Scattered native trees and soil heterogeneity in grazing land on the Northern Tablelands of NSW.

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Abstract

Over extensive areas of the Australian landscape, native vegetation is in the form of scattered trees and shrubs, beneath which the ground-storey vegetation is largely grazed or otherwise managed. It is estimated that scattered trees occupy as much as 20 million hectares of farmland in Australia. Although their cumulative influence on the landscape might therefore be profound, the effects of scattered native trees on soils in these agricultural landscapes has received limited attention. This study investigated the influence of scattered Blakely's Red Gum (*Eucalyptus blakelyi*) trees on both near-surface and deeper soil layers in temperate grazed pastures on the Northern Tablelands of NSW. Trends of increased soil pH, organic matter and nutrient concentrations were found in surface soils around individual trees confirming previously observed patterns. However, variation in soil chemistry with depth in the soils provides a new insight into the processes of plant-induced soil change in these environments. These findings have significant implications with regard to the heterogeneity of soils associated with scattered native trees and their importance in the management of landscape health, soil acidification and nutrient retention in these landscapes.

Key Words

Scattered trees, soil heterogeneity, soil acidity, soil carbon, soil nutrients.

Introduction

Over extensive areas of the Australian landscape, native vegetation is in the form of scattered trees and shrubs, beneath which the ground-storey vegetation is largely grazed or otherwise managed. It is estimated that scattered trees occupy as much as 20 million hectares of farmland in Australia (Reid and Landsberg 2000), and their cumulative influence on the landscape might therefore be profound. Single trees in otherwise cleared landscapes have been shown to have a profound impact on soil heterogeneity. For example, modification of soil acidity has been observed under single trees of a range of species (Crampton 1982, Ryan and McGarity 1983, Boettcher and Kalisz 1990, Prober *et al*. 2002; Wilson 2002; Graham *et al*. In press) although the nature of this change can vary between species. Soil organic matter and nutrient status have also typically been found at higher levels in the zone around trees and shrubs within the canopy zone (e.g. Belsky *et al*. 1993a, 1993b; Chilcott *et al*. 1997; Rhoades 1997; Dean *et al*. 1999; Wilson 2002; Graham *et al*. In press). It has therefore been clearly demonstrated that trees create a distinct mosaic across the landscape with localised zones of soil heterogeneity. In order to understand the significance of these effects on soils in the agricultural landscapes of Australia, we need to more fully understand the mechanisms driving these changes. This requires an understanding of the effects of these trees on sub-surface soil conditions.

In the work presented here, we seek to build on existing work relating to soil spatial heterogeneity and present preliminary data regarding the change in soil properties with depth under single, scattered *E. blakelyi* trees, in grazing landscapes of the Northern Tablelands of NSW.

Methods

Ten *E. blakelyi* trees were selected from paddocks on the University of New England *Newholme* Field Laboratory. These sites were on yellow chromosol soils derived from granodiorite and are typically acid with low organic matter and nutrient status. These sites had previously been used for work examining soil spatial heterogeneity and details regarding the site can be found in Wilson (2002). At each tree, a transect was laid out on a bearing due north, beginning at the tree stem. Along each transect, soil samples were collected at four points arranged in proportion to the tree canopy size. Soils were collected at

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intervals : 0.5m from the tree stem, at half the canopy radius (0.5r), at 1r and 2r. The latter sample point was located in the open paddock at least two canopy radii from the next nearest tree. At each sample point, a soil core, 80 cm deep was collected using a coring device of 45mm diameter. A depth of 80 cm was selected for practical reasons, this being the depth at which weathered granite parent material was typically reached.

Soils were collected in depth intervals of 0-5 cm, 5-10 cm, 10-20 cm and then in 20 cm increments to 80 cm. Mineral soil samples were dried at 40^{o}C for 48 h and subsequently analysed at the Incitec/Pivot Werribee laboratory for pH (1:5 soil in 0.01M $CaCl_2$), organic carbon percentage (Walkley and Black), extractable phosphorus (Colwell) and a full suite of cations by ammonium acetate extraction (Rayment and Higginson 1992).

