FLOODING DURING A DROUGHT?
Climate Variability and Fire in the Southwest

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Last August, a flash flood from monsoon rains came crashing down Bonita Canyon in the Santa Catalina Mountains north of Tucson and muddy waters swept a victim from inside his home to his death three quarters of a mile away. Local residents were shocked that loss of life and property could occur from flash flooding at a time Arizona was experiencing multiyear drought. Flash flooding is always a danger in the desert, but as local resident Dean Prichard reported to the *Arizona Daily Star*, "I have lived out here 29 years and I have never seen it run like this. It is worse than the 1983 floods."

Western forests accumulate underbrush and smaller trees during fire suppression. Photo courtesy of the U.S. Forest Service Fire Effects Laboartory.

This flood came on the heels of the 2003 Aspen Fire that devastated much of the Santa Catalina range. New studies suggest that accumulated fuel loads and drought created conditions favorable not just for the Aspen Fire but for post-fire flash flooding, and this situation is typical for most fires in the semi-arid Southwest. Researchers are increasingly documenting a strong relationship between climate variability, historical forest management practices, and fires in the Southwest.

Climate variability may precondition the desert Southwest to large catastrophic fires. Swetnam and Betancourt (1998) found a correlation between the climate phenomenon known as El Niño Southern Oscillation (ENSO) and large fires in the southwestern United States. ENSO creates alternating periods of wet (El Niño) and dry (La Niña) climate in the Southwest. Analysis of tree rings from the last three centuries shows a high correlation between drought and the number of acres burned. The most catastrophic and widespread fires immediately followed wet El Niño periods when the vegetation growth was enhanced. These large fuel loads burned extensively during subsequent La Niña droughts.

Swetnam and Betancourt also documented the influence that twentieth century fire suppression practices have had on the region. Natural small fires restrict undergrowth, leaving only the largest trees, whereas fire suppression allows underbrush to accumulate (see photos above). Ignition of these dense forests generates high intensity crown fires. Higher-temperature fires can vaporize organic debris within the upper soil, which condenses and fills the pores in the soil to create a hydrophobic layer that restricts the passage of water. Fire-induced hydrophobic layers can decrease infiltration, increase erosion, and increase surface runoff during rainstorms.

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USGS streamflow measurements in Sabino Canyon of the Santa Catalina range recorded flow response during early monsoon rain events following the Aspen Fire (Hirsch and Costa, 2004). Streamflow exceeded 2,000 cubic feet per second at the Sabino Canyon gauge in two storms within six weeks of the fire under the prevailing drought conditions. In historical comparison, from 1932 to 1999, peak annual streamflow exceeded this threshold 38 percent of the time. These early monsoon rains also suspended 10,000 milligrams of sediment in each liter of water in Sabino Creek, whereas end-of-winter rains carried only 30 milligrams of sediment per liter.

An Aspen Fire Study Team from the University of Arizona was mobilized to study links between vegetation and post-fire soil impacts on hydrologic response. The impacts were similar to those described elsewhere in this issue, including hydrophobic soil development, flash flooding, debris flows, and high suspended solid and nutrient loads during early post-fire rain events.

The Aspen Fire Study team confirmed observations by Chandler and others (1983) that shifts in soil infiltration capacity varied by vegetation zone. Field measurements to determine how rapidly water can move through soil were made on unburned and burned soils in the Santa Catalinas, using a soil corer air permeameter. In unburned soils, significantly more infiltration was measured in the woodland-chaparral zone than in the coniferous zone. However, burned soils in both zones were equally resistant to water infiltration.

These results suggest that the woodland-chaparral zone is an effective buffer of storm runoff before a fire, and that optimum protection from post-fire flooding may be achieved by focusing fire-fighting efforts to protect that zone. The upper Bonita Canyon watershed, severely burned in the Aspen Fire, is entirely in the woodland-chaparral zone, which likely contributed to the magnitude of last year's devastating flash flood.

The Aspen Fire Study Team includes UA co-investigators B. Ekwurzel, T. Ferré, and B. Nijssen with graduate students K.D. Chief, S.E. Desilets, and M. Guardiola-Claramonte. Contact Brenda Ekwurzel at ekwurzel@hwr.arizona.edu.

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