Soil carbon content and soil carbon pool structure in a managed open woodland: preliminary results and implications for modelling soil carbon dynamics

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1. Introduction

This poster presents results from a collaborative project which seeks to combine a range of theoretical and empirical approaches to develop a landscape-scale carbon budget for a managed open-woodland landscape in south-central Queensland, Australia.The project includes linking newly developed remote-sensing technologies with spatially-explicit historical records of land-use activity and empirical measurements of carbon in the major terrestrial pools of living biomass, litter and soil. In May 2002 fieldwork was conducted to quantify variability in soil carbon, litter and coarse woody debris across the study landscape. The methods and preliminary results of the soil sampling are presented below, and the implications of these results for modelling soil carbon dynamics in terrestrial ecosystems are discussed.

2. Field methods

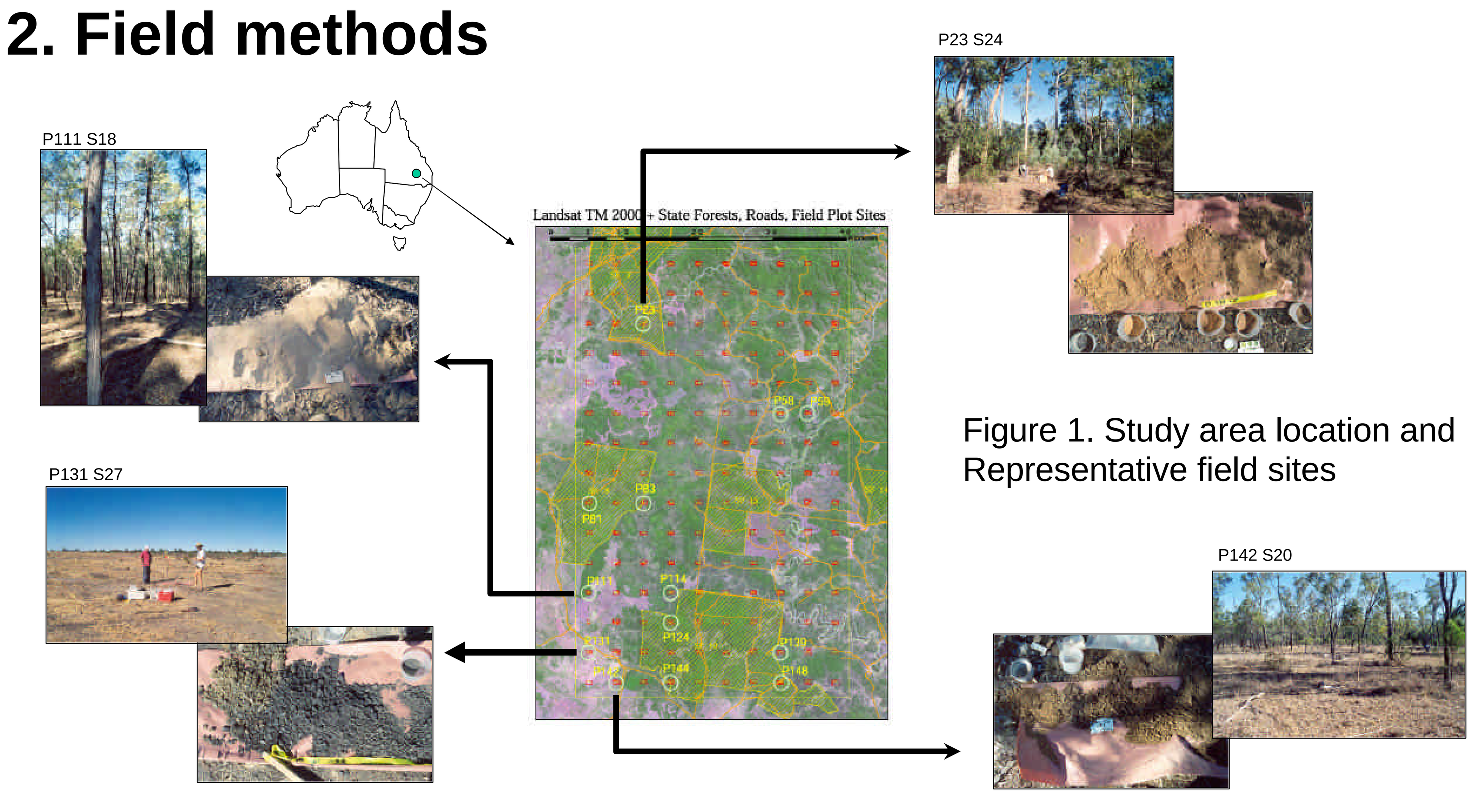

Figure 1. Study area location and Representative field sites

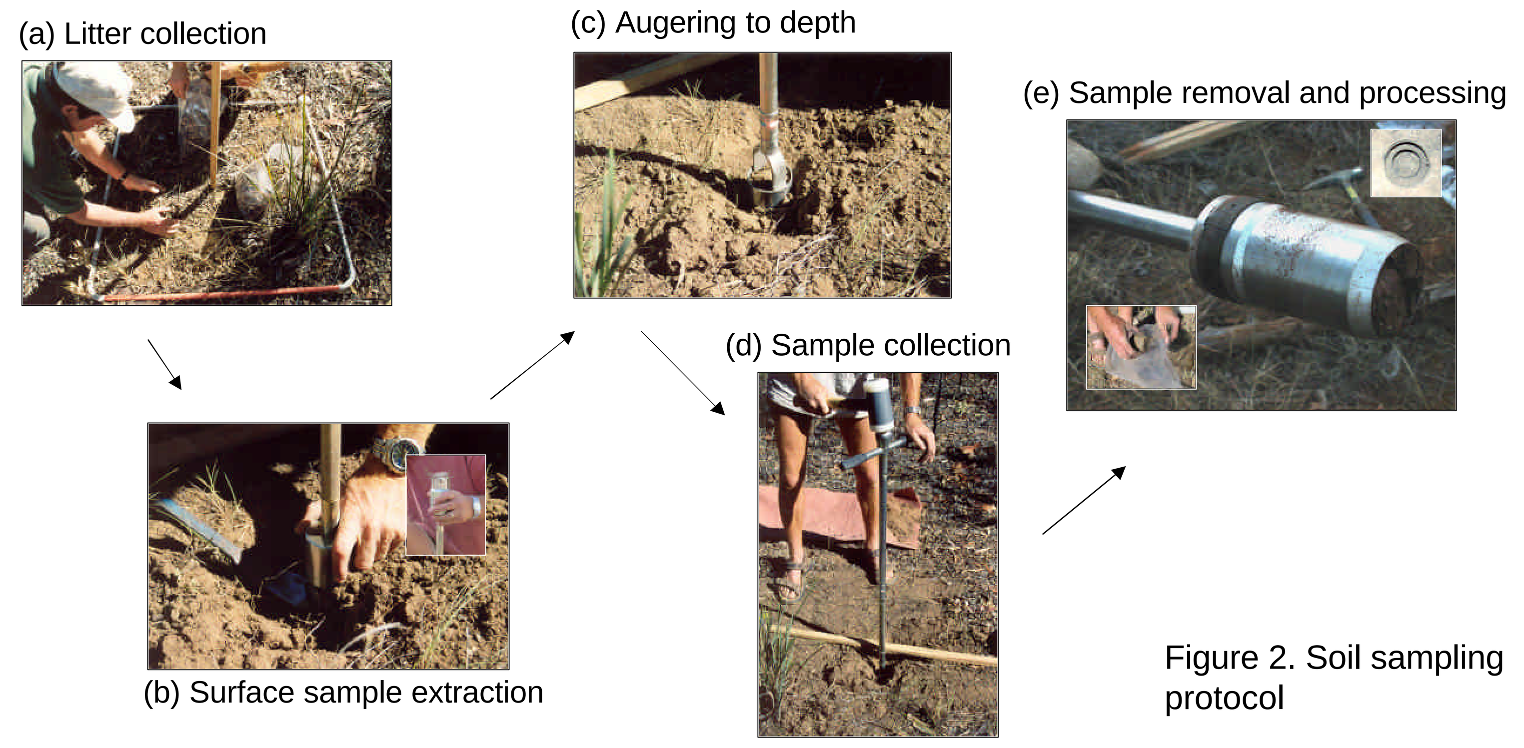

Figure 2. Soil sampling protocol

The Injune study landscape covers an area of approximately 1900km^2, and comprises a mosaic of open woodland communities, soils types, and land-use histories. Fourteen permanent plots (50m x 50m), which had previously been surveyed by Lidar remote sensing and for field biomass, were revisited and surveyed for soil carbon, litter and coarse woody debris. Within each plot three soil cores were located at random. Soil cores were sampled to a depth of 1m.

