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Carbon sequestration potential of ash deposits from wildfires: the case of the 2009 Black Saturday Fires, Australia

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Wildfires contribute significantly to global carbon dioxide emissions. However, the carbon (C) that is stored in the vegetation and released during burning is taken up in the post-fire period by the regrowing vegetation and litter accumulation in cases where a full biomass recovery occurs. Many wildfire events could therefore be considered C-neutral over longer timescales. In addition the charred C material (charcoal, back carbon), which is largely deposited within ash, is highly resilient to breakdown and is likely to remain stored in soils, sediments and aquifers for much longer than the period needed for full biomass recovery. This additional effect could result in net C sequestration during a fire-regrowth cycle. To date, the role of ash has rarely been considered in detail in studies examining C fluxes from wildfires. One reason for this neglect may be the often rapid rate of ash redistribution within, and removal from, burnt sites by wind and water erosion. As field studies are often initiated some time after a fire, the potential importance of this C deposit may not always be obvious.

Here we quantify the C deposited in ash from biomass burning during the catastrophic 2009 'Black Saturday' in Victoria, Australia. The fires occurred during unprecedented extreme fire weather when dry northerly winds gusting up to 100 km/h coincided with the highest temperatures ever recorded in this region. These conditions, combined with the high fuel loads of mostly long-unburnt eucalypt forests, very low fuel moisture content and steep topography, led to unprecedented fire intensity. Three replicate sites each were sampled for extremely high burn severity and high burn severity (as determined by vegetation destruction), and four sites to represent long unburnt control terrain, within mature mixed-species eucalypt forests in April 2009 near Marysville, $\sim$80 km NE of Melbourne. Additional exploratory sampling was carried out in 'rainforest'. The ash layer and soil samples from 0 to 5 cm depth were collected at 20 sample grid points at each replicate site. Long-unburnt sites were sampled to estimate pre-fire fuel load.

The average fuel load at unburned control sites was 29 t/ha, which equates to a maximum C emission potential of $\sim$14.5 t/ha (based on a 50% C content in the dry fuel). The average ash load deposited at burned sites was 14.8 t/ha with a C content of 7.4%. This equates to a C deposition of 1.1 t/ha. These values suggest relatively high combustion efficiency for this extreme wildfire event. Nevertheless, these values indicate that over 7% of the C previously stored in the vegetation was deposited in ash on the forest floor. Much of the ash in this rugged terrain has since been redistributed and accumulated into footslope and other deposits, which serves to protect the C stored therein from being consumed in future fires. The longer-term fate of this C, and its potential for contributing to C sequestration, is discussed in the context of the SE-Australian fire regime.