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Fire and the influence of aspect on hydrological change in two small forest catchments, SE Australia

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Climate modellers have predicted the frequency of wildfire to rise in SE Australia. In response, forest managers have proposed a large increase in the area and frequency of planned fuel reduction burns. Eucalypt forests are well adapted to recover from fire, and the ecological response of individual plant species and communities to fire has been extensively studied. However, little consideration has been given to the interactions and feedbacks between fire regimes and hydrologic regimes, and the long term implications for the stability of forested ecosystems. The hydrology of forested catchments change following fire, resulting in immediate changes to the partitioning of precipitation between evaporation, transpiration, surface runoff and deep drainage. Streamflow patterns, net primary productivity, plant survival, soil properties, erosion and nutrient dynamics, and water quality are all affected by changes to hydrologic partitioning. Burning areas repeatedly and more frequently has the potential to permanently change the water and nutrient balance of a forested system.

Current research in SE Australia suggests that the magnitude and temporal patterns of post-fire partitioning of precipitation is extremely sensitive to the dryness index of the forest, this index is defined as the balance between energy (radiation) and precipitation for a particular catchment. These changes can be complex and difficult to predict. For example, the removal of soil protection by plants and litter increases the exposure of the soil surface to solar energy, which increases soil dryness and may alter the seasonal oscillation in soil water repellency, ultimately affecting surface runoff and the erosion of soil and associated nutrients. However, the degree to which water repellence affects runoff and erosion depends on the forest and soil type, which in turn is related to the dryness index of the catchment.

This paper describes the early results from an experiment aimed at determining the sensitivity of post-fire hydrologic partitioning to small variations in the dryness index of the catchment. Two small (0.5 ha) adjacent catchments, one with a northerly aspect and the other with a southerly aspect, were instrumented following a high severity wildfire to measure changes to the hydrologic partitioning. The initial phase of the measurements focused on surface runoff and associated sediment and nutrient loss, as transpiration was reduced to zero following the fire. Rainfall, solar radiation, temperature and humidity were also monitored, with periodic field campaigns to measure soil water repellency, infiltration, and gravimetric water content across each catchment.

Initial results from the first year of this study suggest that the amount of surface runoff from the north facing (drier) catchment was double that of the south facing catchment, with runoff to rainfall ratios of 0.24 and 0.11, respectively, for event sampling periods with >20mm of rainfall. Although the analysis is still underway, it is apparent these large hydrologic differences have occurred in response to greater water repellency in the drier catchment (presumably due to drier surface soil conditions). Increased surface runoff in turn resulted in 95% more sediment from the north facing catchment. These early results suggest that the impact of changed fire frequency on the long term nutrient balance of forested systems in SE Australia is likely to be highly dependent on the dryness index of the particular forest.

Two years after the fire the two catchments are displaying very different recovery trajectories in terms of vegetation regrowth, which is likely to result in substantial differences in hydrologic behaviour. The focus of the study has shifted to quantifying the partitioning between transpiration, evaporation and deep drainage as the forest recovers, changes that have important implications for net primary productivity and carbon storage in forested landscapes.