CENTRE FOR LAND REHABILITATION NEWSLETTER

The University of Western Australia

CENTRE FOR LAND REHABILITATION

October 2006

Introduction

The last few months have been extremely busy for the Centre for Land Rehabilitation (CLR). The CLR organised a course on Landscape Function Analysis, as well as an international workshop on Biology and Covers Design. This workshop was followed by the First International Seminar on Mine Closure, a large international event which the CLR co-hosted with the Australian Centre for Geomechanics. As this Newsletter is going to press, Dr Chris Walker, a visiting scientist from the UK, is giving a course on Arbuscular Mycorrhizal Fungi. More on these events below.

A number of interesting research projects have been launched this year with assistance of an ARC linkage grant. Details of these projects can also be found below.

Staff Changes in the CLR

Yinglong Chen, a PhD graduate from Murdoch University, joined the CLR in June 2006 to work on a forest rehabilitation project with Worsley Alumina Pty Ltd until the end of the year. One of his responsibilities is to identify nutrient deficiencies in mine spoil for the establishment and growth of selected native tree species. He is involved in an Australian Flora Foundation project to assess the importance of mycorrhizal fungi in native perennial legumes with potential in agricultural production, and assisted in examining AM fungi in Jarrahdale soil. Before moving to Australia in 2002, Yinglong had obtained 12 research projects from various funding sources, such as the ACIAR, ITTO, IFS, CIFOR and APP, during his employment within the Chinese Academy of Forestry. He played a leading role in some of the research on mycorrhizal symbiosis in China and produced a number of publications, including 4 books which are being used as standard references by Chinese audiences. His interests include cultivation and conservation of commercial forest mushrooms, diversity and functions of mycorrhizal fungi in ecosystems, development of inoculation technology as well as its applications in forest plantations, plant restoration and land rehabilitation.

Dr Emmanuel Mapfumo, Faron Mengler and Annelies de Ruiter have recently left the CLR. We wish them all the best for the future!

Biology and Covers Design Workshop

A workshop on *Biology and Covers Design* was held on Tuesday 12th September, 2006, immediately preceding the inaugural Mine Closure Conference at Perth's Sheraton Hotel. The workshop was extremely well attended with approximately 75 participants, limited only by the workshop format restriction on numbers.

The workshop comprised 6 formal lectures describing several fundamental factors relating to the implementation of an appropriate cover for mine site rehabilitation purposes. These included Engineering aspects (Dr Andy Fourie; UWA); Soil fertility (Dr Mark Tibbett; UWA); Faunal ecosystems (Dr Alister Spain; JCU); Root integrity and water use (Dr Erik Veneklaas, UWA); Floral ecosytems and utilisation (Dr Anita Diaz, Bournemouth Uni, UK), and Criteria for rehabilitation planning (David Tongway; ANU).

During the information transfer of these knowledge areas, several key themes and questions emerged throughout the day which included:

- Is engineering driving closure; or closure driving engineering?
- Is water a problem to be managed or a resource to be exploited?
- How deep should a soil cover be?
- What should dominate: engineering or biology?
- How much does biological development impinge on engineering principles?
- How long should trials on cover be monitored?

These points were explored further in an open forum discussion led by a panel comprising the invited speakers at the end of the workshop to identify priority areas warranting further attention. This session attracted excellent participation of delegates. There was general consensus that the success of closure be based on local environmental parameters. The duration of the closure period and in turn the length of research projects addressing this issue and how these might be resourced attracted good discussion. It was concluded that the 1-5 year term of current projects is probably too short to fully assess the rehabilitation of many Australian landscapes. However, there was no definitive answer to the issue of funding longer term projects.

The very high interest in *Covers* was demonstrated by the productive discussion amongst delegates throughout the workshop and the number of other interested parties unable to attend due to limitation on workshop numbers clearly reflects the potential to re-schedule a subsequent workshop.

Dr Paul Greenwood, Senior Research Fellow, CLR

Biology and Covers Design Workshop, 12th September 2006

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New Research Projects for 2006

The CLR launched the following research projects this year with funding from ARC linkage grants.

