Final Report

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JFSP Project Title: Synthesizing Empirical Results to Improve Predictions of Post-wildfire Runoff and Erosion Responses, AGU Chapman Conference

PI: Pete Robichaud
USDA Forest Service, Rocky Mountain Research Station
1221 S Main St., Moscow, ID 83844
Phone: 208 883 2349, E-mail: probichaud@fs.fed.us

Abstract:

We hosted an American Geophysical Union Chapman Conference to bring together a broad spectrum of the scientific community to discuss and propose resolutions for current research issues confronting the post-wildfire research community regarding post-wildfire runoff and erosion. The five day meeting was held as Estes Park, Colorado from 25-31 August 2013. This conference brought together researchers (from different countries representing a variety of scientific disciplines) who have had infrequent opportunities and insufficient time to synthesize the different post-wildfire responses. Additionally, for the first time, meteorologists were invited to help address some of the persistent research issues. This conference built communication bridges between fields, assessed how to overcome existing limitations of wildfire-response research, and suggests methods to best incorporate existing and future empirically-based knowledge into useful predictive models of post-wildfire response. The four processes of precipitation, infiltration, runoff, and sediment transport were the themes used to generate the key invited speakers and focused discussions.

AGU CHAPMAN CONFERENCE

JOINT FIRE SCIENCE PROGRAM

Background and Purpose

The purpose of this conference was to bring together a broad spectrum of the scientific community to discuss and propose resolutions for current research issues confronting the post-wildfire research and mitigation community regarding post-wildfire runoff and erosion, and to explore ways to integrate the complex nature of post-wildfire responses. For example, as we expanded our knowledge of the interactions of changing climate regimes with meso-scale (~1-10 km^2), short-duration and highly variable precipitation patterns that drive post-wildfire responses in mountainous forest regions, by rethinking our approach to predicting rainfall amounts and intensities within the models. Models and supporting publications describing process-based, stochastic, or statistical models of post-wildfire processes (Robichaud et al., 2006, 2007; Cannon et al., 2010a) have emerged over the last few years (for example, ERMiT funded by JFSP). Although these models represent major advances in the domain of post-wildfire process prediction, their application often is spatially-limited.

The conference gathered field-, modeling- and application-oriented scientists from across the world representing the wildfire impact community. This conference built communication bridges between fields, assessed overcoming existing limitations of wildfire-response research, and determined how to best incorporate existing and future empirically-based knowledge into useful predictive models of post-wildfire response. To achieve truly unified predictive models of post-wildfire processes, the four processes of precipitation, infiltration, runoff, and sediment transport were themes that we followed throughout the conference. The PI and four co-conveners (J. Moody, R. Shakesby, D. Martin, S. Cannon) organized the Conference, which included ample time for topical sub-meetings related to disciplinary and newly emerging research issues. Sponsors included the Joint Fire Science Program, Decagon Devices, USGS, Rocky Mountain Research Station, National Science Foundation, Nature Conservancy, and American Geophysical Union.

Our specific objectives for the conference were to:

1) Determine a conceptual framework arranging the wide range of post-wildfire hydrologic and geomorphic responses into similar groups or post-wildfire domains that capture the salient characteristics and thus provide a context within which unified theories and predictive models for post-wildfire processes can be developed.
2) Identify the important drivers and processes that affect post-wildfire response at varying spatial and temporal scales in different post-wildfire domains.
3) Integrate results from studies conducted at different temporal and spatial scales.
4) Determine future critical research needs and establish uniformity for data acquisition to assure spatial and temporal comparable data.
5) Develop a strategy for distilling the diversity of knowledge about different post-wildfire domains, in order to provide managers with improved predictive models upon which they can base management decisions.

Key findings

The outcome of this conference, which focused specifically on post-wildfire hydrological and erosional responses, was a 'coming of age' for post-wildfire research, which has yet to be recognized as a scientific discipline. Post-wildfire research is challenging because wildfires frequently burn in complex mountainous terrain and responses are frequently driven by additionally complex meso-scale (1-10^4 km^2), spatially and temporally variable rainfall. Thus, responses are highly variable spatially and

transient in nature producing shallow (0-1 cm), unsteady overland flow on hillslopes and unsteady, non-uniform flow in channels.

This conference brought together 67 researchers (from seven different countries representing a variety of scientific disciplines) who have had infrequent opportunities and insufficient time to synthesize the different post-wildfire responses (Table 1). Additionally, for the first time, meteorologists were invited to help address some of the persistent research issues. Some of these issues were: 1) up-scaling of results, 2) identifying appropriate temporal and spatial rainfall metrics, 3) quantitatively relating soil burn severity to infiltration parameters, 4) identifying causes for increased post-wildfire runoff, and 5) identifying how to measure and represent transient processes. Highlights and new challenges emerged from each of the five topic sessions of the conference (organizational framework, meteorology, infiltration, runoff, and erosion) (Figure 1).

