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Erosion Risk Management Tool (ERMiT) User Manual

(version 2006.01.18)

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Predict
post-fire

erosion

treatment
effectiveness

and recovery

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Abstract

The decision of where, when, and how to apply the most effective post-fire erosion mitigation treatments requires land managers to assess the risk of damaging runoff and erosion events occurring after a fire. To aid in this assessment, the Erosion Risk Management Tool (ERMiT) was developed. This user manual describes the input parameters, input interface, model processing, and output files for version 2006.01.18.

ERMiT is a web-based application that uses Water Erosion Prediction Project (WEPP) technology to estimate erosion, in probabilistic terms, on burned and recovering forest, range, and chaparral lands with and without the application of erosion mitigation treatments. User inputs are processed by ERMiT to combine rain event variability with spatial and temporal variabilities of soil burn severity and soil properties, which are then used as WEPP input parameters. Based on 20 to 40 individual WEPP runs, ERMiT produces a distribution of rain event sediment delivery rates with a probability of occurrence for each of five post-fire years. In addition, event sediment delivery rate distributions are generated for post-fire hillslopes that have been treated with seeding, straw mulch, and erosion barriers such as contour-felled logs or straw wattles.

Key words: erosion prediction model, FS WEPP, post-fire assessment, BAER treatments

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Preface

The Erosion Risk Management Tool (ERMiT) uses Water Erosion Prediction Project (WEPP) technology as the runoff and erosion calculation engine. WEPP simulates both interrill and rill erosion processes and incorporates the processes of evapo-transpiration, infiltration, runoff, soil detachment, sediment transport, and sediment deposition to predict runoff and erosion at the hillslope scale (Flanagan and Livingston, 1995). The ERMiT interface uses multiple runs of WEPP over a range of input parameters to predict event sediment delivery in probabilistic terms on burned and recovering forest, range, and chaparral lands. This ERMiT User Manual provides the information needed to access, run, and interpret ERMiT output; however, the conceptual framework of the model has not been included. The reader is directed to Robichaud and others (in press) for details of the underlying assumptions and probability calculations of the ERMiT model. This technical article describes: 1) the components of the ERMiT model; 2) the variability of rainfall, soil burn severity, and soil properties (input parameters) that influence postfire erosion; and 3) how the input parameter variabilities are combined to produce a probability distribution of event-based erosion rates with and without application of mitigation treatments.

ERMiT is a dynamic process-based model that can be readily updated as additional data and validation results become available. User feedback is greatly appreciated.

Peter R. Robichaud

Purpose of Erosion Risk Management Tool

Erosion Risk Management Tool (ERMiT) (Robichaud and others 2006) provides a distribution of rain event erosion rates with the likelihood of exceeding these values. This is unlike most erosion prediction models, which typically have "average annual erosion" as output. ERMiT is a web-based application that uses Water Erosion Prediction Project (WEPP) technology to predict erosion in probabilistic terms on burned and recovering forest, range, and chaparral lands, with and without the application of mitigation treatments (see Appendix A for model assumptions). ERMiT combines weather variability with spatial and temporal variabilities of soil properties to model the range of post-fire erosion rates that are likely to occur. Based on a single 100-year WEPP run and 20, 30, or 40 ten-year WEPP runs, ERMiT produces a distribution of runoff event sediment delivery rates with corresponding exceedance probabilities for each of five post-fire years. In addition, sediment delivery rate distributions are generated for hillslopes that have been treated with seeding, straw mulch, straw wattles, and contour-felled log erosion barriers.

ERMiT's "event sediment delivery exceedance probability" output can help managers decide where, when, and how to apply treatments to mitigate the impacts of post-wildfire runoff and erosion on life, property, and natural resources. With ERMiT, managers can establish a maximum acceptable event sediment yield and use ERMiT to determine the probability of "higher than acceptable" sediment yields occurring. The maximum acceptable event sediment yield will vary within a burned area. For example, a short term decline in water quality may be more acceptable than damage to a cultural heritage site, and modeling the hillslopes above these two resources would likely have different user-designated exceedance probabilities and treatment criteria. By modeling various hillslopes within a burned area, managers can determine the probabilities of erosion-producing runoff events occurring, the expected event sediment deliveries, and rates of recovery for the post-fire conditions that exist.

Accessing ERMiT

ERMiT can be run from the Internet on the FS WEPP web page (http://forest.moscowfsl.wsu.edu/fswepp/), which is maintained by the USDA Forest Service, Rocky Mountain Research Station. To run ERMiT, select metric or U.S. conventional units and click the "ERMiT" graphic. The "personality" field is used to maintain individual user information when groups of users share a single Internet Protocol (IP) address. Agencies are increasingly networking computer systems so that users within the same forest may have the same IP address.

Input Data

User inputs for ERMiT are:

- climate
- soil texture
- soil rock content
- vegetation type (forest, range, chaparral)
- hillslope gradient and horizontal length
- soil burn severity class
- for range and chaparral, pre-fire plant community description (relative distribution of shrub, grass, and bare soil cover in percentages).

User inputs are entered on a single interactive browser screen (fig. 1). When the cursor hovers over the input parameter name, short hints are provided in the status bar found in the lower left corner of the monitor screen (fig. 2). More extensive explanations related to the input parameters are found on linked pages accessed by clicking on the "?" icon next to the parameter name.

Climate

ERMiT is linked to Rock:Clime (version 2004.04.26) (Elliot and others 1999; Elliot and Hall 2000), which provides climate parameter files for more than 2600 weather stations across the United States. These parameter files specify:

- station name, latitude, longitude, and elevation
- statistical characterizations of:
  - historical daily precipitation
  - minimum, maximum, and dewpoint temperatures
  - solar radiation
- monthly probabilities of a wet day following a wet day, and of a wet day following a dry day
- a time-to-peak distribution
- wind data

Rock:Clime allows the user to create a custom climate parameter file by making modifications to monthly precipitation depth, monthly maximum and minimum temperature, and monthly number of wet days in an existing climate parameter file.

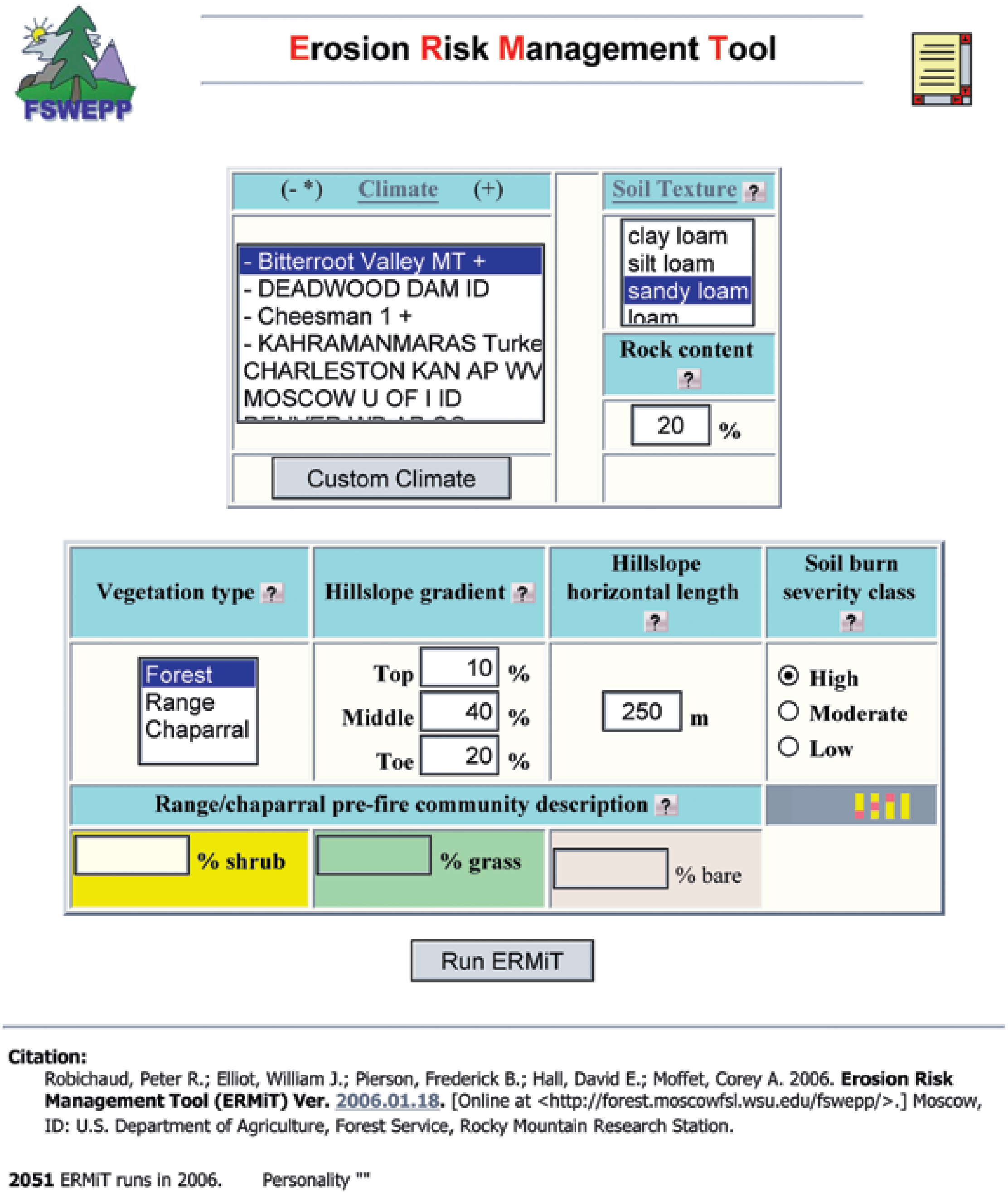


Figure 1. The ERMiT input screen with example user selections.

Figure 2. The browser screen “status bar” provides helpful hints as the curser moves over the input screen, in this case, over the hillslope top gradient box.

Amount of monthly precipitation may be modified using data generated by PRISM (Parameter-elevation Regressions on Independent Slopes Model) (Daly and others 1994; Elliot 2004) or user data. PRISM provides elevation and monthly precipitation values on a 2.5 arc-minute grid across the conterminous United States (PRISM gridded data, normals, 1971-2000. http://www.ocs.orst.edu/prism/).

ERMiT uses the climate parameter file (with all user modifications) as input to CLIGEN (version 4.31) (Nicks and others 1995) to generate a WEPP formatted stochastic daily weather data file. This weather data file includes:

- daily precipitation amount, duration, time-to-peak, and peak intensity
- minimum, maximum, and dewpoint temperatures
- solar radiation
- wind velocity and direction

Climate files—status designations

The input page for ERMiT displays a short list of standard climates and, in some cases, a list of "custom climates" generated by users of that IP address. The name of a climate station listed in the ERMiT climate selection list may be preceded by a "source of data" symbol. Lack of a preceding symbol indicates that the climate station is one of the standard stations available immediately to all users.

- A leading asterisk (*) indicates that the climate file is a "custom climate" created by a user of the current IP address. Each custom climate, available only on the computer where it was created, is generally accessible for at least one week after creation. [Because the linkage is through the Internet Protocol (IP) address of the connection in place when the custom climate is created, America Online (AOL) users may encounter difficulties as their IP connects are not persistent, even within a single ERMiT run. Thus, AOL users may be unable to use custom climates once they are created. In addition, dial-in users may get different IP addresses each time they connect to the Internet, which limits the use of a custom climate to a single session.]
- A leading dash (-) indicates that the climate file for the station has been made available, for a period of time, perhaps for an instructional session.
- A trailing plus (+) sign indicates a modified climate file; in other words, some of the standard climate station parameter values within this file were modified.

