Final Report (1 October 05)

Risk Assessment of Fuel Management Practices on Hillslope Erosion Processes (Phase II) 01-3-02-08

Project Location: Moscow, ID; Boise, ID; Riverside, CA

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Duration: 3 years (continued from Risk Assessment of Fuel Management Practices on Hillslope Erosion Processes Phase I, 98-1-4-12 which ended on September 30, 2001. Phase II reports covers accomplishments made from September 30, 2001 through September 30, 2005.

Executive Summary: After wildfires, the use of rapid response field protocols allowed measurements of postfire soil infiltration, soil erodibility, and hillslope erosion rates, while long-term measurements provided data on postfire rehabilitation treatment effectiveness and general recovery rates from both rangelands and forest lands. These data (from both Phase I and II) were used to expand and validate the current suite of web-based erosion prediction tools, and to develop the erosion risk management tool, ERMiT. The continuation of this project through Phase II has made it possible to complete the development ERMiT, a probability-based erosion prediction tool, which is applicable to postfire assessments on forest, range and chaparral lands.

Various postfire mitigation treatments have been evaluated and effectiveness results have been incorporated into ERMiT as well as disseminated via presentations, workshops, and publications. Ground cover treatments work better than barrier-type treatments for short duration, high intensity rainfall events. No matter what treatments are applied, postfire erosion still occurs; however, erosion is reduced to a greater extent by ground cover treatments.

Numerous technology transfer opportunities were used to deliver the findings from this research and to introduce the new ERMiT model to Burned Area Emergency Response teams, hydrologists, soil scientists, engineers, and consultants. During the last four years, 32 presentations, 5 postfire restoration workshops, 12 WEPP training workshops, and 15 publications have resulted from this project. Hundreds of specialists have been using these research results and web-based erosion prediction tools to improve postfire decision-making processes.

Introduction

Since variability is a dominant characteristic of both weather and postfire soil physical properties, it is inherent to erosion processes as well. The research and modeling efforts funded by the Joint Fire Science Program were designed to measure and incorporate this variability into a probabilistic erosion model. In many forest, and rangeland conditions, erosion may be minimal under normal, vegetated conditions. However, when the site is disturbed by fire, logging, grazing, or other management activities, erosion rates can increase dramatically. Natural resource managers and postfire rehabilitation teams need accessible tools that can reliably predict the increased soil erosion following wildfires, as well as the potential erosion mitigation effectiveness that can be expected from specific postfire treatments. With this knowledge, they are able to evaluate risks and apply cost/benefit analysis to the decision-making processes.

Phase II—Goal and Objectives

We proposed to compare the effectiveness of various postfire erosion mitigation practices to non-treatment on sediment yields for rangelands, chaparral, and forests.

The specific objectives were:

1) Determine how well the current BAER postfire erosion mitigation treatments meet federal agencies' objectives of reducing erosion and runoff.
2) Determine effectiveness of mitigation treatments at reducing sub-watershed sediment yields and meeting BAER objectives of reducing downstream risk to life and property, and their effects on water quality when compared to sub-watersheds without treatment.
3) Assess the impact of wildfire and prescribed fire on rangeland erosion and infiltration.
4) Use the information gained from objectives 1, 2 and 3 to populate our Erosion Risk Management Tool (ERMiT) for commonly used hillslope treatments.

Accomplishments

Given that the largest post-disturbance erosion rates occur when high intensity rainfall occurs on steep hillslopes during the first year after severe wildfires, obtaining the needed data required that field sites be selected and equipment installed immediately after fire suppression. To accomplish this task, a rapid response protocol (funded during the phase I) was used to install new postfire sites in Phase II. This protocol included advanced purchase and preparation of all equipment and tools, fire safety training for all field crews, and direct communication with the Fire Incident Commands and the BAER teams. Maintenance of both new and existing sites has been continued through Phase II as data from multiple years are needed to track the effects of natural recovery. Research efforts often involve cooperative efforts with federal land managers and tribal governments that assist in installation, monitoring, and maintenance of these sites.

Our first postfire field research work was initiated in 1998, immediately following the North 25 Fire. The rapid response protocol used and refined on ten wildfires in the successive years of the project. Many sites have remained operational beyond Phase I and through Phase II of this project. The data collected have provided the needed parameters for erosion modeling (including infiltration, soil erosion, and recovery rates), evaluation of various erosion mitigation strategies (including new treatments), and continued refinement of erosion prediction models and validation from forest, range and chaparral lands.

Objective 1—BAER treatment effectiveness

Postfire treatment effectiveness studies have provided critical information to land managers to who must make decisions quickly after a fire. Simulated rill studies and hillslope scale treatment studies measured natural postfire site variability and treatment performance under both natural rainfall and design-storm events. For example, one experiment used rill simulation equipment owned by Soil and Water Engineering Unit in Moscow and the Agricultural Research Service in Boise to compare straw mulch, wood straw, scarification and untreated control plots immediately after the Hayman Fire. For the following three years, natural rainfall was used to compare treatment effectiveness. Other hillslope treatments, including hydromulch, surfactants, straw mulch, hydromulch, and flow check erosion barriers structures, have been evaluated in a range of ecosystems; thus, results are available for a wide range of conditions.