At the start of the conference, an organizational framework was proposed, which grouped post-wildfire responses into similar domains based on characteristics of fire, precipitation, and geomorphic regimes. The purpose was to identify patterns and thus understand the reasons for different post-wildfire responses. Some insights were that: 1) human activity and drought are becoming increasingly important in modifying fire regimes, and thus 2) fire regimes are non-stationary such that fire-return intervals based on historical records may not be representative of current and future conditions. Large wildfires and plantation forestry were identified as causing major changes in vegetation composition in some landscapes resulting in new fire regimes, but post-wildfire responses still depend on vegetation recovery characteristics.

Several new insights were presented during the meteorology and infiltration sessions. A new fire behavior model was demonstrated that couples for the first time the atmosphere with wildfire behavior in complex mountainous terrain. Such terrain can cause differential heating and instability leading to intensified rainfall over burned areas. Runoff models were shown 1) to be insensitive to available techniques of representing rainfall, and 2) to predict relative change (useful for land and emergency managers) better than absolute change. Intermittency and the temporal structure of rainfall were highlighted as important characteristics controlling post-wildfire runoff responses that need further research. The temporal sequence of rain may be important in runoff and may promote transient ash crust development (which can further increase runoff by temporarily impeding infiltration), while the lack of rain expressed as “landscape aridity” was found to correlate with the degree of channel erosion.

The runoff and erosion sessions present some new perspectives. ‘Breach’ or ‘surge’ hydrology was identified as a new challenge needed to improve prediction of post-wildfire floods as burned debris frequently forms temporary ‘dams’ in channels and on hillslopes. These ‘dams’ store water and when breached create a sudden surge with greater peak discharges than expected. Additionally, field measurements indicate that time to peak discharge is shorter for post-wildfire floods. This breach hydrology was further highlighted by recent modeling of debris flows in channels with varying gradients. Landscape erosion was found in some circumstances to have a positive rather than negative relation with increasing spatial scale--possibly reflecting increased post-wildfire runoff connectivity.

There was recognition of a lack of models to predict post-wildfire channel scour, bank erosion, and biological effects on sediment transport, all of which impact infrastructures and water quality. Snowmelt was identified as an additional driver of post-wildfire response in some regions. Finally, because of field

complexity, physically-based models are needed to isolate, investigate, and provide insight into the effects of single variables on runoff and erosion.

Table 1. Participant list for AGU Chapman Conference.

