



After the Smoke Clears, Debris Flow Threat Emerges

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There is considerable misunderstanding about what constitutes a “debris flow.” The media frequently gets it wrong, referring to these events as mudslides. But, the term mudslide does not really do a post-fire debris flow justice. They are much more than mud.

After wildfires, debris flows can occur when rainfall impacts the denuded hillslopes. Very little of the rainfall soaks into the soil, with most of it running off rapidly and converging in channels. The runoff erodes material both from the hillslopes and channels, gradually becoming a slurry of soil, rocks, and mud. The slurry can quickly pick up speed as well as additional rocks, large boulders, and trees. The flows do not behave like water either, and are generally not contained completely within a channel. So, what you end up with is a freight train of mud, water, boulders, trees, and anything else charging down the side of a mountain and grinding up anything in its path.



Members of the National Burned Area Emergency Response Team assess the aftermath of a major debris flow in Amago Creek in an area impacted by the 2007 southern California fires.

This past spring, I visited the aftermath of a debris flow in Amago Creek on the La Jolla Indian Reservation outside of San Diego—one of the many large flows that impacted the watersheds hit hard by the southern California fires in October, 2007. Massive boulders and piles of tree trunks lined the edges of the creek bed, testament to the power of the flow, created when the drainages above gave way and charged down the channel.

Fred Nelson, a member of the La Jolla Indian Tribe, pointed out older boulders sitting high above on the banks above the current debris flow—evidence of previous slides in the same drainage, possibly decades or centuries before. The amount of material that moved down the creek was awe-inspiring, and perhaps even more amazing is the fact that only one house was destroyed during the Amago Creek debris flow. An early warning system installed in the drainage alerted local emergency responders that a rainfall threshold had been reached and a flow was likely. The lone resident in the path of the flow was evacuated by the local fire department just as mud was entering her home.

Much of the credit for the awareness of the threat in Amago Creek and elsewhere around southern California goes to USGS research geologist, Sue Cannon, and her modeling of the debris flow potential in the aftermath of the fires. In a telephone interview, Cannon said that after the immediate threat of fire subsides, debris flows can become the next biggest danger in some areas impacted by wildfire. “Fires can remove all of the vegetation from hillsides and at the same time alter the ability of soil to absorb water—creating what are termed hydrophobic soils that greatly increase runoff.”

Cannon and her team, working out of a lab in Golden, Colorado have been developing a series of models that attempt to identify watersheds most at risk for debris flows. They have also been looking to predict how big events will be in terms of the amount of material that could potentially move.

The first model on the probability of flows uses a variety of data including: average basin gradient, high severity burn area, percent organic matter, and peak rainfall intensity (highest peak you would expect within 3 hours in a storm of 5-10 year return interval).

The volume model is based on the area of the basin with slope greater than 30 percent, high and moderate burn severity area, and total storm rainfall.

When these two models are combined, a map of relative hazard is produced, and these help in identifying the basins which have the highest chance of producing the biggest events, given the occurrence of certain rainfall thresholds.

After the southern California fires of 2007, Cannon’s maps were in high demand and led to productive collaboration with the National Weather Service, FEMA, and the National Burned Area Emergency Response team.

Jayme Laber, a hydrologist with the National Weather Service, says that NWS was able to integrate Cannon’s rainfall thresholds into their monitoring and this allowed them to issue watches and warnings for specific basins that were threatened with debris flows.

Debris flows after previous fires in southern California. Photo: USGS



“We are monitoring weather as it happens, but we aren’t geology experts. Sue and her group provided us with very detailed information on the types of events that could trigger flows—if you get this much rain in 15 minutes, there will be problems. This helped us to focus our warning systems and get information to the emergency responders.”

The same maps were also integrated with FEMA’s flood mapping to create “hazard awareness maps.”

Jonathon Bartlett, the GIS lead with FEMA’s Multi-Agency Support Group, said that the hazard mapping is directly responsible for timely evacuations in the Modjeska Canyon and Silverado areas before a number of debris flow events.

“Local emergency managers were enthusiastic about using these maps. We gave the maps to emergency managers, public works officials, and fire departments. They worked with us to identify critical facilities at risk and design evacuation strategies.

Not only were the maps useful in alerting emergency responders to the threats, but also for getting mitigation measures in place before the flows actually occurred.

Burned Area Emergency Response (BAER) teams are responsible for identifying potential post-fire impacts to federal lands. In southern California, that primarily meant identifying the threat of debris flows on the ten Indian reservations that were impacted by the fires.

“We recognized the huge potential for debris flows in some of the watersheds. It made my hair stand up when I realized the severity of the burns in areas with lots of loose material ready to be mobilized,” said Annette Parsons, a GIS specialist with the BAER team. “That gave us a red flag that we should contact Sue Cannon.”

Lorri Peltz-Lewis works as a hydrologist for the national BAER team. She said that the BAER team worked closely with Cannon, and helped her research team to validate the model data, especially burn severity data. BAER teams in the field conducted burn severity testing to validate information coming from remotely sensed imagery that were used as important inputs in identifying areas of high and moderate burn severity. The team evaluated the watersheds for hydrophobicity (water repellancy) in numerous areas and made estimations of the canopy remaining in burned areas. The team also determined values at risk (VARs), such as schools, roadways, hospitals, and houses. The VAR locational data was critical to the modeling efforts. This input data was provided to the BAER team models as well as Cannon’s models. Evaluations of the two sets of models provided additional information on areas requiring any additional field inspections.

The teams worked quickly given the fact that there was only a month between the end of the fires and the arrival of the first storms with significant rainfall.

Lorri Peltz-Lewis says, “The BAER team did work that would normally take many years to complete in a matter of weeks.”

“I can’t stress how good USGS and the other teams were in response to these fires. We couldn’t believe they could run these models this quickly and produce such effective outputs,” stated Jonathon Bartlett.

As the BAER team interactively helped Cannon to update the maps in the field, Cannon in turn helped the BAER team to focus on areas that they had not identified from observations in the field. Peltz-Lewis says that the resulting maps helped the team to identify additional VARs schools, roadways, hospitals, and houses that could potentially be impacted. Working with the tribes, the BAER team then moved to get mitigation measures in place, including cement K-rail protection and sandbags in places likely to be impacted when the winter rains arrived.

Back at Amago Creek, the wrecked home that sat in the way of one of the biggest flows connected to southern fires sits among boulders and twenty foot high piles of tree trunks. Workers were already busy constructing a new home a few hundred yards away. Fred Nelson says that members of the local fire department arrived at the home just as mud was coming in the front door. They had been alerted of the potential for a flow through the San Diego Early Warning System. The firefighters carried the elderly woman out of her home in knee deep mud, moments before the main flow completely destroyed the home.

The actions at Amago Creek are a perfect example of just-in-time lifesaving made possible through detailed and thorough scientific research and application.

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