BIOLOGICAL AGENTS IN REGOLITH PROCESSES: CASE STUDY ON THE SOUTHERN TABLELANDS, NSW

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INTRODUCTION

Regolith encompasses all materials between hard rock and fresh air and can be argued to include all biota. As the interface between the four spheres, i.e., litho-, atmos-, hydros and bio-sphere, regolith reflects the interactions of both materials and processes from each. As an integral part of regolith, animals, plants and micro-organisms play a vital role in regolith development and evolution. Although organisms have long been recognised in pedology (Jenny 1941), research into the impact of organisms on the regolith is in its infancy. The detachment and transfer of material by the biota—collectively called bioturbation, is one good example of this early stage of research. Through bioturbation, meso- and macro-biota cause changes in the physical and chemical composition of the regolith and soil. To date, many of the interactions taking place are unmeasured and the cumulative effect is unknown. The way in which the results of bioturbation influence other landscape processes is even less well understood. As a result of bioturbation, regolith particles are dislodged, built, broken down, reworked and deposited in a range of different forms from where they originated. They may pass from loose, uncompacted and friable to compact, cemented and erosion resistant, or vice versa.

The amount of material moved and the relative importance of bioturbation occurring in dry sclerophyll forest ecosystems in southeast Australia has not been assessed. In this work, the bioturbation resulting from the activity of ants, mound building termites, earthworms, echidnas, tree uprooting and wombats is investigated in a dry sclerophyll forest at Mulloon Creek on the Southern Tablelands of NSW, Australia.

METHODS

Straightforward and simple methods were employed to measure material transfer. Representative estimates suitable to a reconnaissance study such as this were made on the frequency and distribution of all the organisms active on the study site during initial surveys and the result was the list of organisms mentioned. Then individual examples of episodic processes such as tree fall were individually measured and estimates of frequency and return periods made from available evidence of time since disturbance, age of disturbance, deterioration and destruction. For continuing processes, such as echidna scrapes, wombat burrowing and termite mound construction, small plots were monitored over periods of a month across the seasons. Earthworm populations were sampled and literature based calculations of volumes made. Results were extrapolated up from plots to the hillslope scale and then to catchment estimates based on landscape proportions and the frequency and distribution survey data. Simple geometrical calculations were made to estimate volumes from voids and mounds or heaps. Bulk densities of regolith materials were assumed to be more or less constant, during and after bioturbation.

RESULTS

The density and distribution of biotic activity in dry sclerophyll forests is somewhat surprising (Table 1).

Table 1: The density and distribution of biotic activity at Mulloon Creek.

Biota	Density (ha^{-1})	Distribution*
Ant mounds	51.6	Agg. to Conc.
Earthworms	16,730.0	Aggregated
Echidna scrapes	25.0	Concentrated
Termite mounds	0.8	Concentrated
Up rooted trees	29.0	Uniform
Wombat burrows	1.2	Concentrated

* Measures of distribution are defined as follows:
Aggregated = found at only 1 or 2 sites across the study area;
Concentrated = activity concentrated in particular environments on the site;
Uniform = occurred over the entire study area.

However, the relative size of the individual transfer of materials reflects perceptions of bioturbation (Figure 1).