Figure 1 shows the location of the study area, and a representative range of the plots sampled. At each of the three cores within each plot the Eijkelkamp soil coring system was used to remove bulk-density samples (soil volume = 100cm^3) at depths of 0-5cm, 25-30cm, 50-55cm, 75-80cm and 100-105cm. This yielded a total of 42 soil cores, and a maximum of 210 individual soil samples. Figure 2 illustrates the process of sampling a single core.

3. Analysis

Each 100cm^3 sample was sieved to separate stones and root material (> 2mm) from the remaining matrix (< 2mm) (Figure 3). Roots were dried at 75^{O}C and the carbon content calculated as 43% of the oven-dried weight. The < 2mm fraction was analysed for TOC by Leco combustion of air-dried (40^{O}C) samples, and also by Mid-Infrared (MIR) analysis to estimate the soil pool structure (Inert organic matter (IOM), Resistant Plant Material (RPM, turnover time *c.* 6.6 years), and Humus (HUM, turnover time *c.* 50 years)). For each of the 43 cores a soil carbon density (gC/cm^3) vs. depth (cm) graph was constructed (Figure 4). Soil carbon stocks (gC/cm^2, expressed as tC/ha) were estimated by fitting a simple exponential decay curve to the data, and numerically integrating under the curve to the desired depth.

