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Understanding carbon pools to improve emission estimates from fires

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BACKGROUND

As forests represent a large fraction of global carbon (C) pools, it is important to understand C partitioning in forest biomass (Lal 2004; Schulze 2000) and how it may change after fire. Data was collected across forested sites in the ACT and NSW to determine the variation in biomass of fractions of surface fuel layers. Each of the fractions (leaves, twigs, fine fraction (<9 mm) and 'other', including woody fruits, charcoal and bark, were characterised chemically (total C content) and used to develop and validate a predictive C model.

COLLECTION OF SURFACE FUELS

Surface fuel samples were collected from sub-plots (north, east, south and west) in burnt and nearby unburnt sites using a metal sampling ring (Fig. 1). Surface fuel was removed from within the ring, taking care to exclude as much mineral soil as possible (Fig. 2). Samples were oven-dried for 48 h at 60°C then passed through a 9 mm sieve to separate different fractions. Larger material (>9 mm) was separated into leaf, twig and 'other' fractions. Material less than 9 mm in diameter was classified as the 'fine fraction' and included fragments of organic material in various stages of composition, small seeds and fruits and sand. Weights of each fuel fraction was recorded and, where necessary, the weight of the fine fraction was adjusted to take into account the weight of any non-organic material (eg. Mineral soil). Samples from plots located in burnt sites may have contained large (>9 mm) fragments of charred leaves, twigs and bark and there may have been ash and charred organic matter in the fine (<9 mm) fraction.

Figure 1. Litter sampling ring used to collect surface fuels.

Figure 2. Area within litter ring after surface fuel has been removed

MEASUREMENT OF TOTAL CARBON

To chemically characterise the data, C content for each fraction was determined using combustion analysis. All fuel fractions were finely ground and C content was analysed using an Elementar Vario Max CNS system (Analysensysteme GmbH, Hanau, Germany).

CARBON AND BIOMASS DATA

Figure 3. Unburnt site located in ACT.

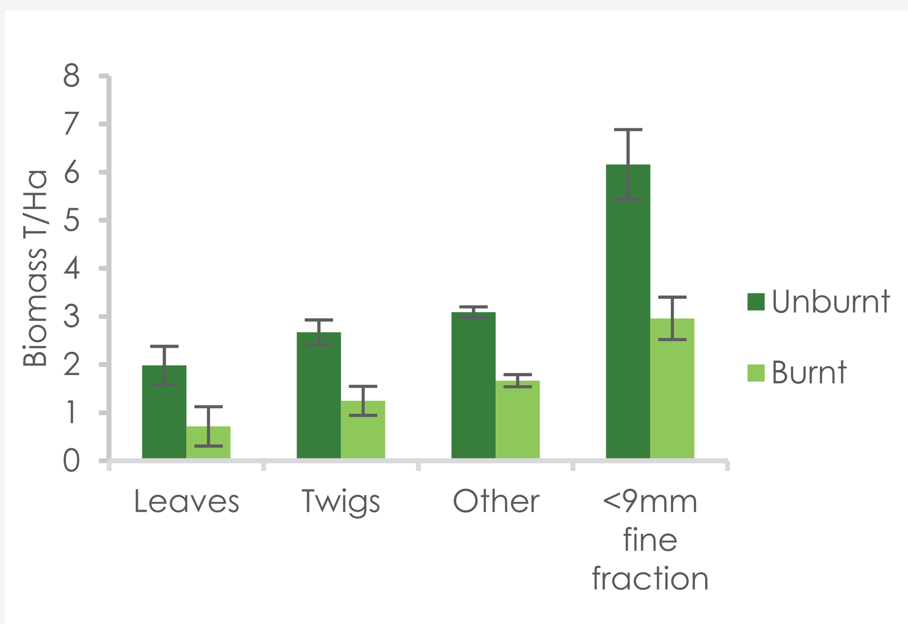

Figure 4. Mean biomass (t ha^{-1}; ± standard deviation) of each of the four fractions of surface fuel from unburnt and burnt sites: leaves, twigs, other and fine fraction (<9 mm).

