are clearly delineated in the output. Onsite effects of erosion include a section on time-integrated (average annual) soil loss over the areas of net soil loss. This quantity is the one which is most analogous to USLE estimates. It is the soil loss estimate which is most closely tied to onsite loss of productivity. The section for onsite effects also includes estimates of average deposition over the areas of net deposition. Lastly, it provides a table of soil loss at each of a minimum of 100 points down the slope. The second section of the output is for offsite effects of erosion. It includes estimates of sediment loads leaving the profile. This is the sediment which is a potential problem in terms of delivery to waterways, as well as the offsite delivery of agricultural pollutants which may be bound to soil particles. This section also includes sediment particle-size information. Since agricultural pollutants are preferentially bound to certain size classes of sediment, this information can have significance in assessing offsite pollution problems.

The output options also include the potential for obtaining monthly or daily (storm-by-storm) estimates of onsite and offsite effects of erosion. The output as a whole provides a potentially powerful tool for conservation planning. The model estimates explicitly where and when soil loss problems are occurring on a particular hillslope for a given management option on a selected field. It also provides a quick and inexpensive method for evaluating conservation methods.

The model may also be executed in the single-storm mode. For this case, all of the parameters used to drive the hydrology and erosion components of the model must be input by the user, including soil conditions for the day of the rainfall event, crop canopy, surface residue, days since last disturbance, surface random roughness, oriented roughness, etc. In the continuous simulation mode the influence of these user inputs, which represent the initial conditions for the simulation, is small since the model adjusts each of these variables internally. In the single-storm mode, user inputs have a major influence on the output. The single-storm option of the model requires a great deal more knowledge on the part of the user to interpret and use the output for planning, evaluation and design for conservation purposes. The single-storm model helps in understanding and evaluating the factors which influence erosion on a hillslope; it is of limited value in evaluating conservation systems where conditions change as a function of time.

Erosion equations

In this section the erosion component of the WEPP profile model is described briefly. The fundamental equations for sediment continuity, detachment, deposition, shear stress in rills, and transport capacity are presented. Relationships describing temporal modifications to baseline erodibility parameters as a function of above- and below-ground residue, plant canopy and soil consolidation are also presented.

Sediment continuity equation
The WEPP erosion model computes estimates of net detachment and deposition using a steady-state sediment continuity equation:

$$\frac{dG}{dx} = D_f + D_i \tag{15.1}$$

where x (m) is distance downslope, G (kg s^{-1} m^{-1}) is sediment load, D_i (kg s^{-1} m^{-2}) is interrill erosion rate and D_f (kg s^{-1} m^{-2}) is rill erosion rate. Interrill erosion, D_i, is considered to be independent of x. Rill erosion, D_f, is

positive for detachment and negative for deposition.

Interrill erosion in the model is represented as a process of sediment detachment and delivery to concentrated flow channels, or rills, whereby the interrill sediment is then either carried off the hillslope by the flow in the rill or deposited in the rill. Sediment delivery from the interrill areas is considered to be proportional to the square of rainfall intensity, and the constant of proportionality is the interrill erodibility parameter. The function for interrill sediment delivery also includes terms to account for the effects of ground and canopy cover.

Net soil detachment in rills is calculated when hydraulic shear stress exceeds the critical shear stress of the soil and when sediment load is less than sediment transport capacity. For rill detachment

$$D_f = D_c \left[1 - \frac{G}{T_c} \right] \qquad (15.2)$$

where D_c (kg s^{-1} m^{-2}) is detachment capacity by flow and T_c (kg s^{-1} m^{-1}) is sediment-transport capacity in the rill. When shear stress exceeds critical shear, detachment capacity, D_c, is expressed as:

$$D_c = K_r \, (\tau_f - \tau_c) \qquad (15.3)$$

where K_r (s m^{-1}) is a rill soil erodibility parameter, τ_f (Pa) is flow shear stress acting on the soil particles, and τ_c (Pa) is the rill detachment threshold parameter, or critical shear stress, of the soil.

