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STREAM NOTES

To Aid in Securing Favorable Conditions of Water Flows

Rocky Mountain Research Station

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A Synthesis of Post-Fire Road Treatments of BAER Teams

by Randy B. Foltz and Peter R. Robichaud

Watersheds with satisfactory hydrologic conditions (greater than 75% of the ground covered with vegetation and litter) and adequate rainfall sustain stream baseflow conditions for much or all of the year and produce little sediment and erosion. Fire consumes accumulated forest floor material and vegetation, altering infiltration by exposing soils to raindrop impact or creating water repellent soil conditions, thus reducing infiltration and consequently increasing runoff. Runoff plot studies show that, when severe fire produces hydrologic conditions that are poor (less than 10% of the ground surface covered with plants and litter), surface runoff can increase more than 70% and erosion can increase by three orders of magnitude (DeBano and others 1998; Robichaud 2005). Roads are one of the most impacted forest infrastructures (fig. 1). In the post-fire environment, road drainage features must accommodate flows under these changed and variable conditions to prevent failure (fig. 2). Road structures designed for the unburned forest condition are often unable to accommodate increased runoff, sediment, and debris following fire.

Burned Area Emergency Response (BAER) teams estimate post-fire increases in stream flows and make judgments on the ability of existing road structures to accommodate these new flow regimes. If necessary, treatments are prescribed to address user safety and road infrastructure investment, as well as to prevent disruption of use or unacceptable degradation of critical natural and cultural resources. Nationwide road structure replacement costs in the 1990s were about 20 percent of the total post-fire rehabilitation expense (Robichaud and others 2000). BAER team members use a variety of tools to estimate the post-fire increase in runoff and sediment. These vary from local expertise to computer models.

The overall goal of the publication, ***A Synthesis of Post-Fire Road Treatments for BAER Teams: Methods, Treatment Effectiveness, and Decisionmaking Tools for Rehabilitation*** (Foltz and others 2010), was to develop a resource for BAER teams to assist them in making post-fire road rehabilitation decisions. This publication synthesizes the most useful post-fire analysis tools for use in determining

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

Website:
http://www.stream.fs.fed.us

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Figure 1. Road at risk as seen from burned forest slope.

the required capacity of road structures and guidelines and procedures for prescribing road treatments after wildfire. The objective was to provide a one-stop collection of techniques to assess post-fire flows, road treatments, and experienced BAER team member's insights into the techniques and treatments. Here we summarize the results and recommendations discussed in Foltz and others (2010).

BAER Team Specialists Interviews

This study included U.S. Forest Service BAER projects in the Western continental United States (Regions 1 through 6). We began by requesting Burned Area Report (FS-2500-8) forms and monitoring reports from the Regional headquarters and Forest Supervisors' offices. We interviewed 30 BAER specialists regarding their experiences with post-fire rehabilitation. Hydrologists, engineers, and soil scientists comprised 87% of the specialists. During the face to face interviews we collected their gray and relevant peer-reviewed literature that they believed were important for BAER analysis. The experience of these BAER specialists ranged from six to over 30 years.

The interviews included discussions about what methodology the specialists used to complete road related sections of the FS-2500-8. The sections were "Hydrologic Design Factors" and "Road Treatment Recommendations."

Hydrologic Design Factors

The "Hydrologic Design Factors" section is used to document the methodology for calculating increased flows following fires. These increased flows are used to guide the road treatment recommendations. Table 1 lists the factors found on the Burned Area Report (FS-2500-8). When the specialists were asked what methodology they used for each of these factors, "professional judgment" and "consult with hydrologist" were the most frequent responses. These responses indicate the importance of professional judgment and the BAER team hydrologist when selecting BAER team members.

The "Estimated reduction in infiltration" factor is critical in the determination of treatment recommendations. This factor is used to estimate the post-fire peak flow that the road must accommodate. There is no nationwide accepted methodology; thus BAER team members choose the method most appropriate for each post-fire assessment. The most frequently used method to predict peak flow was the U.S. Geological Survey (USGS) Regression Equation followed by the Natural Resources Conservation Service (NRCS) Curve Number, Rule of Thumb by Kuymjian, and TR-55. Other responses included the Erosion Risk Management Tool (ERMIT), and Fire-Enhanced Runoff and Gully Initiation (FERGI) model.

USGS Regression

The USGS Regression method was the most commonly used post-fire runoff estimation method (43%). The Department of Interior U.S. Geological Survey (USGS) developed regression equation methods to estimate magnitude and

Figure 2. Washed out ditch. The ditch could not accommodate the increased post-fire flow.

