The Forest Service WEPP Interfaces

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Abstract:

The Water Erosion Prediction Project (WEPP) model was found to be too time-consuming for Forest Service specialists to learn and apply. To make the WEPP technology available to these specialists, interfaces to run the WEPP erosion model and CLIGEN weather generator were developed to run on the World Wide Web with a web browser. These interfaces include the X-DRAIN program, a lookup table for sediment delivery from forest roads; WEPP:Road, a WEPP interface for forest roads; Disturbed WEPP, a WEPP interface for disturbed forests and rangelands; and Rock:Clime, an interface to the CLIGEN weather generator with an expanded database to complement our WEPP interfaces.

Keywords: Forest roads, Forest operations, Forest hydrology, Erosion models, WEPP

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Prediction of soil erosion by water is a common practice for natural resource managers for evaluating impacts of upland erosion on soil productivity and offsite water quality. Erosion prediction methods are used to evaluate different management practices and control techniques.

The first widely-accepted prediction tool was the Universal Soil Loss Equation (USLE) (Wischmeier and Smith, 1978). The USLE continues to be applied throughout the world. In recent years, it has been superseded by the Revised USLE (RUSLE) (Renard et al., 1997). The USLE technology, however, does not adequately address sediment delivery. Numerous variations have been developed to incorporate delivery into the USLE technology and alternative empirical models were developed to address this shortfall.

With the advent of personal computers the ability to apply process-based models to soil erosion became feasible. With the process models came the requirement of much larger and more complex input data sets. Early models, such as CREAMS (Knisel, 1980), required large text files generated with a text editor (or punch card machine). Later models, such as WEPP (Flanagan and Livingston, 1995), included file building interfaces. Currently, Windows-based interfaces are under development for the RUSLE and WEPP (Water Erosion Prediction Project) models.

The Forest Service wanted to develop the WEPP model for forest conditions. Forest templates were developed for the model (Elliot and Hall, 1997) and workshops were held throughout the U.S. to show Forest Service specialists how to apply the model. More than 200 specialists were trained between 1995 and 1998. Of those specialists, only three or four used the model, because the interface was too difficult to operate, and too much time was required to assemble the data and interpret the results. The Forest Service, however, desires to use the best available erosion technology to support its numerous planning activities. To make the WEPP technology available to Forest Service specialists, a set of Internet interfaces was developed to run WEPP for many forest conditions on our servers using a web browser. This paper describes those interfaces.

Description of WEPP

The Water Erosion Prediction Project (WEPP) soil erosion model was developed by an interagency group of scientists including the USDA's Forest Service, Agricultural Research Service (ARS), and Natural Resources Conservation Service, and the Dept. of Interior's Bureau of Land Management and US Geological Survey. Scientists from these agencies throughout the United States have been working since 1985 to develop an erosion prediction model to replace the Universal Soil Loss Equation (USLE).

The WEPP model is a complex computer program that describes the processes that lead to erosion. These processes include infiltration and runoff; soil detachment, transport, and deposition; and plant growth, senescence, and residue decomposition. For each simulation day, the model calculates the soil water content in multiple layers, plant growth, and residue decomposition. The effects of tillage processes and soil consolidation are also modeled.

The WEPP model can be run for a hillslope, or a watershed. The base model is for a hillslope, predicting soil erosion from a single hillslope profile of any length up to about 400 m. The hillslope can have a complex shape, and can include numerous soils and plant types along the hillslope. Each unique combination of soil and vegetation is considered to be an overland flow element (OFE) (Figure 1). The watershed option links hillslope elements of specified widths together with channel and impoundment elements.

Input Files

The hillslope option requires four input files. (1) The daily climate file includes the description of daily precipitation, temperatures, radiation and wind. A climate generator is available to generate typical weather sequences. The generator has a database of weather station statistics mainly on non-mountainous terrain distributed on approximately a 60-mile grid for the entire U.S. (2) The slope file contains two or more sets of points describing the slope at intervals along the profile. (3) The soil file can contain up to 10 layers of soil describing the texture and other properties of the soil. The most critical inputs are the erodibility and hydraulic conductivity of the surface layer. (4) The management file contains descriptions of each of the plant communities and descriptions of each of the tillage systems employed. The management file also contains the surface condition at the start of the simulation.

Forest Applications

In forests, the majority of sediment comes from forest roads, and in some conditions, from skid trails or burned areas. A set of typical templates for forested areas and roads are available from our Internet site (Elliot and Hall, 1997) for the MS DOS hillslope version of WEPP.