Viewing climate station files using the "Climate" link

- **Click** the underlined title, Climate, to link to a new page.

The new page contains a summary of the monthly mean maximum and minimum temperatures, precipitation, and number of wet days (in other words, days with precipitation) for the selected climate station. A table of the weather stations used to determine the wind, dewpoint, solar radiation, and time-to-peak parameter values is shown as well. From the climate page, the user may also view the entire climate parameter file and a simple line map (based on U.S. Census Bureau TIGER/Line® files) showing the location of the station based on the listed latitude and longitude. The climate parameter file can be saved as a *.par file in the WEPP Windows directory structure and used for other applications in addition to ERMiT.

Selecting and modifying climates using the "Custom Climate" button

- **Click** "Custom Climate," which opens Rock:Clime, to select a climate station that is not in the ERMiT selection list, or to generate a custom climate.
- **Select** the state of interest.
- **Click** "SHOW ME THE CLIMATES" to add a new climate.

A list of available climate station parameter files for the selected state is displayed. The user has three choices:

1. **Add** any of the listed climate stations to ERMiT's climate selection menu by selecting the climate station and clicking "ADD TO PERSONAL CLIMATES."
2. **View** the parameters for the selected climate station by clicking "DESCRIBE CLIMATE."
3. **Modify** climate parameter values by clicking "MODIFY THE CLIMATE," which will open an interactive screen with access to PRISM monthly precipitation values based on latitude and longitude input, and will also allow the user to enter and modify climate data from an existing parameter set.

Hint—after using a linked climate page, click "Retreat" or "Return to input screen" from any climate screen. The current ERMiT session will be lost if you close the browser window.

To create a climate parameter file for areas outside the Rock:Clime coverage area (in other words, outside the United States), select a similar available climate within the United States and modify it to more closely match the climate of the area to be modeled. For climates that are substantially different from an existing parameter file, it is best to start with a climate that is drier than the target climate.

Soil Texture

Users can select from among four soil textures: clay loam, silt loam, sandy loam, and loam (fig. 1), based on the USDA soil texture classification system.

Click the “ ? ” icon next to the “Soil Texture” title to view soil descriptions and the corresponding ASTM Unified Soil Classification System group symbols.

Click the “Soil Texture” title to view the soil parameter values used for ERMiT’s initial 100-year WEPP run. [The available ranges of soil parameter values and the use of these values for the different WEPP runs are discussed in the Process section of this User Guide and in Robichaud and others (in press).]

Rock Content

In ERMiT, rock content refers to the proportion of rocks found in the upper soil profile. Values up to 50 percent may be specified within the “Rock Content” box (fig. 1). There is no mechanism to adjust soil parameters for rock outcrops or surface rock cover.

Vegetation Type and Range/Chaparral Pre-fire Community Description

The user can select one of three vegetation types to model: forest, range, or chaparral. If the user selects “range” or “chaparral,” he or she may specify the proportion of shrub, grass, and bare soil in the “Range/chaparral pre-fire community” boxes. The default values for range communities are 15 percent shrub, 75 percent grass, and 10 percent bare ground. The default values for chaparral communities are 80 percent shrub, 0 percent grass, and 20 percent bare ground. For values other than the default values, the user enters percent shrub and grass cover and ERMiT adjusts percent bare ground to total 100 percent, if possible—if not, ERMiT adjusts shrub or grass values to total 100 percent. These input fields are inactive when “forest” vegetation is selected.

Hillslope Gradient and Horizontal Length

The topographic inputs for ERMiT are hillslope horizontal length and hillslope top, middle, and toe gradients. Hillslope horizontal length is the length of the hillslope being modeled and includes the three slope sections—top, middle, and toe (fig. 3). Top gradient is the steepness, in percent, of the upper 10 percent (by length) of the hillslope. Middle gradient is the steepness of the main portion (central 80 percent) of the hillslope. Toe gradient is the steepness of the lower 10 percent of the hillslope. These values may be obtained from field surveys, digital elevation models (DEMs), topographic maps, or geographical information system (GIS) data layers. Enter zero for top gradient if the top of the slope being modeled starts at the top of the hill. The maximum allowable hillslope horizontal length is 1000 ft (300 m) with a gradient between 0 and 100 percent (45 degrees). ERMiT sediment delivery predictions refer to the amount of sediment that leaves the modeled hillslope profile.

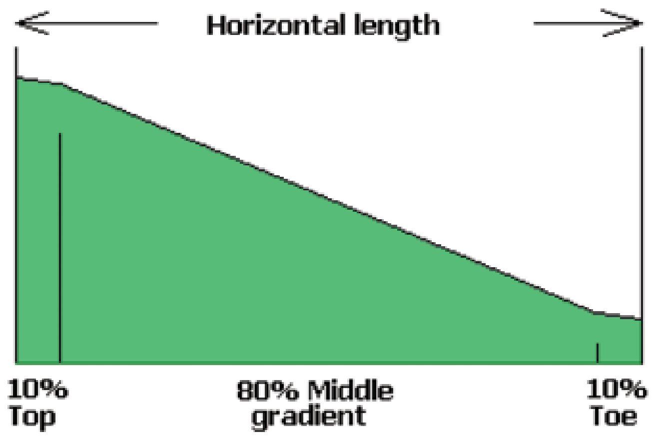


Figure 3. Hillslope profile illustration viewed by clicking the “explain” button on the hillslope gradient or hillslope horizontal length box titles.

Soil Burn Severity Class

Soil burn severity is a description of the impact of a fire on the litter, forest floor, and soil. The soil burn severity of a fire varies widely in space, depending on fuel load, moisture conditions, weather (at the time of the fire), and topography (Robichaud and Miller 1999), and creates a mosaic pattern of low, moderate, and high soil burn severity across the landscape. However, analyses of post-fire soil properties (using rainfall simulation experiments) only differentiate two soil burn severity classes, high (H) and low (L) (Brady and others 2001; Pierson and others 2001; Robichaud 1996; Robichaud 2000). In other words, in terms of soil parameter values, only two “levels,” or sets of values, can be distinguished. For modeling purposes, the H and L parameter values are

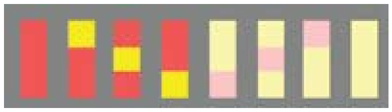


Figure 4. ERMiT input page graphic shows the four, six, or eight spatial arrangements of high and low soil burn severity overland flow elements (OFEs) that are modeled based on the user-selected soil burn severity classification. Red represents high and yellow represents low soil burn severity with bold color arrangements modeled for the first post-fire year and faint color patterns modeled in subsequent years.

arranged on the hillslope in multiple configurations to model the three possible user-designated soil burn severity classifications (low, moderate, high).

A hillslope segment with uniform soil, vegetation, and topography is called an overland flow element (OFE), and each hillslope is conceptually modeled with three OFEs—each representing about one-third of the slope. The red and yellow graphic displayed under the "Soil burn severity class" box in the burn severity portion of the ERMiT input page represents the four (low), six (moderate), or eight (high) spatial arrangements of high and low soil burn severity parameters that are modeled based on the user-selected soil burn severity classification (fig. 4). In figure 4, each OFE is represented as a single square in the rectangular strip of three squares for the hillslope. Red represents high (H) and yellow represents low (L) soil burn severity soil parameter values. Patterns with bold colors are modeled for the first year following fire. Patterns with faint colors are modeled for succeeding years (fig. 4).

Process

Once the input data selections have been made and entered, click "Run ERMiT" to begin the calculations. The following is a description of the erosion calculation processes that occur with each session.

Overview

ERMiT uses WEPP as its erosion calculation engine. WEPP models the processes of interrill and rill erosion, evapotranspiration, infiltration, runoff, soil detachment, sediment transport, and sediment deposition to predict runoff and erosion at the hillslope scale (Flanagan and Livingston 1995). In addition, spatial and temporal variability in weather, soil parameter values, and soil burn severity are incorporated into ERMiT. Three general steps were used to incorporate parameter variability into the model:

1. Establish a range of possible parameter values from field measurements.
2. Select five representative values from within the range.
3. Assign an "occurrence probability" to each selected value.

Temporal variation, the change in soil parameter values over time due to recovery, is modeled by changes in the occurrence probabilities assigned to the selected values for each year of recovery.

Initially, ERMiT runs WEPP for the user-specified climate, vegetation, and topography using the "most erodible" soil parameters and soil burn severity spatial pattern with the 100-year weather file. ERMiT selects the single event with the largest runoff value in each of the 100 years. From the 100 selected runoff events, the 5th, 10th, 20th, 50th, and 75th largest runoff events (and the year those events occurred) are chosen for further analysis. Each selected event year and its preceding year is run through WEPP multiple times using all combinations of the 10 soil parameter sets and four, six, or eight soil burn severity spatial arrangements. The three sources of variation (climate, soil burn severity, and soil parameters) are each assigned an independent occurrence probability. These independent occurrence probabilities are combined to determine the occurrence probability associated with each of the 100, 150, or 200 sediment delivery predictions (fig. 5).

Initial 100-year WEPP Run

A 100-year weather file, generated using CLIGEN, is used by WEPP to produce a 100-year runoff record for the combination of soil and burn severity conditions that have the greatest potential to generate runoff for the site—three high soil burn severity OFEs that use the "most erodible" soil parameter set (Soil 5) values for interrill erodibility (K_i), rill erodibility (K_r), effective hydraulic conductivity (K_e), and critical shear (τ_c). ERMiT selects the single event with the largest runoff value in each of the 100 years. From those 100 selected runoff events the 5th, 10th, 20th, 50th, and 75th largest runoff events (and the year those events occurred) are chosen for further analysis. The runoff values are not representative of the modeled scenario; rather, these values are predicted runoff under the most extreme high severity burn conditions. However, the precipitation characteristics of the selected runoff events are representative of the range of events that have the potential to generate runoff.

