

Advances in plant conservation biology:

Implications for flora management and restoration



Symposium program and abstracts

Perth, Western Australia

25-27 October 2005

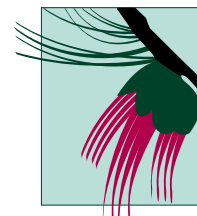


The symposium logo

The logo is a stylised image of *Calothamnus graniticus* subsp. *leptophyllus* designed by the Department of Conservation and Land Management's Senior Graphic Designer, Gooitzen van der Meer.

The genus *Calothamnus*, from the family *Myrtaceae*, is endemic to Western Australia and is commonly found throughout the south-west. The name *Calothamnus* means "beautiful bush" but the genus is commonly known as claw flowers due to the striking red claw-shaped flowers.

There are 46 taxa in the genus, of which 15 are listed as threatened, rare or poorly known. *Calothamnus graniticus* subsp. *leptophyllus* is one of the taxa in the genus that is listed as rare and in need of further survey. It is known from just a few populations south of Perth and in the Stirling Ranges.



**Advances in plant
conservation biology
Symposium, Perth**



Advances in plant conservation biology:

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Organising committee

David Coates – Department of Conservation and Land Management (WA)

Andrew Crawford – Department of Conservation and Land Management (WA)

Kingsley Dixon – Botanic Gardens and Parks Authority (WA)

Shelley McArthur – Department of Conservation and Land Management (WA)

Leonie Monks – Department of Conservation and Land Management (WA)

Deanna Rokich – Botanic Gardens and Parks Authority (WA)

Joanne Smith – Department of Conservation and Land Management (WA)

Advances in plant conservation biology:
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Program

Tuesday 25 October 2005

- 8.00 am Symposium registration - Technology Park Function Centre
- 9.00 am Welcome and launch by CALM Executive Director, Kieran McNamara
- Rarity**
Chair: David Coates (CALM)
- 9.30 am Peggy Fiedler (BBL Sciences, California), Brenda J. Grewell, Douglas Partridge and Megan Keever
Understanding rare plants in the Golden Gate Estuary (California): The relationship between scale and understanding
- 10.00 am Colin Yates (CALM), Phil Ladd (Murdoch University), David Coates and Shelley McArthur (CALM)
Hierarchies of cause: Understanding rarity in an endemic shrub with a highly restricted distribution
- 10.30 am Morning tea
- Biogeography and phylogeography**
Chair: Kingsley Dixon (BGPA)
- 11.00 am Stephen D. Hopper (University of Western Australia) and Paul Gioia (CALM)
Scaling up – floristic hotspots and their uses for conservation
- 11.30 am Greg Keighery, Neil Gibson, Sue Patrick, Michael Lyons and Stephen van Leeuwen (CALM)
Biological survey and priorities for flora conservation
- 12 noon Margaret Byrne (CALM)
Phylogeography and implications for conservation
- 12.30 pm Lunch
- Conservation genetics and systematics**
Chair: Hans Lambers (University of Western Australia)
- 1.30 pm Andrew Young (Plant Industry, CSIRO, Canberra)
Molecules, monitoring and models; integrating demographic and genetic information to inform conservation decision making for grassy woodland ecosystems
- 2.00 pm Siegy Krauss, John Bussell, Grace Zawko (BGPA), Tian He (Curtin University) and Liz Sinclair (Murdoch University)
Landscape restoration genetics in south-west Western Australia – a practical contribution to bushland restoration
- 2.30 pm David Coates and Jane Sampson (CALM)
Plant mating systems in conservation and assessing population persistence
- 3.00 pm Terry MacFarlane (CALM)
The role and relevance of taxonomy in conservation
- 3.30 pm Afternoon tea

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Restoration ecology

Chair: Mark Webb (BGPA)

- 4.00 pm Richard Hobbs (Murdoch University)
Managing plant populations in fragmented landscapes: Restoration or gardening?
- 4.30 pm Kingsley Dixon and Deanna Rokich (BGPA)
Recent advances in restoration ecology
- 5.00 pm Deanna Rokich and Kingsley Dixon (BGPA)
Advances within the Bold Park restoration program

Wednesday 26 October 2005

Demography and modelling

Chair: Neil Burrows (CALM)

- 9.00 am Eric Menges (Archbold Biological Station, Florida)
Integrating demography and fire management: An example from Florida scrub
- 9.30 am Byron Lamont (Curtin University), Neal Enright (University of Melbourne), Juergen Groeneveld (Leipzig, Germany)
Conservation biology of banksias
- 10.00 am Mark Burgman (Melbourne University), Helen Regan, Yakov Ben-Haim, Atte Moilanen and Jane Elith
Decisions under severe uncertainty for single and multiple species conservation
- 10.30 am Morning tea

Ex situ conservation

Chair: Deanna Rokich (BGPA)

- 11.00 am Robin Probert (Royal Botanic Gardens, Kew)
Pre-storage factors critically affect the utility of seeds for conservation: A review of the underlying biology and practical implications
- 11.30 am Eric Bunn and Kingsley Dixon (BGPA)
Biotechnology in the age of conservation
- 12 noon David Merritt (BGPA)
Seed germination and dormancy of Australian species in relation to storage temperature and seed water content
- 12.30 pm Anne Cochrane, Andrew Crawford and Leonie Monks (CALM)
The significance of ex situ conservation to plant recovery in southern Western Australia
- 1.00 pm Lunch
- 2.00 pm Posters
- 3.30 pm Afternoon tea
- 4.00 pm Drinks – Botanic Gardens and Parks Authority Biodiversity Centre, Kings Park (off Fraser Avenue, West Perth)

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Thursday 27 October 2005

Disturbance regimes and landscape management

Chair: Neville Marchant (CALM)

- 9.00 am Jamie Kirkpatrick (University of Tasmania)
A review of the role of human-induced disturbance regimes in maintaining threatened plant species in Australia
- 9.30 am Grant Wardell-Johnson (University of Queensland)
Towards a landscape conservation culture – broadening the spatio-temporal scope of ecological studies to anticipate change in Australian forested ecosystems
- 10.00 am David Keith (Department of Environment and Conservation, NSW)
Management of fire and disease for flora conservation in variable landscapes: Insights from demography and modelling of long-lived woody plants

10.30 am Morning tea

Re-introductions theory and practice

Chair: Gordon Wyre (CALM)

- 11.00 am Ed Guerrant (Berry Botanic Gardens, Oregon), and Tom Kaye (Institute for Applied Ecology, Oregon)
Reintroduction of rare and endangered plants: Questions, experiments and lessons learnt
- 11.30 am Leonie Monks (CALM)
*Assessing translocation success in the critically endangered *Lambertia orbifolia* subsp. *orbifolia**
- 12 noon Eleanor O'Brien (BGPA, University of Western Australia)
Adaptive variation in forest trees from south-western Australia: Implications for restoration

12.30 pm Lunch

Invasive plants and their management

Chair: Jen McComb (Murdoch University)

- 1.30 pm Hugh Pritchard (Royal Botanic Gardens, Kew)
Management tools for plant conservation: Reproductive traits as a basis for predicting plant invasiveness
- 2.00 pm Kate Brown (CALM)
An adaptive approach to management of an invasive South African grass – A case study from the threatened plant communities of Perth's clay based wetlands
- 2.30 pm Lynley Stone (CALM, Salinity CRC)
Introducing perennial species to mitigate salinity: What are the potential risk and benefits to biodiversity?

3.00 pm Afternoon tea

Plant microbial interactions

Chair: Bernie Dell (Murdoch University)

- 3.30 pm Bryan Shearer, Colin Crane, Sarah Barrett and Anne Cochrane (CALM)
Phytophthora cinnamomi - A major threatening process to flora biodiversity conservation in South Western Australia
- 4.00 pm Mark Brundrett (Department of Environment, University of Western Australia)
New scientific methods for conserving terrestrial orchids

4.30 pm **Closing address**

CALM Science Division Director, Dr Neil Burrows

7.30 pm Symposium dinner – Metro Hotel Perth, 61 Canning Highway, South Perth

UNDERSTANDING RARE PLANTS IN THE GOLDEN GATE ESTUARY (CALIFORNIA): THE RELATIONSHIP BETWEEN SCALE AND UNDERSTANDING.

Peggy L. Fiedler¹, Brenda J. Grewel², Douglas Partridge³, and Megan Keever¹.

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²Graduate Group in Ecology, University of California, Davis, California, United States of America 95696

³BBL Inc. 1100 Dexter Avenue North, Seattle, Washington State United States of America 98109

The Golden Gate Estuary is believed by many to be the most highly urbanized and degraded estuary on the Pacific coast of North America. As a consequence, many endemic plant species are threatened by habitat loss and fragmentation, invasion by exotic species, chronic pollution, and incompatible land uses. Various efforts are underway, however, to understand and document the status of many of these rare species to ensure their persistence in the Estuary; we have been involved in these efforts since the early 1980's. We present brief summaries of eight case studies – single-season field surveys, multi-year field surveys, and detailed field experiments – illustrating the different approaches to protecting rare taxa, and draw conclusions about what how long it takes and what it costs to gather useful data for rare plant protection. In more detail, we contrast three studies to illustrate the relative costs and levels of effort. The Suisun thistle (*Cirsium hydrophilum* var. *hydrophilum* [Asteraceae]), believed extinct until rediscovery in 1989, was the subject of a low cost, short term, but intensive field survey in 2003. Results of this work documented a highly localized, but significantly larger population size (by several orders of magnitude). Mason's lilaeopsis (*Lilaeopsis masonii* [Apiaceae]) is the subject of a ten-year compliance monitoring effort in the Napa River ecosystem. Five years of data collection have revealed a highly dynamic but geographically stable metapopulation over a six mile reach. In the most intensive study, the rare root hemiparasite Soft bird's beak (*Cordylanthus mollis* subsp. *mollis* [Orobanchaceae]) was introduced successfully in created vegetation gaps to test the hypothesis that local disturbance can be a useful technique to restore rare plant populations and enhance individual fitness. In comparing all eight studies conducted during the last 25 years, we have come to understand that, while varying levels of effort and funding provide similarly varying levels of information, each level provides results essential for protection and management of rare plant populations.

HIERARCHIES OF CAUSE: UNDERSTANDING RARITY IN AN ENDEMIC SHRUB WITH A HIGHLY RESTRICTED DISTRIBUTION

Colin J. Yates¹ and Philip G. Ladd²

¹Science Division, Department of Conservation and Land Management, Locked Bag 104, Bentley Delivery Centre, Western Australia, Australia 6983.

²School of Environmental Science, Murdoch University, Murdoch, Western Australia, Australia 6150.

Verticordia staminosa ssp. *staminosa* is an extremely rare plant species occurring as an isolated population of approximately 1200 plants on a granite outcrop in the semi-arid agricultural region of Western Australia. We aimed to determine a hierarchy of causes for explaining the shrub's extremely restricted distribution. We measured seed production for three consecutive years and demography for five consecutive years. We used transition matrix models to describe the shrub's population dynamics and stochastic simulations to explicitly compare the effects of low rainfall and disturbance on population viability. *Verticordia staminosa* ssp. *staminosa* produces large numbers of seeds each year and has flower to fruit ratios greater than reported for related rare and common congeners. Seedling recruitment occurs in most years with pulses in the wettest years. The finite population growth rates rate ranged from 0.997 to 1.184. Elasticity analyses showed that population growth rate was more sensitive to stasis of established plants than to seedling recruitment. Stochastic growth rates declined under low rainfall regimes with increased incidence of disturbances that killed established plants. Rarity in *V. staminosa* is best explained by evolutionary history and the interaction of climate change and disturbances such as fire that kill plants. Climatic fluctuations since the late Pliocene have led to stochastic extinction episodes of populations on other granite outcrops resulting in the currently restricted distribution. We discuss the implications of our findings for management of the species.

SCALING UP – FLORISTIC HOTSPOTS AND THEIR USES FOR CONSERVATION

Stephen D. Hopper¹ and Paul Gioia²

¹School of Plant Biology, The University of Western Australia, Crawley, Western Australia Australia 6009.

²Science Division, Department of Conservation and Land Management, Locked Bag 104, Bentley Delivery Centre, Western Australia, Australia. 6983.

Much activity in flora conservation is focused on threatened species or communities. This work is essential to inform management and minimise extinction. Yet the pace of change and rate of destruction of native flora in some regions are so great that higher-level strategic approaches are needed for effective conservation in the short term. Centres of species richness and endemism have been of interest ever since the world-wide system of biogeographic regions was founded by Augustin de Candolle in 1820 on the basis of the distribution of plants. Recently, data on centres of endemism have been combined with that on conservation status to identify 25 global biodiversity hotspots for strategic priority in conservation management and research. This initiative is now leading to national and regional studies identifying hotspots at different scales. Here, we review the theory behind hotspots and compare their utility for conservation against other approaches such as vegetation mapping and the exciting raft of approaches used in conservation planning for the Cape Floristic Region in South Africa. These themes are explored using a case study of the Southwest Australian Floristic Region.

