Conference Program
WEDNESDAY 28 NOVEMBER 2012

	Social Sciences Lecture Theatre	Theatre Auditorium	Banquet Hall North	Case Study Room
8:30	Kingsley Dixon and Steve Bosak			
	Plenary Presentations			
Chairperson	*Kingsley Dixon*			
9:00	Stephen Hopper			
9:35	Leanne Liddle			
10:10	**Morning Tea**	**Morning Tea**	**Morning Tea**	**Morning Tea**
	Plenary Presentations			
Chairperson	*Steve Bosak*			
10:30	Hamish Jolly			
11:05	David Merritt			
11:40	David Pannell			
12:15	**Lunch**	**Lunch**	**Lunch**	**Lunch**
		Restoration in production landscapes	*Forest and woodland restoration*	*Seed sourcing guidelines for restoration success*
Chairperson		*David Pannell*	*Vern Newton*	*Siegy Krauss*
1:20		David Carr	Katinka Ruthrof	Kym Ottewell
1:40		Carmen Castor	Elizabeth MacPhee	Alice Quarmby
2:00		Bonny Dunlop	Rachel Standish	Anja Zimmerman
2:20		Wendy Bradshaw	Leonie Valentine	Paul Nevill
2:40		Cathleen Waters		Margaret Byrne
3:00		**Afternoon Tea**	**Afternoon Tea**	**Afternoon Tea**
		Planning restoration and measuring success	*Forest and woodland restoration / Scale*	*Seed sourcing guidelines for restoration success*
Chairperson		*Matt Todd*	*David Merritt*	*Siegy Krauss*
3:20		Ben Miller	Sarah Goldin	Melissa Millar
3:40		Jo Russell	Justin Jonson	Siegy Krauss
4:00		Singarayer Florentine	Geoff Woodall	David Coates
4:20		Kamal Melvani	Leonie Seabrook	Ann Smithson
4:40		Alexander Gold	Simon Kilbane	Nola Hancock

Evening 5:30-7:30	Student and Early Career Event – venue: Acorn Room (located on the first floor above the UWA refectory – 100m from the conference venue)

Plenary Presentations
Oral Session
Symposium

THURSDAY 29 NOVEMBER 2012

	Theatre Auditorium	Banquet Hall North	Case Study Room	Seminar Room 1
	Methods	*River Restoration*	*Banksia woodland restoration*	*Arid zone spinifex*
Chairperson	*Justin Jonson*	*Kieryn Kilminster*	*Jason Stevens*	*TBA*
8:40	Melissa Coyle	John Quinn	Kingsley Dixon	Matthew Barrett
9:00	Jen Ford	Matt Grimbly	Vern Newton	Todd Erickson
9:20	Peter Adkins	Shenandoah Bruce	Mark Brundrett	Wolfgang Lewandrowski
9:40	Dave Bright	Julie Robert	Cath McChesney	Nathan Reid
10:00	Bridget Johnson			Ben Anderson
10:20	**Morning Tea**	**Morning Tea**	**Morning Tea**	**Morning Tea**
	Methods	*Island and Coastal Restoration*	*The Australian Seed Bank Partnership*	*Restoration with native grasses in Australia*
Chairperson	*Ben Miller*	*Bruce Clarkson*	*David Merritt*	*Kingsley Dixon*
10:40	Cameron Mounsey	Mandy Trueman	Lucy Sutherland	Ian Chivers
11:00	Lisa Granqvist	Bruno Foglianil	David Coates	Todd Erickson
11:20	Chong-Hwa Park / Seunggyu Jeong	Judy Fisher	Linda Broadhurst	Cathleen Waters
11:40		Yudi Krisno Wicaksono	David Merritt	Jason Stevens
12:00			David Freudenberger	Panel Discussion
12:20	**Lunch**	**Lunch**	**Lunch**	**Lunch**
	Mine Restoration	*Education*	*Aquatic Ecosystems: Restoration Interactions*	*Optimising our collective efforts: Australian environmental NGO networking meeting*
Chairperson	*Matt Todd*	*Leanne Liddle*	*Judy Fisher*	*Tein McDonald*
1:20 PM	Matthew Daws	David Neidel	Richard Shaw	
1:40 PM	Lucy Commander	Jenny Hunter	Jonathan Newman	
2:00 PM	Matthieu Villegente		Clemens van de Wiel	
2:20 PM	Xanthe Pedersen		Julie Robert	
2:40 PM	Ping Lu		Discussion	
3:00 PM	**Afternoon Tea**	**Afternoon Tea**	**Afternoon Tea**	**Afternoon Tea**
	Mine Restoration	*Urban Restoration*	*Wetland Restoration*	*Towards the development of principles and standards for ecological restoration in Australia*
Chairperson	*Matt Todd*	*Bruce Clarkson*	*TBA*	*Justin Jonson*
3:20 PM	Ian Sluiter	Bruce Clarkson	Ken Wallace	
3:40 PM	C. Ellery Mayence	Catharina Sack	Paul Drake	
4:00 PM	Hamid Amir	Catherine Bryan	Jasmine Rutherford	
4:20 PM	Peter Golos	Toni Cornes	Ryan Vogwill	
4:40 PM	Yvonne Nussbaumer	Bruce Clarkson	Discussion	
Evening	*Plenary Presentation*			
	Pavan Sukhdev			

Plenary Presentation
Oral Session
Symposium

FRIDAY 30 NOVEMBER 2012

	Theatre Auditorium	Banquet Hall North	Case Study Room	Seminar Room 1
	Plenary Presentation			
Chairperson				
8:40	Lesley Hughes			
	Services and Offsets	*Threatened species*	*Pollinators in ecological restoration*	
	Justin Jonson	*Steve Hopper*	*TBA*	
9:20	Tanya Llorens	Louise Beames	Myles Menz	
9:40	Kane Smith	Charly Zongo	Alison Ritchie	
10:00	Simon Gensous	Eric Bunn	Sean Tomlinson	
10:20	**Morning Tea**	**Morning Tea**	**Morning Tea**	**Morning Tea**
	Mine Restoration	*Threatened species*	*Living stream restoration*	*Seagrass Restoration*
Chairperson	*Bruno Fogliani*	*Steve Hopper*	*Judy Fisher*	*Marion Cambridge*
10:40	Patrick Audet	Kate Brown	Julie Robert	John Statton
11:00	Stephane McCoy	Bob Dixon	Antonietta Torre	Elizabeth Sinclair
11:20	Esperanza Maribel Agoo	Heather James	Brett Kuhlman	Renae Hovey
11:40	Anand Datar	Shane Turner	Judy Fisher	Jason Tanner
12:00	Cherie Gellert		Discussion	Illena Gecan
12:20	**Lunch / SERA AGM (in Banquet Hall North)**	**Lunch/SERA AGM**	**Lunch / SERA AGM (in Banquet Hall North)**	**Lunch / SERA AGM (in Banquet Hall North)**
	Mine and Fauna Restoration	*Physiology and hydrology for mine restoration*	*The role of plant translocations in restoring and maintaining biodiversity: policy, planning and practice*	*'Novel' ecosystems in restoration and rehabilitation - Innovative planning or lowering the bar?*
Chairperson	*Michael Craig*	*Etienne Laliberte*	*David Coates*	*Patrick Audet*
1:20	Michael Craig	Jason Stevens	Simon Nally	Michael Perring
1:40	Michael Young	Erik Veneklaas	Tricia Hogbin	Jennifer Firn
2:00	Joanna Burgar	Augustine Doronila	Leonie Monks	Peter Erskine
2:20	Morgan Lythe	Luis Merino Martín	Avi Holzapfel	Carla Catterall
2:40	Ashley Olson		Noushka Reiter	Jonathan Majer
3:00	**Afternoon Tea**	**Afternoon Tea**	**Afternoon Tea**	**Afternoon Tea**
3:20	Closing remarks			
3:40	Student Prize			
4:00	*Kingsley Dixon*			
4:20				
4:40				

Plenary Presentation
Oral Session
Symposium

Oral and Poster Abstracts

A response to macrophyte decline in a constructed stormwater treatment wetland

Peter Adkins

Swan River Trust

Theme: Methods, Techniques and Technologies used in Restoration

Constructed in 2004, the Liege Street Stormwater Treatment Wetland is located in Cannington, Western Australia, approximately 10 kilometres south-east of the Perth CBD. The wetland, which receives drainage runoff from a 530 ha mainly commercial and residential catchment, was designed to improve water quality in stormwater prior to discharge into the Canning River and also to improve habitat value in this area of the Canning River Regional Park. Since its construction, macrophyte coverage in the wetland has reduced by more than 70%, mainly due to the development of sulfidic sediments throughout the wetland. The use of a small scale dredge and desludging tubes, assisted by earthmoving plant, allowed removal of the pyritic sediment from the wetland, reducing the risk of the sediment oxidising during the removal process and becoming an environmental hazard. Removal of the sulfidic sediment, combined with decreased sumpland depths and changes to operational water levels, are intended to facilitate seasonally drying of vegetated sumplands. These changes are intended to promote vegetative growth, improving wetland function and discouraging the accumulation of sulfidic sediments in the sumplands. This paper will provide an overview of the issues at the Liege Street Wetland that have led to the macrophyte decline and the restoration activities undertaken to address the issue.

Ecosystem restoration in abandoned mine sites in the Philippines

Esperanza Maribel Agoo[1], John Rey Callado[2]

[1]De La Salle University, [2]Philippine National Museum

Theme: Mine Restoration

The Philippines faces problems brought about by small- and large-scale mining activities such as degradation of land, contamination of waters, destruction of biodiversity, in addition to the health and social consequences of these activities. To address these problems, *Department of Environment and Natural Resources – Mines and Geosciences Bureau Mineral Action Plan* prioritized the remediation and rehabilitation of abandoned mines. In this connection, a botanical survey was conducted in selected abandoned mine sites in the provinces of Negros Oriental, Zambales, Benguet, and Marinduque. The botanical survey in these sites yielded at least 41 species of pteridophytes in 30 genera and 16 families, and 316 species in 256 genera, and 84 families of seed plants. 41 of the seed plant species are endemic to the country. Dominant species include ferns, grasses, sedges, forbs and other plants highly adapted to degraded soils. The vegetation types within the sites are identified as grassland, grassland-shrubland, and secondary forest, which represent different stages of succession from pioneer to late seral stage. Recommendations are presented for the rehabilitation of the sites which include enhancing revegetation using native seral grasses as well as introduced species, land preparation and other assisted natural regeneration techniques, reestablishment of faunal habitats, and maintenance of these restored ecosystems. Priority plant species for rehabilitation of the sites are also presented.

The 'CNRT Biotop' project: the biological potential of New Caledonian ultramafic topsoils and its management for ecological restoration of degraded mining areas

Hamid Amir[1], Laurent L'Huillier[2]

[1]Université de la Nouvelle-Calédonie, [2]Institut Agronomique néoCalédonien (IAC), New Caledonia

Theme: Mine Restoration

'CNRT BioTop' is a multidisciplinary project aiming to study the variations of biological characteristics of New Caledonian ultramafic topsoils and their management to improve ecological restoration methods. Two mine sites have been chosen for field experiments on the evolution of stored topsoils and on the effects of mycorrhizal fungi combined or not with organic amendments, on the adaptation and growth of endemic plant species. We present some results obtained in this context. Only 15–30% of the initial plant diversity of the area were represented in the seed bank of the topsoil after it have been stripped off and moved to be stored. The evolution of the topsoil seed bank during the storage varied a lot depending on the plant species. Seeds of *Alphitonia neocaledonica* (*Rhamnaceae*), characterized by a physic dormancy stayed alive after 1 year on stored topsoil, even in deep horizons; but non-dormant seeds of *Gymnostoma deplancheanum* (*Casuarinaceae*) loosed their viability after 2 months. The density of viable AMF spores in the 2 studied topsoils were 2 times lower after 1 year storage. The mycorrhizal potential, measured by growing sorghum plants in samples of stored topsoils, was reduced significantly after 6 months storage. Experiments on coating endemic plant seeds with AMF spores for their use in ecological restoration with hydroseeding method were also performed. Coating seeds with 10% alginate containing a minimum of 100 AMF spores present the best advantages: AMF spore germination was reduced but was sufficient to induce mycorrhizal colonization.

Triodia regeneration strategies after fire

Graeme Armstrong

Charles Darwin University

Symposium: Arid zone spinifex (Triodia) restoration

This paper presents the results of research in the central Kimberley on the post-fire regeneration strategies of 9 *Triodia* spp. All species can be classified into one of three regeneration strategies: obligate seeder, obligate resprouter and facultative resprouter. The observed phenology of some *Triodia* spp. in this habitat is in sharp contrast to previous work with some species being able to germinate and set seed within months after a fire, during the wet season. The work also showed that despite species being competitors in the landscape the community structure has existed, with fire, since at least the late Pleistocene.

Examining the emergence of species mono-dominance on rehabilitated north Stradbroke Island

Patrick Audet, Amanda Gravina, Vanessa Glenn, Phill McKenna, Helen Vickers, Melina Gillespie, David Mulligan

Centre for Mined Land Rehabilitation and The University of Queensland

Theme: Mine Restoration

Monitoring of post-rehabilitated sites following sand mining was conducted within the Amity, Bayside, Gordon and Ibis mining areas located across North Stradbroke Island, southeast Queensland, Australia. Based on a chronosequence of land revegetation spanning 4 to 20 years post-rehabilitation, the density and composition of revegetated species assemblages was assessed by distinguishing between periods of 'older' (pre-1995) and 'younger' (post-1995) rehabilitation practices and compared with proximal reference communities. The general rehabilitation outlook appeared promising whereby a functional forest structure had been achieved across most sites over a relatively short time. However, the specific development of 'older' sites had deviated from the desired natural analogues as indicated by the decrease in under-storey heath and the emergence of Black Sheoak (*Allocasuarina littoralis*) as a mono-dominant species. Changes in the vegetation composition coincided with differences among various edaphic parameters suggesting that altered edaphic conditions could have facilitated an opportunistic colonization by this species. Meanwhile, its above- and below-ground feedback behaviour (i.e., relating to leaf-litter allelopathy and soil-nitrogen fixation) may have further perpetuated its mono-dominant distribution. From these projections, it is recommended that considerations be made regarding the ecological context for species re-colonization when planning for post-disturbance land rehabilitation to avoid potentially unintended rehabilitation outcomes.

Review of desert spinifex (*Triodia* spp.) restoration research

Matthew Barrett

Kings Park and Botanic Garden and The University of Western Australia

Symposium: Arid zone spinifex (Triodia) restoration

Arid-zone spinifex (*Triodia* spp.) dominate hummock grasslands over almost a quarter of Australia and are keystone species where they occur. Most arid-zone resource development projects impact *Triodia* spp. as a conspicuous element of the pre-existing communities, and they are therefore desirable or essential restoration targets. High climatic variance presents challenges to arid system restoration at the best of times. Considering the numerous species (>70) and the climatic range of their occurrence across arid and semi-arid Australia, relatively little data is available on Triodia restoration, seed biology or ecophysiology. Based on a states and transition model of the Triodia lifecycle, I will present an overview of research to date, identify key knowledge gaps and discuss ongoing and future research required to meet restoration challenges.

Interactions in monsoon vine thickets: people, plants, fauna, fire and restoration in the Dampier Peninsula, Western Australia

Louise Beames1, Nyul Nyul Rangers2, Judy Fisher4,5

1Environs Kimberley, 2Nyul Nyul Rangers, 4SERCUL, 5Fisher Research

Theme: Threatened Species, Populations and Communities

Bardi Jawi and Nyul Nyul Indigenous Rangers have worked with Environs Kimberley and partners to understand interactions within Monsoon Vine Thickets (MVT) of the Dampier Peninsula, a unique, culturally significant and Vulnerable TEC. This rainforest-allied ecosystem occurs in patches, within and behind the swales of coastal dunes. MVT contain valuable bush-tucker, medicines, important water places and cultural sites. They provide habitat and refugia for birds, bats and other animals, which move between patches, maintaining their connection. Known threats include fire, weeds, clearing, tourism and recreation. With the DEC, we utilised remote sensing to map the fire history of all 79 MVT between 1990 and 2010. Our findings revealed significant annual fire damage and losses in MVT canopy cover. We identified two health indicators; vegetation structure and ant communities, and developed, trialled and implemented protocols measuring across three habitat types; the middle (M), edge (E) and Outside (O) the MVT vegetation. We found significant interactions between litter depth, litter volume, canopy cover, fire count and vegetation trend with separations in ant fauna and vegetation structure between habitats. These new understandings of the impacts and interrelationships between fire and MVT, invasive plants and ants have enabled us to identify the most vulnerable patches on Bardi Jawi and Nyul Nyul country, overlay cultural and conservation priorities and adapt fire and weed management. The collaboration between Indigenous Rangers with strong traditional, local knowledge and practical skills, ecologists, and partners, has enabled the development of sound, culturally-informed science that is useful for management.

Recruitment of additional plant species within revegetated land

Wendy Bradshaw

South Coast Natural Resource Management

Theme: Restoration in Production Landscapes

The medium to low rainfall area (300–600 mm) of southern Western Australia has been extensively cleared for agricultural production. In an attempt to address various natural resource management issues, a small proportion (<1%) of the thirteen million cleared hectares has been replanted with native plants during the last 25 years. During this period, a range of revegetation/restoration approaches have been used. Older revegetation sites generally have fewer species than recent revegetation efforts and lack structural diversity. This study aimed to determine if any native plant species, other than those originally planted/sown, have colonised 1–15 year-old revegetated land in the Great Southern region of Western Australia. A range of survey techniques were used and revealed that a large diversity of native plant species have colonised revegetated land. Recruitment of myrtaceous species, not originally planted or sown, was commonly observed and their occurrence and density was not uniform within or between sites. At some sites recruitment of members of the Mimosaceae, Papillionaceae, Proteaceae and Ericaceae was observed, yet these families were absent in the original species mix. A range of other genera were encountered and the ecological significance of these observations is discussed.

Propagation of rushes and sedges and their use in revegetation projects

Dave Bright

Regen[4] Environmental Services

Theme: Methods, Techniques and Technologies used in Restoration

When replanting or revegetating degraded areas, it is 'best practice' to use local provenance material with as much genetic diversity as possible. In recent years, many thousands of a few species of sedges and rushes (members of the *Cyperaceae*) have been used extensively around Perth, WA, particularly in wetland plantings, through buffer zones and in compensation/detention basins but, unfortunately, because most are considered impossible to grow from seed, they have been propagated by tissue culture from (often) unknown provenance and with an extremely narrow genetic diversity. Using Bare Twig Rush (*Baumea juncea*) as an example, it will be shown how it is possible (and relatively easy) to produce large numbers of plants from seed. Seed appears to be mature when one year old and is retained for some time allowing collection over several months. The author has collected in October, November, December and February, obtaining, in a few hours of collecting, between 1g and 14g. There are approximately 200 seeds per gram and a single germination trial has shown a germinability of greater than 27% with the potential for increasing plant numbers by a factor of 7 or 8 by division in a single growing season. Similar results have been achieved with Jointed Twig Rush (*Baumea articulata*), Spreading Sword-sedge, (*Lepidosperma effusum*), Coastal Sword Sedge (*L. gladiatum*), and Pithy Sword Sedge (*L. longitudinale*).

Building better genetic outcomes for Yellow Box (*Eucalyptus melliodora a.Cunn. Ex schauer*, Myrtaceae) restoration: the selection of seed and evaluation of past efforts

Linda Broadhurst

CSIRO

Symposium: The Australian Seed Bank Partnership: A national network to advance seed management for conservation and restoration

Yellow Box (*Eucalyptus melliodora*) is a broadly distributed southeastern Australian species that also forms part of endangered box gum woodland ecological communities. The restoration of these communities is currently the focus of land management agencies, requiring the selection of high quality seed sources. But identifying these seed sources and determining the spatial scale over which they can be used without inducing potentially negative outcomes, is critical to these projects. In addition, it is important that we evaluate past restoration efforts to ensure that current approaches are building adaptive and resilient vegetation. Using a community-science approach, Yellow Box was sampled from across the species range to assess population genetic structure. Combining this data with ecological information may help identify major discontinuities among Yellow Box populations to guide seed movement. To further help assess the scale over which seed can be moved, genetic and demographic assessments of two provenance trails are providing valuable data on the response of different seed sources in a single environment. Genetic restoration in terms of the genetic diversity being generated by seed crops and interactions with surrounding natural vegetation are also being evaluated in five restored sites. This information will help to improve current restoration practices, especially in highly fragmented agricultural landscapes where production outcomes dictate where restored populations are located and how large they can be.

Weed control followed by summer wild fire facilitates restoration of seasonal clay-based wetlands in South-west Australia

Kate Brown

Department of Environment and Conservation

Theme: Threatened Species, Populations and Communities

The plant communities of seasonal clay-based wetlands of south-west Australia are amongst the most threatened in Western Australia and have recently been listed under the commonwealth Environmental Protection and Biodiversity Conservation Act as critically endangered. Over 90% have been cleared for agriculture and urban development and weed invasion is a major threat to those that remain. The South African geophyte, Watsonia meriana var. bulbillifera, is particularly invasive within these communities forming dense monocultures displacing the diverse herbaceous understorey. Meelon Nature Reserve, a remnant clay-based wetland on the Pinjarra Plain 200 km south of Perth, has been the focus of a six year adaptive management project investigating the response of the native plant community to W. meriana var. bulbillifera removal, the selectiveness of the herbicide 2-2DPA (Dalapon, Propon) and the role of summer wild fire in the restoration of the native plant community. Between August 2005 and August 2008, 90 1 m x 1 m plots along fifteen permanently marked transects were established and species composition and cover recorded each year within each of three treatments until August 2011. The treatments included pre fire W. meriana var. bulbillifera control, post fire W. meriana var. bulbillifera control and an untreated control site. Six years after the initial treatment, indications are that plant communities of the seasonal clay based wetlands of south-west Australia have the capacity to recover following major weed invasion and that summer wild fire can play a role in the restoration process. Implications for the management of clay-based wetlands across south-west Australia will be discussed.

Increases in average water levels on the Swan: Canning system are challenging foreshore stability: bioengineering techniques provide the adaptability needed to meet this challenge

Shenandoah Bruce

Syrinx Environmental PL

Theme: River Restoration

The Swan-Canning River foreshore intertidal zone is a dynamic ecotone that requires constant adaptive management to ensure human-river interaction is sustainable. Managing urban estuarine ecosystems is, and will become, increasingly complex under future environmental and development pressures. Adaptation is essential to the successful integration of urban ecological restoration. Ecological restoration is dependent on the establishment of suitable riparian vegetation, based on reference ecosystems and historical data. This is the first step in restoring ecological function. Riparian vegetation provides essential ecosystem services including; nutrient and energy cycling, fauna habitat, erosion prevention, passive water treatment, aesthetics and recreation. Bioengineering is a proven means to restore ecosystem services in riverbank environs. The structural characteristics of bioengineering are adaptable and versatile, making this technique ideally suited to a dynamic environment. The practical application of bioengineering on the Swan-Canning system must manage many challenges, primarily the observed and predicted increases in water levels which cause a spatial shift in the area defined as foreshore. This creates a conflict of land-use between foreshore ecosystems and urban infrastructure. These challenges in foreshore restoration can be overcome through adaptive management and science communication. Management outcomes for the future must incorporate allocation of land for foreshore environments and inclusion of urban interaction within these spaces. Restoration practitioners must continue to use multidisciplinary approaches to develop and refine science based foreshore management practices. Communication of the advantages and shortfalls of restoration approaches will advance the successful and sustainable implementation of ecological restoration in the Swan-Canning foreshore.

Setting comprehensive and effective completion criteria for banksia woodland restoration

Mark Brundrett, Karen Clarke, Vanda Longman

Department of Environment & Conservation

Symposium: Banksia Woodland Restoration

The Banksia Woodland Restoration project is a large offset-funded restoration project targeting banksia woodlands on Bassendean Dunes on the eastern Swan Coastal Plain. The primary objective of this project is to revegetate and manage banksia woodland, especially to provide new feeding areas for Carnaby's Black Cockatoos and restore habitat for the threatened orchid *Caladenia huegelii*. Restoration of new habitats, which commenced in 2012, consisted of planting and direct seeding into topsoil transferred from Jandakot Airport. One of the greatest challenges in restoration practice is to develop completion criteria based on flora data that represents the diversity of local plant community types while acknowledging limitations to plant recovery in disturbed habitats. To develop completion criteria for banksia woodland restoration sites, it was necessary to conduct flora surveys in topsoil source and reference areas in order to provide species lists, and cover and density targets for each particular plant community type. These surveys determined the relative abundance, dominance and frequency of occurrence of native and weed species. Additional species were added from a dataset that resulted from five floristic studies that sampled and analysed 1121 quadrats on the southern Swan Coastal Plain in the 1990s, and that lists banksia woodland species and the frequency of their occurrence for each floristic community type. Species were also assigned to ecological categories according to propagation strategies and these lists were used to guide seed collection targets, and seed lists for direct seeding and nursery orders. Reconstructed historic vegetation maps were also used to adjust completion criteria targets to soil and hydrology variations within sites. Monitoring is now underway to identify gaps in species recruitment from topsoil, as well as to guide direct seeding, planting and weed control over the next 3 years.

Restoring urban forest? Don't forget the epiphytes!

Catherine Bryan[1], Bruce R. Burns[2]

[1]The University of Waikato, [2]The University of Auckland

Theme: Urban Restoration

Epiphytes play important ecological roles in both tropical and temperate forest, but some are slow to recolonise degraded forest patches, despite ecological restoration efforts. Temperate rainforest patches in New Zealand follow this pattern, especially small patches that remain within urban landscapes. New Zealand is home to 73 vascular, non-parasitic epiphyte species. A survey of the epiphyte populations on 750 trees across the Waikato region (North Island, New Zealand) showed that 45% of the region's 29 epiphyte species were absent from forests within Hamilton City, the region's largest urban centre. Those epiphytes present were most abundant on larger diameter host trees especially those with non-peeling bark and broad spreading crown architecture. Increased abundance was also recorded when soil-building nest epiphyte species were present on a host tree. Local restoration practitioners wish to include these plants in restoration projects but lack best practise methodologies. To develop guidelines for epiphyte restoration, reintroduction trials have been established in forest patches within Wellington and Hamilton cities, designed to identify the most important factors for successful epiphyte establishment. The Wellington trial began in 2007 and focusses on the hemi-epiphyte Metrosideros robusta. The Hamilton trial began in 2012 and is focussed on the shrub epiphytes *Griselinia lucida* and *Pittosporum cornifolium*. The trials involve a range of treatments including different host tree species, attachment techniques, attachment heights, plant aspects, and plant positions. Results to date indicate that native host trees and larger root bundles improve survivability.

