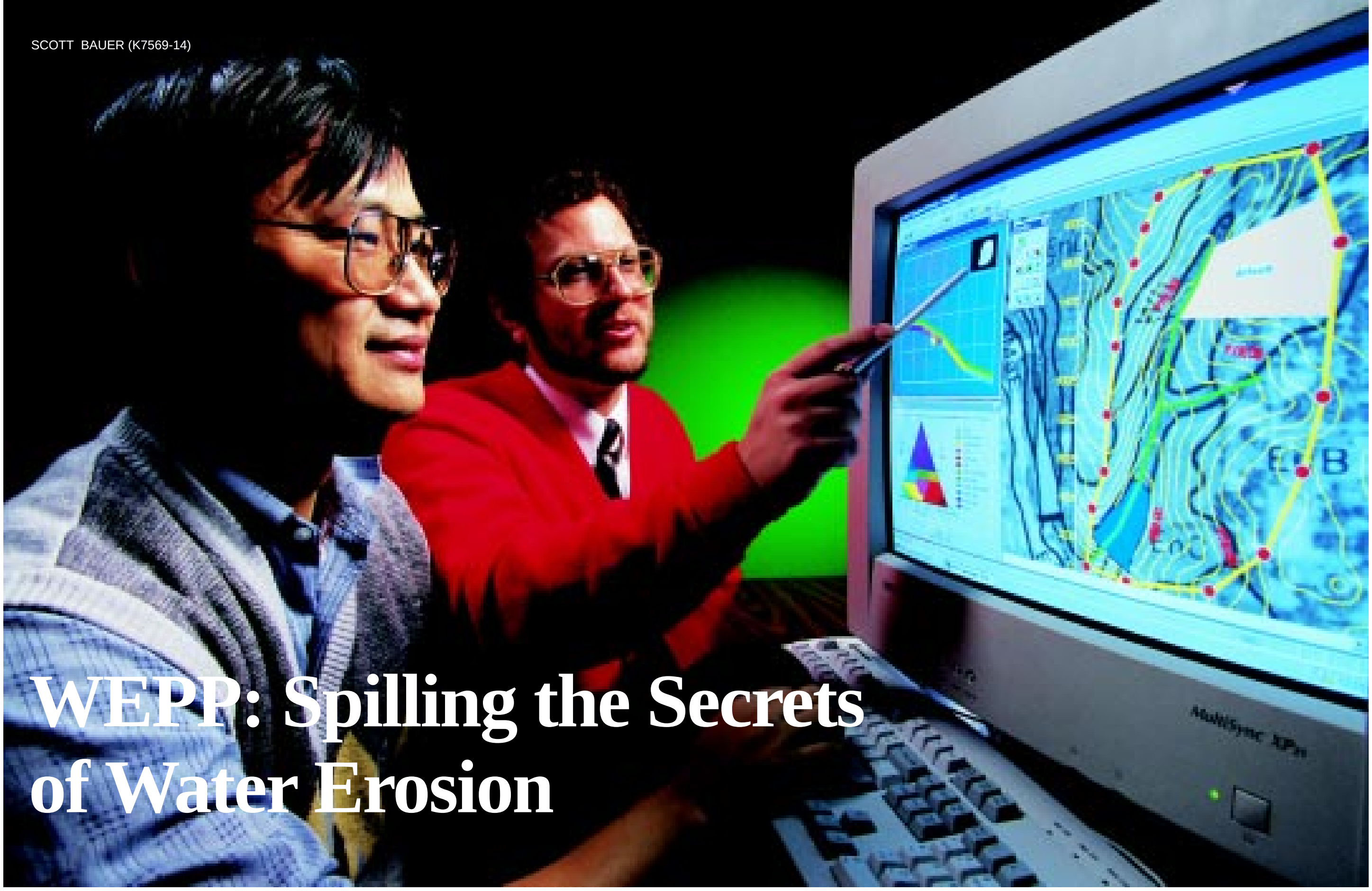


SCOTT BAUER (K7569-14)

WEPP: Spilling the Secrets of Water Erosion

A new multiplatform graphical Windows interface is being developed to support transfer of the WEPP prediction technology to field users. Computer programmer-analyst Hailiang Fu (left) and agricultural engineer Dennis Flanagan discuss the design of the watershed top view and profile side view interface screens.

“A nation that destroys its soils destroys itself.”

— Franklin D. Roosevelt

FDR’s observation is as worrisome today as it was in 1937. Lester Brown of World Watch presents convincing numbers about erosion’s relationship to a shortage of farmland. Carol Browner, who heads the U.S. Environmental Protection Agency, describes the products of soil erosion as our greatest water quality problem.