Table 1. Hydrologic Design Factors from the Burned Area Report (FS 2500-8).

Hydraulic Design Factor
Estimated vegetation recovery period
Design chance of success
Equivalent design recurrence interval
Design storm duration
Design storm magnitude
Estimated reduction in infiltration

frequency of floods of both gaged and ungaged streams. The flood-frequency relations at gaged and ungaged sites were developed for various hydrologic regions based on their stream gage records, basin characteristics, and numerous studies throughout the United States. The regression methods and necessary supporting maps and tables for twelve western states are available in Foltz and others (2010).

USGS Regression methods have been incorporated into StreamStats (USGS 2007), which is a web-based tool used to obtain streamflow information. Users can access StreamStat online (http://water.usgs.gov/osw/streamstats/index.html) and estimate peak flow at a given location.

Curve Number

The NRCS Curve Number methods were the second most commonly used post-fire runoff estimation method (30%). The Curve Number method was developed by the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) to estimate runoff depth. It considers rainfall, soil, cover type, treatment/conservation practice, hydrologic condition, and topography (slope steepness). Users select a Curve Number (CN) based on these factors to represent the pre- and post-fire conditions. Guidance for CN selection is included in Foltz and others (2010).

There were two Curve Number methods that BAER teams used frequently, namely, WILDCAT4, (Hawkins and Greenberg 1990) an MS DOS program, and FIREHYDRO (Cerrelli 2005), an EXCEL spreadsheet. Both methods are available at http://forest.moscowfsl.wsu.edu/BAERTOOLS/ROADTRT/Peakflow/CN/.

Rule of Thumb

The Rule of Thumb by Kuyumjian was used by 7% of the BAER interviewees. Experienced BAER team members often used their own rule of thumb, which they developed based on their experience and post-fire monitoring and observation. Like any regression model, the rules of thumb can be very good when applied in conditions similar to those where it was developed. Their accuracy becomes increasingly suspect when conditions depart from where it was developed. Kuyumjian's rule relates post-fire peak flow to the product of precipitation intensity of the design or damaging storm and the area with high and moderate burn severity for the southwestern United States.

TR-55

Seven percent of the BAER team members used TR-55 to calculate post-fire runoff increase. TR-55 is a simplified procedure to calculate the storm runoff volume, peakflow rate, hydrograph, and storage volume for storm water management structures in small watersheds in urban areas. Rainfall distribution type and runoff Curve Number are two of the important factors necessary for TR-55.

The current version of TR-55 computer model is WinTR-55. It is available at the NRCS web site http://www.wsi.nrcs.usda.gov/products/W2Q/H&H/Tools_Models/WinTR55.html.

ERMiT

ERMiT (Robichaud and others 2007), a FS WEPP (Water Erosion Prediction Project) Interface, which is used primarily for post-fire erosion prediction was used by 5% of the BAER interviewees. The WEPP model was developed by an interagency group of scientists from the U.S. Department of Agriculture's Agricultural Research Service, Forest Service, and Soil Conservation Service (currently Natural Resources Conservation Service); U.S. Department of Interior Bureau of Land Management; U.S. Geological Survey; and several university cooperators. The WEPP model predicts soil erosion and sediment delivery by water using stochastic weather generation, infiltration theory, hydrology, soil physics, plant science, hydraulics, and erosion mechanics (Flanagan and Livingston 1995). Several FS WEPP interfaces were developed by the U.S. Forest Service Rocky

Mountain Research Station, Soil and Water Engineering Research Work Unit, Moscow, Idaho to make the model easier to use. The interfaces applicable to BAER road treatment work are ERMiT, Cross Drain, WEPP:Road, WEPP:Road Batch, Peak Flow Calculator, and Tahoe Basin Sediment Model.

Each of the FS WEPP interfaces can be run from the web site (http://forest.moscowfsl.wsu.edu/fswepp/). ERMiT reports rainfall event rankings and characteristics (including runoff), the exceedance probability associated with sediment delivery, and mitigation treatment comparisons.

After the publication of Foltz and others (2010), a peak flow calculator was added to the FS WEPP interfaces. This interface uses runoff output from ERMiT and the TR-55 methodology to predict peak runoff and runoff volume. The calculator is applicable to watersheds smaller than 900 ha (2,000 ac). It is an online tool available at http://forest.moscowfsl.wsu.edu/fswepp.