Advances in tissue culture and cryopreservation for ex situ plant conservation

Eric Bunn, Kingsley Dixon

Kings Park and Botanic Garden

Theme: Threatened Species, Populations and Communities

In vitro techniques can save critically endangered plant species, but maintaining culture lines over long periods of time is expensive with risks including introduced contaminants and potential for accumulation of various epigenetic or somaclonal variations. Cryopreservation is recognized as the best means of combatting the risks mentioned above and is now widely used for long-term storage of plant germplasm for conservation purposes. The aim of this study was to investigate a new cryopreservation procedure for improving cryopreservation of endangered plants. Vitrification involves the pre-treatment of plant material, usually apical tips derived from in vitro grown shoots, with cryo-protectants, prior to immersion in liquid nitrogen at -196oC. There are now many derivatives of the basic vitrification protocol, the most recent being droplet vitrification, which allows faster cooling rates compared to standard vitrification protocols. The droplet vitrification method was applied to shoot tips of a range of endangered in vitro propagated plants at KPBG that have previously been cryopreserved using other vitrification protocols. Improved survival post-cryostorage has been recorded with endangered species of Grevillea (*Proteaceae*), Pityrodia (*Cholanthaceae*), Eucalyptus (*Myrtaceae*), Hemiandra (*Lamiaceae*) and Tetratheca (*Tremendraceae*), thus confirming the droplet vitrification method possess significant advantages over prior methodology. Ex situ conservation of endangered plants will benefit from the successful fusion of improvements in in vitro and cryopreservation technologies. Maximizing post-cryogenic survival is a key factor in improving the efficiency of cryo-collections and new cryo-techniques such as droplet vitrification would appear to be capable of delivering these efficiencies.

Faunal re-colonisation across a production landscape: a case-study examining the response of bats to restored mine-pits in South-western Australia

Joanna Burgar[1], Michael Craig[1], Giles Hardy[1], Richard Hobbs[2]

[1]Murdoch University, [2]The University of Western Australia

Theme: Mine and Fauna Restoration

Within the recognised biodiversity hotspot of south-western Australia, Alcoa mines and restores approximately 600ha of jarrah (*Eucalyptus marginata*) forest annually. While restoration of mine-pits is considered successful in terms of floristic composition and eucalypt density, fauna are assumed to passively recolonise. To test this assumption, bat community assemblages were surveyed in restored mine-pits of a variety of ages and eucalypt densities, as well as reference, unmined forest. All 64 sites were sampled twice each during maternity and mating seasons across two years between 2010 and 2012. During the first year invertebrates were sampled from a sub-set of restored and unmined sites while in the second year two bat species were radio-tracked to their diurnal roost sites. All nine species of bats inhabiting the jarrah forest were recorded in both restored mine-pits and unmined forest. However, bat activity was significantly higher in unmined forest than restored mine-pits, regardless of restoration age or eucalypt density. Invertebrate biomass was greater in unmined forest than restored mine-pits while all tracked bats only utilised unmined forest for diurnal roosting. While restored mine-pits may be considered successful in terms of vegetation, they provide suboptimal habitat for bats. Structurally, the oldest restored forest is still dissimilar to that of unmined forest, and tree hollows, important for roosting, take many decades to form so will be lacking from restoration for some time. Plant community assemblage and forest structure may be a better benchmark of restoration success for faunal communities than the current focus on eucalypt stand density.

Local provenance and identification of historical refugia in *eucalyptus leucophloia* in the Pilbara

Margaret Byrne[1], Michael Zhou[2], Melissa Millar[1], Stephen van Leeuwen[1]

[1]Department of Environment and Conservation, [2]Christ Church Grammar School

Symposium: Seed Sourcing Guidelines for Restoration Success

Traditional approaches to seed collection for restoration that typically advocate a narrow definition of the 'local provenance' for a species may not be appropriate for widespread species in a time of changing climate. The level and extent of underlying genetic diversity can be an indicator of local adaptation and provide information for determination of appropriate seed collection zones. Genetic diversity in Snappy Gum (*Eucalyptus leucophloia*), a widespread species in the Pilbara region of Western Australia, was investigated to determine contemporary and historical patterns. Nuclear genetic diversity was high, typical of that found in other eucalypt species with wide spread distributions. Population differentiation was low with only 6% of variation partitioned between populations. There was little structure across the Pilbara with no clustering of populations based on geographical proximity or in association with obvious topographical, physiogeographical or geological features. Populations towards the edges of the species distribution within the Pilbara showed greater levels of differentiation from populations within the species main range. Analysis of diversity in the chloroplast genome, which provides a perspective on historical influences, showed a signature of high diversity in the Hamersley and Chichester Ranges indicating they have acted as refugia during climatic oscillations in the Pleistocene. Seed collections for restoration of mine sites within the ranges should focus primarily on populations within the ranges as these harbour the reservoir of genetic diversity that has persisted through historical times.

Ecology of *Hydrocotyle ranunculoides* in its native range

Guillermo Cabrera Walsh

FUEDEI- ARS

Symposium: Aquatic Ecosystems: Restoration Interactions

Hydrocotyle ranunculoides is perennial macrophyte that forms dense interwoven mats on stagnant or slow moving waters. It is native to the Americas, but has become invasive in many countries around the world. Its rapid and thick growth can block watercourses interfering with their economic and ecological functions. The ecology of *H. ranunculoides* and of some of its natural enemies from Argentina was studied, oriented to the potential for biological control of the plant. A monthly sampling plan was designed to obtain data on natural enemy diversity and damage levels, presence and development of competitor plants, and biomass variations of individual *H. ranunculoides* patches in its temperate range. Results suggest competitor plants and climatic factors have little bearing on the survival of this species, and that its invasive success relies on its high cold tolerance, compared to the other aquatic plants in this ecosystem. Two key natural enemies, the weevil *Listronotus elongatus* and the fungal pathogen *Cercospora* sp., may have an important role in the demise of individual *H. ranunculoides* patches. In its natural environment of the lower Parana Delta, *H. ranunculoides* seems to behave as a fugitive species, because although its presence in the ecosystem is permanent, the individual patches are comparatively short-lived. We discuss the implications of these characteristics for a biocontrol strategy in its exotic range in Europe, where it grows in large, monospecific stands.

Landscape-scale restoration in an agriculturally and biologically rich landscape

David Carr[1], Leah Mackinnon[2]

[1]Stringybark Ecological, [2]Border Rivers - Gwydir Catchment Management Authority

Theme: Restoration in Production Landscapes

The North West Slopes and Plains of NSW are home to some of the most profitable agriculture in Australia, based on dryland and irrigated crops on alluvial soils. The diversity of soils, altitude, topography and drainage systems has created a diversity of species and ecosystems, many of which are now threatened. Parts of the landscape have been overcleared leading to a loss of ecosystem services for both the natural and the agricultural environment. An ongoing project led by the Border Rivers-Gwydir Catchment Management Authority has been working to restore ecological communities on agricultural land. The project uses an ecosystem services approach to find common benefits from restoration for both agriculture and biodiversity. Project innovations include the use of agricultural precision planters to sow native species and the development of seed supply planning based on Threatened Ecological Communities. Recent research has focussed on the combination of assisted natural regeneration, direct seeding and seedling transplant. The project is about to move into an implementation stage, with major funding being received from the Commonwealth Government's Biodiversity Fund. Specific restoration methods designed to provide connectivity, crop and pasture shelter, habitat for beneficial insects in cotton and maintain water quality in rivers will be used. As well as restoration innovations this project will have an extensive extension program to ensure the community has a say in its design and development. The challenge remains to undertake ecological restoration at a landscape scale in such a way that enhances or supports agricultural productivity.

Combating weeds in old-fields restoration: the use of ripping, topsoil removal and herbicides

Carmen Castor, Mike Cole

University of Newcastle

Theme: Restoration in Production Landscapes

Re-establishing native vegetation structure on old-fields can be fraught with difficulty. The intensity and type of past land use influences the amount of grass and weeds and the proportion of exotic species. These can hinder the slower growing native shrubs and trees and out-compete native herbaceous plants and seedlings. Soil seed banks also typically have high proportions and densities of exotic weed species, so any surface disturbance can promote a flush of weed growth. On several sites in the Hunter Valley, NSW, we have trialled ripping, topsoil removal and herbicides to prepare land for replanting and reseeding. Results have been variable, depending on site conditions, but overall best practice was found to be topsoil removal (with or without ripping) both for planted and seeded species. Topsoil removal reduced weed numbers during establishment and in some cases the effect has lasted for over three years. Ripping produced the next best results and was especially favourable for planted species, but also created enough open space for some seeded species to establish when topsoil was left intact. Herbicide application was not successful, as the site was covered by invasive weeds and grasses within 18 months, to the same extent as untreated areas, and very few native plants established from seed.

Fauna as change agents and beneficiaries in novel ecosystems: what do novel ecosystems do for fauna (and vice versa)?

Carla Catterall

Griffith University

Symposium: Novel ecosystems in restoration and rehabilitation: Innovative planning or lowering the bar?

Novel ecosystems (NE; newly-occurring spatial combinations of species and functional relationships resulting from human interventions) are often described and discussed in terms of the dominant visible structuring organisms – the vascular plants. However animals comprise the majority of species within them, and the faunal assemblage will depend on the vegetation which these plants provide (structure, functional composition, spatial context). Animal-plant interactions may also strongly influence the plants' reproductive success, recruitment, survival and growth. Animals are therefore important change agents of how novel ecosystems develop over time, and of their potential contributions to biodiversity conservation. Additionally, the frequent occurrence of non-native and invasive species (plant or animal) as a major or minor component of NE has caused considerable angst in discussions of goal-setting for management and restoration. Here I will outline some specific case-studies related to the following questions. Can NE support diverse fauna communities? How do functional interactions involving animals and plants influence NE dynamics (including frugivore-plant interactions and the roles of invasive species)? How do the associated trajectories of community change relate to ideas of 'restoration' or 'degradation'? I conclude that NE are indeed the dominant contemporary regime across all landscapes. Whether we like it or not, most conservation and restoration is actually the management of novel ecosystems, and to be effective in this enterprise we need to make progress in goal-setting, adaptive and experimental approaches to management, embracing evidence-based decision making, and integrating monitoring with restoration practice.

Native grass seed farming from purpose-grown crops

Ian Chivers

Native Seeds Pty Ltd, Victoria

Symposium: Restoration with native grasses in Australia

Given that Australia is largely either grassland or grassy woodland there is a necessary need to revegetate degraded land using grasses either as grasses only, or as part of a mix of vegetation types. However, there have been limitations to achieving this, principally they have been those of regular supply and consistent high quality of seed. These limitations mainly arise through the reliance upon wild-stand harvested seed from remnant areas of native grasses. These areas are often on poorer soils, frequently with rocks that have prevented earlier cultivation, and have had no particular care since cropping or other agricultural operations commenced. Harvesting of seed from these stands can be spasmodic and unreliable owing to the reliance on natural rainfall for stimulation of seed production. These areas receive no fertilizer or irrigation and usually have had no weed control activities undertaken prior to harvest. To overcome these limitations it has been necessary to establish purpose-grown crops of native grasses especially for seed production. In effect this is the start of a domestication process for these grasses – a process that has occurred over many thousands of years for most of the introduced grasses. The change away from wild-stand harvesting to cropping production has transformed the availability of seed and the quality of seed. Crops are now being grown under managed conditions where they are sown into bare paddocks as a monoculture, often irrigated and fertilized, and always managed to keep out weeds. This has required the development of a number of techniques for the maintenance of those crops as monocultures, including the development of specialist harvesters for different crops, the establishment of methodologies for the processing of the seed to remove chaff and other impurities and a greater understanding of the factors that enhance germination and establishment of the target grasses. While wild stand harvests are still important for some crops, there are now many tonnes of seed produced each year under cropping conditions and they usually reach higher standards of germination and purity than those from wild stand harvests.

Bringing indigenous biodiversity back into new zealand cities

Bruce Clarkson

The University of Waikato

Theme: Urban Restoration

New Zealand's 20 largest urban centres vary considerably in terms of their extant indigenous biodiversity resource in the built up matrix (<1% to 9% cover) and in their approach to protecting and enhancing it. To achieve a universal target of 10% cover, urban ecosystems dominated by indigenous species will require a range of approaches from restoration of existing remnants to reconstruction of ecosystems. Ecological barriers to overcome include altered soil conditions and processes, rapidly shifting and often warmer microclimates, and novel species assemblages. Despite these limitations, there are unique opportunities to conserve indigenous plants and animals within these urban environments that are not present in extensive wildland tracts. For example, grazing by farm animals can be completely controlled and predators such as weasels and stoats are less abundant in city environments, also the volunteer worker is nowhere more abundant and capable of being mobilised. Perhaps the most significant challenge to achieving the 10% target, however, is to coordinate action between management agencies so that regional or catchment scale ecosystem processes and function are restored. Further, a convergence of many skills including engineering, landscape architecture, aboriculture, horticulture and ecology is needed to undertake successful restoration in city environments. Examples will be drawn from several North Island cities to illustrate how coordination, convergence and integration can assist in bringing indigenous nature back into the city and reconnecting urban dwellers with their natural heritage.

Urban ecology international programmes update

Bruce Clarkson

The University of Waikato

Theme: Urban Restoration

Urban ecosystems are increasingly the focus of new ecological restoration research and practise. We will provide an update on three international urban restoration programmes and explain how more Australasian cities can be involved.

1) Cities and Biodiversity Outlook (CBO) The CBO is a global assessment of the links between urbanisation, biodiversity and ecosystem services. Two publications, the CBO-1 synthesis and the CBO-1 Scientific Foundation, are in preparation under the auspices of the Secretariat of the Convention on Biological Diversity (SCBD) and the Stockholm Resilience Centre. The CBO will deliver conservation and sustainable use guidance to decision-makers.

2) Cities (Singapore) Biodiversity Index (CBI) The CBI was initiated by the National Parks Board Singapore, the SCBD, and the Global Partnership on Cities and Biodiversity. The index benchmarks the biodiversity and environmental stewardship of cities and provides an evaluation and monitoring tool. The CBI contributes to policy at local, regional and national levels and is useful in the development of urban biodiversity management plans.

3) Comparative ecology of cities The National Center for Ecological Analysis and Synthesis, California is sponsoring comparative urban biota research to understand, preserve, and monitor biodiversity in cities. The first publication, a comparison of bird and vascular plant assemblages for 54 and 110 cities respectively, is currently under review by the Proceedings of the National Academy of Sciences.

Patterns of genetic diversity in two key understorey species, *Allocasuarina humilis* and *Kennedia coccinea*, used for forest rehabilitation in Western Australia: implications for seed sourcing

David Coates

Department Environment and Conservation, Western Australia

Symposium: Seed Sourcing Guidelines for Restoration Success

The Forest Management Plan 2004–2013 for Western Australia requires that 'local' seed collection zones be used for species rehabilitation. Although it has been generally agreed that local provenance should be used in rehabilitation it may be less appropriate for widespread species in a time of rapid climate change, particularly where a narrow definition of local provenance is used. The rationale for a local provenance approach is based on the significance of local adaptation and extent of its underlying genetic variation. A reasonable surrogate for adaptive variation can be obtained through analysis of genetic variation as population genetic divergence provides strong evidence that adaptive divergence can occur. Analysis of genetic structure was carried out in two key understorey species used in forest rehabilitation, the wind pollinated *Allocasuarina humilis* and insect pollinated *Kennedia coccinea*. Despite the large geographic range for both species population differentiation was relatively low with 10% (*A. humilis*) and 14% (*K. coccinea*) of the variation partitioned between populations. While there was little genetic structure evident across the range of *A. humilis* some structure was evident in the forest populations of *K. coccinea* with the southern forest, far north eastern forest and Porongurups differentiated from central forest populations. Combined with previous studies we suggest that seed collection zones for more common widespread species can be broader than currently prescribed. One relatively conservative approach now being considered is the sourcing of seed for rehabilitation from within the same landscape management unit (areas of similar underlying geology, landforms, soils and climate).

Seeds and threatened species management

Anne Cochrane, Andrew Crawford, Leonie Monks, Rebecca Dillon, Sarah Barrett, David Coates*

Department of Environment and Conservation, Western Australia, *Presenting Author

Symposium: The Australian Seed Bank Partnership: a national network to advance seed management for conservation and restoration

The collecting and banking of seeds in secure off site facilities is a key strategy in the conservation of wild plant species at risk in a rapidly changing environment. Storing high quality seed off-site (ex situ seed conservation) is a cost effective means of safe guarding genetic diversity. This strategy is used to complement in situ protection, and in some instances may be the only viable management action for conserving wild species diversity. As an insurance policy against extinction, seed banking can also be used to support research into a better understanding of the seed biology and ecology of a species. More critically, in Western Australia, seed science and genetic research underpin the use of banked seeds in one of the world's largest and most comprehensive rare flora translocation programs. Currently, the Department of Environment and Conservation has 1760 collections representing 315 threatened taxa in secure ex situ storage. These collections have supported 50 translocations (introductions, reintroductions and augmentations) into 85 different sites. In addition these collections can contribute seed resources for restoring threatened ecological communities. In this paper we provide compelling evidence of the importance of seeds in managing and conserving threatened flora and vegetation communities using case studies of Western Australian plant species, including *Banksia brownii*, *B. ionthocarpa* and *Lambertia orbifolia*.

Identifying and alleviating recruitment failures from seed and topsoilt to improve restoration success

Lucy Commander, Luis Merino Martin, Peter Golos, Jason Stevens, Ben Miller, David Merritt,
Kings Park and Botanic Garden, The University of Western Australia

Theme: Mine Restoration

Despite best efforts to restore ecosystems using topsoil and seed, we may fail to return some species in sufficient densities in the resulting restored communities. A problem-solving approach to determine and prevent the causes of recruitment failure will be presented, using examples from across Western Australia, including Sinosteel Midwest Corporation, which aims to restore 70% of the pre-existing species diversity of a Threatened Ecological Community on Banded Ironstone Formation substrates. Firstly, vegetation surveys in the reference community are used to identify the target species and their densities. Communities are restored using topsoil and seed. To determine which species will return from topsoil, we undertake both ex-situ and in-situ emergence studies. Prior to seed broadcasting, seed quality is assessed to ensure that it is not limiting germination. Once broadcast, seeds may not germinate, germinate but not emerge, or emerge but not survive, and these life-stage transitions can be teased apart using seed germination, seed burial and emergence studies. Seed quality and seedling emergence data is then used to inform seeding rates. Hence, using a combination of seedling emergence from topsoil and broadcasting, seed quality and germination testing, dormancy alleviation, and seed burial we will try to elucidate the limiting stage for recruitment, and determine the optimal methods for biodiverse restoration.

Urban ecosystem reconstruction at Waiwhakareke Natural Heritage Park, Hamilton City, New Zealand: insights from seven years of indigenous vegetation monitoring

Toni Cornes
University of Waikato

Theme: Urban Restoration

Since human settlement, 51% of New Zealand's indigenous vegetation cover has been removed, with the greatest losses in lowland and urban landscapes. Hamilton City has lost over 99% of its original indigenous ecosystems, with less than 70ha currently remaining. In Hamilton City whole ecosystem reconstruction is needed to make substantial indigenous vegetation gains. The reconstruction of native ecosystems on 60ha of agricultural pasture began at Waiwhakareke Natural Heritage Park in 2004 and is one of few urban ecosystem reconstructions in New Zealand. The park is located on the edge of Hamilton City adjacent to Hamilton Zoo and residential suburbs. The project involves reinstating five ecosystem types once dominant in the region and implements planting plans based on natural successional pathways and guidelines from restoration research. As of June 2012, 18ha have been planted. To quantify ecological progress, biannual vegetation monitoring and experimental trials are taking place. With the successive integration of new plantings into the park, research results are continually improving planting methods; this has included changes to plant spacing, selection and timing of enrichment planting, application of mulch in drought prone areas, and targeted weeding. This adaptive management has increased plant survivorship and enhanced biodiversity. The long term monitoring of Waiwhakareke Natural Heritage Park will enhance our understanding of reconstruction of ecosystems from scratch and enable the development of best practice recommendations for self-sustaining urban ecosystems.

Changing contract criteria on two sites on the Sunshine Coast, Queensland, Australia

Melissa Coyle

Ecological Consultant

Theme: Methods, Techniques and Technologies used in Restoration

Ecological rehabilitation contract criteria are often developed as if the rehabilitation site is at the bottom of the recovery spectrum. However many sites are much more resilient, with opportunities for better and less costly rehabilitation. In many cases accepted techniques to achieve contract criteria can reduce resilience, suppress natural recruitment, degrade ecological values and increase costs. Contract criteria for two recent projects on the Sunshine Coast, Queensland were adapted to better recognise site resilience at the suggestion of the contractor, Ecological Natural Area Management (ENAM), and the agreement of land managers, project proponents and permitting agencies. Existing permits for an environmental offset at Glasshouse Mountains required re-vegetation and mulching of a regrowth area. ENAM proposed resilience mapping the site, resulting in three treatment types and significantly reduced planting and mulching. Post construction conditions at Castaways Beach required stabilisation and revegetation. The site had a lot of resilience, but the conditioned solid mulch mat would have suppressed virtually all of it. ENAM suggested using SoilSaver Jute-Mesh® with an open weave, resulting in the natural recruitment of hundreds of plants. The negotiation processes, planning and operational techniques and project outcomes for these projects will be detailed to foster questioning of contract criteria and stimulate ideas for developing contract criteria and monitoring that: Better recognise where a site is on the recovery spectrum; take advantage of opportunities across the recovery spectrum; and better protect existing ecological values.

Improving habitat quality of restored forests for reptiles: lessons from an Australian eucalypt forest

Michael Craig[1,2], Vicki Stokes[3], Andrew Grigg[3], Kimberley Christie[1], Giles Hardy[2], Richard Hobbs[1],

[1]Murdoch University, [2]The University of Western Australia, [3]Alcoa of Australia Ltd.

Theme: Mine and Fauna Restoration

Restoration, by reducing the negative effects of habitat fragmentation, is becoming increasingly important in saving global biodiversity. However, increasing evidence indicates passive faunal recolonization of restored areas may take centuries for some species, reducing restoration benefits for those species. Reptiles are typically the slowest vertebrate group to recolonize restored areas due to their low vagility and, often, specific thermal and microhabitat requirements, but few studies have examined their recolonization of restored areas. We examined reptile recolonization in pits restored after bauxite mining in south-western Australia to identify filters that slow, or prevent, reptile return and identify practices that reduce their effect. Three species, *Cryptoblepharus buchananii*, *Egernia napoleonis* and *Christinus marmoratus* were slow, or failed, to recolonize restored mine-pits. All rely on slow-developing microhabitats (e.g. coarse woody debris) for shelter so the absence, or scarcity, of these microhabitats in restored forest is likely a unidirectional filter slowing their recolonization. Studies on *E. napoleonis* suggested coarse woody debris densities need to be ~50 logs ha-1 to accelerate recolonization by that species. Another reptile, *Morethia obscura*, was common in unmined forest and rapidly recolonized restored areas but disappeared as restored areas matured. Thinning and burning restoration was effective in facilitating recolonization by this species but effects were short-term (<7 years), indicating that overdense vegetation structure is a dynamic filter influencing recolonization, probably due to thermal requirements. Our studies show active management of restored areas to facilitate and accelerate faunal recolonization is required for some species, to maximise biodiversity benefits from restoration.

Triggering recruitment in a eucalypt woodland remnant with fire and mechanical disturbance

Haylee D'Agui, Richard Harris

Curtin University

Poster Presentation

Agriculture has significantly impacted global landscapes, with widespread clearing of native vegetation resulting in fragmentation of natural habitats. The temperate eucalypt woodlands of Western Australia's wheatbelt have been reduced to small isolated fragments resulting in altered ecological processes, including fire regimes, with fire now infrequent, or totally suppressed in areas historically exposed to regular burning, reducing recruitment in dominant tree species, including Salmon Gum (*Eucalyptus salmonophloia*) and Red Morrel (*E. longicornis*). The 3500ha Westonia Common in the eastern wheatbelt has a long history of fire suppression, and appears to have a species poor, sparse understory. Can the reintroduction of fire disturbance, or the use of mechanical disturbance where fire is not an option, increase woodland recruitment and biodiversity? Eight 4x4m plots, containing four 1.5x1.5m sub-plots were established within the woodland and each sub-plot randomly allocated a treatment (control, fire, mechanical disturbance, fire and mechanical disturbance). A parallel greenhouse trial is underway, using soil taken from each plot, treated with fire, disturbance, smokewater, heat, and gibberellic acid, to determine the contents of the soil seed bank. Preliminary field results indicate that both forms of disturbance are beneficial in promoting germination, while greenhouse trials indicate that not all species present within the seed bank are also currently growing within the woodland. Thus it is suggested that the managed reintroduction of disturbance, either fire or, where fire is not an option, mechanical disturbance, would benefit recruitment and biodiversity within Eucalypt woodlands.

Landform element diversity as a restoration tool

Anand Datar, Sven Arnold, Alex Lechner, David Mulligan

Centre for Mined Land Rehabilitation, Sustainable Minerals Institute, The University of Queensland

Theme: Mine Restoration

Broad-scale mining involves the destruction of extensive landscapes including both abiotic (e.g. landform) and biotic (e.g. species abundance) ecosystem components. Post-mining ecosystem rehabilitation typically starts with the reconstruction of topography. The common industry practice is to use landform elements such as plateaus, terraces, and gentle slopes for stabilisation purposes. This tends to results in the generation of uniform landforms in rehabilitating landscapes. However, past research from both undisturbed and agricultural landscapes indicate positive correlation between diversity in landform element characteristics, mesoclimate, and ecological attributes (e.g. vegetation cover). The objective of this study is to investigate if those findings are still valid on microsite scale of post-mining landscapes. The study site is a successfully rehabilitated post-sand-mining area located at North Stradbroke Island, Qld, Australia. The relationship between variance in three landform elements (relief, slope, aspect), derived from remote sensing data and determinants of ecological recovery represented by ecological indicators (e.g. species richness) measured with field surveys is investigated. The results indicate a positive correlation between variance in landform elements and ecological status. The results are sensitive to grid cell size and the spatial scale of investigation. Reducing those uncertainties (e.g. scale-specific monitoring surveys) is therefore a critical step forward to develop innovative landform reconstruction strategies that facilitate ecosystem recovery on post-mining areas.

Effects of nitrogen and phosphorous fertiliser regime on restoration of jarrah forest following bauxite mining

Matthew Daws[1], Tim Morald[2], John Koch[1]

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Theme: Mine Restoration

Alcoa of Australia Ltd has two bauxite mines in the Darling Range of Western Australia. The Darling Range has a species-rich forest dominated by jarrah (*Eucalyptus marginata*). Annually, Alcoa mines and restores ~800ha of forest with a goal of re-establishing a self-sustaining jarrah-forest ecosystem. Removal of vegetation and disturbance of the soil profile during mining reduce nutrients pools available for restoration. While fertiliser rates need to be sufficient to support establishing vegetation, they also need to be low enough to minimise potential negative impacts on species composition e.g. competition with weedy species or direct negative impacts of high phosphorous on some proteaceous species. Consequently, a key aspect of rehabilitation is optimising fertiliser rates. High fertiliser rates have been used previously to maximise tree growth rates in rehabilitation with nitrogen and phosphorous each applied at >80 kg ha-1: lower rates are now used in recognition that these might promote higher plant diversity. Here we review previous trials of fertiliser application rates on jarrah forest restoration and present the results of a field-trial established in 2009. This trial assessed the effects of nitrogen and phosphorous fertilizer rates on plant establishment. Nitrogen (0 and 20 kg ha-1) and phosphorous (0, 20 and 40 kg ha-1) were applied factorially. At 15 months after establishment, seedling density was greatest at the higher fertiliser levels, largely resulting from higher numbers of ephemeral species. The different fertiliser regimes also impacted on species richness and cover. Management implications of these results will be discussed.

