DWLBC REPORT

Improving Biodiversity Outcomes of Restoration Works: Habitat Restoration Workshop Proceedings

2008/08

Government of South Australia
Department of Water, Land and Biodiversity Conservation

Improving Biodiversity Outcomes of Restoration Works: Habitat Restoration Workshop

Proceedings

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Workshop co-ordinated by Ivan Clarke, Janet Kuys and Robert Wallace

Land and Biodiversity Services Division
Department of Water, Land and Biodiversity Conservation

Report DWLBC 2008/08

Government of South Australia
Department of Water, Land and Biodiversity Conservation

Knowledge and Information Division

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FOREWORD

South Australia's unique and precious natural resources are fundamental to the economic and social wellbeing of the State. It is critical that these resources are managed in a sustainable manner to safeguard them both for current users and for future generations.

The Department of Water, Land and Biodiversity Conservation (DWLBC) strives to ensure that our natural resources are managed so that they are available for all users, including the environment.

In order for us to best manage these natural resources it is imperative that we have a sound knowledge of their condition and how they are likely to respond to management changes. DWLBC scientific and technical staff continues to improve this knowledge through undertaking investigations, technical reviews and resource modelling.

Rob Freeman
CHIEF EXECUTIVE
DEPARTMENT OF WATER, LAND AND BIODIVERSITY CONSERVATION

ACKNOWLEDGEMENTS

This work was financially supported by the Native Vegetation Council of South Australia and coordinated and part funded by the Department of Water, Land and Biodiversity Conservation (DWLBC).

The workshop organising group was Ivan Clarke and Janet Kuys (Senior Environmental Consultants, Rural Solutions SA), Robert Wallace (Habitat Restoration Senior Project Officer, DWLBC) and Merri Tothill (Facilitator, Rural Solutions SA).

Group discussion sessions held during the workshop were facilitated by Donna Bartsch, Catherine Miles, Jeff Edwards, Saideh Kent, Jodie Reseigh, Di Delaine, and Zita Stokes (Rural Solutions SA). Additional support was provided by Kathy Vitkovsky (typing) and Ligita Bligzna (DWLBC).

DWLBC would like to thank Georgina Williams for her traditional indigenous welcome to the participants of the workshop and for a glimpse into the history of Kaurna land.

Special thanks to each of the guest speakers for comments and revision of drafts of their presentation sections and Ivan Clarke, Donna Bartsch and Robert Wallace for final draft review.

Cover photograph: Revegetation at Morella Basin, Martin Washpool Cons. Park, Z. Stokes.

CONTENTS

WORKSHOP OVERVIEW

Restoration is the assisted recovery of modified ecological systems to meet predetermined conservation goals. The overarching biodiversity goal of habitat restoration work, including revegetation, should be to maintain existing conservation values.

There is a clear case for habitat restoration work in South Australia to occur concurrently with the management of remnant habitats, but actions need to be prioritised at state, regional and local levels to ensure the wise use of limited resources.

Presentations and discussions at the workshop highlighted that effective restoration will require:

- clear goals at regional, landscape and patch scales to address species needs at appropriate levels
- goals which take not only ecological but economic and social factors into account
- an understanding of the past history and nature of change in the system in question, to direct restoration actions
- management of regeneration and/or active habitat reconstruction designed to target the range of species' resource and structural requirements
- assessment and incorporation of appropriate genetic complexity (taking into consideration that geography and taxonomy are not always good indicators of genetic relatedness)
- monitoring and evaluation over appropriate spatial scales and time frames to enable adaptive management
- adaptive management that includes appropriate disturbance regimes and
- community engagement, education and inspiration.

Habitat restoration work should be closely aligned to the basic principles expounded within the scientific community relating to ecological restoration. The scientific community is often diverse however in its opinions when looking for the best approach, and most appropriate methodologies, in resolving landscape issues relating to ecological function and habitat restoration.

The Northern Murray Mallee Project illustrates the complexities of sub-regional modelling and goal setting. Approaches can range from addressing the needs of 'focal' species to restoring crucial ecosystems that have been disproportionately cleared or degraded.

There is a large gap between what is scientifically and logically desirable for the management of natural resources (NRM) and what is currently achievable in the form of on-ground works. There is particularly the need and desire within the natural resource management community to bring together differing experience and technical information to better understand how to set goals in a changing world, understand what level of habitat diversity to aim to restore and how to monitor and maintain sites over the longer term.

Large-scale revegetation work at Morella in the Upper South East and trials on Kangaroo Island to address fragmentation show that while simple vegetation cover is relatively easy to achieve on a large-scale (eg via machine direct seeding) in a short time frame, recreating a complex system with a ‘natural’ plant structure and diversity in the short-term still relies on using tubestock planting, with the associated monetary and labour cost being extremely high. Bird monitoring at Morella showed that simple revegetation on a large-scale near to other remnant vegetation can still be of use to many species.

The Morella case study and also observations at sites at Palmer showed that natural regenerative processes can add plant diversity over the longer term but that ongoing management of threats (eg pests) at such sites is imperative. The assessment of threats and regenerative potential must form a focus for prioritising actions at sites – revegetation is not necessarily the first priority for restoration although this is where many community groups and landholders focus their efforts.

Emphasis has been placed on “scaling-up” and being strategic to meet landscape-scale objectives. Processes for engaging landholders and securing land for large-scale and/or targeted patch-scale works need thought to account for social and economic factors. Strategies to get involvement of those currently NOT interested need to be employed and appropriate financial incentives or re-imbursements need to be developed and supported. The Bangham Vegetation Links project showed that incentive funding programs can generate more outputs if community participation is possible during the development phase (eg via community input to and engagement within Steering Committees).

There are challenges for community-based groups and volunteers with regard to the complexity of considerations, conflicting land-use goals and perceptions of what is desirable for “conservation”. To maintain longer-term community momentum, education needs to simplify key issues and more clearly define “best practice” and how it relates to ecological function and sustainability on the ground.

There needs to be better alignment between government departments, scientists and practitioners. Perceived problems with restoration projects can often be related to short funding cycles, lack of long-term monitoring and little or no evaluation at relevant scales. Funding bodies should consider the full timeframes, issues and costs involved in restoration works and monitoring if targeted biodiversity conservation outcomes are to be realised and evaluated.

The level of interest in habitat restoration within the community is high, which was reflected in the high level of workshop participation and discussion. The workshop has started the process of reviewing actions to improve habitat restoration for biodiversity outcomes, but requires some sustained input to follow-up on suggested actions. Support for future events and information exchange across regional SA will help maintain the momentum and interest illustrated through participant feedback from community and agency representatives.

INTRODUCTION

WORKSHOP BACKGROUND

On April 12–13th 2007, a two-day workshop was held at Charles Hawker Centre, Urrbrae focussing on Habitat Restoration. The aims of the workshop were:

- to define what is needed to provide significant biodiversity outcomes with revegetation
- to collect and synthesize knowledge of 'experts' from across Australia and
- to identify key variables/treatments for consideration when planning and implementing habitat restoration.

The themes covered over the two-day workshop were 'Theoretical frameworks underpinning on-ground works' and 'Habitat restoration technical directions'. The workshop program is presented in Appendix A.

The workshop was organised and funded by the Land and Biodiversity Services division of the Department for Water, Land and Biodiversity Conservation and the Native Vegetation Council of South Australia.

Guest speakers represented organisations including Department of Water, Land and Biodiversity Conservation (DWLBC), Department for Environment and Heritage (DEH), University of Adelaide, CSIRO, Rural Solutions SA, Trees for Life and the indigenous community. A list of the key stakeholder groups and organisations who attended are listed in Appendix B.

SUPPORTING DOCUMENTS

These proceedings have been produced as a record of the workshop presentations. DWLBC has also produced an Improving Biodiversity Outcomes of Restoration Works: Outcomes and Review (Clarke *et al.* 2007) that incorporates key issues, questions and recommendations, from policy through to planning and implementation, which were raised by guest speakers and during group discussions at the workshop. In conjunction, DWLBC will in the near future also produce practical and useful documents that incorporate and elaborate on technical aspects of habitat restoration in South Australia.

WORKSHOP SPEAKERS

Assoc. Prof. David Paton (Head of Ecology and Evolutionary Biology, Adelaide University)

Presentation: Habitat Restoration.

David has broad interests in ecological management and restoration. He has monitored birds and their resources in the Coorong since the 1980s, documented responses of flora and fauna to drought and fire in Ngarkat Conservation Park since 1990, looked at the ecology and management of declining woodland birds in the Mt Lofty Ranges and investigated the values of remnant and revegetation areas at Monarto.

Andrew West (Ecologist, Department for Environment and Heritage)

Presentation: Targeted Goal Setting for Landscape Restoration Outcomes.

Andrew has worked for DEH in various roles since 1996, including Natural Resource Management Officer in the SE, State Bushcare Coordinator, Bush Management Adviser in the MLR region and Ecologist - Threatened Species and Ecological Communities. In 2006 Andrew took up a position as Ecologist - Ecological Restoration and is now working on the State-wide planning project "Implementing Ecological Restoration in SA".

Dr. Nigel Willoughby (Ecologist, Department for Environment and Heritage)

Presentation: Modelling Biodiversity Priorities at a Sub-Regional Scale: The Northern Murray Mallee Project.

Nigel studied *Melithreptus* honeyeaters in the Mount Lofty Ranges from 2000-2004 and has been grappling with the question of how to plan to conserve biodiversity for most of the last eight years, first as biodiversity planner for Kangaroo Island, then with a species focus during the *Melithreptus* study and now as restoration ecologist for the SA Murray-Darling Basin.

Dr. Peter Cale (Ecologist, Department for Environment and Heritage)

Presentation: Restoration for Fauna Outcomes.

Peter did his degree and PhD in WA on landscape-scale conservation issues in collaboration with CSIRO. He has worked since then on Rivercare issues and research-based programs delivering information to the community on landscape management. Peter is currently an Ecologist for the Threatened Mallee Birds Recovery Program, which seeks to use birds as a focus for the management of Mallee systems within the SA Murray Darling Basin region.

Dr. Linda Broadhurst (Research Scientist, CSIRO Plant Industry)

Presentation: Seed Provenance: Issues and Considerations.