Name	Affiliation	Email Address
Adams, Jordan	Tulane University, New Orleans, La.	jadams15@tulane.edu
Altmann, Garrett	University of Alaska	garrett.altmann@gmail.com
Balfour, Victoria	Univ of Montana	victoria.balfour@umconnect.umt.edu
Barros, Ana	Civil Engin. Duke University	barros@duke.edu
Bart, Ryan	San Diego State University	rbart@rohan.sdsu.edu
Bautista, Susana	University of Alicante, Spain	s.bautista@ua.es
Bevenger, Greg	Forest Service	gbevenger@fs.fed.us
Bigio, Erica	University Arizona	ebigio@email.arizona.edu
Bladon, Kevin	University of Alberta, Edmonton, Alberta	kbladon@tru.ca
Bodí, Merche	University of Valencia	merche.bodi@uv.es
Brogan, Daniel	Colorado State University	buckhtr@gmail.com
Cannon, Sue	USGS, Golden, Colorado	cannon@usgs.gov
Cerdà, Artemi	University of Valencia, Spain	artemio.cerda@uv.es
Chen, Li	DRI, Las Vegas, Nevada	li.Chen@dri.edu
Chief, Karletta	University of Arizona	kchief@email.arizona.edu.
DiBaise, Roman	Cal Tech	rdibiase@caltech.edu
Doerr, Stefan	Swansea University, U.K.	S.Doerr@swansea.ac.uk
Dunkerley, David L.	Monash Univ., Melbourne	david.dunkerley@arts.monash.edu.au
Ebel, Brian	University of Colorado	bebel@usgs.gov
Gochis, Dave	NCAR	gochis@ucar.edu
Goodrich, Dave	ARS Tucson, Arizona	Dave.Goodrich@ars.usda.gov
Guertin, Phil	Univ. Arizona	phil@snr.arizona.edu
Hyde, Kevin	RMRS Missoula	kgeogmt@msn.com
Ichoku, Charles	Climate & radiation laboratory	Charles.Ichoku@nasa.gov
Istanbulluoglu, Erkan	University of Washington	erkani@u.washington.edu
Jordan, Peter	BC Minsitry of Forestry	Peter.Jordan@gov.bc.ca
Judy, Barbara	Nat. Park service, Bandelier	barbara_judy@nps.gov
Kean, Jason	USGS, GD, Golden, Colorado	jwkean@usgs.gov
Langhans, Christoph	University of Melbourne, Australia	Christoph.Langhans@unimelb.edu.au
Luce, Charlie	RMRS Boise Idaho	cluce@fs.fed.us
MacDonald, Lee	Colorado State University (retired)	Lee.MacDonald@colostate.edu
Malkinson, Dan	University of Haifa, Haifa, Israel	damalk@geo.haifa.ac.il
Martens, Amanda	University of Alberta, Edmonton	amartens@ualberta.ca
Martin, Deborah A.	USGS, Boulder, Colorado	damartin@usgs.gov
McKinley, Randy	USGS EROS data Center	rmckinley@usgs.gov
Meyer, Grant	University of New Mexico	gmeyer@unm.edu
Miller, Mary Ellen	Michigan. Technical Res. Inst.	memiller@mtu.edu
Moody, John A.	USGS, Boulder, Colorado	jamoody@usgs.gov
Nyman, Petter	University of Melbourne	nymanp@unimelb.edu.au
Orem, Caitlin	University of Arizona	oremc@email.arizona.edu
Reaney, Sim	Durham University	sim.reaney@durham.ac.uk
Rengers, Francis	University of Colorado	Francis.Rengers@Colorado.edu
Robichaud, Pete	USFS, Moscow, Idaho	probichaud@fs.fed.us
Ryan-Burkett, Sandra	USFS, Fort Collins, Colorado	sryanburkett@fs.fed.us
Santín Nuno, Cristina	University of Swansea, U.K.	C.S.Nuno@swansea.ac.uk
Scott, David F.	Canada	david.scott@ubc.ca
Shakesby, Rick	Swansea University, England	r.a.shakesby@swansea.ac.uk
Sheppard, Brian Scott	University of Arizona	bss1@email.arizona.edu
Sheridan, Gary	University of Melbourne	sheridan@unimelb.edu.au
Shillito, Rose	DRI, Las Vegas, Nevada	Rose.Shillito@dri.edu
Shmeer, Sarah	Colorado State University	sarah.schmeer@yahoo.com
Sidman, Gabriel	University of Arizona	gabrielsidman@email.arizona.edu
Silins, Uldis	University of Alberta, Edmonton, Canada	uldis.silins@ualberta.ca
Staley, Dennis	USGS, Golden, Colorado	dstaley@usgs.gov
Stempniewicz, Victoria	Northern Arizona University	vs288@nau.edu
Stoof, Cathelijne R.	Wageningen Univ. Netherlands	cathelijne.stoof@cornell.edu
Tao, Jing	Duke University	jing.tao@duke.edu
van der Sant, Rene	University of Melbourne, Australia	r.vandersant@student.unimelb.edu.au
Veblen, Tom	University of Colorado	Thomas.Veblen@Colorado.edu
Vieira, Diana C.S.	University of Aveiro, Portugal	dianac.s.vieira@ua.pt
Wagenbrenner, Joe	RMRS-Moscow	jwwagen@mtu.edu
Williams, Chris	University of Alberta, Edmonton	chris.williams@ualberta.ca
Williams, Jason	ARS- Boise	Jason.Williams@ars.usda.gov
Wittenberg, Lea	University of Haifa, Haifa, Israel	leaw@geo.haifa.ac.il
Wohlgemuth, Pete	PSW Riverside	pwohlgemuth@fs.fed.us
Youberg, Ann	Arizona Geol. Survey	ann.youberg@azgs.az.gov
Young, Dave	USFS, Redding, California	dyoung@fs.fed.us

Several oral and posters presentations identified the need to create a set of widely applicable standard measurement methods for quantifying post-wildfire response (e.g. ash, pyrogenic carbon, soil hydraulic properties, erosion, and soil erodibility). Such standard methods will readily permit meaningful comparisons and insights into the causes of different responses. Implementing these standards and collaborating with the meteorologists will help advance post-wildfire research as a recognized scientific discipline.

Figure 1. Meeting format and agenda.