Postfire Hillslope Treatment Studies—Field Research Locations:

- Erosion barriers (contour-felled log, straw wattle, hand-dug contour trench)—Valley Complex Fires, Bitterroot National Forest, Montana
- Contour-felled log erosion barriers—Mixing Fire, San Bernardino National Forest, California
- Flow check erosion barriers and wheat straw—Hot Creek Fire, Boise National Forest, Idaho
- Surfactants—Roberts Fire, Flathead National Forest, Montana
- Soilset hydromulch, wheat straw, and needle cast—Myrtle Creek Fire, Idaho Panhandle National Forest, Idaho
- Hydromulch—Cedar Fire, Viejas Reservation, Cleveland National Forest, California
- Wood straw, wheat straw, and scarification—Hayman Fire, Pike and San Isabel National Forest, Colorado.

Findings:

- Erosion rates generally recover by an order of magnitude each successive year after a wildfire.
- Short-duration high-intensity rainfall events are the driving factor in determining erosion rates. The greater the rainfall intensity the less effective any treatment will be at reducing erosion.
- Contour-felled log erosion barriers were less effective at reducing erosion from short duration, high intensity rain events than from low intensity, longer duration events. After observing runoff and sediment flowing around the ends of erosion barriers, end berms,

which increase the sediment storage capacity of the erosion barrier, were tested and recommended for inclusion in the installation protocol.

- The installation of contour-felled logs disturbed the soil over 10 to 15% of the hillslope area, which may have increased the erosion.
- Flow check erosion barriers performed similarly to contour-felled log erosion barriers.
- Ground cover treatments (straw mulch) were more effective than barrier-type treatments (contour-felled log erosion barriers) at reducing erosion.
- Hydromulch was less effective than straw mulch at reducing erosion.
- Surfactant did not reduce hillslope erosion.

Publications: #1, 2, 3, 4, 10, 11, 12, 13, 14, 15

Objective 2—Erosion mitigation treatment effectiveness with small watersheds

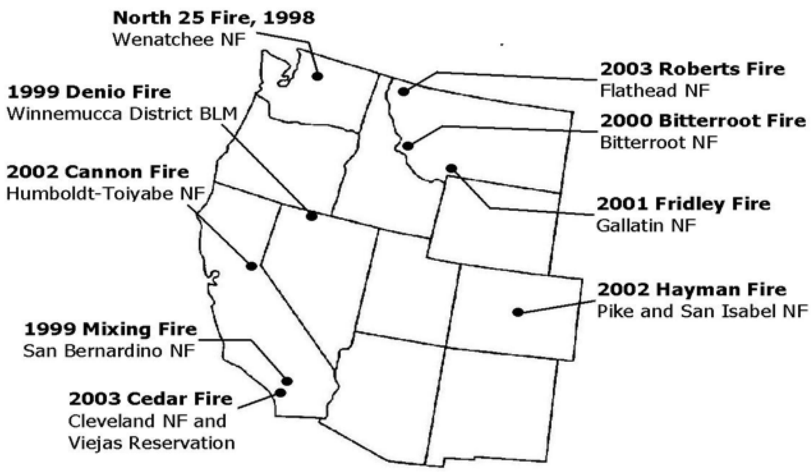
To quantify the effectiveness of some postfire mitigation practices, small-paired watersheds (2 to 10 ha) were installed in various ecosystems throughout the western US. Following eight major wildfires, paired watersheds were installed to compare sediment yields from contour-felled log, aerial-applied straw mulch, and aerial hydromulch to untreated catchments. These sites are remotely monitored and assessed via cell phones and radio transmissions, and the transmitted data are uploaded to our web site (http://forest.moscowfsl.wsu.edu/weather) on a daily basis.

Paired-watershed Treatment Effectiveness Studies—Field Research Locations:

- <u>Contour-felled Log Erosion Barriers</u>
    - North 25 Fire, Wenatchee National Forest, Washington
    - Mixing Fire, San Bernardino National Forest, California
    - Valley Complex, Bitterroot National Forest, Montana
    - Fridley Fire, Gallatin National Forest, Montana
    - Cannon Fire, Humbolt-Toiyabe National Forest, California
    - Hayman Fire, Pike and San Isabel National Forest, Colorado

- <u>Mulch Treatments</u>
    - Hayman Fire, Pike & San Isabel National Forest, Colorado
    - Cedar Fire, Viejas Reservation, Clevland National Forest, California
    - Roberts Fire, Flathead National Forest, Montana

