Iron-clad partnerships essential for restoring banded ironstone communities

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Right: Mining has cut back into the north-west slopes of the Koolanooka Hills Threatened Ecological Community. Photo: Luis Merino-Martin

Left: Ben Miller, Davide Abate and Lucy Commander conducting a vegetation survey of BIF vegetation community. Photo: Luis Merino-Martin

For the past six years, scientists and students at Kings Park have been engaged in research to develop a comprehensive restoration plan for Sinosteel Midwest Corporation (SMC) iron ore mining operations east of Morawa in the Koolanooka Hills. Given the mine is located in a Threatened Ecological Community (TEC), SMC recognised the importance of achieving successful rehabilitation in an environmentally sensitive area. SMC was also serious about meeting its regulatory obligation that required 70% of the original species diversity for mining impacted areas to be re-established.

The partnership with SMC is one of Kings Park's most comprehensive restoration partnerships, providing research that underpins the practical restoration necessary to restore plant species of banded ironstone formations following mining. The project also has an ambitious goal, to not just revegetate a mine, but to actually restore a TEC on ironstone ranges.

Small, ancient ironstone ranges that are floristically distinct from surrounding vegetation communities present a substantial challenge for restoration scientists. These ironstone ranges that occur on the edge and beyond of the South West Australian Floristic Region (Gibson et al. 2012) contain banded iron formations (BIF) that are attractive for mining.

Ellery Mayence and Luis Merino-Martin preparing to install soil moisture probes into soil profile of typical BIF vegetation community. Photo: Lucy Commander

Luis Merino-Martin inspects a 'Gerlach' run-off plot after installation. Photo: Davide Abate

Rainfall simulator being used to measure runoff on waste dump slopes. Photo: Luis Merino-Martin

In fact, Australia's first iron ore was mined and exported in 1966 from BIF at Koolanooka Hills, 19 km east of Morawa. An explosion in global demand for iron ore has seen mining expand onto many of these unique ranges. Many plant and animal species found on these ironstone ranges occur nowhere else (that is, they display a high level of endemism) and this means there is an enormous challenge to balance species conservation with the economic value of the mineral resources upon which they are situated (Gibson 2012) and to develop restoration protocols for so many species of plants. It is therefore imperative that research be conducted on how to return this unique flora associated with ironstone ranges after cessation of mining.

Restoration is a key action for re-establishing lost biodiversity and ecological function in disturbed landscapes. Restoring ecological communities following mining is particularly challenging, as new landforms are often created and soils are physically different because they may have been taken from several metres below the original soil surface or have altered chemistry. In the semi-arid zone, limited water availability due to low and erratic rainfall is an issue that makes restoration even more challenging, as it limits the availability of seed that can be collected and the success of plant recruitment and survival.

Seed mix prepared for sowing.

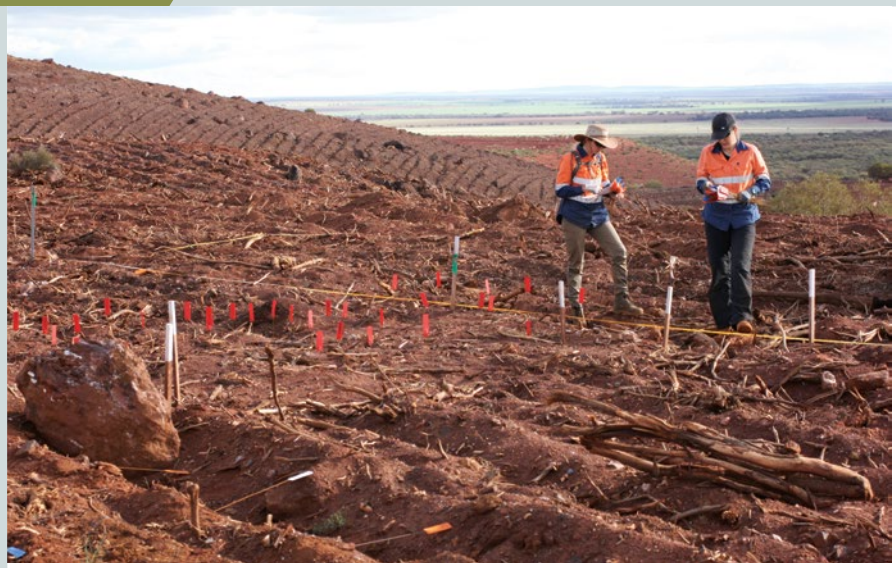
Peter Golos spreading seed mix onto plots. Photos: Lucy Commander

The first step in undertaking any restoration project is to set targets. Although SMC was required to replace 70% of the original diversity, we needed to determine exactly how many species needed to be replaced and which species were suitable. To develop this number, an area of natural vegetation in the TEC, adjacent to the Koolanooka mine (affectionately known as Kooli) was surveyed to determine species present and plant density in a 7 ha area. This area was equivalent to the TEC restoration trial area and the design ensured that targets for restoration on the waste rock dump were scale appropriate.