Linda is the group leader for the Conservation and Restoration sub-program at CSIRO Plant Industry. Her research is directed towards improving the restoration of highly degraded Australian landscapes through a better understanding of the scale and importance of seed and symbiont provenance, the effects of seed quality on restoration success and how vegetation fragmentation influences seed quality, population persistence and gene flow.

Martin O'Leary (Technical Officer, Department for Environment and Heritage)

Presentation: Provenance, a Taxonomic Perspective: Eucalyptus/Acacia.

Martin has worked for the last 20 years at the State Herbarium, being involved with the curation of the *Acacia* and Myrtaceae collections, general plant identifications, advice to the public and collection trips around Australia. Recently he has described several new species of *Acacia* and has just published a study of *Acacia retinodes*, together with the closely related *Acacia uncifolia* and *Acacia provincialis*.

Peter Tucker (Senior Environmental Consultant, Rural Solutions SA)

Presentation: Changing Community Perceptions on Restoration Planning and Management.

Peter recently moved to Struan in the South East where he is working with Rural Solutions SA's Environmental Design and Management Team. Peter previously spent 8 years with Trees For Life's 'Bush For Life' program assisting volunteers, community groups and landholders to manage bushland with particular emphasis on bushland weeds.

Andrew Allanson (Operations Manager North 'Bush For Life', Trees for Life)

Presentation: Discussion of Where and What Level of Intervention is Ecologically Appropriate to Meet the Best Outcomes.

Andrew has been involved in Trees For Life's 'Bush For Life' Program since it's inception in 1994, involving the community in managing remnant bushland in Local Government reserves, Heritage Agreements and other private properties containing bushland.

Dr. Jodie Reseigh (Senior Environmental Consultant, Rural Solutions SA)

Presentation: Monitoring and Evaluation.

Originally from a farming family in the South East of South Australia, Jodie still plays an active role in the family property at Murray Bridge. Jodie gained a PhD from the University of New England looking at relationships between agricultural management and native grassy vegetation near Armidale on the Northern Tablelands of NSW. Jodie joined Rural Solutions SA in late 2004 and specialises in grassy ecosystem management and monitoring and evaluation of on-ground works.

Craig Whisson (Executive Officer, Native Vegetation Council Secretariat, DWLBC)

Presentation: Native Vegetation Legislation.

Craig is employed within DWLBC as the Executive Officer to the Native Vegetation Council. He has a wealth of experience vegetation clearance legislation, Heritage Agreements and native vegetation clearance application assessment.

Donna Bartsch (Senior Environmental Consultant, Rural Solutions SA)

Presentation: Case Study - Bangham Vegetation Links.

Donna has over eight years experience in Natural Resource Management in the South East region of SA. She has extensive experience in implementation and delivery of devolved grant schemes and more recently market-based tools to engage the rural community in natural resource management activities. Donna is now based at Mt Barker, focusing on NRM planning support.

Zita Stokes (Senior Environmental Consultant, Rural Solutions SA)

Presentation: Case Study – Large-Scale Revegetation at Morella Basin.

Zita worked for 11 years in the South East region promoting revegetation and vegetation management through consultancies, managing incentive schemes and general community extension. Currently she is based at Mt Barker Natural Resources Centre working through DWLBC to support the State-wide planning project: “Implementing Ecological Restoration in SA” with DEH.

David Taylor (Threatened Species Officer, Department for Environment and Heritage)

Presentation: Case Study - Recovering Kangaroo Island’s Fragmented Landscapes.

David originally worked for State Forests NSW. Over the last five years, he has been working towards threatened plant species recovery on Kangaroo Island and tinkering with intensive habitat restoration trials for approximately 3.5 of those years. He has a definite tendency to bite off more than he can chew (a necessary trait amongst habitat restorers).

PRESENTATIONS

HABITAT RESTORATION

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REASONS FOR RECONSTRUCTING HABITAT

Only 7% remains of temperate woodlands in the Mount Lofty Ranges. Certain parts of the landscape have been more cleared than others (Table 1).

Table 1: Extant vegetation with altitude in the Mount Lofty Ranges

Elevation (m)	Total area (ha)	Native vegetation (ha)	% remnancy
0 – 150	320 332	7 086	2.2
150 –300	183 928	17 883	9.7
300 – 450	203 711	21 149	10.4
> 450	41 285	6 851	16.6
Total	**749 256**	**52 969**	**7.1**

We must think bigger than the landscape. Regionally, birds carry out important jobs that sustain ecosystems. New Holland Honeyeaters, Red Wattlebirds and Eastern Spinebills, for example, pollinate plants such as *Astroloma*, *Banksia* and *Grevillea*. Experiments show a significant decrease in the percentage of flowers that set fruit if birds are excluded from reaching the flowers (Table 2), indicating that bird-assisted pollination is of significance. Honey bees currently also play an important role in pollination, but if bees were taken out of the system then it would be dependent on birds.

Table 2: Plants dependent on birds for pollination

	% Flowers Setting Fruit	
Species	**Birds excluded**	**Natural pollination**
Astroloma conostephioides	0.1	16.8
Epacris impressa	1.4	8.5
Brachyloma ericoides	16.0	26.9
Callistemon rugulosus	14.4	27.0
Correa reflexa	10.7	26.1
Grevillea ilicifolia	17.1	54.0
Bansksia ornata	22.3	58.1

Nectarivorous birds follow flowering patterns in the Mount Lofty Ranges (Figure 1). In this region, there are reasonably abundant flowers in winter and spring, but we need to manage birds through all seasons.

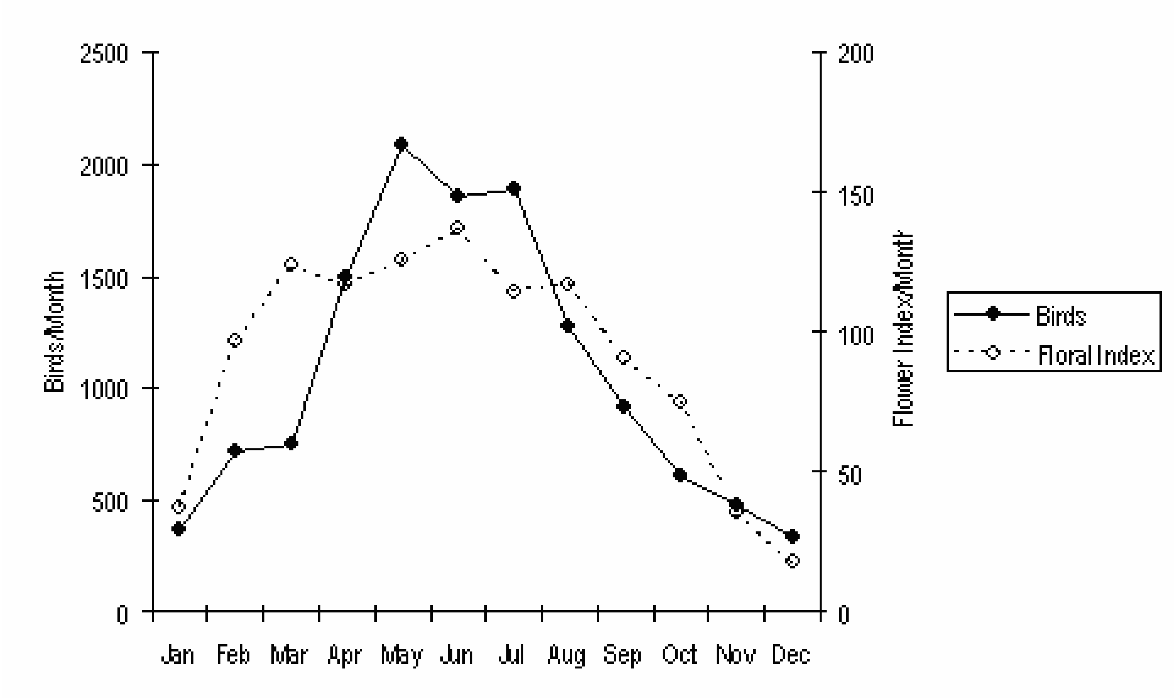

Figure 1: Seasonal flowering and honeyeater abundance at Hale CP.

The habitats that support nectarivorous birds during summer and autumn were the more productive vegetation types that existed on fertile and easily cleared land. These vegetation types have been disproportionately cleared with few quality remnants now left. As a result, many populations of the birds that depend on the vegetation types with summer-autumn flowering plants are in decline. Decline of these birds then affects pollination and results in decreased seed set, which potentially leads to further vegetation decline.

Studies show that “natural” levels of pollination are limited in the Mount Lofty Ranges – the percentage of flowers setting fruit are not reaching their full potential (Table 3).

Table 3: Pollinator limitation to fruit production in the Mount Lofty Ranges

	% Flowers Setting Fruit	
Species	**Natural**	**Additional Pollination**
Astroloma conostephioides	18	65
Epacris impressa	9	55
Xanthorrhoea semiplana	265	368
Grevillea lavandulacea	3	22
Grevillea ilicifolia	5	8

Many birds can move across the landscape (without “corridors”!). Studies in the Mount Lofty Ranges show bird movements from the south right up through to the north of the region, following seasonal feeding patterns (Figure 2). The degradation of one significant habitat patch can have ramifications throughout the region. This indicates that we must take a whole-of-region approach to management.

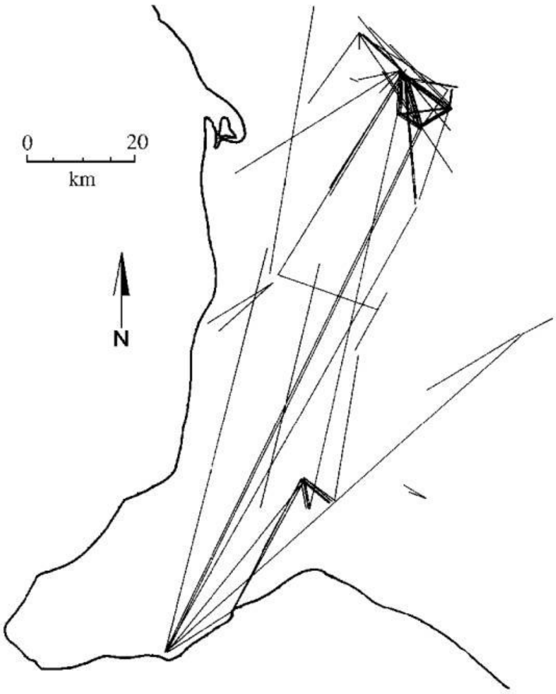

Figure 2: Movements of honeyeaters throughout the Mount Lofty Ranges.

