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FIRESTORM: Modelling the water quality risk of wildfire.

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Following wildfire, loss of vegetation and changes to soil properties may result in decreases in infiltration rates, less rainfall interception, and higher overland flow velocities. Rainfall events affecting burn areas before vegetation recovers can cause high magnitude erosion events that impact on downstream water quality. For cities and towns that rely upon fire-prone forest catchments for water supply, wildfire impacts on water quality represent a credible risk to water supply security. Quantifying the risk associated with the occurrence of wildfires and the magnitude of water quality impacts has important implications for managing water supplies. At present, no suitable integrative model exists that considers the probabilistic nature of system inputs as well as the range of processes and scales involved in this problem.

We present FIRESTORM, a new model currently in development that aims to determine the range of sediment and associated contaminant loads that may be delivered to water supply reservoirs from the combination of wildfire and subsequent rainfall events. This Monte Carlo model incorporates the probabilistic nature of fire ignition, fire weather and rainfall, and includes deterministic models for fire behaviour and locally dominant erosion processes. FIRESTORM calculates the magnitude and associated annual risk of catchment-scale sediment loads associated with the occurrence of wildfire and rainfall generated by two rain event types. The two event types are localised, high intensity, short-duration convective storms, and widespread, longer duration synoptic-scale rainfall events. Initial application and testing of the model will focus on the two main reservoirs supplying water to Melbourne, Australia, both of which are situated in forest catchments vulnerable to wildfire.

Probabilistic fire ignition and weather scenarios have been combined using 40 years of fire records and weather observations. These are used to select from a dataset of over 80,000 pre-processed spatially distributed fire intensity and flame height maps, generated by a fire behaviour simulator. This part of the model predicts the annual risk of the water supply catchment burning and the spatial extent and severity of the burn. These spatial fire severity maps may be combined with vegetation maps and information on soils to determine initial conditions for modelling of sediment and associated contaminant loads delivered to reservoirs.

Erosion and water quality models that form part of the overall model framework include a catchment-scale constituent load model to represent widespread rainfall events and a semi-distributed runoff and erosion connectivity model applied at the small catchment scale for convective storm events. Recent work has shown that localised, intense convective storms may also generate debris flows after fire in south-eastern Australia. Therefore, for the application of the model framework to reservoirs supplying Melbourne, an empirical debris flow erosion model is included. For the localised event models, sediment is routed from sub-catchments through the main channel network to the reservoir boundary. These erosion models are modular so that FIRESTORM may be adapted for use in a region of the world that experiences different dominant erosion processes.

FIRESTORM will enable water supply managers to estimate the current water quality risk of wildfire and allow scenario testing to explore the effect of mitigation strategies (e.g. planned burning, post-fire erosion control measures) designed to reduce fire impacts and the magnitude of loads entering reservoirs. This model will be a valuable new tool for better decision making to protect future water supplies.