Final Report

The Effects of Soil Properties, Fuel Characteristics, and Vegetation Recovery on Post-Fire Hydrology and Sediment Yield in Chaparral Steeplands

Joint Fire Science Program project number **03-2-3-13**

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Project Rationale

In southern California, the unrelenting urban encroachment into the wildlands has created a wildland/urban interface that is increasingly difficult to manage. Wildfires coupled with heavy winter rains can unleash flood and debris flow events that result in the loss of life, property, and infrastructure in areas built in and around natural drainages and floodplains. This places an extra burden on watershed managers who must be able to quantitatively predict the effects of post-fire management actions on the hydrologic regime for a particular watershed.

In September 2002, the Williams Fire burned 38,184 acres (15426 ha) of chaparral steeplands, including >90% of the San Dimas Experimental Forest (SDEF). The fire burned at moderate to high severity on 23,713 acres (9580 ha). The fire threatened 15 miles (24 km) of urban interface adjoining the wildlands, including the communities of Glendora, San Dimas, La Verne, Claremont, and Mt Baldy. Steep, erodible slopes, hydrophobic soils, and loss of vegetative cover combine to produce accelerated runoff and erosion; efficiently conducting both water and debris downslope. Within the SDEF, the Williams Fire provides a unique opportunity to describe and analyze the impacts of fire and historical management practices on post-fire hydrologic response and sediment yield in chaparral ecosystems at the wildland/urban interface.

Quantification of post-fire hydrologic response and sediment yield is urgently needed as a benchmark to test existing runoff/erosion models. Moreover, there has been very few studies that have evaluated on-site water repellency, hillslope hydrology, vegetation, and watershed response simultaneously. Furthermore, the Williams Fire provides a unique opportunity to compare post-fire runoff and erosion response for two fires (1960 and 2002) from the same small watersheds using historic and modern datasets. Documenting differences in runoff and erosion response from watersheds subjected to the management manipulation of vegetation type-conversion that has altered the pre-fire fuel characteristics and structure will serve to improve numerical modeling. Numerical modeling for planning and risk assessment at the wildland/urban interface is critical for all land managers, regardless of jurisdiction, fuel type, or geographic area.

Objectives of this Project

Our overall objectives are to quantify runoff and erosion response to wildfire, and to describe post-fire soil and vegetation properties that affect this response. Information obtained from this

research can help resource managers better understand how fire and previous watershed treatments influence post-fire hydrological and erosional response in chaparral ecosystems and specifically at the wildland/urban interface.

Specific objectives are:

1) Quantify the hydrologic response and sediment yield of small (3-5 acre [1-2 ha]) chaparral-covered watersheds burned in the 2002 wildfire using flumes and debris basins constructed after a previous wildfire in 1960. By comparing modern and historic results, we will be able to document the runoff and erosion response from two nearly identical fires in the same small watersheds.

2) Document and analyze the differences in hydrologic and sediment yield response from watersheds with radically different management-induced pre-fire fuel characteristics and vegetation structure. Watersheds that were type-converted from chaparral to grass vegetation after burning in the 1960 wildfire persisted with a different vegetation assemblage prior to the Williams Fire.

3) Quantify the immediate post-fire vegetation response (a measure of watershed recovery) on adjacent watersheds with vastly different treatment history, diverse pre-fire vegetation, and variable pre-fire fuel characteristics.

4) Describe the spatial variability and persistence of post-fire soil water repellency across watersheds with different pre-fire vegetation types. Previous evidence from the study area suggests that there is a large variability in the spatial contiguity of post-fire soil water repellency, and also a large variability in the cessation and re-establishment of soil non-wettability.

5) Quantify post-fire water storage capacity and antecedent moisture conditions across the hillsides and compare to the post-fire watershed hydrologic response. Knowing the water holding capacity of the soil and weathered bedrock – determined by developing moisture characteristic curves coupled with the depth of soil and extent of weathered bedrock – combined with the precipitation inputs may allow us to estimate the magnitude and timing of surface runoff.