Net deposition is computed when sediment load, G, is greater than sediment transport capacity, T_c. For the case of deposition

$$D_f = \left[\frac{V_f}{q} \right] [T_c - G] \qquad (15.4)$$

where V_f (m s^{-1}) is effective fall velocity for the sediment, and q (m^2 s^{-1}) is flow discharge per unit width.

Hydrologic inputs

Three hydrologic variables are required to drive the erosion model. They are (a) effective rainfall intensity, I_e (m s^{-1}); (b) peak runoff per unit area, P_r (m s^{-1}); and (c) effective runoff duration, t_r (s). Rainfall intensity is generated by

the CLIGEN climate generator and the runoff peak and duration are computed by the hydrologic component of the WEPP model. The simplest method of transposing the dynamic hydrologic information into steady-state terms for the erosion equations is to assign the value of P_r to the peak value of runoff on the hydrograph. The effective duration of runoff, t_r, is then calculated as the time required to produce a total runoff volume equal to that given by the hydrograph with a constant runoff rate of P_r. Thus, t_r is given as:

$$t_r = \frac{V_t}{P_r} \tag{15.5}$$

where V_t (m) is the total runoff volume for the rainfall event. Effective rainfall intensity, I_e, which is used to estimate interrill soil loss, is obtained from the equation

$$I_e = \left[\frac{\int I^2 dt}{t_e} \right]^{1/2} \tag{15.6}$$

where I is rainfall intensity (m s^{-1}), t is time (s) and t_e is the total time (s) during which rainfall rate exceeds infiltration rate.

Flow shear stress

Shear stress of channel flow is computed at the end of an average uniform profile length by assuming a rectangular channel geometry. The uniform profile is assumed to have a constant or uniform gradient, S, that passes through the endpoints of the profile. The shear stress from the uniform profile is used as the normalization term for hydraulic shear along the profile. Width, w (m), of the channel at the end of the rill is calculated using the relationship

$$w = c \, Q_e^d \tag{15.7}$$

where Q_e (m^3 s^{-1}) is flow discharge at the end of the slope and c and d are coefficients derived from data on the effect of rill geometry on flow rate and discharge from the study of Gilley et al. (1990). Discharge rate is given by

$$Q_e = P_r \, L \, R_s \tag{15.8}$$

where L (m) is slope length, and R_s (m) is the average distance between flow

channels on the hillslope.

The sensitivity of the model to rill spacing, R_s, and channel width, w, was investigated by Page (1988). Estimates of predicted sediment load were sensitive to rill spacing when an increase in flow shear from increased rill spacing (hence discharge) caused flow shear to exceed the threshold of critical shear of the soil and initiate rilling. The effect of rill spacing on average sediment loss per unit area was minimal for the condition that shear stress was always greater than critical shear stress. Increased rill spacing causes a greater flow volume in the rill, a higher shear stress acting on the soil, and increased sediment load. However, the loss of soil must then be averaged over the larger contributing area to the rill, resulting in the relative insensitivity of average soil loss per unit area to rill spacings.

A similar effect was observed for rill width. Decreased rill width causes increased flow depth and shear. However, the area of scour in the rill is less and hence average soil loss is not greatly affected. A large effect was seen only when increase in flow shear crossed the threshold of critical shear of the soil. Since most sediment is lost for large runoff events where critical shear of the soil is greatly exceeded, the effect of rill spacing and width on predicted soil loss was not considered to be great in terms of overall model sensitivity.

Depth of flow is computed using the friction factor of the rill, the channel width and the average slope gradient. Hydraulic radius, R (m), is then computed from the flow width and depth of the rectangular channel. Shear stress acting on the soil at the end of the uniform slope, τ_{fe} (Pa), is calculated using the equation

$$\tau_{fe} = \gamma \, S \, R \left[\frac{f_s}{f_t} \right] \tag{15.9}$$

where γ is the weight density of water (kg m^{-2} s^{-2}), S is average slope gradient, f_s is friction factor for the soil, and f_t is total rill friction factor. The ratio of f_s/f_t represents the partitioning of the shear stress between that acting on the soil and the total hydraulic shear stress, which includes the shear stress acting on surface cover (Foster 1982). Shear stress along the rill is then calculated as a function of distance, x, and shear stress at the end of the hillslope.