How does soil fertility affect jarrah forest rehabilitation after mining? This project will examine the effect of fertiliser additions on the species composition and functional diversity of jarrah forest that develops after bauxite-mining. It is directly relevant to the achievement of the sustainable use of natural resources in Australia. Expected outcomes are best-practice management guidelines regarding the amount of fertiliser that results in the most effective achievement of completion criteria, and also an improved understanding of the consequences of fertiliser application on the biodiversity (plants and soil biota) and ecosystem function of rehabilitated forest ecosystems.

Phosphorus - A Key Factor in the Development of Novel Perennial Herbaceous Deep-rooted Pasture Legumes This research aims at the development of urgently needed perennial pasture legumes, to expand perennial pasture options for southern Australia beyond lucerne. The development of new deep-rooted perennial pasture legumes has enormous potential to improve nutrient and water use over large areas of agricultural land. Benefits in terms of reducing soil erosion and acidification are also likely. An understanding of the responses of new perennial legumes to soil phosphorus is a prerequisite for the development of new perennial farming systems. Overall, both environmental and financial benefits will accrue at scales ranging from individual farmers and rural industries through to the general community.

Novel strategy for optimising fertilizer input coupled with organic residue management for sustainable reconstruction of jarrah forest ecosystem

This project is aimed at judicious management of the rehabilitation process following surface mining by reducing initial fertilizer input along with using organic residue accumulated following pre-mine clearing of vegetation. This approach has the potential for 'speeding-up' the ecosystem development process by initiating early microbial development in rehabilitation practice and reducing the deleterious effect of heavy fertilization. Apart from these ecological advantages, reducing fertilizer application lowers minesite rehabilitation cost incurred by mining companies. This project will be the first attempt to use organic residue and streamlining the use of mineral fertilizers in mine rehabilitation practice.

Dr Mark Tibbett, Director CLR

Arbuscular Mycorrhizal Fungi

Since 17 August, Dr Chris Walker, formerly of UK Forest Research, has been the recipient of a Gledden Senior Visiting Fellowship to work with CLR on mycorrhizal fungi associated with minesite rehabilitation. He currently runs an independent laboratory carrying out research into mycorrhizal fungi. Arbuscular mycorrhizal (AM) fungi are a major part of the soil biota, and the CLR research is aimed at discovering isolates of these organisms that might be used to enhance establishment of seedlings in rehabilitation sites.

In August, Chris collected material from rehabilitation of various ages at Jarrahdale. Unlike many fungi, those forming AM will not grow on nutrient agar, but must be in symbiosis with a host plant. Consequently, the Jarrahdale samples have been used to inoculate host plants in pots by mixing the soil with a sterilised sand substrate and adding seedlings. These "pot cultures" were then placed in sealed systems and will be allowed to grow for several months, after which they will be sampled for establishment of mycorrhizas and production of their characteristic spores (see image). This work is ongoing and will be continued by CLR staff after Chris has returned to the UK.

During his stay at the CLR, Chris will be teaching a one-week workshop on the methods of handling AMF. About a dozen people will attend the workshop, which will be aimed at demonstrating practical methods of isolating, purifying, and working with these fungi. The course will begin with an introduction to the fungi themselves, including a brief examination of the systematic position (they are now in their own phylum), and a description of the characteristics used to place them in individual genera. This will be followed by a detailed examination of the species characteristics of some of the almost 200 species known in the group.

The fungi are rather cryptic, as they spend most of their life cycles within the roots of plants. They have to be stained with special methods so they can be seen and assessed, and these methods will be demonstrated and then used in research projects. The species are identified from spores that usually form in the soil, and the methods for extracting and examining these spores will be demonstrated, followed by practical sessions to gain experience in their use.

Methods of isolating the fungi will then be discussed, demonstrated, and participants will make up their own isolation attempts. The participants will then be able to make up and keep a reference collection of specimens for future comparisons. It is intended that the people participating in this course will gain sufficient skill to pursue research into the possible benefits of AMF in minesite rehabilitation.

Dr Chris Walker, Visiting Fellow, Royal Botanic Gardens, Edinburgh, Scotland

A spore of an AM fungus from a rehabilitated minesite

Planning for Mine Closure and Land Rehabilitation

Mining can have a devastating effect on the landscape in which an ore body is exploited. In the most severe cases, this compares to the effect of extreme natural disasters such as tsunami, earthquakes and meteorites; where the biota is all but wiped-out and the landscape physically and chemically degraded. Through the activities of mining, materials long-since buried deep underground are placed at the earth's surface. These substrates often lack physical integrity as surface materials and may be chemically reactive, potentially toxic or have little nutrient or water holding capacity. A denuded landscape and poor materials with which to re-construct ecosystems may compound the problems faced by mining companies confronting the cost of rehabilitation prior to closure. It is from this difficult starting position that environmental officers must find a way of remediating and rehabilitating post-mining landscapes.

