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

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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

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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

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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!

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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

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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

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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

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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

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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]

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

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]

[1]Kings Park and Botanic Garden, [2]The University of Western Australia, [3]Seed Conservation Centre, Botanic Gardens of Adelaide

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
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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

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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.