- <u>No Treatment</u>
    - Denio Fire, Winnemucca District, BLM, Nevada



Findings:

- Sediment yields generally decrease by an order of magnitude each year; however, postfire recovery rates vary depending on precipitation characteristics. In monsoon climates postfire recovery takes longer and erosion rates can be similar for the first two postfire years.
- Ground cover increases about 15 to 20% each year after a fire and the natural recovery strongly influences the observed sediment reduction.
- There was no difference in peak flows, runoff, or sediment yields between the control and the contour-felled log treated watersheds. However, runoff and sediment yields tended to be lower on the contour-felled log treated watersheds with low intensity rain events.
- Sediment trap efficiency of contour-felled logs decreased with increasing rainfall intensity. Generally, sediment trap efficiency did not exceed 67% for any storm, and decreased to 30 to 40% for short duration, high intensity events.
- The data from 3000 contour-felled log performance characteristics measurements suggests that inefficient log performance is related to logs being installed off-contour and runoff undermining or going around the ends of the log. Adding earthen berms and turning the ends of straw wattles upslope increases the storage capacity by 10 to 16% and allows the sediment-laden runoff to pool behind the barrier.
- Straw mulch treatments reduce erosion better than any other assessed treatment.
- Hydromulch is not as effective as straw mulch. The short fiber lengths of most hydromulch products make it less resistant to the shear force of runoff allowing it to be removed by rill erosion.

Publications: #5, 7, 9, 10, 11, 12, 18

Objective 3—Wildfire and prescribed fire on rangelands

Considerable efforts were made to understand the spatial variability of runoff and erosion in steep mountain sagebrush communities following prescribed fire and wildfire disturbances. Using rainfall simulators on small plots (0.5 m by 0.5 m) and large (6.5 m by 5 m) plots, allowed both interrill and rill erosion processes as well as the interaction between the two to be examined. Postfire recovery rates for infiltration and erosion were also measured.

Rangeland Study Sites:

- Eighth Street Fire, Boise District, BLM, Idaho
- Denio Fire, Winnemucca District, BLM, Nevada
- Reynolds Creek Experimental Watershed, ARS, Idaho

Findings:

- Rainfall intensity often exceeds infiltration capacity for short duration, high intensity rainfall events.
- Postfire water repellent soil conditions can occur under the sagebrush thereby reducing infiltration by 30% the first year, 10% the second year, and 0 to 5% the third year.
- Hillslope erosion increased by 2 orders of magnitude immediately after prescribed fire and wildfires.
- Rill erosion is the dominate erosion process on burned, steep rangeland, which is similar to findings from burned forest lands.
- Parameters for ERMiT were developed from these field studies and are incorporated into the model.

Publications #2, 6, 16

Objective 4—Erosion Risk Management Tool (ERMiT)

The Erosion Risk Management Tool (ERMiT), a web-based interface, was developed using the Water Erosion Prediction Project (WEPP) technology to estimate erosion in probabilistic terms for burned and recovering forest, range and chaparral lands with and without mitigation treatments. ERMiT is a departure from traditional modeling approaches, which generally provide an ‘average erosion value’ for a given set of conditions. Because erosion after wildfires is not ‘an average’ but rather an anomaly, a probabilistic approach is applied to a range of values for the input variables—climate and rainfall patterns, soil properties, and burn severity (appendix 2A). These inputs are used to generate a ‘probability of exceedence’ for a range of potential event erosion rates. In addition, event erosion rate distributions are generated for hillslopes that have been treated with seeding, straw mulch, straw wattles and contour-felled log erosion barriers. The output was to be specifically tailored to enable BAER teams and land managers to evaluate the relative risks for a distribution of postfire erosion rates (appendix 2B). Field measurements made in Phase I and II of this project were used to populate ERMiT's database, develop and modify the conceptual models of the processes used to calculate potential erosion rates, and to validate ERMiT's erosion rate predictions. The model was released for trial review in 2002, used by selected BAER Teams in 2003 and 2004, and fully-launched for postfire assessments in 2005. Data obtained from this research was also incorporated into Fuel Management Erosion Analysis (FUME) tool, which is used to compare potential erosion rates after thinning, prescribed fire, and wildfire.

Findings:

- A web-based probabilistic model was developed to incorporate variability in climate conditions, burn severity, and soil properties for postfire erosion prediction and is available at (http://forest.moscowfsl.wsu.edu/fswepp).
- Field measurements of soil parameters were incorporated into input files, which allows forest, range, and chaparral areas to be modeled. By using a range of measured values for infiltration, interrill erodibility, and rill erodibility, natural variabilities that occur in these postfire environments have been accommodated.
- After wildfires, a mosaic of high and low burn severity conditions exist. To model this spatial variation of burn severity, a matrix of overland flow elements are processed within the WEPP model.
- Postfire recovery is modeled by increasing ground cover and decreasing soil erodibility based on precipitation characteristics.
- Initial validation of the model (under Robichaud and MacDonald JFSP project) indicated postfire erosion predictions are within the measured range. Validation is continuing with the data from these projects.
- Data from this project has allowed land and fire managers to compare potential erosion rates from thinning, prescribed fire, and wildfire over a natural fire cycle using FUME Fuel Management Erosion Analysis (http://forest.moscowfsl.wsu.edu/fswepp).

