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Short Communication

Soil Erosion Assessment Tool - Water Erosion Prediction Project (WEPP)

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The Water Erosion Prediction Project (WEPP) was initiated in August 1985 to develop new generation water erosion prediction technology for federal agencies involved in soil and water conservation and environmental planning and assessment. Developed by USDA-ARS as a replacement for empirical erosion prediction technologies, the WEPP model simulates many of the physical processes important in soil erosion, including infiltration, runoff, raindrop detachment, flow detachment, sediment transport, deposition, plant growth and residue decomposition. The WEPP included an extensive field experimental program conducted on cropland, rangeland, and disturbed forest sites to obtain data required to parameterize and test the model. A large team effort at numerous research locations, ARS laboratories, and cooperating land-grant universities was needed to develop this state-of-the-art simulation model. The WEPP model is used for hillslope applications or on small watersheds. Because it is physically based, the model has been successfully used in the evaluation of important natural resources issues throughout the United State and in several other countries. Recent model enhancements include a graphical Windows interface and integration of WEPP with GIS software. A combined wind and water erosion prediction system with easily accessible databases and a common interface is planned for the future.

Key words: Erosion models, Runoff, Sediment, Soil conservation, Soil erosion, Water erosion

Introduction

USDA-Agricultural Research Service (ARS) personnel and their cooperates initiated the Water Erosion Prediction Project (WEPP) in August 1985 to produce new generation water erosion prediction technology involved in soil and water conservation and environmental planning and assessment. The WEPP model was developed to serve as a replacement for empirically based erosion prediction model such as the Universal Soil Loss Equation (USLE).

Development of the WEPP model involved research engineers and scientists creating model logic and code, conducting field and laboratory experiments, working on parameterization and model testing, and creating user interfaces and databases. During the first ten years of development, leading up to the 1995 model release, over thirty-five meetings were held across the United States to coordinate project activities. Field rainfall simulation experiments were conducted on over fifty experimental sites, ranging from Western rangelands to Eastern croplands. Four research engineers have served as project leaders over the past twenty-two years of WEPP development. In this paper, we described how the soil erosion prediction technology developed and the future of WEPP technology.

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Model Development History

Federal action agencies in the United States that manage soil and water resources must assess the soil erosion impact of diverse land uses ranging from cotton fields to mountain forests. To assure that the needs of the user agencies were adequately addressed, agency representatives were active participants in the WEPP project from its inception. Representatives of action agencies helped define user needs and provided essential background on the range of resource issues WEPP would need to address.

A Core Team made up of project leaders and technical exports from across the United States supervised WEPP project management and development. The Core Team met regularly to review progress and discuss model development and planning. Goals of the Core Team meetings included updating WEPP participants on the

status of issues and action items identified in previous meetings, and discussing technical items requiring attention. Field tours sometimes occurred during Core Team meetings with the goal of familiarizing WEPP participants with local conditions across the country, and helping to identify the range of issues that should be addressed by the model.

An initial model delivery date of 1989 was established. After each of the Core Team meetings and several of the subgroup meetings conducted between August 1985 and June 1992, a meeting report to the entire WEPP team and a list of actions items was distributed. Also, a USDA-ARS National Program Leader (NPL) was responsible for coordinating erosion research within ARS and provided administrative support for the project and kept top agency administrators informed of project activities and requirements.

Beginning in August 1987, development of the Wind Erosion Prediction System (WEPS), an improved wind erosion prediction technology, closely paralleled WEPP model development (Hagen et al., 1996). Representatives of the WEPS project often attended WEPP Core Team meetings, and have collaborated with WEPP project members for many years on several joint activities.

The WEPP project was initiated to provide a specific product within an established timeline. Many individuals participated in project activities, made important contributions, and then redirected their efforts to other pursuits. As the project progresses and new issues evolved, participation by additional individuals was required to provide renewed energy and expertise. Flanagan et al. (2001) provide additional information concerning WEPP model development.

An extensive team effort at numerous research locations, ARS laboratories, and cooperating land-grant universities was needed to develop this state-of-the-art simulation model. Over 200 individuals representing different federal agencies, universities, disciplines, and international locations have made significant contributions to the WEPP project. Managing and coordinating the efforts of this diverse group was a substantial administrative challenge.

Model Summary

WEPP is a continuous simulation, distributed parameter, erosion prediction computer program that can be applied up to small watershed scales (about 260 ha) over a range of time scales, including individual storm events, monthly totals, yearly totals, or an average annual value based on data for several decades. The model drew heavily on theory, field research, and modeling produced by a wide range of academics and practitioners, including geomorphologists (Nearing et al., 1989). The WEPP model simulates climate, infiltration, water balance, plant growth and residue decomposition, tillage and consolidation, surface runoff, erosion, sediment transport, and deposition, as well as winter processes. The WEPP model°Øs process-based nature enables its transfer to ungauged watersheds without any future calibration, unlike many other existing models.