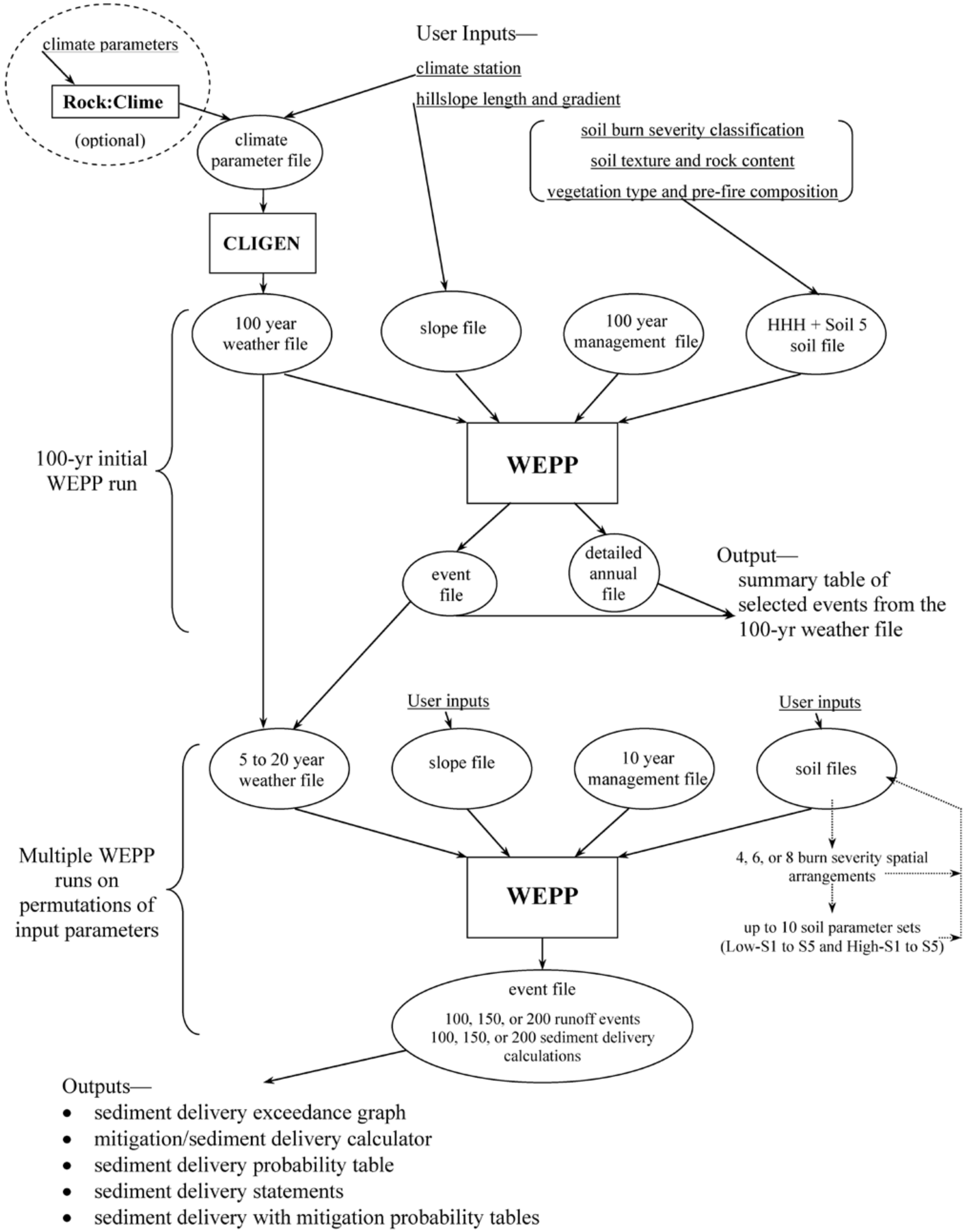


Figure 5. Flow chart of the ERMiT modeling process used to calculate probabilistic sediment delivery using the CLIGEN weather generator and the WEPP erosion prediction engine.

Variability of ERMiT Input Parameters

Climate variability

ERMiT re-runs WEPP using shortened weather files to predict event sediment deliveries. The shortened weather file includes the years with the selected runoff events, plus the preceding year, if they have not already been selected. This ensures that, when the shortened weather file is run, the modeled soil water content on the day of the event is similar to what it was during the 100-year run. The assigned runoff event occurrence probabilities are 7.5, 7.5, 20, 27.5, and 37.5 percent for the 5th, 10th, 20th, 50th, and 75th largest runoff events, respectively. For the selected runoff events, ERMiT records the date, runoff and precipitation amounts, and duration, and calculates the 10- and 30-min peak intensity values, which are displayed in the output.

Spatial (soil burn severity) variability

ERMiT uses two different sets of soil parameter values—one set for low soil burn severity (L) and one set for high soil burn severity (H). Hillslope topographic, vegetation, and soil parameter values are applied in combination for each overland flow element (OFE). ERMiT models each hillside with three overland flow elements, and to incorporate spatial variability due to soil burn severity, several patterns of OFEs are modeled. [For computational efficiency, ERMiT combines contiguous OFEs of the same burn severity and conceptually models the hillslope as either one or two OFEs (for example, HHH=one OFE of H; LLH=one OFE of L and one OFE of H).] For the user-selection of **High** soil burn severity, four spatial arrangements of OFEs are modeled for the first post-fire year:

HHH (10 percent occurrence probability)
LHH (30 percent occurrence probability)
HLH (30 percent occurrence probability)
HHL (30 percent occurrence probability)

The first letter of the triplet represents the upper OFE, the second represents the middle OFE, and the third represents the lower OFE (fig. 6 and table 1). A user selection of **Moderate** soil burn severity (table 1) models the first year following a fire with the three OFEs arranged as:

HLH (25 percent occurrence probability)
HHL (25 percent occurrence probability)
LLH (25 percent occurrence probability)
LHL (25 percent occurrence probability)

A **Low** soil burn severity user selection (table 1) models the first year after a fire with OFEs arranged as:

LLH (30 percent occurrence probability)
LHL (30 percent occurrence probability)
HLL (30 percent occurrence probability)
LLL (10 percent occurrence probability)

To model post-fire recovery (post-fire Year 2 to Year 5) for a **High** soil burn severity user selection, changes in assigned occurrence probabilities are applied and the LLH, LHL, HLL, and LLL spatial arrangements are added. For a **Moderate** soil burn severity user selection, post-fire recovery is modeled by changes in assigned occurrence probabilities and the addition of HLL and LLL spatial arrangements (table 1 and fig. 6). Thus, eight OFE arrangements are modeled for a **High** soil burn severity user selection, six for a **Moderate** soil burn severity user selection, and four for a **Low** soil burn severity user selection to predict the event sediment yield for each of the five post-fire years (fig. 6). For each successive year of post-fire recovery, changes in assigned occurrence probabilities decrease the likelihood of the higher erosion parameters and increase the likelihood of the lower erosion parameters (table 1).

Soil property variability

The variable effects of post-fire ground cover, soil water repellency, and soil erodibility are modeled by using selected values from a range of measured values for interrill erodibility (K_i), rill erodibility (K_r), effective hydraulic conductivity (K_e), and critical shear (τ_c). The range of values for each parameter depends on soil texture and a high or low soil burn severity designation (table 2). From each value range, a cumulative

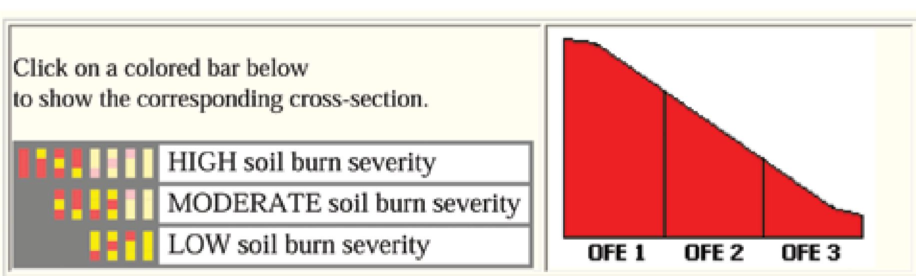


Figure 6. Graphic viewed by clicking on “explain” from the soil burn severity class box. The bold colored squares (red is high and yellow is low soil burn severity) represent the upper, middle, and lower OFEs that are modeled for the first year following a fire. The faint colors indicate OFE arrangements modeled in subsequent post-fire recovery years.

Table 1. With each successive year of post-fire recovery, the assigned occurrence probabilities and the selection of soil burn severity overland flow element (OFE) arrangements (H=high soil burn severity overland flow element; L=low soil burn severity overland flow element) are shifted toward lower soil burn severity.

Hillslope burn severity OFEs	Occurrence probability (%) Year 1	Year 2	Year 3	Year 4	Year 5
	User selected **High** soil burn severity				
HHH	10	0	0	0	0
LHH	30	25	0	0	0
HLH	30	25	25	0	0
HHL	30	25	25	25	0
LLH	0	25	25	25	25
LHL	0	0	25	25	25
HLL	0	0	0	25	25
LLL	0	0	0	0	25
	User selected **Moderate** soil burn severity				
HHH	0	0	0	0	0
LHH	0	0	0	0	0
HLH	25	0	0	0	0
HHL	25	25	0	0	0
LLH	25	25	25	25	25
LHL	25	25	25	25	25
HLL	0	25	25	25	25
LLL	0	0	25	25	25
	User selected **Low** soil burn severity				
HHH	0	0	0	0	0
LHH	0	0	0	0	0
HLH	0	0	0	0	0
HHL	0	0	0	0	0
LLH	30	25	25	25	25
LHL	30	25	25	25	25
HLL	30	25	25	25	25
LLL	10	25	25	25	25

distribution function is created and the 5th, 20th, 50th, 80th, and 95th percentile values are selected. The selected values for all four soil parameters are grouped by percentile ranking into five soil parameter sets:

- 5th percentile values are grouped in Soil 1 (10 percent occurrence probability)
- 20th percentile values are grouped in Soil 2 (20 percent occurrence probability)
- 50th percentile values are grouped in Soil 3 (40 percent occurrence probability)
- 80th percentile values are grouped in Soil 4 (20 percent occurrence probability)
- 95th percentile values are grouped in Soil 5 (10 percent occurrence probability)

The two soil parameter value ranges—one for low and one for high soil burn severity—result in five soil parameter sets for high soil burn severity and another five parameter sets for low soil burn severity (table 2). The current version of WEPP may internally limit some soil parameter values that correspond to highly erodible soil conditions.

In range and chaparral environments, field data indicate that post-fire values for K_i and K_e vary by the proportions of shrubs and grasses in the pre-fire vegetation and by burn severity. This is accounted for by weighting K_i and K_e soil parameter values within each value range based on the user-specified proportions of pre-fire shrub and grass cover with bare soil accounting for the remainder of the 100 percent pre-fire cover.

To model change over time, the occurrence probabilities of Soil 1 and Soil 2 (the less erodible soil parameter sets) are increased, and Soil 3, Soil 4, and Soil 5 (the more erodible soil parameter sets) are decreased for each year of post-fire recovery (table 3). Post-fire recovery is slower in areas affected by monsoons than in other environments because monsoon rains usually come in short bursts of rainfall and do not provide dependable wet cycles for seed germination. ERMiT uses an empirical relationship (total precipitation is less than 600 mm per year and total July, August, and September precipitation is greater than 30 percent of the annual precipitation) to determine if a particular climate is monsoonal. If rainfall data fit the monsoon rainfall definition, then the post-fire Year 2 occurrence probabilities for the soil parameter sets remain similar to Year 1 to reflect the slower recovery in these climates (table 3).

Multiple WEPP Runs

ERMiT re-runs WEPP, using the shortened weather file, for 10 soil parameter sets (High—Soil 1 through Soil 5 and Low—Soil 1 through Soil 5) and for eight soil burn severity spatial patterns. From the WEPP event output, ERMiT determines an event sediment delivery from each combination of rain events, soil parameter sets, and soil burn severity spatial patterns. For the first post-fire year, 100 event sediment delivery predictions are used (table 4). To predict sediment delivery in post-fire Year 2 through Year 5 (recovery), two additional soil burn severity spatial patterns are used for the user-selection of **Moderate** soil burn severity and four additional spatial patterns are used for the user-selection

Table 2. The post-fire value ranges for interrill erodibility (K_i), rill erodibility (K_r), effective hydraulic conductivity (K_e), and critical shear (τ_c) by soil texture and high or low soil burn severity are shown. For range and chaparral lands, user-designated pre-fire canopy cover proportions provide an additional level of classification for K_i and K_e values.

