THE EFFECT OF TWO VERY DIFFERENT TREES ON SOIL & REGOLITH CHARACTERISTICS

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INTRODUCTION

The interaction between vegetation growth and soil development is very poorly understood, but critical to the understanding of the evolution of regolith. Most research has been undertaken in the northern hemisphere (e.g., Wang *et al*. 2000, Breeman *et al*. 2000). These results are not always applicable to Australian conditions—Australia's continental history, soils, vegetation and climate are very different. Also, most research has concentrated on the relationships between agricultural crops and soils (Johnson 2000, Hinsinger *et al*. 2001), not on long term, relatively undisturbed soil and vegetation relationships where much greater influences may be evident. However, all studies acknowledge that different plant species have different effects on pH and mineral concentrations in the root zone or rhizosphere, and that this influence decreases with distance away from the root (Lucas 2001, Gilkes 1998).

The present study set out to choose two very different trees in a natural and relatively undisturbed environment, and to examine the soil beneath them to document differences and similarities. As stated by Gilkes (1998) *"roots chemically modify the regolith to maximise plant uptake of many elements"*, and this study was to determine if soils were measurably different between two different trees in a natural and undisturbed setting. Hamilton (1972) observed that *"litter types and ...particular…soil properties are consistently associated with particular eucalypts"*. The present study considered the influence of two very different trees, not a comparison between Eucalypt species.

The present study set out to measure differences in soil type, pH, electrical conductivity (EC) and some elemental distributions beneath the trees, compared to distance from the roots. A marked difference in the soil type and other soil characteristics was expected in the root zone compared to the less affected central portion of the transect. As one tree was an acacia, which has the ability to fix nitrogen from the atmosphere through a symbiotic relationship with microorganisms associated with its roots, pH was expected to be affected in this area.

METHODOLOGY

The project site was on a lower slope, characterised by shallow yellow chromosols with little effect of run-on or run-off from water or sedimentation. An *Eucalyptus mannifera* ssp *maculosa* (Brittle Gum) and an *Acacia faliciformis* (Mountain Hickory), growing 10 m apart, were chosen for the study. The Brittle Gum was estimated to be a minimum of 100 to150 years old, while the Mountain Hickory was estimated to be 200 to 300 years old (John Banks *pers. comm.*). Both species are native to Australia, endemic to the site, and well represented in this environment.

Soils were sampled at 20 cm intervals both vertically and horizontally along the 10 m costean, from the soil surface to as deep as it was possible to dig. These samples were then dried in the laboratory, pH and EC measured, digested with acids and analysed using ICP for Al, Fe, Mn, Ca, Mg, K, Na and other minor elements.

RESULTS

The onsite analysis from the profiles beneath each tree showed quite different soil properties (Table 1). The root bole of the acacia species extended 200 mm below the soil surface while the eucalypt bole began at the soil surface.

The pH under the acacia sp. changed from 3.5 in the A_1 horizon to 4.5 in the B_2, to 5.5 in the BC. Under the eucalypt the pH changed abruptly from 4 in the A_1 horizon to 6 in the A_2 horizon, and stayed at 6 down through the BC.

A comparison of the laboratory analysis for pH and EC (Figure 1) demonstrates variation along the transect, varying more in the root zones of each tree than beneath the pasture in the middle of the transect. When compared to the soil horizons and root influence it can be seen that the acacia and its roots have a greater effect to depth on pH in soil than does the eucalypt. The lowest pH is measured beneath the acacia, with the depth and extent of low pH (<5) extending for a greater distance. The eucalypt has measurably less effect on soil pH than does the acacia. The surface soil pH beneath the crown of both trees is 4.5 or less, whereas soil pH between the tree canopies under native pasture is closer to 5.

Table 1: Field soil descriptions.

<table>
<tr><th>Acacia Faliciformis</th><th>Depth (mm)</th><th>Eucalyptus manniferra</th></tr>
<tr><td rowspan="4">Solid Root Mass</td><td>0</td><td rowspan="2">A1
Sandy Loam – pH 4</td></tr>
<tr><td>50</td></tr>
<tr><td>100</td><td rowspan="2">A2
Fine Silty Loam – pH 6</td></tr>
<tr><td>150</td></tr>
<tr><td rowspan="6">A1
Sandy Loam
pH – 3.5</td><td>200</td><td rowspan="3">B2
Light Clay
pH - 6</td></tr>
<tr><td>250</td></tr>
<tr><td>300</td></tr>
<tr><td>350</td><td rowspan="6">BC
Light / sandy clay
pH - 6</td></tr>
<tr><td>400</td></tr>
<tr><td>450</td></tr>
<tr><td rowspan="3">B2
Sandy Clay
pH – 4.5</td><td>500</td></tr>
<tr><td>550</td></tr>
<tr><td>600</td></tr>
<tr><td rowspan="2">BC
Light / sandy clay
pH – 5.5</td><td>650</td><td></td></tr>
<tr><td>700</td><td></td></tr>
</table>