Can soil wetters assist germination rates in degraded ecosystems and improve seedling survival in dry environments

Bob Dixon

Kings Park and Botanic Garden

Theme: Threatened Species, Populations and Communities

In situ seed sowing, especially when using rare species, in dry environments is a risky business. Therefore it is imperative to reduce the risk of seed loss, consequently genetic diversity, and the added costs of losing a year's growing time as well as having to repeat the exercise. Seed supply is often limited, viability can be low and seed difficult to germinate. *Eremophila resinosa*, a rare species occurring at Westonia in the eastern Wheatbelt of Western Australia has been successfully germinated in-situ, however in 2010 during one of the driest winters on record germination was very poor. To take advantage of limited rainfall events, seed sowing trials incorporating LURE H20, fairly new to the market and used primarily in agricultural situations, and Ezi-wet as a comparison were initiated. Cultivation of quadrats before application of the soil wetters was compared to cultivation after a minimum 15 mm of rainfall prior to seed sowing. Moisture levels were recorded at seed sowing time in early winter, spring, summer and autumn. Germination rates were recorded in November 2011 and survival assessed in June 2012.

How science underpins successful restoration outcomes: a banksia woodland example

Kingsley Dixon, Jason Stevens

Kings Park and Botanic Garden

Symposium: Banksia Woodland Restoration

In the absence of any prior knowledge about Banksia woodland restoration, the research partnership between Kings Park and Botanic Gardens and Rocla Quarry Products embarked on a novel approach to test ecological restoration theory based on melding the principles of adaptive management (decisions made on the basis of lessons learned) with integrated restoration science (linking core restoration disciplines – topsoil handling, mulch and seed enhancement treatments). Today, as a result of the research partnership, Rocla boasts the highest levels of species and plant reinstatement per unit area of post-mined restoration in the resources sector (>100 plants/5m2). The collaborative research program focused on two key scientific areas of inquiry, (1) seedling recruitment and plant survival, and (2) plant growth and development responses to a reconstructed soil environment. Kings Park scientists believed that these autecological aspects would yield essential information for the development of appropriate ecological restoration practices. As a result, the research program has demonstrated innovation and environmental research excellence through:

- Detailing understanding and optimisation of the regenerative potential of the soil seed bank.
- Resolving methods for topsoil handling and storage.
- Researching and developing innovative seed germination enhancement pre-treatments (e.g. smoke).
- Enhancing greenstock-enabling treatments (e.g. tree-guards, anti-transpirants).
- Definitively testing site treatments (e.g. mulching, irrigation, soil ripping and soil stabilizers).
- Researching the autecology and selective control of dominant weeds species impacting upon native plant survival in restored sites.
- Investigating ecophysiological parameters (nutrient and soil water relations).

Assessing vegetation tolerance and species selection for mine water use on a sulphidic arsenic rich gold mine tailings storage facility in stawell, western victoria

Augustine Doronila

School of Chemistry, University of Melbourne

Theme: Physiology and Hydrology for Mine Restoration

Successful mine closure and rehabilitation often requires the long-term establishment of a healthy vegetation cover. Trees can be excellent candidates in rehabilitation projects providing long-term solutions for biodiversity, carbon offsets, landform stability, as well as provide solutions as bio pumps for saline land rehabilitation and mine water disposal. Assessment of appropriate tree species or varieties for tolerance to saline, hot and dry environments is needed and technology currently exists to measure total tree water use. A case study is outlined from the Stawell Goldmine, Western Victoria where tree water use and tolerance to extreme environment was measured on three Eucalyptus species, a fast growing tree widely used in the Western district, *E. cladoclayx*, a slow growing indigenous Yellow Box *E. melliodora* and the indigenous mallee *E. polybractea*. Sap flow technology measured tree water use over an 18 month period and showed daily tree water use in Sugar Gum averaged 26.35 litres per day in summer and 11.21 litres per day in winter. These values were at least 5 times higher than daily tree water use in Yellow Box and Blue-leaved Mallee. Correlation with temperature and vapour pressure deficit (VPD) variables showed Sugar Gum had higher tolerance to warmer temperatures and drier conditions than Yellow Box and Blue-leaved Mallee. Therefore, Sugar Gum is a much more efficient tree at mine water disposal, has greater tolerance to saline soils, and hot and dry environments than Yellow Box and Blue-leaved Mallee. This study can improve ecohydrological models for safety of tailings storage facilities.

Optimising conditions of the root zone to restore wetland vegetation

Paul Drake[1], Blaire Coleman[1], Rachel Taplin[2]

[1]Department of Environment and Conservation, [2]The University of Western Australia

Symposium: Toolibin Lake - a case study of wetland restoration

Secondary salinisation has exposed Toolibin Lake, an ephemeral freshwater wetland, to excess saline surface water and rising saline groundwater. Consequently, the condition of the native plant species on the lake bed has declined. To manage these plants and their habitat, it is vital to understand how the movement of water and salt in the soil profile affects physiological processes in plant taxa. On the lake bed two plant species co-dominate the canopy strata, *Casuarina obesa* and *Melaleuca strobophylla*. *Casuarina obesa* is shallow rooted and highly tolerant of salinity whereas *M. strobophylla* is deep rooted and moderately tolerant of salinity. To explore the impact of management interventions and climate variability on the Toolibin Lake vegetation, a one-dimensional water and solute balance model (HYDRUS1D) was used. The model's parameter space was determined from field observations of transpiration rate, soil moisture, groundwater depth, soil water and groundwater salinity as well as laboratory measurements of soil water retention, soil texture and leaf turgor loss. Scenario simulations of climate drying, natural leaching and vadose-zone flushing were used to investigate the benefit of possible management interventions aimed at removing salt from the root zone. One consistent pattern across scenarios was that, without management intervention, further salinisation of the root zone would occur. This indicates that without maintaining an adequate depth to groundwater under Toolibin Lake, further deterioration of the plant community is likely to occur and this process will persist under various climate change scenarios.

Bullsbrook biodiversity corridor: long term community landcare

Bonny Dunlop

Ellen Brockman Integrated Catchment Group

Theme: Restoration in Production Landscapes

The North Swan Landcare Group has been actively working since 1997 in Bullsbrook, including the RAAF Base of Pearce, Western Australia. The Bulls Brook is within the Ellen Brook catchment which is the highest coastal contributor of nutrients to the Swan River (SRT, 2009). The project began with a few concerned landholders worried about degradation in their catchment. Much of this land is owned by the Department of Defence (DoD), with their cooperation and through ongoing projects over the past 14 years there has been a significant change to the landscape. The Landcare group has obtained funding of $132,000 from various community grants while the community and the DoD have put in thousands of hours to make the corridor what it is today. The presentation will outline the past 14 years of on ground work, the successes and the differences the community group has made. It will also look at lessons learnt and what plans the Landcare group have for the future of this project. A significant part of this project is a working partnership between community and government to achieve a better outcome for the catchment.

Complexities hidden within the collection, quality, and efficient use of *Triodia* (spinifex) seed

Todd Erickson[1,2], Shane Turner[1,2], Phillip Ainsley[3], Kingsley Dixon[1,2]

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Symposium: Arid zone spinifex (Triodia) restoration

Triodia species form the single most extensive vegetation type across arid Australia. Given their dominance, it is no surprise that Triodia species are a focus of ecological restoration programs in arid regions. A key method of reinstating Triodia plants will be through broadcast seeding, but technologies are yet to be developed to achieve effective seed supply and delivery across the thousands of hectares of disturbed land. Even at a modest seeding rate of 6 kg/ha, the amount of Triodia seed required to address the 20,000 ha of disturbed land in the Pilbara region of WA greatly exceeds 100 tonnes. Just obtaining such a quantity of seed is going to take a large commercial effort. But, what happens when quality of collected seeds is not controlled or considered? Does purchased material actually have the capability to germinate? What is the difference in germination potential between the floret (i.e. dispersal unit that can contain a seed) and the cleaned seed? Does it matter whether seeds are broadcast within intact florets or as de-husked seeds? Which broadcasting technique is going to allow repeatable, cost effective, and large scale restoration success? In this presentation, results will be presented demonstrating (1) the variation in floret fill within species, (2) cleaning methods available to improve floret fill, (3) the techniques available to store seeds for future use, (4) the differences in germination between species under both laboratory and field conditions, and the complexities of seed dormancy amongst species, (5) and current options available for practitioners to improve their use of Triodia seeds.

Seed supply for spinifex (*Triodia wiseana*) arid zone restoration: increased inflorescence production under different irrigation regimes

Todd Erickson[1,2], Shane Turner[1,2], Jason Stevens[1,2], Kingsley Dixon[1,2]

[1]Kings Park and Botanic Garden, [2]The University of Western Australia

Symposium: Restoration with native grasses in Australia

Restoring degraded landscapes is an integral component of conservation land management, mine-site restoration, and environmental policy. For example, the resource industry in the Pilbara region of Western Australia recognises that Triodia species form the core of restoration programs. Sourcing sufficient quantities of Triodia seed to meet the growing demand for restoration has become one of the top priorities for restoration practitioners. A potential cost effective and sustainable method to obtain the tonnage of Triodia seed required is through 'seed farming'. Little is known of the reproductive biology of Triodia and the environmental cues required for inflorescence initiation. We implemented two field trials to test whether increased water availability aids in the quantity, quality, and uniform timing of floret/seed development. If water availability improves these parameters whilst not impeding seed germination capability, there may be the potential to develop seed supply of Triodia under concentrated irrigation plots. Results to date demonstrate that certain irrigation regimes induce greater inflorescence production in mature Triodia plants, with irrigation frequency, rather than total amount, appearing to drive increased production. There appeared to be no adverse effects of irrigation regime on seed germination behaviour. However, despite increased inflorescence production, there was a very low floret fill rate (i.e. increased production of seeds seed was not achieved). Given the low floret fill and the limited knowledge surrounding aspects such as the pollination and flowering biology, and site establishment requirements of Triodia species, further research is required to determine the feasibility of any seed production ventures.

What part of coal production are ecosystems? Lessons in land rehabilitation from central Queensland

Peter Erskine

The University of Queensland

Symposium: Novel ecosystems in restoration and rehabilitation: Innovative planning or lowering the bar?

Open-cut coal mining began in central Queensland's Bowen Basin (a geographic region of over 60,000 km2 containing Australia's largest coal reserves) approximately 50 years ago. Over this period of time, mine rehabilitators have used a variety of tree, shrub and groundcover species to create 'novel ecosystems' to stabilise spoils and provide vegetative cover for pre-supposed final end-land uses. Mines in this region have generally proposed one of two post-rehabilitation end-land uses – either pasture for cattle grazing or reconstructed native communities which potentially provide native fauna habitat. However, legislative and community expectations have changed progressively and, although much of the rehabilitation is currently dominated by an invasive assemblage of exotic Buffel Grass (*Cenchrus ciliaris*) and Sally Wattle (*Acacia salicina*), recent environmental authorities suggest these 'novel ecosystems' will be judged against native reference sites. Here, I present data from a range of mine sites to suggest that some of these systems are (1) relatively stable over time, (2) can cope with drought or related climatic factors, but (3) have very few elements of unmined reference sites. Further, I address some of the moral hazards of whether to accept 'novel pasture systems' as a new regional ecosystem or, rather, to demand that mining companies (as primary benefactors of the exploitation of non-renewable resources) should achieve higher quality native ecosystems that are both resilient and functional into the distant future.

A 'novel ecosystems' approach to invasive plant species control

Jennifer Fir

Queensland University

Symposium: Novel ecosystems in restoration and rehabilitation: Innovative planning or lowering the bar?

It is often recommended that restoring historical disturbance regimes in an ecosystem dominated by an invasive plant species should be used to recruit native species. From a six year field trial, this study demonstrates that novel disturbance regimes based on the present conditions of a weed-dominated community can be more effective at restoring native species abundance. Here, I excluded grazing and applied different control measures to kill and reduce the abundance of an invasive grass introduced from Southern Africa, *Eragrostis curvula*. I found adding fertilizer and maintaining grazing pressure was the most effective treatment at reducing invader abundance and increasing native grasses. There is an issue with declaring this treatment a success since – with novel ecosystems – the original native species may be unknown, unavailable or unable to recruit. Increased native abundance then provides little indication of how restored plant communities are functioning. It is also demonstrated that leaf trait data can be used to evaluate the 'quality' of species assembling in response to control strategies. Management actions in the short-term can change the suite of functional traits characterizing a plant community. This means then that even if the original plant community cannot be recovered, it can be monitored to assess recovery of functional traits and management actions adjusted according to explicit restoration goals.

Coastal ecosystem interactions

Judy Fisher[1,2], Rae Korb[3], Sputore Kate[4]

[1]SERCUL, [2]Fisher Research, [3]SNEC, [4]Coastal Projects N-Perth Region NRM

Theme: Island, Coastal and Marine Restoration

The dynamic rapidly changing fore dunes and limestone outcrops of Perth's coastal ecosystems provide a protective inland barrier from ever changing tides, winds, storms, waves and currents. Coastal plants and animals unique adaptive mechanisms enable them to survive, reproduce and disperse. A balanced ecosystem structured by the vegetation plays a critical stabilising role. SNEC set out to map the weeds within the 6.5 kms of the City of Stirling coastline to improve restoration along the City's coastline. By thinking of our mapping as an enquiry into our ecosystem we tested whether we could deliver information to guide, prioritise and improve effectiveness of our restoration actions. Prior to field work, we devised our methodology to answer six questions: 1. What % of total area mapped occurs for each weed cover category (1–5)? 2. Which are the most common and uncommon weed species? 3. What are the life forms of the weed species? 4. Is there a relationship between dune location, weed species and weed cover category? 5. Is there a relationship between restoration and weed cover values? 6. Field data was interpolated through a GIS System providing a baseline reference dataset to conduct a rapid assessment of differing management scenarios. With flora mapping overlayed the following season, there now exists a powerful Decision Support Tool to utilise understandings of ecosystem interactions to ensure restoration priorities are efficient, cost effective while building resilient plant communities, utilising an holistic approach which lends itself to collaboration and cooperation from all stakeholders.

Commercial microbial inocula: do they work?

Nigel Fisher

Kleinfelder Ecobiological

Poster Presentation

The important role that soil organisms play in nutrient cycling and plant health has long been recognised in the scientific literature, as well as in the agricultural and mining industries. The market for commercially available inocula of important nutrient cycling microbes aimed specifically at Australian native flora is not developed as agriculture with far fewer products. Here the author presents the results of a trial utilising commercially available inocula marketed as capable of inoculating native flora. Eleven species of plants commonly found in the Box-Gum Woodlands of central western New South Wales and parts of Queensland were grown under nursery conditions and harvested after 150 days. Faboideae species trialled were *Acacia spectabilis A.Cunn. ex Benth.*, *A. doratoxylon A.Cunn.*, *Daviesia ulicifolia Andrews*, *Pultenaea cinerascens Maiden & Betche* and *Hardenbergia violacea Schneev.ex Stearn*. Treatments included rhizobial, mycorrhizal+bacteria, and combined inoculation, with commercial nursery soil without inoculation as the control. Preliminary results showed considerable variation between the species. *A. spectabilis* grew well regardless of treatment and formed root nodules with rhizobia (presumably) resident within the control nursery soil. *H. violacea* also nodulated when grown in the control treatment, but showed improved growth with both the rhizobial inoculation treatment with the combined treatment. *A. doratoxylon, D. ulicifolia* and *P. cineracsens* all showed increased survival and growth with each treatment; i.e. no survival in the control, low survival and poor growth after inoculation with mycorrhizal fungi+bacteria, increased growth again with rhizobial inoculation and markedly improved growth with combined inoculation. In addition to D. viscosa, five eucalypt species were trialled; *E. albens*, *E. conica*, *E. dawsonii*, *E. melliodora* and *E. moluccana*. These plants were the subject of two treatments only, the control (as above) and inoculation with mycorrhizal fungi+bacteria. Inoculation actually suppressed growth in the majority of species a phenomenon often recorded in the literature. Preliminary conclusions show that commercially available inocula can infect target plant species and may provide a useful addition to the tools available for rehabilitation in the absence of available topsoil with a viable microbial population.

Measuring, interpreting and understanding

Judy Fisher
SERCUL, Fisher Research

Symposium: Living Stream Restoration

In order to evaluate the outcomes of the Living Stream Construction it is important to gather data on key indicators both pre and post Construction to gain an ecosystem understanding of the ecosystems' response and resilience to Restoration Actions. This knowledge provides key information from which to adapt and plan other Restoration Projects into the Future, as key hydrological processes and features of the waterway are restored. Collection of baseline data prior, during and following restoration, provides an understanding of the restoration effects on the structure and function of the aquatic and terrestrial ecosystems. Water quality measurements and their improvement are a critical component of urban Living Stream Projects, with other biodiversity measures, such as vegetation, canopy cover, aquatic macrophyte and river bank vegetation, aquatic macro invertebrates, bird communities, terrestrial macro invertebrates, mussel and fish communities providing an understanding of the changing structure and function of the restored aquatic and terrestrial ecosystems. An understanding of the interactions and changes across these environmental indicators provides new knowledge on the biodiversity outcomes and effectiveness and success of the Living Stream reconstruction, delivering a measure of restoration direction, and the most effective restoration actions for future Living Stream Projects.

Restoring natural capital: generating prescriptions for evidence-based best practice in the future from experience of the past

Singarayer Florentine, Peter Gell, Martin Westbrooke, Graeme Ambrose, Penny Greenslade, Michelle Graymore, Imogen Schwarz
University of Ballarat

Theme: Planning Restoration and Measuring Success

Restoring natural capital provides one of the most significant practical opportunities for meeting conservation goals. Globally it attracts a budget of over $A1.6 trillion per annum. The Australian government has invested heavily in vegetation restoration projects but there is little evidence with which to assess the success of landscape-level projects because funding applications or reports often do not require a performance assessment. As a result, although adaptive management is widely advocated, there is little or no feed-back to which operators may respond. To redress this problem, a project in two major catchments in western Victoria is evaluating past restoration efforts. The results will be used to co-develop an on-line decision support system that should improve landscape-level restorations and will optimise ecological benefits from future financial and resource investments. The project compares revegetated riparian sites of various ages with reference (remnant) sites. It documents their diversity and vegetation structure and other ecological variables, particularly the associated avifauna, soil microorganisms, soil seed-bank and soil carbon. We are also surveying farmers' attitudes to, and reasons for, revegetation in order to determine factors that influence landholders to carry out such work. Preliminary results show that 45 different tree and shrub species were successfully planted and vegetation structure was well established by 4–8 years. Of the 129 species germinated from the soil seed bank at restored, remnant and unrestored sites approximately half were weeds. Fifty-nine bird species were recorded within restored and remnant sites, with higher diversities at 4–8 year old restored sites and at remnant sites. Results of further analyses will be presented at the conference.

Restoration in a South Pacific biodiversity hotspot, the case of New Caledonia

Bruno Fogliani[1], Adrien Wulff[1,2], Matthieu Villegente[2], Charly Zongo[3]

[1]New Caledonian Agronomic Institute, [2]University of New Caledonia, [3]New Caledonia Government

Theme: Island, Coastal and Marine Restoration

The nearly 180,000 islands of the world are known for their biodiversity richness while they only occupy 5% of the land surface. Islands of the Pacific region account for 5 of the 34 hotspots worldwide, including New Caledonia, one of the smallest. Despite having such a small land area, it has a very high density of endemic plant species. Unfortunately several threats as bush fires, nickel mining, agriculture, urbanisation and invasive species led to reduction and fragmentation of habitats. Humid and dry forests have been reduced by 75% and 99% respectively. An overview of the conservation and restoration history in this country will be presented, focusing on success stories but also where research is lacking. Restoration of nickel open mines is one of the most visible examples. The first trials of revegetation started 40 years ago using exotic species. Then two indigenous species, *Acacia spirorbis* and *Casuarina collina* have been intensively used, but revealed a gregarious behavior, blocking the initiation of plant successions. New methods, such as plantation, hydroseeding and dryseeding lean predominantly on native ultramafic species, considering that only these plants can survive and lead to a sustainable restoration. Actually, the germination of more than 80 pioneer species were studied. Most of them are orthodox (90%) and don't present any dormancy (especially *Myrtaceae*, *Proteaceae*, *Casuarinaceae*) whereas some others present physical (*Rhamnaceae*, *Rubiaceae*), morphological and/or physiological dormancy (*Cyperaceae*, *Dilleniaceae*). Studies on seed ecologyphysiology and topsoils are one of the major advancement for the restoration of ultramafic lands in New Caledonia.

The south east Queensland ecological restoration framework: an agreed set of restoration standards for the region. How we developed and designed the package, agreed on its content and got the package endorsed on a regional level

Jen Ford

Gold Coast City Council

Theme: Methods, Techniques and Technologies used in Restoration

The quality of restoration being delivered across a wide and diverse biological landscape has been inconsistent and while there are many great examples of efficient and effective restoration, there are as many examples of restoration efforts yielding poor results. Environmental managers from eleven Councils recognised that there was a need for a consistent approach to ecological restoration and the development of a 'how to' guide'. The participating eleven local governments and the regional Natural Resource Management body, SEQ Catchments who facilitated the process, identified sixty stakeholders. which assisted in establishing the audience, influenced the design and how the various elements of the framework needed to be communicated so it is practical for all end users. The framework is made up of three parts: a Code of Practice that connects ecological restoration to policy and provides a head of power to the rest of the package; a set of Guidelines which is a decision making tool that guides the user to the most appropriate course of action including how to plan their restoration project; and a 'how to' manual which is a technical and easy to use guide to all aspects of ecological restoration. All documents are reflective of current best practice and provide the minimum acceptable solutions to ecological restoration. Applying standards to all approaches of restoration (natural regeneration, assisted regeneration, reconstruction including revegetation and fabrication) assists in further developing the skills of many end users including the restoration industry, community groups, landholders and many other stakeholders.

Challenges in managing a commercial native seedbank: diverse quantities don't come cheap

David Freudenberger

Nindethana Seed Service

Symposium: The Australian Seed Bank Partnership: A national network to advance seed management for conservation and restoration

Nindethana Seed Service has been collecting and managing commercial lots of seed for the past 35 years and increased the store to manage over 3000 native species. However, most of the species collected, processed, stored and sold are in small lots – a few kilos/year/species collected in a labour intensive manner by increasingly fewer collectors with the requisite botanical skills and passion. The emerging market for large scale diversity plantings (e.g. Biodiversity Fund and carbon sequestration) pose a significant new challenge – diversity measured in tonnes. Historically Nindethana's seed has come from wild populations that are relatively small and fragmented by historical clearing, although a shift towards a combination of orchard and wild seed is now required to fulfil market demands. Access to large populations is seldom possible because they are often found in national parks and reserves where seed collecting is largely prohibited. There is an urgent need to develop seed production orchards, particularly for non eucalypt species to provide large and reliable quantities of seed at affordable prices. Scientific input is urgently needed to assist in the design of seed orchards to ensure appropriate genetic diversity and reduce the risks of genetic pollution (e.g. hybridisation). This scientific input needs to be complemented by investment in developing orchard management technologies including appropriate irrigation, pest management, soil fertility and harvesting systems.

High outcrossing rates suggest an important role for sexual reproduction in a clonal seagrass

Ilena Gecan[1], Siegfried Krauss[1,2], Gary Kendrick[1]

[1]University of Western Australia, [2]Kings Park and Botanic Garden

Symposium: Seagrass Restoration

Seagrasses are primarily clonal plants, with little perceived contribution by sexual reproduction. Few studies have explored or tried to quantify the mating system parameters in seagrass, and what this means for patterns of genetic diversity and connectivity among disjunct and fragmented meadows. We estimated mating system parameters in a widespread Australian seagrass, *Posidonia australis*, using microsatellite DNA markers. Mating system parameters for two P. australis meadows show complete outcrossing (tm = 0.99–1.00). Only 10.4–13.8% of flowers within an inflorescence are full siblings, indicating that multiple plants were responsible for pollinating flowers within a single inflorescence, demonstrating the successful movement and mixing of pollen. Paternity was assigned in 3–5% of seeds with 95% confidence, where the maternal genotype was known (i.e. no allele mismatches). The low levels of paternity assignment could be due to (i) low number of shoots sampled, proportionate to the total number of plants within the meadow, (ii) inadequate number/polymorphism of DNA markers to confidently exclude non-sires, and/or (iii) high levels of gene (pollen) flow between neighbouring meadows. We will be using this information to address critical questions such as the extent of spatial and temporal variability in realised mating patterns and whether we are can predict mating system patterns based on the physical attributes of the seagrass bed, weather and tide conditions at the time of flowering? Despite quite different physical and environmental parameters at each site, both meadows have moderate levels of clonal richness (R = 0.60–0.62) with complete outcrossing.

Four years of revegetation monitoring on a waste rock trial landform

Cherie Gellert

Energy Resources of Australia Ltd

Theme: Mine Restoration

Energy Resources of Australia Ltd (ERA) operates a mine on the Ranger Project Area (RPA), which is located near Jabiru in the Northern Territory. ERA has an obligation to rehabilitate the disturbed areas on the RPA, including revegetation using local native plant species similar in density and abundance to those existing in nearby areas. In 2009 ERA constructed a Trial Landform (TLF) to both demonstrate ERA's revegetation ability and to provide data for refinement of revegetation strategy. The TLF has an area of ~8ha, and has sections with a waste rock only substrate and sections of a substrate comprised of waste rock mixed to different depths with laterite. The laterite mixes were trialled to determine if the incorporation of fine material increases available water for plant growth and survival. Half of the TLF was planted with tubestock in March 2009, with infill planting in January 2010. The other half was direct seeded in July 2009 and December 2009, with infill planting in January 2011. Monitoring of the revegetation has now been ongoing for four years and has shown clear differences in performance between the revegetation methods and substrates. Stem density, height and species diversity is higher using tubestock than using direct seeding. Germination and survival is higher on waste rock; however growth of seedlings is greater on the laterite mix. Further, revegetation monitoring, including Landscape Function Analysis, demonstrates that the vegetation on the TLF is on a trajectory towards becoming similar to woodland in nearby areas.