Soil erosion is indeed a persistent and serious research problem and, with its myriad complexities and variables, one that is terribly difficult for scientists to accurately measure.

This much is known: Despite being a world leader in soil conservation efforts, the United States loses about 6.4 tons of soil per acre each year—that’s over 3.5 tons to water erosion and 2.9 tons to wind erosion—from cultivated row-crop agriculture. This estimate is from the 1992 National Resources Inventory, a record of the nation’s conservation accomplishments and future program needs that’s compiled by USDA’s Natural Resources Conservation Service (NRCS).

Globally, soil loss is believed to be many billions of tons annually. But exactly how many? From where? Where do they end up? And what are the causes of this loss?

“We need new technology to better assess how much erosion occurs and how sediment is deposited on land, as well as a way of accurately determining the best alternatives to manage land so as to prevent erosion,” says ARS agricultural engineer John M. Laflen, WEPP’s project leader.

“That is what WEPP—short for the Water Erosion Prediction Project—is all about,” he says. “Now, land managers, environmentalists, educators, and policymakers around the world will have a powerful new tool to evaluate alternatives for the control of soil erosion by water. This evaluation is critical, if money and effort spent on erosion control are to be effectively used.”

This new generation of soil-erosion prediction technology is now available thanks to over 10 years of ARS research. The team that brought forth the WEPP model includes not only dozens of ARS scientists at 25 locations, but cooperators at USDA’s NRCS and Forest Service and at the U.S. Department of the Interior (USDI)’s Bureau of Land Management (BLM).

Several universities, including Purdue University at West Lafayette, Indiana, have made significant contributions.

"WEPP erosion software is sophisticated, state-of-the-art technology that simulates or mimics the hydrologic and erosion processes that occur on small watersheds or slopes on hills within those watersheds," says Laflen. "WEPP has components to predict erosion on crop, range, and forest lands."

The search for a new set of erodibility values began in 1987 as a cross-country quest. Laflen and ARS hydrologist J. Roger Simonton led research teams that traveled across the United States, conducting experiments on soils from California to Maine, from Washington, D.C., to Washington State.

"The scope and size of this operation," says C. Richard Amerman, "constituted a landmark effort—unique in recent decades—to obtain the geographically distributed set of field data needed to drive the WEPP technology." Amerman is the ARS national program leader for erosion at Beltsville, Maryland.

"WEPP represents a major step forward—almost a quantum leap—in our ability to evaluate alternative land treatments in terms of their impact on soil erosion by water," he says. "WEPP is a real improvement over previous models because of advances in our understanding of how erosion occurs."

For much of WEPP's 10-year development, Amerman coordinated the program nationally to see the model readied for delivery to users.

What is unique about the way WEPP operates? Unlike previous technologies that were statistically pegged to observations at a limited number of sites, WEPP is process-based and, therefore, works for all sites. It emulates scientifically known physical soil erosion processes and, thus, is stronger.

Amerman says ARS hydrologist Leonard Lane provided the vision that brought process-based hydrology to the WEPP technology. And he credits ARS hydraulic engineer George R. Foster with "giving WEPP the heart of the technology—the rill and interrill erosion routines that drive the model—and laying out in detail the structure and function of the model's technology."

Rill erosion is caused by runoff water flowing over the soil, while interrill erosion results from raindrop impact and splash.

their requirements were known at the outset and that they were part of the model-building process.

This foresight eventually saved untold dollars in subsequent retrofits.

ARS agricultural engineer Mark A. Nearing, who was technical director for the WEPP project from 1993 to 1995, led the validation efforts.

"The model has been validated against about 1,000 plot years of natural runoff and erosion data from 12 sites, as well as against data from 15 watersheds around the United States," he says.

SCOTT BAUER (K7567-11)

Flume experiments can be used to obtain data on soil detachment and transport by flowing water for use in testing the relationship in WEPP, as well as in development of prediction equations. Here, ARS scientists Mark Nearing (center) and Dennis Flanagan (second from left), graduate assistants Dmitry Bulgakov (left) and Viktor Polyakov (right), and research associate Tingwu Li (second from right) monitor a flume at the National Soil Erosion Research Laboratory.

As important as the science behind the model is, if the system is to work, the needs of the user must be factored in from the moment the first line of program code is written. Amerman feels that Foster's greatest contribution was bringing representatives of the agencies that will use WEPP into the model design process at the very beginning. Foster made sure that all

"For the first time," says Nearing , "we can estimate soil deposition, sediment yield, how soil loss is distributed in space and time, to better target expensive erosion control measures within the field and throughout the year."