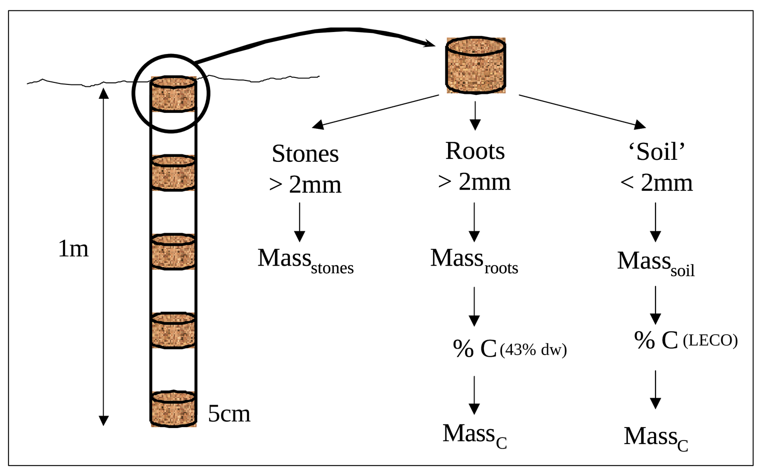

Figure 3. Treatment and analysis of the soil samples

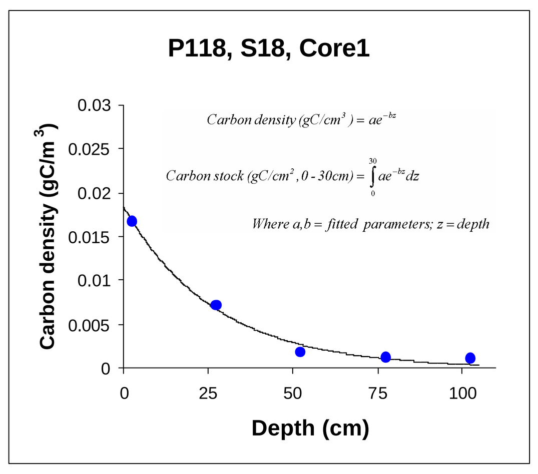

Figure 4. Example calculation of soil carbon stock

4. Results

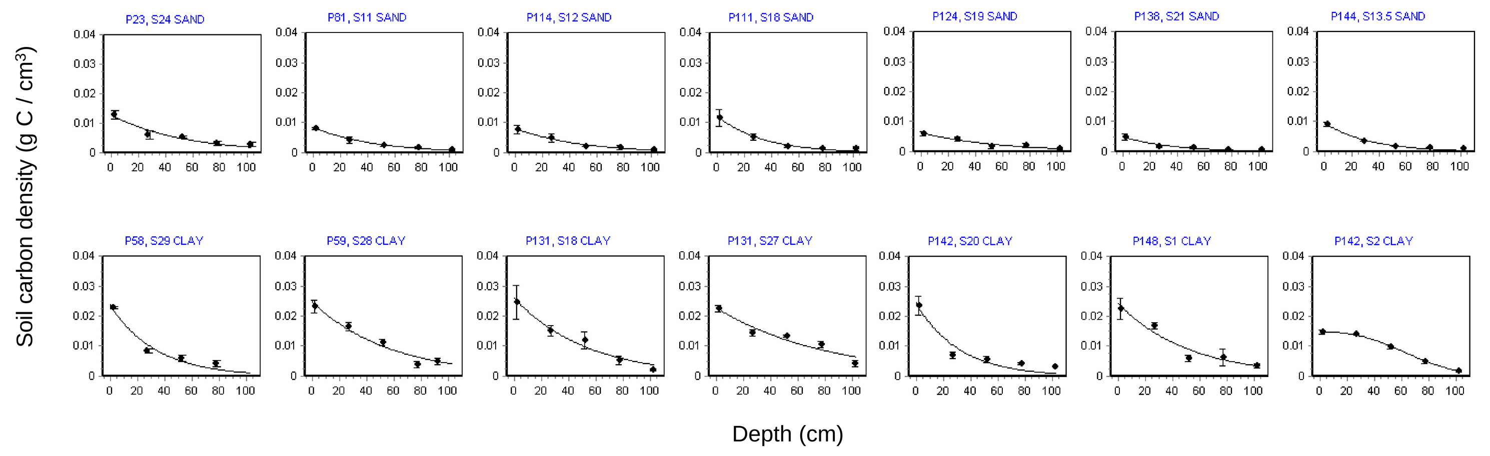

Figure 5. Soil carbon density (gC/cm^3) of the < 2mm sieved fraction for each of the 14 plots. The top row are plots with 'sandy' soils, and the bottom row plots with 'clayey' soils. Points represent mean +/- se (*n* = 3 cores).

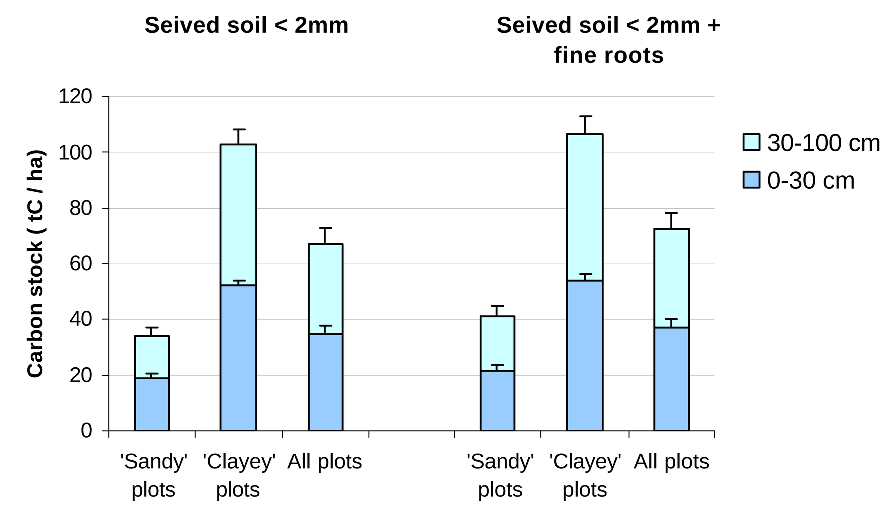

Figure 6. Soil carbon stock down to 1m depth, both including and excluding fine-root material.