Optimisation of ecological restoration: enhanced mycorrhizal colonisation related to phosphorus concentration

Simon Gensous, Antoine Pierrat, Emilie Hascoet, Hamid Amir

Universty of New Caledonia

Theme: Ecosystem Services and Environmental Offsets

New Caledonian ultramafic soils are very rich in heavy metals (nickel, cobalt, manganese and chromium) and excessively poor in phosphorus, potassium and calcium. These ecosystems have developed a specific flora with 82% of endemic species. This high biodiversity is more and more threatened by increasing mining activities. An optimal management of the topsoil and its mycorrhizal symbionts is necessary to ecological restoration of degraded areas. Studies on the role of arbuscular mycorrhizal fungi (AMF) on these soils showed their positive effects on plant mineral nutrition and on alleviation of nickel toxicity, but suggested that strong P deficiency reduced mycorrhizal colonisation. We studied, in greenhouse conditions, the effects of AMF on adaptation and growth of the endemic plant *Alphitonia neocaledonica* (*Rhamnaceae*) and their variations in relation to increasing P concentrations. The first results showed that AMF have a negative effect on plant growth when P concentration in soil was very low, and positive effects when levels of P were higher but moderate. In these conditions, mycorrhizal colonisation of the plants was higher and AMF induced a better P nutrition and a better tolerance to nickel, but the relationships of this last effect with P concentrations was complex and needs more research. These results suggest that it is important to manage P supply to induce a high level of mycorrhizal colonisation and a better growth of endemic plant species for ecological restoration of New Caledonian degraded areas

Using thresholds to guide natural resource management: toward resilience or business-as-usual rebranded?

Alexander Gold

Institute of Environmental Studies, UNSW

Theme: Planning Restoration and Measuring Success

Resilience theory posits that social-ecological systems may contain thresholds that act as tipping points between desirable and undesirable system states. The NSW Natural Resources Commission (NRC) has urged Catchment Management Authorities (CMAs) to apply resilience theory by identifying thresholds in their catchments. CMAs are to maintain a functioning system by investing to remain within thresholds or transform to a more desirable state. With representatives from a CMA and other land management agencies, I convened workshops to build conceptual models and try to identify thresholds governing resilience of endangered upland swamps in the Blue Mountains of NSW. Instead of providing unambiguous targets for management, however, the workshops supported a less-cited yet crucial tenet of resilience theory: that the existence and value of thresholds are likely to change over space and time. Thresholds should thus serve as indicators for monitoring and evaluation that continuously assesses their suitability as management targets and allows management to anticipate system change. Further analysis of the NRC recommendations for applying resilience, of catchment action plans drafted since incorporation of these recommendations, and of key informant interviews, however, suggests that the primary role of thresholds is to serve as management targets rather than as indicators for monitoring and evaluation. Moreover, government requirements severely limit the investment CMAs can make in monitoring and evaluation. The end result is that the use of thresholds may proceed as a conventional, target-based approach to natural resource management rather than a paradigmatic shift toward building resilience.

Debris or not debris: is coarse woody debris a tool for promoting restoration of understory plants and soils in temperate australian woodlands?

Sarah Goldin

The Australian National University

Theme: Forest and Woodland Restoration

Historical clearing and subsequent agricultural practices have altered the structure and species composition of temperate Australian woodlands causing substantial declines in biodiversity. Restoration efforts to address biodiversity loss include the re-introduction of coarse woody debris (CWD), a missing habitat element and nutrient-cycling pathway. However, the impact of CWD additions on understorey plants and soils has not been considered in the woodland context. In this study, it was hypothesised that, establishment and growth of understorey plants would be enhanced within CWD microsites because soil conditions improve and herbivory declines. This hypothesis was tested by comparing understorey plants and surface soils near and at a reference distance away from CWD in an ex-pastoral woodland. Results of significantly greater total dry biomass, total moisture content, total cover and table height near CWD, compared to reference sites, supported the hypothesis. However, there was a significant increase in exotic forb cover and a decrease in species richness near CWD. The observed changes to understorey plants corresponded with significant increases in soil nutrients and buffering of soil temperature and moisture extremes near CWD. Increases in total dry biomass, total cover and table height near CWD was also attributed to protection from herbivory. Consequently, CWD can be considered as a tool for promoting restoration of understory plants and soils. However, because CWD increases the availability of soil resources, CWD could also increase establishment of exotic species and reduce species richness within ex-pastoral woodlands.

Restoring vegetation on waste rock dumps at Telfer mine site in Australia's Great Sandy Desert: topsoil management and plant establishment

Peter Golos, Kingsley Dixon

Kings Park and Botanic Garden, The University of Western Australia

Theme: Mine Restoration

Telfer mine site is found in Australia's Great Sandy Desert. At Telfer vegetation restoration is critical for the long term stability of rock waste dumps but also to the effectiveness of store and release cover system to prevent acid mine drainage. Topsoil is a valuable resource for vegetation restoration to post-mine sites as it contains the seeds of indigenous species adapted to local environmental conditions. The aim of this study was to quantify and describe the soil seedbank and investigate the optimal methods for using topsoil to restore vegetation cover on waste rock dumps at Telfer mine site. Topsoil from three major landforms found in the Great Sandy Desert (sand dunes, sandplains and stony hills) was examined using the seedling emergence method both in situ and ex situ to determine the size, species composition and distribution of the soil seedbank and its response to disturbance. Also examined was the effect of topsoil source, topsoil age, waste dump position (plateau, slope), the addition of rock armour and subsoil to reconstructed soil profiles and the method reconstructing soil profiles on seedling emergence and plant establishment. The topsoil seedbank when used fresh provides a valuable source of propagules for vegetation restoration. However seedling and species abundance and vegetation cover in restoration sites is highly dependent on topsoil source (landform) and method of topsoil harvesting, and also the design and method of reconstructing soil profiles on waste rock dumps in arid environment.

Using innovative imaging techniques to link saltmarsh distribution, on-site hydrology and wetland rehabilitation methods

Lisa Granqvist, Ron Cox

Water Research Laboratory, Civil and Environmental Engineering, UNSW

Theme: Methods, Techniques and Technologies used in Restoration

Coastal saltmarsh has an important ecologic function in tidal wetlands both within Australia and globally. Saltmarsh provides an important habitat and feeding ground for migratory birds and has been shown to be a key foraging ground for many commercial fish species. Additionally, recent studies have highlighted saltmarshes capacity as a carbon sink. Due to rising sea levels, urban and rural development, and upland mangrove migration into traditional saltmarsh areas, the areal extent of saltmarsh has been greatly reduced. To increase the abundance of saltmarsh across estuaries in Australia, a range of large scale remediation works are currently underway. The effectiveness of these strategies, however, is limited, as there is only limited information available on saltmarsh distribution in response to restoration efforts. In order to assess the success of restoration programs and assist in on-ground management strategies, effective techniques for mapping the response of saltmarsh growth under changing conditions are needed. This paper describes a novel approach of mapping the three-year evolution of saltmarsh extent in a large tidally restored wetland system (Tomago Wetlands, NSW, Australia), through the use of geo-rectified elevated digital camera images. The combined elevated images and on-ground mapping technique demonstrates the success of hydrologic based tidal restoration projects and assist in planning future restoration projects. Additionally, the use of this mapping technique will facilitate improved monitoring and adaptive management of coastal saltmarsh environments.

Perth's Canning River Regional Park: post fire collaborative invasive species restoration

Matt Grimbly
SERCUL

Theme: River Restoration

In February 2011 a large fire ravaged the Canning River Regional Park in urban Perth, Western Australia. The South East Regional Centre for Urban Landcare (SERCUL) initiated a meeting with all land managers to determine a constructive and collaborative approach to the management of the inevitable post fire mass weed invasion. The outcome was a funding investment for additional post fire weed management. SERCUL undertook to co-ordination of all Partners, to work together for a collaborative implementation of Post Fire weed management. The Swan River Trust, Department of Environment and Conservation, City of Canning, Wilson Wetland Action Group, Canning River Regional Park Volunteers and SERCUL have conducted extensive and integrated weed management throughout the period since the fire. An important component of SERCUL's activities involves the measurement and understanding of the effects of their Restoration Actions. SERCUL established a soil seed bank study and post fire management monitoring program to measure and cost the effectiveness of such a co-ordinated focussed approach to post fire weed management. The results of this integrated and collaborative approach to intense post fire invasion has demonstrated effective methods which can overcome the impacts of the inevitable weed invasion following intense fire, restoring resilient ecosystems able to better respond to on going unexpected disturbances.

How far is it to your local? A survey on local provenance use in New South Wales

Nola Hancock
Macquarie University

Poster Presentation

A critical component of restoration projects is the decision about where to source seed. Locally-collected seed is often recommended or contractually required because it is assumed to be adapted to local conditions and therefore result in superior survival and growth rates, conferring a greater probability of restoration success. The perceived advantages, which include retaining the genetic 'integrity' of the site, are centred around the avoidance of outbreeding depression and hybridization. These traditional reasons for using locally-collected seed need to be reconsidered in the light of rapidly changing climatic and other environmental conditions; plants that are locally-adapted now, may not be locally-adapted in the future. Understanding current usage of local provenance is pivotal to progressing discussions on its appropriateness under climate change. We present the results of a survey of restoration practitioners in New South Wales on attitudes and practices in relation to local provenance use. We found that the majority of practitioners use local provenance seeds. Respondent's definition of 'local provenance' lacked consistency but a small majority thought that its application was species-dependent. Whilst 80% of participants believe that projections of future climate change are relevant to restoration projects, there is a reluctance to actively manage for this eventuality. However, many respondents would like to see a review of seed-sourcing policy/ guidelines to allow for the inclusion of non-local provenance material. Giving practitioners the ability to maximize genetic diversity will increase the potential for evolutionary adaptability and will provide the opportunity for a 'default' management strategy under climate change.

Is fencing enough to restore rangeland ecosystems?

Richard Harris

Curtin Univiersity

Poster Presentation

Rangelands worldwide have a long history of livestock grazing impacts and the arid rangelands of northwestern Australia are no exception. Feral goats are a relatively new and significant threat to these native plant communities given their board diet and ability to browse and graze in areas that are inaccessible to livestock such as tree foliage, dense shrub thickets, and rocky outcrops. This project aims to understand the impact of feral goats on native plant communities that are characteristic of banded iron formations (BIF) and adjacent lowland Acacia shrublands. BIF are a focus of conservation efforts in the region because they include many restricted endemic plant species. Is a fence enough to promote vegetation recovery? Is vegetation recovery limited by other herbivores such as rabbits and kangaroos? If recovery does occur, how long does it take? In collaboration with the Department of Environment and Conservation and Geraldton Iron Ore Alliance 50 paired plots, with one of each pair fenced (0.25 to 1 ha), have been established in lowland Acacia shrublands and on BIF in the Gascoyne District of Western Australia. The experiment uses a before-after-control-impact design. Unfenced plots are exposed to varying grazing pressures. Monitoring to determine changes in perennial vegetation composition and density, grasses and annual biomass, seedling survival, and vegetation cover using remote sensing, is underway. The design and establishment of this long-term project is summarized along with some initial data and interpretation.

Networking and guidelines: their contribution to the translocation of threatened flora

Patricia Hogbin

Australian Network for Plant Conservation

Symposium: The role of plant translocations in restoring and maintaining biodiversity: policy, planning and practice

Guidelines and information sharing have played a vital role in the development of translocation methods for threatened flora. The Australian Network for Plant Conservation (ANPC) released the first edition of 'Guidelines for the Translocation of Threatened Plants in Australia' 15 years ago. The guidelines were developed from practical experience and applied research and guided many translocation projects. In subsequent years, the use of translocation increased, particularly as an ameliorative measure for development. In many cases, the use of translocation as an ameliorative measure was inappropriate and at best was a waste of resources and at worst may have further threatened the target species. For this reason, the guidelines were reviewed and a second edition was released in 2004. The second edition highlighted factors to consider when determining whether translocation is necessary and provided guidelines specific to ameliorative or compensatory translocations. The second edition was accompanied by the development of a one day workshop on translocation which has since been run over a dozen times both nationally and internationally. These workshops have been attended by over 500 practitioners and decision makers and have highlighted lessons learnt from dozens of translocation case studies. Very few translocation projects are documented in the scientific literature and these workshops provide a valuable opportunity for networking and information exchange that would otherwise be challenging. This presentation will highlight how ongoing networking and guideline revision has contributed to the continual improvement of translocation policy and practice across Australasia.

Threatened plant translocations in New Zealand: lessons learnt

Avi Holzapfel

Department of Conservation

Symposium: The role of plant translocations in restoring and maintaining biodiversity: policy, planning and practice

Translocations of threatened plants is a tool used frequently in New Zealand by both national and local government agencies and, increasingly, by private organizations, community trusts and individual landowners. Drivers for translocations are varied, including the protection of the species, site restoration, advocacy and research. As a consequence, not all are coordinated as part of a formal recovery programm, and effort in monitoring and outcome reporting is variable. Determinants of success, apart from a good understanding of the biology of the species, are context-specific and may not always just relate to the survival of the population. This includes the ongoing ability to identify and sustainably manage threats to a required level. Timeframes involved in outcome monitoring can exceed decades, and challenge planning and resourcing levels commonly available to those undertaking translocations. A number of case studies from New Zealand, including the first successful establishment of a population of a holoparasitic flowering plant, *Dactylanthus taylorii*, illustrate positive experiences and challenges of threatened plant translocations in New Zealand.

Respectful knowledge exchange between indigenous and non-indigenous Australians for successful outcomes: a Kimberley perspective

Jenny Hunter

Theme: Education

This session will share practical examples of successful knowledge exchange between Indigenous and non-Indigenous Australians drawing on a Kimberley perspective. It offers examples of projects which validate traditional ecological knowledge by integrating it from initial consultation to high level decision making resulting in successful outcomes for management and implementation. It will be facilitated by Aboriginal Traditonal Owner, Ted Carlton (Chairperson and Director of MG Corp) and non-Aboriginal Cultural Corridors Consultant, Jenny Hunter. Together they will discuss strategies which acknowledge and respect the shared journey and the integration of both scientific western practice with traditional ecological knowledge to achieve true collaboration. Addressing the 'language barrier' between the voice on the ground and the decision makers who shape our lives, we look at universal needs and truths and the value of arts as a tool to connect. Both presenters are passionate about Indigenous and non-Indigenous working together to share knowledge and wisdom and achieve a more balanced view. By acknowledging the collective knowledge and wisdom of all people we will be more empowered to take proud responsibility for ourselves and our country.

Conservation genetics and demographic analysis of the endangered cycad species *cycas megacarpa* and implications for translocation

Heather James[1], Paul Forster[2], Robert Lamont[1]

[1]University of the Sunshine Coast, [2]Queensland Herbarium,

Theme: Threatened Species, Populations and Communities

Cycas megacarpa is the most southerly occurring cycad species in its genus, with its current known range extending from Mt Walsh National Park to Morinish National Park in South-east Queensland. Over the decades of agricultural and urban expansion, *C. megacarpa* has been in decline and the species is now classified as endangered. It was anticipated that populations of *C. megacarpa* located in Central Queensland would be impacted by a development project. A proposal was made that involved a combination of translocations, augmentations and compensatory offset sites to minimise the impacts. This study aimed to assess the genetic variation of the potentially affected populations and provide recommendations concerning their translocation. All the populations were in a relatively compact area (approximately 340km^2) although fragmented by agricultural land and by roads. The genetic variation and composition of populations directly affected by the development as well as the potential offset sites and potential sites for later seed collection (to augment the translocated populations) were determined using microsatellites and evidence of any genetic differentiation was investigated. Low genetic diversity was found over all populations which is consistent with most other cycad species although inbreeding within the populations was low. These results were used to advise an approach aimed at minimising the potential for adverse genetic impacts and hence generate the highest probability of a successful translocation to produce viable populations for the long term survival of the species in that area.

Investigation into the interplay of processes influencing the establishment and survival of native vegetation at Wairio Wetland, New Zealand

Bridget Johnson

The University of Western Australia

Theme: Methods, Techniques and Technologies used in Restoration

Wairio Wetland on the Eastern shore of Lake Wairarapa, New Zealand has been adversely affected by anthropogenic activities since the 1960s. In 2005, Ducks Unlimited and the Department of Conservation signed a Land Management Agreement where Ducks Unlimited would commence the restoration of the wetland. Survival of trees planted during the first few years was relatively low which led to the decision to involve Victoria University of Wellington in the design and monitoring of a large scale field experiment eight New Zealand native wetland tree species: kahikatea, totara, cabbage tree, tree daisy, kohuhu, karamu, mingimingi, and manuka. The trees have been subjected to different methods of site preparation to determine the best combination of treatments for successful establishment of tree saplings. Treatments included: top soil excavation, release spraying, weed mats, nurse trees (with two combinations of species) and the spacing between nurse species. Survival and growth over the first six months was monitored. Preliminarily results suggest that Olearia virgata grew best in wet areas that had been scraped free of topsoil or drier areas that had not been scraped. Monitoring over the next 18 months will give us a better understanding of which is the most cost effective combination of treatments. Early indications suggest high level survival under all treatments.

Restoring ecological systems: a sensitive dependence on initial conditions

Justin Jonson[1], Simon Smale[2], Lien Imbrechts[1]

[1]Threshold Environmental, [2]Bush Heritage Australia

Theme: Delivering Large Scale Restoration

In southwest Western Australia, an ecological restoration project is being implemented on cleared post-agricultural land at Bush Heritage Australia's Monjebup North Reserve. The project aims to further improve on broad-acre revegetation previously undertaken in the Fitz-Stirling area of Gondwana Link, by including an explicit focus on the restoration of ecosystems and the development of habitat for fauna. To achieve these objectives, BHA commissioned an Ecological Restoration Plan for 435 ha of cleared land located within the 1100 ha property. Detailed soil and vegetation data, as well as specialised information on local fauna requirements for habitat values, were collected to design a restoration plan for the site. Ecological restoration of the first 100 ha of the project was implemented in 2012. The approach included the development of multiple seed mixes matched to soil type. 11,000 seedlings were planted to further boost the diversity and re-create resource-rich nodes of production. In addition, mulched materials from serotinous plant species were spread on scalped soil areas. A number of perennial recalcitrant rhizomatous sedges were also transplanted to facilitate their re-establishment throughout the site. Finally, habitat debris piles were constructed to support the return of local fauna. Restoring native ecosystems to their original structural and functional value is a highly challenging task. In this project, we have attempted to increase habitat heterogeneity and biological productivity at multiple scales, with the view that the intrinsic emergent order found in well-functioning native ecosystems may be realised through a strong investment in establishment of the initial trajectory.

Small scale, large scale: the potential of linking local restorative actions to a national green network

Simon Kilbane

University of Western Australia

Theme: Delivering Large Scale Restoration

The National Green Network for Australia (NGN) is a research project that attempts to spatially articulate national biodiversity conservation and policy targets through increasing protected area representation and maximising ecological connectivity. The idea of a NGN is more than habitat restoration to protect the Australian gene pool against climate change. As well as protecting biodiversity the system has other synergistic benefits. It creates recreational greenways and cultural corridors that can be related to indigenous culture. Through agro forestry such a system sequesters carbon and could help regional landscapes deal with salinity and water security. This paper discusses the potential on-ground implementation of continental-scale NGN designs. In conjunction with the Wheatbelt NRM group based in Northam, Western Australia, this hypothetical NGN was 'ground-truthed' by stakeholders through a design 'charette' workshop. A 25x25km study area in the Avon basin allowed participants from industry, land management and conservation backgrounds to visit key sites, to explore and discuss the merits of the proposed NGN design. Facilitated by their local knowledge and expertise, participants then adjusted and redrew this initial design. While maximising ecological restoration opportunities, the key to resolving designs was in accounting for the cultural demands of landscapes (settlements, agriculture, income, carbon). The design charette provided the opportunity to quickly workshop ideas and the potential to move from theory to practice, from large to local scales. This paper argues for the instrumentality of the NGN in establishing this outcome.

Inbreeding and outbreeding depression in stylidium hispidum: implications for mixing seed sources for ecological restoration

Siegy Krauss[1], Erik Veneklaas[2], Louisa Cockram[2]

[1]Kings Park and Botanic Garden, [2]The University of Western Australia

Symposium: Seed Sourcing Guidelines for Restoration Success

The benefits of composite rather than local seed provenances for ecological restoration have recently been argued, largely on the basis of maximising evolutionary potential. However, these arguments have downplayed the potentially negative consequences of outbreeding depression once mixed provenances interbreed. In this study, we compared intraspecific F1 hybrid performance for four populations of Stylidium hispidum, a species endemic to south Western Australia. To test for outbreeding depression, we conducted controlled pollinations and assessed germination and survival to 6 months for three cross categories (within population crosses, short- and long-distance F1 hybrids) for paired sites (3–10km apart) distributed within two genetically differentiated regions (120km apart). Reciprocal transplant trials with F1 progeny were established for 18 months within initial source populations to further assess outbreeding depression through survival, growth, flowering and seed production. For germination and survival, we found strong evidence for outbreeding depression in long-distance crosses, and inbreeding depression for within population crosses, relative to short distance crosses. For in situ survival and growth, we found evidence for a long-distance cross advantage over both short-distance and within-population crosses. Final seed production results will be presented. Cumulative results that identify an intermediate outcrossing distance (here, equivalent to 10km) in this species are considered in light of the evolutionary consequences of mixing seed sources for biodiversity restoration.

Managing mangrove ecosystem: restoring the potencies by optimalizing the policy and legislation

Yudi Krisno Wicaksono

House of Representative Students in University of Brawijaya

Theme: Island, Coastal and Marine Restoration

Mangrove has several of potencies and advantages that supports mitigation and adaptation of global climate changes. Nowadays, according to UNEP (2010), it is about 35,500km^2 or one fifth of Mangrove forests in the world had gone since 1980s. Mostly Mangrove forest are damaged by dysfunction of different interest. This dysfunction shows strong indication that there is a looseness in running government policy and legislation, so that it is required to have reformation. Mangrove potencies, up to now, are not maintained optimally. Most of the mantaining treatments are done by exploitating, sectoring, and overlapping actions. Anyway, it is needed to re-orient the policy and legislation in preserving and utilizing the mangroves. The Arrangement of Strategies Planning (ASP) as one of the mangrove ecosystem area planning documents is the early step of the re-orientation. ASP is the reference in utilizing and managing mangroves. There are four aspects in arranging ASP: ecological conservation, social development, economic development and administration correction. By arranging ASP, Integrated Mangrove Management (IMM) can be reached. IMM is defined as a process which is policies oriented and development of managing strategy to give concern to problem conflict in utilizing sources and controlling the effects caused by human intervention in mangrove ecosystem periodictly. By following this steps, it is expected that there is a clear slot process in making policy and legislation about managing mangroves, so that the potencies of mangroves can be optimalized furthermore. The successful managing mangroves hopefully can make the future of mangroves everlasting.

Living streams: what plants where, when and why?

Brett Kuhlman
SERCUL

Symposium: Living Stream Restoration

Essential components of the long term success of the Living Stream construction are restoration plantings and weed control. Opportunities and challenges are provided when determining species choice, location of plantings, and weed management into areas dramatically altered by stream channel reshaping, retrofitting and riffle and pool construction. Indigenous species, which are adapted to suit these conditions, are the ones most suited to build a functioning ecosystem, creating a resilient biodiverse ecosystem. Factors such as wetland/dryland areas, which may have changed appreciably following construction, require appropriate species to suit such changed conditions. An appropriate mix of perennial and annual species is important as is their placement to suit different vegetation zones including emergent, fringing, riparian, floodplain or upland ecosystems. In addition the reestablishment of the vegetation structure to include overstorey, midstorey, understorey and groundstorey species is vital role for the ongoing resilience of the Living Stream. Plantings in vegetation groupings based on predicted hydrology and ecotones, and other dynamics such as erosion, screening, local features such as paths and recreation need to be considered carefully during the planning and plant ordering phase of the Living Stream Development. Season and timing of plantings are critical, and dependent upon site conditions, for example late autumn to early spring for dryland species and early spring or summer for wetland species. Site preparation including weed control and ongoing management once planted are critical components for long term success.

Optimising seed germination to advantage direct seeding of *Triodia* (spinifex) species

Wolfgang Lewandrowski[1,2], Todd Erickson[1,2], Kingsley Dixon[1,2]
[1]University of Western Australia, [2]Kings Park and Botanic Garden

Symposium: Arid zone spinifex (Triodia) restoration

Triodia (spinifex) species in the Pilbara contribute to the majority of plant cover in natural vegetation, however are severely limited in post-mining restoration sites. A major reason for their absence is related to seed returned into the field being hindered by low germination and establishment into mature plants that is typically less than 10%. Consequently, restoration of post-mined sites is unable to match densities of population cover in natural landscapes. This could be explained by a recruitment bottleneck between the germination and establishment phases, whereby significant losses of seed material occur. Furthermore, steps required to increase germination potential are still lacking for ecological restoration. Prior to seed germination, innate dormancy issues exist, preventing immediate germination during favorable conditions when seeds are broadcasted. In Triodia this is a combination of a mechanical restriction of the floret surrounding the seed and a physiological dormancy block within the seed. To overcome this interaction, it has been shown that through a combination of cleaning techniques, whereby seeds are removed from their surrounding florets, dormancy alleviating treatments (e.g. wet dry cycling, dry after-ripening) and the application of a germination stimulant, germination has the potential to be maximized. A focus for research after optimising germination treatments is to further improve germination and seedling emergence in the field and further to explore ecophysiological responses of Triodia seedlings during establishment in post-mining sites.

Linear population shape reduces ecological and genetic function in a bird–pollinated plant

Tanya Llorens, Colin Yates, Heidi Nistelberger, Matthew Williams, David Coates
WA Department of Environment and Conservation

Theme: Ecosystem Services and Environmental Offsets

Linear strips of native vegetation are prominent features in agricultural landscapes and revegetation projects, yet there has been little study of the impact of linear geometry on ecological and genetic function. We used microsatellite markers, field surveys and fitness trials to investigate the effect of different aspects of habitat fragmentation on the mating system, pollen dispersal, reproduction and progeny fitness in remnant populations of Banksia sphaerocarpa var. caesia, a common bird-pollinated shrub in the southern agricultural region of Western Australia. We found population linearity to be as important as population size in relationships with variables that could potentially affect population viability. Plants in linear populations had smaller seeds and lower seed germination. As population linearity increased, mating neighbourhood size decreased and pollen pool differentiation increased, indicating a decline in genetic function mediated through changes in bird foraging patterns. Neighbourhood size was highly correlated with seed weight, which in turn was highly correlated with measures of seed and seedling fitness, suggesting a strong effect of paternal diversity on progeny fitness. In contrast to these detrimental effects, plants in linear populations were larger and had more inflorescences, cones and follicles than those in non-linear populations, suggesting that increased resource availability in linear populations may partly compensate for negative effects on the mating system and progeny fitness. We suggest that when planning restoration projects, more consideration be given to the potential impacts of linear population shape on ecological and genetic function and consequent long-term population viability.