Publications: # 8, 10, 12, 16, 17

Deliverables

As part of the continuing technology transfer of the WEPP-based erosion prediction technology, results obtained from this project were incorporated into the suite of erosion prediction models disseminated via the Internet (http://forest.moscowfsl.wsu.edu/fswepp) and in training workshops. These models include Disturbed WEPP, ERMiT and FUME. From January through September 2005, over 40,000 erosion prediction runs have been run on the fswepp server.

Numerous presentation have been made to hydrologists, soil scientists, fuel planners, BAER team leaders, engineers, and ecologists from every federal land management agency, numerous state agencies, and a large number of private consults and land managers. Many informal discussions—on the phone, in emails, at BAER trainings and meetings, over the hood of the truck at a research site—have been instrumental in disseminating of new research findings. The specialist who needs this information does not want to wait for a formal research paper to be published; they need to know immediately how best to predict erosion and what mitigation treatment will work best. Workshops and one-on-one discussions are often the most effective technology transfer techniques. A major public display of the new probabilistic modeling technology occurred at the *2004 Advancing the Fundamental Sciences Conference*, sponsored by USDA-Forest Service in San Diego, CA. Several hundred specialists attended the sessions on postfire erosion prediction and mitigation effectiveness. Excellent feedback, user interaction, and acceptance of the available technology were encountered.

The ERMiT model was used to predict erosion risks on the numerous 2005 wildfires including: School Fire, Umatilla National Forest, Washington; Gregory Fire, Boise National Forest, Idaho; Blackerby Fire, Nez Pierce National Forest, Idaho; Valley Road Fire, Salmon Challis National Forest, Idaho; Mason Gulch Fire, Pike and San Isabel National Forest, Colorado.

Technology transfer has been a focus of this project and we have exceeded our expectations on deliverables (appendix 1). This focus is exemplified by the models being publicly accessible as web-base technology with user-friendly interfaces. In addition to publishing in appropriate journals, the PI's have provided training and support through workshops and conferences along with frequent participation in field-based work where they work directly with specialists using these tools.

Presentations

1. Robichaud, P.R. Fire and erosion: what happens after the smoke is gone? 12^{th} Annual Nonpoint Source Water Quality Monitoring Workshop, Boise, ID. January 2002. Abstract provided. Keynote Speaker.

2. Robichaud, P.R. Dirty work on the Bitterroot: first year erosion results. Bitterroot Restoration Team, Bitterroot National Forest Leadership Team, Hamilton, MT. May 2002.

3. Wohlgemuth, P.M.; K.R. Hubbert; P.R. Robichaud. Postfire water yield, sediment yield, and log erosion barrier effectiveness in small forested watersheds, Southern California. Geological Society of America Annual Meeting, Denver, CO. October 2002.

4. Spigel, K.M.; P.R. Robichaud. First year postfire erosion in Bitterroot National Forest, Montana. Geological Society of America Annual Meeting, Denver, CO. October 2002.

5. Robichaud, P.R. Wildfire and erosion: when to expect the unexpected. Geological Society of America Annual Meeting. Denver, CO. November 2002. Keynote Speaker.

6. Robichaud, P.R. Another burning question: Is erosion after fire bad? Soil Science Society of America Annual Meeting, Indianapolis, IN. November 2002.

7. Robichaud, P.R. From researcher to land/resource manager: how can technology transfer be improved?-the federal perspective. U.S. Geological Survey Third Wildland Fire Science Workshop. Denver, CO. November 2002.

8. Robichaud, P.R., L.H. MacDonald; J. Freeouf; D. Neary; D. Martin. Hayman fire case study: postfire rehabilitation. Lakewood, CO. November 2002.

9. Robichaud, P.R. Treatment effectiveness, the latest . . . Interagency BAER/ESR National Training. Reno, NV. December 2002.

10. Robichaud, P.R. Monitoring effectiveness of postfire rehabilitation treatments at the small watershed scale. Region 1 and Region 4 Adaptive Management Workshop, Coeur D' Alene, ID. January 2003.

11. Elliot, W.J.; P.R. Robichaud; R. Foltz; S. Miller; K.M. Spigel. 2003. Measuring and modeling erosion impacts of fuel management. National Fire Plan Conference, New Orleans, LA. January 2003.

12. Robichaud, P.R. Effectiveness of postfire erosion control techniques "Is the jury still out?" International Erosion Control Association Annual Meeting, Las Vegas, NV. February 2003.