WEPP includes many interactions that occur between the environment and management practices that influence erosion, according to Purdue hydrologist Reza Savabi, who worked on many of the model's components—including winter and subsurface hydrology and water balance.

"These interactions make the model especially useful in studying the effects on soil erosion when land management, climate change, soil disturbances, and many other shifts occur," says Nearing. "Its key advantage is that it predicts rill and interrill erosion separately, which other prediction tools are not designed to accommodate."

Agricultural engineer Arlin Nicks, who recently retired from the ARS Soil and Water Resources Research Laboratory in Durant, Oklahoma, developed the weather and climate component of WEPP. Nicks' weather model, called Climate Generator (CLIGEN), artificially generates the climate data needed to drive WEPP—so that the actual weather data from a site and the data generated by CLIGEN will have the same statistical properties.

CLIGEN averages climate parameters of the station under consideration with the parameters of the surrounding stations. Results from ARS computer simulation studies, using National Weather Service data and the CLIGEN model, proved consistent with those obtained using other prediction tools like the Revised Universal Soil Loss Equation.

Nearing and Laflen worked with ARS agricultural engineers Dennis C. Flanagan and James C. Ascough, II, in developing and testing the erosion-prediction technology at the National Soil Erosion Research Laboratory in West Lafayette, Indiana. Flanagan developed the WEPP hillslope profile model; Ascough, the WEPP watershed model.

The combined watershed/hillslope WEPP program allows users to simulate runoff, erosion, and sediment delivery from small agricultural watersheds or portions of fields in those watersheds. In addition to work on the scientific components of the erosion model, Flanagan and Ascough also guided first-generation model interface programs to assist users in generating and organizing input information for model simulations.

Systems engineer for WEPP, ARS computer specialist Charles R. Meyer, is leading the effort to link the WEPP model with a new user-friendly graphical interface that "greatly assists model users in determining input parameter values, assessing databases, organizing model runs, and viewing and interpreting output," he says.

"Graphic information is understood more easily than numbers, so this interface should make it quicker and easier for users to enter information about slope length, incline, soil prop-

SCOTT BAUER (K7568-1)

Microbiologist Diane Stott and hydrologist Reza Savabi look at how the interception of rainfall by crop residue changes the water balance component of the WEPP computer model.

Managing the WEPP Project

During the 12 years of WEPP's development, three ARS scientists led the many researchers and action agency personnel involved in readying the model for use.

ARS hydraulic engineer George R. Foster initiated the WEPP project and was its leader from its beginning in 1985 until 1987. Then ARS hydrologist Leonard J. Lane at the Southwest Watershed Research Laboratory in Tucson, Arizona, took over until 1989.

John M. Laflen, an agricultural engineer now stationed at the National Soil Tilth Laboratory in Ames, Iowa, was the last ARS scientist to lead the WEPP development project, from 1989 to the present. He supervised completion of the model and is currently facilitating WEPP's implementation by users.

erties, and how the watershed is being managed," says Meyer, who works at the West Lafayette laboratory. He is heavily involved in the effort to link all ARS erosion models through the user-friendly graphical interface.

Flanagan was lead editor for the final WEPP model technical documentation, user summary documentation, and a multimedia CD-ROM for transfer of the technology to users.

"The WEPP95 CD-ROM is one major tool for transferring the model to users worldwide," says Flanagan. "This multimedia disk contains all of the WEPP software, databases, electronic documentation, and html [hypertext markup language] training materials."

The WEPP model technical and user documentation is available in several formats and can be viewed electronically or printed. An html browsing program is included to allow viewing of multimedia—text, audio, video, images—information on erosion processes, erosion prediction technology and installation, and use of the WEPP model. The CD-ROM also contains a 16-minute film that helps introduce first-time users to the program.

The CD-ROM can be used to install WEPP model software with climate and soils data for all 50 states. Sets of validation data from natural runoff plots and sample model input file sets are also on the disk.

Flanagan was also instrumental in developing the World Wide Web pages that allow users to download WEPP software and learn how to install and use the erosion model. Most of the information on the CD-ROM is available through the Internet.

WEPP software was recently delivered to several cooperators, including USDA's Forest Service (FS) and the BLM. Aware that the model could be applied to solve erosion problems that are part of their missions, these agencies are anxious to train users. For example, the BLM hopes to use WEPP to control erosion on rangelands.

The FS is also champing at the bit. "We've already trained about 100 people at WEPP workshops around the country," says William J. Elliott, who is project leader of engineering technology for improved forest access, at the FS Intermountain Research Station in Moscow, Idaho.