Ecosystem restoration of a trial landform constructed with hard waste-rock materials at Ranger Uranium Mine, Northern Territory

Ping Lu[1], Peter Poole[1], Mike Saynor[2], Anja Zimmermann[1], Cherie Gellert[1]
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Theme: Mine Restoration

In 2009, a trial landform was constructed at Ranger Uranium Mine (Ranger), which is located 250 km east of Darwin in the wet-dry tropics. Ranger is surrounded by, but separate from, the World Heritage-listed Kakadu National Park. The trial landform of ~8ha was constructed to test ERA's ability to successfully build and rehabilitate mine landforms with the ultimate goal of establishing self-sustaining ecosystems. The experimental design of the trial landform was based on the outcomes of extensive past research, including characterization of analogue habitats and past revegetation trials on waste-rock stockpiles at Ranger. The trial landform comprises three equally-sized areas, (1) primary rock, (2) a 2 m-thick growth medium comprising a mix of lateritic materials and primary rock overlying primary rock, and (3) a 5m-thick growth medium as in (2). The areas are further split to determine the success of direct seeding and tubestock re-vegetation methods and irrigation. Ongoing monitoring of the trial landform includes flora, fauna, whole-tree water use (xylem sap flow), soil moisture levels, erosion rates, run-off water quantity and quality, radon exhalation and weather: 3.5 years worth of results will be presented. Temporal changes in these parameters will be critical for determining the time required for the final landform to stabilise. and the rate at which self-sustainable ecosystems are re-established. There are significant implications from the trial landform in the context of final landform design methodologies, the rates at which ecosystems re-establish and trend towards agreed final closure criteria.

The value to invertebrates of snipped wood applications in rehabilitated bauxite mines in South-Western Australia

Morgan Lythe[1], Vicki Stokes[2]

[1]Curtin University, [2]Alcoa of Australia ?

Theme: Mine and Fauna Restoration

Woody debris and leaf litter are important components of forest ecosystems, providing habitat for many invertebrate species. The action of these saproxylic invertebrates in the decomposition of woody debris also returns a significant amount of nutrients to the system. In jarrah forest areas rehabilitated after bauxite mining, it can take many decades for this debris to build up to levels equivalent to the surrounding unmined forest, and hence many of the species associated with fallen wood and litter may be slow to return to rehabilitated areas. Alcoa of Australia has trialled a new technique involving the spread of snipped wood waste onto the surface of areas rehabilitated following bauxite mining prior to seeding and planting. In 2008, nine test plots with three different treatment levels of snipped wood (0t/ha, 100t/ha and 300t/ha) were established. To determine the effectiveness of this method in encouraging the return of saproxylic invertebrates, in 2012 the now 4-year old rehabilitated plots were surveyed by means of seasonal pitfall trapping, Tullgren funnel litter extraction and hand collection. We compared the differences in the fauna between treatment levels and between unmined forest controls. Here, we present the results of these surveys and discuss whether the application of fine woody debris during early stages of rehabilitation is an effective technique for restoring an invertebrate fauna which is similar to that of unmined natural forest.

Restoration of a snow gum woodland: 60 years on...

Elizabeth MacPhee

National Parks and Wildlife Service

Theme: Forest and Woodland Restoration

The construction of the Snowy Hydro Scheme in SE Australia resulted in over 400 sites of disturbance in what is now Kosciuszko NP. These sites all contravened at least one regulation of National Parks and some were considered to have extreme environmental issues with instability, steep slopes, threatened species impacts, weeds and some a complete lack of biological function. Snowy Hydro was corporatised in 2000 and by doing this thay gave back the environmental liability to NPWS. Funding was contributed by Snowy Hydro to National Parks and is to be used specifically for this restoration work. The sites range from spoil dumps, quarries, old towns, stream guaging stations, roads etc. In 2004, a small rehabilitation team was created within NPWS and so far have rehabilitated over 100 sites and managed the planting of 800,000 native tubestock and have removed over 80km of woody weeds in high altitude waterways. Sub-alpine landscapes in particular Snow Gum woodlands were altered and destoyed through the construction of the scheme. A primary goal of the former sites project is to restore this type of woodland. This paper will outline the process of restoration for one site, Snowy Adit; where over 100,000 seedlings have been planted with nearly 100% survival. The techniques used for site assessment, the restoration methodology used; i.e. engineering design, compost production, planting technique, tubestock management, use of organic mulches, timing issues, the success of the techniques and the application of these techniques to other woodland restoration projects will be discussed.

Is 37 years sufficient for full return of the ant biota following restoration?

Jonathan Majer[1], Elliot Hughes[1], Lewis Mounsher[1], Andrew Grigg[2]

[1]Curtin University, [2]Alcoa of Australia Ltd

Symposium: Novel ecosystems in restoration and rehabilitation; Innovative planning or lowering the bar?

To provide an assessment of ecosystem recovery in 1975-bauxite mined areas, the ant fauna of one area to be planted with Corymbia calophylla, one to be seeded with mixed native species, one to be topsoiled but unrehabilitated, and a forest control was sampled monthly, and latterly annually, between 1976 and 1989. In this 'long-term' study, it was concluded that although composition of the ant fauna had converged on that of the forest over the 14-year period, differences still persist. A companion 'short-term' study was performed in 1979 in 30 bauxite mines of different ages and rehabilitated by a range of different methods, plus three forest controls. As with the long-term study, the rate of fauna return, and the type of ants present, varied with the methods of rehabilitation used and no plots had converged on the forest in terms of the ants present. In order to examine the assertion that the observed differences between rehabilitated areas and forest controls will lessen with time, both sampling programs have been repeated in 2012, using identical sampling methods, although only four of the rehabilitated areas from the short-term study were resampled. This presentation compares the current fauna with that observed in the original surveys to see whether differences in outcomes between the different rehabilitation prescriptions persist and whether the passage of considerable periods of time is an effective means of ensuring that fauna recovery does take place.

Borrow site restoration within the Shark Bay World Heritage Area

C. Ellery Mayence

Botanic Gardens and Parks Authority

Theme: Mine Restoration

Restoring landscapes degraded by mining activities can be labour-intensive and financially costly. Such settings, however, provide unique opportunities to develop and test novel approaches to restoring native plant communities. At Shark Bay Resources, a evaporative solar salt facility within the Shark Bay World Heritage Area, Western Australia, a innovative approach to creating habitat islands or patches of vegetation is being trialled to revegetate substrate borrow sites. The trials include two large factorial experiments employing two substrate materials (borrow site substrate and reference area topsoil), three seeding approaches (no added seed, addition of untreated seed, and addition of pre-treated seed), and two seedbed protection approaches (no protection and installation of a partially-buried cardboard windbreak). Prior to experimental set-up, each trial site was deep ripped to approximately 1 m to alleviate compaction, an impediment to past restoration attempts. For this study it was hypothesised that no significant benefit will be gained by seeding into reference area topsoil as opposed to borrow site substrate (based on a preliminary substrate and soils investigation), that pre-treated seed will exhibit greater germination success compared to untreated seed as a result of dormancy-breaking pre-treatments (e.g., hot water, smoke water), and that cardboard windbreaks will benefit seed germination and seedling establishment through protection from wind and blowing sand stress, increased soil and substrate moisture retention, and decreased small mammal herbivory. It is envisioned that results from these studies will increase the restoration capabilities of Shark Bay Resources, thereby benefiting the ecological integrity of the surrounding World Heritage Area.

Adaptive management for effective restoration of an urban bushland in Kings Park

Catherine McChesney

Kings Park and Botanic Garden

Symposium: Banksia Woodland Restoration

Kings Park and Botanic Garden, located in Perth, Western Australia, is internationally renowned for having a large area of bushland within close proximity to a capital city. Despite being subjected to a range of past and ongoing disturbances since European settlement, a rich diversity of flora, fauna and fungi persists. The goal of ecological restoration in Kings Park is to reverse the degradation of native biological diversity to the point where the ecosystem becomes autonomous, as much as is possible in an urban bushland setting. An adaptive management framework, incorporating a simple conceptual model of Kings Park, was outlined. Key factors driving the restoration approach were identified and included:

- Permanent ecological disconnection from surrounding bushland remnants – requires ongoing system inputs;
- restoration occurs within the existing bushland structure – restricts abiotic interventions; capitalizes on in situ native biotic resources and controls introduced biotic resources;
- resource constraints – focuses on direct introduction of plants and improving habitat for fauna and fungi;
- limited regional species pool – requires ongoing revegetation with local native species;
- biodiverse region – maximizes species richness of the revegetation mix;
- propagation techniques unavailable for many species – reduces species richness of the revegetation mix;
- harsh growth conditions for plants/ limited local native propagules – favors tubestock plantings over direct seeding;
- high visitation – promotes biodiversity conservation; minimizes adverse effects of recreation and risk management on biodiversity;
- lack of reference sites – incorporates value judgments because of the difficulty of defining meaningful, measurable targets;
- permanent staff – combines monitoring with informal observations during regular on-ground operations to evaluate progress; and
- complex ecosystem – requires ongoing scientific research to underpin ecological restoration.

Native species mine revegetation at goro in New Caledonia: strategies and challenges for industrial scale restoration

Stéphane McCoy

Vale New Caledonia

Theme: Mine Restoration

New Caledonia is renowned as a biodiversity hotspot because of its high level of diversity and endemism. These laterites also represent 25% of the world known nickel reserves and have been mined for over a century. Mine overburden previously dumped into valleys causing coastal pollution is now the focus of revegetation operations. These operations aim to produce vegetation similar to surrounding habitats because the peculiar properties of ultramafic soils exclude future agricultural or pastoral land uses. Revegetation efforts of mined lands have focussed since the 1990 on the diverse assemblage of endemic species from surrounding maquis heathlands tolerant of mine site conditions to generate pioneer vegetation suited to seedling colonisation from surrounding areas. Small scale germination and plantation trials have shown promising results for many pioneer endemic species. However there are numerous challenges in their large scale implementation on mine sites. A main hurdle in large scale seedling production is the annual variation in seed availability of target pioneer species, their viability, and storage and germination requirements compared to the diverse assemble of secondary species. To date, 230 endemic species have been produced from seed at Vale New Caledonia native species nursery. 50 pioneer species belonging to the families Myrtaceae, Cunoniaceae, Casuarinaceae, Cyperaceae and Proteaceae show promising growth results. However a ranking of the frequency in which these species have been produced over the past 16 years, indicates that the annual seed production and subsequent availability for revegetation of many key pioneer is highly variable leading often to an over representation of secondary maquis heathland species that are slower growing. Strategies to ensure that large scale native species restoration resemble the composition of surrounding vegetation include mass production of robust pioneer species by satellite nurseries in neighbouring communities to ensure quantities are available for restoration and seed priming for sedge species with poor field germination for direct seeding techniques.

Tree dominated agriculture for environmental services and sustainable livelihoods in Sri Lanka

Kamal Melvani

Neo Synthesis Research Centre

Theme: Planning Restoration and Measuring Success

Forest cover in Sri Lanka is less than 25% of her land extent of which less than 9% is primary forest while 91% is naturally regenerated or plantation forest. Loss of forest cover has negative impacts: non availability of wood, reduced biodiversity, increased soil erosion, changes in hydrological productivity and reduced carbon sequestration. These impacts are already felt and will intensify if sustainable alternatives are not adopted. However the alternative selected must consider that large tracts of land are unavailable and forest restoration may need to happen in agricultural landscapes where home gardens are converted to forest gardens. Such restoration must include a 'livelihood' component that goes beyond the provision of environmental goods and services. The Neo Synthesis Research Centre has practiced a system of 'regenerative agriculture' in Sri Lanka for the past 20+ years. It focuses on tree cropping that ensures long term, risk free income and the cultivation of annual crops in a section of the garden kept as open space that provides rural households with income and food security in the short term. The diversity of crops and the adoption of biological methods of cultivation ensures wholesome food, non toxic environment for biodiversity and clean water amongst other benefits. While many applications of regenerative agriculture have been practiced successfully in diverse ecozones in Sri Lanka there is the need is to assess their efficacy in social, economic and ecological terms in order to test their scientific validity and replicability. This paper seeks to describe such assessment.

Ecological and population genetic implications for conservation and restoration of a rare orchid

Myles Menz[1], Kingsley Dixon[1], Rod Peakall[2]

[1]Kings Park and Botanic Garden, [2]ANU

Symposium: Pollinators in Ecological Restoration

Orchids are one of the world's most diverse plant families and are well known for forming complex and specialised ecological interactions. One of the most specialised pollination interactions is sexual deception, whereby the orchid co-opts a male insect into mating with it, thus affecting pollination. Here we use the rare, sexually deceptive terrestrial orchid *Drakaea elastica* as a case study highlighting the need for intimate ecological knowledge in conservation or restoration programs involving specialised pollination interactions. We determined that *D. elastica* requires microhabitat patches of open, bare sand and low density ground-level vegetation. The majority of genetic variation lies within populations, with a relatively low overall FST = 0.03, however this was significant on a regional scale. We found differences in the pollinator attracted to some flowers, revealing the presence of different chemotypes within *D. elastica*. This was further corroborated with GC-EAD analysis which revealed differences in the response of some pollinators to compounds in the odour bouquet of *D. elastica*. A mark-recapture experiment on the specific pollinator, *Zaspilothynnus gilesi*, revealed that the majority of movements were less than 100 m, and that *Z. gilesi* does not occur in agricultural pasture. Consequently the majority of pollen movements should occur within populations of *D. elastica*, with potential for movements between adjacent populations within natural habitat. We conclude that conservation projects aiming to protect or augment populations of rare orchids, in particular those forming specialised interactions need to consider microhabitat requirements, mycorrhizal and pollinator associations.

Applying ecohydrology in mining restoration projects: lessons from ecological succession of mine slopes for future research

Luis Merino-Martín[1], C. Ellery Mayence[1], Ben Miller[1], Jason Stevens[1], Mariano Moreno-de las Heras[2], Tíscar Espigares[2], Jose M. Nicolau[2]

[1]Kings Park and Botanic Garden, [2]Universidad de Alcalá

Theme: Physiology and Hydrology for Mine Restoration

Mining restoration is a complex activity with natural abiotic processes developing interactively with ecological succession within newly constructed environments. Ecohydrological processes are imperative for the functioning of such ecosystems, with the behaviour of slopes in particular playing a significant role in the evolution of restored landscapes. Slope behaviour and its influence on processes such as runoff and erosion can dramatically affect the constructed environment as well as adjacent undisturbed ecosystems. In previous slope research in a post-coal mining environment, overland flow was identified as a key driver of ecological succession, notably that overland flow volume directly influenced the control of water resources, and hence, successional processes. The identification of overland flow as a driver of both abiotic and biotic processes calls for it to be more widely considered as an ecological factor in restoration projects. This previous research is presented as a foundation to the development of a new experimental approach for post-mining restoration on banded ironstone communities in semi-arid Western Australia. The scarcity of topsoil resources, a common problem throughout the mining industry with respect to restoration, encourages research aimed at identifying alternative growth media. Incorporating hydrology into this research will yield data that informs restoration decisions and benefits restoration success.

Managing seed longevity and dormancy release during the seed banking phase

David Merritt

Kings Park and Botanic Garden

Symposium: The Australian Seed Bank Partnership: a national network to advance seed management for conservation and restoration

Seed banking is a fundamental step in the restoration of degraded habitat. Seed banks can establish and maintain genetically and geographically representative samples of plant germplasm able to be used years, decades, or even centuries into the future as a resource for large-scale restoration projects. However, all seeds have a finite lifespan. Even under ideal storage conditions the longevity of seeds varies greatly between species. Recent research across Australia highlights that seed longevity varies by at least four orders of magnitude, and has identified many species that are short-lived and that require more considered storage procedures. Experimentation on alternative storage technologies, such as cryostorage, shows promise for short-lived seeds, but some seeds, particularly those of orchids, remain challenging to manage. Correctly managing seeds during the storage process requires knowledge not just of seed storage behaviour, but also of seed dormancy type and germination requirements. For some seeds, it is clear that dormancy can be manipulated and alleviated during storage by varying the storage environment. But can (and should) seed dormancy be broken prior to storage, without impacting on the longevity of seeds? Or should dormancy be broken after storage, immediately prior to delivery of seeds to restoration sites? These questions remain only partly answered. Planning ahead for the end use of the seeds and providing for flexibility in the storage environment is one key to ensuring seeds are ready to be used when needed. This paper will outline new research findings and future directions in Australian seed banking.

Connectivity and restoration in *Acacia woodmaniorum* (Maslin and Buscomb), a rare endemic of the Yilgarn Banded Ironstones

Melissa Millar, Margaret Byrne

Department of Environment and Conservation

Symposium: Seed Sourcing Guidelines for Restoration Success

Restoration ecology science is increasingly recognising the importance of contemporary evolutionary processes that maintain genetic connectivity for achieving successful long term restoration outcomes. The negative genetic impacts of reduced connectivity and mate limitation are well recognised and have been shown to be especially relevant to species that exhibit a degree of self incompatibility. In order to inform post-mining restoration practices we assessed historical and contemporary levels of genetic connectivity, as well as aspects of the contemporary mating system for Acacia woodmaniorum, an EPBC listed species of the Western Australian Banded Iron Formations. While fine scale genetic structure is observed, estimates suggest historical gene flow has been more than sufficient to maintain adaptive connectivity across the species range and largely negate any impacts of increased inbreeding in small, disjunct populations. A highly outcrossed contemporary mating system suggests a genetic self incompatibility mechanism. Immigration of outcrossed pollen combats mate limitation and results in large effective population sizes even in small, disjunct populations, but suggests a high dependence on dispersal of outcrossed pollen for reproductive success. Alteration to pollinator numbers, assemblages or behaviour that negatively affects the introduction of outcrossed pollen is likely to have significant affect on production of viable seed and reproductive success. The pattern of genetic structure also suggests an influence of wind on insect mediated pollen dispersal. Establishment of restored populations with high levels of diversity may alleviate any affect of mate limitation and placement of restored populations in the landscape will be critical for this taxon.

Current practice fails to provide adequate data to plan or assess restoration in relation to targets of species richness and community type as set by law

Ben Miller, Erin Picken

Kings Park and Botanc Garden

Theme: Planning Restoration and Measuring Success

In Western Australia, as elsewhere, Government approval for mining and other activities impacting on natural ecosystems with significant conservation value is often granted with a proviso of post-impact restoration. While varying on a case-by case basis, development approvals often specify targets for biodiversity reinstatement which appear to be increasing in precision and rigor. A precedent recently set with approval for a mine impacting a Threatened Ecological Community in Western Australia's Mid-west demands the re-establishment of pre-existing vegetation communities, and sub-communities incorporating ≥70% of the original species diversity. The setting of these targets creates a challenge to restoration practitioners and consultants to develop an adequate baseline of realistic and usable data. This is a challenge as the measurement and definition of species richness and community types is not straightforward. Observed species richness varies with measurement scale as well as successionally and seasonally. Community definition varies significantly between the several most commonly employed approaches (including numerical classification), each of which is also dependent on the details of sampling design, and is ultimately subjective. Here we examine the data and analyses typically employed, and those required, to set and test targets of species richness and community definition for ecological restoration. We illustrate the restoration implications of inappropriate baseline establishment and offer some recommendations to increase the utility and repeatability of approaches to baseline target establishment.

Threatened plant translocations in Western Australia: lessons learnt

Leonie Monks, David Coates

Department of Environment and Conservation

Symposium: The role of plant translocations in restoring and maintaining biodiversity: policy, planning and practice

Translocations are increasingly being used in an attempt to prevent extinction or to restore population viability of threatened plant species. For translocations to be effective in achieving these goals they must be carefully planned, implemented and monitored. Long term monitoring is essential as this allows practitioners to accurately assess success or failure and, where necessary, to take corrective action to avert failure. Recently, there has been an increasing interest in the use of translocation as a tool to aid in climate change adaptation. If translocation is to be effective at mitigating species decline under likely climate change scenarios then previous plant translocations must be examined closely and the lessons learnt shared. The Western Australian Department of Environment and Conservation has implemented translocations for more than 60 plant species over the past two decades. Using an adaptive management framework the knowledge and experiences gained from early translocations have been used to improve the success of later attempts. This talk will discuss some of the plant translocations underway in Western Australia and highlight the lessons learnt along the way.

Vegetation spatial pattern as a tool to measure restoration success

Cameron Mounsey[1,2], Gavan McGrath[1], Jason Stevens[2], Christoph Hinz[1], Waqar Ahmad[3], Kingsley Dixon[2],

[1]The University of Western Australia, [2]Kings Park and Botanic Garden, [3]CSIRO

Theme: Methods, Techniques and Technologies used in Restoration

The spatial structure or pattern of vegetation has been widely used as an indicator of ecosystem function in arid and semi-arid environments. Mediterranean environments, however, have received less attention. Furthermore, this spatial analysis is not commonly applied to assess attributes of restoration sites. This study utilised very high resolution, colour-infrared aerial imagery to examine the spatial pattern of restored Banksia woodlands on the sandy soils of the Swan Coastal Plain, in Perth, Western Australia, as they developed along a 20 year restoration chrono-sequence. Patch metrics and textural indices were assessed and used as indicators of function, and hence, restoration success. Field measurements of functional traits (hydrology, and soil physical and chemical properties) were taken to support image-derived information. The potential exists for this technology and methodology to become standard restoration monitoring practice in many environments, and holds particular promise in assisting to identify and target areas where further intervention and restoration management is required.

Translocation: challenges and policy responses

Simon Nally

Department of Sustainability Environment, Water, Populations and Communities

Symposium: The role of plant translocations in restoring and maintaining biodiversity: policy, planning and practice

The translocation of threatened species is increasingly used in Australia to meet conservation, animal welfare, social, and development offset objectives. Although historically applied in response to a threat to a species, its potential use for assisted colonisation in response to a changing climate has precipitated an expanded interest in translocation as a tool to manage threatened species. Conservation translocation protocols for threatened species, mostly for reintroduction, are well established within Australian States and at an international level. These protocols usually address; short term translocation purpose, animal welfare, biological and ecological needs of the organism, translocation methods, monitoring, and, increasingly, genetic considerations. Despite this well-established guidance, the success of translocations is often confounded by unclear objectives, unsuitable success criteria, or insufficient monitoring. The interplay of multiple objectives for a translocation and of its recipient site (e.g. ecosystem restoration, assisted colonisation, and iconic place protection) can further increase the risk of unclear objectives. Responding to the challenges of the differing objectives of translocation or of interstate or international movement may be assisted by a cohesive policy framework that addresses key gaps between existing protocols. In addition to supporting systems to balance and clarify translocation objectives, policy can help guide effective risk management, genetic management to maximise evolutionary potential, success criteria, the co-establishment of interdependent species, and community engagement. This guidance is likely to improve the targeting and success of this important conservation tool.

Forest restoration through capacity building and training

David Neidel, Pangestuti Astri

Environmental Leadership & Training Initiative

Theme: Education

Forest restoration is critical for conserving biological diversity and ensuring the adequate provision of fundamental environmental services. Restoration of degraded lands, however, has had minimal success, in terms of quality and extent, due to financial, technical, political, and socio-economic constraints. This presentation will explore some of the challenges to scaling up forest restoration efforts by examining the work of the Environmental Leadership and Training Initiative (ELTI). ELTI is a joint program of the Yale School of Forestry and Environmental Studies and the Smithsonian Tropical Research Institute aimed at increasing local capacity for forest conservation and restoration in tropical Asia. ELTI consists of two components: the Training Program works with a variety of research institutions to offer a variety of practical training events, while the Leadership Program works with Training Program alumni to ensure that the knowledge and skills learned through the trainings are implemented on the ground. This presentation will provide an introspective assessment of ELTI's work on forest restoration. It will discuss the array of strategies that ELTI is using to scale-up forest restoration, focusing particularly on our attempts to bridge the science-practice gap. It will explore some of the challenges that have arisen in this work and the key lessons learned. The importance of network building to overcome impediments to field implementation will particularly be discussed. Finally, it will present some of ELTI's achievements to date while underlining the difficulty in formulating and actualizing metrics of success.

Variable spatial genetic structure in three co-occurring riparian tree species (*Eucalyptus camaldulensis*, *Eucalyptus victrix* and *Melaleuca argentea*): implications for seed sourcing and conservation

Paul Nevill

Kings Park and Botanic Garden

Symposium: Seed Sourcing Guidelines for Restoration Success

The concept of local provenance is widely applied in native plant community restoration, revegetation and conservation, where the local provenance is typically defined using a combination of climate, geomorphological and genetic information. Where information on the spatial distribution of genetic diversity and the extent of gene flow between locations is not available, predictions are often made based on the life history traits of the species. However, this is problematic as species with very similar life history traits can have very different spatial genetic structures, due for example to different histories of range expansions and contractions. Here we investigate genetic variation at nuclear and chloroplast markers in populations of three co-occurring Pilbara riparian tree species: *Eucalyptus camaldulensis*, *Eucalyptus victrix* and *Melaleuca argentea*. Bayesian clustering, maximum likelihood estimates of migration rates, as well as genetic variance partitioning based methods were used to assess the spatial genetic structure of these three riparian species and in particular, contrasting the extent of differentiation within and among creek systems. Critically, genetic structuring was found to vary significantly between the three study species, which highlights the importance of species-specific studies on the geographic distribution of genetic variation. This study generates novel data on landscape drivers of genetic structuring in the Pilbara, and provides restoration practitioners with a solid genetic basis to guide seed sourcing for optimal restoration and biodiversity conservation outcomes.

Management of *Hydrocotyle ranunculoides* in Europe

Jonathan Newman

Centre for Ecology and Hydrology

Symposium: Aquatic Ecosystems: Restoration Interactions

Hydrocotyle ranunculoides is known to be present in at least 5 countries of North West Europe. Despite its limited distribution, where it occurs it forms very dense floating mats that block waterways, with the consequent loss of most submerged macrophytes, restriction of marginal habitat, simplification of habitat structure and significantly increased potential flood risk. Methods of control of this species range from exclusively mechanical removal (harvesting) in the Netherlands to a combination of methods including mechanical control of large floating mats followed by application of glyphosate based herbicides combined with the aquatic approved sticker adjuvant TopFilm, followed also by hand pulling of fragments. No single method of control has proved successful at completely eliminating this species and the only sites in the UK where eradication has proved successful are where dedicated water managers have ensure continued control efforts over a period of years. The most successful regime at the moment appears to be hand pulling in early spring to remove as many of the small marginal mats as possible, followed by more hand pulling or application of herbicides, followed by mechanical removal if required followed by more hand pulling and herbicide application. This process goes on between early spring and late autumn. Restriction of trade in the species at specialist aquatic nurseries has limited the increase in distribution in the UK since about 2005, but further action is required to ensure a complete ban on the sale of this and other nuisance aquatic macrophyte species.