Results were analysed using ANOVA to determine if a pronounced canopy effect could be detected across the site. For this analysis 0.5 m and 0.5r sample points were taken together as the 'inside-canopy' points while 1r and 2r were combined to represent 'outside' canopy. At the time of writing, multi-variate analyses were being performed on the depth profile data and in this paper, only preliminary results for this data set are provided on the basis of visual analysis and standard error.

Results

Broad differences in soil properties were assessed for sample points inside and outside the tree canopy at the soil surface (0-5 cm). Mean values from the 10 trees studied showed a significant canopy affect on the surface soil for all soil properties (Figure 1). Soil pH, carbon, nitrogen, phosphorus, calcium and indeed all other properties that were determined on these surface soils were found to be higher 'inside' than 'outside' the tree canopy.

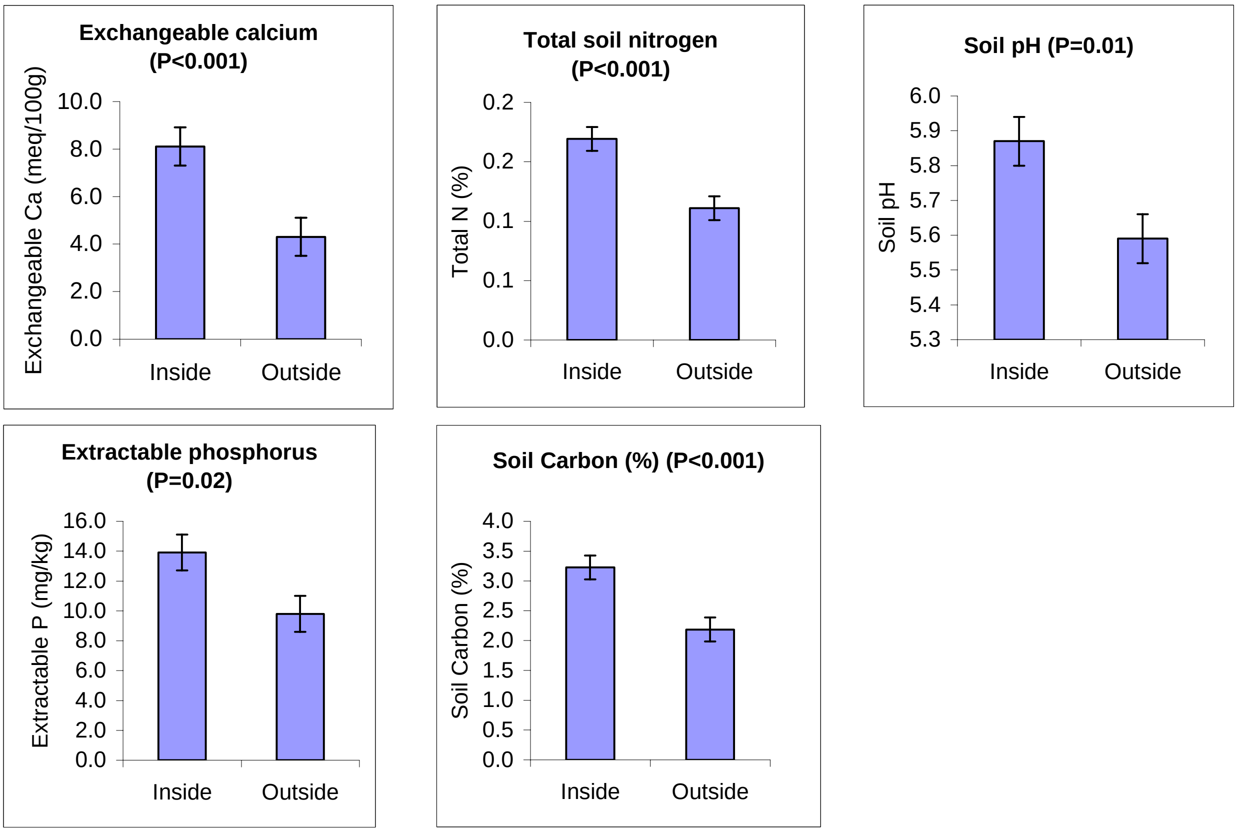
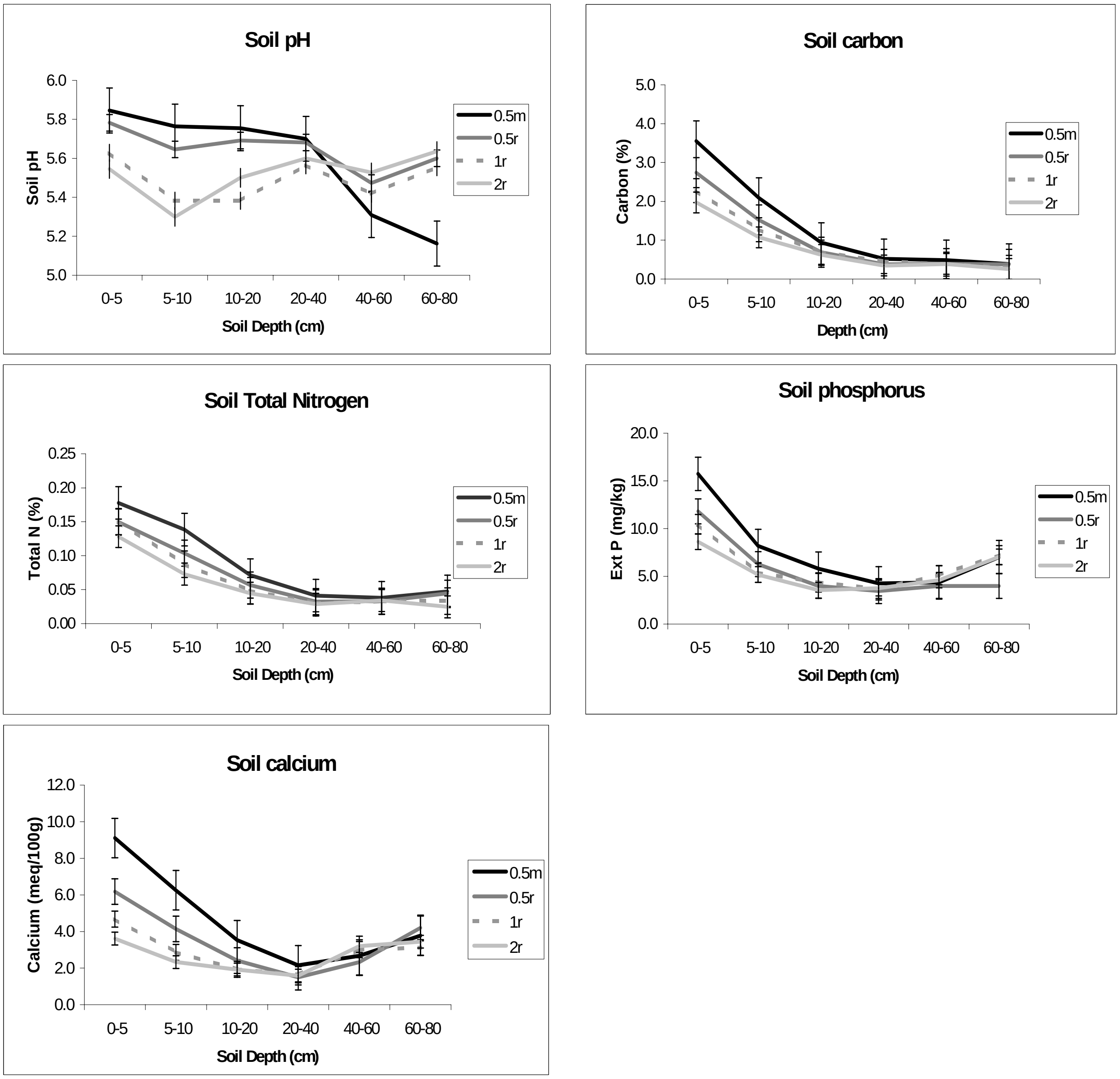


Figure 1. Surface soil properties (0-5cm) inside and outside the canopy of *E. blakelyi*.

