Rehabilitation research in mineral sands mining: the challenge in Eneabba kwongan

Mark P. Dobrowolski (1,2)

1) Iluka Resources Ltd, Perth WA 6000, Australia

2) School of Plant Biology, The University of Western Australia, 35 Stirling Hwy, Crawley WA 6009, Perth, Australia

Correspondence: Mark Dobrowolski, mark.dobrowolski@iluka.com

Rehabilitation context: Iluka Resources is rehabilitating land to native vegetation following mineral sands mining at Eneabba, 250 km north of Perth, Western Australia, with the aim of returning a functioning kwongan ecosystem. Kwongan, meaning "sand-plain" in the indigenous Noongar language, is a term used for the botanically diverse, low heath vegetation occurring on the sand-plains of WA. Rehabilitation of post-mining areas in the Eneabba kwongan began in 1977; since then, approximately 1500 ha has been rehabilitated to native vegetation with 850 ha in planning. Research on rehabilitating the vegetation, soils and fauna has been invaluable to the operational program, but also to increasing our understanding of kwongan vegetation, landscape and ecosystem. This paper will present an historical review of these rehabilitation research themes and how future research, grounded in validated ecological theory, will aid rehabilitation practice.

Historical research themes: Initial research focussed on the immediate methodological difficulties of rehabilitation. These included stabilising the reconstructed soil surface against wind erosion in the hot, dry, windy summers of Eneabba (Bell et al. 1986), sourcing seed for broadcast and propagation, and nutrient allocation and cycling in kwongan vegetation and rehabilitation (Bell & Lamont 1990). Practical solutions have developed although these fundamental challenges remain. For example, harvest of kwongan vegetation shoots and spread of this mulch on rehabilitated ground stabilised the surface against wind erosion, provided niches for seed germination and organic matter to initiate nutrient cycling, and also distributed seeds of key species, many of which are serotinous/bradysporous. This practice ceased due to concerns of the harvesting impact to off-mine path vegetation; there being no new mining activity in kwongan vegetation, which can provide mulch resources from areas destined to be cleared. Surface stabilisation must now be provided by a nurse crop of *Secale cereal* (rye), which although not weedy, shows allelopathic effects on germinating seed. Seed collection and broadcast provides seedling recruitment of serotinous species, although a distance-defined local provenance for seed collection restricts access to this resource. Topsoil seed stores provide complementary species to the rehabilitated vegetation although far fewer seedlings recruit from topsoil compared to the mulch of serotinous species (which are now collected and broadcast). In addition, as topsoil ages in stockpiles it becomes depauperate in both seed (Bellairs & Bell 1993) and beneficial microorganisms (Jasper 1995), and aging selectively favours hard-seeded species such as *Acacia blakelyi*, a woody species that can dominate rehabilitation areas.

In addition to the challenges of obtaining propagules, many species are recalcitrant (cannot be propagated easily from seed or vegetatively) and have been the subject of research on propagation and dormancy breaking (Meney et al. 1990; Dixon & Nielsson 1992; Meney et al. 1993; Scaffidi et al. 2011). Species from the *Cyperaceae, Restionaceae* and *Ericaceae* form the majority of these recalcitrants, with the former two families representing a plant life-form largely absent from rehabilitated vegetation in comparison to undisturbed kwongan. Innovative methods being trialled at Eneabba for transferring largely intact vegetation within topsoil profiles could address recalcitrant species loss from rehabilitated vegetation. Once established, rehabilitated vegetation should be resilient and responsive to periodic disturbance that a functional kwongan ecosystem encounters. Wildfire is the key disturbance. The vegetation dynamics after fire (purposefully lit) have been investigated in rehabilitation and adjacent kwongan vegetation (Herath et al. 2009). More recent wildfires at Eneabba will allow further research on this resilience.

Dobrowolski, M.P. 2014. Rehabilitation research in mineral sands mining: the challenge in Eneabba kwongan. In: Mucina, L., Price, J.N. & Kalwij, J.M. (eds.), *Biodiversity and vegetation: patterns, processes, conservatio*n, pp. 29-30. Kwongan Foundation, Perth, AU.

