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Carbon loss from planned fires in southeastern Australian dry *Eucalyptus* forests

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ABSTRACT

This study reports the immediate impact of planned fires on carbon distribution and storage in six forest types of south-eastern Australia. Aboveground carbon (AGC) ranged from 56 to 183 Mg C ha^{-1} where between 4 and 11 Mg ha^{-1} (or 6% of AGC) was lost in planned fire. Between 3.6 and 5 Mg C ha^{-1} was redistributed within the forest to the soil surface as char and partly combusted organic matter. Most carbon was lost from litter while near surface vegetation and dead trees either standing or lying were the next largest C loss groups. Overstorey tree biomass (Mg C ha^{-1}) was a significant predictor of carbon loss in major fuel categories, explaining 45% of total carbon loss. The loss of coarse woody debris (CWD, %) was strongly correlated with losses in litter (%, R^2 = 0.44) and with fireline intensity (%, R^2 = 0.38).

These C loss estimates in planned fire establish an empirical basis for further modeling to identify management options for mitigating fire-induced C losses from SE Australian *Eucalyptus* forests.

1. Introduction

At a global scale forests are significant carbon (C) stocks that can be affected by fires to increase C release to the atmosphere. The mitigation of C emissions from forest fire is a priority for land managers, especially in the fire prone forests of NW and SE USA, Mediterranean Europe, Russia and Australia, where wildfire extent has increased rapidly over the last decades (e.g. Sommers et al., 2014). These increases in wildfire extent have occurred in many seasonally dry forest areas and are generally associated with extreme hot and dry weather accompanied by wind (Williams, 2013).

Planned fire is the most widespread management activity in Australia's southern eucalypt forests where it is has been practiced for over 50 years to reduce the impact of intense wildfire (e.g. Hodgson, 1967; McCaw, 2013; Tolhurst and Cheney, 1999). Several damaging megafires in south-eastern (SE) Australia's forests since 2002 have focused attention on the need to increase the area of planned fire as part of a strategy to reduce wildfire risk to humans, assets and ecosystems (e.g. Attiwill and Adams, 2013). It seems that climate change is increasing the number of days that forests can burn and in combination with more extreme weather is tipping the balance to more fire in SE Australian forests. Because of the potential for both wildfire and planned fire to impact forest C balance and greenhouse gas emissions (Bradstock et al., 2012), land management agencies need to adapt fire management to maximize forest carbon storage over management cycles of decades. Several studies demonstrated that planned fire at a short interval before wildfire can reduce immediate carbon losses by 45–50% (e.g. Valliant et al., 2013; Volkova et al., 2014). Quantitative data on fire-induced forest C losses is needed to provide an informed basis for management of planned fire to minimize C emissions while achieving effective fuel reduction (Adams, 2013). In this regard Australian fire science lags behind the USA and Canada where data about fire impacts on C balance are available (e.g. LANDFIRE, 2010; Stephens et al., 2012).

Visual guides to rank fuel hazard in Australia's southern *Eucalyptus* forest have been developed and applied in burn planning and operations since the 1960s (e.g. McArthur, 1967) and more recently (Gould et al., 2007; Hines et al., 2010). However detailed empirical measurements of low and high intensity fire impacts on the distribution of forest C, integrating measurements of all aboveground, forest floor and surface soil changes, have only recently begun to appear in the literature (Bennett et al., 2014; Volkova and Weston, 2013a; Volkova et al., 2014). To date, these studies report C inventory for open forest dominated by *Eucalyptus obliqua* in the state of Victoria, Australia. Bennett et al. (2014) report the impacts of experimentally regulated and 3–7 times repeated planned fires over 27 years. While 3-year interval burning is highly unlikely to have occurred naturally in these forests or to