"WEPP allows forest managers to better address site-specific erosion problems—like the impact of timber harvesting on sediment in streams—in a scientific manner," says Elliott. "Right now, people make seat-of-their-pants decisions based on their experience—without much science be-

A technician times the rate of advance of a harmless green dye in runoff water coursing through furrows during a WEPP field experiment at Tifton, Georgia.

JOHN LAFLEN

hind them. Such decisions are not very defensible in court battles to support forest-management decisions."

Forest managers can thank the late Edward R. Burroughs who, as an FS research engineer at the intermountain station, adapted WEPP—as it was being developed—for that agency's use on roads and disturbed areas. He ran the same types of intensive tests on forestlands as Laflen did on croplands.

Other federal agencies, like USDI's Geological Survey, are also eager to reap the model's advantages, as are numerous consultants, university faculty, and researchers at scientific institutions around the world.

David Schertz, national agronomist for NRCS's biological conservation sciences in Washington, D.C., says that his agency views WEPP as a new generation of erosion prediction technology.

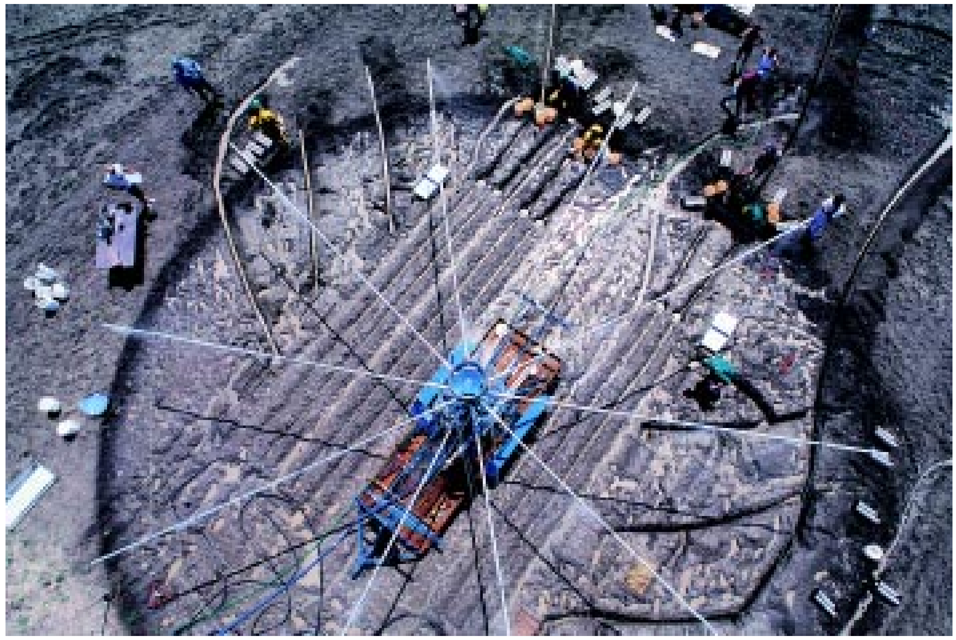
"We plan to implement WEPP—after appropriate databases have been developed and tested in the agency—in conservation planning," says Schertz. "Its use in such activities, especially those regarding water quality, will offer us a new means of calculating concentrated flow and routing of sediment from fields."

And WEPP has been demonstrated to groups worldwide—in Australia, Austria, Belgium, Brazil, Canada, China, Costa Rica, India, Italy, Mexico, Portugal, Russia, Uganda, and Ukraine. Already, WEPP's been put to work in an international study related to global climate change.

A major advancement in erosion modeling, WEPP has been used on every continent but Antarctica and has received extensive testing worldwide—in Austria, Australia, Italy, Portugal, and China. Where specific experimental data have been available, WEPP has performed well.

These documented data sets were presented to 150 potential users from

TIM MCCABE (K2705-4)



This rainfall simulator and test plot at Cottonwood, South Dakota, enabled technicians to measure water runoff rates and collect soil samples in a WEPP cropland field study.

federal agencies and institutions at a special symposium sponsored by the Soil and Water Conservation Society in August 1995.

Users can obtain the most current model release and other information through the World Wide Web.

"This method of software delivery is innovative and efficient and allows for easy updating of information," says Flanagan. "Electronic mail is sent to large lists of WEPP users to notify them of important updates, patches, and meetings. Internet users from the United States and over 50 foreign countries have accessed and downloaded WEPP information and/or software. The National Soil Erosion Research Laboratory's file server records hundreds of information requests each month."—By **Hank Becker,** ARS.

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WEPP and supporting databases, WEPP fixes, WEPP documentation, and additional material are available on the WEPP home page. Access it at http://soils.ecn.purdue.edu:20002/~wepp/wepp.html