Soils also showed considerable heterogeneity with depth. Figure 2 illustrates soil change with depth at each sampling point, again averaged over all of the ten trees sampled. It can be seen that the spatial, canopy effect observed in Figure 1 is more accurately described by a progressive decline in the soil values with distance from the tree stem reaching a minimum in the open paddock. It can also be seen that these differences between soil sample points diminished with depth in the soil for most properties and were no longer significant at depths greater than 10-20cm.

Most soil properties showed a pattern of decline with depth in the soil. However, the pattern for soil pH, was quite different. For soil pH, the soil at 5-10cm had the lowest value at the 2r sample point. At this sample point, pH then increased progressively with increased depth in the soil. Under the tree however, the pattern was quite different. No reduction of soil pH was observed in the near surface layers within the tree canopy. However, a distinct and marked decline in pH was observed at 40-60cm in the soil adjacent to the tree stem. At the two intermediate points along the transects, pH change down the profile had patterns intermediate to that inside and outside the canopy.

Figure 2. Soil change with depth under *E. blakelyi* on the Northern Tablelands, NSW



Discussion

The soils sampled under *E. blakelyi* at Newholme showed a clear pattern of soil heterogeneity at the soil surface where a clear canopy effect could be detected. For all the soil properties determined, a significantly higher value was found in surface soils ‘inside’ compared with ‘outside’ the tree canopy. This result confirms the findings of similar work elsewhere (e.g. Ryan and McGarity 1983, Chilcott *et al.* 1997; Prober *et al.* 2002; Wilson 2002; Graham *et al.* In press) and suggests that trees in these grazed landscapes are a focus around which higher soil pH and carbon and soil nutrient accumulation takes place. It has been suggested in some instances that such patterns in grazed paddocks result largely from animal camping (Hilder 1964; Comino 1983). However, Graham *et al.* (In press) have demonstrated that this is not always the case, and that trees impose this pattern even in the absence of animal camping. Our results would therefore support the notion that the presence of trees in these grazing landscapes promotes 'patches' or 'islands' (Dean *et al.* 1999) of high pH, organic matter and nutrient accumulation.

The observed 'inside' versus 'outside' canopy effect in fact resulted from a progressive decrease in most soil parameters with distance from the tree stem, reaching a minimum in the open paddock. This difference between sites however was largely limited to the surface (0-5cm and 5-10cm) layers. Below this depth, little difference existed for most of soil parameters determined. For most soil properties the presence of trees and associated nutrient retention or soil enrichment would therefore seem to be restricted to the near surface layers and their effect on the bulk of the soil below these depths is limited.

The pattern of soil pH with depth was quite different. Lower soil pH was found in the 5-10cm layer of the soil 'outside' the tree canopy and this is a common feature in grazed pastures on the Northern Tablelands. This soil acidification has been widely discussed elsewhere and probably results from livestock production, through the export of soil nutrients in products and increased nitrogen leaching from urine, and legumes in these pastures (Helyar and Porter 1989; Robinson *et al.* 1995, Lockwood *et al.* 2003, Condon *et al.* 2004).

This surface acidification was not present in the soils under the tree canopy. However, a zone of increased soil acidity was found at depth in the soil (40-60cm) at the sampling point closest to the tree stem. It has been proposed in the literature (Noble *et al.* 1996, 1999) that trees operate as 'biological pumps' extracting alkalinity from depth in the soil, redistributing this to the soil surface in litter fall causing a rise in surface pH. It has also been proposed that, as a balancing process, trees will induce acidity at depth although few empirical data have been presented to date to support this assertion. Our results would appear, at first sight, to support such a mechanism.

The removal of alkalinity from the soil at depth is thought to accompany cation uptake in a process that achieves charge balance, but no depletion in soil calcium, nor any other cation, was found in the deeper soils near or at distance from trees in our study. This suggests that cation depletion is not directly linked with deep soil acidification. It might therefore be possible that soil acidity at this depth can best be explained by a range of other mechanisms such as acid exudation from roots. Alternatively it might be the processes operating under the pastures that have caused these differences in subsoil pH. Work is continuing to resolve the mechanisms by which these changes take place.

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