BIOLOGICAL SURVEY AND PRIORITIES FOR FLORA CONSERVATION

Greg Keighery, Neil Gibson, Sue Patrick, Michael Lyons and Stephen van Leeuwen

Science Division, Department of Conservation and Land Management, Locked Bag 104, Bentley Delivery Centre, Western Australia, Australia 6983

Biological survey has been an integral component of conservation planning for over 30 years in Western Australia, particularly because of the diverse and poorly documented nature of the vascular flora. Surveys are conducted at 3 levels; regional; sub-regional and local, the first normally involving multidisciplinary teams. Regional surveys provide data on flora to allow establishment of a CAR reserve network to protect biodiversity. However, they also add greatly to knowledge of the flora, viz. the Wheatbelt survey provided detail on the distribution of 3160 taxa, found 20 previously unknown taxa, 3 presumed extinct taxa and new populations of 22 rare taxa.

Subregional surveys are normally plant based, for example the Southern Swan Coastal Plain survey (around the capital Perth) documented a series of rare communities (now listed as Threatened), provided detail on the distribution of 2000 taxa, found 15 previously unknown taxa, 3 presumed extinct taxa and new populations of 10 rare taxa.

Local area surveys, such as the Lake Muir Nature Reserves listed nearly 1,000 taxa, removed three declared rare taxa, recorded the largest known population of nationally threatened species and recorded one new taxon.

Systematic survey at any scale of a poorly known flora captures both expected and unexpected records. They document the conservation status of the vascular flora and the occurrence of weeds. They provide information to both add and remove taxa and communities from statutory protection.

THE INFLUENCE OF THE PAST IN THE PRESENT - PHYLOGEOGRAPHY IN THE ANCIENT AUSTRALIAN LANDSCAPE

Margaret Byrne

Science Division, Department of Conservation and Land Management, Locked Bag 104, Bentley Delivery Centre, WA 6983

Australia has an ancient landscape that has had a relatively stable geological history with no major glaciation events, although it did experience climatic oscillations during the Pleistocene. Current distributions and patterns of diversity and endemism are related to the impacts of historical processes. Phylogeography uses the geographic distribution of phylogenetic lineages to give insight into the influence of historical processes on population structure. Comparative phylogeographic studies can highlight major influences of historical processes enabling patterns of biodiversity to be understood in a historical context providing greater predictive power for conservation management. Comparative phylogeographical analysis of widespread species in the south of Western Australia has inferred past fragmentation as the most likely cause of the patterns of population structure present today. This is consistent with biogeographical evidence for climatic oscillations during the Pleistocene due to cyclic contraction and expansion of the mesic and arid zones leading to fragmentation in the transition area between these zones. Significant fragmentation events can still be detected in maternal lineages even after secondary expansion occurs.

MONITORING, MOLECULES AND MODELS: INTEGRATING ECOLOGICAL AND GENETIC APPROACHES TO STUDYING PLANT POPULATION VIABILITY IN DEGRADED LANDSCAPES

Andrew Young

Centre for Plant Biodiversity Research, CSIRO Plant Industry, GPO Box 1600, Canberra Australian Capital Territory, Australia 2601.

Quantifying the spatial and temporal dynamics of plant populations to assess intrinsic rates of increase and predict the probability of local species persistence is an extraordinarily difficult task. This is particularly true for fragmented or degraded habitats where the scales and frequencies of critical processes such as pollination, seed dispersal, recruitment and flowering may have changed significantly in response to disturbance. Populations in such environments must also cope with other environmental stresses such as increased competition from weeds, elevated levels of herbivory, or changes in soil chemistry that present new selective challenges. Knowledge of these basic population processes, their relative influence on population viability, and how they are affected by landscape condition and structure is critical if we are to be successful in integrating conservation of plant biodiversity and maintenance of ecological function with production within mixed natural-agricultural landscapes. A sound scientific footing for doing this is important as such landscapes now represent the only arenas for the conservation of many of the planet's most diverse plant communities. Here I will outline several studies that have combined ecological, genetic and modeling methods to investigate the importance of factors such as mate limitation, inbreeding and hybridization in determining the viability of native plant populations in Australian agricultural environments.

LANDSCAPE RESTORATION GENETICS IN SOUTH-WEST WESTERN AUSTRALIA - A PRACTICAL CONTRIBUTION TO BUSHLAND RESTORATION

Siegy Krauss¹, John Bussell¹, Grace Zawko¹, TianHua He² and Liz Sinclair³

¹Kings Park and Botanic Garden, Botanic Gardens and Parks Authority, Fraser Ave, West Perth.

²Curtin University, Kent Street, Bentley, Western Australia, Australia 6102.

³Division of Science and Engineering, Murdoch University, South Street, Murdoch, Western Australia, Australia 6150

The restoration of diverse plant communities requires an understanding of the extent of the local genetic provenance and the delineation of appropriate seed collection zones. Potential risks of introducing foreign genotypes include poor performance where there is a home-site advantage, founder effects, genetic swamping and outbreeding depression. While recognizing that there are occasions when foreign genotypes may need to be introduced, genetic integration with indigenous populations and the management of intra-species diversity, should in general be a priority for the restoration of diverse native plant communities. With examples from the Western Australian flora, we identify how powerful molecular markers, novel statistical approaches, and minimal sampling, are making a practical contribution to the identification of genetically appropriate seed collection zones for many species. We also highlight the need for further studies to assess issues relating to seed source populations that may impact on restoration activities, as well as the ongoing need to better understand the biological significance of introducing foreign seed, for example through reciprocal transplant experiments to assess home-site advantage.

PLANT MATING SYSTEMS IN CONSERVATION AND ASSESSING POPULATION PERSISTENCE

David J. Coates and Jane F. Sampson

Science Division, Department of Conservation and Land Management, Locked Bag 104 Bentley Delivery Centre, Bentley, Western Australia 6983

The persistence of plant populations in highly disturbed and fragmented landscapes depends on a number of key factors such as population size, isolation and habitat disturbance. These factors may significantly influence the mating system of these populations by affecting pollinator availability and behaviour, the ability to find mates in self-incompatible species, inbreeding in self-compatible species and the size of the pollen pool. These in turn might be expected to influence key variables critical for population persistence such as seed production, seed germination and seedling fitness. The investigation of mating system variation in plant populations can therefore provide valuable insight into the ability of plant populations to persist following significant habitat loss. Here we investigate mating system variation in five rare species: *Banksia cuneata*, *Lambertia orbifolia* (Proteaceae); *Verticordia fimbrialepis*, *Eucalyptus rameliana* (Myrtaceae); *Acacia sciophanes* (Mimosaceae) and two common species *Calothamnus quadrifidus* (Myrtaceae) and *Acacia anfractuosa*. All seven species are animal pollinated with mixed mating systems. Population variation in mating system parameters was investigated in relation to population size, isolation and habitat disturbance. We show that although the mating system will vary depending upon pollination biology and life -history, as populations get smaller, more isolated and habitat disturbance increases there is a trend towards increased inbreeding and smaller effective sizes of paternal pollen pools. These findings will be discussed in relation to the conservation and management of rare and threatened species and plant populations of more common species in vegetation remnants in fragmented landscapes.

THE ROLE AND RELEVANCE OF TAXONOMY IN FLORA CONSERVATION

Terry D. Macfarlane

Science Division, Department of Conservation and Land Management, Locked Bag 104, Bentley Delivery Centre, Western Australia, Australia. 6983.

Taxonomy is concerned with classifying, characterising and naming organisms and consequently has major relevance to practical conservation and to other fields of biology that contribute to conservation research. Our knowledge of relative biodiversity derives from a long history of taxonomic work, and knowledge of the distribution and rarity of plant species is based primarily on specimen collections. Contemporary taxonomic work is substantially directed toward conservation objectives in addition to traditional scientific curiosity. Species, subspecies and varieties that are recognised by taxonomists must be conserved, and if they are rare or threatened, then substantial management costs will be involved, and legal implications may arise. There is therefore a responsibility to ensure that taxa are well-founded and scientifically defensible. Similarly there is a need for good lists or censuses of currently recognised taxa arranged in classifications that indicate relationships to guide conservation workers and researchers. The role of taxonomy is constantly adjusting to demands engendered by scientific and technological advances and changing social trends. Examples include alternative approaches to classifying organisms, integrating the results of molecular studies of plants, developing modern database systems to provide dynamic taxonomic information about plants, improved ways of recording and verifying populations of rare plants, better plant identification tools, conforming to international standards and contributing to global projects and networks. Issues of special concern in Western Australia include coping with a rich biodiversity, a substantial proportion of which is not formally described taxonomically, urgent conservation demands in the face of serious environmental threats which impacts on taxonomic work, a current initiative to improve consistency of plant names nationally, a greater demand for taxonomic and herbarium services by an increasing conservation workforce, and an increasing pace of taxonomic change through research advances.

MANAGING PLANT POPULATIONS IN FRAGMENTED LANDSCAPES: RESTORATION OR GARDENING?

Richard Hobbs

School of Environmental Science, Murdoch University, Murdoch, Western Australia, Australia 6150.

Ecosystem fragmentation results in major changes in a number of environmental and biotic parameters which affect the ability of plant populations to persist. All stages of the plant life cycle may be impacted in either negative or positive ways by the changed biophysical settings caused by fragmentation and associated changes in the surrounding landscape. This may result in plant populations being lost or significantly reduced from patches of native vegetation, leading to the need for active management intervention. This intervention may take the form of management of threatening processes such as changed hydrology, altered fire regime, weed invasion, disease or herbivory, reversal of ecosystem degradation such as soil structural changes, or the reintroduction of plants of species which no longer persist in an area or where numbers are very low. These management actions range from preventative management through to active restoration, and an important but often unasked question is "What are we trying to achieve, and to what lengths will we go to achieve it?" Is there a limit to the degree of intervention which is desirable in conservation terms, beyond which we are no longer conserving but rather cultivating and gardening? When do we cross the line between maintaining a "natural" system and creating an artificial and potentially unsustainable system? I discuss this question in relation to management of remnant vegetation in urban and agricultural settings and suggest that a careful mix of species-based and process-based management is required for us to succeed in the goal of biodiversity conservation in fragmented landscapes.

RECENT ADVANCES IN RESTORATION ECOLOGY

Kingsley Dixon and Deanna Rokich

Science Directorate, Botanic Garden and Parks Authority, Fraser Avenue, West Perth, Western Australia, Australia 6005.

The Botanic Gardens and Parks Authority (BGPA) is committed to conserving, restoring and enhancing the biodiversity of the designated bushlands under its custodianship, and of the States biodiversity in general. This commitment is achieved through a *integrated and innovative restoration research* and *adaptive management* approach. The first key feature of the approach is the *integration of research areas* for effective delivery of conservation and restoration outcomes. Each research area represents the outcomes of a multi-disciplinary team approach. For example, the restoration of a post-disturbed site typically involves research into conservation genetics, seed dormancy, seed banking, propagation science, and cryo-conservation. An additional key feature of the approach is an *adaptive management* approach, involving intimate links between all BGPA research disciplines (seed science, propagation science, conservation genetics and germplasm storage) through the restoration ecology discipline, and operations staff; as well as industry, community groups, practitioners, researchers and government agencies. In combination, this approach achieves practical outcomes and enables timely application of research outcomes to conservation and restoration programs. This presentation will provide an overview of recent advances in the restoration of our State's biodiverse ecosystems.

RECENT ADVANCES IN THE BOLD PARK RESTORATION RESEARCH PROGRAM

Deanna Rokich and Kingsley Dixon

Science Directorate, Botanic Garden and Parks Authority, Fraser Avenue, West Perth, Western Australia, Australia 6005.

The Botanic Gardens and Parks Authority (BGPA) restoration research team was recently expanded and is guiding BGPA management to enable 'best practice' restoration of one of the most significant bushland areas within greater metropolitan Perth, the Bold Park bushland. The release of the Bold Park 'Environmental Management Plan 2000-2005' (EMP) in 2001, committed the BGPA to restoration of sixty hectares of degraded Bold Park bushland. To facilitate successful restoration, several areas of intensive research were highlighted as being pivotal to the success of the program. As such, the Bold Park restoration research program involves the integration of BGPA's science disciplines (genetics, weed ecology, propagation science, seed science, floristics and germplasm storage), and strong links between science, managers, operations, community groups and stakeholders, with the expected outcome being the restoration of Bold Park bushland to a more diverse and healthy ecosystem. This presentation will provide an overview of project results to date.