Figure 1. Overland flow elements

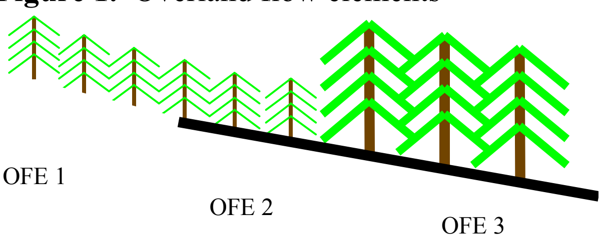
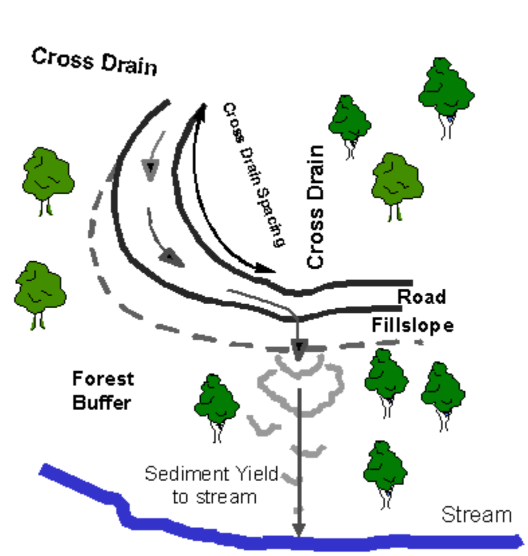


Figure 2. Template for X-DRAIN program and WEPP:Road interface



We have found that in forest conditions, soil erodibility properties depend on the surface cover. For example, the same soil experiencing different fire severities will have different erodibility properties (Robichaud, 1996). A soil that has been altered to become a road has different erodibility properties than does a forest soil regardless of disturbance. When running WEPP for road or forest conditions, it is important to ensure that the soil and vegetation management files are complementary. We have found that novice users fail to make this important link, resulting in inappropriate and improbable erosion predictions.

WEPP Interfaces

The 1995 release of WEPP (Flanagan and Livingston, 1995) included a fully functional user interface which performed well on an MS DOS platform. The watershed option, however, was difficult to use, and the complex management file builder did not work in an MS DOS window in Windows environments. Currently, the ARS is distributing both the MS DOS and the Windows 95 interfaces (USDA ARS, 2000).

Both the MS DOS and the Windows interfaces allow users to alter approximately 400 input variables needed for a WEPP run. Occasional users find it difficult to keep track of which combinations of files to use for typical forest and range conditions and may specify unlikely combinations of soil and management on these highly flexible interfaces. To offer the erosion and sedimentation prediction capabilities of the WEPP model to a greater number of forest users, a set of simplified user interfaces was developed. These interfaces are intended to be run with a web browser from our web sites, but standalone versions have been developed (Elliot et al., 1999). On-line documentation aids in selection of input conditions, and provides example applications.

X-DRAIN. The first of the forest interfaces was the cross drain program X-DRAIN, which is a simple front end to access the predicted sediment yields from about 130,000 WEPP runs. X-DRAIN is based on three OFEs consisting of a road, a fill slope, and a forested buffer (Figure 2). The user selects one of 82 climates, one of five soils, one of four buffer slope steepness values, and one of five buffer lengths on the input screen (Figure 3). The sediment yield in kilograms or pounds at the end of the buffer is then presented on the output screen for 20 different sets of road gradient and cross drain spacing values (Figure 4). For example, in Figure 4, the sediment yield is 96 kg for a 120-m long road segment with a 4% gradient. X-DRAIN is useful for determining sediment yields for typical road networks to aid in road design, watershed sediment analysis, and road closure activities. X-DRAIN is on our web sites, and is also distributed as a standalone program by the Forest Service San Dimas Technology and Development Center (Elliot et al., 1998).

WEPP:Road. The X-DRAIN program is useful for making rapid assessment of the sediment potential from a road network. In some cases, greater site details are known, and the input options offered by X-DRAIN are not adequate. For these conditions, the WEPP:Road interface was developed. Like X-DRAIN, it describes the conditions shown in Figure 2, and has an input and an output screen (Figures 5 and 6).

