Arizona Geology

Vol. 34, No. 3
FALL 2004

Published by the Arizona Geological Survey

THE STATE AGENCY FOR GEOLOGIC INFORMATION

MISSION

To inform and advise the public about the geologic character of Arizona in order to increase understanding and encourage prudent development of the State's land, water, mineral, and energy resources.

ACTIVITIES

PUBLIC INFORMATION

Inform the public by answering inquiries, preparing and selling maps and reports, maintaining a library, databases, and a website, giving talks, and leading fieldtrips.

GEOLOGIC MAPPING

Map and describe the origin and character of rock units and their weathering products.

HAZARDS AND LIMITATIONS

Investigate geologic hazards and limitations such as earthquakes, land subsidence, flooding, and rock solution that may affect the health and welfare of the public or impact land and resource management.

ENERGY AND MINERAL RESOURCES

Describe the origin, distribution, and character of metallic, nonmetallic, and energy resources and identify areas that have potential for future discoveries.

OIL AND GAS CONSERVATION COMMISSION

Assist in carrying out the rules, orders, and policies established by the Commission, which regulates the drilling for and production of oil, gas, helium, carbon dioxide, and geothermal resources.

Fire and Sediment Deposition

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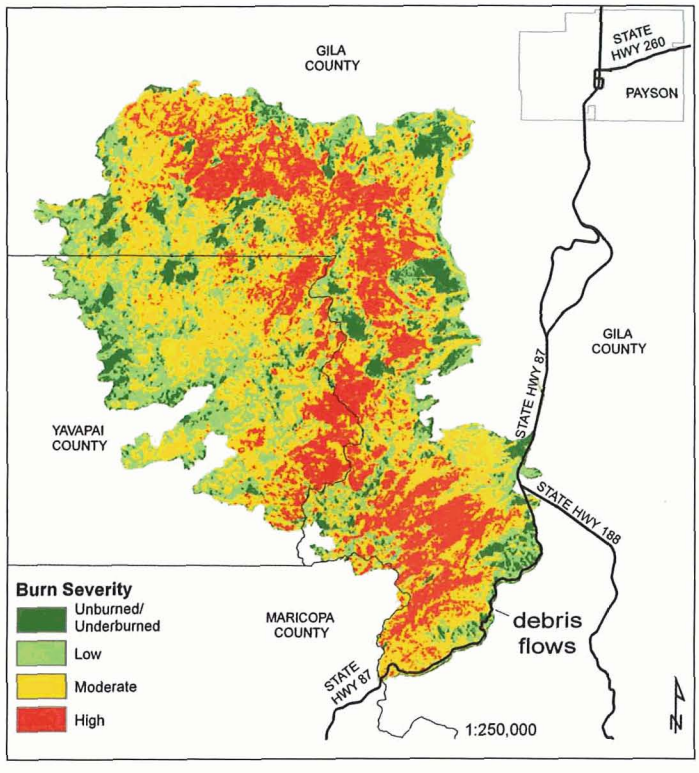

Figure 1. Location and intensity of the Willow Fire, which burned in June and early July, 2004. Map provided by the U.S. Forest Service

If you were in Arizona during late June and early July you may have seen smoke towering above the Willow Fire, which burned 120,000 acres (about 187 square miles) in the Tonto National Forest between Phoenix and Payson (Figure 1). Although there was concern for a time that the fire would burn into the Payson area, it did not reach Payson and ultimately caused little damage to structures. The southward spread of the fire was stopped along State Route 87 (a major 4-lane highway) about 20 miles southwest of Payson. Fires are obviously an important part of the Arizona landscape–many have occurred in the high country of Arizona in the past couple decades. In addition to damaging forests and human-built structures, fires increase the potential for flooding and related mass movements in mountain watersheds.

Before the Willow Fire was completely contained, U.S. Forest Service staff asked the Arizona Geological Survey to join their Burned Area Emergency Response team to assess potential for mass movements (landslides, debris flows, rockfalls) along SR 87. In response, Ann Youberg and I reviewed pre-fire aerial photographs, burn-intensity maps, and topographic maps and then conducted a one-day field survey of the burned area with Forest Service personnel July 16. We recognized evidence of past debris flows in two small, steep, moderately burned drainages and inferred that post-fire debris flows could pose a threat to the highway. One week after our field reconnaissance, debris flows did indeed occur in these drainages, temporarily closing the southbound lane of SR 87.

Intense fires that burn vegetation and soil can lead to enhanced runoff, flooding, and debris flows. Vegetation and soil on mountain slopes capture or temporarily detain moisture and play a major role in moderating the amount of runoff that results from rainstorms. On steep, heavily vegetated slopes where fires burn intensely, post-fire increases in runoff may be dramatic. In addition, when fire destroys trees, grass, and other plants, soil is vulnerable to erosion. Because fires in Arizona typically occur in the early summer, fire-denuded watersheds are vulnerable to enhanced runoff and erosion during the following monsoon season.