EVIDENCE OF DECLINE

It is predicted that the Mount Lofty Ranges will lose a significant fraction of its bird species in the future. There is an extinction debt whereby the true impacts of environmental change are not immediately seen, but will become apparent some time in the future. Already some species have been lost and few have a chance of recolonising.

Birds no longer seen in the Mt Lofty ranges include:

Azure Kingfisher
Brown Quail
Bush Stone-curlew
Glossy Black-cockatoo
King Quail
Little Lorikeet
Red-chested Button-quail
Regent Honeyeater
Spotted Quail Thrush
Swift Parrot

Birds that are declining in the Mt Lofty Ranges include:

Black-chinned Honeyeater
Beautiful Firetail
Brown Treecreeper
Chestnut-rumped Hylacola
Crested Shrike-tit
Diamond Firetail
Dusky Woodswallow
Hooded Robin
Jacky Winter
Red-rumped Parrot*
Restless Flycatcher
Rufous Whistler
Scarlet Robin
Southern Emu-wren
Southern Whiteface
Square-tailed Kite
Tawny-crowned Honeyeater
Tree Martin*
Willie Wagtail*
Yellow Thornbill

All but the three species marked * had population sizes less than 1500 in the mid 1990's. Some declining species now occur as a small number of birds in widely spaced locations (Figure 3).

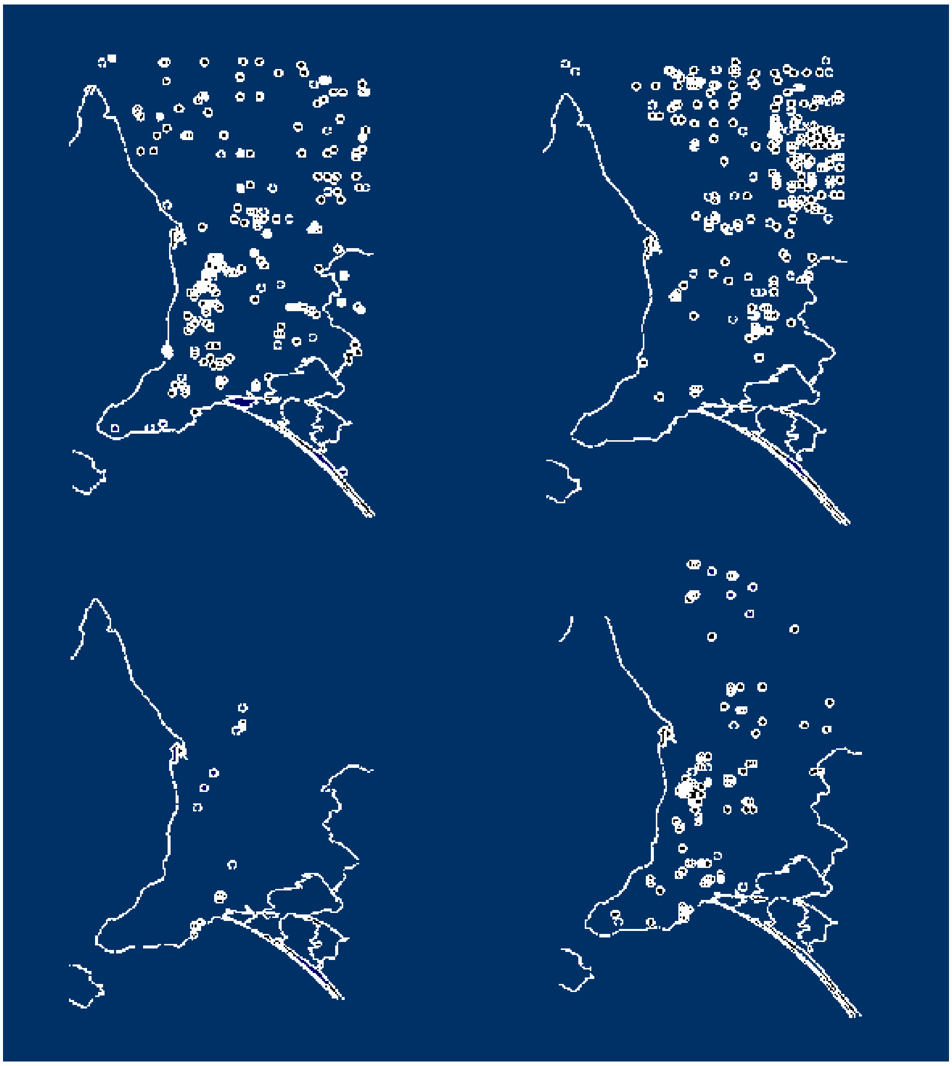

Figure 3: Distributions of four declining bird species in the Mount Lofty Ranges (top left: Varied Sitella, top right: Brown Treecreeper, bottom left: Black-chinned Honeyeater, bottom right: Crested Shrike-tit).

Some specific examples of evidence we have for local declines in bird numbers follow:

- the average population size of Tree Martins observed in backyard surveys in the Adelaide area has dropped from 800 in the early 1980's down to less than 100 in the late 1990's
- Scarlet Robins show a decline in numbers from 1.1 Scarlet Robins/100 birds caught in 1961-1970 down to 0.11 SR/100 birds caught in 1991-2000
- the Brown Treecreeper was common in Belair National Park only two generations ago. In 1997 there were two left and by March 2001 the last male had died.

More habitat is urgently required to increase bird numbers regionally. Regional increases start with local habitat extension – focus on putting habitat back strategically to enhance remnant patches.

Current revegetation does not counter declining woodland bird numbers because the overall area treated is small, patch sizes are small (often <1 ha) and the revegetation is mainly done on poor quality land.

Currently the Mount Lofty Ranges only has 7% remnancy of suitable habitats for woodland birds. A further 10,000 hectares of habitat only amounts to another 3%. We need to aim ideally for more like a total of 30% cover of suitable habitat.

HOW LARGE SHOULD PATCHES BE?

Home range estimates for a pair of birds varies widely from as little as 1-5 hectares up to 100 hectares depending on the species (Table 4).

Table 4: Home range estimates for bird pairs in the Mount Lofty Ranges

Species	Home range (ha)	Longevity (years)	Longest movement (km)
Restless Flycatcher	10 - 100	5	2
Southern Emu-wren	2 - 10	3	2
Scarlet Robin	3 - 50	8	72
Hooded Robin	5 - 100	8	2
Jacky Winter	10 - 20	5	0
Crested Shrike-tit	5 - 20	11	10
Rufous Whistler	2 – 20	15	10
Brown Thornbill	1 - 5	17	9
Yellow-rumped Thornbill	5 - 100	9	37
Yellow Thornbill	5 - 20	11	2
Varied Sitella	20	6	0
Diamond Firetail	2 -20	5	5

An example of a large-scale revegetation site is at Monarto. The revegetation is 1 680 hectares in size and consisted of 600 000 trees and large shrubs of 250 plant species. It was planted at 4.5 to 6 metre spacings.

Bird surveys have been carried out at the site and 70 species have been found which is 85% of the region’s avifauna species. Seventeen species have been found to be breeding (plus four in nest boxes). The home ranges of selected species have been found to be larger in this revegetation than naturally. Ground-dwelling species and treecreepers are absent.

WHAT DOES HABITAT LOOK LIKE?

Will any revegetation do? We need to define what the animals need and then base revegetation on those needs. Current revegetation suffers from:

- limited species/floristic diversity
- limited structural diversity
- poor dispersion patterns

- high plant densities and
- poor tree and patch architecture.

Native woodland with typical understorey is complex and not arranged in rows. In natural systems there is temporal diversity (from regeneration patterns) as well as spatial diversity. For example in a Drooping Sheoak - Pink Gum woodland, there would be some seedlings, maybe a few saplings, many large trees and some old-growth trees (Figure 4).

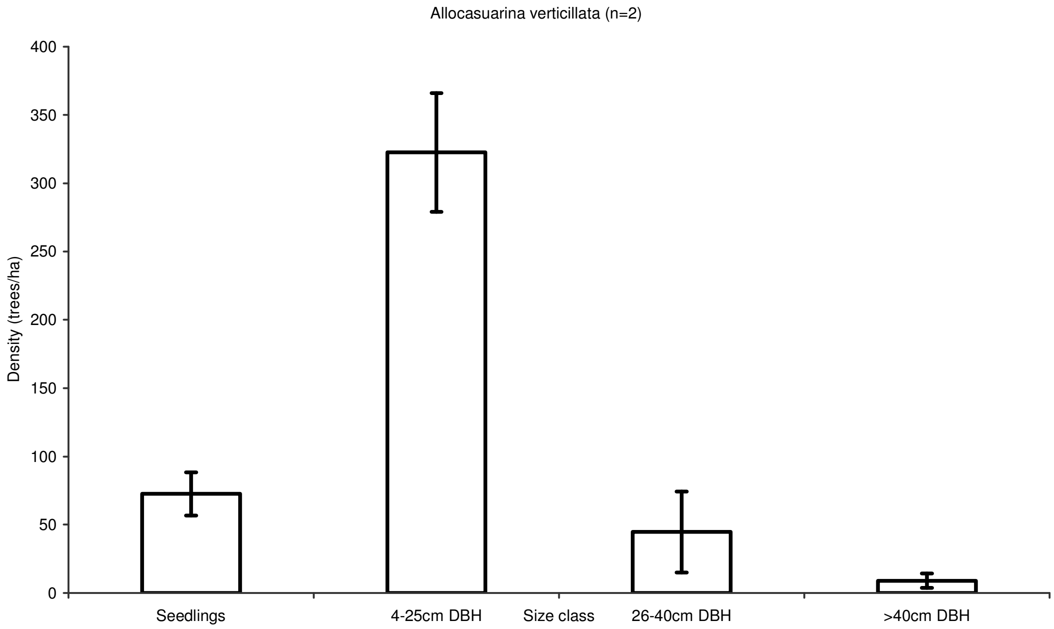

Figure 4: Example of size class distribution of *Allocasuarina verticillata* in a remnant woodland

We need to redesign habitat – matching tree density to different animal requirements. Density of plantings affects growth rate and quality/quantity of fruits (higher density, less fruit) and this can affect use by fauna. Studies on Kangaroo Island, for example, have shown that Glossy Black Cockatoos prefer larger Drooping Sheoak trees (with more cones) for foraging.

