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Post-fire reconstructions of fire intensity from fire severity data: quantifying the role of spatial variability of fire intensity on forest dynamics

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Large, high-intensity fires have direct and long-lasting effects on forest ecosystems and present a serious threat to human life and property. However, even within the most catastrophic fires there is important variability in local-scale intensity that has important ramifications for forest mortality and regeneration. Quantifying this variability is difficult due to the rarity of catastrophic fire events, the extreme conditions at the time of the fires, and their large spatial extent. Instead fire severity is typically measured or estimated from observed patterns of vegetation mortality; however, differences in species- and size-specific responses to fires often makes fire severity a poor proxy for fire intensity. We developed a statistical method using simple, plot-based measurements of individual tree mortality to simultaneously estimate plot-level fire intensity and species-specific mortality patterns as a function of tree size. We applied our approach to an area of forest burned in the catastrophic Black Saturday fires that occurred near Melbourne, Australia, in February 2009. Despite being the most devastating fire in the past 70 years and our plots being located in the area that experienced some of the most intense fires in the 350,000 ha fire complex, we found that the estimated fire intensity was highly variable at multiple spatial scales. All eight tree species in our study differed in their susceptibility to fire-induced mortality, particularly among the largest size classes. We also found that seedling height and species richness of the post-fire seedling communities were both positively correlated with fire intensity. Spatial variability in disturbance intensity has important, but poorly understood, consequences for the short- and long-term dynamics of forests in the wake of catastrophic wildfires. Our study provides a tool to estimate fire intensity after a fire has passed, allowing new opportunities for linking spatial variability in fire intensity to forest ecosystem dynamics.