CARBON AND BIOMASS DATA

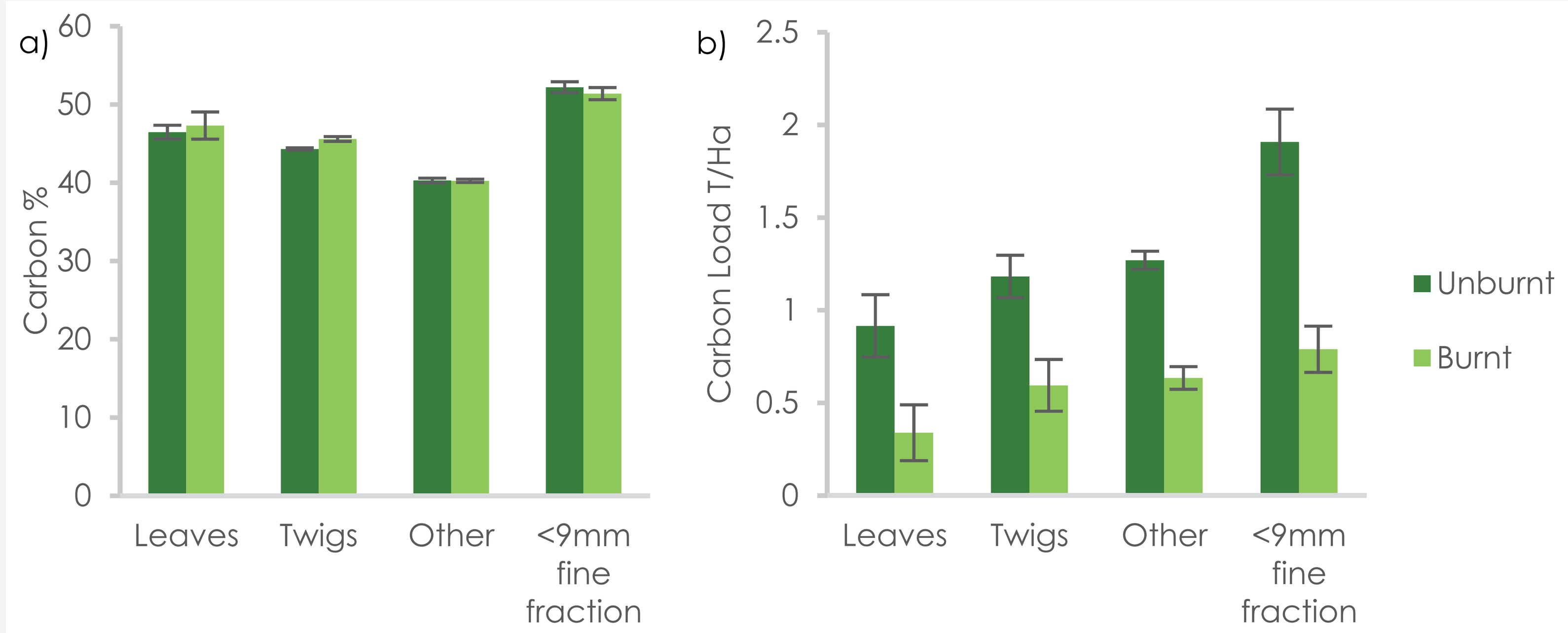

Figure 5. (a) Mean carbon (%; ± standard deviation) and (b) carbon load (t ha^{-1}; ± standard deviation) of each of the four fractions of surface fuel from burnt and unburnt sites; leaves, twigs, other and fine fraction (<9 mm).

CALCULATIONS AND C EMISSIONS ESTIMATES

The carbon load for each surface fuel fraction is the product of its biomass (T ha^{-1}) and the carbon content (%) (Fig. 5). The total carbon fuel load (TCFL) for the surface fuel at each site is the sum of the carbon load of each fraction. An estimate of the C removed from the biomass can be made by calculating the difference in total carbon load before and after fire. Not all of the C removed is emitted to the atmosphere – a small proportion remains in the char. Therefore, an emission factor (EF; g C g^{-1}C fuel) for the carbon loss is less than unity. If the area (A) of the fire is known, the mass of C emitted (E) to the atmosphere is then calculated as:

$$E = A \times [TCFL_{before} - TCFL_{after}] \times EF$$

END USER STATEMENT

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Use of prescribed burning creates emissions and particulates. However, fire management can potentially decrease the emissions produced by fires via modifications to their size and intensity. Currently, agencies such as ACT Parks and Conservation Service and National Parks and Wildlife Service NSW don't have the capacity to report how much C is emitted from their prescribed burning programs. With the recent public focus on air quality, the ability to estimate C emissions it is vital for management agencies. A better understanding of how much C is stored in different fuel fractions and how much remains after a fire will help fire managers to tailor their prescribed burning programs to reduce emissions.

WHAT IS NEXT?

- Creation of a 'user friendly' interface in which estimates of carbon content in tonnes per hectare can be made
- Determining accurate emission factors and testing their applicability to other forest types

REFERENCES

Lal R (2004) Soil carbon sequestration impacts on global climate change and food security. Science 304, 1623-1627.

Schulze E.D. (2000) The carbon and nitrogen cycle of forest ecosystems. *Carbon and Nitrogen Cycling in European forest ecosystems*, Ecological Studies (Analysis and Synthesis), vol 142. 506 p. Springer, Berlin, Heidelberg

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