FERGI

The FERGI model was used by 2% of the BAER team members. The FERGI model was developed by the U.S. Forest Service, Rocky Mountain Research Station, Boise Aquatic Science Lab (Istanbulluoglu and others 2004). The FERGI model is a physically based mathematical description of hillslope hydrologic and geomorphic response to a set of weather events. The model is applicable to any part of the western United States. FERGI estimates the probability of post-fire rainfall excess, runoff generation amount, and gully initiation positions on hillslopes with and without mitigations using contour felled logs/log barriers.

The FERGI model is accessible from the Forest Service intranet (http://frames.nbii.gov/fergi/) and runs online.

Road Treatments

Using one or more of the post-fire peak flow estimation methods, the BAER team decides whether or not the road network can accommodate the increased flow. If it concludes that the existing road drainage structures are adequate, a recommendation of no changes is made. If it concludes that the drainage structures are not adequate, a variety of road treatment options are available (table 2). The BAER interviewees were asked what treatments they selected. Rolling dips/water bars/cross drain, culvert upgrading, ditch cleaning, armoring, culvert removal, and trash racks constituted 80% of the most frequently used road treatments (fig. 3). Culvert upgrading was used mainly in Regions 1, 4, and 6 where fish habitat protection is a high priority. Culvert removal was used often in Region 3 where flash flooding is common. Trash racks were used in Regions 3 and 5.

Table 2. Road treatments commonly used by BAER road specialists.

Road Treatment
Armored road crossing
Channel debris cleaning
Culvert inlet/out armoring/modification
Culvert removal
Culvert risers
Culvert upgrading
Debris/trash rack
Ditch cleaning/armoring
Hazard/warning sign
Outsloping road
Relief culvert
Road closure
Road decommissioning
Rolling dip/water bar
Storm patrol

Additional Information

For a more in-depth discussion and complete list of references on this topic, please refer to the publication: Foltz, R.B.; Robichaud, P.R.; Rhee, H. 2010. A Synthesis of Post-Fire Road Treatments for BAER Teams: Methods, Treatment Effectiveness, and Decisionmaking Tools for Rehabilitation. Gen. Tech. Rep. RMRS-GTR-228 Fort Collins, CO. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 152 p. Hardcopies of publication can be obtained by placing an order to Publications Distribution,

Figure 3. A) Example of ditch cleaning. One of the road treatments commonly used by BAER specialists. B) A culvert being upgraded to a larger size. One of the road treatments commonly used by BAER specialists.

Rocky Mountain Research Station, Fort Collins by telephone (970-498-1392), facsimile (970-498-1396), or e-mail (rschneider@fs.fed.us). An electronic copy of RMRS-GTR-228 can also be downloaded at http://www.fs.fed.us/rm/pubs/rmrs_gtr228.html or http://forest.moscowfsl.wsu.edu/BAERTOOLS/ROADTRT/.

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References

Cerrelli, G.A. 2005. FIRE HYDRO, a simplified method for predicting peak discharges to assist in the design of flood protection measures for western wildfires. In: Moglen, Glenn E., eds. Proceedings: 2005 watershed management conference—managing watersheds for human and natural impacts: engineering, ecological, and economic challenges; 2005 July 19-22; Williamsburg, VA. Alexandria, VA: American Society of Civil Engineers: 935-941.

DeBano, L.F.; Neary, D.G.; Folliott, P.F. 1998. Fire's effects on ecosystems. New York, NY: John Wiley & Sons. 333 p.

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. 131 p.

Foltz, R.B.; Robichaud, P.R.; Rhee, H. 2010. A Synthesis of Post-Fire Road Treatments for BAER Teams: Methods, Treatment Effectiveness, and Decisionmaking Tools for Rehabilitation. Gen. Tech. Rep. RMRS-GTR-228 Fort Collins, CO. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 152 p.

Hawkins, R.H.; Greenberg, R.J. 1990. WILDCAT4 Flow Model. School of Renewable Natural Resources, University of Arizona, Tucson, AZ.

Istanbulluoglu, E.; Tarboton, D.G.; Pack, R.T.; Luce, C. 2004. Modeling of the interactions between forest vegetation, disturbances, and sediment yields. Journal of Geophysical Research. 109: F01009.

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. 2005. Measurement of post-fire hillslope erosion to evaluate and model rehabilitation treatment effectiveness and recovery. International Journal of Wildland Fire. 14: 475-485.

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). Gen. Tech. Rep. RMRS-GTR-188. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 24 p.