Sustainable land rehabilitation requires more than meets the eye. The placement of some long-stored "top-soil" and the sowing of a few native plants on a newly created landform does not ensure successful rehabilitation. Land rehabilitation in a mining context invariably involves constructing or reconstructing the terrestrial ecosystem, literally from the ground up. Sustainable ecosystem reconstruction requires the initiation of suitable and self supporting below-ground and above-ground processes that require careful manipulation of biotic and abiotic components. Thoughtful management of early soil and early ecosystem development underpin the long-term success of any revegetation programme. The naïve planting of seedlings without considerations of the developing ecosystem and its functions will have little chance of long-term success, even when initial results are promising. A developing ecosystem needs to meet design objectives that will underpin the stability and success of the rehabilitation. In a terrestrial context this includes an eclectic range of measurable parameters such as:

- Soil materials with sufficient water holding capacity and drainage.
- The recycling of litter and release of nutrients.
- Balanced microbial communities to keep pathogens in check
- A supply of suitable plant pollinators.
- Ecosystem engineers – mainly invertebrates
- Mycorrhizal networks to support newly emerging seedling and encourage ecological succession.

In counterpoint to these, there are several unfavorable parameters that can also be gauged and subsequently managed for in the new landscape design. Dysfuntional or unfavorable parameters include:

- Soil materials that disperse, slake or hard-set.
- Climatic irregularity, particularly occasional extreme rainfall events.
- Waste materials that have acid generating potential
- Recalcitrant or difficult to germinate plant species
- Waste materials with extreme salinity
- Slope angles that encourage soil erosion

It requires skilled workers to accurately measure and interpret all these parameters, especially in an integrated fashion. These issues can become still more complex when dealing with partial failures in rehabilitation or specific issues such as environmental toxins. Consequently, the establishment of ecosystem function may itself have to be partly experimental on a site-by-site basis and outside scientific experts are often required to give advice and conduct trials.

Its is through consideration of rehabilitation during the mining process that real savings can ultimately be made as the mine moves towards final closure. Early characterization of mine materials coupled with consideration about their storage and future use can help optimize (for example) waste rock dump designs with reactive wastes encapsulated deep within the dump and stable materials used to dress outer embankments. Preliminary revegetation trials can then be carried out, leading to incremental rehabilitation that can pay big dividends as the regulators can approve a successful rehabilitation practice before the mine closes.

When a new ecosystem begins to develop it progresses through a series of stages as it matures. This is known as an *ecological succession* and can be defined as a sequence of ecological changes in an area whereby one group of plant or animal species successively gives way to another. This culminates in what is known as a climax community, the stable end-point of ecological *succession*. This applies as much below-ground as above-ground communities, a fact too often forgotten by restoration ecologists. The early stages of an ecological succession are dominated by short lived, *ruderal* species which can provide an initial rapid increase in the biodiversity of a system. Such generalist species are likely to be widespread and some may even be considered weeds. However, these initial colonists can facilitate the colonisation of the site by later successional species that are unable to colonise skeletal soils. It is these later successional species that provide ecological stability and complexity to a system. As well as these important ecological roles, late successional species comprise the bulk of the world's endangered species and so they have high conservation value. The procceses by which initial colonists can facilitate ecological succession on mine sites are numerous but include: i) building deeper and more complex soils by sediment capture and decay processes and by forming symbiotic associations with nitrogen fixing bacteria and mycorrhizas; ii) providing the above and below ground food resources for herbivorous invertebrates including ecosystem engineers and carnivourous invertebrates that provide stabilising predator-prey interactions; iii) providing food sources for pollinators and so building populations that can then be available to pollinate later successional species.