Figure 3. X-DRAIN Input Screen

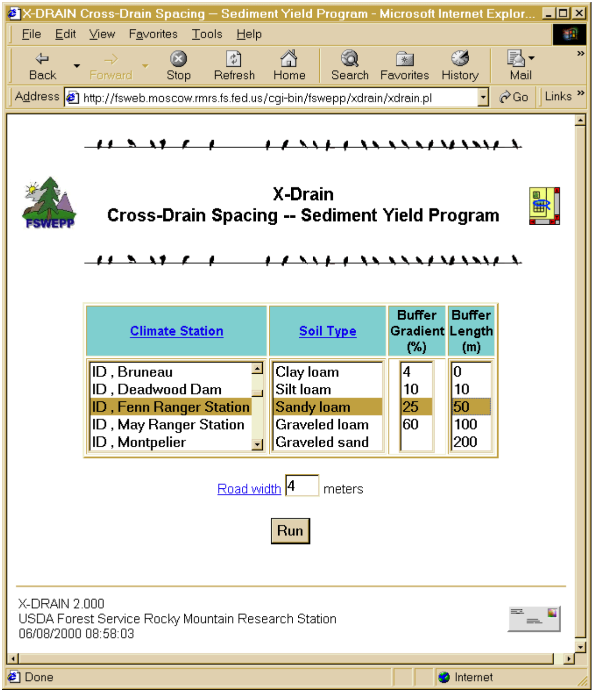


Figure 4. X-DRAIN Output Screen

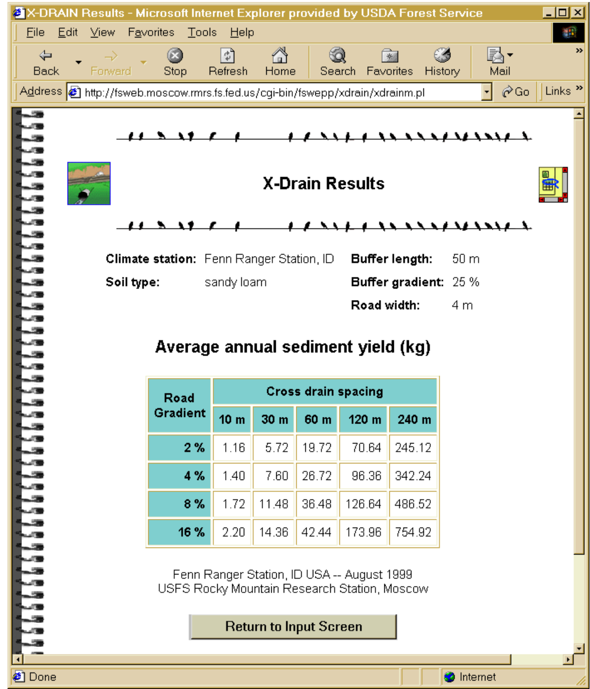


Figure 5. WEPP:Road Input Screen

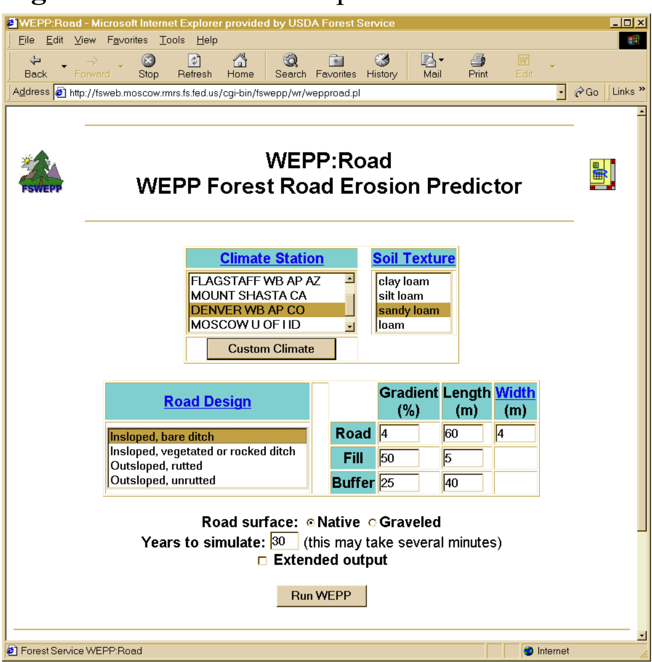
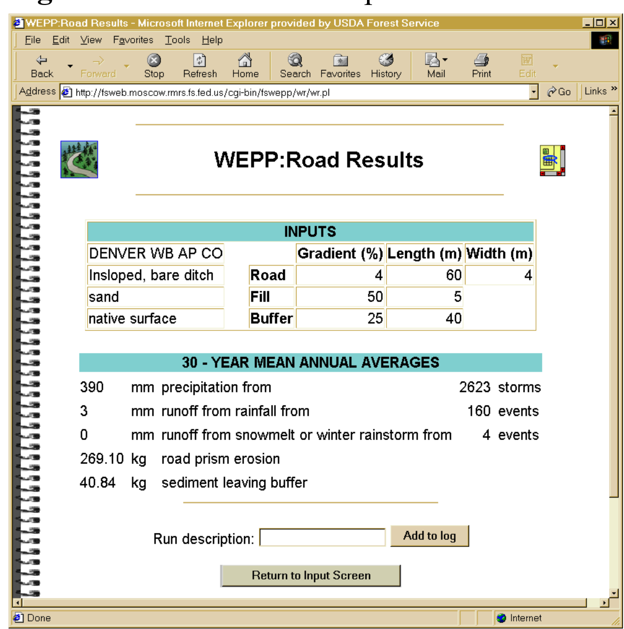


