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The role of soil biodiversity in providing ecosystem services

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Cover image

Cravens Peak Reserve, QLD
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Preface

This report was developed for the Department of Sustainability, Environment, Water, Population and Communities to help inform the Australia State of the Environment (SoE) 2011 report.

The Minister for Environment is required, under the *Environment Protection and Biodiversity Conservation Act 1999*, to table a report in Parliament every five years on the State of the Environment.

The Australia State of the Environment (SoE) 2011 report is a substantive, hardcopy report compiled by an independent committee appointed by the Minister for Environment. The report is an assessment of the current condition of the Australian environment, the pressures on it and the drivers of those pressures. It details management initiatives in place to address environmental concerns and the effectiveness of those initiatives.

The main purpose of SoE 2011 is to provide relevant and useful information on environmental issues to the public and decision-makers, in order to raise awareness and support more informed environmental management decisions that lead to more sustainable use and effective conservation of environmental assets.

The 2011 SoE report, commissioned technical reports and other supplementary products are available online at www.environment.gov.au/soe.

Soil Biodiversity

This is the first time soil biodiversity has been considered in the context of State of the Environment reporting, and there has been little impetus to collect data on status and trends. However a start was made some years ago on consolidating national information on major groups of soil invertebrates with the anticipation that it may provide a starting point for SoE reporting purposes (Woodman et al., 2008).

The role of soil organisms in effecting important ecosystem processes is widely known and well documented, including soil formation, decomposition and nutrient cycling, carbon and nitrogen fixation and sequestration, infiltration, purification and storage of water. What is less known is that it is the bacteria that are responsible for by far the greatest diversity of biogeochemical transformations of any group of organisms. Truly, bacteria are the chemical factories that underpin the soil ecosystem. By way of contrast, most eukaryotes - organisms with cells possessing a nucleus and nuclear envelope - are capable only of fixing carbon or breaking down complex organic matter. But they have other roles to play that affect the physical nature of the soil ecosystem. The invertebrates, especially the larger arthropods, play critical roles in burrowing, drilling, mixing and processing the soil substrate: filling its matrix with a spatial complexity of networks of burrows, pores, tunnels and tubes, sometimes lined with silk or mucus. These so-called 'ecosystem engineers' provide access for the water and air to the soil that are critical requisites for biogeochemical reactions to occur. Other arthropods harvest organic matter and build compost heaps in their nests and burrows, inoculating them with fungi to break down otherwise intractable plant material into food for their colonies.

In recent years we have begun to recognise that far more than the traditional suite of soil organisms is responsible for processes that underpin the health and function of the soil ecosystem in Australia. Soil ecosystem engineers include several groups of spiders, colonially-nesting bees, and various wasps, crickets, beetles, centipedes, cockroaches, millipedes and scorpions, as well as the much better-known termites, ants and earthworms. Some of these lesser-known soil inhabitants spend most of their lives underground; others, like the bees and wasps, do so only in order to lay their eggs and provision brood cells with food for their young in deep burrows that they drill into soils that are often very hard and compacted. In so doing, they greatly increase the interception and infiltration of rainfall and runoff, greatly enhancing the capacity for local soil water recharge. And it has been found that this important ecosystem function can be restored in less than a decade to degraded grazing soils through revegetation of landscapes (Colloff et al., 2010). A new and exciting discovery is that presence of ants and termites in certain cropping soils has a direct effect on improving yields of wheat (Evans et al., 2011, in press). This is achieved through the ecosystem engineering action of ants and termites in improving water infiltration into the soil in the root zone, and reducing loss of soil mineral nitrogen.

It should come as no surprise that Australian soils have a high diversity of temporary and permanent inhabitants from amongst the arthropods, as opposed to the earthworm-dominated soils of many parts of the Northern Hemisphere. In Australia, earthworms are largely confined to higher rainfall regions, whereas ants and termites are much more widespread. Exotic earthworm species dominate many higher rainfall agricultural soils (Woodman et al., 2008). Arthropods have evolved far more diverse

and effective mechanisms than soft-bodied organisms for maintaining body water balance, a critical physiological attribute on the driest inhabited continent on earth. And laying eggs in deep, narrow burrows is a strategy that confers multiple benefits: protecting reproductive investment from the effects of predation and desiccation and allowing for provisioning. By a paradox of physics, water vapour moves along a pressure and temperature gradient from the warmer surface into the cooler burrow, so that high humidity is maintained for the vulnerable developing brood.

Several soil invertebrates are considered of conservation significance, including the giant Gippsland earthworm, massive mound building termites, the honeypot ant and several burrowing spiders. But the distribution and abundance of these organisms is still relatively poorly known and specific conservation management needs that go beyond simply maintaining habitat integrity have not been developed.

Other soil organisms are important invasive species. These include several exotic earthworms and termites, the yellow crazy ant, the red fire ant and the tropical fire ant. All of these have the capacity to displace native species, reduce biodiversity, disrupt food webs with implications for various ecosystem functions and processes, though their nature and magnitude is not well defined.

The major threatening process for soil biodiversity, like many other organisms include habitat loss and fragmentation (Fahrig, 2003), but it is too simplistic to state that agricultural production in general has been the major contributor to habitat loss for soil organisms. The largest areas of production of land in Australia are arid and semi-arid rangelands, where impacts of grazing on soil biodiversity are likely to be negligible compared with impacts of intensive, high-input cropping systems, for example. Tillage practices that result in loss of soil water represent an important threatening process for soil organisms as well as depletion of carbon stocks. Improved tillage that returns crop residues may improve soil biodiversity, carbon stocks and water holding capacity. At a time when carbon storage on agricultural land is a major issue (Sanderman & Baldock, 2010), it may prove to be that soil organisms are major beneficiaries from management practices aimed at soil carbon sequestration and storage. Recent work has highlighted the impact of agricultural land use practices on diversity and abundance of functional groups of soil bacteria (Lyndsay et al., 2010), highlighting the need to consider a broader conservation framework that includes the protection of ecosystem processes and functions as well as biodiversity.

References

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