Studies show that in the same patch of vegetation different bird species make use of different areas and features of habitat. In designing habitats we need to consider:

- species lists
- planting and final plant densities
- dispersion templates
- staged plantings and plant ages/sizes
- habitat needs of fauna in the design
- post planting management
- heterogeneity – temporal and spatial, and
- account for effects of climate change.

We particularly need to improve the following technical aspects:

- better predict habitat type based on soil, topography, aspect etc
- provide templates of what this habitat looks like including plant densities, size classes and dispersion patterns
- identify specific needs of animal species and
- adjust plant species for climate change.

Quality habitat may take a hundred years to build so we must manage remnant vegetation and threats to birds in the interim.

CONCLUSIONS

1. Put back native vegetation on good agricultural areas that have been disproportionately cleared.
2. A regional scale focus for planning is needed for natural resource management and habitat restoration.
3. Woodland birds will continue to decline and species lost unless additional habitat is provided. Climate change will exacerbate losses.
4. Most declining bird species are still present in the region. A window of opportunity exists now to prevent these losses but this opportunity will not exist in the future.
5. We need a significant proportion (~30%) of a region covered in suitable habitat.
6. Revegetate with large patches of native vegetation. Patches should be 20-100 hectares to account for each species that may need to inhabit it.
7. Different birds have different habitat needs.
8. To support ALL birds, we need to build heterogeneous habitat instead of just planting trees.

For further reading consult Paton *et al.* (2004) and Paton (2000).

ECOLOGICAL RESTORATION GOALS AND PLANNING

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RESTORATION: WHAT IS IT?

Restoration is the assisted recovery of modified ecological systems to meet predetermined conservation goals. This does not necessarily equate to a hypothetical (often static) pre-European state. Implications from this are that restoration actions are dependent upon goals, the type of system and the current state of the system.

Restoration prescription = *function* (Goal, System Type, Current State)

Restoration Prescription = the actions that need to be taken to achieve the restoration goal.

Goal = what it is that you are trying to achieve through restoration (the purpose), which may be expressed as the desired "system state".

System Type = the type of system that is the focus of restoration such as a woodland, a wetland, a temperate landscape etc.

Current State = the present condition of the system compared to the desired state.

RESTORATION PRESCRIPTIONS AND GOALS

There is a spectrum of environmental works associated with conservation and restoration. Figure 5 differentiates some of the terms and concepts.

As with all endeavours, restoration requires goals as a basis for both planning and evaluation. Goals should be 'SMART':

- specific
- measurable
- attainable
- relevant and
- time-bound.

'Biodiversity conservation' is not a SMART goal – only a broad statement of intent.

Systems are made up of components, patterns and processes at different levels (Figure 6). System types include ecosystems, communities and populations. System scales range (for example) from landscape, to regional to global.

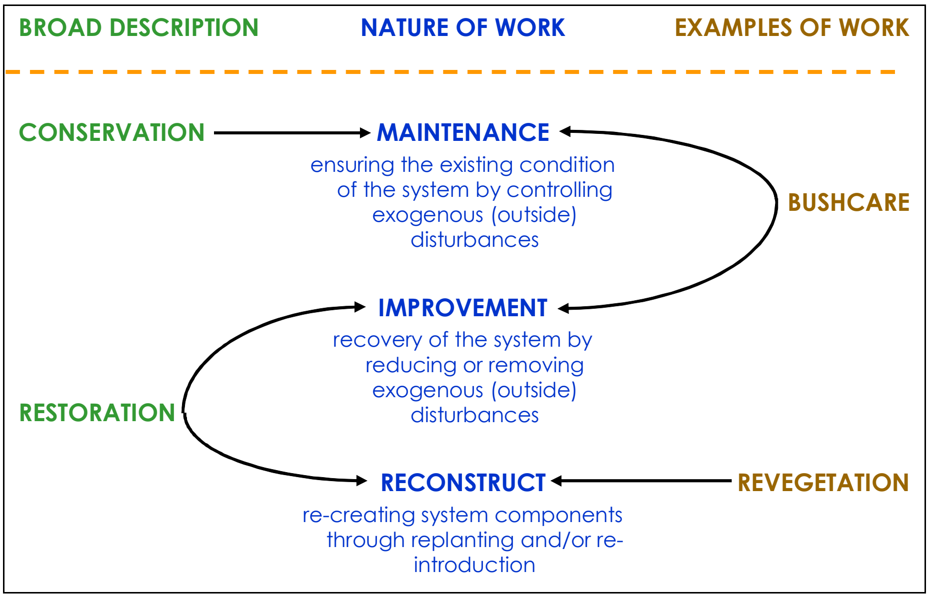

Figure 5: The range of activities from conservation to restoration that might be needed in different systems

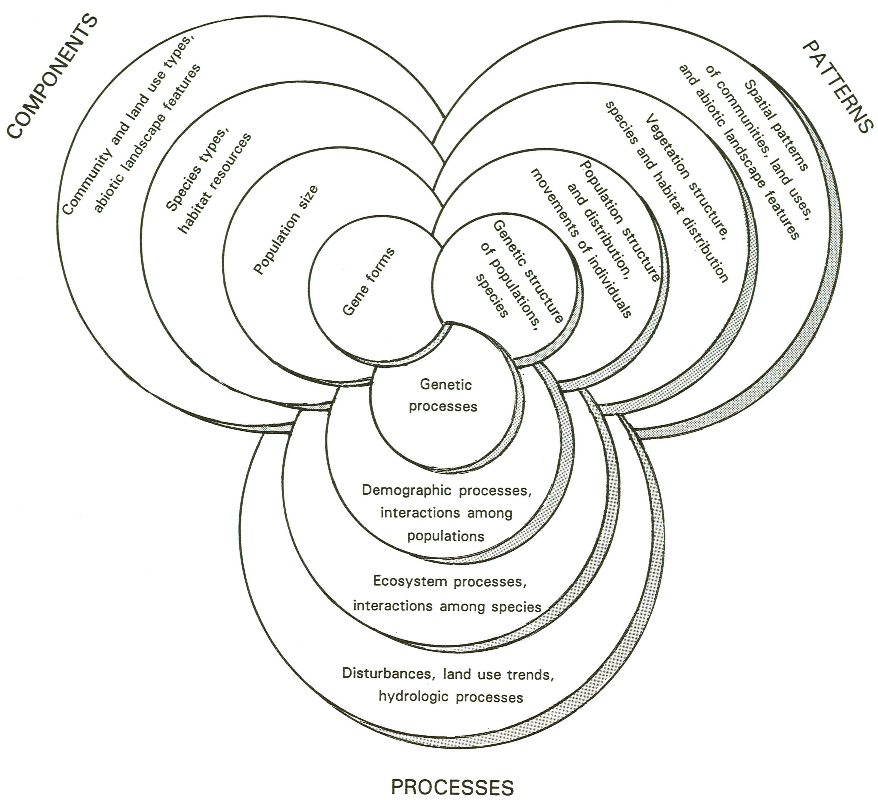

Figure 6: Components, patterns and processes of systems, modified from Groves (2003)

Systems may exist in a number of different 'stable states' (but note that 'states' are not the same as 'condition classes'). Disturbances may lead to a change in the state of a system. These changes may occur abruptly, once a disturbance 'threshold' level is crossed.

Sometimes a system will be able to recover to its former state when a stress or disturbing factor is removed (eg stock removed). It is important to recognise when a system has changed so much (crossed a threshold) that it cannot be returned to its former state by just removing the disturbing factor or giving the system time. For example, if stock grazing, cultivation and weed invasion have reduced a woodland plant community to just trees over pasture, the system will need more action that just removing stock to restore the community (Figure 7).

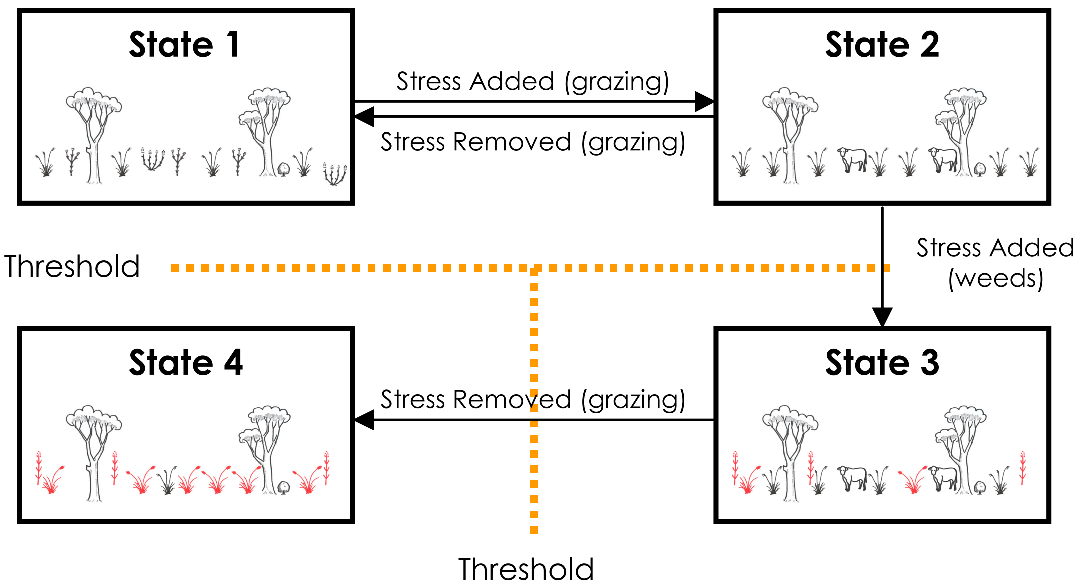

Figure 7: Example of different system states due to disturbances such as stock grazing and weed invasion – by themselves, stock impacts may not have changed the system permanently (State 2), so stock removal results in a return of the system to an approximation of its original state (State 1), but if weeds are present (State 3), removal of grazing will not return the system to its previous state as the weeds will increase and change the system to yet another state (State 4).