INTEGRATING DEMOGRAPHY AND FIRE MANAGEMENT: AN EXAMPLE FROM FLORIDA SCRUB

Eric S. Menges

Archbold Biological Station, P.O. Box 2057, Lake Placid, Florida, United States of America 33862

I integrate information from population viability analyses and studies of life history to suggest fire regimes that protect rare plants in Florida scrub. Types of Florida scrub dominated by resprouters (scrubby flatwoods, oak-hickory scrub) will be resilient to a range of fire return intervals but may be sensitive to patchy fires (that fail to top-kill dominant competitors) and intense fires that create patches of mortality. One PVA on an herbaceous resprouting species that grows in oak-hickory scrub (*Eriogonum longifolium* var. *gnaphalifolium*) suggests that it can tolerate a range of fire return intervals, but is favored by more frequent fires. On the other hand, a short-lived, seed banking, gap specialist species (*Dicerandra frutescens*) favors 6-12 year fire return intervals of fairly complete, intense fires. Relatively frequent fire also helps an annual seed banker (*Warea carteri*). Florida rosemary scrub, dominated by seeding species, has quite different dynamics with respect to fire. Its dominant species (*Ceratiola ericoides*) can be eliminated by frequent fires (< 10 years) and probably also by fire suppression (> 80 years). PVAs on two rosemary scrub herbs (*Hypericum cumulicola* and *Eryngium cuneifolium*) suggest frequent fires would promote persistence. Because local extinctions are likely for these two species, patchy burning patterns would facilitate metapopulation viability. Several other scrub species have population viability unaffected by fire. We use these demographic analyses to more closely specify fire return intervals for various types of Florida scrub and argue that a moderate amount of variation in fire regimes can promote biodiversity while not harming the viability of individual species.

CONSERVATION BIOLOGY OF BANKSIAS

Byron Lamont¹, Neal Enright², Juergen Groeneveld³

¹Curtin University, Kent Street, Bentley, Western Australia, Australia 6102.

²The University of Melbourne, Parkville, Victoria, Australia 3010

³Leipzig, Germany

Species killed by fire are vulnerable to extreme fire regimes: intense fires at intervals less than 12-year intervals can cause local extinction. Fire intervals longer than 45 years (species longevity) can equally result in population demise. Since frequent fires will be patchy there remains the possibility that some plants may escape some fires and act as source plants for recolonisation of the landscape when they are eventually burnt. Our genotyping of individuals in a metapopulation study of *Banksia hookeriana* shows that some seeds may disperse 2 or more km from their parent population. To take advantage of this insight, from a management perspective we need to know the mechanism responsible for this feat – willy-willies, cockatoos? Human-caused bare areas result in prolific growth and flowering of plants growing at the edge of the disturbance. In addition, the flowering period is extended. As a result, plants of *B. hookeriana* and *B. prionotes* are more likely to coflower, leading to hybridisation (13 populations known so far) and potential loss of species identity.

DECISION MAKING UNDER SEVERE UNCERTAINTY FOR SINGLE AND MULTIPLE SPECIES CONSERVATION.

Mark Burgman¹, Helen Regan², Yakov Ben-Haim³, Atte Moilanen⁴ and Jane Elith¹

¹The School of Botany, The University of Melbourne, Parkville, Victoria, Australia 3010.

²Department of Biology, San Diego State University, 5500 Campanile Drive San Diego, California, United States of America 92182-4614.

³Technion - Israel Institute of Technology, Technion City, Haifa, Israel 32000

⁴Metapopulation Dynamics Research Group, Department of Biological and Environmental Sciences, PO Box 65 (Viikinkaari 1), FI-00014, University of Helsinki, Finland.

Classical decision theory suggests that rational decision-makers should seek solutions that maximise expected utility. If decisions can be abstracted to sets of possible states associated with outcomes, the problem reduces to one of selecting the act or strategy that optimises expected benefits, assuming perfect knowledge of probabilities. Yet, the states of the world and the associated utilities are always highly subjective and uncertain. Computer-assisted reserve selection algorithms typically operate on matrices of species presence-absence in sites, or on probabilities of occurrence in grid cells. Like decision-theory problems, there are always errors in data and models - erroneous species data, structural and parameter uncertainty in habitat models, and lack of correspondence between presence and long-run persistence. Despite these uncertainties, methods proceed as if there is no uncertainty. Having two conservation options of apparently equal biological value, one would prefer the option whose value is relatively insensitive to errors. Information-gap decision theory generates species management and reserve design options that are robust to uncertainty. Consideration of uncertainty involves modifications to the typical objective functions, resulting in robust-optimal species management and reserve structures.

PRE-STORAGE FACTORS CRITICALLY AFFECT THE UTILITY OF SEEDS FOR CONSERVATION: A REVIEW OF THE UNDERLYING BIOLOGY AND PRACTICAL IMPLICATIONS.

Robin Probert, Fiona Hay and Michael Way.

Seed Conservation Department, RBG Kew, Wakehurst Place, Ardingly, West Sussex, United Kingdom RH17 6TN

The quality of seed conservation collections and hence their value for species re-introduction or restoration, is critically dependent on factors operating in the period between the point of collection and their arrival under controlled processing and storage conditions. This paper will highlight some of the key findings arising from 30 years of research and practical experience in the conservation of wild plant species at Kew's Millennium Seed Bank. The underlying physiological events occurring during development and maturation that affect whether seeds can be stored successfully and for how long will be reviewed. Inter-species differences in the timing of the acquisition of desiccation tolerance in relation to other reproductive traits will be described and the consequences of these differences for practical seed collecting and post-harvest handling will be revealed. Previously unpublished data will be presented that quantifies the improvements in seed quality that can be expected when post-harvest handling is informed by an understanding of the interaction between physiology and environment.

BIOTECHNOLOGY IN THE AGE OF CONSERVATION

Eric Bunn and Kingsley Dixon

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Recent years have witnessed major advances in conservation biology research in Australia. Some of these include the discovery of the active chemical in smoke – induced seed germination of Australian plants, the intimate relationship between the rare underground orchid, its mycorrhizal and plant partners, and utilizing the latest genetic techniques to unravel the mysteries of species diversity, or advancing biotechnology to propagate critically endangered plants. New research is advancing our understanding of the workings of seeds of native plants, many of which are notoriously difficult to germinate. New paradigms for elucidating the intricacies of seeds dormancy are being developed that will have important implications where there is a requisite to source seed from local provenances for direct seeding to restoration sites, with or without intervening storage intervals. Advances in tissue culture methods such as somatic embryogenesis have enabled the production of over 20,000 somatic embryos of a recalcitrant native rush in a few months, an order of magnitude higher than other methods currently available. Cryogenic research has enabled the long-term storage of many taxa of rare and endangered plants with reduced cost and genetic stability. Over 20 species of vascular plants, seed and numerous mycorrhizal fungi (mainly orchid spp.) are now stored in liquid nitrogen at Kings Park. The Science Directorate of Botanic Gardens and Parks Authority has been at the forefront of many of these advances (particularly smoke research) and continues to advocate and progress excellence in conservation science for restoration of biodiversity in Western Australia.

SEED GERMINATION AND DORMANCY OF AUSTRALIAN SPECIES IN RELATION TO STORAGE TEMPERATURE AND SEED WATER CONTENT

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This paper will present recent research findings regarding seed storage and germination of Australian species. The paper will focus on the effects of the storage environment on seed longevity and seed dormancy state.

Seeds stored for long term conservation purposes are generally stored at sub-zero temperatures. Results from a recent study of the effects of seed water on seed survival following exposure to sub-zero temperatures will be examined. Seed germination of two native Western Australian species, *Banksia prionotes* and *Eucalyptus gomphocephala* (selected for their varying oil contents) following storage for 6 months at -18°C, -80°C or -196°C and a range of water contents was examined. For *B. prionotes* seeds (7% lipid content), reducing the storage temperature increased the upper water content limit for storage. Conversely, for *E. gomphocephala* seeds (26% lipid content) reducing storage temperature decreased the upper water content limit and very dry seeds (<5%) exhibited signs of damage when stored at -196°C.

Seeds destined for restoration programs are often stored for short periods of time (< 2 years) and ideally must be highly germinable when removed from storage. The influence of the storage environment on seed dormancy state is largely unresearched for the Australian flora. The effects of storage temperature and seed water content on germination/dormancy of several species (*Anigozanthos manglesii*, *Austrostipa elegantissima*, *Conostylis candidans* and *Stylidium affine*), known to have a dry after-ripening requirement, will be examined. Seed germination (with and without smoke treatment) of seeds stored at 5, 23 and 50°C and 5, 10, 20, 50 and 75% eRH was examined. The rate of after-ripening varied greatly between species. However, for all species, storage at 50% RH maximised dormancy loss, and after-ripening was more rapid at warmer temperatures. Exposure to smoke improved germination, compared to non-smoked seeds, and this improvement increased with time in storage.

The implications of this work for the conservation of Australian species will be discussed.

THE SIGNIFICANCE OF *EX SITU* CONSERVATION TO PLANT RECOVERY IN SOUTHERN WESTERN AUSTRALIA

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Western Australia has a rich endemic flora that is highly threatened. Recovery plans outline actions that identify and address threatening processes with the overall aim to prevent species loss. *Ex situ* conservation and translocation are practical management responses that address the ongoing biodiversity crisis that is threatening this flora. *Ex situ* storage of 223 species of threatened flora (Declared Rare) at the Department of Conservation and Land Management's Threatened Flora Seed Centre has led to 23 translocations, which have contributed to increases in plant numbers for those species by up to three times. This collaboration between *ex situ* practitioners and reintroduction specialists aims to secure plant populations in the wild whilst holding viable collections as insurance.

The immediate goals of *ex situ* conservation are to ensure adequate representation of each species in long-term storage. This assumes that international standards for germplasm conservation will capture a significant proportion of the genetic variability within each species. This material allows for the translocation of species at risk of extinction. The ultimate goal of these translocations is to create viable self-sustaining populations. But how many populations and of what size are needed to secure the long-term future of a species?

The challenge is to acquire the basic knowledge to allow us to define minimum viable population size and to build on existing *in* and *ex situ* conservation information to identify the resources required to achieve this. Currently 60% of Western Australian threatened plant species are represented in *ex situ* seed collections. These collections are often small and seed number can still be a limiting factor in establishing translocated populations. It is clear that these collections have made a significant contribution to the species recovery process however there is a long way to go before any species can be considered 'saved'.

A REVIEW OF THE ROLE OF HUMAN-INDUCED DISTURBANCE REGIMES IN MAINTAINING THREATENED PLANT SPECIES IN AUSTRALIA

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A substantial proportion of threatened vascular plant species appear to be extremely rare, or in decline, because the disturbance regimes required to complete their life cycles have become rare, or are in decline. Changes in fire, grazing and bioturbation regimes have been widely recognized to be causes of decline. There is more evidence that reductions in the frequency and/or intensity of the events that compose the regimes are threatening than for the reverse proposition. There is some evidence that changes in these types of regime have synergistic effects, and some intimation that one of the major controls on fire regime in fertile country may be the grazing regime. Areas with disturbance regimes that enable the survival of threatened species are often badly invaded by exotics and/or poor in native species, making the integrity of vegetation a poor criterion for selection of areas for biological diversity conservation. Indeed, the conservation of many threatened plant species requires a disengagement from the ideal of naturalness. There are a sufficient number of well-documented situations in which the survival of threatened plants depends on bulldozers or sheep to motivate managers to concentrate on the particular requirements of species, not the good of the ecosystem as a whole, or maintaining a notional aesthetic of naturalness.

TOWARDS A LANDSCAPE CONSERVATION CULTURE – BROADENING THE SPATIO-TEMPORAL SCOPE OF ECOLOGICAL STUDIES TO ANTICIPATE CHANGE IN AUSTRALIAN FORESTED ECOSYSTEMS

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The Walpole Wilderness area in south-western Australia occupies over 3700 km² of diverse ecosystems including an extraordinary diversity of vascular plants. Many rare and threatened species and ecological communities in the region urges new approaches to ecosystem planning from single species and ecological community recovery plans to multi-species, multi-community ecosystem planning. Such a change towards a Landscape Conservation Culture is possible because of strong social community commitment and a history of quadrat strategies of data acquisition which allows the derivation of models of continuous gradients underlying ecological patterns and species distributions. The permanent location of floristic quadrats has allowed resampling, and hence the derivation of dynamic models.

Management in a Landscape Conservation Culture requires management regimes that protect and maintain biodiversity in a relevant information rich environment and relies on:

- (a) An integrated framework to interpret knowledge about natural landscape processes.
- (b) A synthesis of data obtained through biological surveys (at a plot scale) and remote sensing (landscape scale), with spatial data handled through GIS.
- (c) An explanatory modeling approach to test ecological theories and current and proposed conservation policies that interpret data and make model-based predictions of species and assemblage distributions under different disturbance scenarios.
- (d) The re-sampling of permanently located quadrats to derive and test temporal models specific to particular community types.

Models built from combined spatial layers exhibiting continuous variation in environmental variables provide area-class maps at different scales, allowing the portrayal of uncertainty associated with vegetation units - a considerable innovation over maps depicting homogenous discrete zones. This approach has wide application for conservation management and planning in Australia.