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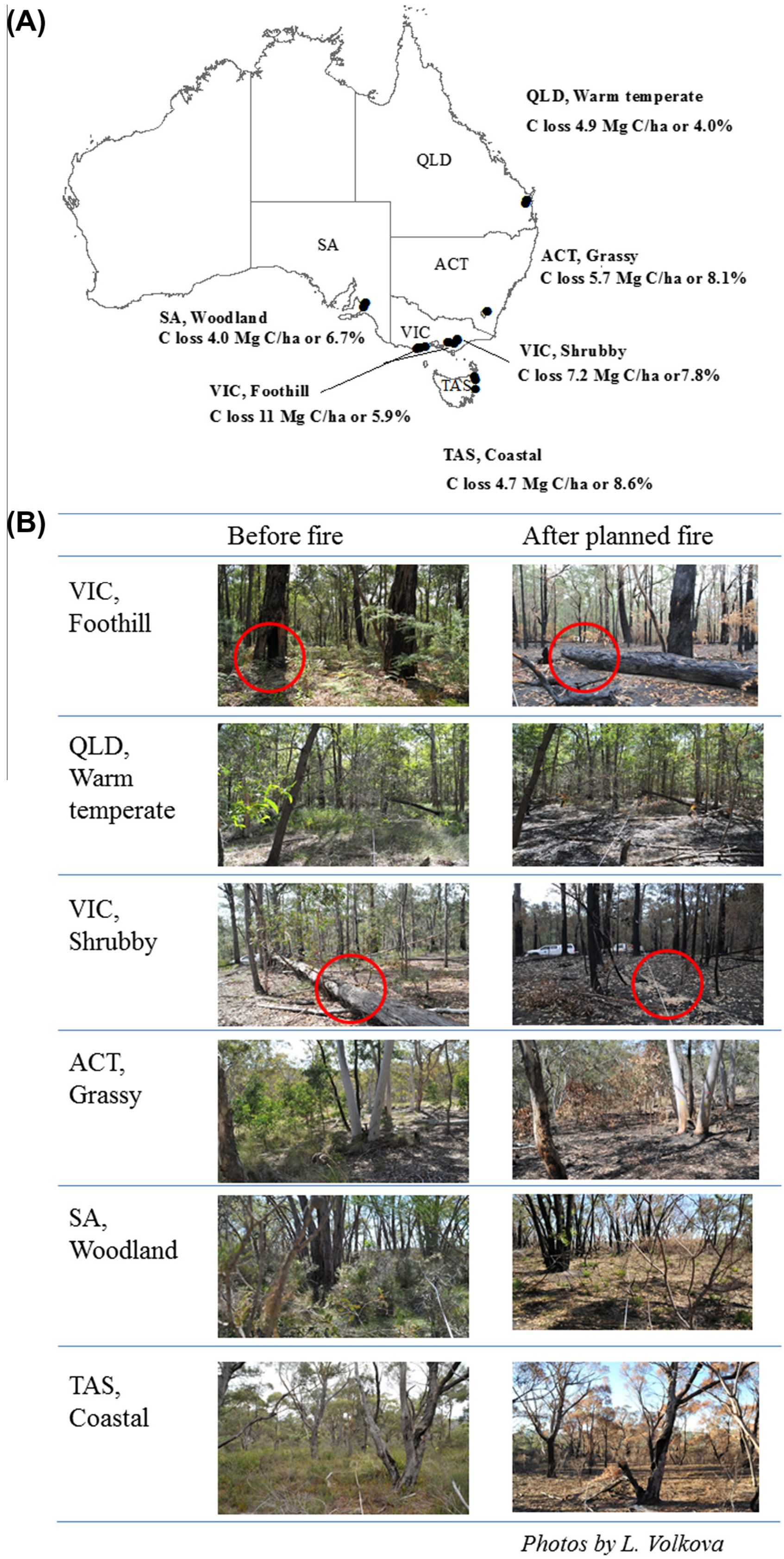

Fig. 1. (A) Study site locations across southeastern Australia. (B) Photographs of the plots pre and post fire are taken from the same location. Red circles highlight conversion of dead standing trees into CWD (Foothill) or complete combustion of CWD during planned fires (Shrubby).