Systems can change due to biotic interactions (eg weed invasion) or abiotic factors (eg salinity) and there may be thresholds associated with each factor. Recovery of a disturbed system sometimes will only require improved management (eg weed control). When more disturbed, the vegetation may need to be manipulated (eg revegetation) and in severely disturbed systems physical factors may need to also be restored (eg hydrological balance) (Figure 8).

The more a system is disturbed, the more effort will be required to restore it, and the less likely it is that the restored area will mimic any historic system. This means that the need for specific restoration goals becomes increasingly important the more the area has been modified (Figure 9).

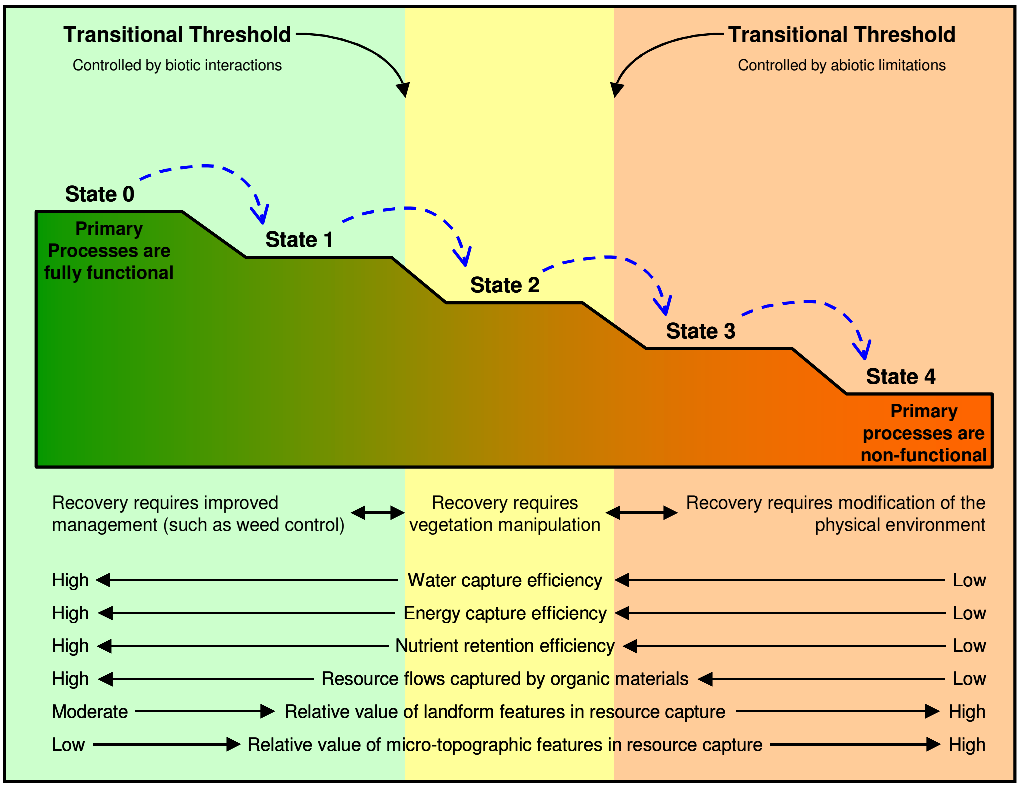

Figure 8: The effect of increasing degradation on a system state and the management actions required for recovery; modified from Whisenant (2002)

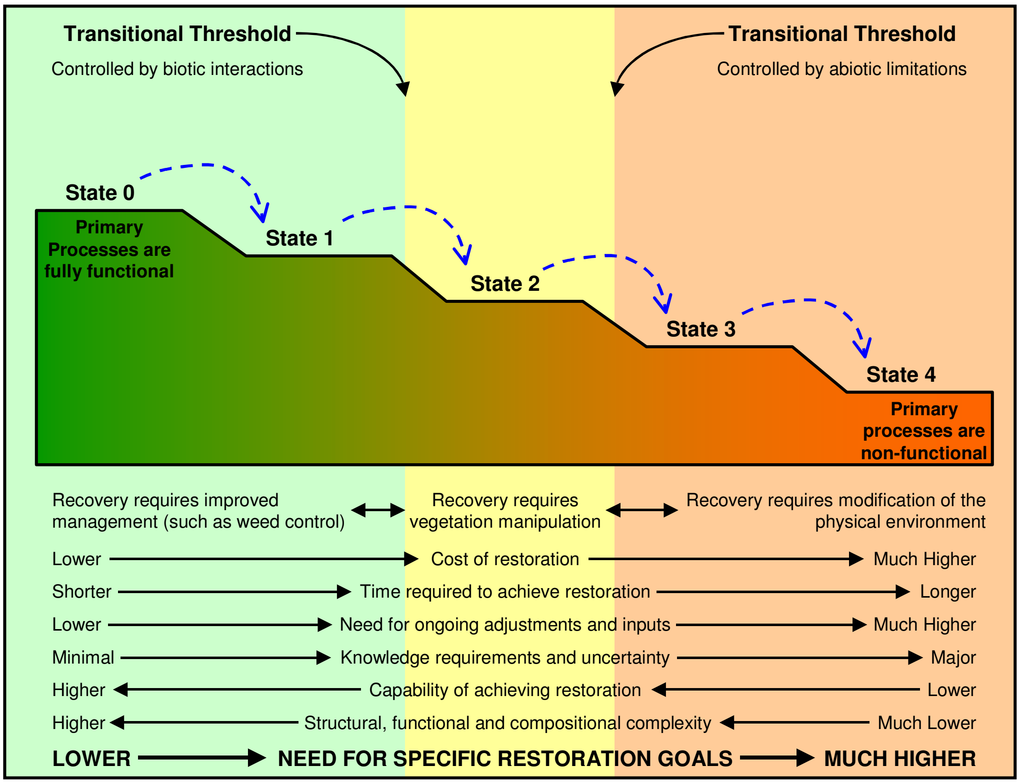

Figure 9: The effect of increasing degradation on the cost and likelihood of effective restoration and the need to determine specific and realistic restoration goals.

RESTORATION: IS IT IMPORTANT?

Landscape modification in SA has been extreme, with direct impacts on biodiversity, land and water resources. Direct impacts on biodiversity include:

- habitat loss
- habitat degradation
- habitat subdivision
- habitat isolation and
- edge effects.

Indirect effects from land and water impacts, including pollution and climate change and the introduction of pest species compound the impacts.

Much of South Australia is in a 'relictual' state (less than 15% vegetation cover remaining). A 2006 assessment showed that 27% of vertebrate fauna and vascular plant species are threatened (endangered, vulnerable or rare) at the State level in South Australia.

In addition to the number of known threatened species, there are many more that are currently declining. For example, on Central Eyre Peninsula there are predicted to be about 170 plant species declining and in the Mount Lofty Ranges, 94 bird species have been identified as declining due to habitat destruction.

Under the least drastic climate change scenarios, improving the resilience and adaptive potential of systems is critical.

WHEN TO RESTORE?

As restoration (especially reconstruction) is difficult and costly, there must be a good reason to attempt it. Restoration should really only be considered when it is necessary to maintain existing conservation values. For example:

- restoring woodlands for nectarivorous birds declining in the Mount Lofty Ranges due to seasonal resource limitations is worthwhile
- in contrast, attempting to reconstruct an arbitrary percentage of different vegetation types presumed to once exist in a region is not worthwhile.

PLANNING FOR RESTORATION

Current approaches to restoration planning across landscapes fall into two broad categories:

- generic pattern-based planning (not ecologically ideal but often carried out for simplicity or due to lack of information) and
- specific goal-based planning (desired for better ecological outcomes).

Generic 'pattern' planning

Generic processes are typified by:

- a lack of formal goals and restoration prescriptions

- the use of generic planning rules largely derived from Island Biogeography Theory (eg ‘bigger is better’)
- a ‘throw in whatever we can grab’ uncritical approach to the analysis of data for planning
- additive approaches to the integration of data (typically GIS-raster driven) and
- a lack of ability to learn from successes and failures as there are no specific (SMART) goals against which to evaluate performance.

There is a tendency currently to go from a situation appraisal straight to setting work actions based upon generic rules, rather than modelling the ecological relationships to define specific goals first. Spatial restoration ‘priorities’, for example, are typically based upon a range of different generic considerations such as:

- the size and configuration of remnant vegetation blocks
- disproportionately cleared or over-cleared vegetation types and
- the presence of threatened species.

Without attempting to understand the processes involved, generic pattern planning suffers from the biodiversity ‘dichotomy’: large habitat areas are identified as important as are threatened species, which are typically located in heavily modified areas. The result is that all areas end up being ‘priorities’ for action. The highest priority is typically assigned to the few areas where these issues overlap spatially, even through these may be locations with the lowest potential to contribute to recovery.

These issues are illustrated in a hypothetical example below (Figure 10, Figure 11 and Figure 12).

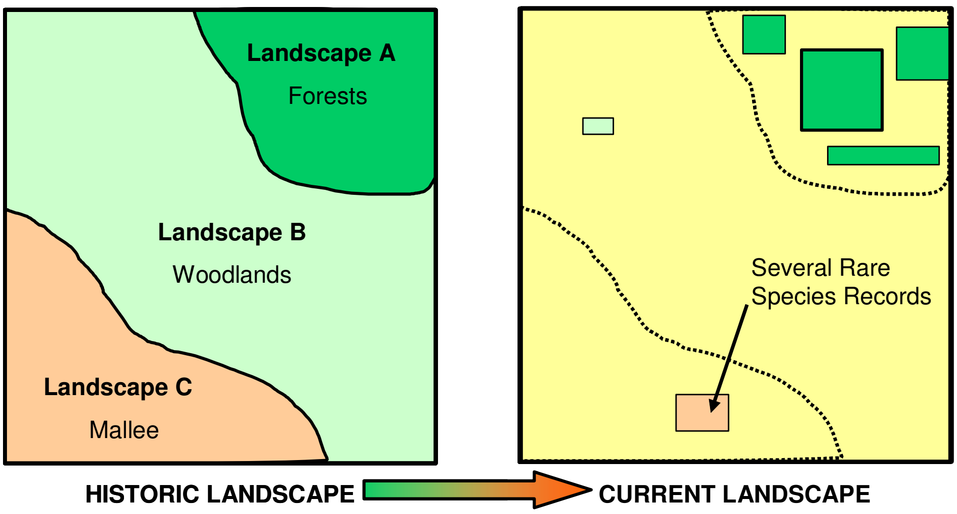

Figure 10: A hypothetical landscape across a climatic gradient, ranging from high rainfall forests to low rainfall mallee. Subsequent disproportionate modification of the landscape has resulted in only a few areas of habitat remaining.

