

Vertical and horizontal distribution of soil properties influenced by individual trees in grazing landscapes of NSW Australia

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Abstract

Scattered paddock trees play an important role in the Australian environment and influence their immediate environment both above- and below-ground. These trees are rapidly being lost from the landscape and there is a need to understand their functions more fully in order to optimise landscape management. This investigation aimed to quantify how single trees influence the soil resource with depth and to investigate the spatial extent of their influence. Three isolated trees were comprehensively examined for their influence on soil chemistry to a depth of 75 cm and to a radial distance of more than 3.5 canopy radii. Modification of soil condition was strongly dependent on the soil property examined, although typically values were higher under the tree at the surface and diminished with distance. We conclude that single trees significantly improve soil condition and that a distance of 2.5 canopy radii is sufficient to explain the spatial influence of scattered trees.

Key Words

Keystone structures, organic matter, competition.

Introduction

In the past decade there has been growing international interest in the influence of trees on their surrounding environment (e.g. Belsky *et al.* 1989; Eldridge and Wong 2005; Gibbons *et al.* 2008; Graham *et al.* 2004; Jackson and Ash 1998; McElhinny *et al.* 2009; Obrador and Moreno 2006; Wilson 2002). Scattered trees can either occur naturally, such as savannas, or in modified environments, such as the remnant paddock trees that exist throughout production landscapes in Australia. These trees are a valuable natural resource for both above- and below-ground ecological services and act as 'keystone structures' in the grazing landscape (Manning *et al.* 2006). However, it has been estimated that within 40 to 185 years, these trees could be lost from the Australian landscape (Gibbons *et al.* 2008).

It has been demonstrated, in a range of environments, that individual trees have the capacity to modify soil condition, organic matter content, nutrient status etc., and therefore they would appear to have value in the production landscape in ameliorating land and soil degradation effects (Yates and Hobbs 1997). In northern NSW, where approximately 60% of agricultural businesses have reported land and soil degradation problems (ABS 2008), these trees might have particular value.

Here we sought to clarify the effects of trees on the surrounding soil, and posed two specific research questions:

1. How does an individual tree influence the soil at different depths?, and
2. How do these vertical changes alter with distance from the tree?

These questions will form the basis for subsequent investigation of tree: soil: pasture interactions.

Methods

The study was conducted on the University of New England's property "Tullimba" 325625E 6626834N near Armidale NSW, Australia. Soils across the property consist predominantly of shallow Yellow Chromosols (Isbell 2002). These soils are characterised by a sandy A horizon 0-20 cm deep and a sandy clay B horizon 20-80 cm deep. The site was historically set stocked with cattle at a rate of 0.4 cows / ha and has single superphosphate applied (rates 100-156 kg/ha) every 1-2 years.

Three isolated (no other trees within a 50m radius) Grey Box (*Eucalyptus moluccana* Roxb) trees were examined. Trees studied were 20-24 m high and had canopy radii from 5-6.2 m. Soils were sampled from four concentric zones around each tree determined by the individual tree canopy radius (cr); a) *inner canopy*: 0-0.5 cr, b) *outer canopy*: 0.5-1 cr, c) *intermediate*: 1-2.5 cr, and d) *open*: 2.5 + 10 m. Each of these zones was divided into eight equal *segments* aligned along principal compass bearings, totalling 32 *segments* across

all zones. In each segment, 1 sample location was located randomly and a soil core collected at depth increments of 0-5, 5-10, 10-20, 20-30, 30-50 and 50-75 cm (totalling 192 samples / tree). Soils were dried at 40°C for 48 hours or until weight stable and analysed for soil moisture, total C, N and S, extractable P, pH (1:5 CaCl₂ & H₂O) and EC at the NSW Natural Resources Laboratory, Yanco.

Results and discussion

There were clear differences in both vertical and horizontal distribution of soil properties in relation to the individual trees studied (Figure 1). However, these patterns differed depending upon the soil property being considered. The results indicate four types of pattern occurring with depth and distance from the tree,

Soil moisture at 0-5 and 50-75 cm moisture content was slightly but significantly higher under the tree canopy compared with the intermediate and open zones. For the other soil depths however, soil moisture was significantly higher in intermediate and open zones.