13. Robichaud, P.R.; F.B. Pierson. Postfire rehabilitation treatment effectiveness: what we know. 56th Annual Meeting of the Society of Range Management, Casper, WY. February 2003.

14. Robichaud, P.R. BAER effectiveness monitoring. Region 1 Soils Workshop, Butte, MT. February 2003.

15. Pierson, F.B.; P.R. Robichaud; K.E. Spaeth. Hydrologic recovery of steep sagebrush rangeland following wildfire. 56th Annual Meeting of the Society for Range Management, Casper, WY. February 2003.

16. Robichaud, P.R. When the rains come . . . postfire rehabilitation effectiveness. Fire Science for Managers and Policy Makers Seminar Series, Washington DC. June 2003.

17. Robichaud, P.R. When the rains come . . . postfire rehabilitation effectiveness. US Senate and House of Representative Staffers, Washington DC. June 2003.

18. Robichaud, P.R. Postfire rehabilitation effectiveness. Wildland Fire Impacts on Watersheds. Geological Society of America. October 2003.

19. Robichaud, P.R.; R.E. Brown. Quick response small catchment monitoring techniques for comparing postfire rehabilitation treatment effectiveness. First Interagency Conference on Research in the Watersheds. Benson, AZ. October 2003.

20. Pierson, F.B.; P.R. Robichaud; K.E. Spaeth; C.A. Moffet. Impacts of fire on hydrology and erosion in steep mountain big sagebrush communities. First Interagency Conference on Research in the Watersheds. Benson, AZ. October 2003.

21. Robichaud, P.R. Erosion after wildfires: what manager's need to know. 2nd International Fire Ecology and Fire Management Congress, Orlando, FL. November 2003.

22. Beyers, J.L.; P.R. Robichaud; G.H. Riechers; P.M. Wohlgemuth. Forest Service postfire rehabilitation effectiveness research. National Fire Plan Conference, Reno, NV. March 2004.

23. Elliot, W.J.; P.R. Robichaud. Sources of Sediment in Fuel Management. Twenty-first Annual Forest Engineering Conference, Moscow, ID. March 2004.

24. Robichaud, P.R. The effectiveness of the United States postfire emergency erosion control treatments, European Geoscience Union, April 2004. Nice, France. Keynote Speaker.

25. Robichaud, P.R. Why some postfire emergency rehabilitation treatments work and don't work. Collaborative Investigation of Wildfire, USGS, Boulder, CO, June 2004.

26. Robichaud, P.R.; S. Lewis; D. Laes. Evaluating Hyperspectral images for burn severity classification and water repellent conditions. Collaborative Investigation of Wildfire, USGS, Boulder, CO, June 2004.

27. Robichaud, P.R. Recent findings in postfire emergency rehabilitation treatment effectiveness. International Erosion Control Association Tri-chapter Conference, Reno, NV, August 2004.

28. Robichaud, P.R. Monitoring the effectiveness of postfire emergency rehabilitation treatments: opportunities and challenges. Monitoring Science and Technology Symposium, Forest Service Rocky Mountain Research Station, Denver, CO, September 2004.

29. Robichaud, P.R.; W.J. Elliot; F.B. Pierson; P.M. Wohlgemuth. A probabilistic approach to modeling hillslope erosion after wildfires. Advancing the Fundamental Sciences Conference, Forest Service, San Diego, CA, October 2004.

30. Robichaud, P.R.; P.M. Wohlgemuth; J. Beyers. Monitoring the effectiveness of hydromulch after the 2003 Cedar Fire. Advancing the Fundamental Sciences Conference,

Forest Service, San Diego, CA, October 2004.

31. Wohlgemuth, P.M.; P.R. Robichaud. The effects of selected post-fire emergency rehabilitation techniques on small watersheds sediment yields in southern California. Advancing the Fundamental Sciences Conference, Forest Service, San Diego, CA, October 2004.

32. Hubbert, K.; P.M. Wohlgemuth; P.R. Robichaud. Effectiveness of Aerial Hydromulch on the Cedar Fire in Controlling Water Movement and Erosion. Advancing the Fundamental Sciences Conference, Forest Service, San Diego, CA, October 2004.

Workshops

1. BAER Team Leader Training Workshop, USDA-Forest Service, Reno, NV. April 2002.

2. Worked with the National BAER Program Director (M. Copenhagen) and Regional coordinators on developing changes and direction of the BAER training program.

