Debris-Flow Forecasts Before Wildfires

Wildfires destroy vegetation and reduce the ability of water to penetrate into soils, leaving burned areas susceptible to debris flows during heavy rainfall. Rain during or soon after a fire is particularly dangerous when there are homes, bridges, or other structures in the path of the flowing debris. In such cases, there is little or no time for public officials to take action to minimize potential damage or plan an emergency response. Since 2003, USGS scientists have been able to provide forecasts of debris-flow likelihood based on information about the severity of the fire and the burned soil. But these hazard assessments often allow very little time for action, as rain often follows closely behind the fires. So USGS scientists have also been pursuing a way to assess debris flow hazards **before** the fire occurs.

The aftermath of the January 9, 2018 debris flows in Montecito, California.

The approach they developed is quick and easy, using statistics for a particular area before a wildfire. The key to the method is knowing the potential severity of wildfires given individual vegetation types, based on past wildfires. The results can be used to provide debris-flow forecasts for a range of user-defined fire scenarios. This study considered 3 scenarios: 1) a moderately frequent, moderate severity fire; 2) a moderately infrequent, higher severity fire; and 3) an infrequent fire with very high severity. For each scenario, they are able to state a forecast, for example a forecast might say: "If there is a severe wildfire that happens infrequently at location X, there will be a 60-80% chance that a debris-flow will occur that involves 10,000 cubic meters of material, if there is 0.25 inches or more of rain within 15 minutes."

USGS geologists Francis Rengers and Jeff Coe assess peak flow height after the January 9, 2018 debris flows in Montecito, California.

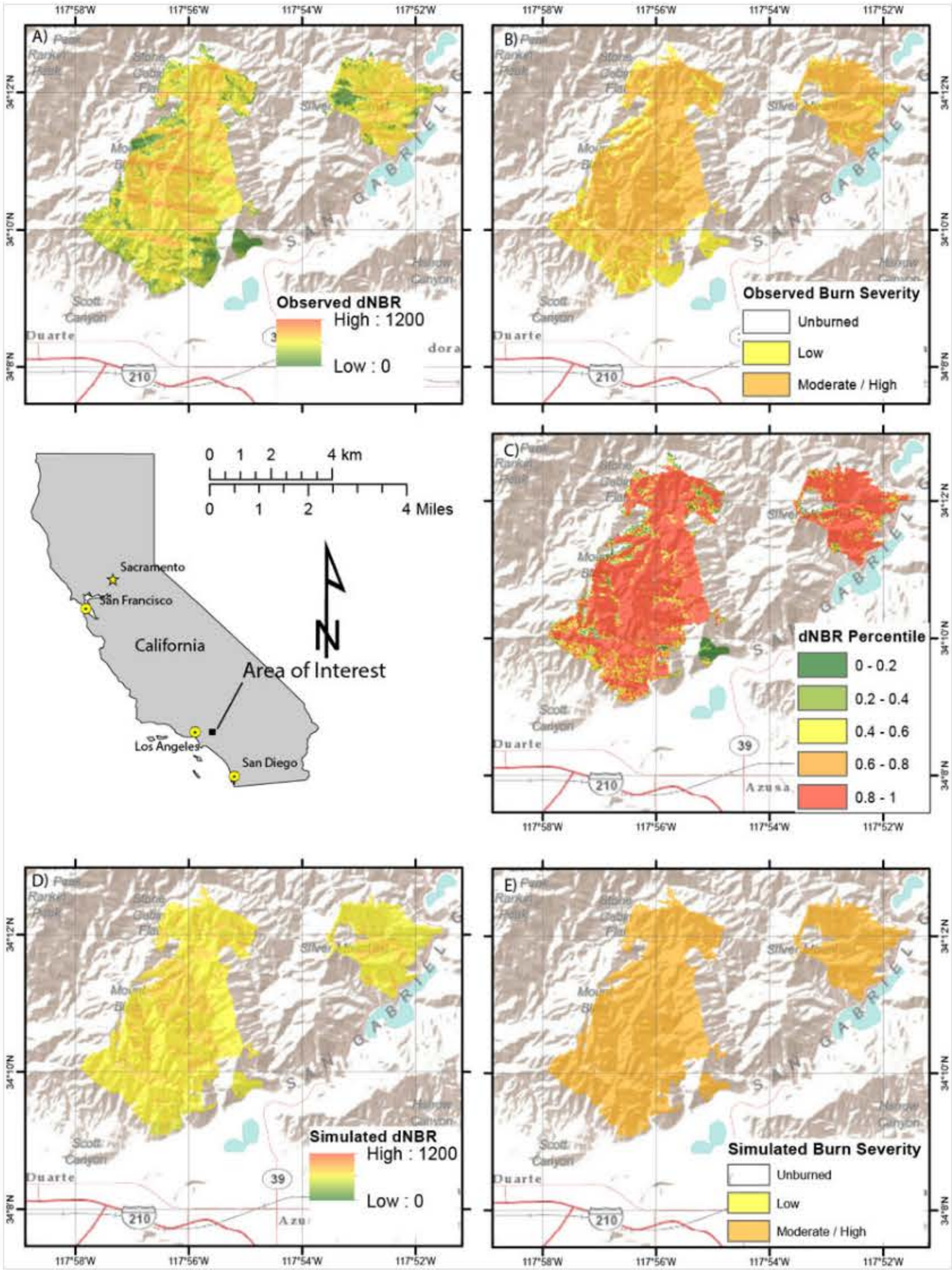
To determine how well the new approach works, the scientists compared the prediction based on this method against a prediction using post-fire data analyses (the standard method). Then they went a step further and tested the accuracy of the prediction resulting from their method against a real-world situation during the winter of 2016-17 in Las Lomas Canyon in southern California. They tested the new versus standard prediction results on 8 burned areas in 4 regions: 1) the San Gabriel and San Bernardino Mountains of southern California, 2) the southern Cascade Mountains of northern California, 3) the central Rocky Mountains of southern Colorado, and 4) the Chelan Mountains of the Cascade Range in central Washington.