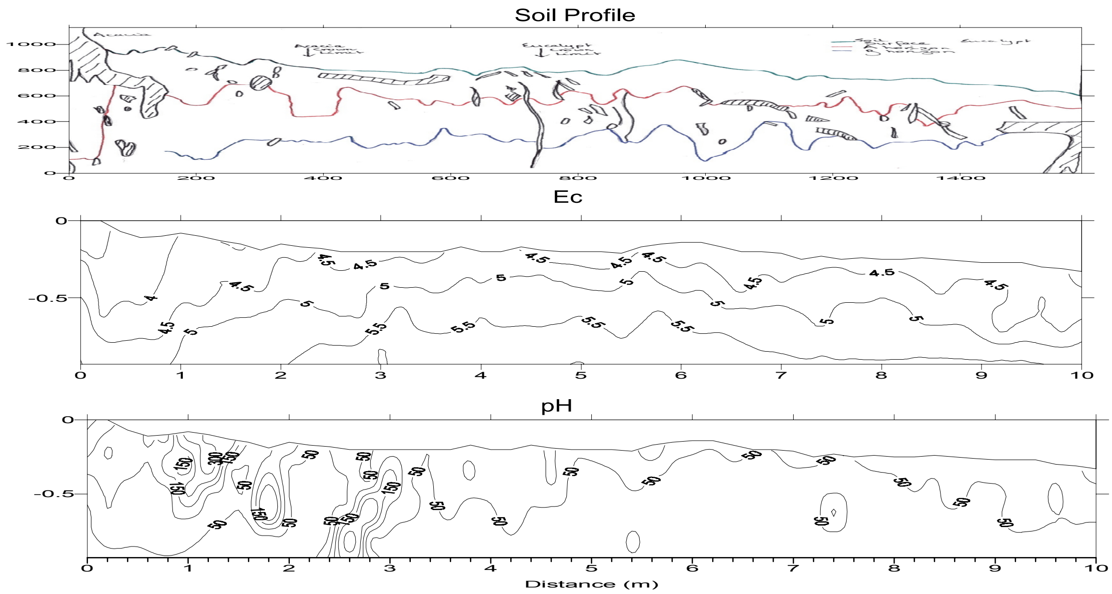

Figure 1: EC and pH comparison

The EC showed greater variation beneath the acacia, with little activity beneath the eucalypt. The EC was highest with strong variation around the main root zone at the base of the acacia. There is another zone of activity just outside the acacia crown limit, with no obvious association to living roots, but a pocket of organic matter is probably the remnants of a dead root. The eucalypt appeared to have little influence on the EC of the soil in its immediate vicinity.

Calcium is a major element that is essential for plant growth (Poswa 2000) and is limiting in the environment. There is a strong concentration of Ca directly below the acacia, weakening out toward the tree crown limit. There is a similar concentration in the surface soils below the eucalypt but no concentration directly below the tree. There are only low values measured in the area of decomposed bedrock (Figure 2).