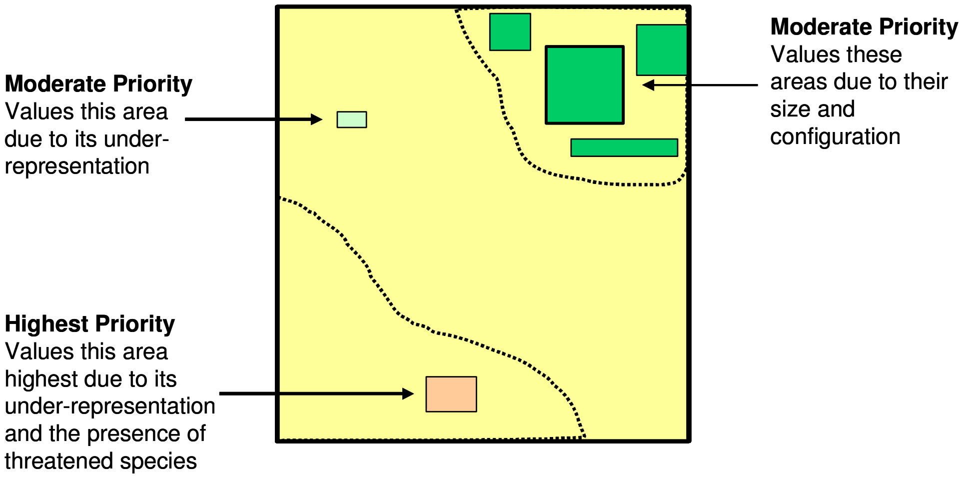

Figure 11: Generic pattern planning values areas based upon a range of generic considerations, such as size and configuration of remnants, current status of species and representativeness of vegetation types.

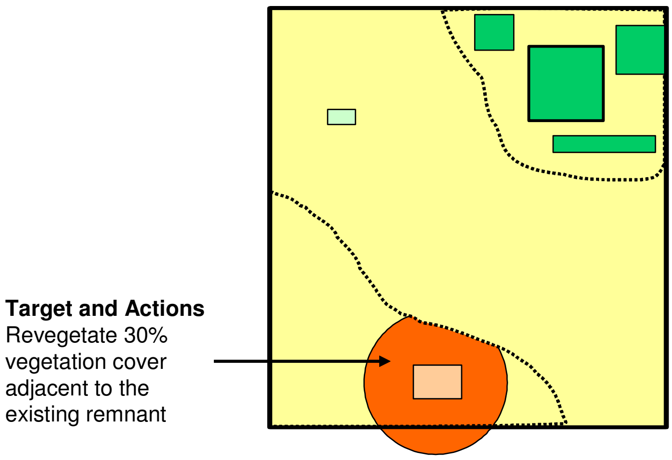

Figure 12: Generic pattern planning typically assigns the highest priority to areas where most issues overlap spatially (in this case, the overlap of threatened species with considerations of patch size and representativeness).

Specific goal-based planning

A specific goal-based planning approach employs an iterative planning process (Figure 13) and aims to clarify system dynamics, required actions and their immediacy. This planning approach avoids the biodiversity dichotomy by setting goals. These processes are typified by:

- formal goals and specific restoration prescriptions
- use of specific planning rules derived for the location and goals
- a critical and targeted approach to data analysis involving multiple assessments (including both environmental and ecological models of species and systems) to try to frame an understanding of the system and its dynamics
- goal-driven integration (ensuring all goals are met and conflicts resolved) and the

- ability to learn from both successes and failures (refine processes).

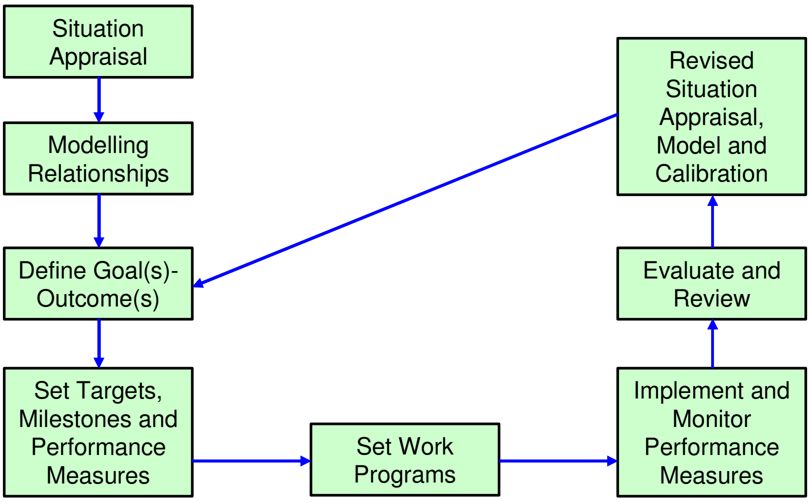

Figure 13: Summary of a goal-based planning approach to restoration

Using the same hypothetical example, a goal-based, targeted approach involves multiple assessments to model systems, understanding their current state (eg where species are stable vs declining), identifying drivers of change and what can be done to achieve restoration goals (Figure 14).

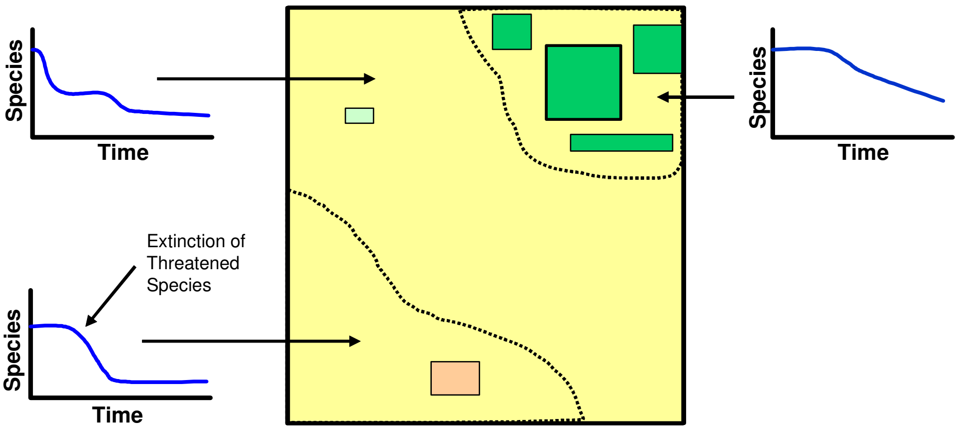

Figure 14: In this example, the former mallee (brown) and woodland (light green) areas have already lost susceptible species, while the former forest areas (dark green) are experiencing a slow decline (eg in birds). However, this decline is due to changes to the woodlands (many bird species require resources from both landscapes to persist).

The biodiversity dichotomy is overcome by looking at issues of immediacy – what must be done now versus what can occur in the future. This can be determined through looking at whether systems are stable (which may be because few impacts have occurred or because they have already lost the species sensitive to current landscape modification) or in an active state of decline (because species are still undergoing active decline which may be able to be addressed through targeted restoration actions) (Figure 15).

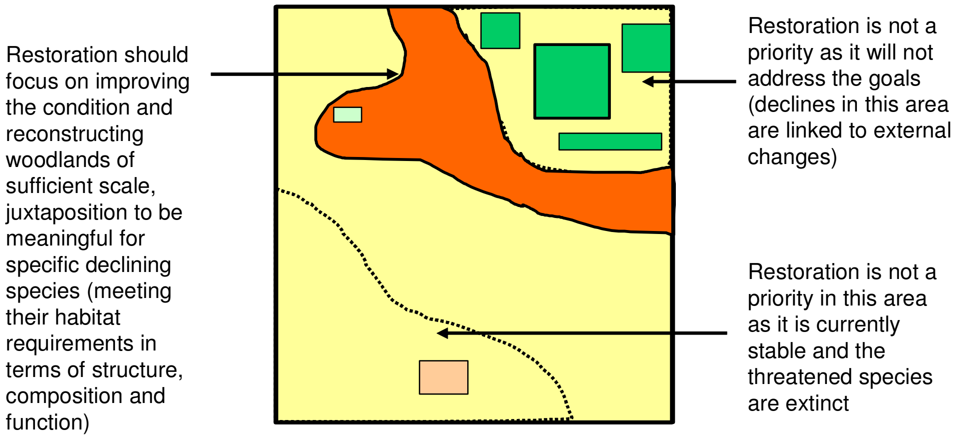

Figure 15: Restoration priorities and actions can be assigned to areas where they will be most effective in maintaining biodiversity. In this case, the ongoing declines (particularly in bird species) are seen within the forest areas (dark green), but are due to the loss of resources formerly provided by the woodlands (light green). So the priority is woodland restoration (red) adjacent to the forest areas.

FUTURE DIRECTIONS

In South Australia, a framework for restoration and sources of information are in the process of being developed. Projects will ideally focus on:

- consistent State-wide goal-based planning to determine restoration needs (including where it is and isn't needed)
- interpreting data to support the implementation of restoration activities (source books of information) and
- learning from successes and failures to create a diagnostic toolkit to guide future restoration.

MODELLING BIODIVERSITY PRIORITIES AT A SUB-REGIONAL SCALE: THE NORTHERN MURRAY MALLEE PROJECT.

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GENERAL MODELS FOR RESTORATION

The aim and vision for the State Biodiversity Plan is 'No Species Loss' (DEH 2007). Two of the most critical requirements for achieving no species loss are:

- a repeatable and defensible planning process (Target 30) and
- ecological knowledge to inform the planning process (Goal 3).

Target 30 is largely addressed by 'Open Standards for the Practice of Conservation' (CMP 2004) which suggests three principles in the conception of conservation projects:

- be clear and specific about the issue or problem you intend to address
- understand the context in which your project takes place
- create a model of the situation in which your project will take place

This presentation focuses on how the Department for Environment and Heritage and the SA Murray Darling Basin Natural Resources Management Board are attempting to use these principles in the Northern Murray Mallee Landscape Trial.