FOREST		**Soil burn severity**	**Clay loam**	**Silt loam**	**Sandy loam**	**Loam**
K_i (X 10^3) (kg-s m^{-4})		low	200 to 500	250 to 600	300 to 1,200	320 to 800
		high	400 to 2,000	500 to 2,500	1,000 to 3,000	600 to 3,200
K_r (X 10^{-4}) (s m^{-1})		low	0.010 to 2.5	0.020 to 3.5	0.030 to 4.5	0.015 to 3.0
		high	2.0 to 8.0	3.0 to 9.0	4.0 to 10	2.5 to 8.5
K_e (mm h^{-1})		low	25 to 8	33 to 9	48 to 14	40 to 18
		high	13 to 2	18 to 3	22 to 5	27 to 4
τ_c (N m^{-2})		low	4	3.5	2	3
		high	4	3.5	2	3
RANGE and CHAPARRAL	**Pre-fire cover**					
K_i (X 10^3) (kg-s m^{-4})	shrub	low	13 to 170	16 to 230	75 to 930	3.4 to 93
		high	39 to 170	49 to 230	230 to 930	11 to 93
	grass	low	1.9 to 15	12 to 150	50 to 650	2.6 to 63
		high	6.6 to 85	40 to 840	170 to 3,600	9.0 to 350
	bare	low	39 to 170	49 to 840	230 to 3,600	11 to 350
		high	39 to 170	49 to 840	230 to 3,600	11 to 350
K_r (X 10^{-4}) (s m^{-1})		low	0.38 to 6.0	0.33 to 7.8	0.090 to 7.2	0.51 to 4.6
		high	3.0 to 27	2.7 to 33	0.95 to 31	3.8 to 22
K_e (mm h^{-1})	shrub	low	15 to 6	22 to 8	29 to 9	22 to 8
		high	11 to 5	16 to 6	21 to 6	16 to 6
	grass	low	13 to 5	26 to 10	17 to 8	15 to 5
		high	10 to 4	21 to 8	14 to 7	12 to 4
	bare	low	10 to 4	21 to 8	14 to 7	12 to 4
		high	10 to 4	21 to 8	14 to 7	12 to 4
τ_c (N m^{-2})		low	1.9	3.4	2.8	0.8
		high	1.5	2.7	2.2	0.6

Table 3. To model untreated recovery over time, the assigned occurrence probability of Soil 1 and Soil 2 (the less erodible soil parameters sets) are increased and Soil 3, Soil 4, and Soil 5 (the more erodible soil parameters sets) are decreased for each year of post-fire recovery.

Soil parameter set	**--------------------- Occurrence probability (%) ---------------------**				
	Year 1	**Year 2 (monsoon)**	**Year 3**	**Year 4**	**Year 5**
Soil 1	10	30 (12)	50	60	70
Soil 2	20	30 (21)	30	30	27
Soil 3	40	20 (38)	18	8	1
Soil 4	20	19 (19.5)	1	1	1
Soil 5	10	1 (9.5)	1	1	1

of **High** soil burn severity (table 1). Thus, a total of 100, 150, or 200 possible predictions are incorporated for **Low**, **Moderate**, or **High** soil burn severity user-selection, respectively.

Combined Occurrence Probability

Each sediment delivery prediction has an associated probability of occurrence, which is calculated as the product of the occurrence probabilities due to each source of variation. For example, the occurrence probability for the event sediment delivery prediction given the rain event associated with the 5th largest runoff (7.5 percent occurrence probability), the HHH soil burn severity spatial arrangement (10 percent occurrence probability), and the Soil 3 parameter set (40 percent occurrence probability) is (0.075)*(0.10)*(0.40)=0.003, or 0.3 percent (table 4). Sediment delivery predictions

Table 4. The assigned occurrence probabilities for the runoff events, soil burn severity spatial arrangements (H=high soil burn severity overland flow element; L=low soil burn severity overland flow element), and the soil parameter sets are combined to provide 100 occurrence probabilities associated with 100 event sediment delivery predictions for post-fire Year 1. Ten of the 100 permutations are shown completely.

Selected rain event [occurrence probability] (%)	Soil burn severity spatial arrangement [occurrence probability] (%)	Soil parameter set [occurrence probability] (%)	100 permutations of the three sources of variability	
			Combined sources of variability	Combined occurrence probability (%)
Rain event associated with the 5th largest runoff [7.5]	HHH [10]	Soil 1 [10]	(5th RO rain event)[a] (HHH) (Soil 1)	(0.075)*(0.10)*(0.10) *100=**0.08**
		Soil 2 [20]	(5th RO rain event) (HHH) (Soil 2)	(0.075)*(0.10)*(0.20) *100=**0.15**
		Soil 3 [40]	(5th RO rain event) (HHH) (Soil 3)	(0.075)*(0.10)*(0.40) *100=**0.30**
		Soil 4 [20]	(5th RO rain event) (HHH) (Soil 4)	(0.075)*(0.10)*(0.20) *100=**0.15**
		Soil 5 [10]	(5th RO rain event) (HHH) (Soil 5)	(0.075)*(0.10)*(0.10) *100=**0.08**
	LHH [30] HLH [30] HHL [30]	Soil 1 [10] Soil 2 [20] Soil 3 [40] Soil 4 [20] Soil 5 [10]	15 combinations	15 calculated occurrence probabilities
Rain event associated with the 10th largest runoff [7.5]	HHH [10] LHH [30] HLH [30] HHL [30]	Soil 1 [10] Soil 2 [20] Soil 3 [40] Soil 4 [20] Soil 5 [10]	20 combinations	20 calculated occurrence probabilities
Rain event associated with the 20th largest runoff [20]	HHH [10] LHH [30] HLH [30] HHL [30]	Soil 1 [10] Soil 2 [20] Soil 3 [40] Soil 4 [20] Soil 5 [10]	20 combinations	20 calculated occurrence probabilities
Rain event associated with the 50th largest runoff [27.5]	HHH [10] LHH [30] HLH [30] HHL [30]	Soil 1 [10] Soil 2 [20] Soil 3 [40] Soil 4 [20] Soil 5 [10]	20 combinations	20 calculated occurrence probabilities
Rain event associated with the 75th largest runoff [37.5]	HHH [10] LHH [30] HLH [30]	Soil 1 [10] Soil 2 [20] Soil 3 [40] Soil 4 [20] Soil 5 [10]	15 combinations	15 calculated occurrence probabilities
	HHL [30]	Soil 1 [10]	(75th RO rain event) (HHL) (Soil 1)	(0.375)*(0.30)*(0.10) *100=**1.13**
		Soil 2 [20]	(75th RO rain event) (HHL) (Soil 2)	(0.375)*(0.30)*(0.20) *100=**2.25**
		Soil 3 [40]	(75th RO rain event) (HHL) (Soil 3)	(0.375)*(0.30)*(0.40) *100=**4.50**
		Soil 4 [20]	(75th RO rain event) (HHL) (Soil 4)	(0.375)*(0.30)*(0.20) *100=**2.25**
		Soil 5 [10]	(75th RO rain event) (HHL) (Soil 5)	(0.375)*(0.30)*(0.10) *100=**1.13**

[a]RO rain event=rain event associated with the ranked runoff event

are paired with their respective combined occurrence probability, and sorted in descending order of sediment delivery amounts. The "exceedance probability" for each sediment delivery prediction is computed as the sum of the occurrence probabilities for all greater sediment yield predictions plus one percent (table 5).

Table 5. The exceedance probability for each event sediment delivery prediction is computed as the sum of 1 plus the occurrence probabilities for all greater sediment yield predictions. The boxed example below shows that an event sediment delivery of 20.6 t ha^{-1} has an exceedance probability of 9.9 percent. Note, only a portion of the 100 sediment delivery predictions are shown.

		---------- Occurrence probability ----------				
Event sediment delivery prediction (t ha^{-1})	**Permutation (RO rain event[a], soil burn severity OFE arrangement[b], soil parameter set)**	**RO rain event[a] (%)**	**Soil burn severity OFE spatial arrangement (%)**	**Soil parameter set (%)**	**Permutation combined occurrence probability (%)**	**Exceedance probability for event sediment delivery prediction (%)**
61.4	5, HHH, 5	7.5	10	10	0.075	**1.08**
52.1	10, HHH, 5	7.5	10	10	0.075	**1.15**
43.9	5, HHL, 5	7.5	30	10	0.225	**1.38**
43.2	5, HHH, 4	7.5	10	20	0.150	**1.53**
42.4	20, HHH, 5	20	10	10	0.200	**1.73**
40.7	5, LHH, 5	7.5	30	10	0.225	**1.95**
40.5	5, HLH, 5	7.5	30	10	0.225	**2.17**
39.1	10, LHH, 5	7.5	30	10	0.225	**2.40**
37.9	10, HHL, 5	7.5	30	10	0.225	**2.63**
37.0	10, HHH, 4	7.5	10	20	0.150	**2.78**
36.5	10, HLH, 5	7.5	30	10	0.225	**3.00**
35.2	5, HHH, 3	7.5	10	40	0.300	**3.30**
34.5	5, HHL, 4	7.5	30	20	0.450	**3.75**
31.8	20, LHH, 5	20	30	10	0.600	**4.35**
31.2	20, HHL, 5	20	30	10	0.600	**4.95**
30.6	20, HHH, 4	20	10	20	0.400	**5.35**
30.6	10, HHH, 3	7.5	10	40	0.300	**5.65**
30.4	20, HLH, 5	20	30	10	0.600	**6.25**
29.2	50, HHH, 5	27.5	10	10	0.275	**6.53**
25.8	5, HLH, 4	7.5	30	20	0.450	**6.98**
25.6	20, HHH, 3	20	10	40	0.800	**7.78**
24.4	10, HHL, 4	7.5	30	20	0.450	**8.23**
21.1	5, LHH, 4	7.5	30	20	0.450	**8.67**
20.6	20, HHL, 4	20	30	20	0.450	**∑+ 1=9.88**
20.3	10, LHH, 4	7.5	30	20	0.450	**10.33**
20.3	10, HLH, 4	7.5	30	20	0.450	**10.78**
19.8	50, HHL, 5	27.5	30	10	0.825	**11.60**
19.7	10, HHL, 3	7.5	30	40	0.900	**12.50**
50 values		50 permutations and occurrence probabilities				50 values
0.7	5, HLH, 1	7.5	30	10	0.225	**69.58**
0.0	5, HHL, 1	7.5	30	10	0.225	**69.80**
20 values of **0.0**		20 permutations and occurrence probabilities				20 values of **69.80**
	Total of 100 permutations					

[a]RO rain event=rain event associated with the ranked runoff event
[b]H=high soil burn severity overland flow element (OFE); L=low soil burn severity overland flow element (OFE)

Erosion Mitigation Treatments

WEPP is not re-run to model mitigation treatments; rather, treatment effects are modeled by increasing the occurrence probabilities of the less erodible soil parameter sets and decreasing the occurrence probabilities of the more erodible soil parameter sets.

Seeding

Robichaud and others (2000) reported that seeding had little measured effect in reducing first year post-fire erosion; seeding effects are more evident in the second and subsequent years. In ERMiT, occurrence probabilities associated with the soil parameter sets are adjusted to reflect the increase in ground cover and subsequent small decrease in erosion after Year 2 (table 6). The seeding rate is assumed to be approximately 8 lb ac^{-1} (9 kg ha^{-1}).

Mulch

Four straw mulch application rates are modeled by ERMiT. The sediment delivery predictions based on each mulching rate are produced by adjusting the occurrence probabilities associated with soil parameter sets (table 7), similar to the adjustments made for increases in natural ground cover during post-fire recovery years (table 3).

Log erosion barriers (contour-felled logs or straw wattles)

ERMiT models straw wattles and contour-felled log erosion barriers by applying a regression relationship, based on user-specified mean log or wattle diameter (in or cm), spacing between rows (ft or m) (fig. 7), and hillslope gradient as entered on the input screen, to determine the potential storage capacity (PSC) for the hillslope:

$$PSC = \frac{1342}{slope} + 0.0029 * (diameter)^2 + \frac{272}{spacing}$$

where *diameter* is in cm, *spacing* is in m, and *PSC* is in m^3 ha^{-1}. *Slope* is in percent (0.05 to 100) and taken from the hillslope gradient entered on the input screen. Potential storage capacity (*PSC*) is converted to a weight per unit volume based on measured sediment bulk densities (table 8).