Success in Meeting Objectives

1) We measured storm event peak flows and annual sediment yields for four years in six small watersheds. We also found the historic records and calculated the peak flows and sediment yields from the same small watersheds following a wildfire in 1960. We are comparing the results of both datasets with records of precipitation amounts and intensities collected from the same raingages. Initial comparisons show similar magnitudes of post-fire watershed response for both runoff and erosion from both fire events. This information has been communicated in both refereed and non-refereed publications as well as in presentations at conferences and symposia. More detailed analysis is continuing, including the testing of existing numerical runoff and erosion models, and the results will be published in fiscal year 2007.

2) We measured storm event peak flows and annual sediment yields for four years in six small watersheds, three in native chaparral vegetation and three that had been type-converted to grassland after the wildfire in 1960. We are comparing the results with precipitation inputs and to the response of the same watersheds after the 1960 wildfire. Initial comparisons between watersheds with different vegetation types show that, while peak flows were similar, slightly more sediment was produced from the native chaparral watersheds. This information has been communicated in a non-refereed publication as well as in presentations at conferences and symposia. More detailed analyses are continuing and the findings will be published in fiscal year 2007.

3) We monitored post-fire vegetation development annually for three years, measuring cover, structure, and species diversity. We are comparing this to similar measurements of pre-fire vegetation made previously in nearby watersheds. Both native chaparral and grassland watersheds experienced a nearly identical initial flush of herbaceous vegetation ("fire followers"). However, after three years, the herbaceous community has waned and the data suggest that the watersheds are exhibiting a regeneration of the respective pre-fire vegetation assemblages. This information has been communicated in a presentation at a conference. More detailed analysis is continuing and the results will be published in fiscal year 2007.

4) We measured soil water repellency at three depths along with soil moisture at two depths in all six watersheds twice a year for three years. This has been combined with identical data from an adjacent watershed taken immediately after the wildfire. The data show that there is a general attenuation of soil water repellency at all depths with time since fire. In addition, we found slightly greater water repellency under the grass vegetation. This information has been communicated in both refereed and non-refereed publications as well as in a presentation at a conference. More detailed analyses are continuing and the findings will be published in fiscal year 2007.

5) We have developed both soil and weathered bedrock water characteristic curves to determine the water holding capacity of the different subsurface materials. We also made repeated determinations of the depth of the soil and estimated the extent of the weathered bedrock. Rainfall records exist from several raingages. From the calculated water holding capacities and the precipitation inputs we need to compare the rainfall excess (if any) to the measured peak flow values from Objectives 1 and 2 above. More detailed analyses are continuing and the results will be published in fiscal year 2007.

In addition to the discrete pieces of this project (soils, vegetation, and watershed), a final synthesis publication will be produced that integrates the effects of soils on vegetation recovery and the influence of soils and vegetation on watershed runoff and erosion response. More detailed analyses are continuing and the findings will be published in fiscal year 2008.

Deliverables

Objective	Proposed	Delivered	Status
1. Quantify watershed hydrologic and erosion response	Peer-reviewed journal article and government report	Two refereed publications have been produced. Publications and data will be posted on the website http://www.fs.fed.us/psw/topics/fire_science/fire_effects/ (currently under construction). Two oral presentations have been made at conferences and symposia. Summary journal article will be produced in fiscal year 2007.	Done Pending Done Pending
2. Describe and analyze response from watersheds with different pre-fire vegetation	Peer-reviewed journal article and government report	One non-refereed publication has been produced. The publication and data will be posted on the website http://www.fs.fed.us/psw/topics/fire_science/fire_effects/ (currently under construction). One oral presentation has been made at a conference. Summary journal article will be produced in fiscal year 2007.	Done Pending Done Pending
3. Quantify immediate post-fire vegetation response	Peer-reviewed journal article and government report	One oral presentation has been made at a conference. The data will be posted on the website http://www.fs.fed.us/psw/topics/fire_science/fire_effects/ (currently under construction). Summary journal article will be produced in fiscal year 2007.	Done Pending Pending
4. Describe soil properties and soil water repellency	Peer-reviewed journal article and government report	One refereed publication has been produced. One non-refereed publication has been produced. The publication and data will be posted on the website http://www.fs.fed.us/psw/topics/fire_science/fire_effects/ (currently under construction). One oral presentation has been made at a conference. Summary journal article will be produced in fiscal year 2007.	Done Done Pending Done Pending
5. Describe post-fire water storage capacity and antecedent moisture conditions	Peer-reviewed journal article and government report	The publication and data will be posted on the website http://www.fs.fed.us/psw/topics/fire_science/fire_effects/ (currently under construction). Summary journal article will be produced in fiscal year 2007. Synthesis journal article of soils, vegetation, and watershed results will be produced in fiscal year 2008	Pending Pending Pending