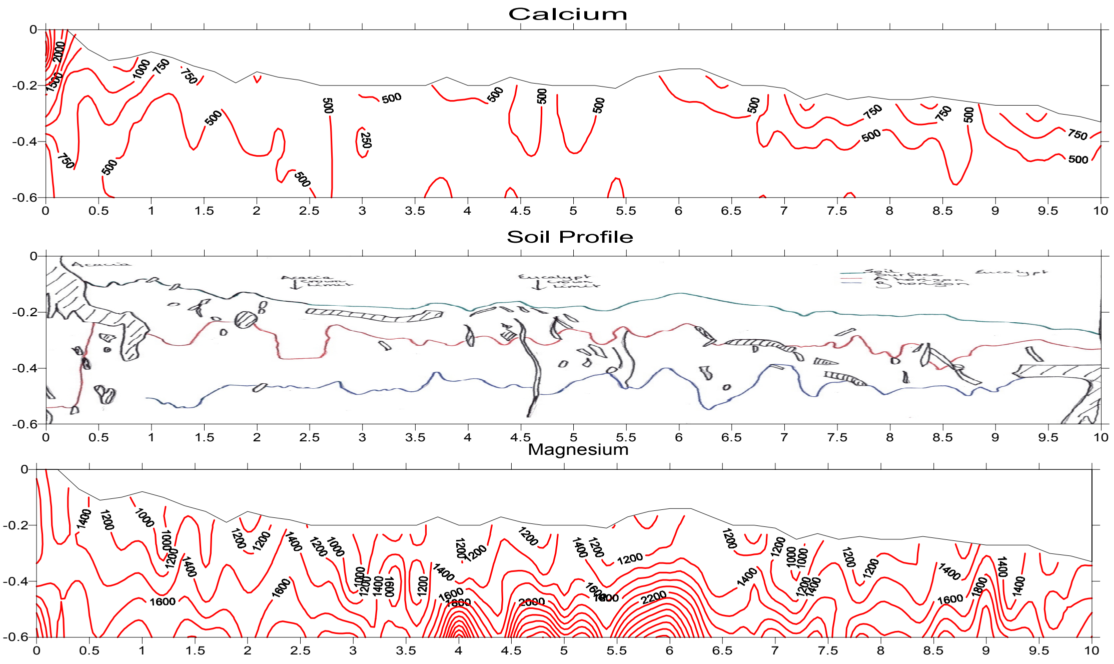

Figure 2: Calcium – Magnesium comparison

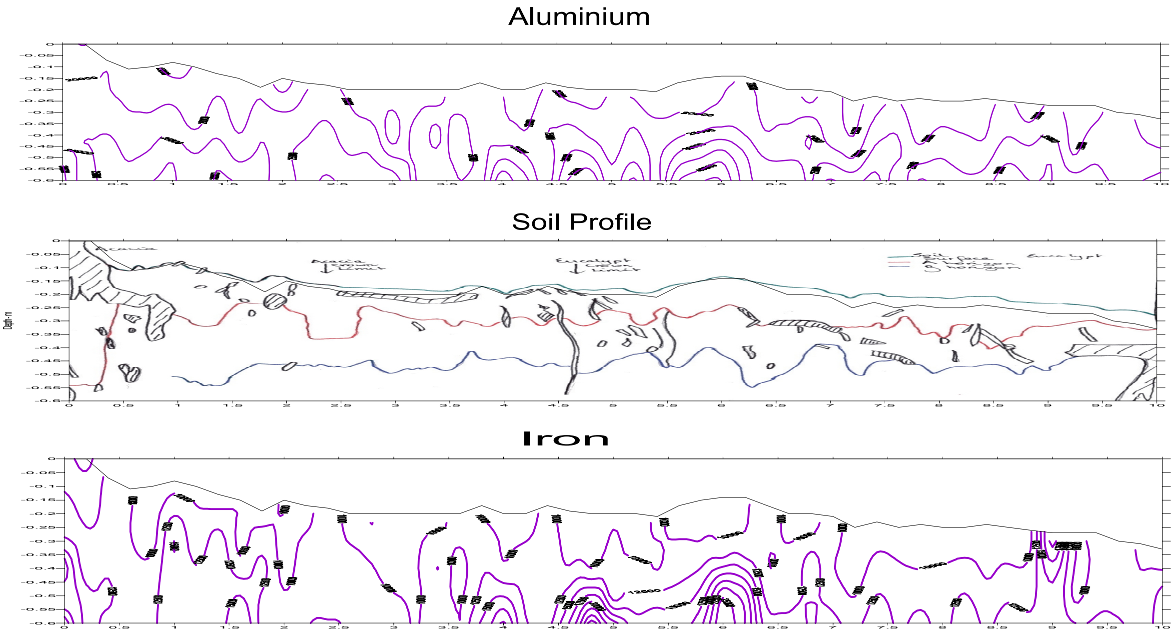

Figure 3: Aluminium and Iron comparison

Magnesium shows high concentration in this area, however, with much lower values measured in the root zones of both trees and the surface soils. It is quite possibly that Ca and Mg are being taken up as nutrients and therefore depleted in the surrounding soil as a result. Aluminium and iron (Figure 3) measure similarly high concentrations in the area least affected by tree root growth and penetration. There is a concentration of Fe in surface soils close to the eucalypt that is not reflected by similar concentrations near the acacia.

DISCUSSION

The acacia has influenced soil development to a greater depth than the eucalypt. This could be due to the greater age of the acacia, and that its decline caused more roots to be shed increasing organic matter in its root zone. This allows for more biotic activity, and increases soil acidity. The sandy clay in the B2 horizon implies a greater breakdown of saprolite in this area, which could be related to the levels of acid in the soil. This agrees with Smith (1969) who observed that root exudates play a role in soil weathering and nutrient availability to the plant.