POPULATION BIOLOGY OF LONG-LIVED WOODY PLANTS: INSIGHTS FOR MANAGEMENT OF FIRE AND DISEASE

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Perennial shrubs are important components of many ecosystems, contributing structural variability, food and shelter for vertebrate and invertebrate fauna, and functional roles in nutrient cycling, carbon sequestration and soil stabilisation. Long-lived shrubs, by definition, have a persistent mature phase that buffers their populations against rapid change. Life-history trade-offs associated with adult longevity, such as low fecundity and rare or episodic patterns of recruitment, further contribute to slow rates of population turnover. These characteristics make it difficult and time-consuming to detect, predict and diagnose population trends, and limit the recovery potential of declining populations. Long-term studies of the common perennial shrubs, *Xanthorrhoea resinifera* and *Epacris barbata*, illustrate these challenges. Demographic monitoring revealed insidious, previously undetected declines across large populations in national parks. High fecundity is partly offset by high rates of seedling mortality or low rates of emergence and very slow growth and maturation. Established plants have generally high rates of survival but episodes of high mortality that have a profound effect on population viability. Synthesis of demographic data in stochastic population models has improved understanding of the sensitivities of population change and allowed the relative merits of alternative management strategies to be explored. Future management of recurring fires and soil-borne disease will mediate stability or continuing decline of these species. The studies illustrate the importance of demographic census and population modelling as powerful tools in plant conservation.

REINTRODUCTION OF RARE AND ENDANGERED PLANTS: QUESTIONS, EXPERIMENTS AND LESSONS LEARNT.

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The science of reintroduction for conservation purposes is relatively new. Reintroduction is used here as a general term that includes the establishment of new populations and reestablishment of extirpated population from *ex situ* material, and the enhancement or augmentation of existing populations. It does not include the translocation of naturally occurring plants from one location to another, which involves a different set of strategic, procedural and ethical considerations.

We embrace the notion, promulgated in the Center for Plant Conservation book, *Restoring Diversity: Strategies for Reintroduction of Endangered Plants*, (1996, Edited by Falk, Millar and Olwell, Island Press) that reintroduction projects for the purpose of conservation are best done as well designed scientific experiments that test explicit hypotheses. In that light, we review a number of empirical reintroduction projects with respect to hypotheses tested, experimental materials and methods employed, and evaluate their success in both biological and project terms.

ASSESSING TRANSLOCATION SUCCESS FOR THE CRITICALLY ENDANGERED *LAMBERTIA ORBIFOLIA* SUBSP. *ORBIFOLIA*.

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Translocation, the deliberate transfer of plant regenerative material from one area to another for conservation purposes (Vallee *et al*), is still in its infancy as a management tool in Australia. The goal of translocation is to establish viable, self-sustaining populations (Guerrant 1996). The difficulty is in setting goals that enable realistic assessment of whether the translocated population will be able to persist in the long-term. In Western Australia many of the species with

translocation programs are long-lived woody perennials with life cycles linked to disturbance events, such as fire. With long intervals between generations there is a need for a methodology that enables us to predict the likelihood of the new population being able to persist. Combined with criteria such as survival, growth and reproduction of the new population, we have used mating system analysis to predict whether the translocation of *Lambertia orbifolia* subsp. *orbifolia* is likely to be successful. *L. orbifolia* subsp. *orbifolia* is a critically endangered large woody shrub confined to three populations in south-western Australia. Translocation to a new secure location was seen as essential action to assist in the recovery of the taxon. The translocation also allowed for the experimental testing and refinement of establishment techniques for future translocations of this and other taxon. Short- and long-term success criteria were formulated to assess whether the translocation was likely to result in a viable self-sustaining population. Short-term criteria, such as the survival of plants, production of flowers and viable seed as well as natural recruitment of second generation plants have all been met six years after translocation commenced. The potential for persistence of the new population in the long-term was assessed using mating system analysis and comparing this with the parameters found in the natural populations of this taxon.

ADAPTIVE VARIATION IN FOREST TREES FROM SOUTH-WESTERN AUSTRALIA: IMPLICATIONS FOR RESTORATION.

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Divergent natural selection can produce geographic structuring of adaptive genetic variation within plant species. This has significant implications for restoration, because adaptive variation among potential source populations may translate to variable performance at restoration sites. Furthermore, interbreeding among adaptively divergent genotypes in subsequent generations may result in outbreeding depression, threatening the long-term persistence of both the restored population and the surrounding natural population. The distribution of adaptive genetic variation within species and the consequences of seed transfer between sites should therefore be given consideration when sourcing seed for restoration.

Reciprocal transplant trials were used to study the consequences of seed transfer over different scales in three forest tree species endemic to south-western Australia (*Eucalyptus marginata*, *Corymbia calophylla* and *Allocasuarina fraseriana*). Trials were established at four sites, with seed from six sites (including each of the trial sites) sown in each trial to facilitate comparison among local and non-local seed sources. Emergence and early survival of seedlings were used as measures of performance. The study was designed to assess whether the performance of seed sown at its home site is superior to that of translocated seed, consistent with a hypothesis of local adaptation.

For all species there was a significant, negative correlation between seed transfer distance and performance, which was largely attributable to reduced performance of seed transferred between the Swan Coastal Plain and the Darling Range, regions of differing soil type. There was little evidence for adaptive variation within regions; among sites within the Darling Range, seed sown at its home site did not exhibit a consistent advantage over seed from other Darling Range sites and there was no relationship between seed transfer distance and performance.

In light of these findings, it is recommended that when sourcing seed for restoration, seed transfer across regions of contrasting soil type be avoided. Within regions, seed transfer was not found to be associated with a loss of fitness and collection from a broad area could in fact be beneficial to maximise genetic variation. This may be important for the long-term persistence of populations on restoration sites, particularly for highly outcrossing species such as forest trees.

MANAGEMENT TOOLS FOR PLANT CONSERVATION: REPRODUCTIVE TRAITS AS A BASIS FOR PREDICTING PLANT INVASIVENESS

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The introduction of invasive species is one of the top five threats to species-rich Mediterranean-type ecosystems; such systems comprise 2.2 % of the world's land area, yet contain 16 % of the world's species. The establishment and regeneration phases are important stages in the life-cycle of a plant and are critically related to a species' seed biology. However, from current contributions in the scientific literature, the role of seed biology in the success of invasive species in non-native environments is currently unclear. For example, studies have suggested that, for particular species, seed mass in the invasive range is greater than in the native range (Buckley et al. 2003) or conversely that small seed size contributes to invasion potential (Rejmanek & Richardson, 1996). There is also limited evidence that soil seed banks for invasive species are more persistent than for related native species (e.g. Van Clef & Stiles, 2001). However, evidence for these effects is, at best, equivocal. We have used data from the Seed Information Database (www.rbgtkew.org.uk/data/sid/) and other data sources to consider how a range of species traits, including seed size, persistence, germination / dormancy and reproductive strategies, contribute to invasiveness. Here we present a multivariate analysis for data from >150 invasive species in an attempt to develop a predictive model for potential invasiveness from reproductive traits.

AN ADAPTIVE APPROACH TO MANAGEMENT OF AN INVASIVE SOUTH AFRICAN GRASS – A CASE STUDY FROM THE THREATENED PLANT COMMUNITIES OF PERTHS CLAY BASED WETLANDS.

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A small 19 hectare remnant on the winter wet flats of Guilford formation clays the Brixton Street Wetlands support many rare and restricted plant species as well as threatened plant communities. As a part of an integrated and adaptive approach to weed management detailed studies have been undertaken to determine effective and appropriate control methods for the invasive South African perennial grass, *Tribolium uniolae*.

A series of trials were established to determine if the grass could be selectively controlled in either early summer after the wetlands had begun to dry, or late autumn early winter when *T. uniolae* had begun active growth but before the wetlands filled. In early summer, flowering time for *T. uniolae*, Fusilade® at 15 ml/L+ Pulse® was 100% effective on mature plants. Younger plants were not effectively controlled at this time. Following further trials in early winter, when active growth had just begun, just before flowering, Fusilade® at 10 ml/L+ Pulse® was found to be effective on younger plants with only 3.9% (se±0.93) survivorship. When there is an early break to the season however, there is standing water in the wetland at this time of year and herbicide application is not appropriate.

Interestingly unplanned summer fire offered a window of opportunity to control *T. uniolae* with plants commencing active growth and resprouting long before the break of season.

Working within an adaptive management framework we have gained an understanding of how the seasonality of the wetlands influences the growth cycle of *T. uniolae*, the role of fire in both the spread and effective control of the weed and how this relates to effective control of *T. uniolae* with grass selective herbicides. In addition mapping the distribution of *T. uniolae* across the wetland has provided baseline information on the patterns of invasion within the different plant communities and revealed possible dispersal mechanisms. All this information formed the basis of a control program that was implemented across the wetlands in the autumn of 2004.

INTRODUCING PERENNIAL SPECIES TO MITIGATE SALINITY: WHAT ARE THE POTENTIAL RISKS AND BENEFITS TO BIODIVERSITY?

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CRC for Plant-Based Management of Dryland Salinity (www.crcsalinity.com.au)

CRC for Australian Weed Management (www.crc.weeds.org.au)

Dryland salinity is one of the most challenging problems faced by land managers today. Forecast to affect over 17 million hectares in Australia by 2050, the rise in groundwater tables bringing dissolved salt to the surface will result in many wetland, dampland and woodland ecological communities being lost. The extensive clearing of deep-rooted perennial native vegetation for agriculture has caused an imbalance in water use across the landscape. Introducing perennial pasture species to mitigate salinity promises to provide significant environmental and economic benefits, but there are also inherent risks which must be considered and managed appropriately. Some of these risks include the establishment of new plant species as environmental weeds, hybridisation with native species and gene flow from cultivated populations into natural populations. Presented here is an overview of potential risks and benefits to biodiversity of introducing new perennial species. Risk assessment and management options are presented, and areas where further research is required are identified.

PHYTOPHTHORA CINNAMOMI - A MAJOR THREATENING PROCESS TO FLORA BIODIVERSITY CONSERVATION IN SOUTH WESTERN AUSTRALIA

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Phytophthora cinnamomi infestation is a major threatening process affecting the viability and genetic diversity of the flora of south-western Australia. Forty percent of the described plant species in the South-West Botanical Province are susceptible to the pathogen. However considerable variation of plant species susceptibility to *P. cinnamomi* within taxonomic units make occurrence within family and genus poor predictors of species susceptibility. The fungicide phosphite is a proven effective control strategy for the protection of threatened plant communities from *P. cinnamomi* infestation. Applications of the fungicide have slowed progress of the pathogen, but varying plant species responses to phosphite application is probably a major factor influencing effective control of *P. cinnamomi* by phosphite in native communities. While taxa are highly responsive to phosphite application and effective control is achieved, phosphite is not effective in other taxa and no control of the pathogen attained. Variation in susceptibility and phosphite effectiveness to *P. cinnamomi* within threatened flora and the genus *Lambertia* is described and implications for management of flora threatened by the pathogen discussed.

NEW SCIENTIFIC METHODS FOR CONSERVING TERRESTRIAL ORCHIDS

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The orchid family is one of the most diverse in Western Australia with 400 taxa of which 36 are Declared Rare and a further 39 priority taxa that require further investigation. Further research is required to understand the main threats to rare orchids in WA, which include habitat loss, salinity, feral animals and climatic extremes. These threats are being met by recovery actions utilising recent scientific advances in orchid research and conservation that are discussed in this review. These recovery actions involve collaborations between universities, government agencies and community groups.

A new orchid seed baiting technique detects mycorrhizal fungi compatible with terrestrial orchids by sowing orchid seeds over organic matter separated from soil. This technique allows the time-course of germination events to be observed and results in protocorms from which mycorrhizal fungi can be isolated or orchids propagated. Orchid seed baiting is now routinely used to identify suitable habitats for transplantation of rare orchids. These experiments have revealed that mycorrhizal fungus activity is concentrated in coarse organic matter and litter, suggesting that orchids may be vulnerable to frequent fires conducted for "fuel reduction" in their habitats.

Knowledge of the diversity and specificity of orchid mycorrhizal fungi is essential for orchid conservation, as the majority of WA orchids have highly specific mycorrhizal associations. Consequently, the presence of compatible is one factor that determines the habitat preferences of orchids. The role of specific fungal associations is examined by comparing the ecology and conservation status of orchids to members of other large plant families. The majority of rare orchids have highly specific associations with fungi and pollinating insects. In contrast, the weed-like orchids *Disa bracteata* and *Microtis media* were found to be compatible with a wide diversity of fungi and are also capable of self-pollination. Knowledge of the diversity of fungi compatible with orchids has resulted in new hypotheses about the habitat specificity and ecology of orchids. These fungi are now being routinely used to propagate rare terrestrial orchids for translocation back into natural habitats.