Once we had a target list of species, we developed the appropriate methods for their return. These included natural recruitment through seed dispersal, utilising the topsoil seedbank, sowing wild collections of seed, or planting tubestock grown from seed or cuttings. A combination of field, glasshouse and laboratory experiments identified and optimised the methods of return for each species.

One of the many challenges at the site was the limited amount of topsoil available to restore areas that were larger than the areas cleared. Topsoil contains the soil seed bank and is typically cleared and stockpiled prior to mining. With a topsoil deficiency the use of supplementary soil substrates and their influence on plant recruitment was investigated.

The use of different seed technologies such as (left) seed pelleting and (right) seed priming were tested at Koolanooka. Photos: Lucy Commander



Top: Arielle Fontaine and Rachel Ord placing pin tags to help identify species and treatments applied for planting and seeding. Photo: Lucy Commander

Centre: With the irrigation system installed Anthea Challis, Arielle Fontaine and Rachel Ord prepare tubestock for planting. Photo: Peter Golos

Bottom: Experimental plot completed after tagging, planting and seeding. Photo: Lucy Commander

Physiochemical and hydrological soil traits of topsoil, waste rock and a mining by-product (fines) were experimentally tested. Not surprisingly, seedling emergence was greatest from topsoil. Seedling emergence in a substrate that combined waste rock and topsoil was also a suitable substrate, hence mixing waste rock with topsoil may be a useful technique to maximise the coverage of topsoil over larger areas, however, the topsoil seed bank will be diluted and additional seeding and planting will be required.

Growing plants on the fringes of the northern Wheatbelt is challenging for both farmers and restoration ecologists. The large variability in annual rainfall means that relying on natural rainfall alone can be very risky and our preliminary irrigation trials indicated exactly this. We decided to include irrigation (tubestock and seeding) in our restoration trial to supplement the winter rainfall. As we were limited to the quantity of water available for irrigation and the amount of seed available for seeding we decided to concentrate these resources on a concept termed a 'resource island'. Our field results showed irrigation improved seedling emergence up to ten-fold. Also, there was 30-90% survival of tubestock with just a single watering at time of planting.

We were interested in plant health and so undertook a number of ecophysiological measurements on plants in both the restored and undisturbed areas. This will help us compare plant performance in restoration site to reference site and identify if there are any constraints to plants accessing soil water in restoration sites. Longer-term monitoring will help inform us as to the resilience of restored vegetation. The good news is monitoring to date has found that plant performance is better in the restoration site than in the reference site, because there is a greater amount of soil moisture stored near the surface compared to the intact reference system.

A number of honours students have been mentored during the research program, including Erin Picken (BIF vegetation communities found at Blues Hills); Clare Courtauld (germination and emergence of several species under water stress); Sarah Boys (seed priming, a seed pre-treatment to increase germination speed); and Marlee Starcevich (seed coating technology to overcome abiotic limitations to emergence and to more easily facilitate mechanised seeding).

This five-year research project has been one of the largest completed by Kings Park with five scientists and five technicians employed on the project at various times, and in-kind support from numerous others. The project was truly multidisciplinary, including seed scientists, restoration ecologists, ecohydrologists and ecophysiologists. The scientists also worked alongside SMC's senior management (Executive General Manager, Stuart Griffiths, Environment and Approvals Manager, Wayne Ennor and Environmental Superintendent, Stephen Neill) and various consultants, to develop completion criteria, direct seed collection efforts, improve management of the precious seed resource, develop seed mixes and interpret the restoration monitoring data.

All research scientists and technical assistants involved in this project have provided SMC valuable and significant research findings with practical outcomes including the production of a restoration manual for their use in ongoing and future vegetation restoration work on their tenements.

Importantly for SMC, we have demonstrated at Koolanooka that at least 70% restoration of TEC species can be achieved with best practice restoration. It has been a great opportunity for science to directly inform the practice of ecological restoration following mining.

Given the success of the project, SMC has committed to a further five years of research with Kings Park and other partners. Also, SMC is proud to support additional publication of research papers, which will further contribute significantly to the conservation and restoration of Western Australia's unique flora. ■

Additional reading

Gibson N, Meissner R, Markey AS, Thompson WA (2012) Patterns of plant diversity in ironstone ranges in arid South Western Australia. Journal of Arid Environments 77, 25-31.

Above: Monitoring restoration sites brings pleasures such as *Schoenia cassiniana*. Photo: Arielle Fontaine

Below: Koolanooka TEC offset site 16 months after commencing the restoration trial. Photo: Peter Golos