



STREAM NOTES

To Aid in Securing Favorable Conditions of Water Flows

Rocky Mountain Research Station

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Erosion Risk Management Tool (ERMiT)

by Peter R. Robichaud

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-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.

The Erosion Risk Management Tool (ERMiT) (Robichaud and others 2006, 2007) was developed to provide land managers with a tool to determine post-fire erosion hazard probabilities and balance the costs and potential benefits of post-fire mitigation treatments. 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. Using ERMiT, managers can establish a maximum acceptable event sediment yield and determine the probability of "higher than acceptable" sediment yields occurring. 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.

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John Potyondy, Program Manager.

The PRIMARY AIM is to exchange technical ideas and transfer technology among scientists working with wildland stream systems.

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CORRESPONDENCE:
E-Mail: rmrs_stream@fs.fed.us
Phone: (970) 295-5983
FAX: (970) 295-5988

Web Site:
<http://www.stream.fs.fed.us>

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Using the ERMiT Model

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. 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 10-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.

Input Data

User inputs for ERMiT are: 1) climate, 2) soil texture, 3) soil rock content, 4) vegetation type (forest, range, chaparral), 5) hillslope, 6) gradient and horizontal length, 7) soil burn severity class, and 8) range/chaparral pre-fire plant community descriptions. The interactive browser screen in ERMiT provides brief hints to the user for inputting data and links to obtain more extensive explanations related to the input parameters.

Process

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 measured parameter values from field experiments.
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.

WEPP is not re-run to model mitigation treatment effectiveness. Instead, treatment effects are modeled by increasing the occurrence probabilities of the less erodible soil parameters sets, decreasing the occurrence probabilities of the more erodible soil parameter sets, and/or adjusting treatment performance as compared to measured effectiveness.

Output

Output from the ERMiT analysis includes a plot of hillslope sediment delivery exceedance probabilities versus the predicted event sediment delivery amounts for each of the first five post-fire years. The mitigation treatment comparisons calculator within ERMiT allows the user to select an exceedance probability to assess the corresponding event sediment delivery predictions by different mitigation treatments for each of the first five post-fire years. The interactive probability exceedance function allows the user to define different levels of risk (exceedance probability) for potential erosion and then compare the relative effectiveness of various treatments to non-treatment as well as to one another.





Figure 1. The effects of the 2000 Valley Complex Fires on the Rye Creek drainage, Bitterroot National Forest, Montana (photo courtesy of USDA Forest Service 2000).

ERMiT Application Example

An example of an ERMiT application is presented to illustrate the user interface and model output formats and to describe the sediment delivery prediction analyses. The context for this example is the 2000 Valley Complex Fires that burned in the Bitterroot National Forest of Montana (fig 1). 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 is for a 900 ft slope adjacent to Rye Creek. The hillslope has a sandy loam soil with 25 percent rock and gradients of 15 percent at the top, 45 percent at mid-slope, and 25 percent at the toe (fig. 2). For this example, a custom climate for the site was generated in Rock:Clime (Elliot and others 1999) and the relevant climatic data needed to run the model are summarized in figure 3.

The post-fire assessment team needed to determine the risk of post-fire erosion that exceeded 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) 3.0 ton/ac 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 (3.0 ton/ac) 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, the post-fire assessment team was able to compare the effects of mulching at different rates (fig. 4). On the untreated hillslope, sediment delivery estimates with 10 percent exceedance probability are nearly 12.2 ton/ac, which is well above the 3.0 ton/ac tolerable limit set by the assessment team. Mulching at a rate of 0.5 ton/ac lowers the sediment delivery prediction with a 10 percent exceedance probability to 3.2 ton ac^{-1} , which is still above the tolerable limit set by the postfire assessment team. However, mulching at a rate of 1.0 ton/ac lowers the predicted sediment delivery with a 10 percent exceedance probability to 1.2 ton/ac, which is within the acceptable limits set by the team. Mulching at 1.5 ton/ac does not lower the predicted event sediment delivery enough to justify the additional mulch (fig. 4). These ERMiT predictions support the assessment team's recommendation to apply straw mulch at a 1.0 ton/ac rate on the burned hillslope.

Summary

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

Figure 2. Input screen in ERMiT for a hillslope in the Rye Creek drainage (2000 Valley Complex Fires, Bitterroot National Forest, Montana).



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.

Additional Information

ERMiT was released in 2006 (Robichaud and others 2006) and can be run from the Internet on the USDA Forest Service WEPP web page (<http://forest.moscowfsl.wsu.edu/fswepp/>). The user manual, *Erosion Risk Management Tool (ERMiT) User Manual (version 2006.01.18)*, provides a detailed discussion of input parameters, input interface, model processing, output files, and assumptions for the model. For additional information and references, please refer to the following publication: Robichaud, P.R.; Elliot, W.J.; Pierson, F.B.; Hall, D.E.; Moffet, C.A.; Ashmun, L.E. 2007. Erosion Risk Management Tool (ERMiT) user manual (version 2006.01.18). RMRS-GTR-188. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 24 p. Copies are

Climate parameters for Rye Creek, MT +
46.36°N 113.94°E; 6986 feet elevation
81 years of record

Month	Mean Maximum Temperature (°F)	Mean Minimum Temperature (°F)	Mean Precipitation (in)	Number of wet days
January	32.6	14.6	4.58	9.3
February	39.4	19.1	3.54	7.1
March	48.2	24.4	3.75	7.4
April	59.3	30.5	2.86	7.3
May	67.7	37.2	3.54	8.9
June	75.0	43.8	2.88	9.6
July	84.5	46.9	1.26	5.7
August	83.1	45.0	1.91	6.0
September	71.7	38.0	1.80	6.4
October	58.9	30.4	2.00	6.4
November	43.2	23.0	3.03	8.2
December	34.4	16.9	3.67	8.7
Annual			34.81	91.0

Figure 3. Output screen of custom climate data generated for a hillslope in the Rye Creek drainage, Bitterroot National Forest, Montana. Climate data from the Stevensville, Montana climate station were used to customize the climate data for the site based on its location and elevation.

Mitigation Treatment Comparisons

Probability that sediment yield will be exceeded 10 % 90	Event sediment delivery (ton ac ⁻¹)				
	Year following fire				
	1st year	2nd year	3rd year	4th year	5th year
Untreated	12.21	5.52	1.35	0.98	0.26
Seeding	12.21	3.83	1.12	0.75	0.26
Mulch (0.5 ton ac ⁻¹)	3.23	3.11	1.35	0.98	0.26
Mulch (1 ton ac ⁻¹)	1.16	1.87	1.35	0.98	0.26
Mulch (1.5 ton ac ⁻¹)	1.08	1.64	1.35	0.98	0.26
Mulch (2 ton ac ⁻¹)	0.4	1.49	1.35	0.98	0.26
Erosion Barriers: Diameter 0 ft Spacing 50 ft 90					
Logs & Wattles	12.21	5.52	1.35	0.98	0.26

Return to input screen

Figure 4. The mitigation treatment comparisons calculator generated by ERMiT for a hillslope in the Rye Creek drainage (2000 Valley Complex Fires, Bitterroot National Forest, Montana).

available online at http://www.fs.fed.us/rm/pubs/rmrs_gtr188.pdf.

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Peter R. Robichaud is a research engineer; USDA Forest Service, Rocky Mountain Research Station, 1221 South Main St., Moscow, ID 83843; 208-883-2349; probichaud@fs.fed.us; probichaud@fs.fed.us.