CONSERVATION GENETICS OF THE ENDANGERED NEW ZEALAND SHRUB *HEBE SPECIOSA* (PLANTAGINACEAE).

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All extant populations of *Hebe speciosa* (Plantaginaceae), a threatened endemic New Zealand shrub, were investigated using the Amplified Fragment Length Polymorphism technique (AFLP). Genetic diversity indices varied significantly among geographical regions and were positively correlated with population size. Among-population genetic differentiation was high (mean pairwise $F_{st} = 0.47$), implying complex historical relationships between disjunct populations and negligible contemporary gene flow. Southern populations exhibited extremely low genetic diversity relative to those found in Northland, suggesting that these populations may be more recent in origin. Patterns of genetic relationship among some populations indicate pre-European M_{ori} dispersal and cultivation. The three northernmost populations were found to contain the majority of the species' remaining genetic diversity and thus, should be a focus for future conservation management. Some southern sites may also be culturally significant as evidence of M_{ori} trade and cultivation of *Hebe speciosa*.

ASSESSING AND MANAGING THE RISK OF GENE FLOW FROM PLANTATIONS INTO NATIVE EUCALYPTS IN AUSTRALIA

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With the large increase in eucalypt plantations in Australia over the last decade for environmental, farm and industrial purposes, there is concern that native eucalypt gene pools may be contaminated by pollen flow from plantations consisting of locally exotic species or provenances. Australia is the custodian of the majority of the world's native eucalypt forests and therefore management of hybridisation and gene flow is one of the many sustainability issues that need to be addressed by forest and land managers. Hybridisation between exotic *E. nitens* and native eucalypt species in Tasmania has been studied as a model for assessing the risk of genetic invasion. We studied its pollen dispersal, flowering synchrony and crossability with all Tasmanian species of subgenus *Symphyomyrtus*. Clear barriers to hybridisation were detected in many cases and the species and population most at risk have been identified. Furthermore, we studied the early age fitness of hybrids with one of the species at risk, *E. ovata*, to help predict the longer-term consequences of exotic hybridization. This risk assessment indicated clear opportunities for the implementation of practical measures to minimize or eliminate the risk of gene flow from plantations. We are currently extending this work to the case of *E. globulus* plantations across southern Australia, including the risk and consequences of gene flow from *E. globulus* plantations into other native species of subgenus *Symphyomyrtus* and also into native *E. globulus* populations.

**CONSERVATION OF THE WESTERN AUSTRALIAN UNDERGROUND ORCHID,
*RHIZANTHELLA GARDNERI***

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- i) The Western Australian Underground Orchid (*Rhizanthella gardneri*) is unique among the 400 plus species of orchids found in WA. It is entirely subterranean and does not appear above ground, even during flowering. The relationship with *Melaleuca uncinata* is unique in the orchid world with a symbiotic mycorrhizal fungus forming a link between the orchid and the *Melaleuca*. The species is currently listed as threatened flora under Western Australia's Wildlife Conservation Act and the Commonwealth EPBC Act and ranked as Critically Endangered due to there being little left of its specialized habitat which is threatened by drought and senescence. Just two flowering plants of *Rhizanthella gardneri* were found during intensive surveys of known populations in May-June 2005. Using a combination of Natural Heritage Trust, State Government and other funding a collaborative research and recovery program is being implemented by CALM, the Botanic Gardens and Parks Authority, UWA and community groups under the auspices of the Narrogin District Threatened Flora Recovery Team.
- ii) *Rhizanthella gardneri* is limited to two regions, separated by 300km, of southern Western Australia. Within these regions, Corrigin and Munglinup, seven individual populations of varying health have been recorded in the past 25 years. These populations all exist in *Melaleuca uncinata* thickets where flowers are usually observed under thick leaf litter accumulating at *Melaleuca* bases. Detailed analysis of six of these populations suggests that there are significant habitat and climatic requirements for underground orchid presence and hence survival. Furthermore, surveys performed over the past 25 years suggest a positive correlation between the number and health of flowering *R. gardneri* plants observed with rainfall from the previous summer. This improved understanding of *R. gardneri* habitat characteristics, health and functioning will help in the conservation of existing and potential populations.

AN ADAPTIVE APPROACH TO MANAGEMENT OF AN INVASIVE SOUTH AFRICAN GRASS – A CASE STUDY FROM THE THREATENED PLANT COMMUNITIES OF PERTHS CLAY BASED WETLANDS.

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A small 19 hectare remnant on the winter wet flats of Guilford formation clays the Brixton Street Wetlands support many rare and restricted plant species as well as threatened plant communities. As a part of an integrated and adaptive approach to weed management detailed studies have been undertaken to determine effective and appropriate control methods for the invasive South African perennial grass, *Tribolium uniolae*.

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SUCCESSFUL TRANSLOCATION OF THE CRITICALLY ENDANGERED *CORRIGIN GREVILLEA GREVILLEA SCAPIGERA* (A S GEORGE) TO SECURE SITES IN THE WHEATBELT OF WESTERN AUSTRALIA.

Eric Bunn¹, Bob Dixon² and Greg Durell³

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The Corrigin Grevillea (*Grevillea scapigera*) is known from only 5 plants in the wild. Since 1993 translocation efforts have been carried out to ensure the *in situ* survival of this species. Currently three 0.2 ha translocation sites are managed (1600 plants). Translocation initially involved vegetative propagation of 10 clones representing 86% of the known genetic diversity. New and under-represented clones continue to be added to the sites. Many of the plants have originated from clonal cryostored material, raised by tissue culture then grown on and planted out. Seed from micro-propagated individuals has been viable, with the resulting seedlings planted out to monitor fitness. Flowering and seed set over numerous years has built up a large soil seed bank and natural recruitment has occurred at two sites. The translocation project is accompanied by ongoing research and trials to maximise success and better understand the species life history and population genetics. On-site trials and research include long term seed storage (50 years), weed control trials, reticulation trials and simulated disturbance events (cold smoke treatment). Large quantities of seed are also stored *ex situ*. Research is ongoing into genetic stability of the translocated populations. Project collaborators: BGPA Kings Park Science Directorate, CALM Narrogin District, Corrigin Shire LCDC, the Bullaring Community and many other volunteers. Funding received: NHT, WWF and Environment Ministers Community Conservation Grants.

LIFE ON THE EDGE – CONSERVATION BIOLOGY OF THE IRONSTONE ENDEMIC *TETRATHECA PAYNTERAE*

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Tetratheca paynterae subsp. *paynterae* ms is an insect-pollinated, leafless shrub confined to approximately 4 hectares of banded ironstone outcrops in the Windarling Range, southern Western Australia. The species is listed as rare and endangered, with reductions in its habitat from iron ore mining. The population consisted of 7000 individuals in two sub-populations; 2000 individuals were removed during mining activities in 2004. Approval for removal of a further 1000 plants is dependent on demonstration of no impact on the viability of the remaining population. To address these management issues, a research program was initiated to examine genetic and ecological patterns and processes in *T. paynterae* and related species, and to optimise propagation procedures for *ex situ* and *in situ* conservation.

Genetic diversity was estimated using microsatellite markers to provide a baseline for monitoring the impact of mining and for ensuring diversity is maintained in *ex situ* populations. The level of genetic variation estimated from 260 individuals, sampled from throughout the population, was moderate ($H_E = 0.62$) but lower than other Australian species with more widespread distributions (mean $H_E = 0.8$ for eucalypts). Inbreeding coefficients were significant ($F_{IS} = 0.05$) and suggest substructuring in the population. Genetic divergence was evident wherever there were gaps of 100 m or in the distribution of plants along the range (subpopulations). This may reflect the preference of pollinators (native bees) to move among adjacent plants along the ironstone formations rather than across areas devoid of tetrathecas. This will be further investigated by paternity analysis. The significant genetic divergence among subpopulations ($F_{ST} = 0.05$) indicates the importance of representing these distinct genetic units in *ex situ* and *in situ* conservation programs.

Translocation of *T. paynterae* will be challenging as the species grows exclusively in lateral cracks in the ironstone outcrops with little or no visible soil. Germination studies have revealed physiological dormancy and an after-ripening requirement that can best be overcome using a combination of gibberellic acid, scarification and smoke water. However, seedling mortality after germination is high suggesting specific habitat requirements. Mycorrhizal fungi have been identified in the roots and may be necessary for long-term survival. Propagation from cuttings has had mixed success but preliminary results from tissue culture are promising.

THREATENED FLORA SEED CENTRE

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The flora of the South West Botanical Province of Western Australia has the highest concentration of rare and threatened endemics in Australia and is recognised as one of the world's top 25 biodiversity hotspots. Threatening processes that adversely impacts on the survival of many of these plant species include land clearing leading to habitat fragmentation, disease, salinity and weed invasion. The Western Australian Department of Conservation and Land Management's Threatened Flora Seed Centre provides the capacity for the long-term storage of seed of rare, threatened and poorly known species thereby helping to conserve this unique flora for future generations. This genebank is an integral part of the State flora conservation strategy that involves on ground management and off site conservation. Stored seed is a source of material for recovery of wild populations and for *ex-situ* scientific research into seed biology, conservation genetics and disease susceptibility.

CASE STUDY: CONSERVATION BIOLOGY OF RARE SPECIES IN AN URBAN REMNANT

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We evaluated the worth of a short research program for understanding the biological characteristics of two rare species with application to improving translocation outcomes. *Conospermum undulatum* Lindl. is listed as threatened and *Macarthuria keigheryi* Lepschi as vulnerable under the Federal Environment Protection and Biodiversity Conservation Act. The species occur within bushland around the Perth International Airport that is managed for conservation by the Westralia Airports Corporation.

Survey indicated local extinction at all sites within bushland at airport that had previously supported the species, except at one site for each species where the species were restricted: *C. undulatum* to sandy patches across the top of a low ridge and *M. keigheryi* to sandy patches with minimal inter-specific competition. The *C. undulatum* population is lacking in juvenile plants. The *M. keigheryi* population is strongly skewed towards small plants of < 100 stems. *M. keigheryi* is browsed heavily by rabbits where exposed and thrives where sheltered from rabbits within unpalatable vegetation. Seed of *M. keigheryi* was rapidly removed in a cafeteria-style experiment, although seed of *Macarthuria australis* and *Gompholobium tomentosum* was removed at equally high rates.

Seed viability was high in *M. keigheryi*, but variable in *C. undulatum*. Seed imbibition indicated that seed of neither species had 'physical' dormancy. Germination rates, in untreated fresh seed, were 11% for *C. undulatum* and 0% for *M. keigheryi* and increased to 27 and 3%, respectively, when treated with giberellic acid. Thermic shock killed the seed of *C. undulatum* and did not affect the seed of *M. keigheryi*.

A strike rate of 33% was obtained for young material of *C. undulatum* raised in 'fertil-pot' (paper mache) containers. Strike rates of ~75% were obtained for young cutting material of *M. keigheryi*, regardless of container-type. Struck cuttings of *M. keigheryi* have flowered and seeded profusely, providing a seed orchard resource. Overall the knowledge from the program will underpin successful population enhancement through translocation.

SEED GERMINATION BIOLOGY OF ARID ZONE SPECIES IN WESTERN AUSTRALIA

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Shark Bay Salt Joint Resources (SBSJV) operates a solar salt facility within a unique World Heritage Area at Shark Bay in Western Australia. Little is known of the natural processes driving plant recruitment, and SBSJV is committed to undertaking rehabilitation of 140 ha of borrow pits that have provided soil for building and construction. To successfully broadcast seed and produce greenstock for revegetation it is essential to understand the germination ecology of Shark Bay's indigenous species. The Shark Bay area has an arid climate with sporadic winter rainfall, and occasional summer cyclonic systems. This study, observed the effect of fluctuating temperature simulating summer and winter (33/18°C and 26/13°C), gibberellic acid, smoke water, and the newly discovered chemical in smoke (3-methyl-2H-furo[2,3-c]pyran-2-one), a butenolide, on the germination of several dominant species at SBR. Initial results show that some species are non-dormant and are able to germinate under summer or winter conditions, while others can only germinate in winter. Other species have a requirement for butenolide or exhibit physiological dormancy (seed germinated after being excised from fruits or germination required warm stratification). Implications of the findings for rehabilitation are discussed. The study is of regional significance to land managers and conservation agencies with an interest in restoration of other arid zones around the world.

Key Words: seed germination, dormancy, restoration, 3-methyl-2H-furo[2,3-c]pyran-2-one, arid zone, World Heritage Area.