Figure 6. WEPP:Road Output screen



On the WEPP:Road input screen, the user can select from the short list of climates, but will likely prefer to select one of the more than 2600 climates available through the Rock:Clime interface to the ARS CLIGEN weather generator. The user also selects a soil from one of four textures. The road surface choices are insloped with bare or covered ditch, or outsloped with or without ruts. The road and buffer topographic features allow values of slope steepness ranging from near zero to 100 percent, and lengths ranging from 1 m to 300 m. The user specifies the number of years of run. At least 30 years are recommended, and 50 to 100 years are preferable for climates with annual rainfall below 500 mm. Users also must select the appropriate road width and can specify the presence of gravel.

The output from WEPP:Road presents not only the amount of sediment delivered from the forest buffer to a stream, but also the average precipitation, the runoff, and the amount of sediment leaving the eroding portion of the road prism. If the user selects ☑ Extended output then the WEPP Annual abbreviated hillslope output is presented, allowing the user to determine the distribution of erosion and deposition, the presence of a sediment plume in the forest, and the particle size distribution of sediment delivered to the channel. The results from a series of runs of WEPP:Road can be added to a log file (Figure 7) for saving, printing, or copying and pasting into another document such as a word processor or spreadsheet file.

Disturbed WEPP. We are developing Disturbed WEPP for forest conditions including skid trails, prescribed fires, wild fires, and young and mature forest. Options are also available for range conditions including good and poor grass and shrubs. Disturbed WEPP has two OFEs so that users can study numerous combinations of uphill and downhill disturbances, such as a skid trail or harvest area above a buffer zone, or a heavily grazed area above a riparian zone.

Disturbed WEPP has one input and two output screens–one for a calibration vegetation check, and another for a probability analysis (Figures 8, 9, and 10). The input screen (Figure 8) allows the user to select the climate and soil, the vegetation type and cover on the two OFEs, and the topography for each OFE. The user can then select either a vegetation check for calibrating the amount of surface cover, or a WEPP run. The WEPP run will provide a probability analysis as well as mean erosion rates to allow users to determine the likelihood of a given annual erosion amount occurring at the level of disturbance specified. Most sites that are severely disturbed begin to recover quickly except for some rangeland over-grazed conditions. Because a probability analysis is carried out on the output, it is recommended that users select 50 or 100 years of climate for probability runs.

Figure 7. Example of WEPP:Road log file

WEPP:Road log - Microsoft Internet Explorer provided by USDA Forest Service

File Edit View Favorites Tools Help

Back Forward Stop Refresh Home Search Favorites History Mail Print Edit

Address http://fsweb.moscow.rmrs.fs.fed.us/cgi-bin/fswepp/wr/logstuff.pl Go Links

WEPP:Road log

Denver Road

Wed June 28, 2000 11:30

Yrs	Climate	Soil	Surface	Design	Road grad	Road len	Road width	Fill grad	Fill len	Buff grad	Buff len	Precip	RRO	SRO	Sed Road	Sed Profile	Comment
30	DENVER WB AP CO	sandy loam	native	insloped bare	4 %	60 m	4 m	50 %	5 m	25 %	40 m	390 mm	3 mm	0 mm	269.10 kg	40.84 kg	Bare Ditch
30	DENVER WB AP CO	sandy loam	native	insloped vegetated	4 %	60 m	4 m	50 %	5 m	25 %	40 m	390 mm	3 mm	0 mm	176.34 kg	36.17 kg	Veg Ditch
30	DENVER WB AP CO	sandy loam	native	outsloped rutted	4 %	60 m	3 m	50 %	5 m	25 %	40 m	390 mm	3 mm	0 mm	145.98 kg	31.08 kg	Rutted
30	DENVER WB AP CO	sandy loam	gravel	outsloped unrutted	4 %	60 m	4 m	50 %	5 m	25 %	40 m	390 mm	1 mm	0 mm	164.11 kg	5.64 kg	Outslope Gravelled