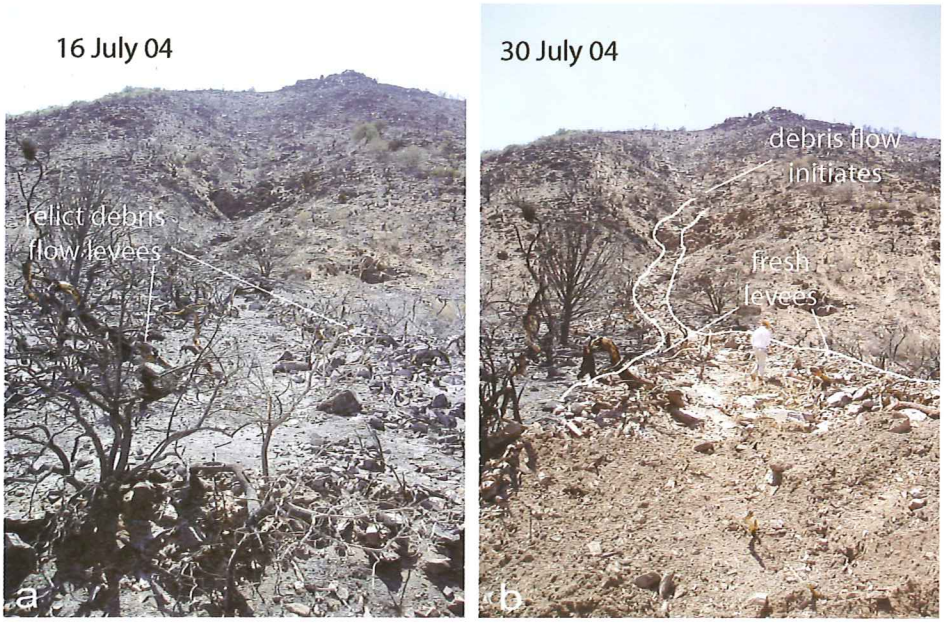

Figure 2. a) Photograph of a small wash near SR 87 taken just after the Willow Fire. **b)** Photograph of the same wash taken a few days after a heavy rain fell July 23, 2004.

Debris flows are mixtures of sediment-rich fluid and rock fragments that flow downhill as slurries. Because the fluid is substantially denser than clear water, debris flows are quite effective at picking up and transporting boulders. Debris flows are triggered by intense runoff in areas that have steep slopes and an ample source of fine soil and rock fragments. They may begin as small landslides or along steep washes when much fine sediment is picked up by floodwater. Fortunately, few people in Arizona have experienced debris flows because the flows typically occur in remote areas. Debris flows are, however, an important process of erosion and deposition in the mountains of Arizona. Although debris flows have commonly occurred after fires in Arizona and elsewhere in the western U.S., they can also occur in steep terrain without fire if precipitation is sufficiently intense. If you look at the mountain ranges surrounding your home, you may see nearly vertical white stripes extending part way down the mountainside. Many of these features are erosional scars left by debris flows.

Figure 3. The debris flow that moved along this small channel reached the ditch of SR 87 and lapsed onto the edge of the highway. The debris flow in the next drainage to the north crossed the highway

During our field survey of fire-related hazards, we found evidence that debris flows had occurred in the past on two small drainages near SR 87 (Figure 2). The hillslopes and channels of these drainages are very steep, and the watersheds were devoid of living vegetation after the fire. As these channels exit the mountains, they spill out onto small, cone-shaped alluvial fans. Unfortunately, the southbound lane of SR 87 is cut into the toes of these fans. We observed parallel alignments of boulders and boulder piles on the fans that are typical of deposits left by debris flows.

On the evening of July 23, an intense thunderstorm occurred in this part of the burned area. All of the larger drainages that cross under SR 87 experienced substantial floods, but none overtopped the highway. Debris flows occurred in many small, steep drainages, including the two that we had identified as representing a potential hazard. These debris flows developed in steep channel reaches, picked up many boulders as they headed down the channels, and spilled out onto and across the alluvial fans. One of the flows covered the southbound lane of SR 87 (Figure 3). Most of the boulders carried by the debris flows were deposited on the fans, adding to the levees and boulder piles that existed prior to the recent events. The Arizona Department of Transportation quickly cleaned up the debris.

The important question for the near future is whether more debris flows will impact SR 87 in this area. The potential for enhanced runoff will exist in the burned watersheds for several years, at least. Because so much sediment was removed from the channels that produced debris flows, decades or centuries will probably pass before sufficient sediment accumulates to sustain another debris flow in these watersheds.