The research focus at Eneabba has not been exclusively on vegetation and its ecology. Invertebrate fauna studies using ants as bio-indicators revealed rapid return of species, with comparable species richness in rehabilitated and control sites, although functional group profiles of ants were not equivalent (Bisevac & Majer 1999). Soil investigations have also featured in research at Eneabba, including assessment of the soil structural development in tailings, and soil water modelling to estimate profile depth to support kwongan vegetation through periodic drought. Soil factors, given their importance to species filtering in vegetation community assembly, deserve greater research attention.

Future research for rehabilitation practice: Future research at Eneabba will necessarily include the practical aspects of rehabilitation, for example, trialling alternative stabilisation methods prior to their broad-scale adoption, and the long-term effectiveness of the delivery method of plant propagules for field recruitment and survival of seedlings. As well as this applied research that can be quickly implemented to solve the immediately obvious and practical problems, successful rehabilitation practice requires a foundation in fundamental ecological theory. Future research on this theme at Eneabba will test models of plant community assembly using a plant functional trait perspective, and an understanding of the key environmental drivers. Such research will help inform plant species selection for rehabilitation, particularly in historically backfilled areas with greater alteration of soil conditions. Research in ecological theory will also allow a more realistic appreciation of the likely outcomes of rehabilitation, and assist in setting achievable targets for re-instating a functional ecosystem.

Acknowledgements: The author is grateful for the helpful comments of Cameron Payne, Anél Joubert and Rob Brown.

References

Bell, D.T., Carter, D.J. & Hetherington, R.E. 1986. Experimental assessment of wind erosion after soil stabilization treatments at Eneabba, Western Australia. *Environmental Geochemistry and Health* 8: 99–104.

Bell, D.T. & Lamont, B.B. 1990. *Plant and soil ecology of natural areas and rehabilitated minesites near Eneabba. Report No. 45. Project No. 43.* Minerals and Energy Research Institute of Western Australia, East Perth, AU.

Bellairs, S.M. & Bell, D.T. 2008. Seed stores for restoration of species-rich shrubland vegetation following mining in Western Australia. *Restoration Ecology* 1: 231–240.

Bisevac, L. & Majer, J.D. 1999. Comparative study of ant communities of rehabilitated mineral sand mines and heathland, Western Australia. *Restoration Ecology* 7: 117–126.

Dixon, K.W. & Nielsson, G. 1992. *Post mining re-establishment of native heaths (Epacridaceae). Report No. 94. MERIWA Project No. M129.* Minerals and Energy Research Institute of Western Australia, East Perth, AU.

Herath, D.N., Lamont, B.B., Enright, N.J. & Miller, B.P. 2009. Impact of fire on plant-species persistence in post-mine restored and natural shrubland communities in southwestern Australia. *Biological Conservation* 142: 2175–2180.

Jasper, D. 1995. *Soil microbiology for revegetation incorporating field inoculation with VA mycorrhizal fungi. Report No. 147. AMIRA Project No. 257A and MERIWA Project No. M204.* Minerals and Energy Research Institute of Western Australia, East Perth, AU.

Meney, K.A., Dixon, K.W., Pate, J.S. & Dixon, I.R. 1990. *Rehabilitation of mining affected flora. Report No. 66. MERIWA Project No. 98.* Minerals and Energy Research Institute of Western Australia, East Perth, AU.

Meney, K., Dixon, K. & Pate, J. 1993. *Propagation and post-mining establishment of native rush and sedge species. MERIWA Report No. 121. Project No. M158.* Minerals and Energy Research Institute of Western Australia, East Perth, AU.

Scaffidi, A., Flematti, G.A., Nelson, D.C., Dixon, K.W., Smith, S.M. & Ghisalberti, E.L. 2011. The synthesis and biological evaluation of labelled karrikinolides for the elucidation of the mode of action of the seed germination stimulant. *Tetrahedron* 67: 152–157.

Construction of the vegetation direct transfer (VDT) trial at Eneabba, Western Australia. Excavator cut **(A)** and direct placement **(B)** of ~30 cm soil with largely intact kwongan vegetation. Photos: C. Payne.