Done Internet

Figure 8. Disturbed WEPP input screen

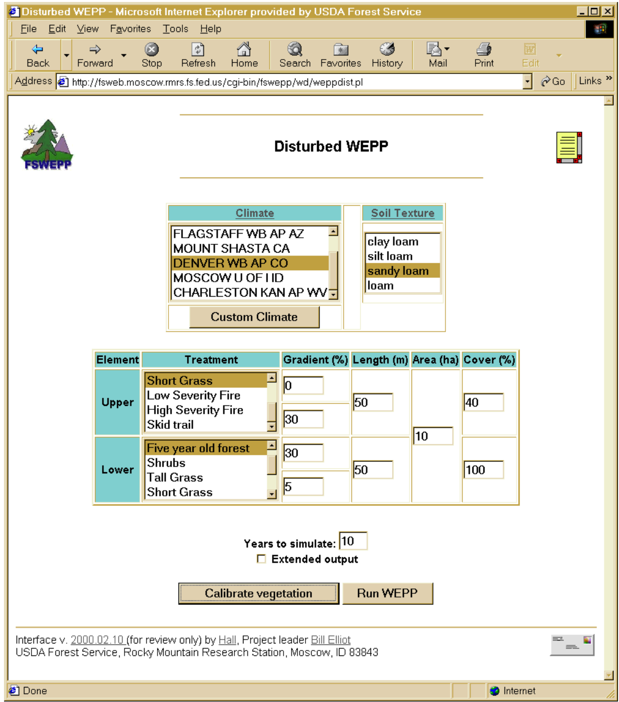


Figure 9. Disturbed WEPP output for 10-yr vegetation calibration

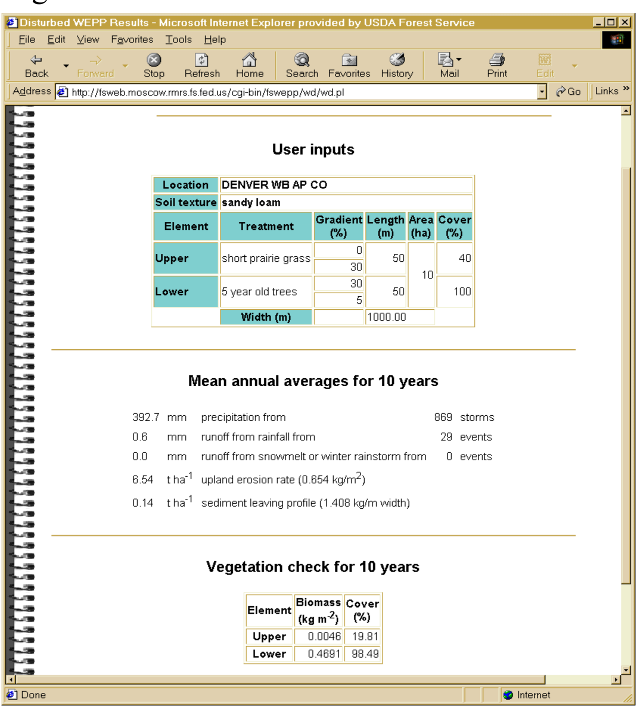
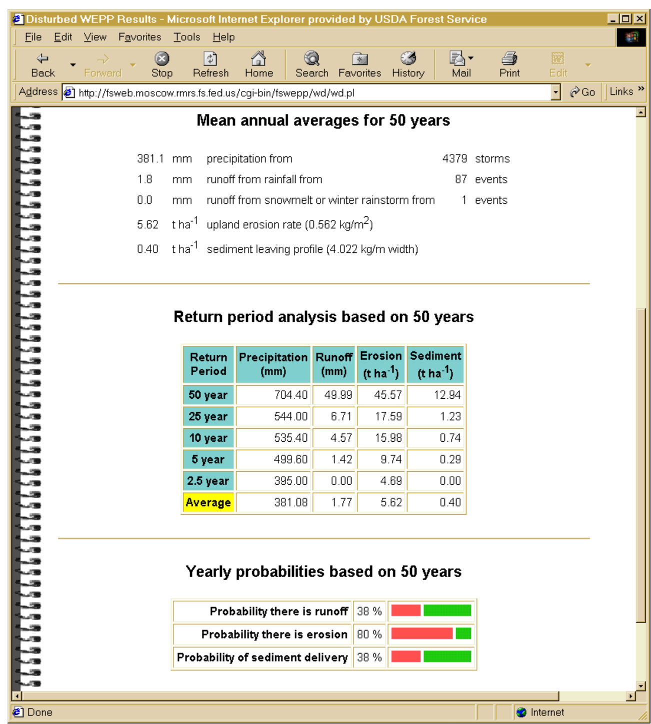