U.S. Department of Interior, Geological Survey. 2007 (March 14—last update). Welcome to StreamStat [Homepage of StreamStat], [Online]. Available at: http://water.usgs.gov/osw/streamstats/index.html [2008, May 11].

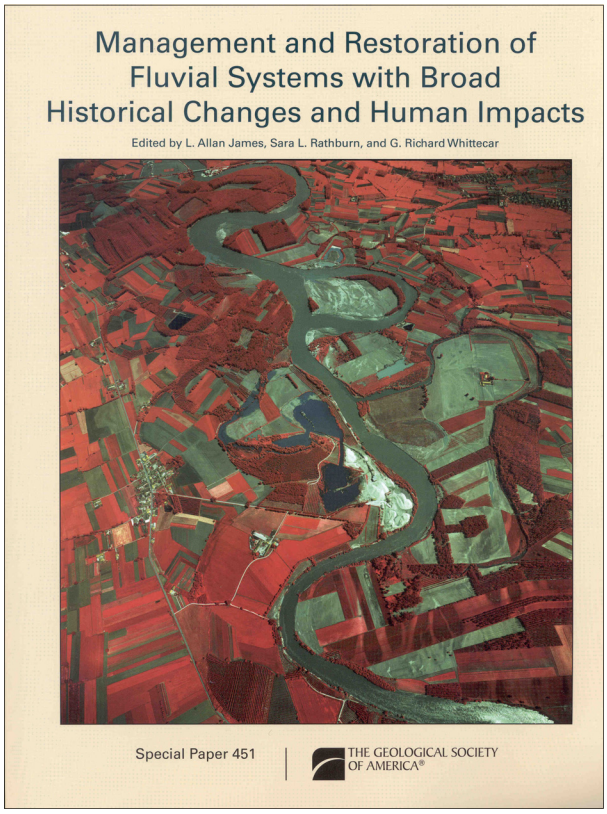
Randy B. Foltz is a Research Engineer; USDA Forest Service, Rocky Mountain Research Station, 1221 South Main St., Moscow, ID 83843; 208-883-2312; rfoltz@fs.fed.us.

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.

Management and Restoration of Fluvial Systems with Broad Historical Changes and Human Impacts

Management and Restoration of Fluvial Systems with Broad Historical Changes and Human Impacts is a multi-disciplined collection of papers that evaluate the long-term effects of anthropogenic activities on fluvial systems, present analytical methods for examining and understanding fluvial systems, and examine or recommend policies for river management and restoration. Most of the papers in this publication are broad in scope and examine different topics in a variety of diverse fluvial systems. The various papers in this publication emphasize the importance of recognizing the complexity and dynamics of fluvial systems that have been subjected to anthropogenic activities that vary temporally, spatially, and in intensity. Additionally, papers in this publication present methods and strategies for managing rivers altered by anthropogenic activities.

Within this framework, the fourteen separately authored chapters are organized into three sections. The first section, "*Large-Scale, Long-Term Sediment and Geomorphic Changes*", consists of nine papers that provide background information and examples of long-term natural and anthropogenic changes that occur in watersheds, and how these changes alter stream processes and channel characteristics. The emphasis on sediment loads in most of these papers reflects the importance of sediment in fluvial processes, channel responses and morphology, and stream functions such as habitat diversity. The second section, "*Hydrologic Considerations for River Restoration*," consists of three chapters that provide examples of the importance of hydrology to stream systems, examines how hydrologic changes drive stream processes, and/or presents methods for evaluating hydrologic changes. The third section, "*River Management and Restoration*", consists of three chapters that evaluate the success or examine the feasibility of stream restoration. Each of these papers provide a useful assessment of effective stream restoration methods and/or the importance of identifying stream reaches where restoration activities are likely to be geomorphically and ecologically successful and sustainable.



The information in this publication will be a useful reference to scientists and practitioners conducting studies assessing channel dynamics and/or developing plans to restore or improve fluvial and ecological processes along a stream. Additionally, the papers in this publication demonstrate the challenges of managing river systems that are responding to legacy conditions and that may have been highly altered by human activities. ***Management and Restoration of Fluvial Systems with Broad Historical Changes and Human Impacts*** is published by the Geological Society of America and can be purchased for $78 ($49 GSA members) online at http://rock.geosociety.org/Bookstore/default.asp?oID=0&catID=9&pID=SPE451. The citation for this book is: James, A.L. Rathburn, S.L. Whittecar, G.R. (editors). 2009. Management and Restoration of Fluvial Systems with Broad Historical Changes and Human Impacts. Geological Society of America Special Paper 451. 244 p.