3. U.S. Geological Survey, Third Wildland Fire Science Workshop. Denver, CO. November 2002.

4. USDA-Forest Service, US Department of Interior, Interagency BAER/ESR Training Workshop. Reno, NV. December 2002.

5. Watershed Restoration Short Course. Washington State University. Wenatchee, WA. September 2003.

6. Wildland Fire Impacts on Watersheds. Geological Society of America. Denver, CO. October 2003.

7. ERMiT was incorporated into **12 FSWEPP workshops** taught by Dr. Elliot during the past 3 years. Attendees include Forest Service, BLM, Bureau of Reclamation, NRCS, Soil and Water Conservation Society, State Agencies, Tribes, and Consultants interested in using the latest technology to predict erosion from a variety of management actions in range, chaparral and forest environments. In the last three years over

Publications from Phase II
(see Phase I Final Report for publications prior to 2002)

1. Robichaud, P.R.; R.E. Brown. 2002. Silt fences: an economical technique for measuring hillslope erosion. *USDA Forest Service, Rocky Mountain Research Station General Technical Report RMRS-GTR-94.* 24 p

2. Pierson, F.B.; D.H. Carlson; K.E. Spaeth. 2002. Impacts of wildfire on soil hydrological properties of steep sagebrush-steppe rangeland. *International Journal of Wildland Fire 11:145-151.*

3. Spigel, K.M. 2002. First year erosion rates in Bitterroot National Forest, Montana. *M.S. Thesis. University of Wisconsin-Madison*. 147 p.

4. Robichaud, P.R.; L.H. MacDonald; J. Freeouf; D. Neary; D. Martin; L. Ashmun. 2003 Postfire rehabilitation of the Hayman fire. Chap 5. In: Graham, R. Editor, Hayman Fire Case Study. *USDA Forest Service, Rocky Mountain Research Station General Technical Report RMRS- GTR-114*, Chap 5:293-313

5. Robichaud, P.R.; R.E. Brown. 2003. Quick response small catchment monitoring techniques for comparing postfire rehabilitation treatment effectiveness. *Proceedings, First Interagency Conference on Research in the Watersheds*. Agricultural Research Service. Pp. 663-667.

6. Pierson, F.B.; P.R. Robichaud; K.E. Spaeth; C.A. Moffet. 2003. Impacts of fire on hydrology and erosion in steep mountain big sagebrush communities. *Proceedings, First Interagency Conference on Research in the Watersheds*. Agricultural Research Service. Pp. 625-630.

7. Covert, S.A. 2003. Accuracy assessment of WEPP-based erosion models on three small, harvested and burned forest watersheds. *M.S. Thesis. University of Idaho*. 49 p.

8. Robichaud, P.R.; W.J. Elliot; F.B. Pierson; D.E. Hall; C.A. Moffet. ERMiT Erosion Risk Management Tool interface version 2005.04.20. Available at: http://forest.moscowfsl.wsu.edu/fswepp [accessed 20 April 2005].

9. Covert, S.A.; P.R. Robichaud; W.J. Elliot; T.E. Link. 2005. Evaluating the WEPP-based erosion predictions for three small timber harvested watersheds. *Transaction of American Society of Agricultural Engineers 48(3):1093-1100*.

10. Robichaud, P.R.; R.E. Brown. 2005. Postfire Rehabilitation Treatments: Are We Learning What Works? *Proceedings, Managing Watersheds for Human and Natural Impacts, Williamsburg, VA. 12 p. American Society of Civil Engineers, Reston, VA.*

11. Robichaud, P.R.; J. Wagenbrenner. 2005. Hayman Fire Rehabilitation Treatment Monitoring, Progress Report. Report on file at: Rocky Mountain Research Station, Moscow, ID.

Publications in Progress

12. Robichaud, P.R. The effectiveness of the United States postfire emergency erosion control treatments. *International Journal of Wildland Fire*. In Press.

13. Spigel, K.M.; P.R. Robichaud. First year erosion rates after the 2000 Bitterroot Fires. *Hydrological Processes.* Under review.

14. Robichaud, P.R.; F.B. Pierson; R.E. Brown; J. W. Wagenbrenner. Comparing the postfire effectiveness of three hillslope erosion barrier treatments using simulated and natural rainfall. *Hydrological Processes*. Under review.

15. Robichaud, P.R.; T.R. Lillybridge; J.W. Wagenbrenner. Effectiveness of postfire seeding and fertilizing on hillslope erosion in north-central Washington, USA. *Catena*. Under review.

16. Moffet, C.A.; F.B. Pierson; P.R. Robichaud; K.E. Spaeth. Modeling soil erosion on steep sagebrush rangeland before and after prescribed fire. *Catena*. Under review.

17. Robichaud, P.R.; W. J. Elliot; F.B. Pierson; D.E. Hall; C.A. Moffet. Predicting postfire erosion and mitigation effectiveness with a web-based probabilistic erosion model. *Catena*. Under review.