Field observations indicate that the potential storage capacity is rarely fully utilized, and that sediment trapping efficiency (sediment stored by erosion barriers divided by the sum of the sediment leaving the hillslope and the stored sediment) varies with rainfall intensity. ERMiT calculates a weighted maximum 10-min rainfall intensity ($I_{10\text{-}W}$) based on the maximum 10-min rainfall intensity (I_{10}) estimated from each rain event associated with the 5th-, 10th-, 20th-, 50th-, and 75th-ranked runoff events. $I_{10\text{-}W}$ is calculated as the sum of the I_{10} for each storm multiplied by its respective occurrence probability, such that:

$$I_{10\text{-}W} = (I_{10\text{-5th rank}} * 0.075) + (I_{10\text{-10th rank}} * 0.075) + (I_{10\text{-20th rank}} * 0.2) + (I_{10\text{-50th rank}} * 0.275) + (I_{10\text{-75th rank}} * 0.375)$$

where $I_{10\text{-}W}$ (mm h^{-1}) is the weighted maximum 10-min rainfall intensity and $I_{10\text{-5th rank}}$, $I_{10\text{-10th rank}}$, $I_{10\text{-20th rank}}$, $I_{10\text{-50th rank}}$, and $I_{10\text{-75th rank}}$ are the maximum 10-min rainfall intensity (mm h^{-1}) estimated from each rain event associated with the 5th-, 10th-, 20th-, 50th-, and 75th-ranked runoff events, respectively. Rainfall intensity for snowmelt events is taken to be zero.

Field data were used to determine erosion barrier sediment trapping efficiency functions based on $I_{10\text{-}W}$ for the first two post-fire years:

Year 1: $EFF_{y1} = -0.84\ (I_{10\text{-}W}) + 114$

Year 2: $EFF_{y2} = -1.4\ (I_{10\text{-}W}) + 116$

where *EFF* is the trapping efficiency (percent) of the erosion barriers and $I_{10\text{-}W}$ is the weighted maximum 10-min rainfall intensity (mm h^{-1}).

Table 6. The assigned occurrence probability of the seeded soil parameter sets for each of five post-fire years.

Soil parameter set	Occurrence probability (%) Year 1	Year 2	Year 3	Year 4	Year 5
Soil 1	10	50	60	70	70
Soil 2	20	30	30	27	27
Soil 3	40	18	8	1	1
Soil 4	20	1	1	1	1
Soil 5	10	1	1	1	1

Table 7. The assigned occurrence probability for soil parameter sets in each year for four application rates of straw mulch. The percent ground cover due to straw mulch is indicated for each application rate.

Soil parameter set	Year 1	Year 2	Year 3	Year 4	Year 5
Straw mulch application rate = **0.5 t ac^{-1}** (1 t ha^{-1}) for **47 percent ground cover**					
	--------------------occurrence probability (%)------------------------				
Soil 1	70	60	50	60	70
Soil 2	20	25	30	30	27
Soil 3	8	13	18	8	1
Soil 4	1	1	1	1	1
Soil 5	1	1	1	1	1
Straw mulch application rate = **1 t ac^{-1}** (2 t ha^{-1}) for **72 percent ground cover**					
Soil parameter set	**----------------------occurrence probability** (%)----------------------				
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Soil 1	90	70	50	60	70
Soil 2	7	20	30	30	27
Soil 3	1	8	18	8	1
Soil 4	1	1	1	1	1
Soil 5	1	1	1	1	1
Straw mulch application rate = **1.5 t ac^{-1}** (3.5 t ha^{-1}) for **89 percent ground cover**					
Soil parameter set	**----------------------occurrence probability (%)----------------------**				
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Soil 1	93	77	50	60	70
Soil 2	4	15	30	30	27
Soil 3	1	6	18	8	1
Soil 4	1	1	1	1	1
Soil 5	1	1	1	1	1
Straw mulch application rate = **2 t ac^{-1}** (4.5 t ha^{-1}) for **94 percent ground cover**					
Soil parameter set	**----------------------occurrence probability (%)----------------------**				
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Soil 1	96	78	50	60	70
Soil 2	1	16	30	30	27
Soil 3	1	4	18	8	1
Soil 4	1	1	1	1	1
Soil 5	1	1	1	1	1

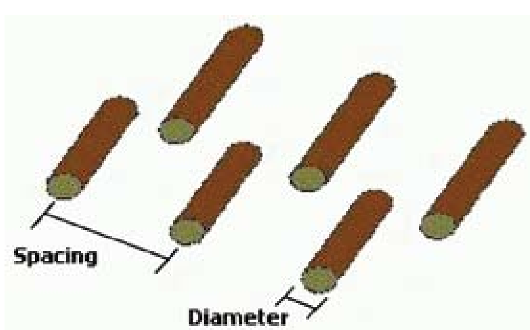


Figure 7. Erosion barrier diameter and spacing between rows.

Table 8. Observed sediment bulk density values used in ERMiT to convert erosion barrier storage volume (m^3 ha^{-1}) to mass (Mg ha^{-1}).

Soil texture	Sediment bulk density (Mg m^{-3})
clay loam	1.1
silt loam	0.97
sandy loam	1.23
loam	1.16

The sediment trapping efficiency of erosion barriers continues to decreases with time because of reduction in potential storage capacity as well as settlement, decay, and movement of the erosion barriers. After the second year, efficiency is estimated as a percentage of the preceding year, such that:

Year 3: $EFF_{y3} = 0.75 * EFF_{y2}$
Year 4: $EFF_{y4} = 0.55 * EFF_{y3}$
Year 5: $EFF_{y5} = 0.45 * EFF_{y4}$

Output

Summary of Input Selections and Initial 100-year WEPP Run

Summary of user selections

The top of the ERMiT output screen reports user inputs (fig. 8). The name of the selected standard climate station is listed. If the climate was user-modified, the climate summary output (fig. 8) includes:

- maximum temperature by month (degrees Fahrenheit or Celsius) [T MAX]
- minimum temperature by month (degrees Fahrenheit or Celsius) [T MIN]

Bitterroot Valley MT +
Modified by Rock:Clime on January 10, 2003 from STEVENSVILLE MT 247894 0
T MAX -6.27 -2.51 2.39 8.56 13.23 17.29 22.57 21.77 15.42 8.34 -0.41 -5.31 deg C
T MIN -15.20 -12.67 -9.75 -6.34 -2.63 1.03 2.77 1.74 -2.19 -6.42 -10.51 -13.92 deg C
MEANP 116.33 89.92 95.25 72.64 89.92 72.90 32.00 48.51 45.72 50.80 76.96 93.22 mm
WET 9.34 7.09 7.36 7.33 8.86 9.58 5.71 5.96 6.43 6.44 8.18 8.74

sandy loam soil texture, **20%** rock fragment

10% top, 40% average, 20% toe hillslope gradient

250 m hillslope horizontal length

high soil burn severity on **forest**

Figure 8. Summary of input parameters.

100 - YEAR MEAN ANNUAL AVERAGES				
895.29	**mm**	annual precipitation from	9182	storms
10.31	**mm**	annual runoff from rainfall from	261	events
7.42	**mm**	annual runoff from snowmelt or winter rainstorm from	174	events

Figure 9. Precipitation and runoff values from the initial 100-year high soil burn severity WEPP run.

- mean precipitation by month (in or mm) [MEANP]
- number of wet days by month [# WET]

User inputs for soil texture, rock content, hillslope gradient and length, soil burn severity, and vegetation type are also reported.

Precipitation and runoff values from the initial WEPP run

The average annual precipitation and runoff values, as well as the total number of precipitation (rainfall and snowmelt) runoff events, generated in the initial 100-year WEPP run, are reported in the output screen (fig. 9). This initial WEPP run used the "most erodible" soil parameters—in other words, soil parameter set High—Soil 5 and soil burn severity spatial arrangement HHH.

Selected storm characteristics

An output table shows some of the characteristics of the five rain events associated with the five runoff events selected for further analysis (fig. 10). The first table row also reports the largest (ranked 1st out of 100 for runoff) modeled runoff event, which is presented for user interest only. The storms listed on rows two through six (ranked 5th, 10th, 20th, 50th, and 75th for runoff) are used to determine input for the 5- to 10-year weather file WEPP uses for the multiple runs. Rain event descriptors include:

- *Storm rank*—rank of the total runoff amount from the largest to smallest
- *Storm runoff* (in or mm)—total runoff modeled by WEPP for the storm
- *Storm precipitation* (in or mm)—total precipitation (rain or snow) for that event
- *Storm duration* (h)—length of the storm event
- *10-min and 30-min peak rainfall intensity* (in h^{-1} or mm h^{-1})—estimated values of rainfall intensity for the given storm, calculated from information CLIGEN provides for the storm ["N/A" indicates that a value could not be calculated, and generally

Rainfall Event Rankings and Characteristics from the Selected Storms						
Storm Rank based on runoff (return interval)	Storm Runoff (mm)	Storm Precipitation (mm)	Storm Duration (h)	10-min Peak Rainfall Intensity (mm h^{-1})	30-min Peak Rainfall Intensity (mm h^{-1})	Storm Date
1	43.2	69.5	3.12	133.95	95.55	July 26 year 27
5 (20-year)	18.7	37.3	1.79	53.50	42.45	July 15 year 94
10 (10-year)	17.1	43.1	2.97	115.87	71.71	June 2 year 62
20 (5-year)	13.6	29.3	2.45	77.70	48.42	June 13 year 60
50 (2-year)	7.5	26.8	2.12	30.76	25.70	June 23 year 40
75 ($1^1/_3$-year)	3.7	17.2	1.96	27.19	20.84	September 12 year 37

Figure 10. Rainfall event rankings (based on runoff) and characteristics from the selected storms.

indicates a snowmelt event in which no precipitation occurred].

- *Storm date*—month and day when the storm event occurred, and the nominal year (1 to 100). The storm date can be useful in helping to determine what type of event occurred—snowmelt, spring storm, etc.

Sediment Delivery Exceedance Probability Graph for Untreated Condition

Below the inputs and selected storm event summaries, a graphical output shows hillslope sediment delivery exceedance probabilities plotted against the predicted event sediment delivery amounts for each of the first five post-fire years (fig. 11). The spacing between the plotted lines represents the predicted natural (untreated) recovery rate for the hillslope being modeled.

- **Click** on the graph to display the sediment delivery and exceedance probabilities in table format.

Interpreting the sediment delivery exceedance probability graph

As an example, draw an imaginary horizontal line across the graph (fig. 11) at 10 percent probability. It crosses the 1st year (furthest right) curve at about 20.5 t ha^{-1} sediment delivery. Thus, there is a 10 percent probability that a single rain event will result in at least 20.5 t ha^{-1} sediment delivery to the base of the hillslope during the first year following a fire. The 2nd year curve crosses the imaginary horizontal 10 percent probability line at about 13 t ha^{-1} sediment delivery; the 3rd year curve at about 5.5 t ha^{-1}; the 4th year at about 2.5 t ha^{-1}; and the 5th year curve at about 2 t ha^{-1} (fig. 11). Thus, there is a decrease in predicted event sediment delivery (with a 10 percent chance of exceedance) for each year of post-fire recovery.