TERMINALIA CANESCENS (COMBRETACEAE): A TROPICAL TREE WITH PHYSIOLOGICALLY DORMANT SEED

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Terminalia canescens (DC.) Radlk (Family Combretaceae) is a dominant tree species in natural vegetation in the Kimberley region of Western Australia. It is rarely found in minesite rehabilitation areas in the eastern Kimberley. *Terminalia canescens* mainly occurs in dense stands on the plains and not steep hill slopes and riverbeds. Seedlings were found in sites where temporary puddles formed in the wet season. Controlled experiments were conducted to determine the factors limiting germination. Soaking alone (24 h), improved germination (18 ± 5 cf $52 \pm 4\%$) and this was further enhanced ($75 \pm 5\%$) by cutting the distal end off the seed and then soaking (24 h). Untreated seeds commenced germination at 38 days and hence were considered dormant. Germination occurred from 15-37°C with a maximum at 25°C. A seed pre-treatment was developed for use in seeding rehabilitation areas. Drying seeds after soaking for 24 hours did not decrease germination, hence soaked (24 h) seeds could be dried for ease of handling during sowing. Seeds did not respond to light, dark or smoke water, and germination was inhibited by burning and gibberellic acid. These results suggest that *Terminalia canescens* exhibits physiological dormancy, which is broken down by soaking during the wet season.

SUCCESSFUL STORAGE OF SEED FROM THREATENED WEST AUSTRALIAN PLANTS

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The rich and diverse flora of Western Australia comprises a large number of taxa (almost 2500) that are listed as being rare, threatened or poorly known. *Ex situ* conservation of these taxa as seed is an important component of the conservation efforts being carried out to protect these 'at risk' taxa. The Threatened Flora Seed Centre (TFSC) run by Western Australia's Department of Conservation and Land Management is the facility primarily responsible for the collection and storage of this material using conventional seedbanking conditions as recommended by the FAO/IPGRI genebank standards. It has been suggested that the use of these conditions may not be appropriate for Australian species. Examination of storage data from the TFSC from over 350 accessions (176 taxa, 46 genera and 16 families) has shown that although a decline has been found in some collections the vast majority have shown no significant decline in viability after storage for periods between one and eleven years. Furthermore, the few cases exhibiting a decline in viability appear to be accession-specific rather than a species response.

PLANT STRATEGY IN EARLY ESTABLISHMENT UNDER THREE LIGHT REGIMES

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One of the major bottle-necks in grassland restoration at nutrient-rich sites is the severe competition for light between seedlings and established species. We investigated whether we could use the CSR classification to predict seedling establishment success. We hypothesized: (1) *Seedlings of competitive species perform worse than stress-tolerators under reduced light conditions*; (2) *This is only relevant for light intensities between light saturation point and light compensation point*.

We imitated a light gradient with two types of green filters. Light Green (Lee-Filter 121) reduced the light intensity to values above the light saturation point whereas Dark Green (Lee-Filter 124) suppressed light to values below this point. A transparent filter served as Control. Nineteen species were selected, divided over five categories between competitive (C) and stress-tolerance (S).

Stress-tolerant species had higher mortality rates than more competitive ones, but they died mainly in the period after 40 days when seedlings became juveniles. They also showed a larger decrease in the number of leaves, leaf area and lower dry matter production. The same was true for the different treatments: there was a clear relation between light intensity and plant performance parameters except for leaf area.

Under ample nutrient supply light acts as an environmental filter: stress-tolerant species are suppressed more than competitive ones. Contrary to the hypothesis, light limitation comes into effect also at levels above the saturation point. We conclude that competitive ability at the adult phase is a good predictor of seedling establishment success. 'The more mass, the better survivor' seems true.

RECOVERY OF THE CRITICALLY ENDANGERED BUSSELTON IRONSTONE COMMUNITY AND COMPONENT RARE FLORA

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Restricted areas of ironstone soils associated with unusual plant communities occur in a number of areas in the south west of Western Australia. The Busselton Ironstone Community is a species-rich plant community located on seasonal wetlands on ironstone and heavy clay soils on the Swan Coastal Plain near Busselton. There are a total of 11 Declared Rare Flora (Threatened Flora) of which six are Critically Endangered, and six Priority flora that occur in this Ironstone community. These are either totally confined or largely confined to it, or may be shared with the ironstone of the Scott Coastal Plain. Major threats to the community are dieback disease caused by *Phytophthora* species, hydrological change, inappropriate fire regimes, insufficient knowledge to guide management, and weed invasion. Considerable resources continue to be invested in the recovery of the community and component Declared Rare Flora. Recovery actions for the community include:

- Purchase of several areas of land that contain the community
- Aerial spraying of sites that contain *Phytophthora* susceptible species and threatened species with the chemical phosphite, to control the disease
- Fencing
- Researching resistance to *Phytophthora* species
- Translocations of five threatened ironstone taxa
- Groundwater monitoring
- Weed control
- Collection and storage of seed from seven ironstone species

DEVELOPING A GENERAL FRAMEWORK OF RARE PLANT POPULATION RESPONSES TO HABITAT FRAGMENTATION.

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To effectively manage plant populations for conservation, there is a need to provide reliable information on the conditions required for maintaining viable populations. This is particularly true for rare taxa occurring in a fragmented landscape, such as that of south-west Western Australia. Western Australia contains over 45% of Australia's gazetted threatened flora, 80% of which are found within the south-west region. Resources do not exist to undertake comprehensive studies of population dynamics for every rare plant species of this region. By assigning rare plant taxa into functional groups, based on their floral architecture and putative pollinator, their fire life history (sprouter versus non-sprouter) and germination requirements, models will be developed for each functional group. Representative taxa will be chosen from each functional group for detailed investigation on how rates of pollination, seed production and seed fitness are affected by population size and landscape context. The information gained from these models will be extrapolated to other taxa within each functional group thereby providing guidelines for flora conservation, threatened ecological communities, and restoration/revegetation programs. Here we present findings on our allocation of the 351 declared endangered plant taxa of Western Australia into floral architecture functional groups and how these groups respond to landscape fragmentation.

INTRODUCTION, GROWTH AND PERSISTENCE *IN SITU* OF ORCHID MYCORRHIZAL FUNGI

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The introduction, growth and persistence of orchid mycorrhizal fungi *in situ* were studied using a seed baiting method. A mycorrhizal fungus from the carousel spider orchid *Caladenia arenicola* was introduced to sites within an area from which the orchid and fungus were absent, adjacent to a natural population of *C. arenicola*. In the first growing season, the fungus grew up to 50 cm from its introduction point, usually persisted over the summer drought into the second season and even into the third season, stimulating germination and growth to tuber formation of the seeds in the baits. Watering the inoculated areas significantly increased seed germination. This suggests that it is possible to reintroduce the mycorrhizal fungi either before or together with seeds of orchid species needing re-establishment in an area

INVESTIGATION OF BROADLY COMPATIBLE MYCORRHIZAL FUNGI FROM THE SPIDER ORCHID *CALADENIA FALCATA*

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Orchid species from the genus *Caladenia* are considered to have among the most specific mycorrhizal relationships in the orchid family, with seeds of each species generally only germinated by its own mycorrhizal fungus. However, we report here that *Caladenia falcata* has a broadly compatible fungus that germinates seeds of *C. falcata*, the hybrid *C. falcata* × *longicauda*, and species with different degrees of taxonomic affinity to *C. falcata*. In general, germination was greater from species that were more closely related to *C. falcata*: seeds from *Caladenia* species generally germinated well on most *C. falcata* isolates; species from same subtribe (Caladeniinae) germinated well to the stage of trichome development on only some of the fungal isolates and rarely developed further; and seeds from species from different subtribes (Diuridinae, Prasophyllinae, Thelymitrinae) or tribes (Orchideae, Cranichideae) either germinated well to the stage of trichome development but did not develop further, or did not germinate at all. A broadly compatible fungus may be of considerable use in conservation work, such as in situations where a specific fungus appears to have poor saprophytic competence or where soil conditions have been altered.

CONSERVATION GENETICS OF AN ENDANGERED ENDEMIC, *EUCALYPTUS MORRISBYI*

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Eucalyptus morrisbyi is one of the most endangered eucalypts in Australia, restricted to two main populations in Tasmania. The populations are separated by 20 km, occurring in the Risdon Hills and on Calverts Hill, and differ markedly in size and health. While they are both in reserves, the small population at Risdon Hills has experienced a marked decline in the last two decades. A hypervariable chloroplast marker and six nuclear microsatellites were used to quantify genetic diversity. There was a high level of clonality at Risdon Hill, indicating that a census based on stem number has underestimated the number of genetic individuals. The two populations showed equally high levels of genetic diversity (average $H_E = 0.69$) in the adult trees, and little difference in inbreeding levels despite the large difference in population size. Marked genetic differences between the two populations, with virtually no sharing of chloroplast haplotypes, and little sharing of microsatellite alleles ($F_{ST} = 0.19$) among populations, indicates that both populations are clearly required to conserve the genetic diversity of this species. Analyses of 366 offspring from 9-11 trees from each population revealed high outcrossing rates, little bi-parental inbreeding, and high genetic diversity (average $H_E = 0.65$) in both seedling populations. This indicates that open-pollinated seed collections from these populations capture a high level of genetic diversity and are a valuable resource for *ex situ* conservation plantings.

CAN THE SEED BANK PREVENT GENETIC CHANGES IN *GREVILLEA CALEYI* POPULATIONS?

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Long-lived seed banks potentially slow the rate of genetic changes within a plant population. In this study, I investigated whether the soil-stored seed bank of the endangered, fire-sensitive shrub, *Grevillea caleyi*, may buffer some of the genetic changes associated with population fragmentation. This species has had recent severe reductions in population size, so that many populations are at risk of demographic extinction and potentially deleterious genetic changes. *Grevillea caleyi* seeds may persist in the soil for many years and over at least two generations. Using seven microsatellite loci, I genotyped post-fire seedlings and pre-fire adults from two small populations (< 20 pre-fire adults). In both populations, post-fire seedlings contained greater genetic diversity than pre-fire adults, including several unique alleles, which indicates that the seed bank is acting as a reservoir of additional genetic diversity. However, levels of inbreeding and fine-scale genetic structure were significantly higher among the seedlings than adults, suggesting that genetic changes are occurring in these populations despite the influence of the seed bank. In addition, only a small proportion of the pre-fire adults appeared to have contributed to the seed bank, which, over time, should result in a loss of genetic diversity.

INVASION OF HEATHLANDS IN SOUTHWESTERN AUSTRALIA BY *ALLOCASUARINA HUEGELIANA*

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Conservation in fragmented ecosystems such as those in the Western Australian wheatbelt aims to maintain viable and representative species assemblages. Large areas within the reserve system that are not at risk from processes such as salinity and grazing by livestock are essentially unmanaged since there is a perception of lower levels of threat. However it is becoming clear that the species assemblages within these nature reserves are changing. Observations indicate that in many reserves in the wheatbelt, *Allocasuarina huegeliana* is actively invading the species-rich sandplain heathlands and may eventually dominate these systems and cause a decline in floristic diversity.

Alterations to naturally occurring disturbance regimes, particularly fire and herbivory, have been suggested as primary factors contributing to the expansion of *A. huegeliana*. Fire is a dominant feature across much of southwestern Australia but many wheatbelt reserves have not been burned for a long time. Additionally, the loss of most medium-sized mammal fauna has dramatically altered browsing regimes. Consequently, many remnant areas now potentially lack two key processes that have previously been important drivers of ecosystem dynamics.

Preliminary results indicate that the invasion of heath by *A. huegeliana* is occurring throughout the wheatbelt. Further investigations aim to understand how fire and herbivory interacted in the past and how their absence is now affecting the ability of *A. huegeliana* to invade heath remnants. The potential implications of continued invasion on the retention of species and communities of conservation importance will be considered.

RISK ASSESSMENT FOR *ACACIA SALIGNA* AGROFORESTRY

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CRC for Plant-Based Management of Dryland Salinity (www.crcsalinity.com.au)

The native Western Australian species *Acacia saligna* has been selected as a priority for further development as a perennial agroforestry crop. It is likely to be used for wide-scale revegetation in southern agricultural areas of Australia to mitigate the effects of dryland salinity. However, the use of native perennial species for revegetation may pose risks to the maintenance of natural biodiversity in these areas. Sustainable use of natives such as *A. saligna* will require comprehensive risk assessment covering aspects of both genetic and weed risk. In Western Australia, the likelihood and predicted impacts of genetic contamination via pollen flow into remnant populations from domesticated populations of *A. saligna* must be assessed. This will require measurement of the levels and distances of gene flow possible between genetically divergent populations and assessment of the relative fitness of hybrids compared to parental genotypes. Such information will aid the development of guidelines for plantings including suitable isolation distances for large domestic populations. In South Australia where *A. saligna* has become naturalised and presents a weed risk, its evaluation will include assessment of which of the four recently described variants is predominant and whether the principal means of reproduction is sexual or asexual. This will provide guidelines for the use of *A. saligna* in non-native areas where it may present a weed risk. Collectively the work will aid the conservation of remnant vegetation and its genetic diversity both within and beyond the species natural range.