6. Technology Transfer	Field tour Workshop and field tour	Field tour to local managers and practitioners announcing the project (October 2003). Workshop and field tour to local managers and practitioners to communicate the findings and implications of the project (May 2006),	Done Done

Presentations and Publications

Presentations

(see also Publications list below)

Wohlgemuth, Peter M. 2003. Post-fire erosion control research on the San Dimas Experimental Forest: Past and present. Offered oral presentation at the First Interagency Conference on Research in the Watersheds, October 27-30, 2003, Benson, Arizona.

Hubbert, Ken R. and V.Oriol. 2003. Seasonal changes to soil water repellency following wildfire in chaparral steeplands. Offered oral presentation at the Soil Science Society of America Annual Meeting, November 2-6, 2003, Denver, Colorado.

Wohlgemuth, Peter M. and Peter R. Robichaud. 2004. The effects of selected post-fire emergency rehabilitation techniques on small watershed sediment yields in southern California. Offered oral presentation at the 'Advancing the Fundamental Sciences', Forest Service National Earth Sciences Conference, October 19-22, 2004, San Diego, California.

Wohlgemuth, Peter M. 2006. Hillslope erosion and small watershed sediment yield following a wildfire on the San Dimas Experimental Forest, southern California. Offered oral presentation at the Eighth Federal Interagency Sedimentation Conference, April 2-6, 2006, Reno, Nevada.

Narog, Marcia G. 2006. Historical land use affects post-fire vegetation development. Offered oral presentation at the Ecological Society of America, 91st Annual meeting, August 6-11, 2006, Memphis, Tennessee.

Publications

Wohlgemuth, Peter M. 2003. Post-fire erosion control research on the San Dimas Experimental Forest: Past and present. In, Renard, Kenneth G., McElroy, Stephen A., Gburek, William J., Canfield, H. Evan and Scott, Russell L., eds. 2003. First Interagency Conference on Research in the Watersheds, October 27-30, 2003. U.S. Department of Agriculture, Agricultural Research Service. pp. 646-650.

Hubbert, Ken R. and V.Oriol. 2003. Seasonal changes in soil water repellency following wildfire in chaparral steeplands, southern California. Extended abstract, 5th Symposium on Fire and Forest Meteorology Joint with 2nd International Wildland Fire Ecology and Fire Management Congress. Available online at http://ams.confex.com/ams/FIRE2003/techprogram/paper_67224.htm

Wohlgemuth, Peter M. and Peter R. Robichaud. 2004. The effects of selected post-fire emergency rehabilitation techniques on small watershed sediment yields in southern California. Proceedings of the 'Advancing the Fundamental Sciences', Forest Service National Earth Sciences Conference.

Hubbert, K.R. and V, Oriol. 2005. Temporal fluctuations in soil water repellency following wildfire in chaparral steeplands, southern California. International Journal of Wildland Fire. 14:439-447.

Wohlgemuth, Peter M. 2006. Hillslope erosion and small watershed sediment yield following a wildfire on the San Dimas Experimental Forest, southern California. Proceedings of the Eighth Federal Interagency Sedimentation Conference. Published on Disk. ISBN 0-9779007-1-1.

Field Location

The San Dimas Experimental Forest (SDEF) comprises 17,190 acres (6,945 ha) in the foothills of the San Gabriel Mountains, located approximately 36 miles (58 km) NE of Los Angeles, California. It is part of the Angeles National Forest, with elevations that range from 1300 to 5700 feet (396 to 1,737 m). Topography is rough, characterized by deeply cut channels and slopes averaging 68%. The climate is Mediterranean with cool, wet winters and hot, dry summers. Average annual rainfall is 28.0 inches (71.1 cm) at Tanbark Flats, with most of the precipitation falling from December to March. The primary plant community throughout the SDEF is chaparral, but coastal sage and scrub, oak woodland, and mixed conifer habitats also occur in the SDEF. Some areas of the Forest have been type-converted from native chaparral to grassland.