The major inputs to WEPP are a climate data file, a slope data file, a soil data file, and a crop/management data file. If the user is simulating irrigation, additional input files are necessary. Applying WEPP in a watershed also requires additional input files which provide information on channel and impoundment characteristics as well as watershed configuration. The default set of model contains cropland, rangeland, and forest management inputs for a wide range of conditions. Soil input information can be obtained for thousands of soils in the NRCS (National Resources Conservation Service) Soils-5 and NASIS (National Soil Information Service) database. Information from over 4,000 climate stations can be used with the CLIGEN (Climate Generator) (Nicks et al., 1995) weather generator to produce a time series of synthetic climate inputs for erosion simulation throughout the United States. Complex slope shapes with multiple soils, cropping, and management conditions can be easily simulated.

Model outputs are also numerous, and can be viewed either graphically or in text format, depending upon the wishes of the user. The most basic output contains the runoff and erosion summary information, which may be produced on a storm-by-storm with monthly, annual or average annual basis. The time-integrated estimates of runoff, erosion, sediment delivery, and sediment enrichment are contained in those outputs, as well as the spatial distribution of erosion on the hillslope.

As a whole, the output provides a potentially powerful tool for conservation planning. The model estimates where and when soil loss problems occur on a given hillslope for a given management system and allows the user to easily view and interpret the results. The WEPP provide an inexpensive and rapid method for evaluating various soil conservation options.

Beside the continuous improvement of the Windows WEPP interface, watershed simulations become increasingly complex and difficult to do as larger areas need to be represented. As a result, additional work was initiated at the National Soil Erosion Research Laboratory (NSERL) in 1996 to link the WEPP model with Geographic Information Systems (GIS), and utilize digital elevation data to automatically delineate watersheds, channels, hillslopes, and representative hillslope profiles (Cochrane and Flanagan, 1999). An ESRI ArcView extension known as GeoWEPP (Renschler et al., 2002; Renschler, 2003) was released in 2001. A web-based WEPP GIS system (Flanagan et al., 2004) that allows users to locate and simulate any location in the United States via their web-browser connected to a server at the NSERL was recently provided. Both this web-based product and GeoWEPP provide spatial and graphical display outputs of predicted erosion risk areas in a watershed.

Future Model Enhancements

WEPP and WEPS science and computer code are currently being used in a new modeling project to create a combined process-based wind and water erosion model (Flanagan et al., 2005). To achieve this objective, the hillslope erosion component from WEPP has recently been extracted as an independent computer program.

The WEPP hilllsope erosion computer code has also been inserted as a module into the Object Modeling System (OMS). OMS is software modeling development platform created by the ARS-Agricultural Systems Research Unit in Fort Collins, Colorado, that allows model components to be easily built form legacy code in the FORTRAN, C, and JAVA programming languages (David et al., 2002). These modules can then be linked to form new models (Ascough et al., 2005). Modules for surface hydrology, water balance, water erosion, wind detachment, and a prototype model that can simulate either wind or water detachment for multiple storm events were developed from 2004-2006. Project plans are to complete a combined wind and water prediction systems, including easily accessible database and interfaces, by 2011.

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토양 침식 예측 모델 - Water Erosion Prediction Project (WEPP)

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토양침식을 예측하는 WEPP(Water Erosion Prediction Project)모델은 연방 정부기관이 토양과 물 보전 및 환경을 계획하고 평가하는데 활용하고자 1985년 8월 차세대 물에 의한 토양침식을 예측하기 위해 만들어졌다. 미 농무성 농업연구소에 의해 개발된 WEPP 모델은 경험적인 침식 예측을 위한 도구로써 침투, 유거수, 강우와 물에 의한 토양입자의 분리, 침전물의 이동, 퇴적, 작물의 생장 및 수확 후 잔여물의 분해 등을 포함한 토양 침식과 관련된 많은 중요한 물리적 과정을 모의한다. WEPP 모델은 모델을 구성하는 모듈의 입력자료와 모델을 시험하기 위해서 필요한 자료를 경작지, 초지, 산림 등 광대한 현장 실험 결과들로부터 얻었다. 미국내 여러 농업연구소와 협력 대학 등 수 많은 연구소의 큰 노력으로 모델을 만들 수 있었다. WEPP 모델은 경사지 혹은 작은 유역 규모에 적용이 가능하며, 물리적 모델이기 때문에 미국과 다른 여러 나라에서 중요한 자연자원을 효과적으로 평가할 수 있다. 최근 들어 DOS프로그램으로 만들어진 초기 WEPP모델을 윈도우 인터페이스와 GIS 프로그램을 통합하여 향상시켰다. 또한, 바람과 물에 의한 침식을 통합 예측하는 시스템을 쉽게 이용할 수 있도록 구축 중에 있다.