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Applying soil science for restoration of post mining degraded landscapes in semi-arid Australia: challenges and opportunities

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Introduction
Current challenges in ecological restoration of post mining environments include the deficit of original topsoil which is frequently lost or damaged, and the lack of soil forming materials. A comprehensive knowledge of soil properties and processes and an adequate management of soil resources are critical to improve the restoration success of these degraded areas. In particular, understanding soil physical, chemical and biological parameters is decisive in environments where water is a limiting factor for seedling establishment and plant survival. To improve the restoration success of biodiverse semi-arid areas disturbed by mining activities (Pilbara region, Western Australia), we conducted experiments to (i) analyse changes in soil physico-chemical properties and soil microbial activity of topsoil stockpiles to optimise its handling and minimise deterioration of nutrients and soil biota, (ii) test climate effects on seedling emergence of native plant species and (iii) assess the potential of mine waste materials as a suitable growth medium for seedling emergence of native plant species under various water regimes.

Methods
The experimental studies were conducted in controlled environment facilities where air temperature, relative humidity and soil moisture were monitored routinely. Watering regimes were selected to represent rainfall patterns of the area. As a growth media we used material obtained from topsoil stockpiles and waste materials from an active mine site, which were mixed at different ratios. Samples were collected from different parts of the topsoil stockpiles and analysed to determine physical, chemical and biological properties.

Results
No large discrepancies in physical and chemical values were detected at different positions of the stockpiles. However, microbial activity was highly variable, particularly inside the stockpiles. Seedling emergence on topsoil growth media was highly dependent on climate factors with emergence rates varying significantly ($P < 0.001$) across species. Highest emergence rates were obtained for Acacia adoxa and Grevillea pyramidalis in the 30°C scenario and adequate soil moisture levels (mean % $\pm$ SE 71 ± 5.3 and 80 ± 3.8 respectively). With available water, emergence was above 30% for all species and growth media types (topsoil, waste and mixes of topsoil and waste at 50:50 and 25:75 ratios). However, under drought conditions, emergence severely decreased for all species. In particular, Gossypium robinsonii and Grevillea pyramidalis did not show any response with less than 50% of topsoil in the composition of growth media. Our results suggest that changes in precipitation regimes can have a critical effect on seedling emergence of native plant species from the Pilbara. Understanding soil physico-chemical properties of soil materials and changes in soil moisture related to rainfall patterns and growth media blends are crucial to predict the success of seedling emergence and ultimately achieve biodiverse restoration in semiarid areas.

This research is part of a broader multi-study approach, the Restoration Seedbank Initiative project, a partnership between The University of Western Australia, BHP Billiton Iron Ore, and Kings Park and Botanic Garden.

Keywords
Pilbara region, biodiverse ecosystems, soil microbial activity, topsoil stockpile, dry environments, land rehabilitation.