THE MILLENNIUM SEED BANK – A COLLABORATIVE PARTNERSHIP

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The flora of southwest Western Australia is unique. With more than 8000 species it is recognised as one of the world's 25 biodiversity hotspots. This corner of the State has the highest concentration of rare and threatened endemic plants in Australia. The loss of biological diversity is the most serious environmental problem facing this area. The major threats are habitat loss due to land clearing, salinity, weed invasion and introduced pathogens such as the dieback disease, *Phytophthora cinnamomi*.

In 2001 the Department of Conservation and Land Management (CALM) and the Botanic Gardens and Parks Authority (BGPA) became partners in the Millennium Seed Bank Project (MSBP) managed by the Seed Conservation Department at the Royal Botanic Gardens, Kew, United Kingdom. This collaborative seed collecting and conservation project is focussing on collecting seeds from wild species primarily from the world's arid and semi-arid regions. The goal is to store 10% of the world's dryland flora by the end of the year 2010 in one of the world's largest seed bank. To achieve this Kew has enlisted the help of people from around the world through the development of collaborative partnerships. As well as Australia, countries as diverse as the United States, Madagascar, South Africa, Chile and Lebanon are involved in the project. This partnership will provide duplicate collections of material for storage at the Millennium Seed Bank and in facilities in Western Australia. This will help achieve the long-term objectives of conservation and restoration of native plant diversity within Western Australia.

It is anticipated that over the life of the project, the Millennium Seed Bank, the Department of Conservation and Land Management and the Botanic Gardens and Parks Authority will be contributing to the conservation of some 60% of Western Australia's threatened flora.

HARDENBERGIA VIOLACEA: A THREATENED SPECIES IN TASMANIA

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Hardenbergia violacea (Fabaceae) is a well-known flowering plant that is listed as endangered on the Tasmanian *Threatened Species Protection Act 1995*. It is restricted to one site in Tasmania, a sandstone outcrop on the Pontos Hills near Penna in the south-east of the State. The plant was recorded from this area around 1857 by the English botanist Augustus Oldfield, who then sent the specimen to Joseph Hooker at the Kew Gardens in London. This early record suggests that the species is native to Tasmania.

Hardenbergia violacea was known from two small populations in the Pontos Hills. The fact that these sites had not been verified for 15 years prompted the Threatened Species Section to visit the populations. Surveys relocated 21 individuals of *Hardenbergia violacea* from the northern site but unfortunately no plants were found at the southern site. The major threat to *Hardenbergia violacea* is grazing by sheep and native animals. A land conservation fencing initiative approximately 10 years ago is thought to have protected the species at the northern site. Fortuitously, a local native plant nursery had collected cuttings and seed from the southern, now extinct site. Two plants from this original collection are still growing and produce seed annually, from which the nursery propagates seedlings to sell.

Extension surveys are planned for similar habitat in the area. However, it is considered unlikely that the species occurs anywhere else as it is a very distinctive plant that is readily recognised and would have been collected if present.

A listing statement has been prepared which covers intended management for the species. Improved fencing is planned to more effectively exclude sheep and wire cages will be constructed and placed over plants to further protect them from herbivory. The landowner is actively involved in the species' conservation and will be undertaking on-ground works at the site.

Monitoring will investigate population ecology and the effectiveness of grazing exclusion. Efforts to recruit seedlings to boost numbers at the extant site will be undertaken. A translocation program will also be considered to reintroduce *Hardenbergia violacea* to the southern, extinct site, should attempts to recruit seedlings from the soil-stored seed bank fail.

Conservation genetics research at the School of Plant Science, University of Tasmania, will be carried out as part of an Honours research program. This project will conduct molecular work to identify differences between Tasmanian plants of *Hardenbergia violacea* and those on the mainland to determine the significance of the species' occurrence in Tasmania. The project will also assess the genetic variation of the nursery plants and compare them with material from the northern, extant site.

With effective on-ground management informed by genetic research, we hope to secure the population of wild *Hardenbergia violacea* in Tasmania and work towards successfully reintroducing the plant back to the second and currently extinct site.

CHALLENGES FACING THREATENED PLANT CONSERVATION IN A SMALL STATE.

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Tasmania currently has 486 flora species listed on the *Threatened Species Protection Act 1995*, yet there are limited resources available for their conservation and management. While additional funds have been sought to implement recovery actions for species, they generally focus on a subset of the 97 Commonwealth listed flora species. To spread the focus, our approach has been to create and build on an easily accessible data and information base. The greatest threat to threatened flora species in Tasmania is inadvertent destruction due to a change in land use. To attempt to address this threat we have developed an easy to use GIS based natural values reporting system that provides information to determine the potential for threatened species to occur at a site. This enables flora surveys to be targeted and to be conducted at the appropriate time of year for these species to be identified. This has required the collation, maintenance and update of threatened flora records and we are now attempting to integrate information on populations in the supporting database. We have also developed a complete set of notesheets or listing statements for all listed flora species, detailing information relevant to the conservation status of the species. The notesheets are a precursor to the more detailed listing statements that are currently being developed. Recovery Plans have also been developed for some species or groups of species. This literature is freely available on the internet and on CD. The information base has proved invaluable to the formulation of projects to address the conservation and management requirements of threatened flora species that have not received much attention to date and to address knowledge gaps. Importantly it empowers the wider community to become more involved with threatened flora conservation in Tasmania.

SAMPLED BUT NOT SEEN – ESTIMATING DEMOGRAPHIC PARAMETERS FOR AN ORCHID WITH AN UNOBSERVABLE LIFE STATE

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ABSTRACT

The threatened orchid *Prasophyllum correctum* D.L. Jones occurs in an isolated patch of grassland in south-eastern Australia. The life-history of *P. correctum* is complex: on any one sampling occasion an individual may be in a detectable state (either flowering, F; or vegetative, V), or a non-detectable state (dormant or dead, 0). In order to understand the response of the population to site management, a demographic census was conducted between 1992 and 2004 during which the life state of 124 individually marked plants was recorded annually. The resulting data set contained individual capture histories, consisting of strings of Fs, Vs and 0s.

The presence of zeros in a capture history complicates standard multi-state mark-recapture models used to determine transition rates between life states: external zeros may represent either long-term dormancy or death, whereas internal zeros represent dormancy. In order to solve this problem, we used the multinomial distribution to specify transition probabilities and survivorship rates of each life state (including death rates), and obtained parameter estimates using maximum likelihood estimation. Standard errors of the transition rates were estimated via bootstrapping.

Results indicated that dormant individuals were much more likely to remain dormant (0.53, 0.04se) or become vegetative (0.32, 0.04se), than return to a reproductive state (0.10, 0.04se). Flowering individuals were also more likely to become dormant (0.36, 0.04se) or vegetative (0.38, 0.04se), as opposed to flowering in consecutive years (0.21, 0.03se). The method will be of interest for future investigations into the impact of management decisions on orchid population dynamics.

RECENT ADVANCES IN *BANKSIA* WOODLAND RESTORATION FOLLOWING SAND EXTRACTION IN SOUTH-WEST OF WESTERN AUSTRALIA.

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The south-west of Western Australia is one of the mega diverse regions of the world. The state is also resource rich, producing over one third of the Australian GDP. The ability to restore sites following mining or extraction in these semi-arid lands is of utmost practical importance, but presents major problems in terms of the areas involved, paucity of knowledge on the restoration ecology of native plants and the strong seasonal aridity associated with a Mediterranean-type ecosystem. To tackle post-mining restoration of bio-diverse ecosystems, restoration research undertaken by Kings Park and Botanic Garden, Perth, Western Australia, has enabled testing of a wide spectrum of new and innovative methods. By analysing topsoil handling for optimisation of soil-borne seed recoveries, understanding ecological processes influencing plant establishment, and using innovative restoration methods, a highly successful species replacement and rehabilitation program has been established for some ecosystems. This presentation will review current restoration practises and data on topsoil handling; seed and plant pre-treatments and restoration research being utilised to restore semi-arid vegetation after sand extraction.

THE GENUS *ACROTRICHE*

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The genus *Acrotriche* comprises of 14 species of heath plants with habits ranging from ground covers to shrubs. The members of this genus are common understorey component in woodlands, forests, heaths and shrublands. Species are present in all states of Australia except the Northern Territory but the distribution is mainly focussed in southern Australia with highest species diversity in South Australia.

Acrotriche species are not included in vegetation restoration projects due to the lack of knowledge regarding their biology and difficulties in propagation. In order to successfully re-establish species, their pollinators must be determined to ensure the long term success of populations.

These plants are easily distinguished by their unusual flowers that are small and often inconspicuous as they are borne on the woody stems of the plants (cauliflory) and are commonly green or less often pink. This genus is named after the hairs at the petal tips that are used in a method of secondary pollen presentation unique to this genus.

As the flowers are often borne below the shrub and are commonly protected by a canopy of stiff pungent leaves, access is difficult and generally confined to crawling invertebrates. Ants are common floral visitors to several species of *Acrotriche*. This leads to the question are these unusual flowers and evolutionary adaptation to facilitate ant pollination? Pollination by ants is relatively uncommon due to the deleterious effects of ant secretions on pollen viability. Research is being undertaken to determine whether ants are indeed pollinators of *Acrotriche* species.

THE INFLUENCE OF SOIL FROM A TOPOGRAPHIC GRADIENT IN THE FITZGERALD RIVER NATIONAL PARK ON MORTALITY OF *BANKSIA BAXTERI* FOLLOWING INFECTION BY *PHYTOPHTHORA CINNAMOMI*

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The Fitzgerald River National Park is an international biome in which *Phytophthora cinnamomi* is destroying *Banksia baxteri*-*Lambertia* scrub-heath in a disease centre over 6 km long in the middle of the park. Current assessment of the vulnerability of healthy areas to infestation by *P. cinnamomi* depends on estimating the probable susceptibility of component plants within the vegetation associations, without knowledge of the potential for the pathogen to develop within the major soil types of the park. Intact soil cores were removed from 5 major soil associations of the park (a relatively fertile loam from the floor of the gorges to the more infertile sandy soils of the plains and uplands) and placed in free draining pots. Cores were also taken from a red loam from incised drainage systems and a gravel and sandy soil from the nearby Ravensthorpe Range for comparison. The cores were planted with seedlings of *B. baxteri* and maintained in a shadehouse. Following establishment of the plants, the cores were inoculated in summer with an isolate of *P. cinnamomi* from the only disease centre in the park. The rate of mortality was greatest in the infertile sandy soils and the soils of the Ravensthorpe Range and lowest in the red loam. The rate of mortality for the Perkin Loam from the gorge floor was intermediate between that of the sands and red loam. While the results of pot experiments have limitations in predicting disease development and must be used with caution, the results do identify the soil types most conducive for disease development.

GREENING AUSTRALIA (WA) PRESENTS AN INSIGHT INTO LANDSCAPE RESTORATION IN THE WESTERN AUSTRALIAN WHEATBELT.

Stapleton D.

Greening Australia (WA)

Since 1999 Greening Australia (WA) has been implementing revegetation projects in partnership with the Blackwood Basin Group, supported by Natural Heritage Trust, with a particular focus on high value biodiversity areas. While direct seeding was the main technique used to revegetate cleared paddocks, seedlings were also used either exclusively or combined with direct seeding.

The poster is a compilation of photos mostly between 2000 and 2004, depicting the scale of operations; the machinery used; and the obstacles and advantages of our efforts:

- **Scale of Operations:** The size of individual revegetation sites usually ranged between 0.5 to 5 ha.
- **Machinery Used:** A range of machinery was used including: cereal cropping (agricultural purpose) seeders; combined tree and seed planter machines; and purpose built native vegetation seeding machines (EGAD1). Advances over the years to the latter, are also shown.
- **Obstacles:** Complications to the revegetation efforts were wide ranging and can be summarised into manageable and partly manageable.
 - Weeds were a major barrier to successful seed and seedling establishment. The use of cropping machines to sow seed, although quicker, required more time for herbicide application to prepare the site. Relying on an often busy farmer to carry out this crucial operation was difficult to manage. Although the tree planter machine used a wide scalp to physically remove weeds, which can increase the risk of erosion or moisture loss, these can be managed especially combined with a wider spectrum of herbicide application.

- Pests such as red legged earth mite, rabbits and kangaroos presented further challenges to establishment. This again required considerable farmer participation.
- Lack of moisture was considered a partly manageable obstacle and the most substantial barrier to seedling establishment. Rainfall during the period was below average and the timing was unfavourable for the majority of project sites and plant species. Despite earlier sowing times to take advantage of earlier rains the results were still poor especially without late winter rains which were lacking during the period.
- Reconciling low participation with worthwhile outcomes is the topic of further consideration including concentrating effort on fewer establishment sites (planning/priorities) and using a wider spectrum of incentives (planning/delivery).
- Outcomes: A significant proportion of revegetation sites struggled to establish during the period regardless of revegetation method used across a range of NHT projects within the project area. Of the direct seeded sites, the majority of them failed to establish adequate cover. Those few that did establish well (shown on the poster) showed higher species and structural diversity than the equivalent sites implemented using seedlings only. It is this diversity which attracts practitioners to use direct seeding and then continually improve machinery and the management of the obstacles outlined above.

