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A rationale for effective post-fire debris flow mitigation within forested terrain

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Abstract

Watersheds recently burned by wildfires are recognized as having an increased susceptibility to debris flow occurrence. The great majority occur within the first 2 years following wildfires. These debris flows are generated primarily through the process of progressive entrainment of material eroded from hillslopes and channels by surface runoff and appears independent of the vegetative community burned. The decreased likelihood of debris flows over time is linked to the restoration of hydrologic function as vegetative cover and soil infiltration functioning return to pre-fire conditions. An exception to this pattern of post-wildfire debris flow susceptibility occurs in burned drainage basins with forest cover. A second, later period of increased debris flow susceptibility due to infiltration-triggered landslides can occur in burned forested basins. This later period of debris flow susceptibility is largely attributable to the fire-induced tree mortality and subsequent decay of tree root networks decreasing soil strength on steep hillslopes which produces an increased likelihood of debris flow occurrence 3 to 10 or more years after the wildfire. Consequently, post-fire mitigation measures in forested terrain must address the risk posed by debris flows caused by progressive entrainment during the 2 years following the wildfire and debris flows due to infiltration-induced debris slides three or more years later. Mitigation for the later debris flows in forested terrain involves identification of areas with infiltration-induced debris slides coincident with concentrations of fire-killed trees. Timely reforestation of these areas after a wildfire limits the loss of soil strength from decaying roots.

Keywords: Emergency response, Debris flows, Timing, Wildfire, Tree roots

Introduction

Post-fire debris-flow hazard potential

Where wildfires affect a vegetative community on steep slopes, a potential exists for post-wildfire debris flows to occur. The increased likelihood of debris flow occurrence from recently burned watersheds is a relatively recent addition to our understanding of post-fire effects and necessitates evaluation of the threat posed to nearby populations, property, and infrastructure (Cannon and Reneau, 2000; Cannon, 2001; Cannon et al., 2001). Debris flows pose a serious threat because they move rapidly, travel significant distances from their point of origin, and exert destructive force along their flow path and within their area of deposition (Hungr, 2005; Giraud and McDonald, 2007; Jordan and Covert, 2009) Post-wildfire debris flows clearly pose a hazard when burned watersheds are adjacent to populated areas (Cannon and DeGraff, 2009) and can even be a hazard in a less populated rural settings (DeGraff et al., 2011). Consequently, post-fire evaluation needs tools to effectively identify, within a burned area, those drainage basins having a greater likelihood of generating debris flows in order to undertake timely and effective mitigation (DeGraff et al. 2007; Cannon et al. 2011; DeGraff et al., 2013; DeGraff, 2014; Staley et al., 2017).

The western United States has experienced an increase in wildfire activity including very large fires since the mid-1980s (Westerling et al., 2006, Barbero et al., 2015; Westerling, 2016). Like change in any natural system, the increase is attributable to multiple factors (Cannon and DeGraff, 2009; Abatzaglou and Williams, 2016). Climatic change in an important factor as reflected by the results of multiple studies using different time scales, spatial scales, fire metrics, or fire proxies (see Table 1, Barbero et al., 2015). Past fire suppression efforts are more clearly a factor influencing increased wildfire activity in forested areas (Parsons and DeBenedetti, 1979) than in

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