EC was clearly separated by the presence of the tree's canopy, and was significantly higher than either the intermediate or open zone throughout the soil mass

pH typically increased with increasing soil depth. At the soil surface, pH was consistently higher under the tree canopy compared with open pasture. However, this pattern was reversed in the deeper soil layers (50-75cm).

Total C/N/S and extractable P were significantly higher under the tree canopy and in the intermediate zone compared with the open pasture. However, this increase is restricted to the top 20 cm of soil. As this pattern was similar across these soil properties only the total C has been presented here. These results suggest that individual trees significantly influence soil condition in their immediate vicinity both horizontally and vertically albeit that the intensity and magnitude of these effects varies between soil properties. Our results suggest that there is,

- Potentially an area of competition between the tree and the pasture understory within the 5-50 cm region for available soil moisture,
- A sufficient litterfall, cation and anion addition from a single tree to significantly elevate soil pH and to increase the nutritional status of the surface soil,
- Incorporation of organic matter at the soil surface rapidly diminished with soil depth

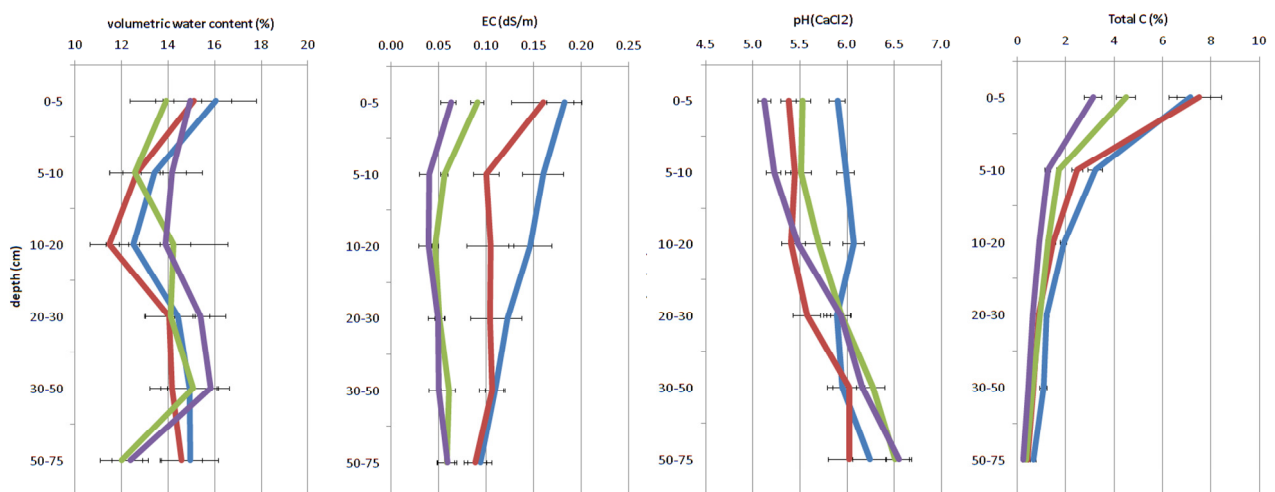


Figure 1. Examples of the changes in some of the selected soil property distribution with depth and distance from the tree. Blue = inner canopy, red = outer canopy, green = intermediate, and purple = open zone. Only 4 of the 7 soil results are shown here as these represent the general trends the other soil properties display. Those with similar trends are indicated in the text above.

Conclusion

This study indicates that trees have a substantial horizontal and vertical influence through the 0-75cm soil mass but that the magnitude, intensity and pattern of these effects differs according to the soil property in question. We further conclude that area distance of 2.5 canopy radius is probably approaching the outer

extent of an individual trees horizontal influence on soil properties in this environment. Further work is now underway to elucidate the processes influencing soils around these trees and to link pasture productivity and quality to these soil patterns.

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