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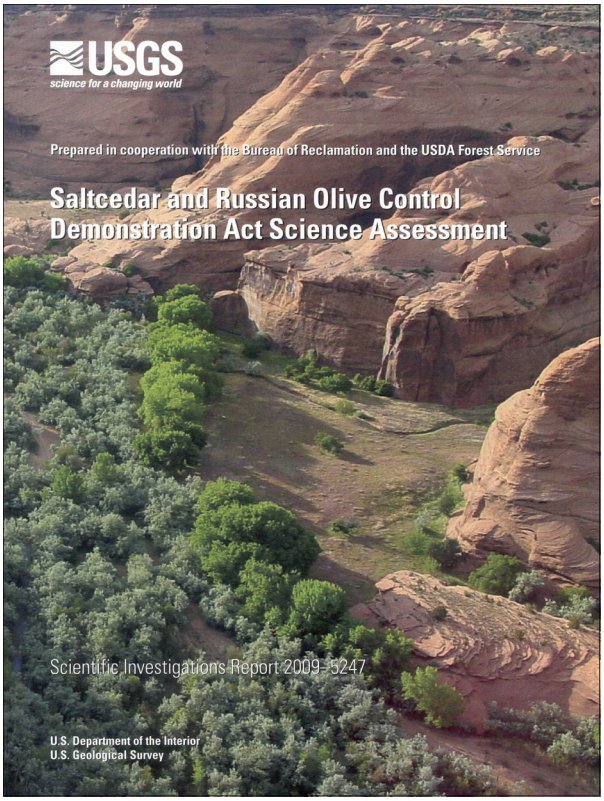
Saltcedar and Russian Olive Control Demonstration Act Science Assessment

Saltcedar and Russian olive are two nonnative tree species that have become the dominant components of vegetation communities along many stream corridors in the western United States. Based on a directive from Congress, the U.S. Geological Survey publication, "***Saltcedar and Russian Olive Control Demonstration Act Science Assessment***," presents a review of the existing state-of-the-science on saltcedar and Russian olive with respect to their distribution and spread, consumption of water, impact on wildlife, potential commercial uses, and responses to different control methods. This publication also discusses the challenges of restoring and/or revegetating stream corridors occupied by saltcedar and Russian olive.

Saltcedar and Russian Olive Control Demonstration Act Science Assessment consists of eight separately authored chapters. Chapter 1, "*Background and Information*", provides background information on the Salt Cedar and Russian Olive Control Demonstration Act of 2006 passed by Congress. Chapter 2, "*Distribution and Abundance of Saltcedar and Russian Olive in the Western United States*," reviews the introduction and distribution of saltcedar and Russian olive in the western United States. Chapter 3, "*The Potential for Water Savings Through the Control of Saltcedar and Russian Olive*," addresses the effects of saltcedar and Russian olive on river flows and groundwater supplies and the potential for increasing river flows and groundwater supplies through the removal or reduction of saltcedar and Russian olive. Chapter 4, "*Saltcedar and Russian Olive Interactions with Wildlife*," synthesizes the published literature on the use of saltcedar and Russian olive by wildlife and discusses potential wildlife responses to measures to control saltcedar and Russian olive and restore native vegetation. Chapter 5, "*Methods to Control Saltcedar and Russian Olive*," summarizes the advantages, disadvantages, risks, methodologies, and costs of various methods available to control saltcedar and Russian olive. Chapter 6, "*Utilization of Saltcedar and Russian Olive Biomass Following Removal*," discusses possible uses of saltcedar and Russian olive wood following removal efforts. Chapter 7,



"*Restoration and Revegetation Associated with Control of Saltcedar and Russian Olive*," reviews restoration and/or revegetation of river bottomlands and other areas that have been occupied by saltcedar and Russian olive. Chapter 8, "*Demonstration Projects and Long-Term Considerations Associated with Saltcedar and Russian Olive Control and Riparian Restoration*," provides recommendations for future studies that would improve our understanding of the various issues surrounding saltcedar and Russian olive.

Saltcedar and Russian Olive Control Demonstration Act Science Assessment is published by the U.S. Geological Survey. It can be viewed or downloaded at http://pubs.usgs.gov/sir/2009/5247/. The citation for the publication is: Shafroth, P.B.; Brown, C.A.; Merritt, D.M (editors). 2010. Saltcedar and Russian olive control demonstration act science assessment: U.S. Geological Survey Scientific Investigations Report 2009-5247. 143 p.

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