Alternatively, choose a target sediment delivery value and observe the trends through time. Draw an imaginary vertical line through the 5 t ha^{-1} sediment delivery on the horizontal axis. The 1st year curve intersects the

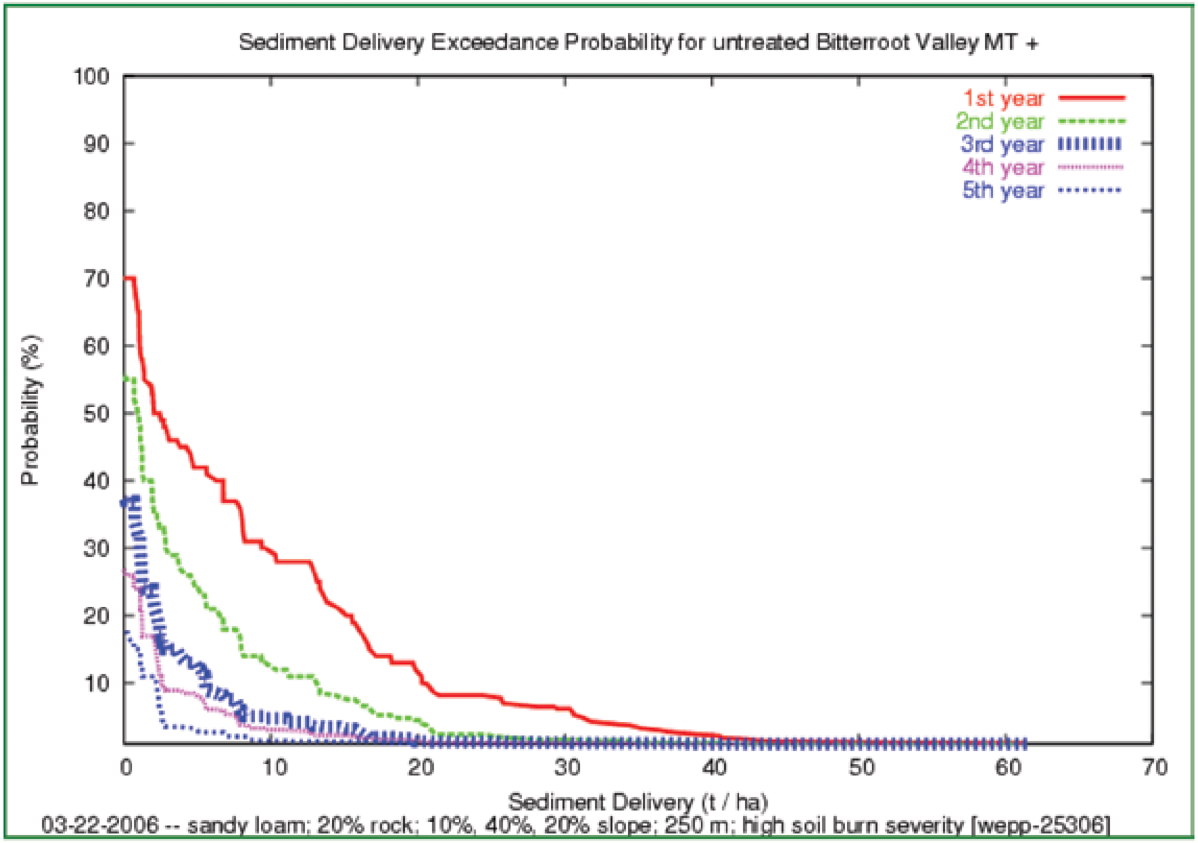


Figure 11. Output graph showing exceedance probability versus event sediment delivery for five years after the fire from the modeled, untreated hillslope.

5 t ha^{-1} line at about 42 percent probability—in other words, there is a 42 percent probability that the modeled hillslope will deliver at least 5 t ha^{-1} of sediment the first year following the fire. The 5th year curve intersects at about 1 percent probability. Thus, the likelihood of delivering at least 5 t ha^{-1} of sediment has decreased from 42 to 1 percent between the 1st and 5th year following the fire (fig. 11).

Mitigation Treatment Comparisons Calculator

The Mitigation Treatment Comparisons Calculator (fig. 12) is an interactive screen that allows the user to select an exceedance probability and have the corresponding event sediment delivery predictions displayed by year and by treatment. Values listed for the untreated hillslope are analogous to drawing a horizontal line across the

Mitigation Treatment Comparisons

Probability that sediment yield will be exceeded 10 % go	Event sediment delivery (t ha^{-1})				
	Year following fire				
	1st year	2nd year	3rd year	4th year	5th year
Untreated	20.53	13.11	5.55	2.63	2.22
Seeding	20.53	7.91	4.89	2.39	2.22
Mulch (1 t ha^{-1})	7.72	7.17	5.55	2.63	2.22
Mulch (2 t ha^{-1})	5.54	5.6	5.55	2.63	2.22
Mulch (3.5 t ha^{-1})	5.53	5.55	5.55	2.63	2.22
Mulch (4.5 t ha^{-1})	5.51	5.53	5.55	2.63	2.22
Erosion Barriers: Diameter 0 m Spacing 50 m go ?					
Logs & Wattles	20.53	13.11	5.55	2.63	2.22

Return to input screen

Figure 12. ERMiT Mitigation Treatment Comparison Calculator.

[Sediment yield--probability table]
[Sediment delivery paragraphs]
Sediment yield--probability of exceedance tables
[untreated | seeding | mulching 47% cover | 72% cover | 89% cover | 94% cover]
[Log & straw wattle efficiency tables]

Figure 13. Text links to supporting tables.

Sediment Exceedance Probability graph (fig. 11) at a selected exceedance probability value.

The Sediment Delivery Prediction Calculator for treatment with erosion barriers (contour-felled logs and straw wattles) is embedded in the Mitigation Treatment Comparisons Calculator (fig. 12). Predictions for contour-felled log or straw wattle erosion barrier treatments require a user-designated mean diameter (0.15 to 3.3 ft or 0.05 to 1 m) and spacing between rows of erosion barriers (10 to 165 ft or 3 to 50 m) (fig. 7).

By using the interactive input box in the upper left corner of the Mitigation Treatment Comparisons Calculator (fig. 12), the user may compare the predicted sediment delivery for a range of occurrence probabilities (1 to 99.9 percent). In addition, by clicking on the printer symbol to the right of each treatment label (or by using the text link further down the page), a full table of predicted event sediment deliveries and their occurrence probabilities by year for an individual treatment are displayed on screen. The tabular output screen allows for comparison of the predicted event sediment deliveries between the untreated hillslope and the treated hillslope, different treatment choices, and various treatment application rates for each of five post-fire years.

Supporting Tables

ERMiT provides supporting tables (four types—nine individual), which are accessible by clicking either on the small printer icons located within the Mitigation Treatment Comparisons Calculator, or on the textual links near the bottom of the output page (fig. 13). These supporting tables include:

1. Sediment delivery—probability table: individual WEPP sediment delivery predictions for each combination of parameters and individual parameter occurrence probabilities (untreated only) (fig. 14)
2. Sediment delivery statements (fig. 15)
3. Sediment delivery—probability of exceedance tables:
    - Untreated
    - Seeding
    - Mulching at four rates:
        - 0.5 t ac^{-1} or 1 t ha^{-1} [47 percent ground cover]
        - 1 t ac^{-1} or 2 t ha^{-1} [72 percent ground cover]
        - 1.5 t ac^{-1} or 3.5 t ha^{-1} [89 percent ground cover] (fig. 16)
        - 2 t ac^{-1} or 4.5 t ha^{-1} [94 percent ground cover]
4. Erosion barrier efficiency tables (fig. 17)

Each ERMiT run is assigned an identification number (Run ID wepp-000000), which is displayed on the screen with the graphs and supporting tables. This ID number allows the user to track results from a single run and compare results from different runs. In the footer at the bottom of the ERMiT output page, the ERMiT version, WEPP version, report on monsoon climate check, ERMiT run ID, and example citation are listed (fig. 18).

Saving Results

All results and supporting tables may be printed using the web browser's print function. Alternatively, the user may copy and paste the ERMiT output into a word processing document or spreadsheet. Generally, the mitigation treatment comparison table will not be active in the applications where it has been pasted. Some browsers support "save as" "Web page, complete," which will preserve the functionality of the mitigation treatment comparison table and retain the graphs and other images. If the output page is saved as a "Web page, HTML only," the functionality of the mitigation treatment comparison table will be retained but the graph and other images will be lost. No log file for accumulating ERMiT results is available.

Management Implications

Federal land management agencies have spent tens of millions of dollars on post-fire emergency watershed stabilization measures intended to minimize flood runoff, peakflows, onsite erosion, offsite sedimentation, and other hydrologic damage to natural habitats, roads, bridges, reservoirs, and irrigation systems (General Accounting Office 2003). The decision to apply post-

Erosion Risk Management Tool probability table

Bitterroot Valley MT +
sandy loam; 20% rock; 10%, 40%,20% slope; 250 m; high soil burn severity
[Run ID wepp-25306]

SEDIMENT DELIVERY (t ha^{-1})					Spatial (1st .. 5th yr)
Rank 5 -- July 15 year 94 (7.5%)					
1.38	19.36	35.21	43.20	61.42	HHH (10%) (0%) (0%) (0%) (0%)
0.96	9.20	18.15	21.06	40.74	LHH (30%) (25%) (0%) (0%) (0%)
0.69	2.78	5.65	25.81	40.50	HLH (30%) (25%) (25%) (0%) (0%)
0.00	2.03	16.56	34.48	43.92	HHL (30%) (25%) (25%) (25%) (0%)
0.68	2.70	5.46	6.55	28.02	LLH (0%) (25%) (25%) (25%) (25%)
0.00	0.00	0.00	12.30	29.54	LHL (0%) (0%) (25%) (25%) (25%)
0.00	0.00	0.00	18.84	30.31	HLL (0%) (0%) (0%) (25%) (25%)
0.00	0.00	0.00	0.50	16.27	LLL (0%) (0%) (0%) (0%) (25%)
Rank 10 -- June 2 year 62 (7.5%)					
9.37	15.58	30.58	36.99	52.11	HHH (10%) (0%) (0%) (0%) (0%)
5.61	9.34	13.85	20.30	39.12	LHH (30%) (25%) (0%) (0%) (0%)

Table rows deleted include the remainder of Rank 10 storm
and all of Rank 20 and Rank 50 storms

Rank 75 -- September 12 year 37 (37.5%)					
0.00	0.00	1.39	4.24	16.28	HHH (10%) (0%) (0%) (0%) (0%)
0.00	0.00	1.01	4.52	8.14	LHH (30%) (25%) (0%) (0%) (0%)
0.00	0.00	0.72	1.26	2.43	HLH (30%) (25%) (25%) (0%) (0%)
0.00	0.00	0.00	0.00	1.08	HHL (30%) (25%) (25%) (25%) (0%)
0.00	0.00	0.72	1.26	2.43	LLH (0%) (25%) (25%) (25%) (25%)
0.00	0.00	0.00	0.00	0.00	LHL (0%) (0%) (25%) (25%) (25%)
0.00	0.00	0.00	0.00	0.00	HLL (0%) (0%) (0%) (25%) (25%)
0.00	0.00	0.00	0.00	0.00	LLL (0%) (0%) (0%) (0%) (25%)
soil 1	soil 2	soil 3	soil 4	soil 5	
(10%)	(20%)	(40%)	(20%)	(10%)	1st year
(30%)	(30%)	(20%)	(19%)	(1%)	2nd year
(50%)	(30%)	(18%)	(1%)	(1%)	3rd year
(60%)	(30%)	(8%)	(1%)	(1%)	4th year
(70%)	(27%)	(1%)	(1%)	(1%)	5th year

Figure 14. The individual WEPP event sediment delivery predictions (untreated hillslope) are provided for each combination of three variability components—runoff event (arranged by section), soil burn severity spatial arrangement (arranged by row), and soil parameter set (arranged by column—Soil 1 through Soil 5 from left to right). Highlighted percentages are the individual occurrence probabilities for each component of the permutation by post-fire year.