2013	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
	25-Aug	26-Aug	27-Aug	28-Aug	29-Aug	30-Aug
0750--0800		Welcome & Field Trip Intro	Introduction	Introduction	Introduction	Introduction
0800-0820			*Summary for Topic #1*	*Summary for Topic #2*	*Summary for Topic #3*	*Summary for Topic #4*
0820-0840		Half-day field trip Front Range Post-wildfire Response Domains				
0840--0900			**Brian Ebel**	**Cathelijne Stoof**	**Joe Wagenbrenner**	**Gary Sheridan**
0900--0920			**Gabriel Sidman**	**Merche Bodí**	**Kevin Hyde**	
0920--0940			**Dave Gochis**	**Stefan Doerr**	**Jason Williams**	**Jason Kean**
0940--1000						
1000--1020	Travel & Registra-tion and Young Career Scientist Activity		Poster BREAK	Poster BREAK	Poster BREAK	Poster BREAK
1020--1040						
1040--1100			**David Dunkerley**	**Vicki Balfour**	**Ryan Bart**	**Naama Tessler**
1100--1120				**Karletta Chief**	**Dave Goodrich**	**Peter Jordan**
1120--1140			**Ana Barros**			
1140--1200				**Li Chen**	**Sim Reaney**	**Roman DiBiase**
1200--1220		Box Lunch	Box Lunch Half-day field trip National Center for Atmospheric Research NCAR Boulder, Colorado Coupling Atmospheric-Wildland Fire Modeling			
1220--1240				LUNCH	LUNCH	LUNCH
1240--1300						
1300--1320		**Set up posters**				
1320--1340				Measure Soil Hydraulic Properties onsite	**Petter Nyman**	**Erkan Istanbullouglu**
1340--1400		**Deborah Martin**			**Christoph Langhans**	
1400--1420		**Sue Cannon**			**Rene Van der Sant**	Poster BREAK
1420--1440		**Grant Meyer**			Poster BREAK	
1440--1500		**Ann Youberg**				
1500--1520		Poster BREAK			**Cristina Santin**	**Take down posters**
1520--1540					**Dennis Staley**	*Summary for Topic #5*
1540--1600		**Uldis Silins**				
1600--1620		**Dave Scott**		Meeting of Young Career Scientists	Meeting of Working Groups	Meeting of Working Groups
1620--1640		**Tom Veblen**				
1640--1700		**Susana Bautista**				
1700-1800		OPEN		Working Groups	Working Groups	Working Groups
1800-1930	Aspen Dining Hall	Group Dinner in Walnut Room **Rick Shakesby**	Aspen Dining Hall	Aspen Dining Hall	Aspen Dining Hall	Banquet in Walnut Room **Pete Robichaud**

Table 2. Deliverable Cross walk.

Deliverable Cross walk	Description	Delivery date(s)
Manuscript	Submitted to *Earth Sciences Review*	Jan 2013 PUBLISHED JUNE 2013
Scientific Newspaper	Summary article in *EOS,* Transactions of American Geophysical Union (weekly scientific newspaper)	Sep 2013 ACCEPTED 3 JAN 2014
Report	Conference Program and List of participants	Aug 2013 COMPLETED
Proceedings	Conference proceedings (if applicable)	Sep 2013 COMPLETED
Manuscripts	Summary of topic areas combined into a peer-reviewed journal article	Jan 2014 SPECIAL ISSUES IN IJWF HAS BEEN PROPOSED, STILL IN PROGRESS TO DETERMINE INTEREST
Final Report	Future direction working paper and final report	Jan 2014 FINAL REPORT COMPLETED

Future work

The impact of this Chapman conference on the post-wildfire responses community did not end with the closing remarks. Several working groups volunteered to formulate plans for resolving some of the important issues to advance the post-wildfire science. These informal working papers will be used to spur discussion and future proposals for research projects and guide existing model enhancements. Successful improvements to predictive technologies hinge on three fundamental elements: 1) knowledge of inputs or key hydrological processes necessary to enhance predictive capability, 2) technical expertise to implement model enhancements, and 3) model calibration and validation. The working group meeting focused primarily on element 1 and assumed factors for element 2, such as technical expertise and computing power, do not typically limit model improvement. We acknowledge that element 3 is critical to model evaluation, but did not specifically address this issue. We identified four key areas requiring research relative to process understanding (element 1) and subsequent inclusion in hydrologic models: 1) precipitation uncertainty, 2) gully and channel runoff, 3) ash and charcoal delivery, and 4) soil water repellency.

A Special Issue in *International Journal of Wildland Fire* has been proposed; the conveners are waiting to determine the level of interest from the participants.

PI Robichaud will be discussing conference results with Forest Service Regional and National Burned Area Emergency Response (BAER) leaders at their annual meeting in early February, 2014. One possibility is to share the knowledge gained at the conference with BAER team members would be to invite three or four key speakers from the conference to attend the next scheduled national BAER training to discuss some of the important findings. Alternatively, webinars could be developed on each of the themes discussed.

Moody, JA, RA Shakesby, PR Robichaud, SH Cannon, and DA Martin, 2013. Current research issues related to post-wildfire runoff and erosion processes. *Earth-Science Reviews* 122, 10-37.

Moody, JA, DA Martin, 2013. Collection of abstracts for AGU Chapman Conference synthesizing empirical results to improve predictions of post-wildfire runoff and erosion responses. 184 p.