There is also a need for careful monitoring during early ecoystem and soil development as a complex, and potentially chaotic, system stabilises after the rehabilitation process. This is essential for two reasons (i) to check for any reversal of site remediation (ii) to assess the sustainability of ecosystem function. This is best built into a comprehensive environmental management system and will require monitoring of site stability, chemistry, hydrology and the fate of indicator species. In partnership with regulators, this can include rehabilitation success criteria. These must be established from a credible scientific basis. As each minesite and final land use is different, this requires several years of research and monitoring of early rehabilitation efforts. Without a sound scientific basis, success criteria are no more than educated guesswork and can miss the key indicators of ecosystem function. Well-planned and well-resourced rehabilitation is more likely to lead to successful and timely mine closure and the return of bonds secured by regulators. This can be a very positive outcome for a mining company financially, and in term of public relations and the prospects for permission to mine new leases. It can also be a positive outcome for the local community, the regulators and the environment.

Dr Mark Tibbett, Director CLR

Dr Anita Diaz, Senior Lecturer, School of Conservation Sciences, Bournemouth University, UK

Landscape Function Analysis Course, 11th September 2006

Landscape Function Analysis

The CLR held a one-day introduction to Landscape Function Analysis (LFA) on September 11th at the Shenton Park Field Station. The course was run by David Tongway (Australian National University), the originator of the approach, and comprised both theory and field work components.

LFA is a field-based monitoring system which employs visual indicators at landscape and patch scale to assess how well a landscape is working as a biogeochemical system. Indicators include litter and cryptogram cover, soil crusting and soil texture. It is applicable to all landscape types but is widely used in arid and semi-arid rangelands. LFA provides a rapid, low-cost landscape assessment tool that is able to be used by non-specialists. The method is compatible with other monitoring procedures that focus on structure and composition, as opposed to function. A total of 20 people from government and private industry attended the course, which, despite the weather!, was very well received.

As there was considerable interest in the course, the CLR intends to organise another one. Keep an eye on the CLR website: www.clr.uwa.edu.au for further information!

Trudy Worthington, Graduate Research Assistant, CLR

First International Seminar on Mine Closure

From 13th-15th of September 2006 the First International Seminar on Mine Closure took place at the Sheraton Perth Hotel. The Seminar, co-hosted by the Centre for Land Rehabilitation and the Australian Centre for Geomechanics was the first Seminar of its kind, bringing together more than 200 experts from different fields and countries to discuss all aspects of mine closure. The aim of Mine Closure 2006 – as it is more commonly known – was to exchange knowledge and experiences of mine closure strategies, processes and products in order to minimize future environmental and social impacts. The issues that were addressed included Planning for Closure, Hydrology of Wastes and Covers, Pedogeneses, Landform Stability, Contaminant Risks and Off-Site Impacts, Financing Closure, Social Impacts and Ecosystem Reconstruction. The Seminar included plenary sessions as well as parelllel sessions where theses issues could be addressed in more detail. Papers presented at the Seminar had been subjected to a peer review process ensuring a very high standard.

Mine Closure 2006 also provided a great opportunity for networking, and for mining companies, consultancies and suppliers of relevant equipment to show their wares in the adjacent trade exhibition.

Mine Closure 2006 was the first event in a series of seminars on this topic, with the next seminar taking place in Chile in October 2007. The following seminar is due to take place in South Africa. At the conclusion of the last Seminar, a hard bound publication featuring the best papers from all three seminars will be produced.

For a copy of the proceedings of Mine Closure 2006, please complete and return the Publications Order Form on the CLR website: www.clr.uwa.edu.au .

Annelies de Ruiter, Marketing and Events Coordinator, CLR

Upcoming Events

Seminars on a range of topics are held on Tuesday afternoons from 4-5 pm in the Agriculture Lecture Theatre at The University of Western Australia. The seminars are free of charge and registration is not necessary. Meet the speakers and the other participants over a drink in the Faculty Common Room afterwards! The Seminars for this Semester have just finished, but keep an eye on the CLR website (www.clr.uwa.edu.au/events) for the dates and programme of the next series!

Another Soil Test course is planned for February 2007, and, by popular demand!, we also plan to organise another Landscape Function Analysis course. Check out the CLR website (www.clr.uwa.edu.au/events) for further information.

If you would like to be informed by email of our news and events, please fill out the Mailing List Form on the CLR website (www.clr.uwa.edu.au/events).

Newsletter edited by Annelies de Ruiter.

For further information about CLR staff, activities, publications and events, please contact the CLR at 08-6488 3827 or clradmin@cyllene.uwa.edu.au, or consult the CLR website: http://www.clr.uwa.edu.au