Erosion Risk Management Tool event sediment delivery table

Bitterroot Valley MT +
sandy loam; 20% rock; 10%, 40%,20% slope; 250 m; high soil burn severity
[Run ID wepp-25306]

Untreated

There is a 10% chance that sediment delivery will exceed 20.53 t / ha in the first year following the fire.
There is a 10% chance that sediment delivery will exceed 13.11 t / ha in the second year following the fire.
There is a 10% chance that sediment delivery will exceed 5.55 t / ha in the third year following the fire.
There is a 10% chance that sediment delivery will exceed 2.63 t / ha in the fourth year following the fire.
There is a 10% chance that sediment delivery will exceed 2.22 t / ha in the fifth year following the fire.

Seeding

There is a 10% chance that sediment delivery will exceed 20.53 t / ha in the first year following the fire.
There is a 10% chance that sediment delivery will exceed 7.91 t / ha in the second year following the fire.
There is a 10% chance that sediment delivery will exceed 4.89 t / ha in the third year following the fire.
There is a 10% chance that sediment delivery will exceed 2.39 t / ha in the fourth year following the fire.
There is a 10% chance that sediment delivery will exceed 2.22 t / ha in the fifth year following the fire.

Mulch (1 t ha^{-1})

There is a 10% chance that sediment delivery will exceed 7.72 t / ha in the first year following the fire.
There is a 10% chance that sediment delivery will exceed 7.17 t / ha in the second year following the fire.
There is a 10% chance that sediment delivery will exceed 5.55 t / ha in the third year following the fire.

Figure 15. A portion of the sediment delivery statements from the ERMiT event sediment delivery table.

fire treatments to reduce runoff and erosion is based on a risk analysis—assessing the probability that damaging floods, erosion, and sedimentation will occur; the values that are at risk for damage; the need for reducing the risk of damage; and the magnitude of risk reduction that can reasonably be expected from mitigation treatments. Potentially damaged resources can be identified and the costs of post-fire erosion mitigation treatment can be determined; however, the risk of damaging runoff, erosion, and sedimentation occurring and the effectiveness of mitigation treatments are not well established. Consequently, managers often must assign these probabilities and estimate treatment effectiveness based on past experience and consensus of opinion.

Land managers need more information and tools to determine hazard probabilities and balance the costs and potential benefits of treatments. Unlike most erosion prediction models, ERMiT does not provide "average annual erosion rates." Rather, it provides a distribution of event erosion rates with the likelihood of their occurrence. Such output can help managers make erosion mitigation treatment decisions based on the probability of high sediment yields occurring, the value of resources at risk for damage, cost, and other management considerations. ERMiT is most useful when managers determine an event sediment delivery that can be tolerated without sustained damage to the resource(s) at risk and the probability of that event occurring (see example in Appendix B). This would likely vary throughout a burned area. For example, short term declines in water quality may be tolerated without sustained damage, but not damage to a unique cultural heritage site. Modeling the hillslopes above these two resources would likely require different user-designated exceedance probabilities and treatment criteria.

Application of post-fire erosion mitigation treatments does not eliminate erosion, but treatments can reduce the hillslope response to many rain events. After wildfires, managers can use ERMiT to estimate the probabilities of erosion-producing rain events occurring, expected hillslope event sediment deliveries, and predicted rates of recovery for the burned area. In addition, realistic estimations of treatment effectiveness will allow managers to make more cost-effective choices of where, when, and how to treat burned landscapes.

Erosion Risk Management Tool: Mulch (3.5 t / ha)

Bitterroot Valley MT +
sandy loam; 20% rock; 10%, 40%,20% slope; 250 m; high soil burn severity
[Run ID wepp-25306]

Sediment delivery (t / ha)	Percent chance that sediment delivery will be exceeded					Permutation Event rank Spatial burn Soil class	
	1st year	2nd year	3rd year	4th year	5th year		
61.42	1.01					5HHH5	
52.11	1.01					10HHH5	Output table rows 1 to 3 (first three rows)
43.92	1.04	1.02	1.02	1.02		5HHL5	
28.02		1.3	1.23	1.16	1.06	5LLH5	
25.81	1.47	1.32	1.25			5HLH4	Output table rows 22 to 24
25.64	1.49					20HHH3	
15.48	2.12	2.34				50LHH5	
15.14			3.19	2.26	1.34	10LHL4	Output table rows 49 to 51
14.66	2.14	2.45	3.52			10HLH3	
7.9	4.03	5.34				20LHH2	
7.59	4.27	6.09	7.54	5.33		20HHL2	Output table rows 76 to 78
6.92			7.61	5.39	2.17	50LHL5	
2.54			17.26	10.64	5.88	10LHL1	
2.43	13.18	13.53	17.36			75HLH5	Output table rows 103 to 105
2.43		13.62	17.45	10.73	5.97	75LLH5	
0.5					16.48	5LLL4	
0.13					17.79	10LLL1	Output table rows 130 to 132 (last 3 rows)
0	37.56	40.06	38.39	26.68		5HHL1	

Figure 16. Selected rows from the sediment delivery—probability of exceedance table for mulching at the 3.5 t ha^{-1} or 89 percent cover rate.

Erosion Risk Management Tool: contour-felled log/straw wattle

Bitterroot Valley MT +
sandy loam; 20% rock; 10%, 40%,20% slope; 250 m; high soil burn severity
[Run ID wepp-25306]
i_{10}=46.898

1st year	Maximum caught (t ha^{-1})				
74% efficient	Diameter (m)				
Spacing (m)	0.05	0.1	0.3	0.5	1
3	164.44	164.64	166.77	171.02	190.94
5	98.02	98.21	100.34	104.59	124.51
10	48.19	48.39	50.52	54.77	74.69
25	18.3	18.5	20.62	24.87	44.79
50	8.34	8.54	10.66	14.91	34.83

4th year	Maximum caught (t ha^{-1})				
21% efficient	Diameter (m)				
Spacing (m)	0.05	0.1	0.3	0.5	1
3	45.86	45.92	46.51	47.7	53.25
5	27.34	27.39	27.98	29.17	34.73
10	13.44	13.5	14.09	15.27	20.83
25	5.1	5.16	5.75	6.94	12.49
50	2.33	2.38	2.97	4.16	9.71

2nd year	Maximum caught (t ha^{-1})				
50% efficient	Diameter (m)				
Spacing (m)	0.05	0.1	0.3	0.5	1
3	111.18	111.32	112.76	115.63	129.1
5	66.27	66.4	67.84	70.71	84.18
10	32.58	32.72	34.16	37.03	50.5
25	12.37	12.51	13.94	16.82	30.29
50	5.64	5.77	7.21	10.08	23.55

5th year	Maximum caught (t ha^{-1})				
9% efficient	Diameter (m)				
Spacing (m)	0.05	0.1	0.3	0.5	1
3	20.64	20.66	20.93	21.46	23.96
5	12.3	12.33	12.59	13.13	15.63
10	6.05	6.07	6.34	6.87	9.37
25	2.3	2.32	2.59	3.12	5.62
50	1.05	1.07	1.34	1.87	4.37

3rd year	Maximum caught (t ha^{-1})				
38% efficient	Diameter (m)				
Spacing (m)	0.05	0.1	0.3	0.5	1
3	83.39	83.49	84.57	86.72	96.82
5	49.7	49.8	50.88	53.04	63.14
10	24.44	24.54	25.62	27.77	37.87
25	9.28	9.38	10.46	12.61	22.71
50	4.23	4.33	5.41	7.56	17.66

	Theoretical capacity (t ha^{-1})				
100% efficient	Diameter (m)				
Spacing (m)	0.05	0.1	0.3	0.5	1
3	220.85	221.12	223.97	229.68	256.43
5	131.64	131.91	134.76	140.47	167.22
10	64.73	64.99	67.85	73.55	100.31
25	24.58	24.85	27.7	33.41	60.16
50	11.2	11.46	14.32	20.02	46.78

Figure 17. ERMiT erosion barrier efficiency calculator.

Citation:
Robichaud, Peter R.; Elliot, William J.; Pierson, Frederick B.; Hall, David E.; Moffet, Corey A. 2006. **Erosion Risk Management Tool (ERMiT) Ver.** 2006.01.18. [Online at <http://forest.moscowfsl.wsu.edu/fswepp/>.] Moscow, ID: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

WEPP VERSION 2000.100
ERMiT run ID wepp-25306
Observed annual precip 884.3 mm; July, August, September precip 126.1 mm (14.26 percent): NON-MONSOONAL climate

Figure 18. Output screen footer information.

References

Brady, J.A.; Robichaud, P.R.; Pierson, F.B. 2001. Infiltration rates after wildfire in the Bitterroot Valley. Presented: 2001 ASAE annual international meeting: An Engineering Odyssey; 2001 July 30-August 1; Sacramento, CA. Paper Number 01-8003. St. Joseph, MI: American Society of Agricultural Engineers. 11 p.

Daly, C.; Neilson, R.P.; Phillips, D.L. 1994. A statistical-topographic model for mapping climatological precipitation over mountainous terrain. Journal of Applied Meteorology. 33: 140-158.

Elliot, W.J. 2004. WEPP internet interfaces for forest erosion prediction. Journal of the American Water Resources Association. 40(2): 299-309.

Elliot, W.J.; Hall, D.E. 2000. Rock:Clime Beta CD Version Rocky Mountain Research Station Stochastic Weather Generator Technical Documentation [online at http://forest.moscowfsl.wsu.edu/fswepp/docs/0007RockClimCD.html]. Moscow, ID: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station [accessed 23 March 2006].

Elliot, W.J.; Scheele, D.L.; Hall, D.E. 1999. Rock:Clime Rocky Mountain Research Station Stochastic Weather Generator Technical Documentation [online at: http://forest.moscowfsl.wsu.edu/fswepp/docs/rockclimdoc.html]. Moscow, ID: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station [accessed 23 March 2006].

Flanagan, D.C.; Livingston, S.J. (eds.) 1995. WEPP user summary. NSERL Report No. 11. West Lafayette, IN: U.S. Department of Agriculture, Agricultural Research Service, National Soil Erosion Research Laboratory. 123 p.

General Accounting Office. 2003. Wildland fires: better information needed on effectiveness of emergency stabilization and rehabilitation treatments. Report GAO-03-430. Washington, D.C.: U.S. General Accounting Office. 55 p.

Nicks, A.D.; Lane, L.J.; Gander, G.A. 1995. Weather generator. In: Flanagan, D.C.; Nearing, M.A. eds. USDA-Water Erosion Prediction Project Hillslope Profile and Watershed Model Documentation. NSERL Report No. 10. West Lafayette, IN: U.S. Department of Agriculture, Agricultural Research Service, National Soil Erosion Research Laboratory. 2.1-2.22.

Pierson, F.B.; Robichaud, P.R.; Spaeth, K.E. 2001. Spatial and temporal effects of wildfire on the hydrology of a steep rangeland watershed. Hydrological Processes. 15: 2905-2916.

Robichaud, P.R. 1996. Spatially-varied erosion potential from harvested hillslopes after prescribed fire in the interior Northwest. Moscow, ID: University of Idaho. 219 p. Dissertation.