The principles should not necessarily be viewed as hierarchical or directional. It will be an iterative process to determine the biodiversity targets, the context in which they occur and modelling their requirements.

THE ISSUE OR PROBLEM YOU INTEND TO ADDRESS

There has been a suite of tools used to specify biodiversity targets, or the aspect of biodiversity that is desirable to influence through management. These tools can be broadly split into 'species based' and 'ecosystem based'.

Species management is potentially much easier than other ways of managing 'biodiversity', as the requirements of individual species can be relatively easy to determine and manage for. Such approaches include:

- a focus on threatened species – by definition they are a high priority for management if 'no species loss' is the goal, but restoration must be tailored specifically to their requirements and may not provide for all species in the landscape
- flagship species (eg large charismatic vertebrates that hold public attention, eg Malleefowl, Glossy Black Cockatoo, Pygmy Bluetongue) or

- umbrella species (require large areas of habitat and are therefore supposed to provide for the needs of other species).

Perhaps the most common criticism of species-based tools is the problem of assuming that managing for single species necessarily meets the requirements of any other species. Ecosystem based targets have been seen as a solution to the problems of species approaches. Ecosystem management proposes that by keeping the ecosystem healthy, the requirements of component species will also be met - a view that is by no means universally accepted. Ecosystem approaches that encompass a wider scope than species-based approaches include:

- the ‘coarse filter’ approach:
  - retain most of the biodiversity of an area through the maintenance of different types of ecosystems - each ecosystem being a ‘coarse filter’ for the biodiversity it contains
    - matrix-forming ecosystems – dominant over large areas
    - patch-forming ecosystems – small scale eg soaks, granite outcrops
  - some species will be missed and it can be hard to define restoration targets without resorting to other forms of goals.
- keystone species
  - species of exceptional importance, whose presence is crucial to maintaining the organisation and diversity of the ecosystem – an example in the Murray Mallee is *Triodia* (Porcupine Grass/Spinifex), which provides resources for a range of other species and plays a large role in determining fire behaviour in communities where it is found
- focal species (select species that address problems with ecosystem function)
  - the species in a landscape most likely to be threatened in the most demanding way by any one particular threatening process
  - a multi-species umbrella will theoretically capture all species needs
  - determines minimum management and/or restoration requirements for each threat or threatening process
- managing for resilience
  - resilience is defined as the ability of a landscape to return to its former state after a disturbance
  - the ‘insurance hypothesis’ suggests that greater biodiversity insures ecosystems against declines in function because greater species presence provides more guarantee that some will maintain functioning even if others fail and the health of the system as a whole should be maintained in the face of changing conditions.

Using these tools practically and effectively is usually hindered by a lack of adequate data or knowledge.

THE CONTEXT IN WHICH YOU ARE WORKING

A number of frameworks have been developed for generalising the state of landscapes, helping place them in context and to understand what general principles might apply.

The McIntyre and Hobbs (1999) variegation model evolved from ‘island biogeography’ principles. Island biogeography provides a description of landscapes in terms of islands (patches) of habitat in a sea (matrix) of cleared land. The variegation model examines two aspects of the landscape – habitat destruction and habitat modification. The model classifies landscapes in their least degraded state as 'intact' then progressively as destruction and modification of habitat becomes more extensive as 'variegated', 'fragmented' and 'relictual' (Figure 16).

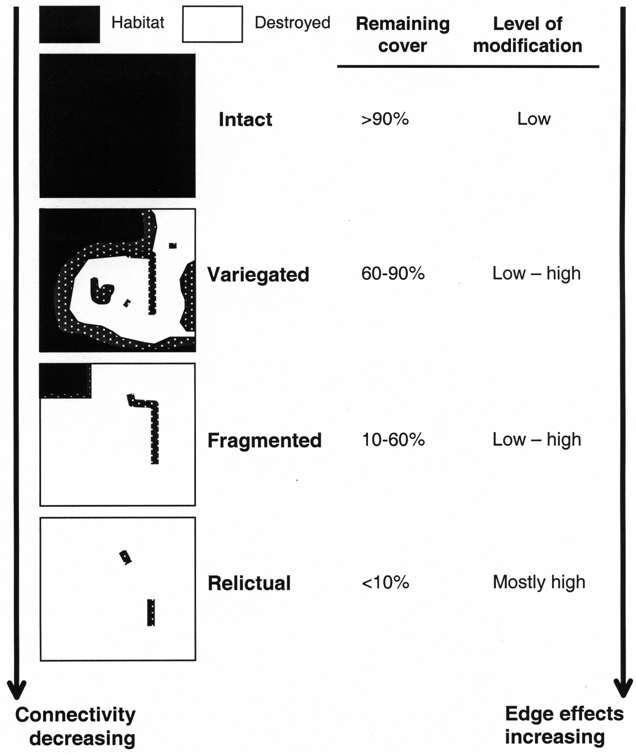

Figure 16: A framework for classifying landscapes in terms of habitat destruction: the 'variegation' model of McIntyre and Hobbs (1999).

Further refinements of this framework (McIntyre and Hobbs 2000) point towards different management action priorities in different types of landscapes: eg habitat maintenance vs improvement vs reconstruction (Table 5).

Table 5: Priority actions for differing landscapes (McIntyre and Hobbs 2000)

	Intact	Variegated	Fragmented	Relictual
1) Maintain	Matrix	Matrix	Least modified fragments	-
2) Improve	Patches, connecting areas	Buffer areas, connecting areas, patches	Fragments, matrix	Fragments
3) Reconstruct	-	-	Buffer areas, connecting patches	Buffer areas

Note: The term matrix is used in landscape ecology to define the bulk of the landscape. In an intact area, the matrix refers to the areas of native vegetation – a matrix of native vegetation with embedded cleared areas. In a relictual area, matrix refers to the areas of agricultural land – a matrix of cleared areas with embedded areas of native vegetation.

As an example of how the concept can be applied, in a highly cleared (relictual) landscape, patches are unlikely to be viable in the long-term without some level of restoration – they need improvement in order to be retained. There is little point in reconstructing connecting areas as there is little left in the landscape that can respond – reconstruction efforts should instead focus on buffering habitat areas from surrounding land use.

McIntyre and Hobbs' framework relies heavily on the level of habitat clearance, and their priority actions are necessarily general. One further framework currently being used in the northern Murray Mallee trial provides for more specific landscape information to be used.

Cale (2007) presents a general landscape 'state and transition' model. State and transition models identify the current state of a system and identify its likely trajectory over time (i.e. is it a stable state or likely to change?). Such models require an understanding of what processes have historically and are currently causing change. Thus state/transition modelling allows history to be traced and/or comparisons to be made between different systems. Such modelling also allows potential thresholds to be identified – points at which a system becomes so changed that its recovery to the former state is impossible without specific restoration actions.

CREATE A MODEL OF THE SITUATION IN WHICH YOUR PROJECT WILL TAKE PLACE

This section outlines current models of three landscapes in the northern Murray Mallee and the subsequent preliminary biodiversity targets.

In the study area the three landscapes are named after 'Laut' associations: Billiatt, Holder and Pata. A landscape diagnosis was carried out that shows the state of each area in terms of habitat fragmentation (ie represented as % remaining vegetation cover). According to the McIntyre and Hobbs variegation model, Billiat is variegated with 70% vegetation cover remaining, Holder is fragmented (25%) and Pata is relictual (2%).

Fire is by far the most dominant natural disturbance in the mallee. It forms a major component of most models of recruitment in mallee and hence in the ability of plants to survive and adapt to their environment. However, changes to the fire regime are likely to have impacted the vegetation types of the mallee, as different fire regimes have been shown to alter the composition and structure of mallee vegetation.

After fire, water availability and grazing are the dominant natural processes of the mallee system.

The major novel disturbance to Murray Mallee landscapes is vegetation clearance. Other disturbing factors that have caused change to structure, composition and functioning include grazing (by native increaser species, introduced pests and domestic livestock) and weed invasion.

The original medium sized mammal fauna of the mallee completely disappeared during early European settlement of the area, probably during the late 1800s.

Billiatt – a 'threatened species' approach

There has been relatively little clearance in the Billiatt system due to poor soils. The main driver in the current state of the landscape is time since fire (a fire in 1988 burnt a large proportion of remnant vegetation) and rainfall since fire.

There are relatively few weeds. Patches within the Billiatt landscape are in relatively good condition, but periodic disturbances of a large proportion of the landscape due to fire degrade condition of the landscape.

Billiatt supports a number of threatened species, which are absent in surrounding landscapes (presumably due to habitat loss from surrounding landscapes). These species, of which the Red-lored Whistler (Vulnerable in SA) is one, are affected by large-scale fires, such as occurred in 1988 across 80% of the Billiatt landscape.

The conservation goal then is to allow the continued existence of threatened species in the Billiatt area. Management focuses on ensuring future fires do not burn a large percentage of habitat all at once. The outcome of this management can be measured by the continued presence of each of the threatened species.

Holder – a ‘focal species’ approach

Early pastoral activity apparently resulted in a thickening up of the scrub over time probably through changed fire regimes and grazing impacts. Vegetation clearance started from about 1914, associated with railway development and wood chopping for fuel.

Weeds are not a significant problem - patches are generally in good condition but clearance is likely to have altered the composition of landscape components.

Murray Mallee dunes can exist in various states: with dense shrubby understorey or with *Triodia* as dominant understorey or in an open degraded state. Past clearance in Holder reduced the amount of shrubby dune vegetation.

The Southern Scrub-robin is generally confined to the shrubby dune element in the Holder landscape (they are not found in the *Triodia* dominated dunes or the swales) and their populations appear to be declining. The Southern Scrub-robin has thus been chosen as a focal species tool to determine adequate shrubby dune habitat (but we are yet to determine if it is the most habitat-limited species). Restoration targets would focus on increasing the extent of shrubby dune habitat, with the expectation that more habitat would halt the decline in abundance of the Southern Scrub-robin, and the other species that require this habitat.

Pata – a ‘coarse filter’ approach

There was no early pastoralism in the Pata system, but the presence of relatively productive soils resulted in extensive clearance for wheat farming in the 1800’s and then more clearance away from the river associated with new railway development starting in 1914.