An industry perspective on achieving biodiverse banksia woodland return

Vern Newton[1]

[1]Rocla Quarry Products

Symposium: Banksia Woodland Restoration

Perth sits at the centre of one of the world's 25 global biodiversity hotspots. A key resource centre (silica and building products) operated by Rocla is located 30km north-east of Perth (Gnangara) on the Swan Coastal Plain on the suburban outskirts of Perth. The development of metropolitan Perth is highly dependent on the significant sand resources that are generally restricted to isolated pockets in specific geological units within the metropolitan regions' Bassendean dune system. As a result, the company impacts the Banksia woodland plant communities in the path of the mine, which are supported by the deep siliceous Bassendean dune sands. The process of sand extraction requires clearing of the Banksia woodland vegetation from undulating hill-sites, stripping the topsoil and removing the underlying white and yellow quartz sand horizons constituting 18–40m of the sand profile, thereby reducing the resultant sand profile depth by at least 20m. A major priority of the company is to restore the post-sand extracted sites with a plant community closely resembling the pre-sand extracted Banksia woodland plant community. Devoid of any existing restoration information, Rocla over the past 18 years has developed, in collaboration with Kings Park and Botanic Garden, procedures to ensure >75% of species return in their restoration sites. This presentation will highlight some of the key advances in planning and restoration implementation that have enabled these industry leading restoration outcomes.

Reconstructing a native forest ecosystem at Mount Owen Mine

Yvonne Nussbaumer, Carmen Castor

The University of Newcastle

Theme: Mine Restoration

Mount Owen open-cut coal mine is passing through 50% of Ravensworth State Forest in the Hunter Valley NSW. As a consequence, Thiess Pty Ltd and Xstrata Coal, together with the University of Newcastle, has initiated the Forest-Woodland Reconstruction Research Program in the spoil placement area and a Biodiversity Offsets Research Program, using the Ravensworth State Forest remnant as the reference community. Research on the soil placement area has focused on using forest or pasture topsoil as a growth medium, as well as finding topsoil substitutes. Experiments to date have looked at the use of biosolids, municipal waste compost, chitter and pasture subsoil, as well as the application of fertilizer and gypsum. Forest topsoil has consistently produced the best outcomes in terms of plant density and species richness, while pasture topsoil has performed worse than bare spoil due to high weed and grass competition. Capping pasture topsoil with either chitter or subsoil reduced competition long enough for native species to become established. Pasture subsoil was the best of the media trialled to date, while biosolids produced mixed results due to high weed and grass competition in the field. Inoculation of plants growing in these substrates with rhizobia bacteria improved plant growth. Long term monitoring of experiments provides insight into their resilience to environmental stresses such as drought and therefore the likelihood for long-term sustainability.

Fauna colonisation of newly established mine rehabilitation at a mineral sands mine in arid southwest New South Wales

Ashley Olson[1], Michael Priest[2], Simon Cook[1]

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Theme: Mine and Fauna Restoration

This study assessed colonisation by birds, small mammals, reptiles and amphibians of a newly rehabilitated mine waste dump, OB3 (Overburden Stockpile 3), at the Bemax, Ginkgo Mine in far southwest NSW. The construction of a large mining void to facilitate a sand mining operation has resulted in the establishment of a permanent 34ha elevated hill feature. The vast majority of overburden at OB3 is comprised of overburden sands and clays which have been capped with 20cm of calcareous subsoil followed by 20cm of topsoil, representative of the surrounding region. The landform has been cross-ripped with woody debris placed over batter areas to reduce erosion. Revegetation commenced in mid 2009 involving direct seeding along with some targeted areas of tree and shrub tubestock planting. Flora surveys conducted in May 2010 and September 2011 have established the floristic and structural composition of OB3. In 2011 we began fauna surveys of pads and batter slopes at OB3 as well as in surrounding remnant vegetation which was separated by approximately 100 m of cleared land. Our surveys consisted of pit-fall trapping for small mammals and herpetofauna and timed observations for bird species. Both birds and herpetofauna showed greater species richness within the remnant habitat, although some species were found exclusively within OB3, including the only amphibian recorded, *Neobatrachus sudelli*. Pit-fall trapping revealed a bias towards certain mammal species, namely Fat-tailed Dunnart (*Sminthopsis crassicaudata*) and House Mouse (*Mus musculus*) within OB3, while Common Dunnarts (*Sminthopsis murina*) were the dominant within the remnant habitat.

Seed quality and management of plant genetic resources in fragmented landscapes

Kym Ottewell[1], Mike Gardner[2], Andrew Lowe[2]

[1]Department of Environment and Conservation, [2]Australian Centre for Evolutionary Biology and Ecology, Adelaide University

Symposium: Seed Sourcing Guidelines for Restoration Success

Identifying appropriate sources of seed for ecological restoration is a complex, yet critical, process. In fragmented landscapes, reduced stand density and changed plant-pollinator interactions can lead to changes in individual plant mating patterns, for example, through increased inbreeding or reduced pollen diversity. These mating patterns drive immediate gains or losses of genetic diversity in populations and are expected to directly impact the fitness of future generations. Through a review of the literature we provide a meta-analysis of the general effects of habitat disturbance on mating patterns of animal-pollinated trees and shrubs. We demonstrate these effects using several case studies of mallee and woodland eucalypts in southern Australia. Through microsatellite analysis of open-pollinated progeny arrays collected from isolated trees, remnant patches and 'intact' forest we show that the mating patterns of these trees show a correlation with stand density and pollinator mobility. We then explore the fitness consequences of these altered plant mating patterns in a common garden experiment and find that pollen diversity is a significant predictor of progeny fitness, in addition to outcrossing effects. The findings of this work have applications to management of plant genetic resources. We focus on the implications of these findings for the use of plant genetic resources in restoration and revegetation.

Riparian wildlife habitat mapping with LiDAR and high resolution imagery

Chong-Hwa Park, Seung-Gyu Jeong

Seoul National University

Theme: Methods, Techniques and Technologies used in Restoration

Drastic change of stream topography and vegetation after flooding makes riparian corridor surveys obsolete frequently. Advanced remote sensing technologies could be employed for the mapping and monitoring of stream renovation projects. The objective of this paper is to produce accurate riparian wildlife habitat maps by merging high resolution multi-spectral data and canopy height obtained from LiDAR. Such maps can be used to evaluate wildlife habitat and to connect fragmented riparian wildlife passages of river corridors in urban areas of Korea. Land cover classification based on OOC was carried out by merging spectral data of high resolution imagery and vertical data of LiDAR. Spectral bands of the DMC digital high resolution are RGB, and NIR, and spatial resolution is 0.2 m. First, riparian land cover map was produced tree, shrub, grass, bare earth, and water surface. Overall accuracy was 66.25%, and those of water and bare earth classes were 82.5% and 70%, respectively. But the accuracies for shrub and grass classes were less than 54% due to the confusion with each other class. Second, Canopy Height Model were produced based on the LiDAR data. Threshold values between bare earth, grass and shrub, and tree were set at 3m and 5m, respectively, for the data fusion of spectral and height data. Third, land cover classification based on the data fusion and OOC was carried out. The classification accuracies for the two classes, shrub and grass classes, were improved to 60% level. The classification accuracy may be improved by adjusting the height threshold based on the phonological stage of the remotely sensed data, too. Finally, wildlife habitat maps for above mentioned bird and mammal communities were produced.

Evaluation of native Australian grass species for tolerance to sodium sulphate salinity in bauxite processing residue sand

Xanthe Pedersen[1], Martin Fey[1], Richard Bell[2]

[1]The University of Western Australia, [2]Murdoch University

Theme: Mine Restoration

Introduced grasses are currently used as temporary vegetation cover on bauxite residue storage areas (RSA) to suppress dust and erosion. Native Australian grass species are ecologically preferable, but their tolerance to the alkaline, sodic, and saline soil conditions of bauxite residue is unknown. Twenty-seven native grass species were pre-screened for their requirement of gibberellic acid and smoke water to break seed dormancy, a common problem for establishment of these species. Thirteen species were then compared with two currently-used, introduced grass species for their ability to emerge in bauxite residue sand pre-treated with gypsum, washed, then amended with Na_2SO_4 to produce salinity (ECe) ranging from 2 -12dS/m. Austrostipa scabra and Chloris truncata showed the greatest tolerance to salinity with no inhibition up to 10dS/m. Neurachne alopecuroidea displayed a moderate-high tolerance to salinity with a 20% decrease in emergence over the treatment range. *Microlaena stipoides* and *Themeda triandra* exhibited moderate inhibition and *Bothriochloa bladhii*, *Brachyachne convergens* and *Enneapogon polyphyllus* displayed low tolerance to salinity. No native species had emergence exceeding 50% and none exceeded the emergence of the introduced species, *Lolium rigidum*. This investigation highlights the need to test the germinability of seed and dormancy-breaking requirements prior to use. *Austrostipa scabra*, *C. truncata* and *N. alopecuroidea* show potential as early-stage rehabilitation species, while *M. stipoides* and *Themeda triandra* could be established when salinity has declined. Field performance, including productivity and competition of these grasses compared with introduced species, remains to be tested on bauxite RSA.

Novel ecosystems: a necessary consideration for restoration planning in the 21st century

Michael Perring, Kristin Hulvey, Lori Lach, Tim Morald, Rebecca Parsons, Rachel Standish
The University of Western Australia

Symposium: Novel ecosystems in restoration and rehabilitation: Innovative planning or lowering the bar?

Novel ecosystems are now widespread across the global biosphere, having arisen through abandonment of intensively used land or through human-caused biotic and abiotic changes to supposedly unaltered 'natural' systems. Thresholds (ecological, economic and social) present in these systems prevent the return of historically accurate species assemblages, a restoration goal that may be questioned in this era of multiple, rapid and pervasive environmental changes. Here, we present an alternative restoration goal of providing those processes and outcomes valued by humans i.e. ecosystem services. We discuss the background and design to the Ridgefield Multiple Ecosystem Services experiment, set up on former agricultural land in the highly fragmented wheatbelt of Western Australia. This experiment investigates how different native species assemblages provide desired ecosystem services (including carbon sequestration, nutrient cycling, soil erosion control, maintenance of biodiversity, and invasion resistance) and whether trade-offs exist among these services. Additionally, we ask whether novel components to the flora are detrimental to service delivery. This is a much needed experimental investigation of how novel ecosystems can contribute to appropriate restoration goals in certain circumstances. However, novel ecosystems are neither conservation nor restoration panacea and careful distinctions must be made between those novel ecosystems that have arisen inadvertently and require management action in the 21st century, and those that are planned, innovatively or otherwise.

The need for standardising quality assessments of seeds used in rehabilitation and restoration projects in Western Australia

Alice Quarmby
Western Botanical

Symposium: Seed Sourcing Guidelines for Restoration Success

As many mining projects progress towards mine site closure and evaluating rehabilitation success, the requirement for quality seed resources is on the rise. Currently there are no broadly accepted standards defining the quality of seeds that can be sold by seed merchants. The quality of seed needs to consider both the viability and the purity of the collection. These affect the sowing rates, amount of seed required, and ultimately the cost of rehabilitation projects. If a seed merchant does not provide information on the viability (seed fill) of the collections they are providing, a buyer is likely to assume that they have 100% healthy seeds. For some species, however, seed fill can be less than 50%. This would mean that you need double the quantity of seed (and cost) to deliver the same outcome as a collection with 100% seed fill. For particular species (e.g. from the Myrtaceae family) it is common for chaff material to be included in the seed collection. While chaff can be removed using various cleaning techniques, it is more common for it to remain in the collection due to time and effort required to separate the material. Depending on the sowing technique, e.g. direct seeding versus automated nursery machinery, the effect of impurities in the collection are either not important or cause considerable problems in the propagation results. It is therefore recommended that the seed purity and viability information are provided for all seed collections for sale.

Pastoral stream restoration through integrated farm management: how do responses match expectations over the first decade post-implementation in a New Zealand hill catchment?

John Quinn, Robert Davies-Colley, Glenys Croker, Kerry Costley
National Institute for Water and Atmospheric Research

Theme: River Restoration

Catchment rehabilitation has become a widely accepted approach for improving water and habitat quality of pastoral streams but long-term evaluation of its effectiveness is rare. In 2001, a farm scale Integrated Catchment Management experiment was established on a sheep and beef farm at Whatawhata Hill-land Research Centre, West of Hamilton, NZ, to evaluate effects on economic performance, biodiversity and aquatic ecosystem health of an integrated package of land management actions, developed by a stakeholder group, towards achieving long-term economic and ecological sustainability. We evaluated response trajectories of a range of stream ecosystem attributes (i.e., hydrology, water quality, channel morphology, shade, stream temperature, instream vegetation, macroinvertebrates and fish) to sub-catchment management changes. These involved a change in the livestock system and (i) pine afforestation with 10 m riparian planting setbacks in the steepest, most erosion prone, least productive, areas; (ii) cattle exclusion and riparian poplar planting and 30% upland afforestation, and (iii) native reforestation of riparian areas. Responses were compared with adjacent reference sites in native forest and pasture below native forest, in a BACI experiment from 1995 .Ten years after implementation, attribute responses have varied from 'step change' (e.g., for *E. coli*) to 'rubber band' (relatively rapid response as pressures decreased, e.g., for stream temperature and invertebrate community metrics) to highly lagged (for nitrate, channel width and large wood). Shade development, via riparian vegetation growth, was a key driver of several responses. The proximity to colonist sources has likely contributed to the relatively rapid response of macroinvertebrates to habitat improvement.

Spinifex microchemistry and mineral exploration potential

Nathan Reid
CSIRO

Symposium: Arid zone spinifex (Triodia) restoration

Spinifex (*Triodia* spp.) grasslands cover vast areas of arid Australia, across a variety of soils and landscapes. These grasses are deep rooted and long lived, hence have great potential as a biogeochemical sampling media for mineral exploration. The analysis of T. pungens and T. scariosa leaves from field sites over buried Au mineralisation (Coyote, Oberon and Tunkillia Prospects) shows that there is a multi-element anomaly in the vegetation over the projected mineralisation, the haloes are of different scales depending on the local landscape setting and dispersion potential of each element associated with mineralisation. The magnitude of the anomalies is similar for each site independent of underlying substrate. Overall, spinifex chemical composition has the potential to act as a point indicator of substrate geochemistry with very minimal dispersion (hundreds of metres only) that can delineate the extent of a potential ore deposit. *T. pungens* and *T. scariosa* also have Cr accumulation potential, discovered during the mineral exploration studies, from several field sites (Coyote, Oberon, Tunkillia and North Miitel Prospects). Triodia species are shown to be able to accumulate Cr up to potentially toxic levels independent of substrate concentration. This could be due to accumulation (active transport) or the lack of a barrier mechanism (passive uptake) within the plant.

The role of translocation in Victorian orchid conservation

Noushka Reiter[1], Richard Thompson[2], Rob Cross[2], Glen Johnson[3], Karen Lester[3], Julie Whitfield[4], Mary Argall[1], Gail Pollard[1], Ann Lawrie[5]

[1]Wimmera Catchment Management Authority, [2]Royal Botanic Gardens Melbourne, [3]Department of Sustainability and Environment, [4]North Central Catchment Management Authority, [5]RMIT University Melbourne

Symposium: The role of plant translocations in restoring and maintaining biodiversity: policy, planning and practice

Victoria is host to approximately 380 species of orchids, more than half of which are threatened. A major success of the Victorian Orchid Conservation program has been establishing ex situ symbiotic germination techniques for a number of these species. Currently 30 of these threatened orchid species are being propagated for reintroduction and approximately 150 in situ populations of 50 orchid species are being protected. The Victorian Orchid Conservation Project aims to implement a range of actions from the National Recovery Plans and Flora and Fauna Action Statements of 80 species of terrestrial orchids from across the state of Victoria. Using ex situ symbiotic germination and reintroduction, this collaborative project is a collaboration between the Wimmera Catchment Management Authority, Victorian Department of Sustainability and Environment, the Royal Botanic Gardens Melbourne, the Australasian Native Orchid Society, the University of Melbourne, RMIT University and many community groups. Summaries of five endangered orchid reintroductions and lessons learnt from these recovery work conducted on them over the past decade are presented. The work includes surveys, long term monitoring, propagation, habitat modification, re-introductions and mycorrhizal phylogenetic work. The species highlighted here are *Caladenia cruciformis*, *Caladenia robinsonii*, *Caladenia xanthochila*, *Diuris dendrobiodes* and *Thelymitra epipactoides*.

Measuring the success of banksia woodland restoration using ecological markers

Alison Ritchie

The University of Western Australia, Kings Park and Botanic Garden

Symposium: Pollinators in Ecological Restoration

The delivery of pollinator services is key to the functionality, self-sustainability and success of restored populations. The Southwest of Western Australia on a global scale, has a high proportion of bird pollinated species and diversity of pollinators. The importance of these pollinator guilds for outcrossing and production of genetically robust outbred seed in West Australian plant populations is known, however their implications for restoration success is rarely taken into account. To address these issues, pollination studies of *Banksia attenuata* and *Banksia menziesii,* two keystone tree species used in Banksia woodland restoration are being conducted. Pollination and mating systems of the summer flowering *B. attenuata* and winter flowering *B. menziesii* within post-mining restored populations are compared to natural fragmented and natural unfragmented populations. In this presentation I will focus on comparing and contrasting observed pollinator visitation rates, pollinator assemblages and foraging behaviour between the two Banksia species and between population types.

An effective way forward to understand, learn and respond to restoration actions

Julie Robert
SERCUL

Theme: River Restoration

South East Regional Centre for Urban Landcare (SERCUL), with 15 years extensive restoration experience, has an underlying philosophy to incorporate the scientific method, as fundamental to all project delivery, both ecological and social. Extensive experience in restoration projects has identified the ideal strategy for effective outcomes to be the incorporation of inclusive partnerships for ecological and social outcomes, utilising independent collaborative research driven from the bottom up, rather than top down from Research Institutions. To this end SERCUL restoration ecologists, practitioners and invasion ecologists developed a Framework (Fisher, 2011), to which SERCUL staff has contributed information based on their extensive experience in restoration projects. The outcome was a Monitoring Plan (Fisher, 2011) to respond to identified knowledge gaps utilising an ecosystem management approach to understand i) ecosystem interactions, ii) native and weed species interactions and iii) measurable outcomes of restoration projects. This Framework, incorporating all Project Partners, enables the willing conversion of evidence based techniques into standard practice without coercion, while adapting restoration methods based on new understandings of functional interactions and processes in complex often highly disturbed urban systems. The Monitoring Plan has been incorporated into the $A8.6 million Urban Waterways Renewal (UWR) project, with 11 Restoration Projects managed and implemented by SERCUL. This is the biggest project ever conducted by a community group in Western Australia, receiving $A4 million of Australian Government funding under the Water for the Future initiative. Other funding was provided by the Western Australian Department of Water, Water Corporation, Swan River Trust, and the Cities of Canning, Gosnells and Armadale. Current outcomes from the ecological interactions study, utilising an ecosystem management approach will be presented (Fisher JL (2011) Report to SERCUL).

Hydrocotyle and the management experience in Perth, Western Australia

Julie Robert
SERCUL

Symposium: Aquatic Ecosystems: Restoration Interactions

Hydrocotyle ranunculoides represents a major threat to the biodiversity and amenity of freshwater waterways in Western Australia. *H. ranunculoides* is listed as a declared weed, as priority P1 for containment and P2 for eradication, in the State of Western Australia requiring landholders to control and eradicate where possible. In 1991 Floating mats of Hydrocotyle covered large areas of the Canning River from bank to bank, with the eventual cleanup cost in excess of $A2 million dollars. A total of approximately $A4.5 million dollars has been spent removing *H. ranunculoides* from the Swan Canning river system, however large localized infestations remain causing a loss of biodiversity, damage to infrastructure and an increase in management costs. The Hydrocotyle Working Group (HWG), a stakeholder partnership formed in 2002, managed by South East Regional Centre for Urban Landcare (SERCUL) to coordinate the control and management of *H. ranunculoides* with members from the City of Canning, Water Corporation, Department of Environment and Conservation, Swan River Trust, Department of Agriculture, Local community and Catchment groups. The HWG recommends that consideration be given to funding a comprehensive research project utilising a knowledge acquisition and systems approach to understand its impacts on biodiversity and to enable the eradication of *H. ranunculoides* in the National Heritage listed Canning River Regional Park and wider Swan-Canning River catchment. The Symposium is designed to bring together experts to establish an effective way forward for the Research and management of this species.

The nuts and bolts of successful living stream planning and implementation

Julie Robert
SERCUL

Symposium: Living Stream Restoration

The South East Regional Centre for Urban Landcare (SERCUL) is a community organisation which has developed, and implemented projects to improve the health of our waterways and other ecosystems through the promotion and utilisation of an integrated approach to catchment management. SERCUL's primary area of river management is the most weed infested river in Western Australia, the Canning River a tributary to the Swan River. A major focus has been the development of Living Streams with the first being constructed in 2000 as part of the implementation of the Bannister Creek Management Plan, a tributary to the Canning River, with a further 11 Living Stream Restoration Projects currently under construction, managed and implemented by SERCUL, as part of the $A8.6 million Urban Waterways Renewal (UWR) project, receiving $A4 million of Australian Government funding under the Water for the Future initiative, in partnership with the Western Australian Department of Water, Water Corporation, Swan River Trust, and the cities of Canning, Gosnells and Armadale. The effective implementation of such projects in highly urbanised systems where the waterway has functions including stormwater conveyance and water detention within often straightened systems involves complex interactions and coordination between the doers and the neighbours. SERCUL Staffs' expertise in reaching agreement between engineers, state and local government agencies, environmental consultants, contractors and local people, and coordinating large scale machinery, site assessments, planning approvals and volunteers, provides the impetus for success which must be achieved before the restoration actions can begin.

Closure cost modelling: benefits of forward planning

Jo Russell
Karara Mining Limited

Theme: Planning Restoration and Measuring Success

Historically mining companies have based the financial provision for closure and rehabilitation on unconditional performance bonds lodged with the Department of Mines and Petroleum (DMP). This can lead companies to be unprepared for the cost of closing a mine site, as bonds only cover a proportion of the cost of rehabilitation. In July 2011 the Guidelines for Preparing Mine Closure Plans were issued by the Department of Mines and Petroleum and the Environmental Protection Authority. These guidelines describe the standards required for the closure of mine sites which apply to both existing and new mining operations. Among the key changes is a requirement to include estimates of mine closure costs in the Mine Closure Plan to be submitted to Government as part of the project approvals process. The estimates must be supported by information on the costing method, assumptions made and financial processes used to estimate costs. Karara Mining Limited engaged SRK Consulting to develop a preliminary cost estimate for the implementation and management of rehabilitation and mine closure for the Greater Karara Project. Conceptual reclamation and closure methods were used to evaluate the various components of the mining operations and standardised cost modelling tools employed to prepare a closure cost estimate. Mine personnel provided user input data describing the physical layout, geometry and dimensions of project components. Along with this data, the model used first principle methods to estimate quantities, productivities, and work hours required for various closure tasks based on 2011 standardised industry unit costs for labour, equipment and materials. This methodology allowed KML to develop an increasingly accurate closure cost estimate that will reflect changes over the life of the project and assisted KML with fulfilling the requirements of the new Closure guidelines.

Developing a tool kit to maximise success in managing environmental assets degraded through altered hydrology

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Symposium: Toolibin Lake: a case study of wetland restoration

One of the main challenges in managing Toolibin Lake has been the development of a planning framework that allows for the prioritisation of investment in acquiring and interpreting data. This challenge has arisen as the hydrology was significantly altered prior to biophysical mapping and monitoring to assess water and salt fluxes. As a consequence, the main hydrological drivers of vegetation stress and death can only be identified through long term study and investment in both catchment and asset scale spatio-temporal datasets capable of mapping and explaining surface-groundwater dynamics. Datasets critical for the successful management of Toolibin Lake's hydrology are derived from a range of geophysical and remotely sensed techniques. Adopting an integrative approach allowed for the calibration and validation of data to produce a quantitative assessment of the lake's hydrology. Mapped outputs from this work form the foundation datasets for numerical modelling to underpin restoration at Toolibin Lake.

Restoration of an iconic canopy species with specific regeneration niche requirements during low-intensity prescribed burning

Katinka Ruthrof, Leonie Valentine, Giles Hardy

Murdoch University

Theme: Forest and Woodland Restoration

Regeneration is a necessity for long-term development and sustainability of forest ecosystems. Regeneration of the dominant canopy species, *Eucalyptus gomphocephala*, in many parts of its fragmented distribution in Western Australia, is nominal. Local extinction of the population could occur as older serotinous trees senesce or, more recently, succumb to massive canopy dieback. *Eucalyptus gomphocephala* has a specific regeneration niche, mass recruiting in ashbeds in canopy gaps. Ashbeds can be created by burning coarse woody debris (CWD) piles at high temperatures. However, burning individual CWD piles is too labour intensive for larger, intact forest areas. Furthermore, ashbeds may not occur naturally in intact forests following low-intensity, fuel reduction burns that are prescribed for many E. gomphocephala forests and woodlands. We investigated whether regeneration could be facilitated by creating CDW piles prior to a prescribed fire. Intervention techniques included: control (no CDW) gaps; control (no CWD) gaps+broadcast seed of *E. gomphocephala*; created ashbeds; and created ashbeds+broadcast seed. Results indicated that a) the majority of CDW piles burnt at high temperatures (>600Co), b) control plots, + broadcast seed, contained few seedlings, and c) ashbeds, especially those that were seeded, contained high numbers of seedlings. Thus, *E. gomphocephala* regeneration can be facilitated at an operational scale as part of prescribed fire activities, through creation of CWD piles and broadcast seeding. This research is applicable for managers working in forest systems that are subject to low intensity prescribed burns where key species have specific regeneration requirements.

A landscape neo-baroque: design as a cultural strategy for the restoration of urban ecosystems

Catharina Sack

FALVA, University of Western Australia

Theme: Urban Restoration

This paper presents a cultural strategy for ecological restoration. It rejects the culture/nature binary by presenting the baroque as a landscape design strategy aimed towards the restoration of novel ecosystems. The baroque creates an atypical armature for structuring scientific systems into the creation of the expanding suburban landscape mosaic. This paper elaborates on how baroque design strategies can overcome the creation of market-driven, water and nutrient craving landscapes. Baroque characteristics, seemingly pejorative and counter to the scientific methodology, are used to create resilient and ecologically productive novel ecosystems grounded in a critical and autochthonous aesthetic of botanical complexity. The paper focuses on Perth, Western Australia, a rapidly expanding settler-city located in an internationally recognized biodiversity hotspot. While uniquely high in plant endemism and species richness, the city's fringes are smoothed over and bulldozed with little regard. As are all landscapes, the landscape of Perth is the sum of its parts; the inimitable details of Perth's parts are, however, widely misunderstood. Part of the Southwest Australian Floristic Region, the landscape's extreme age and stability, its isolation and Gondwanan botanical heritage, and the ability of its plants to thrive in old, leached stable soils are some of the factors that account for this botanical richness. As are many Mediterranean places, it is a landscape that is dry, crunchy and not green. While the scientists continually strive to understand the specific, the inhabitants persistently crave the verdant picturesque. Without an acute and novel approach to modify current development practices, Perth's biodiversity is headed for extinction. This paper proposes one such approach.