Figure 10. Disturbed WEPP output from WEPP run



The output for a Disturbed WEPP run is presented in Figure 10. Note that the mean values are presented, as well as the first, second, fifth, tenth and twentieth greatest annual values for precipitation, runoff, erosion, and sediment yield values from the entire length of run. The probability that any of these same values was non-zero is also presented.

Rock:Clime. The Rock:Clime interface was developed for the ARS CLIGEN climate generator (Flanagan and Livingston, 1995). The database has been expanded from the ARS database of about 1200 stations, to over 2600 climates from all 50 states, Puerto Rico, and the Pacific Islands. Current plans are to supplement the CLIGEN database with the PRISM monthly precipitation values estimated at a 4-km grid for the entire U.S. (Oregon State University, 2000). Another planned improvement is to allow users to modify the monthly precipitation amounts, number of wet days, and maximum and minimum temperatures from a "nearby" climate to more nearly reflect the site of concern.

Rock:Clime can be accessed from either WEPP:Road or Disturbed WEPP screens. Users select their desired state and then the desired station to match the site. In some cases, the best climate may be in a different state. Users can also use the Rock Clime interface to generate daily climate input files formatted for WEPP for downloading. This feature may be particularly useful for all WEPP users when the PRISM database is incorporated into the interface.

Validation

The validation of the WEPP model is beyond the scope of this paper, but the model has received widespread validation both in the U.S. and abroad. Discussions of validations of the X-DRAIN program and WEPP:Road are incorporated into their respective documents, available online. Generally, erosion rates and sediment deposition lengths predicted by these two interfaces are within the range of variation of observed values for a given site. Work is underway to provide validation data for Disturbed:WEPP and Rock:Clime.

Internet Sites

The FS WEPP interfaces are available on two Web servers. One is at Washington State University, and is available to anyone with access to the World Wide Web. The other is located on the Forest Service Intranet server in Moscow, ID, and can be accessed by anyone within the Forest Service network and by some other federal agencies. The Intranet site will generally be faster for users within the Forest Service.

The interfaces are regularly updated, and potential users are encouraged to visit the FS WEPP sites whenever they are faced with a sedimentation problem to evaluate the usability of the site for each problem. User comments are welcome, and we encourage all users to take the opportunity to have an input into the development of more user-friendly interfaces to the WEPP model.

User Feedback

These interfaces have now been presented to more than 100 specialists at eight Forest Service and/or BLM workshops in the Western U.S. The X-DRAIN program has been presented to several hundred road engineers at another five Forest Service training sessions. Users generally have been enthusiastic, and have been applying the interfaces to fire and road analysis throughout the U.S. It is our intent that these interfaces become the erosion prediction method of choice for these specialist applications.

Summary

The WEPP program was found to be too time-consuming for Forest Service specialists to learn and apply. To make the WEPP technology available to these specialists, interfaces to run the WEPP erosion model and CLIGEN weather generator were developed to run on our internet servers. These interfaces include the X-DRAIN program, a lookup table for sediment delivery from forest roads; WEPP:Road, a WEPP interface for forest roads; Disturbed WEPP, a WEPP interface for disturbed forests and rangelands; and Rock:Clime, an interface to the CLIGEN weather generator with an expanded database to complement our WEPP interfaces.

Sites

Internet for all users:

http://forest.moscowfsl.wsu.edu/fswepp/

Intranet for Forest Service Users:

http://fsweb.moscow.rmrs.fs.fed.us/fswepp/

Forest files and other information:

http://forest.moscowfsl.wsu.edu/4702/

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