Soil beneath the eucalypt is less acid because it does not fix N. Also the tree is still actively growing with no evidence of crown loss, providing less organic matter in the soil to influence soil development. The pattern of mineral distribution indicates translocation by both tree species, with each tree species showing a different ability to make use of, and concentrate minerals from the soil in which it grows.

The pattern of influence in the soil agrees with Hamilton's (1972) documentation of influence decreasing with distance from the root zone. This also agrees with other recent studies in the field (Gilkes 1998, Hinsinger & Gilkes1996).

CONCLUSION

The study of vegetation influence on soil development has been limited to a preoccupation with the ability of soils to provide nutrients to agricultural crops. Soil development, tree growth and human activity are measured in different time scales, and this is a limiting factor to experimentation. The present study only looks at summary soil variables. There is scope for further analysis of soil nutrient and nutrient transfer through vegetation on this site. This is only one site. The opportunity exists to continue this type of study with different tree species, and in different climatic zones to see if the influence of trees on soils is consistent. Further study should concentrate on the same species of tree to determine if results were consistent, or continue to consider the influence of different trees to build baseline information with which to compare further studies.

In this undergraduate, summer scholar study, soil was sampled in a linear grid pattern, regardless of its proximity to roots. In future studies, outside the constraints on resources and time restraining this research, it may be beneficial to use a soil sampling pattern that reflects the presence of roots, both large and small, as well as linear sampling along the transect. This will increase the amount of information on the direct effect of roots. Further study will enhance the understanding and interpretation of the relationship between vegetation and soil development, the related effects of root development and the development of regolith.

REFERENCES

ANDERSON G. 2001. *Influence of macro and meso biota on regolith development and evolution in a dry sclerophyll forest*. Honours Thesis, Australian National University, unpublished.

BREEMAN N.V., LUNDSTROM U.S. & JONGMANS A.G. 2000, Do plants drive podzolization via rock-eating mycorrhizal fungi? *Geoderma* **94(2-4)**, 163-171

CORBETT, J.R. 1969. *The Living Soil: the processes of soil formation*. Martindale Press P/L

FIELD J.B. 1981. *The sources of solutes in, and chemical budgets for three small rural catchments in New England, NSW.* Thesis for Doctor of Philosophy, University of New England, unpublished.

GILKES R.J. 1998. Biology and the regolith: an overview. *The State of the Regolith*. Geological Society of Australia **Special Publication 20**, 110-125

HAMILTON C.D. 1972. *The nature and causes of spatial variation in forest ecosystems*. Thesis for Doctor of Philosophy, Australian National University, unpublished.

HINSINGER P., BARROS O., NETO F., BENEDETTI M.F., NOACK Y. & CALLOT G. 2001. Plant induced weathering of a basaltic rock: Experimental evidence. *Geochimica et Cosmochimica Acta* **65(1)**, 137-152.

HINSINGER P. & GILKES R.J. 1996. Mobilisation of phosphate from phosphate rock and alumina-sorbed phosphate by the roots of ryegrass and clover as related to rhizosphere pH. *European Journal of Soil Science* **47**, 533-544.

JEFFEREY D.W. 1987. *Soil-plant relationships – an ecological approach*. CROOM HELM

JOHNSON D.L. 2000. Soils and Soil-Geomorphology Theories and Models: The Macquarie Connection. *Annals of the Association of American Geographers* **90(4)**.

LUCAS Y. 2001. The Role of Plants in Controlling Rates and Products of Weathering: Importance of Biological Pumping. *Annual Review Earth Planet. Science* **29**,135-163.

MITCHELL P. 1988. The influences of vegetation, animals and micro-organism on soil processes. *In:* VILES H.A. ed. *Biogeomorphology.* Oxford Basil Blackwell, p 43-82.

PATON T.R., HUMPHREYS G.S. & MITCHELL P.B 1995. *Soils – a new global view*. Macquarie University UCL Press

POSWA A., DAMBRINE E., POLLIER B. & ATTEIA O. 2000. A comparison between Ca and Sr cycling in forest ecosystems. *Plant and Soil* **225,** 299-310.

WANG Z., GOTTLEIN A. & BARTONEK G. 2001. Effects of growing roots of Norway Spruce (Pica Abies [L.]Karst)and European Beech (Favus sylvatic L.) on rhizosphere soil solution chemistry. *Journal of Plant Nutrition and Soil Science* **164**, 35-41

YOUNG A. & YOUNG R. 2001. *Soils in the Australian Landscape*. Oxford University Press.