Spatial optimisation of managed regrowth for fauna recovery in the brigalow

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[1]Environmental Decisions Group, [2]The University of Queensland, [3]CSIRO

Theme: Delivering Large Scale Restoration

Investment in the carbon economy, such as carbon farming initiatives and investment in carbon offset schemes, is predicted to change attitudes towards broad-scale revegetation in agricultural regions. In Queensland, where energy extraction industries (coal mining and coal seam gas extraction) are rapidly expanding, investment by these industries in revegetation for carbon offsets may offer a viable alternative income stream to landholders. Revegetation offers benefits not only for carbon but also for biodiversity conservation, particularly if native vegetation is used for carbon sequestration. The Brigalow Belt bioregion in Queensland offers a unique opportunity to use managed regrowth to increase fauna recovery outcomes for a range of threatened fauna species. Many Brigalow (*Acacia harpophylla*) ecosystems are now endangered due to clearing for agriculture but a characteristic of this species is its ability to regrow from suckers when disturbed. Strategic identification of locations where restoration through managed regrowth can maximise opportunities for fauna recovery, while minimising economic costs and conflict with other land uses, is critical to increase the likelihood of success. This project applies spatial prioritisation techniques based on species occurrence, habitat suitability within existing remnant and regrowth vegetation, and landscape connectivity. We estimate opportunity costs such as land values, existing and potential land use, average agricultural income and potential income from alternative sources of land use. We use time steps to account for increasing use of regrowth vegetation by fauna as it matures. Results will identify priority areas to maximise potential fauna recovery outcomes from managed regrowth, while minimising opportunity costs.

The potential for classical biological control of *hydrocotyle ranunculoides* in Europe

Richard Shaw

CABI

Symposium: Aquatic Ecosystems: Restoration Interactions

Hydrocotyle ranunculoides, known as floating pennywort, has become one of the most feared aquatic plants by land and water managers in Europe despite being a relative newcomer. It has spread rapidly in its introduced range to cover still and slow-moving water bodies to the exclusion of native species and many leisure activities. It is also known to block drains and could exacerbate flooding. Current control relies mainly on mechanical removal in much of Europe but in the UK, innovative formulations of glyphosate can be effective. Nonetheless, *H. ranunculoides* is very unlikely to be controlled by conventional means so an alternative approach is required. More than 30 years ago, researchers in the native range of South America highlighted a weevil (recently renamed *Listronotus elongatus*) with an apparently restricted host range from Argentina as a potential biological control agent (Cordo et al. 1982). Research in 2006/7 confirmed the potential of this weevil amongst other natural enemies. Subsequently, a full biocontrol programme was initiated in the UK in 2010 and further potential agents have been revealed including a petiole-mining fly (*Eugaurax* sp.) and a Puccinia rust. This paper will consider the characteristics and likely host range of each of the most interesting natural enemies in turn. We conclude that there is excellent potential for the management of this weed by natural means in Europe and beyond. whilst classical biological control is a novel technique in Europe, floating pennywort is likely to be reunited with at least one of its natural enemies soon.

Conservation genetics and ecology of endangered swamp orchids *phaius australis* and *p. Bernaysii*: what are the implications for conservation in a changing world?

Laura Simmons, Robert Lamont

University of the Sunshine Coast

Poster Presentation

Swamp Orchids, *Phaius australis* and *Phaius bernaysii*, are some of the most iconic and beautiful plants in the coastal and littoral wetlands of east coast Australia. However, these orchids are endangered due to habitat loss, fragmentation and illegal collection. Future climatic change threatens to push such flora with small population sizes, limited connectivity and narrow environmental tolerances, to extinction. Little is known about the biology or ecology of Swamp Orchids and how they might respond to climate change: they occur in disjointed coastal areas from north Queensland to central New South Wales, on sand islands and in isolated western Queensland patches. Does the species have genetic variability or display plasticity across its range? Do population dynamics change over the climatic gradient? Would translocations assist survival of the species? This doctoral research will test theories for plants occurring over latitudinal gradients by undertaking population census, ecological and reproductive studies linked with climate, habitat and fragmentation. These results may be utilised in population dynamic modelling (RAMAS GIS), habitat modelling (Maxent) coupled with climate change models (SIM CLIM) to predict future range shift. Genetic variability and diversity across the species' range will also be assessed using microsatellite markers produced through NextGen Sequencing. This range-wide, holistic understanding of the species response to climate will result in an estimation of future viability, persistence and conservation implications. Outcomes will be presented to land managers and community groups to guide habitat protection, recovery and restoration plans including design of translocation programs, increasing the likelihood of long-term survival.

Measuring genetic diversity in a successful restoration site: implications for future seagrass restoration

Elizabeth Sinclair[1], Jennifer Verduin[2], Siegfried Krauss[1,3], Gary Kendrick[1]

[1]The University of Western Australia, [2]Murdoch University, [3]Kings Park and Botanic Garden

Symposium: Seagrass Restoration

Seagrass meadows are in decline globally. A number of experimental methods have been tested to help restore meadows. However, they have largely been unsuccessful in the long term, are usually monitored over the short-term, and often with little or no input from genetically based methods to ensure diversity, despite evidence to suggest that increased levels of genetic diversity increases intraspecific survival as well as overall diversity. Cockburn Sound, a natural embayment south of Perth, WA, has seen a 77% decline in seagrass cover since the 1967. In small, localised areas natural recruitment has been very successful, while other parts have not been able to recruit and recover naturally. A transplant trial was conducted between 2004 and 2008 as part requirement of a seagrass loss compensation measure mitigating the impacts of shell sand dredging. Sprigs (15–20 cm lengths of rhizome with roots and shoots) were planted in a bare sand area. We assessed genetic diversity in this transplant area and compared diversity to the original donor sites. Shoot samples were collected using a standard random coordinates method in March 2012, and genotyped using seven microsatellite DNA markers. Genetic diversity was very high in the restoration site and comparable to the donor sites. The spatial arrangement of the multilocus genotypes showed that transplant material for the restoration site was sourced from the same genetic provenance, although none of the same plants were sampled. The high level of genetic diversity and choice of site may have played an important role in the success of this restoration trial.

Spinifex-mallee revegetation at Wemen in semi-arid northwest Victoria: implications for the sand mining industry in the Murray-Darling depression bioregion of southeastern Australia.

Ian Sluiter[1], Ralph Mac Nally[2]

[1]University of Ballarat, [2]Monash University

Theme: Mine Restoration

Revegetation involving the hummock-forming grass Spinifex (Triodia scariosa) has to date, not been undertaken with success in the Murray-Darling Depression Bioregion. Revegetation success with Spinifex and mallee trees is an imperative with the impending prospect of new sand mines in Spinifex-Mallee vegetation communities across the Bioregion. We assessed hand-planting trials of tubestock incorporating a high proportion of Spinifex grass and mallee species in a cleared paddock at Wemen in northwest Victoria, adjacent to a former mineral sands mine (Wemen Mine). Botanical assessments of the Wemen trials were conducted in October 2011 after being established in June 2001. A Bayesian model was constructed to determine species-specific survival proportions relative to the overall average. The overall mean survival rate was 0.58. Species having substantially greater survival proportions were Mallee (*Eucalyptus* spp.) trees, Needlewood (*Hakea* spp.) trees and Spinifex. Species having substantially smaller survival rates than the average were mostly Wattle (*Acacia* spp.) taxa. The implications for sand mine rehabilitation with Spinifex and mallee species are discussed.

Environmental offsets: are they effective in promoting restoration?

Kane Smith

Ecofund Queensland

Theme: Ecosystem Services and Environmental Offsets

The increasing implementation of environmental offsets as government agencies seek to counterbalance unavoidable environmental impacts that result from development activities is showing them to be effective in achieving restoration outcomes. In Queensland, environmental offsets are a legislative requirement triggered by impacts on particular environmental values. Typically, the delivery of environmental offset projects involves the identification, protection and ongoing management of areas of land with a similar suite of environmental values to the land that is subject to development. Strategically implemented offsets support the restoration of degraded ecosystems, address threatening processes and restore and re-establish habitat for threatened species. Offset projects can also provide additional environmental benefits beyond project boundaries. Environmental resilience can be improved by strategically locating offsets to add to and buffer protected areas, establish biodiversity corridors and improve water quality in creeks and rivers. Environmental offset projects typically involve initial restoration groundworks (such as fencing, weed control, pest animal management and revegetation) and on-going maintenance (including fire management), which is coordinated under an offset area management plan. Ecofund engages experienced practitioners to undertake major on- ground works and negotiates financial payments to landholders for land management activities where appropriate. Offset management continues for the life of the project, which is typically until the vegetation has reached its pre-clearing condition. In Queensland, the responsibility for funding initial and ongoing management actions lies with the developer and failure to adequately manage offset sites can lead to compliance breaches and legal proceedings.

Should we change restoration strategy in the face of climate change? A case study from Western Australia

Ann Smithson

Kings Park and Botanic Garden, The University of Western Australia

Symposium: Seed Sourcing Guidelines for Restoration Success

Best practice restoration is usually based on the premise of local adaptation, such that locally sourced propagules (for example seed) are utilised to achieve high-quality restoration. However, with climate change predicted to impact restoration through altered survival and reproductive success, it has been suggested that our strategy should change from one of local sourcing of seed to one of maximisation of diversity of sources, perhaps even focus on seed sourcing from predicted climatic extremes. Specifically it has been hypothesised that for any one species restored, increased seed source diversity will increase survival, and thus restoration success, in an unpredictable climate. In this talk, I will present the results of an experimental study initiated in an exceptionally dry year where the survival and reproductive success of local and widely sourced seedlings was compared at multiple sites for two plant species, one of which is normally outcrossing and one of which is normally selfing. I will also contrast the genetic diversity of seed source populations, and test the relationship between genetic diversity and both survival rates and reproductive success. Can we predict the benefits and costs of local vs genetic-diversity seed sourcing in an unpredictable climate?

Digging deeper for woodland restoration: exploring the role of soil fungi

Rachel Standish[1], Georg Wiehl[2], Tim Morald[1], Chris Walker[1], Mark Tibbett[3]

[1]The University of Western Australia, [2]CSIRO Ecosystem Sciences, [3]Cranfield University

Theme: Forest and Woodland Restoration

Temperate eucalypt woodlands throughout southern Australia are in decline and yet there is limited understanding of how to intervene to promote their restoration. Woodland decline has been linked to livestock grazing, climate change and weed invasion among other factors. Fencing to exclude livestock grazing is one of few tools commonly used for maintaining and restoring remnant woodlands in Australia in agricultural landscapes. We begin this talk by describing our research to determine the benefits of fencing York gum woodlands in Western Australia's wheatbelt. While we observed clear benefits of fencing, it was the highly degraded sites that did not recover after fencing that stimulated our interest in soil properties, particularly soil fungi. Soil fungi could potentially improve the establishment and persistence of native plant species, and ultimately, contribute towards the functioning of the woodland ecosystem. We hypothesized that a combination of missing soil fungi, high soil nutrients and invasive weeds was preventing the recovery of more degraded woodland sites. So next, we present preliminary data on the presence and absence of soil fungi in woodland soils using different techniques including molecular analysis (T-RFLPs), spore counts and plant baiting. Finally, we present the results of a microcosm experiment designed to test the contribution of soil fungi to (weed) invasion resistance. We conclude by presenting a synthesis of our data and ask whether we have enough evidence to test a basic yet unanswered question in restoration ecology – do soil fungi facilitate restoration or follow it?

Aquaculture of *posidonia australis* seedlings for seagrass restoration programs: effect of sediment type and organic enrichment on growth

John Statton[1,2], Kingsley Dixon[1,2], Gary Kendrick[2]

[1]Kings Park and Botanic Gardens, [2]University of Western Australia

Symposium: Seagrass Restoration

Seeds of the seagrass *Posidonia australis* are desiccation-sensitive and since there is no seed dormancy seeds cannot be stored for use in restoration projects. To realize the restoration potential of seed-based restoration of Posidonia this study investigated preconditioning seedlings of Posidonia in aquaculture facilities prior to transplanting to extend the restoration window from a few weeks (for fresh seed) to months or even years (for preconditioned seedlings). Here, we tested two levels of organic matter addition, 0% and 1.5% sediment dry weight and three sediment types; two heterogeneous sediments typical of low-energy marine environments (i) unsorted calcareous and (ii) unsorted silica, and a homogeneous sediment typical of high-energy marine habitats (iii) well-sorted silica. We then evaluated seedling survival, biomass and development over a period of seven months in tank culture. There was 100% survival over the seven month experimental period for seedlings. Seedling leaf, root, rhizome and total biomass increased when organic matter was added to unsorted calcareous and unsorted silica sediment but not well-sorted silica sediment, though this increase was significant only after seven months of growth. The characteristics of the sediment also influenced seedling root length and architecture. Root length and number of lateral root branches was greatest in unsorted sediments and when organic matter was present. This study demonstrates that tank culture of *P. australis* enabled seedlings to be available for restoration purposes for at least seven months, and with modification of the sediment composition, larger *P. australis* seedlings with more substantial root systems can be produced.

Restoration ecophysiology: understanding restoration outcomes

Jason Stevens

Kings Park and Botanic Garden

Theme: Physiology and Hydrology for Mine Restoration

Restoration programs need to meet increasing public, regulatory and company expectations within reasonable time frames, highlighting the need to deliver effective and efficient restoration outcomes. In order to increase restoration efficiencies we need to capitalise on successes and minimise risks of failure, however currently the drivers underpinning these outcomes are often poorly understood. The question therefore remains – why is our restoration succeeding or failing to meet expectations? This presentation will outline how plant ecophysiology can be used by practitioners throughout the planning, implementation and evaluation phases of restoration programs to provide an efficient understanding of the restored system and its potential trajectories. Despite being a fundamental science for describing plant responses to environmental conditions, to date ecophysiology has been largely overlooked in ecological restoration programs, perhaps the result of a perception of relevance and/or prohibitive costs. By using ecophysiology, practitioners may gain a more subtle understanding of plant function in response to the restoration environment, develop proxies for community expectations, and have more rapid feedback loops (traditionally restoration performance indicators are <5 years) that may be modelled into longer-term restoration trajectories, all of which support traditional restoration monitoring approaches. With the continual development and refinement of physiological monitoring techniques for understanding plant function in intact reference species/systems and the development of real time remote plant monitoring systems, the gap between basic ecophysiology and the requirements of the restoration practitioner is closing.

Increasing seed-use efficiency of Australian native grasses

Jason Stevens[1], David Symons[1], Ian Chivers[2], Kingsley Dixon[1]

[1]Kings Park and Botanic Garden, [2]Native Grasses Pty Ltd

Symposium: Restoration with native grasses in Australia

There is an urgent need to identify perennial species that have the potential to be successful in the low to medium rainfall (<300–500mm) regions of Australia. Given the large genetic diversity that exists, there is large potential for the development of native perennial species (particularly grasses) that are already well adapted to the climatic and edaphic conditions of Australian farming/pasture systems. The overall aim of this program is to improve opportunities to introduce native grasses, through developing and testing seed enhancement techniques, allowing for the rapid scaling-up of sowing of native grasses onto a broad-scale. By lowering the establishment costs associated with increased germination performance it is anticipated that we will observe a greater use of native perennial grasses in, and production capacity for, Australasian restoration systems. This presentation will unpack the complexities associated with native grass germination and how germination enhancement (streamlining seed cleaning processes and testing a diverse range of dormancy alleviation techniques) is providing promising outcomes for increasing establishment success in several widespread native grass species.

Building and sharing our knowledge: how the hidden life of seeds can support restoration

Lucy Sutherland

Australian Seed Bank Partnership

Symposium: The Australian Seed Bank Partnership: a national network to advance seed management for conservation and restoration

Until recently, there has been little effective data sharing between Australia's conservation seed banks. These seed storage and research facilities gather and manage foundation scientific information on Australia's native flora, including seed species identification, origin and provenance, morphology, germination and dormancy requirements, storage characteristics, phenology and ecology. The work conducted on these ex situ collections generates scientifically verifiable information to support such activities as habitat restoration and plant conservation. The Australian Seed Bank Partnership is working with the Atlas of Living Australia to create a free on-line seed information hub to assist with sharing and linking data of the seeds and seed biology of Australian native plants. This hub enables conservation seed banks to manage their existing local databases, and allow them to upload and download data, creating a shared and integrated view of Australia's conservation seed bank resources. This paper introduces and describes the new seed hub and how it supports ecological restoration by providing authoritative information on the phenology of seed development and maturation of wild species and the spatial and temporal variation for these factors. Information from the seed hub can help overcome establishment issues such as seed storage, seed pre-treatments and suitable soil for seedling establishment. The hub offers future possibilities to expand the scope of seed information to cover on-line seed identification tools, spatial predictive modelling tools and online tool and workspaces for native seed related citizen science and community engagement.

Combining nature and technology to rehabilitate seagrasses in South Australia

Jason Tanner[1], Andrew Irving[1], Mandee Theil[1], Sue Murray-Jones[2]

[1]SARDI Aquatic Sciences, [2]DEWNR

Symposium: Seagrass Restoration

Over 5000ha of seagrass has been lost along the Adelaide metropolitan coast due to anthropogenic pollution and coastal development. Recently, however, there has been signs of natural regeneration in areas where sand movement is low, indicating that water quality has improved and that it may be an opportune time to investigate restoration. After earlier work using traditional transplanting techniques, we have had good success at facilitating natural recruitment at small scales using hessian sandbags in areas of relatively high water and sand movement. This technique relies on the viviparous seedlings released by Amphibolis, which have small 'grappling hooks' on their distal end which entangle in the hessian. Initial recruitment can be on the order of hundres of seedling per sq m, with rapid growth, and infilling between bags occuring on the order of 4–5 years. Interannual variability in recruitment has been high, however, and necessitated developments on 2 fronts to overcome. First, we started with little idea of the reproductive cycle of Amphibolis, and so had to better understand its biology. We have also been working with materials scientists to prolong the longevity of the hessian, which was prone to rapid breaking down, while still retaining an ultimately biodegradable product. More recently, we have been working to extend the technique to fruiting taxa such as Posidonia, as well as examining the influence of substrate characteristics such as grain size and organic matter content.

Towards a mechanistic approach to pollinator restoration

Sean Tomlinson[1,2], Raphael K. Didham[1], Kingsley Dixon[1,2]

[1]University of Western Australia, [2]Kings Park and Botanic Garden

Symposium: Pollinators in Ecological Restoration

There has recently been a general recognition that conservation and environmental management programs would benefit from a more scientific approach and a mechanistic understanding of critical processes underpinning the systems in question. We pursue these concepts using the parable of the Honey possu , Tarsipes rostratus. The Honey possum is an obligate nectarivore, known to feed on plant species from only the Myrtaecaea, Proteaceae and Epacridacae. We investigated how the population fluctuated in response to rainfall and fire over a 20-year period, and also changes in energetics, diet and movements during a period of decreased food availability in late summer. Populations increased with increased flowering rates of Banksia illicifolia and winter rainfall two years prior to trapping. Burnt habitats were associated with low populations. During the late summer food gap, the entire energetic requirement of the Honey possums is met through access to two species of plant, but estimated home ranges required to supply these resources average 6 hectares. Understanding the requirements of the Honey possums suggests that longterm management of the pollination services provided by this species is dependent upon the management of Banksia illicifolia, Beaufortia sparsa and Adenanthos meisneri populations, and the reduction of broad-scale fires. Using these concepts as a template, we intend to expand our techniques into studies of insect pollinators in order to understand crucial aspects of ecological restoration in Banksia woodlands on the Swan Coastal Plain. We present preliminary data on Honey bees Apis mellifera as a proof of concept for insect systems.

Bannister Creek living stream: restoring a more natural hydrology and channel structure to improve stream health

Antonietta Torre

Department of Water

Symposium: Living Stream Restoration

A major cause of degradation of urban waterways is the change in catchment hydrology resulting from conventionally drained urban areas. Flows become more frequent and variable and peak flows become larger. The complex interactions between surface flows, groundwater hydrology, water quality, channel form, aquatic habitat and riparian vegetation characteristics of a waterway are dramatically disturbed by the alterations to the flow regime. An objective of stormwater management is to ensure a more natural catchment hydrology is maintained or restored. Approaches to detain flows and reduce flood peaks and 'flashiness' have been successfully implemented in the Bannister Creek catchment. However, there are limitations to the feasibility of retrofitting an urbanised catchment to restore a more natural hydrology. In combination with catchment works, intervention to the stream channel itself can improve the resilience of the channel to erosion and increase the hydraulic diversity of the channel, and hence the biodiversity. Bannister Creek is located on Western Australia's Swan Coastal Plain, where there is a superficial aquifer and high connectivity between surface water and groundwater systems. Bannister Creek was originally a chain of wetlands, which were channelised to drain the land and enable urban and agricultural development. Drainage channels in the Bannister Creek catchment commonly include both stormwater from surface runoff and groundwater that has been deliberately intercepted by drains installed to manage seasonal peak groundwater levels. Understanding these factors and their implications for flow regime and nutrient transport was essential to planning and designing the Bannister Creek Living Stream. Rehabilitation efforts in the Bannister Creek catchment have focused on mimicking natural systems and restoring key hydrologic processes and features of the waterway as the foundation for ecological recovery.

Mapping modified vegetation in order to assist restoration prioritisation in the Galapagos Islands

Mandy Trueman, Rachel Standish, Richard Hobbs

The University of Western Australia

Theme: Island, Coastal and Marine Restoration

In highly modified ecosystems it is difficult to decide where limited conservation dollars can best be spent in order to maximise restoration and conservation outcomes. The novel ecosystems conceptual framework can assist in making such pragmatic decisions. Our study aims to use the novel ecosystem framework to in the Galapagos Islands to help prioritize sites for restoration in the Galapagos Islands, based on plant species assemblages. We surveyed vegetation in the National Park area of the humid highlands that has been heavily invaded by introduced plants. We are now assessing the difference between the modified vegetation and reference conditions in order to classify ecosystem types as historical (same as or similar to reference conditions), hybrid (somewhat dissimilar to reference) or novel (very dissimilar to reference). We will look for indications of thresholds by correlating the proportions of vegetation cover made up of native and exotic plants with the native and exotic plant species richness across our sites. We will also map current vegetation across the landscape. The spatial extent of novel ecosystem types can then be compared to a model of pre-disturbance vegetation to help prioritize sites for restoration action.

Moving house: can we relocate the trap door spider *Idiosoma nigrum*?

Alexa Tunmer

Curtin University

Poster Presentation

The declared rare shield-backed trapdoor spider (*Idiosoma nigrum*) is endemic to Western Australia and occurs in fragmented populations in the midwest and Wheatbelt areas. It threatened by feral animals, natural disasters (flooding, fire) and from development (such as agricultural and mining). Adult females mature at 5 years and live for up to 30 years, producing multiple broods during their lifetimes and never leaving their burrows. It is thought that mature females are unable to rebuild their burrows after the original is destroyed, only repair slight damages. Little is known about the behaviour of the species and if representatives of an at risk populations can be translocated to other suitable environments prior to development or disturbance. Translocation has never been trialled with *I. nigrum* and rarely with any trapdoor spider. This study trials translocation of spiders from within the footprint of the Jack Hills Iron Ore mine, 800km north of Perth, to artificially created burrows nearby. Our trials have translocated 80 spiders to test the life stage and burrow conditions needed for success (size of burrow, use of original door, and presence of spiders under the same vegetation type). Individuals have also been established in pots in a laboratory to allow detailed observations of their response to translocation. Initial field results show high survival (75% of translocated spiders), and we will present results 5 months after translocation.

Seed ecology of two endangered West Australian plant species: *Androcalva perlaria* (malvaceae) and *Symonanthus bancroftii* (solanaceae)

Shane Turner, Christine Best, Bob Dixon, Kingsley Dixon

The University of Western Australia, Kings Park and Botanic Garden

Theme: Threatened Species, Populations and Communities

Long-term conservation of threatened flora requires the input of different research fields to ensure the maximum likely-hood that a species will not disappear. A thorough understanding of the key factors regulating in situ germination enables managers to predict the longevity of the soil seed bank and what factors are required to stimulate germination. To develop management tools the aim of this study was to investigate different seed biology attributes of two threatened species as a means to better manage in situ populations. The seed ecology of *Androcalva perlaria* and *Symonanthus bancroftii* was investigated. *Androcalva perlaria* has fewer than 80 plants remaining while *Symonanthus bancroftii* is only known from two plants. Using seeds a series of different experiments have been performed including water uptake studies, responses to different germination conditions, dormancy loss requirements, rapid seed ageing and in situ seed burial to ascertain the key variables that regulate in situ recruitment. Seeds from both species were found to be highly dormant though dormancy could be removed by the use of hotwater (*A. perlaria*) and afterripening (*S. bancroftii*). Seeds of *S. bancroftii* were also observed to become highly Kar1 responsive during afterripening and soil storage. Seed burial has also confirmed that seeds maintain high viability (~90%) during soil storage for at least 18 months to 2½ years. The seeds of both species are dormant when fresh and both appear to require fire to stimulate in situ recruitment though both are triggered by different fire components ie heat (*A. perlaria*) and smoke (*S. bancroftii*). The seeds of *A. perlaria* possess physical dormancy while the seeds of *S. bancroftii* possess physiological dormancy. In addition, both appear to have the capacity to persist for significantly longer than 12 months in the soil seed bank.

Responses of biodiversity to prescribed burning in urban woodlands

Leonie Valentine[1], Katinka Ruthrof[1], Leonie Stubbs[2], Barbara Wilson[3]

[1]WA Centre of Excellence for Climate Change, Woodland and Forest Health, [2]Friends of Paganoni Swamp, [3]Department of Environment and Conservation

Theme: Forest and Woodland Restoration

Bush remnants in urban landscapes hold a wide range of social and ecological values, but maintaining these values can be challenging. Prescribed burning to reduce fire risk to human life and infrastructure is often necessary within bush remnants, and fire may be an important restoration tool for target species and communities. We used a transdisciplinary approach, involving community groups, land and fire managers and researchers, to understand the impacts of prescribed burning on non-target biodiversity attributes in an urban bush remnant. Paganoni Swamp woodland reserve (700ha) has high biodiversity values within the Perth Metropolitan Region, and contains one of the few remaining large populations of tuart (*Eucalyptus gomphocephala*). The area had been unburnt for more than 30 years, and a prescribed burn to part of the reserve was administered by the Department of Environment and Conservation following consultation with community groups and researchers. We established five paired monitoring sites in the burnt and unburnt regions. At each site we examined floristic composition, vegetation structure and reptile community composition. Within the first year of the prescribed burn, floristic composition was significantly different between burnt and unburnt sites and vegetation cover was lower in the burnt sites. Fewer reptile species and abundances were detected in the burnt sites. In addition, fewer juveniles of the common dwarf skink *Menetia greyii* were detected in burnt sites. We hope that the continued collaboration between community groups, researchers and land managers will facilitate an adaptive management strategy for prescribed burning within bush remnants.