Robichaud, P.R. 2000. Fire effects on infiltration rates after prescribed fire in northern Rocky Mountain forests, USA. Journal of Hydrology. 231-232: 220-229.

Robichaud, P.R.; Miller, S.M. 1999. Spatial interpolation and simulation of post-burn duff thickness after prescribed fire. International Journal of Wildland Fire. 9(2): 137-143.

Robichaud, P.R.; Beyers, J.L.; Neary, D.G. 2000. Evaluating the effectiveness of post fire rehabilitation treatments. Gen. Tech. Rep. RMRS-GTR-63. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 85 p.

Robichaud, P.R.; Elliot, W.J.; Pierson, F.B.; Hall, D.E.; Moffet, C.A. 2006. Erosion Risk Management Tool (ERMiT) Ver. 2006.01.18 [Online at <http://forest.moscowfsl.wsu.edu/fswepp/>.]. Moscow, ID: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station [accessed 5 June 2006].

Robichaud, P.R.; Elliot, W.J.; Pierson, F.B.; Hall, D.E.; Moffet, C.A. [In press]. Predicting post-fire erosion and mitigation effectiveness with a web-based probabilistic erosion model. CATENA.

Appendix A. Model Assumptions

ERMiT runs WEPP (version 2000.100) in cropland mode with the following parameter (WEPP variable names in parentheses) values in the management and soil files:

- The model year begins the day after the wildfire occurs and ends on the anniversary day of the fire.
- Ground cover effects are modeled by adjusting soil erodibility/cover values based on field measurements from a variety of soil types and soil burn severity conditions.
- Management file:
    - No biomass
        - “biomass energy ratio (beinp)” set to zero
    - No decomposition
        - “decomposition constant to calculate mass change of above-ground biomass, surface, or buried (oratea)” set to zero
        - “decomposition constant to calculate mass of change of root-biomass (orater)” set to zero
    - Initial conditions set to give 1 percent cover
        - “initial canopy cover, 0 to 1 (cancov)” set to 0.01
        - “days since last tillage (daydis)” set to 9999
        - “days since last harvest (dsharv)” set to 900
        - “initial interrill cover, 0 to 1 (inrcov)” set to 0.01
        - “initial residue cropping system (imngmt)” set to perennial
        - “initial rill cover, 0 to 1 (rilcov)” set to 0.01
    - No surface effects
    - Annual planting date set to May 1 (Julian day 121)
    - Annual harvest date set to September 1 (Julian day 244)
- Soil Input file:
    - One soil layer
    - “percentage of organic matter (orgmat) in the layer” set to 5 percent by volume in forest vegetation type and 1 percent by volume in range and chaparral vegetation types
    - “albedo of the bare dry surface soil (salb)” set to 0.2
    - “Initial saturation level of the soil profile porosity (sat)” set to 0.75 m/m
    - “depth of soil surface to bottom of soil layer (solthk)” set to 400 mm
    - “percentage of sand in the layer (sand)” varies by soil texture
    - “percentage of clay in the layer (clay)” varies by soil texture
    - “cation exchange capacity in the layer (cec)” varies by soil texture
    - “rock fragment amount (rfg)” is user-specified, maximum 50 percent
    - “interrill erodibility (ki)” varies by soil texture and <bs> and <sp>[1] (table 2)
    - “rill erodibility (kr)” varies by soil texture and <bs> and <sp>[1] (table 2)
    - “baseline critical shear (shcrit)” varies by soil texture and <bs> and <sp>[1] (table 2)
    - “effective hydraulic conductivity (avke)” varies by soil texture and <bs> and <sp>[1] (table 2)

[1]<bs> represents the discrete **soil burn severity** spatial arrangement (“HHH,” “HHL,” “LHH,” etc.) used in a WEPP run. <sp> represents the discrete **soil parameter** set (High “Soil 1” to “Soil 5” and Low “Soil 1” to “Soil 5”) used in a WEPP run. Individual runs of WEPP use each applicable soil burn severity spatial arrangement with each soil parameter set, generating a WEPP output file for each combination of these two variable sets for each selected rain event.

Appendix B. Example

An example ERMiT run is presented to illustrate the user interface and model output formats and to describe the sediment delivery prediction analyses. The context for this example run is the 2000 Valley Complex Fires that burned in the Bitterroot National Forest of Montana. These large wildfires burned many steep hillslopes at high severity. The water quality of the streams and rivers within the burned area are highly valued resources that were at risk from large increases in sedimentation. This example run is for an 800 ft slope above Rye Creek, which has a sandy loam soil with 20 percent rock content. The hillslope gradients are 10 percent at the top, 40 percent at mid-slope, and 20 percent at the toe (fig. B1).

The post-fire assessment team will determine the risk of post-fire erosion that exceeds a tolerable limit for event sediment delivery at the base of the hillslope. To use the Mitigation Treatment Comparisons Calculator, the post-fire assessment team established the following decision criteria: 1) 3 t ac^{-1} was the maximum tolerable single event sediment delivery in post-fire Year 1; and 2) straw mulch treatment will be applied if the Year 1 risk of exceeding the event sediment delivery limit (3 t ac^{-1}) is greater than 10 percent and straw mulch application will reduce that risk to 10 percent or less.

By setting the output table to 10 percent exceedance probability (circled in fig. B2), the post-fire assessment team was able to compare the effects of mulching at different rates. On the untreated hillslope, sediment delivery estimates with 10 percent exceedance probability are nearly 9 t ac^{-1}, which is well above the 3 t ac^{-1} tolerable limit set by the assessment team. Mulching at a rate of 0.5 t ac^{-1} lowers the sediment delivery prediction with a 10 percent exceedance probability to 3.4 t ac^{-1}, which is still above the tolerable limit set by the post-fire assessment team. However, mulching at a rate of 1.0 t ac^{-1} lowers the predicted sediment delivery with a 10 percent exceedance probability to 2.4 t ac^{-1}, which is within the acceptable limits set by the team. Mulching at 1.5 t ac^{-1} does not lower the predicted event sediment delivery enough to justify the additional mulch (fig. B2). These ERMiT predictions support the assessment team's recommendation to apply straw mulch at a 1 t ac^{-1} rate on the burned hillslope.

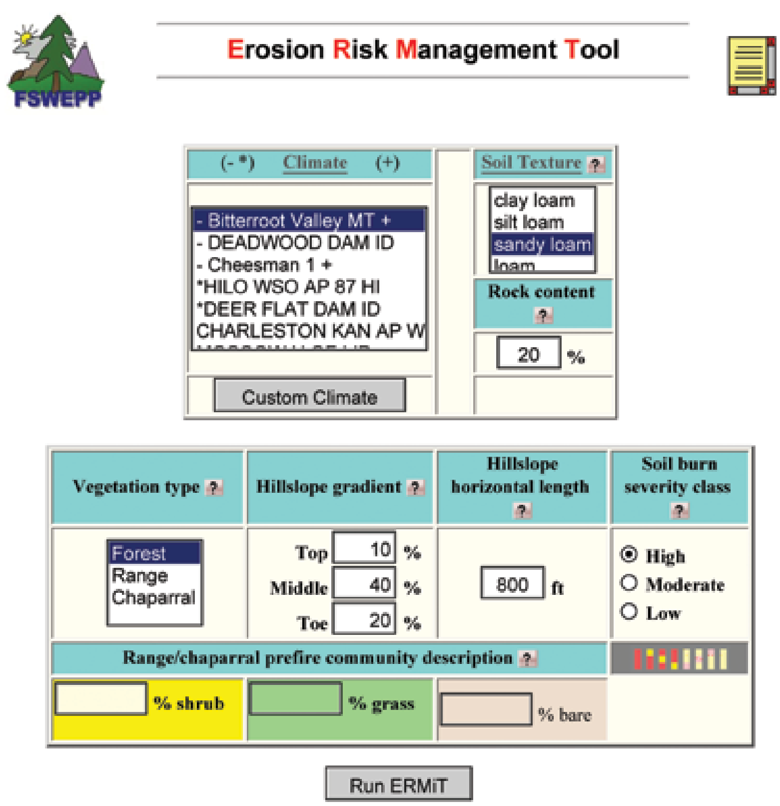
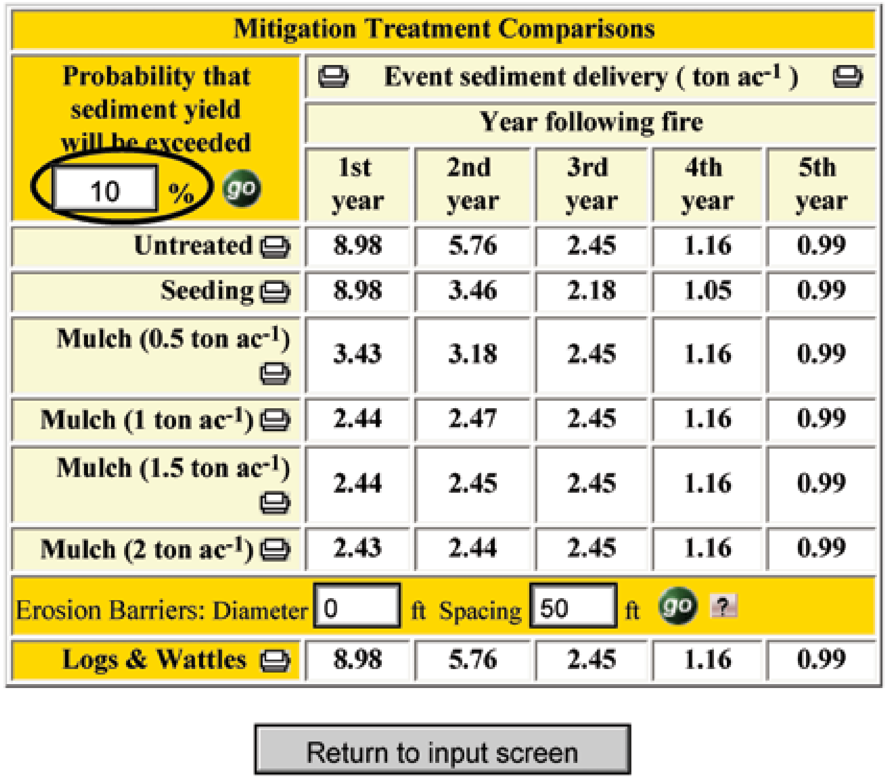


Figure B1. Input screen for example scenario.



Mitigation Treatment Comparisons					
Probability that sediment yield will be exceeded 10 % go	Event sediment delivery (ton ac^{-1})				
	Year following fire				
	1st year	2nd year	3rd year	4th year	5th year
Untreated	8.98	5.76	2.45	1.16	0.99
Seeding	8.98	3.46	2.18	1.05	0.99
Mulch (0.5 ton ac^{-1})	3.43	3.18	2.45	1.16	0.99
Mulch (1 ton ac^{-1})	2.44	2.47	2.45	1.16	0.99
Mulch (1.5 ton ac^{-1})	2.44	2.45	2.45	1.16	0.99
Mulch (2 ton ac^{-1})	2.43	2.44	2.45	1.16	0.99
Erosion Barriers: Diameter 0 ft Spacing 50 ft go ?					
Logs & Wattles	8.98	5.76	2.45	1.16	0.99

Figure B2. Mitigation Treatment Comparison Calculator for example scenario.

RMRS

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The Rocky Mountain Research Station develops scientific information and technology to improve management, protection, and use of the forests and rangelands. Research is designed to meet the needs of the National Forest managers, Federal and State agencies, public and private organizations, academic institutions, industry, and individuals.

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