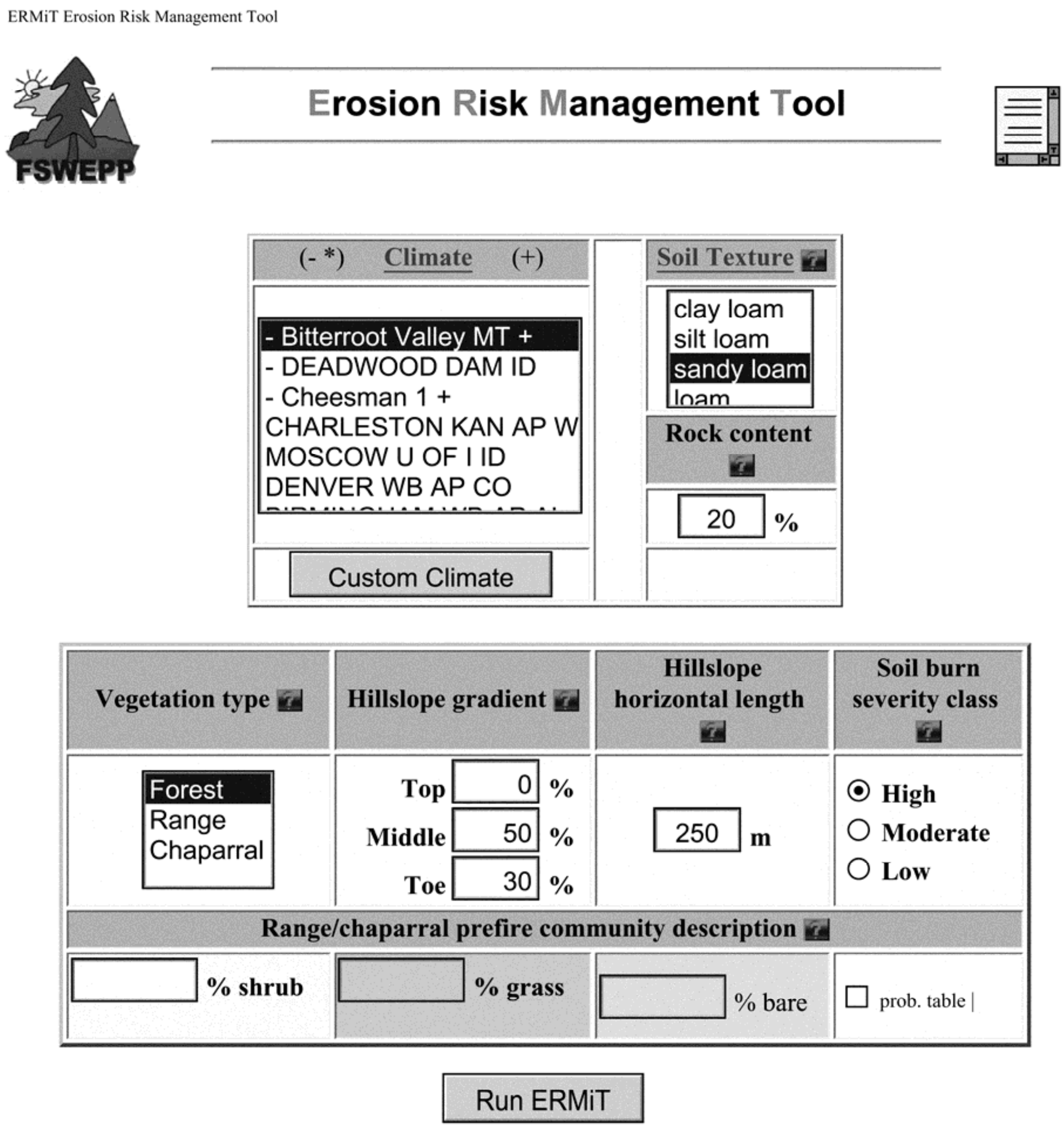
18. Robichaud, P.R. Evaluating the effectiveness of contour-felled log erosion barriers as a postfire emergency rehabilitation treatment. *Journal of Hydrology*. In preparation.

Appendix 1. Proposed deliverables.

Objective	Deliverable	Date
1. Treatment comparison	• Presentation of treatment effectiveness at BAER Team Workshops and Regional Meetings	From year 2
	• Technical paper on treatment effects	Year 3
2. Paired Watersheds	• Technical paper on research findings	Year 3
3. Rangelands Fire Effects	• Two technical papers on research findings	Year 3
4. Populate Erosion Risk Management Tool (ERMiT)	• Internet interface updated with new treatments	From year 2
	• Two technical papers on technology transfer	From year 3/4