APPLYING POPULATION GENETICS THEORY FOR IMPROVED OUTCOMES IN LANDSCAPE RESTORATION

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The practice of ecological restoration is rapidly growing worldwide. A key issue for plant community restoration is the identification of appropriate seed collection zones. Typically, seed or green stock material has been collected from any available source, but new guidelines and standards are being developed as to the best strategy for collection. Information on the population genetic structure of a species contributes valuable information to the decision-making process, but is very expensive and time-intensive if carried out on a species-by-species basis. Deciding where this material should come from has been the subject of recent debates, with well-supported theoretical and empirical evidence for and against the movement of genotypes. Population genetics theory can provide a guide as to how to obtain good estimates of genetic diversity and gene flow. However, key practical constraints to its application in ecological restoration affect the quality of data collected. We highlight some of the practical problems typically based around sampling design, marker development, time, and financial constraints. These issues will be illustrated with genetic data from several Western Australian endemic plant species.

WHAT'S PREVENTING NATIVE REGENERATION OF ABANDONED FARMLAND IN THE WHEATBELT?

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Abandoned farmlands offer a significant opportunity for restoration of native vegetation in the fragmented agricultural landscape of south-western Australia. Currently, farm abandonment is not widespread in this region but is predicted to increase with further soil degradation and changes in agricultural policy. Fields that have been abandoned tend to be dominated by non-native annual grasses, even 30 to 40 years after farming has ceased. There are several potential barriers to their regeneration. The availability of seed, which is largely determined by dispersal mode and distance to native remnant vegetation is likely to be important. Introduced grasses may outcompete the native seedlings for scarce water resources. Equally, the germination and establishment of native seedlings might be prevented by the soil conditions that are altered as a result of cultivation. For example, native species and their symbiotic mycorrhiza that are adapted to the nutrient-poor soils might be sensitive to the residual effect of superphosphate fertilizer. Our poster will highlight aspects of our research to determine which of these barriers operate in wheatbelt old-fields.

REEDIA SPATHACEA F. MUELL. IN QUESTIONS OF CYPERACEAE PHYLOGENY, PHYLOGEOGRAPHY AND CONSERVATION IN SOUTH WEST WESTERN AUSTRALIA

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South west Western Australia is a global centre of diversity for the large family Cyperaceae (sedges) however the evolutionary relationships within the local members of this family have hitherto been unclear. *Reedia spathacea* is a monotypic genus restricted to a small number of disjunct wetlands within the High Rainfall Zone (HRZ), where it is usually the dominant structural component of the vegetation. These wetlands are regionally atypical as they are maintained by hydrological factors largely independent of climate (such as artesian flow from the deep Yarragadee aquifer) and have either endangered or critically endangered conservation status. The wetlands may constitute long term refugia for their HRZ endemic biota.

Reedia was used as a focus in this study to explore the phylogeny of the sedge genera of the region (using chloroplast *rbcL* sequences and morphological characters). The genetic variation between *Reedia* populations was also examined using chloroplast Restriction Fragment Length Polymorphisms (RFLPs) to gain insight into the historical biogeography of the genus and as a first test of the refugial nature of the wetlands it inhabits.

The resulting phylogeny was consistent with *Reedia* as a basal member of the Schoeneae clade of Cyperaceae that includes most of the sedges of the HRZ. The morphological features of *Reedia* implied poor adaptation to frequent or intense fire. The RFLP markers did not distinguish significant genetic differences between the extant populations of *Reedia*, suggesting that these populations have not been reproductively isolated from each other for a lengthy period and are thus unlikely to constitute Evolutionarily Significant Units. These findings have implications in the conservation and management of *Reedia spathacea* and the threatened ecological communities it inhabits.

DEVELOPMENT OF SEED ENHANCEMENT TECHNOLOGY FOR OPTIMISING SEED PERFORMANCE FOR EFFECTIVE LAND RESTORATION

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Current practices utilising native seeds for land restoration purposes are significantly below standards acceptable in comparable industries such as horticulture and agriculture. On average, success of seed broadcasting methodologies are merely 10-15% in most land restoration programs, with the remaining 85-90% of seeds lost to disease, predation, non-optimal germination conditions, and seed/seedling stress. Therefore, techniques must be developed and refined to increase seed performance, which decrease restoration costs and the amount of native seed used in restoration programs and hence increase restoration success. Seed priming, for increased rate of seed germination; acetyl salicylic acid treatment to impart stress tolerance to seeds and young seedlings; and synthetic seed coatings for improved germination success, ease of mechanical sowing and as a delivery system for additional seed enhancement chemicals, are three seed-based techniques currently being investigated by Kings Park scientists to improve seed performance. Results have been very encouraging with significant improvements in germination and germination rates, seedling stress tolerance and seed delivery systems, already attained. Results presented in this poster provide an overview of current research outcomes and an insight into future research directions.

A NEW WAY OF ASSESSING SEED DORMANCY IN AUSTRALIAN PLANTS: A CASE STUDY IN AUSTRALIAN RHAMNACEAE

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The Rhamnaceae is a worldwide family represented by over 900 species, approximately 100 of which are endemic to Australia. Many genera from south-west Western Australia are required in significant numbers for land restoration programs but propagation by seeds has traditionally been problematic. Research by Baskin and Baskin (2004) demonstrates that a systematic approach to seed dormancy classification has been integral to the successful germination of plant species world-wide. Utilising a similar approach this study outlines the steps taken to classify seed dormancy in Australian Rhamnaceae resulting in the germination of several key genera.

**ILLUMINATING THE DARK OF THE FOREST FLOOR: MANAGING THE 'FAIRY LANTERNS'
THISMIA RODWAYI IN WOOD PRODUCTION FORESTS IN TASMANIA**

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Thismia rodwayi (Burmanniaceae) is a seldom-seen herbaceous flowering plant with an unusual subterranean habit that occurs in Tasmania and the eastern states of the Australian mainland and New Zealand.

A new record from a proposed State forest coupe near Meander, in Tasmania's central north, prompted further surveys for the species. These focussed on the proposed coupe and adjacent areas and assessed the extent, abundance and habitat of the species to allow management recommendations to be developed. Surveys of similar forest in the wider Meander area were also undertaken. Less intensive surveys of sites elsewhere in the State were also undertaken.

The surveys substantially increased knowledge of the habitat and distribution of *Thismia rodwayi*. Previously known from only four records, the species is now known from over twenty sites from five disparate areas of the State. *Thismia rodwayi* occurs only in wet eucalypt forest with a shrub-layer dominated by one or more of *Pomaderris apetala*, *Bedfordia salicina* and *Olearia argophylla*.

Surveys of further coupes for *Thismia* purely on the basis of apparently suitable habitat is not considered practical because of the cryptic and ephemeral habit of *Thismia*, and the fact that some disturbances (e.g. selective logging and fire) are apparently not detrimental to the species. The exclusion of forestry operations from all potentially suitable habitat is considered to be an inappropriate management prescription because its preferred habitat is widespread and well reserved. However, coupes within close proximity of a known *Thismia* site may warrant surveys, and/or habitat retention.

As an example, the management prescriptions applied to the *Thismia*-containing coupe in the Meander area excluded logging from most sites supporting the species. However, one site was selectively logged to allow the effect of logging to be monitored. A broader management plan has been developed for a larger forest block known to support the species – this takes account of the area of suitable habitat that is reserved, proposed for development as plantation and proposed for management under native forest silviculture. Annual monitoring of known populations is undertaken.

MANAGING THREATENED FLORA IN WOOD PRODUCTION FORESTS IN TASMANIA: A PRAGMATIC APPROACH

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Tasmania supports c. 1800 native vascular species of which c. 445 are listed as threatened on State legislation. About 200 species are considered forest-dependent, and many more are associated with other vegetation types but may extend into forests.

Forestry operations in Tasmania are regulated by the Forest Practices Authority (FPA), an independent statutory authority. Most operations require a Forest Practices Plan (FPP), which is prepared and certified by a Forest Practices Officer (FPO) trained and accredited by the FPA. FPOs evaluate proposed FPP area using planning tools to assess natural and cultural values. These planning tools include databases with point locality information and manuals that identify habitats strongly associated with threatened flora. The FPO must seek advice from FPA specialist staff if a significant value (e.g. threatened plant species) is known or likely to occur in an FPP area.

Threatened flora that occur in wood production forests are managed under the Tasmanian *Forest Practices Code*. The Code uses a partnership approach between the FPA and the agency responsible for the Tasmanian *Threatened Species Protection Act 1995* (Department of Primary Industries, Water and Environment) to deal with threatened flora that could be affected by forestry activities. Liaison often involves other parties such as the FPO, the landowner and other specialists and is undertaken to ensure that the threatened flora population will not be deleteriously affected by the forestry activity.

The nature of the proposed operation and the characteristics (ecology, distribution, population size) of the species determine if prescriptions are needed to avoid or reduce adverse effects from the forestry operation. In many cases, FPPs do not require special prescriptions because the species is known to persist (or become more abundant) after forestry disturbance. In other cases, site-specific prescriptions are developed (such as modified silviculture or machinery hygiene protocols) to ensure that the population is maintained on site. In a few cases, forestry operations are excluded entirely (e.g. for highly localised species, or species susceptible to pathogens that might be introduced by forestry activities). Landowners who feel aggrieved by constraints can appeal to an independent tribunal, which evaluates the scientific and economic consequences of the FPA's decision.

The Forest Practices Authority undertakes regular monitoring of the implementation and efficacy of management prescriptions. This contributes to refinement of prescriptions, which is further underpinned by research into the ecological requirements of threatened species.

PATTERNS OF PLANT DIVERSITY IN BANDED IRONSTONE RANGES COMPARING THE ENVIRONMENT OF FOUR ENDEMIC *TETRATHECA* TAXA

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Massive banded ironstone ranges are common landforms of the semi-arid Eastern Goldfields region of Western Australia. Increased world demand for iron ore has focussed the attention of miners on the ranges yet a detailed knowledge of their vegetation, flora and ecology remains far from complete. Recent detailed floristic studies on individual ranges show high beta diversity in species composition between adjacent ranges and highly localized distributions for many species. Exemplifying patterns of plant diversity on the ranges are taxa in the genus *Tetradlea* (Tremandraceae). Five taxa, are presently known from five adjacent ranges occurring within a 50 km radius; *T. erubescens* on the Koolyanobbing Range; *T. aphylla* on the Helena and Aurora Ranges; *T. harperi* on the Jackson Range, *T. paynterae* subsp. *paynterae* on Windarling Range; and *T. paynterae* subsp. *cremnobata* on the Die Hardy Range. All taxa are small leafless woody shrubs occurring in similar upland areas of the ranges. Why adjacent ranges each have an endemic *Tetradlea* is unknown. Evaluating the causes of rarity for the taxa is of intrinsic interest for further understanding the extraordinary patterns of plant diversity in south-west Australia, and will aid in determining management priorities especially for *T. paynterae* subsp. *paynterae* which is threatened by mining. In 2004 we began comparative investigations of the environment, reproductive biology, demography and population dynamics of the banded ironstone tetradleas. In this study we present results comparing the physical environment and associated plant communities for four of the taxa.

A PRELIMINARY INVESTIGATION OF OUTCROSSING RATES AND REPRODUCTIVE SUCCESS IN *XANTHORRHOEA JOHNSONII* IN SOUTH EAST QUEENSLAND, AUSTRALIA

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Outcrossing rates and seed set in *Xanthorrhoea johnsonii* (Lee) were measured at four different flowering densities (0.20, 0.16, 0.09, 0.02 plants m⁻²) in Toohey Forest to investigate the relationship between outcrossing rates and seed set with respect to flowering densities. Plant height, inflorescence length and seed set were measured for one hundred plants from each of the four flowering densities. Allozyme data from progeny arrays of 20 seeds from ten plants at each flowering density were used to determine maternal outcrossing rates and correlated paternity. Significant levels of selfing were found in plants at the lowest flowering density ($t_m=0.901 \pm 0.016$), the second highest flowering density ($t_m = 0.956 \pm 0.008$) and the highest flowering density ($t_m=0.948 \pm 0.008$). The significant levels of selfing found at the higher flowering densities suggest that during mass flowering events, geitonogamous pollination can occur. The highest number of pollen donors in the progeny arrays ($r_p=0.395 \pm 0.028$) occurred at the second lowest flowering density. Seed set measured as a rate per unit of inflorescence was lowest for plants at the lowest flowering density. The overall findings suggest that at low flowering densities, outcrossing rates and seed set are reduced. At intermediate flowering densities outcrossing rates, pollen donors and seed set remained high. These results have implications for the long-term genetic variability and viability of populations, especially at low effective population sizes. These preliminary findings are the basis of a more detailed study of outcrossing rates (using microsatellite markers) and flowering densities.

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Advances in plant conservation biology: Implications for flora management and restoration Registrations

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