Sediment transport capacity

Sediment transport capacity and sediment load are calculated on a unit channel width basis within the erosion component. Sediment load is converted to a unit field width basis at the end of the calculations. Transport capacity is calculated

as a function of x, using a simplified form of the Yalin sediment transport equation of the form

$$T_c = k_t \, \tau_f^{3/2}$$

<div align="right">(15.10)</div>

where τ_f is hydraulic shear acting on the soil (Pa), and k_t is a transport coefficient ($m^{1/2} \, s^2 \, kg^{-1/2}$). Transport capacity at the end of the slope is computed using the Yalin equation as modified by Foster & Meyer (1972) for non-uniform sediment. The coefficient k_t is calibrated from the transport capacity at the end of the slope, T_{ce}, using the method outlined by Finkner et al. (1989). A representative shear stress is determined as the average of the shear stress at the end of the representative uniform average slope profile and the shear stress at the end of the actual profile. The representative shear stress is used to compute T_{ce} using the Yalin equation and k_t is then determined from the relationship given in Equation 15.10. Differences in sediment transport capacity between the simplified Yalin and the original Yalin equations, using the calibration technique, are minimal (Finkner et al. 1989).

Limits of application

The erosion predictions from the WEPP profile model are applicable to "field-sized" areas or conservation treatment units. The maximum size "field" is about a section (640 acres or 260 hectares), although an area as much as three times this large may be needed for some rangeland applications. As topographic complexity increases, the field size to which the model output applies decreases. On some very complex areas, the "field" may be much smaller. The WEPP model cannot be applied to areas where permanent channels, such as classical gullies and stream channels, are found.

The profile model cannot be applied to areas with channels which are farmed over and known as concentrated flow or "cropland ephemeral gullies". However, the watershed version of the WEPP model specifically addresses areas with ephemeral gullies. The watershed version should also be used for estimating erosion in terrace channels or grassed waterways on cropland and in rangeland and forestland applications where "fields" may contain large concentrated flow channels.

Summary

The USDA/WEPP profile computer model represents a new generation of technology for estimating soil erosion caused by rainfall and overland flow on hillslopes and is an alternative to currently used erosion prediction technology in the US. The model is based on hydrologic and erosion processes, including major components for climate, infiltration, water balance, crop growth and residue decomposition, surface runoff and erosion. It calculates spatial and temporal distributions of soil loss. The model has been designed to include a user interface which is easily useable by soil conservation planners in the field. The model structure is modular to facilitate replacement of components as new research provides refinement and improvement of existing prediction procedures. A steady-state sediment continuity equation is used as the basis for the erosion computations of net detachment and deposition. Similar to other erosion models, such as the one used in CREAMS (Foster et al. 1981), the WEPP erosion model calculates erosion from rill and interrill areas and uses the concept that detachment and deposition rates in rills are a function of the portion of the transport capacity which is filled by sediment. However, unlike other recent models, the WEPP erosion model partitions runoff between rill and interrill areas and calculates shear stresses based on rill flow and rill hydraulics rather than sheet flow (Page 1988).

Erodibility parameters are based on the extensive field studies of Laflen et al. (1987) and Simanton et al. (1987), which were specifically designed and interpreted for the erosion model. Temporal variations of erodibility are based on the consolidation model of Nearing et al. (1988). Cropping-management effects are directly represented in the model by terms for plant canopy, surface cover and buried-residue effects on soil detachment and transport. Because the WEPP erosion routines use daily water balance and infiltration routines which are spatially varied, the model can calculate erosion for the case of non-uniform hydrology on hillslopes, resulting in estimates of spatially varied erosion and sediment yield.

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