Predicting post-wildfire risks to and vulnerability of transportation infrastructure

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Extended Abstract

Wildfires are a natural process in the western landscape that were overwhelmingly suppressed for the majority of the mid-20th century. Due to a combination of climate change and accumulating fuels in some forest ecosystems, we have now observed a 20-fold increase in the annual burned area over the last 40 years in this landscape where we have since settled and constructed homes and infrastructure (Murphy et al., 2019). Burned landscapes exhibit profoundly altered hydrology, particularly following extreme and severe wildfire activity, causing increased runoff generation even in response to relatively low recurrence interval rainfall events (Staley et al., 2020). This increased runoff can cause extensive erosion to the landscape, delivering large volumes of sediment and woody debris to river channels (Murphy et al., 2019). Additionally, the increased runoff can increase streamflow response times and magnitudes (e.g. Hallema et al., 2017; Rust et al., 2019; Saxe et al., 2018). The increased volume of water and sediment loads in rivers can pose both direct and downstream risks to transportation infrastructure.

Given the increasing risks posed to infrastructure after wildfire, there is a need for easy-to-use tools to rapidly assess potential impacts from post-wildfire debris flows to infrastructure, either immediately following a fire or pre-emptively to assist in planning and management. To that end, we introduce a new Python-based, GIS toolkit to spatially model downstream and direct post-wildfire sedimentation impacts to infrastructure. The tool incorporates elements of the Utah State University AppLied (USUAL) Watershed Tools (David et al., 2023), the current USGS post-fire debris flow hazards model (Staley et al., 2017) and regional debris flow volume models (Gartner et al., 2014, 2008; Wall et al., 2022) into a single framework to identify and map the potential locations of direct debris flow risks along transportation corridors, as well as their associated rainfall intensity thresholds (derived from Staley et al., 2017). The tool eliminates the need for manual GIS mapping or analysis of potential debris flow catchments along transportation corridors and automatically identifies debris flow locations (Figure 1) based on inputs of topography, soil erodibility, wildfire severity, and roads of interest. Additionally, the toolkit contains a modified version of Fire-WATER (see presentation by David et al.) allowing users to route sediment eroded upstream through river networks to assess potential downstream impacts to downstream infrastructure (e.g. culverts and bridges).

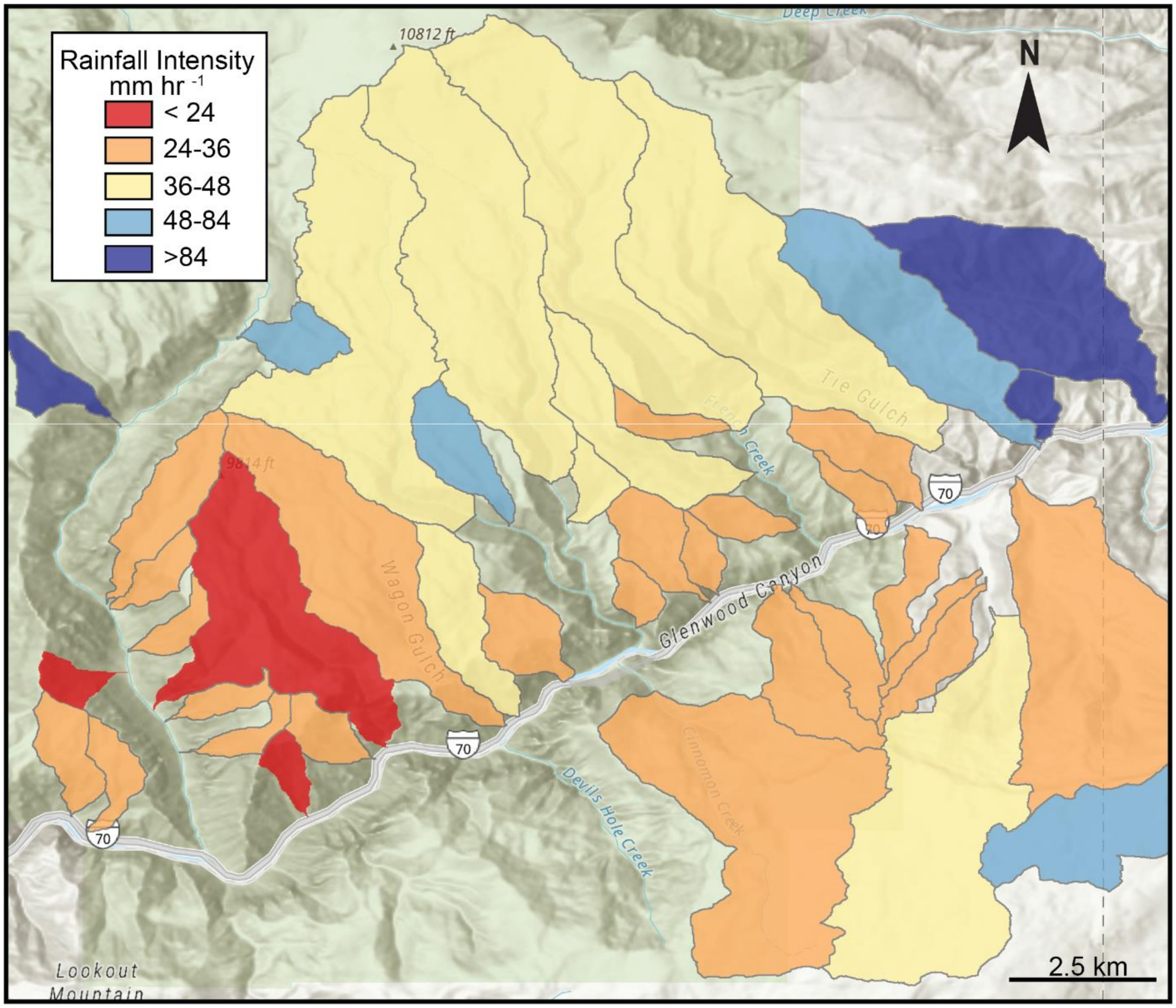

Figure 1. Example of sub-catchment delineation and debris flow probability analysis along I-70 for the Grizzly Creek fire in Colorado, USA. Each sub-catchment is shaded based on the rainfall intensity needed to create a 50% probability of generating a debris flow.

Many departments of transportation across the West are facing challenges in assessing and addressing their vulnerability to post-fire erosion, and the consequences of not being prepared can be expensive or potentially deadly. Rapid assessment of risks after wildfire could help agencies make more informed public safety decisions, and pairing this new GIS framework with models of simulated wildfire could provide agencies a powerful tool to assess and address their potential vulnerabilities before wildfire ever occurs.

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