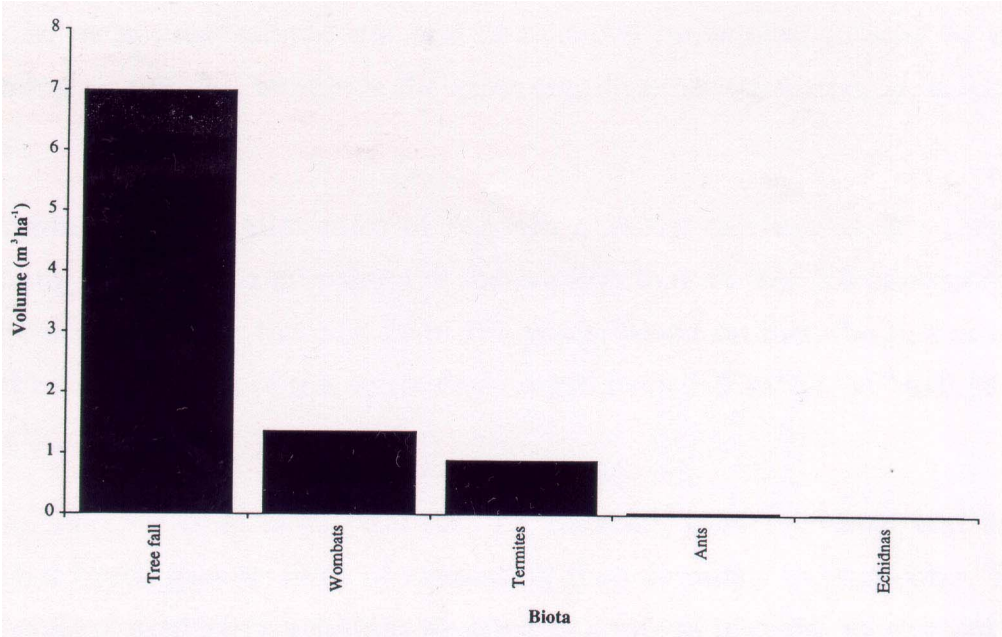

Figure 1: The relative total volumes of material disturbed per hectare as a result of bioturbation at Mulloon Creek.

The impact of bioturbation on the regolith and in particular on soil formation varies by agent (Table 2).

Table 2: Summary of the impacts of bioturbation by ants, earthworms, echidnas, termites, trees and wombats on the regolith and regolith materials.

Biota	Structure	Depth* (cm)	Impact
Ants	Mound	~10 (6 - 30)	Structural change of surface horizons
Earthworms	Casts	6 (0 - 15)	Mixing of A_1 horizon
Echidnas	Pit and spoil	8 (4 - 11)	Disturbance of surface layer
Termites	Cemented mound	30 (20 - 50)	Partial inversion of soil horizons
Tree fall	Pit and mound	20 (5 - 42)	Inversion of soil horizons
Wombats	*Burrow and* spoil pile	*(30 – 240)*	*Excavation of B and B/C* horizons

*Depths are given as averages with the range presented in brackets.

The primary effect of ant nest building activity is a mixing of the top 6 to 30 cm of the soil. Construction of mounds, chambers and tunnels changes the fabric of soil, reduces bulk density and provides sites for increased water infiltration and aeration. At Mulloon Creek ants moved material at 0.03 to 0.04 $m^3ha^{-1}yr^{-1}$. The activity of these earthworks leads to incorporation of organic material into the mineral soil and homogenisation of the top 5 to 15 cm of the soil profile, but population densities are very low on average in dry sclerophyll forests and the activity is seasonal and is concentrated only in small areas of alluvial soils where conditions are suitable for earthworms. Echidna activity moved material at a rate of 0.07 to 0.08 $m^3ha^{-1}yr^{-1}$. The result of this activity is a mixing or mineral soil with litter, increasing decomposition and enhancing A horizon formation. Material including topsoil, subsoil, saprolite and rock is moved at a rate of 0.07 to 0.01 $m^3ha^{-1}yr^{-1}$ by the action of tree uprooting to an average depth of 20 cm (Figure 2). The upheaval and deposition of this material onto the soil surface results in an inversion of soil layers. In construction of burrows, wombats move B and C horizon material at an estimated rate of 0.08 to 0.13 $m^3ha^{-1}yr^{-1}$ and expose it to surface processes so that it is readily eroded and moved across the landscape. As a result, wombat activity has a significant impact on erosion and landscape evolution.

Figure 2: An uprooted *E. mannifera* showing the spread of rock material caused by lifting of roots.

DISCUSSION

In comparison to other soil and regolith-forming and -moving processes, bioturbation is significant. Soil material in the top 30 cm of the profile is turned over by bioturbation in 6 to 10 k.y., which is less than the time for the formation of soil calculated for a site east of the study (20 to 100 k.y.) (Heimsath *et al*. 2000). The total volume of material added to the surface through bioturbation of 0.03 to 0.04 mm yr^{-1} is greater than the calculated average rate of erosion on the Southern Tablelands (0.01 mm yr^{-1}) (Bishop 1985, O'Sullivan *et al*. 1996, Young 1983). Therefore, on average, a majority of the regolith material overturned by biota remains at the site and contributes to soil production *in situ*.

CONCLUSION

Thus through the turnover of material, disruption of particles, alteration of fabric and exposure of fresh material to further chemical, physical and biological processes, bioturbation makes a significant contribution to regolith evolution in dry sclerophyll forests. Some of theses processes lead to greater horizonation in the solum such as earthworms and echidnas, while others such as wombats, termites and tree uprooting break down the differentiation into horizons.

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