By looking at 8 diverse burned areas, they could compare their computed forecast using simulated fire data with that using the standard forecasting method with observed post-fire data. They compared values for 3 parameters: the forecasted likelihood of a debris flow, the volume of material in the debris flow, and the amount of rain required to initiate a debris flow. The agreement was good for the likelihood and volume, and bit less accurate for the rainfall amount for debris-flow initiation.

Then they compared the predictions of the simulation method to actual observations of debris-flow occurrence (did it happen or not?). Their prediction for the occurrence, volume of material, and the amount of rainfall to initiate a debris flow agreed very well with what was observed. In fact, the estimates using the simulated fire data were just as good as those based on the post-fire data.

This approach allows a hazard estimation before a fire even occurs. This would allow communities the time needed to identify and prioritize areas in need of risk reduction, develop emergency management and response strategies, and implement mitigation projects to reduce the potential impact of debris flows. The presented method may be applicable throughout the world where there is plentiful information on the regional vegetation and historical fire severity. It can also be modified to forecast other post-wildfire hazards such as flooding and erosion.

- written by Lisa Wald, USGS, October 2018



Observed and simulated estimates of fire severity for the 2016 San Gabriel Complex in southern California. A) Observed dNBR, "stripe"-like features represent data gaps in the original 7 image that have been filtered using an iterative high-pass filter; B) Observed soil burn severity; C) Weibull CDF percentiles of observed dNBR (Pd), D) Simulated dNBR (SimdNBR); E) Simulated soil burn severity. (dNBR - differenced normalized burn ratio; CDF - cumulative distribution function).

For More Information

- [USGS Geologists Join Efforts in Montecito to Assess Debris-Flow Aftermath]

- Staley, Dennis M., Anne C. Tillery, Jason W. Kean, Luke A. McGuire, Hannah E. Pauling, Francis K. Rngers, and Joel B. Smith, Estimating post-fire debris-flow hazards prior to wildfire using a statistical analysis of historical distributions of fire severity from remote sensing data, International Journal of Wildland Fire 2018, 27, 595–608
- Staley, Dennis M., 2018, Data used to characterize the historical distribution of wildfire severity in the western United States in support of pre-fire assessment of debris-flow hazards: U.S. Geological Survey.

The Scientist Behind the Science

Dennis Staley on his fat-tire bicycle competing in the 2018 Iditarod Trail Invitational 130.

Dennis Staley is a research physical scientist with the USGS Landslide Hazards Program. His research primarily focuses on post-fire debris-flow initiation, magnitude, and early warning. In his spare time, he rides long distances on his bicycle. He was the Bike Champion in the Iditarod Trail Invitational 130 in 2018.