Appendix 2—ERMiT Input/Output Screens

2A. Input Screen



2B. ERMiT Climate Output Screen

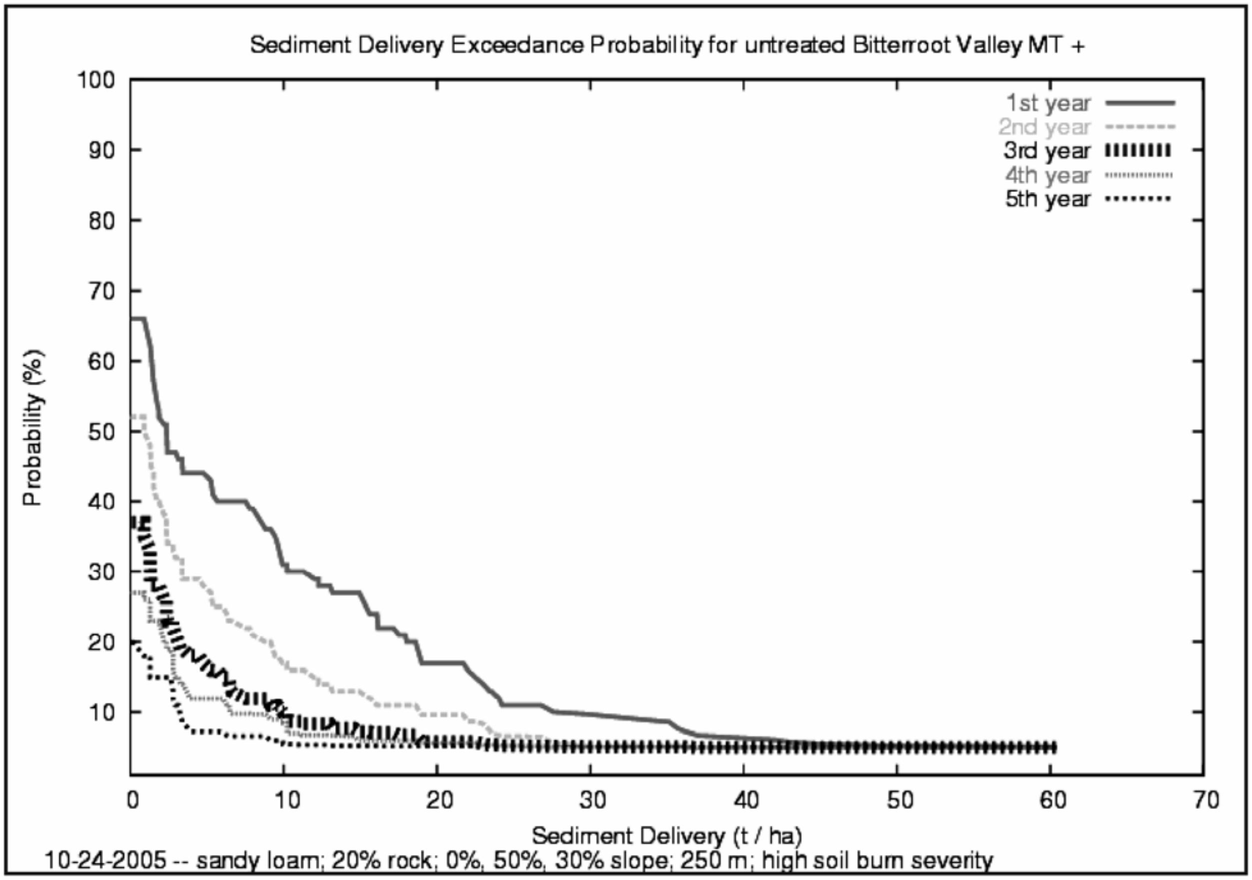
Erosion Risk Management Tool

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
0% top, 50% average, 30% toe hillslope gradient
250 m hillslope horizontal length
high soil burn severity on **forest**

100 - YEAR MEAN ANNUAL AVERAGES				
895.29	**mm**	annual precipitation from	9182	storms
10.61	**mm**	annual runoff from rainfall from	261	events
7.48	**mm**	annual runoff from snowmelt or winter rainstorm from	176	events

Ranking of event (return interval)	Storm Runoff (mm)	Storm Precipitation (mm)	Storm Duration (h)	10-min peak intensity ($mm\ h^{-1}$)	30-min peak intensity ($mm\ h^{-1}$)	Storm date
1	43.1	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**

2B cont. ERMiT Sediment Exceedence Probabilities Output Screen



Target chance event sediment delivery will be exceeded 20 % go	Event sediment delivery (t ha^{-1})				
	Year following fire				
	1st year	2nd year	3rd year	4th year	5th year
Untreated	**18.02**	**8.81**	**3.18**	**2.2**	**0**
Seeding	**18.02**	**5.08**	**2.79**	**1.98**	**0**
Mulch rate 1 t ha^{-1}	**4.79**	**2.94**	**3.18**	**2.2**	**0**
Mulch rate 2 t ha^{-1}	**2.32**	**2.42**	**3.18**	**2.2**	**0**
Mulch rate 3.5 t ha^{-1}	**2.32**	**2.34**	**3.18**	**2.2**	**0**
Mulch rate 4.5 t ha^{-1}	**2.31**	**2.33**	**3.18**	**2.2**	**0**
Logs & Wattles go **Diameter** 0.2 **m** **Spacing** 40 **m**	**12.34**	**4.97**	**0.3**	**0.62**	**0**

Return to input screen