Distinguishing invasive hydrocotyle ranunculoides from non-invasive congeners by DNA barcoding

Clemens van de Wiel[1], Leni Duistermaat[2], René Smulders[1]

[1]Wageningen UR Plant Breeding, [2]NCB Naturalis, section Nationaal Herbarium Nederland

Symposium: Aquatic Ecosystems: Restoration Interactions

Among invasive exotic plants, a number of aquatic species pose a particular ecological threat to water bodies, as in the worst case, they may obstruct water flow by their profuse growth. Therefore, one would opt for preventing them from entering a country or area. However, often related species are commercially traded, and distinguishing invasive from non-invasive species based on morphology alone can be hard at a vegetative stage. Thus, DNA barcoding could be an alternative for reliable identifications, for which the CBOL Plant Working Group proposed the chloroplast sequences rbcL and matK. We additionally tested the trnH-psbA locus, as it is more variable than rbcL and more reliably amplified for sequencing than matK. Using trnH-psbA alone, we were able to distinguish the invasive *Hydrocotyle ranunculoides* from at least six other species from the genus *Hydrocotyle*.

Defining plant functional types to inform arid land restoration

Erik Veneklaas

The University of Western Australia

Theme: Physiology and Hydrology for Mine Restoration

Restoring biodiversity does not guarantee adequate ecosystem functioning. Adequate representation of key plant functional types in restored plant communities is essential. When original plant communities are poorly known or restored communities are faced with severely altered abiotic conditions, knowledge of plant functional types helps design restoration targets and monitor restoration success. This presentation will summarise findings from a number of projects in Australian arid zones where physiological ecological methods were used to define and understand plant functional types.

On the study of New Caledonian dormant native seeds for ecological restoration after mining impact using hydroseeding on the Massif du Koniambo

Matthieu Villegente, Alexis Carteron, Antoine Leveau, Bruno Fogliani
University of New Caledonia

Theme: Mine Restoration

Dealing with mining and ecosystem restoration is always a challenge. It becomes even harder when the country has the incredible honour of belonging to the top ten listed countries for biodiversity preservation. New Caledonia is one of those. It has a very rich and diverse flora composed of 3,371 species, with an endemism rate of 75%. These are due to several factors with, in particular, ultramafic soils that are rich in heavy metals, including nickel, for which New Caledonia has 13% of the worldwide mineral deposit. This valuable economical resource often prevails upon flora richness, leading to destruction of huge areas to access the exploitable soil. The ultramafic Koniambo massif is under the mining activity of Koniambo Nickel SAS. The company currently rehabilitates the massif by hydroseeding as a technique of choice for large-scale rehabilitation. In the recent past, the lack of studies on native seeds, in particular Cyperaceae, has lead to the use of non-native seed species, including common graminoides during hydroseeding. Our initial research aims to characterize dormancy types of technical pioneer native species seeds to find easily applicable pre-treatments to release dormancy. It allowed for example to reduce latency time (15 days instead of 55) and increase germination rate for some Cyperaceae in laboratory conditions. Our main challenge is to apply our laboratory results in the field. Therefore, we performed last February, a hydroseeding experiment to test the effectiveness of our pre-treatments on seed germination and plantlet establishment, using only natives species, including 3 Cyperaceae and 4 woody species.

Toolibin Lake 2012, catchment and asset scale ecohydrolgoical modelling to explain the response of biota to management interventions

Ryan Vogwill[1], Blaire Coleman[2], Rachel Tarplin[1], Christoph Hinz[1], Janaine Colletti[1], Matt Hipsey[1]
[1]The University of Western Australia, [2]DEC

Symposium: Toolibin Lake: a case study of wetland restoration

Altered hydrology due to changed land use threatens the native biota of Toolibin Lake. In addition to revegetation and surface water management in the catchment, interventions at Toolibin Lake include inflow control and pumping of groundwater from beneath the lake bed. Original hydrological targets for recovery of lake floor vegetation included a depth to groundwater greater than 1.5m across 80% of the lake bed, when no surface water was present in spring; and inflows be diverted unless their salinity is below 1,000mg/l. Fifteen years later these targets have been met most of the time, but the level of vegetation recovery has not been uniform, widespread or fully met expectations. There has been some salt flushing in the upper part of the profile but not in the root zones of trees. HYDRUS 1D and WET-OD modelling have helped us understand asset management and re-evaluate hydrological targets. Based on current analyses, a depth to groundwater greater than 8m is required to allow salt flushing to reduce soil ECs to less than the 5 ds/m required for full recovery. Coupled catchment-asset models have allowed testing of management scenarios based on land use changes. Detailed assessments of management feasibility require multidisciplinary investigations integrating hydrology and plant ecophysiology. To achieve this, advanced techniques such as numerical ecohydrological modelling, geophysics and remote sensing have been developed and applied. At Toolibin Lake, good planning, long term monitoring, innovative science and iterative management have been essential to recovery of biodiversity assets.

Recovering Toolibin Lake: an uncertain life

Ken Wallace

Department of Environment and Conservation

Symposium: Toolibin Lake: a case study of wetland restoration

Research suggests that, in the south-west of Western Australia, altered landscape hydrology threatens some 850 native plant and animal taxa with global or regional extinction. Most of these taxa occur in wetlands and remnants of native vegetation on valley floors. Replacement of native perennial vegetation with annual crops and pastures drives the hydrological changes. This has led to extensive salinisation of surface soils and waters, a process termed secondary salinisation. Recovering the remaining, native valley-floor ecosystems requires consistent effort over decades with significant uncertainty attached to outcomes. Management and recovery work in agricultural areas of the south-west has focussed on six catchments, termed natural diversity recovery catchments. In this case study we describe the management approach adopted at the oldest recovery catchment, Toolibin Lake, an ephemeral freshwater wetland listed as a Wetland of International Importance under the Ramsar Convention. Secondary salinisation has exposed Toolibin Lake to increasingly saline surface water and rising saline groundwater. As a result the native biota of the wetland have declined and are under serious threat. To halt degradation of the lake, an integrated package of management tools has been implemented including engineering works and revegetation. Many of the key works have been undertaken on privately-owned farmland, which adds an important social dimension to management. Although evidence suggests we have halted the decline of the lake biota and achieved vegetation recovery in some areas, management continues to be challenging. After outlining the management approach, a number of the factors critical to management success are discussed.

Restoration of semi-arid rangelands through the control of total grazing pressure and rotational grazing management

Cathleen Waters, Gavin Melville, Trudie Atkinson

NSW Department of Primary Industries

Theme: Restoration in Production Landscapes

Within pastoral areas of the semi-arid rangelands considerable incentive funding has been directed toward exclusion fencing to control total grazing pressure (TGP), particularly goats and kangaroo populations. It is assumed that TGP fencing will result in increases in ground cover and help to achieve minimum catchment ground cover targets of 40% in western New South Wales. To date this assumption has not been tested. In this paper, we describe the results of a pilot study undertaken in western New South Wales to assess the impact of TGP fencing in conjunction with alternative grazing management strategies. We examined the effect of TGP fencing on ground cover and floristic diversity using three replicate 0.5ha plots within each of three contrasting management treatments; long- (>5years) and short-term (<2 years) TGP fenced paddocks with rotational grazing (current best practice) and non-TGP fenced paddocks with set stocking (historical district practice). Significant differences in ground cover ($P<0.05$) were found between TGP and non-TGP fenced paddocks, in some cases a two fold increase in ground cover was found within TGP fenced areas. TPG fenced areas also supported a greater number of desirable native perennial grasses and herbaceous species. We discuss these results in terms of native, feral and domestic grazing intensity and long-term impacts on biodiversity and livestock production. These results indicate that the control of external grazing pressure, combined with rotational grazing provides a means for restoring native perennial grasses and achieving catchment ground cover targets.

Ecosystem functioning and rehabilitation of a mosaic landscape

Justin Watson[1], Eileen Campbell[2]

[1]Charles Sturt University, Australia, [2]Nelson Mandela Metropolitan University, South Africa

Poster Presentation

The semi-arid landscape at the locality known as Grassridge in South Africa consists of a unique mosaic of bushclumps and grassland (colloquially termed Bontveld). This mosaic is confined to the ridges that are characterised by shallow soils overlying an extensive calcrete layer (i.e. karst). The grassland has a combination of dwarf shrubs and grasses while the bushclumps have deeper soils (dolines) and support a moderately tall thicket community. The surrounding lowlands and gullies support a tall thicket community. This patchy landscape supports a diversity of endemic flora and fauna that play an essential role in the functioning and dynamics of this ecosystem. The calcrete limestone is sought after for the production of cement. Opencast limestone mining has the potential to significantly alter this landscape. Rehabilitation and monitoring of vegetation cover and composition, soil, fauna and microclimate were compared to natural vegetation to determine appropriate management strategies to reinstate the mosaic landscape. Of the 32 treatments, subsoil and topsoil treatments produced relatively high plant cover and species richness comparable to the natural grassland. Other landscape features including edaphic parameters, microclimatic conditions and invertebrate communities where comparable to the natural grassland. Whilst recreating a functional post-mining grasslands appears relatively simple (and rapid); the establishment of the bushclumps is more complex and requires a more creative and proactive approach. Without active intervention to re-establish the bushclump component of the ecosystem, the functioning and dynamics of the mosaic (Bontveld) landscape has the potential to be lost for eternity.

Clematis pubescens: ex situ propagation and restoration in bauxite mine rehabilitation in the jarrah (*Eucalyptus marginata*) forest of South-western Australia

David Willyams

Alcoa of Australia ?, The University of Western Australia

Poster Presentation

Clematis pubescens Endl. is a geophytic vine species, common throughout the Jarrah forest. *C. pubescens* was a model species during a larger study on geophyte restoration in disturbed lands. Geophytes comprise 33% of the upland Jarrah forest flora and constituted many of the species seldom found in Alcoa of Australia's bauxite mine rehabilitation. By using a combination of phenological and germination research the hypothesis that seed factors caused establishment failure was discounted. Collecting fully ripe seed was critical for propagation success. Ex situ plant manipulations enabled the production of same age plants with 3 shoot and tuber sizes: small, medium or large. The hypothesis that a higher percentage of initially-larger-tuber plants would survive planting in the mine rehabilitation and reproduce was demonstrated. Nearly all initially-small plants with small tubers died during the first summer drought, whereas 67% of plants with large-at-start tubers survived for 3 years. Bare-rooting initially-larger-tuber plants was equally as effective thus allowing large numbers of plants to be easily carried, reducing planting effort and cost. The surviving plants produced seed in the 3rd summer, dispersing it into the surrounding restored forest. Broadcast seed germinated but died during the first summer drought, probably due to inadequate tuber growth and storage. This was also demonstrated with 12 other Jarrah forest geophyte species. These concepts may be globally applicable to the restoration of Mediterranean climate-type geophytes in disturbed lands. Integrated studies of adaptive biology, ex situ propagation and revegetation offer considerable potential for establishing absent geophyte species in mine restoration.

Adoption and refinement of agricultural practices to enable the scaling up of restoration activities in southern Australia

Geoff Woodall

CENRM, UWA

Theme: Delivering Large Scale Restoration

Agriculture is supported by a large national and international research budget that has delivered improved equipment and cultivation systems. The annual area planted with agricultural crops and pastures is large but the number of species grown is small. In contrast, the terrestrial restoration industry operates with a minimal research and development budget, currently operates at a small scale but involves the establishment of an enormous diversity of plant species on cleared agricultural land. This paper aimed to determine whether agricultural technologies can be applied to restoration. A number of agricultural innovations were found to have application to restoration and the refinement and adoption of these agricultural innovations is of paramount importance if large scale restoration is to be achieved. The study clearly showed that agricultural seeding equipment, herbicides, pesticides and nutritional supplements can improve the uniformity and reliability of restoration activities and enable broad scale restoration to be achieved in southern Australia. Several limitations to the use of agricultural practices for restoration activities were identified. This body of work has led to the developed new equipment and approaches that are now being widely adopted by restoration practitioners in southern Australia.

The conservation of the floristic biodiversity in New Caledonia: assessment and challenges to come in a hotspot of biodiversity

Adrien Wulff[1], Laurent L'Huillier[2], Bruno Fogliani[2], Marion Anquez[2], Charly Zongo[3]*

[1]University of New Caledonia, [2]New Caledonian Agronomic Institute, [3]New Caledonia Government, *Presenting Author

Theme: Threatened Species, Populations and Communities

New Caledonia is a territory that has the delicate mission to conciliate an exceptional floristic diversity and quick development of human activities impacting natural habitats. It is one of the main hotspots of the terrestrial biodiversity on Earth because of its richness in endemic plant species. The threats impacting these species and more generally the natural environments, such as fires, urbanisation, introduction of invasive species, but also the increasing development of mining industry, with the tripling of the production of nickel planed for 2013–2015, have increased recently. Fortunately, New Caledonia has the chance to have well-developed research facilities (UNC, IAC, IRD) enabling precise data collections leading to management priorities. They also bring up methods to increase ecological restoration success. These recommendations are taking into considerations by local authorities and mining companies. Then international and local NGOs sensitize the public in order to increase their awareness on the various threats impacting natural habitats. All these actors met during a workshop in April 2012 and the results from the exchanges will be presented here. They first identify the various actions that were undertaken for the conservation of plant biodiversity in New Caledonia. Moreover outside contributors brought their experience to this event, placing the conservation in a more global context. Following that, wills and objectives of each other were exposed in order to plan the various actions to be carried out in the future to preserve this unique natural heritage.

Successful re-colonisation, by vertebrate and invertebrate fauna, of rehabilitated mining areas in Western Australia's Pilbara region: a case study

Michael Young[1], Paul Bolton[1], Trudy Worthington[2]

[1]Outback Ecology, [2]Rio Tinto Iron Ore

Theme: Mine and Fauna Restoration

Assessment of mine site rehabilitation tends to focus on the return of vegetation as an indicator of success. In the Pilbara region of Western Australia, few studies have investigated whether rehabilitated areas provide adequate habitat for fauna. Here we document fauna presence in rehabilitated areas at two of Rio Tinto Iron Ore's Pilbara operations – Brockman 2 and Tom Price. The objectives of this study were to assess which fauna were present at rehabilitation sites, how their assemblages compared to those at adjacent, unmined reference sites and, if fauna were absent, what barriers might exist. We surveyed three rehabilitation sites and three reference sites at each of Brockman 2 and Tom Price, in spring 2011. Methods included trapping and searching for vertebrates, and wet-pitfall trapping for invertebrates with a focus on ants. Habitat assessments used a protocol intended to document characteristics most relevant to fauna. Of the 106 species of native vertebrates recorded, 83 were found at reference sites and 85 at rehabilitation sites. Although vertebrate assemblages differed between study areas and between reference and rehabilitation sites, species lists at rehabilitation sites were broadly comparable to those at reference sites. Of the fauna groups compared, ants appeared to most closely reflect habitat characteristics in their community composition. These findings suggest that rehabilitated areas in the Pilbara can be re-colonised by fauna. However, the absence of particular species at rehabilitation sites suggests barriers to re-colonisation may exist. Further investigation may identify improvements to rehabilitation that remove barriers or limit their impact.

Delineating the potential provenance boundaries of rehabilitation species at Ranger Uranium Mine, Northern Territory

Anja Zimmermann

Energy Resources Australia Ltd

Symposium: Seed Sourcing Guidelines for Restoration Success

Ranger Mine's conservative 30km seed collection zone poses a major risk to revegetation, as there may not be enough seed available at closure. Some of the revegetation species are naturally low or erratic seed producers. In addition, fires frequently whip out entire harvests and can cause delays in flowering and hence seed production. This study investigates the provenance boundaries of Ranger Mine's revegetation in order to possibly extend the 30km seed collection zone. A non-genetic approach was adopted, which assessed environmental factors, gene flow and species traits known to influence genetic variation in plants to identify zones of least likely genetic variation. In identifying the environmental factors, the provenance assessment took into account the unique growing conditions on the constructed final landform, which are unlike those found in the natural surrounding ecosystems. The resulting zones match the eco-geography of the Ranger Mine area and hence maintain the 'home site' advantage of local plants. Some genetic diversity that may be present in more distant seeders is welcomed, as it allows plant populations to respond to environmental changes such as climate change. This so-called 'composite provenancing' approach ensures that the genetic diversity is maximised while the risk of genetic pollution and outbreeding depression is minimised. The outcome of the investigations provides a strong case for changes in the seed collection zone and hence reducing a major risk at mine closure.

Plenary abstract

Stephen D. Hopper – Wednesday 28 November

Hope, theory and practice: restoration ecology and global biodiversity hotspots in a rapidly changing world

Stephen D. Hopper

Royal Botanic Gardens, Kew; Plant Biology/Centre of Excellence in Natural Resource Management, The University of Western Australia

Hope is arguably the greatest gift each generation can pass on to the next. At a time of unprecedented global change, with continuing loss of biodiversity, it is vital that new ways of living sustainably and caring for nature are developed and demonstrated. Restoration ecology continues to offer promise as a critical component of such positive scientific problem-solving. It remains clear that much remains to be done in developing theory and practice in the discipline.

This paper focuses on the special challenge of global biodiversity hotspots, richest in threatened species, and their restoration. Are present theoretical frameworks in restoration ecology sufficient to deliver best on-the-ground outcomes? What does restoration practice tell us? Above all, is it reasonable to remain hopeful for the future? I will use a combination of personal learning experiences and global observations from a botanic garden manager's perspective to draw out themes and hypotheses that deserve urgent focus, especially in Australasia.

Plenary abstract

Leanne Liddle – Wednesday 28 November

Aboriginal knowledge: Why should I care?

Leanne Liddle

Department of Premier and Cabinet

Despite the fact that Aboriginal knowledge has been applied within the Australian landscape for well over 40, 000 years, many scientists remain sceptical about its current value and its contribution to conservation.

Often scientists ignore this critical knowledge which could be the key to maintaining important species within the landscape as they poise the question 'But where is the science in Aboriginal knowledge, and what are the positive outcomes for the environment'?

But to answer these questions, scientists need to know how this knowledge is accessed and have a greater appreciation and understanding of how this knowledge is translated and transferred within Aboriginal culture as well as the relationship that Aboriginal people have with both plant and animal species.

Understanding how Aboriginal knowledge should be applied to conserve the landscape is a key ingredient, to make key decisions that could enable you to become the best practicitioner in conservation management.

This presentation will focus on the tangible and non-tangible elements which Aboriginal people use and know to maintain the integrity of the landscape of both plant and animals, including key behaviours, their relationship with other species, reproductive and flowering cycles, movements and reactions to climate including fire, floods and drought.

Plenary abstract

Hamish Jolly – Wednesday 28 November

The dawn of the symbiotes: when enterprise meets ecology

Hamish Jolly

Dunbar Harper Pty Ltd

Through necessity, the development of what we now think of as ecological protection and restoration began in the roots of environmental militancy.

As the demand for intervention became more mainstream, a Government-led regime followed based on regulation and funding to foster bushland protection and revegetation, directly through environmental agencies and indirectly through subsidy of community and landowner-initiated projects.

The problem is that while legislation may help prevent more environmental damage, there will never be enough in the public purse to manage the escalating and perpetual future costs of reserve management, nor to pay for the multi-billion dollar revegetation and restoration effort at the scale required.

As more land is set aside in reserves, the budget per ha for management is spread thinner. Seismic shifts in investment quantum, focus and geography of each successive Government environmental program leads to dislocation among community and landowner groups, lack of continuity on long term projects and collaboration giving way to competition.

There are signs that, with the best intent, the model is unsustainable. We are observing a progressive and systemic deterioration in the effectiveness of our restoration efforts – the job is simply too big and there is not enough in the public purse to achieve it.

But what happens when the objectives of economic production and business converge with those of ecological restoration? Could we harness compliance and private capital hunting commercial returns to make restoration effective in the longer run.

In short, from militancy to political intent, is the next baton-change in the evolution of environmental protection and restoration a marriage between enterprise and ecology?

This presentation looks at recent examples where this might be so, and explores opportunities for greater integration of business in the environment, with environmental restoration the winner.

Plenary abstract

David J. Merritt – Wednesday 28 November

Doomsday vaults or ecosystem services? Energising seed banks for landscape restoration

David J. Merritt

Kings Park and Botanic Garden, The University of Western Australia

Often promoted in the mainstream media as humanity's saviour to planetary-scale destruction, seed banks in reality, of course, have a myriad of purposes and contribute to serious and increasingly earnest efforts to conserve the world's rapidly declining plant biodiversity. Seed banks for wild species have historically been associated with Botanic Gardens and with the long-term ex situ conservation of biodiversity. However, increasingly, seed banking initiatives are involving local, national, and multi-national collaborative programs encompassing diverse institutions to co-ordinate large-scale seed collections for biodiversity protection.

Undeniably, these seed banking initiatives have achieved laudable conservation goals. Yet seed banks have a role to play beyond the capture and preservation of biodiversity. Seed banks must now turn their attention to restoration.

With contemporary restoration programs aiming to restore biodiverse plant communities at the landscape scale (100's to 10,000's of ha) the return of 10's to 100's of species will be required in many ecosystems. Such large-scale plant re-introductions necessitate the effective use of seeds. This in turn requires sufficient biological and technical knowledge to enable the collection and/or production of seeds, the viable storage of seeds, the reliable germination of seeds, and the efficient delivery of restoration-ready seeds into degraded landscapes. And all of this needs to be done using tonnes of seeds across a huge diversity of wild species.

To truly reverse the tide of species extinction in the wild, seed banks must now renew their goals and focus on the use of the seeds stored within, on their role as a science and technology provider enabling the effective use of seeds in the repair of degraded habitat, and on the formation of new partnerships with the businesses and communities that comprise the restoration industry to achieve landscape scale restoration.

Plenary abstract

David J. Pannell – Wednesday 28 November

Economic perspectives on ecological restoration

David J. Pannell

Centre for Environmental Economics and Policy, University of Western Australia

Ecological restoration decisions are economic decisions. By this, I don't mean that they are decisions that necessarily generate financial benefits, but that they are the types of decisions that economists tackle routinely using robust theories and models. Features of restoration decision problems that conform with standard economic decision problems include the following:

Restoration projects can be implemented at many different scales or using different strategies (e.g. different policy mechanisms), and there are many alternative restoration projects that could be chosen. Decisions must be made amongst these options.

Restoration projects require resources. Those resources may be in limited supply, or they may need to be obtained at the expense of other competing uses of those resources. The cost of the resources required for a project typically increases at an increasing rate as project scale increases.

Restoration projects require time. Benefits and costs may occur for long periods of time and/or occur at different times, requiring a method to allow valid comparisons between them.

Restoration projects involve risk and uncertainty. For example, there is often uncertainty about the cause-and-effect relationships between management actions and environmental outcomes. There are various risks that may lead to project failure. These risks and uncertainties vary between projects and need to be considered when project benefits are evaluated prior to investment.

Restoration projects affect things that humans value. The types of values affected and the extent to which they are affected varies between projects. Values vary depending on the scale of benefits from a project, often increasing at a decreasing rate as the project scale increases.

Restoration projects usually require cooperation from people, potentially including private landholders, businesses, or other organisations or agencies. The realistic likelihood of achieving that cooperation varies between projects and is important in evaluating the likely benefits of a project.

Economics can help environmental managers achieve the most valuable restoration outcomes for the available resources. It can identify those restoration projects that offer the best value for money, and help make the case for funding of these projects. Economic models provide an under-utilized tool for integrating ecology with other information to support strong decision making about restoration.

Plenary abstract

Pavan Sukhdev – Thursday 29 November

Can today's corporation deliver tomorrow's economy?

Pavan Sukhdev

Research Scholar, Yale University, and Founder-CEO of GIST Advisory

Today's dominant economic model has delivered wealth and pulled millions out of poverty, but it is recession-prone, leaves too many unemployed, creates ecological scarcities and environmental risks, and widens the gap between rich and poor. It creates serious looming threats such as climate change and social unrest.

Several hundred billion dollars per year of perverse subsidies (for fossil fuels, unsustainable agriculture and fisheries) and barriers to entry for newer, greener products and services maintain 'business-as-usual'. Also, the associated environmental and societal costs are not taken into account when calculating either corporate performance or national performance.

Viable 'Green Economy' solutions to these problems with our current economic model do exist, but we need to move beyond macro-economic and sectoral proofs and policy tinkering into micro-economic actions and reforms for any significant change to happen. This is because 60% of GDP and 70% of jobs globally are in the private sector.

Corporate influence is the largest determinant of policies. The corporation is the most important institution of our times, driving economic direction and resource use. The challenge is how to deliver tough solutions which cut across policy, self-regulation, and legislation in a manner that does not halt human progress.

A critical dimension of this challenge is that it must achieve change in a very short time – I argue by 2020 – because planetary boundaries are being approached (in some cases, surpassed) at an alarming rate. I argue that the four big changes we must prioritize out to 2020 are all in the realm of 'micro' policy, the operating environment for Corporations.

They include calculating and disclosing corporate externalities (negative externalities such as GHG emissions, water use, pollutants, etc., and positive externalities in the areas of employee education & training, etc.). They include setting limits to corporate leverage to prevent 'too-big-to-fail' corporations from seeding systemic chaos when they fail. They also include replacing taxes on corporate profits with usage charges and resource taxes on resource use and extraction. And finally, they include setting ethical standards in advertising, a key driver of excessive demand.

The new Corporation that will emerge from these changes is 'Corporation 2020', the subject of my lecture, the engine of a green and inclusive 'Economy of Permanence.'

Plenary abstract

Lesley Hughes – Friday 30 November

The biodiversity fund and beyond: triumphs, challenges and risks

Lesley Hughes

Macquarie University, Land Sector Carbon & Biodiversity Board

The Biodiversity Fund is a key component of the Land Sector Package, under the federal government's Clean Energy Future Plan. The Fund is investing around $946 billion over six years (2011–2016) in projects aimed at helping both private and public land managers store carbon, enhance biodiversity and build greater environmental resilience across the Australian landscape in the face of climate change. Funding is allocated under three, non mutually-exclusive themes: to improve landscape connectivity via new, biodiversity plantings; to protect and enhance existing native vegetation; and to manage threats to biodiversity, especially invasive species.

The first round of funding (2011–2012) was deliberately broad in its reach with grants awarded across all states and territories to 313 projects (from over 1500 applications) to the value of $271 million. The second round will be targeted to specific regions considered high priority areas owing to their potential to store carbon and/or level of species richness and endemism, but which are significantly threatened by fragmentation and/or invasive species.

The Biodiversity Fund represents the largest single environmental investment by any Australian government, but the challenges to maximize the positive outcomes are immense. These include communication between the administering department and landholders, and development of appropriate targets, guidelines and monitoring programs within the constraints of government financial agendas.

But the greatest fundamental challenge is that "business as usual" in conservation and restoration practice will be inadequate to meet the challenge of an uncertain climatic future, regardless of the size of the funding bucket. Creative thinking, and a willingness to challenge traditional practice are sorely needed.