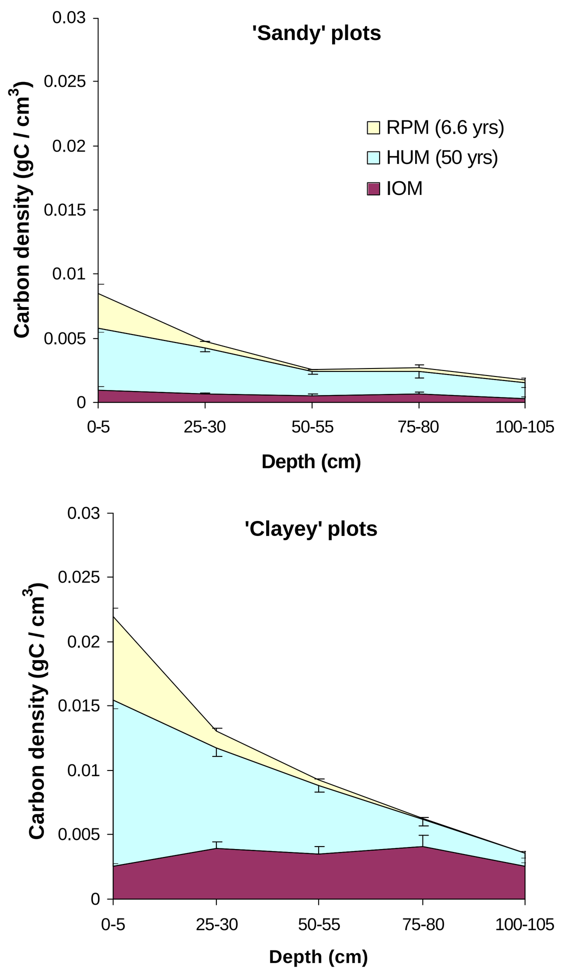

Figure 6. Trends in soil pool structure with depth.

Figure 5 shows the carbon-density vs depth graphs for each of the 14 plots. Half of the plots were characterised as having 'sandy' soils (e.g. loamy sand, clayey sand, sandy loam), and the other half 'Clayey' soils (e.g. medium clay, light clay, clay loam). Figure 6 shows the estimated carbon stocks down to 1m depth for each of these soil types, and the 'all plots' average. Sandy soils had *c.* 19 tC/ha down to 30cm depth, and 34 tC/ha down to 1m. Clayey soils had *c.* 52 tC/ha down to 30cm, and 103 tC/ha down to 1m. Overall plot averages were *c.* 35 tC/ha down to 30cm, and 67 tC/ha down to 1m. In sandy soils fine roots > 2mm added approximately 3 tC/ha when soil C stocks are calculated down to 30cm, and 7 t/ha down to 1m. In clayey soils fine roots added approximately 2 tC/ha down to 30cm, and 3 tC/ha down to 1m. Figure 6 shows the vertical distribution of the IOM, RPM and HUM soil pools. Note the approximately constant IOM with depth, and the regular decay of the more labile RPM and HUM fractions. Note also the different proportions of the IOM component between the sandy and clayey soils.

5. Implications

Many terrestrial carbon cycle models represent soil organic carbon as a collection of discrete 'pools', each characterised by a different turnover time. For example inert organic matter such as charcoal can be classed as one pool, and may have turnover times of 100's – 1000's of years. This can be contrasted with more labile forms of organic matter, which may have turnover times of years to decades. These pools are often considered 'conceptual', in the sense that they cannot be easily observed, simply because soil organic carbon particles exist in the soil matrix as an heterogeneous mixture. The results in Figure 6 confirm other studies and show regular and predictable trends in the soil carbon pool structure with depth. This has two important implications for modelling soil carbon dynamics. First, these results show a definite spatial component to the vertical distribution of turnover times in the soil, indicating that the 'conceptual' soil pools can be associated, in at least an approximate way, with a physical location. Second, in predicting soil C dynamics over year-to-decadal timeframes the most important soil components are the faster-turnover pools, i.e. those pools that are most sensitive to disturbance, and which are most amenable to anthropogenic manipulation. The results in Figure 6 suggest a 'first-order' graphical approximation of the distribution of these pools with depth, depicted in Figure 7. The extent to which Figure 7 can be used as a generalised tool for spatially disaggregating the fast- and slow- soil carbon pools, and how the relative contributions of the IOM component vary under different conditions, needs to be tested with similar data collected from other ecosystems. If the relationship in Figure 7 is generally applicable then this provides an opportunity for approximate yet rapid and low-cost quantification of the gross features of soil carbon pool spatial distributions.

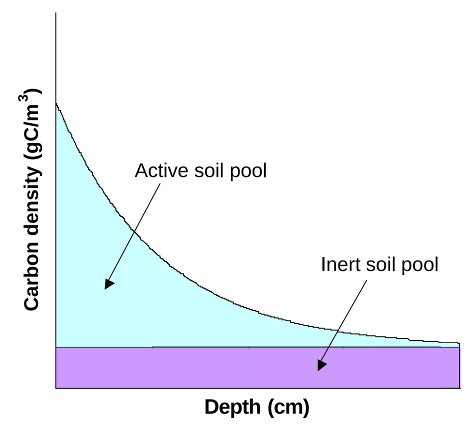

Figure 7. Generalised profile of soil pool fractions.

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