Patches of remnant vegetation are in poor condition, with generally a high level of weed invasion, degradation from wind blown debris and grazing by feral animals and stock. Landscape processes have been disrupted, impacting neighbouring landscapes (saline inflows to the River Murray) and Pata with areas of rising saline groundwater.

The ‘Woorinen’ ecosystem is a dune/swale combination present across most of the northern Murray Mallee outside the Billiatt landscape. In Pata, the swales are a mix of *Eucalyptus gracilis* and *E. oleosa* with a sparse understorey and the dunes often support a community dominated by *E. cyanophylla*.

Remaining relictual patches of these vegetation types have been degraded by stock and rabbit grazing and wind-blown deposits resulting from over-clearance. Weed invasion has been extensive.

The goal is to protect and improve the condition of remaining patches of vegetation. Effective restoration requires management of grazing threats and using revegetation/regeneration to buffer remnants against wind deposits.

One way of measuring the outcome of restoration works is to compare the native species richness with that of introduced species in vegetation surveys across the region (benchmarks have been derived to show the current state that can be used as a future comparison).

FUTURE WORK

The goals presented in the examples in the previous section include our current thinking on both species and ecosystem approaches to goal setting for restoration in the northern Murray Mallee. The next steps are to quantify targets, define in more detail the appropriate restoration actions and the monitoring required to evaluate outcomes.

HABITAT RESTORATION FOR FAUNA OUTCOMES

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RESOURCE REQUIREMENTS OF FAUNA

Within a patch of vegetation there are a whole range of resources utilised by fauna that need to be considered in restoration (Figure 17).

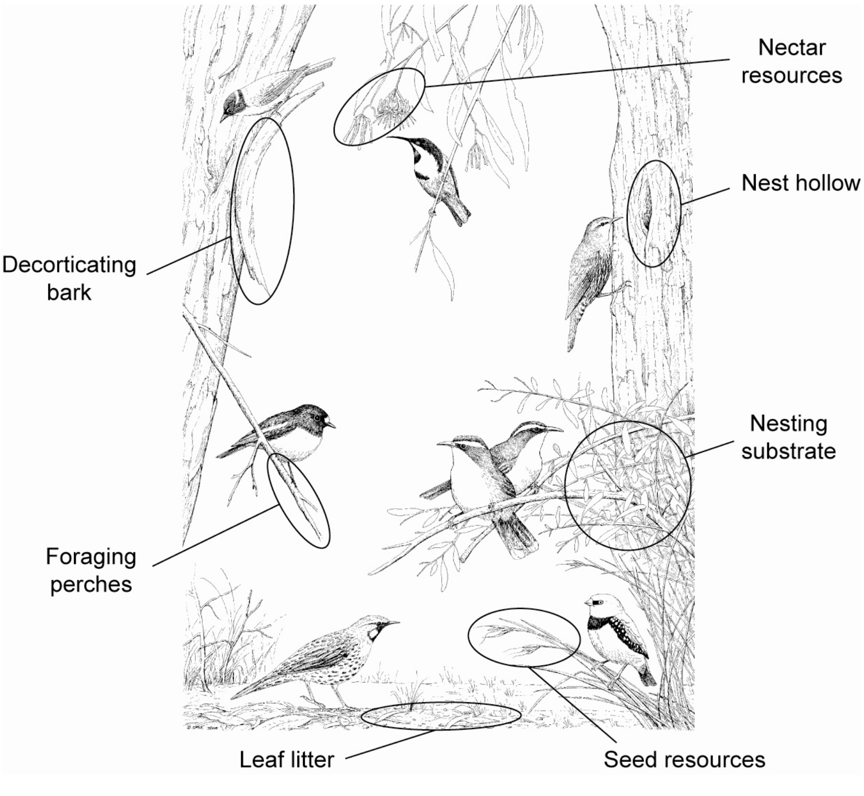

Figure 17: Some habitat resources required by different species of birds

Some of these resources develop as a consequence of the life cycles of the species planted, eg. leaf litter, decorticating bark, hollows. They will happen without direct action by the restoration site manager. The issue for these resources is one of time, but that limitation is beyond the control of the manager. However, managers need to be aware of these time lags, otherwise their expectations from the restoration will be greater than is reasonable.

There are other temporal resource issues that are directly dependent on the activities of the manager, for example the provision of nectar and seed resources. It is not sufficient to say 'this plant provides nectar or seed', there is also a temporal requirement to be considered. For example, a particular grass may provide seed for Diamond Firetails only at a certain time of year and another grass or sedge may then be needed to provide seed at another time. Missing out on temporal elements means the patch fails to meet the needs of that particular species.

Finally there are resources that may differ depending on the planting regime - nesting and foraging substrates for example. Robins forage by pouncing on the ground from a perch 1-2 metres high. Branches of woodland trees provide such perches, but plant these species too densely and they grow in a forest structure with no lateral branches down low.

Of course for some species a single vegetation type will not provide all of the resources required and these species need to move between vegetation types. This raises the issues of landscape adequacy. But first a brief divergence on the issue of spatial scale…

SPATIAL SCALES

Three spatial scales are often thought about with respect to restoration:

- region – comprising areas with similar land use and history - this provides the context of what is possible
- landscape – comprised of a range of patch types - this is the focus scale
- patch – individual vegetation types - this is what drives the focus scale and the scale of individual actions.

Scale is species dependent. For example, for a spider the 'region' may be a single vegetation type, with a landscape comprised of patches such as bare ground, leaf litter and logs. The spatial scale is defined by the species, and therefore an objective is needed, before the appropriate scales for restoration can be determined.

A system (eg a landscape) cannot be understood or managed by focussing only on one scale. Three scales should be considered – the focal scale and at least one above and one below. Few species of fauna are dependent on a single patch type for their persistence. Therefore, for fauna the landscape should be the focus scale, because it considers the interactions between patches, which are what is being restored.

LANDSCAPE ADEQUACY

Landscape adequacy is what determines the success of restoration for fauna, not just patch adequacy. This is because fauna are generally dependent on different patches thoughout their life. So what drives the adequacy of a landscape? The adequacy of a landscape can be reduced by:

- resource limitations – reduced quantity or availability of resources (eg food, breeding resources, area) and/or
- process limitations – dysfunction in patch or landscape processes (eg disturbance regimes, dispersal)

It is important to note that these are not mutually exclusive. A species may be both resource and process limited within a single landscape. In another landscape they may be limited by completely different issues.

The requirements of a species throughout its whole life need to be identified to generate effective habitat restoration. For example, a dragonflies' life cycle (Figure 18) requires the following habitat requirements:

- appropriate aquatic vegetation for the dragonfly to lay eggs on and for the larvae to live in
- appropriate vegetation for the larvae's prey
- emergent fringing vegetation to allow the larvae to emerge and transform into an adult
- appropriate riparian vegetation for the protection of the adult dragonflies.

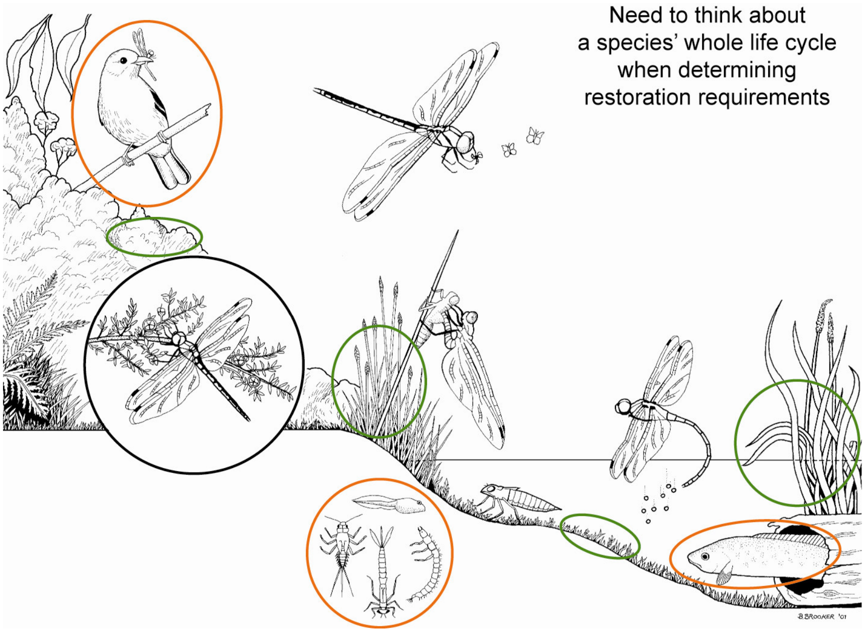

Figure 18: Dragonfly life cycle, including resource requirements (green) and predator/prey items (orange).

To generate a self-sustaining system, the requirements of the dragonflies' predators also need to be understood and taken into account, because without that regulation the Dragonfly population may be dysfunctional. If any part of this is missing then the landscape is inadequate and the restoration will essentially fail.

SPATIAL HETEROGENEITY AND RELEVANT SCALES

Habitat heterogeneity is the diversity of habitat components that are required for a species' persistence. Clearly this is species-specific with respect to what these components are. Different species need different things. However, what is often less appreciated is that habitat heterogeneity is also dependent on the scale at which components are distributed relative to the scale at which the species perceives the landscape.

One of the major changes we have made to many areas is to disrupt these scales and this is encapsulated by the term ‘fragmentation’. We have created landscapes where patches that were once adjacent to each other are now separated by new patch types (ie agriculture) and it is often this that needs to be addressed through restoration.

Consider a hypothetical honeyeater that requires the resources from both shrubland and woodland vegetation. Is the fragmented landscape in Figure 19 adequate for it? That depends on the scale at which the honeyeater operates. If it operates at the scale indicated by the shaded circles, then the patch configuration is not adequate. This honeyeater species would therefore require revegetation of the different vegetation types adjacent to each other (Figure 20) for the landscape to become adequate.

However, if the species operated at a large scale and can move between patches (Figure 21) then the landscape is adequate in providing both sets of resources. In this situation revegetation would be unnecessary for this species to use this area. If however, the species was not willing to cross the open country for whatever reason then this becomes a barrier to using both sets of resources, despite the spatial scale being appropriate. This problem would require some restoration that would overcome the barrier to movement, such as a physical vegetative connection between the two vegetation types (Figure 22).

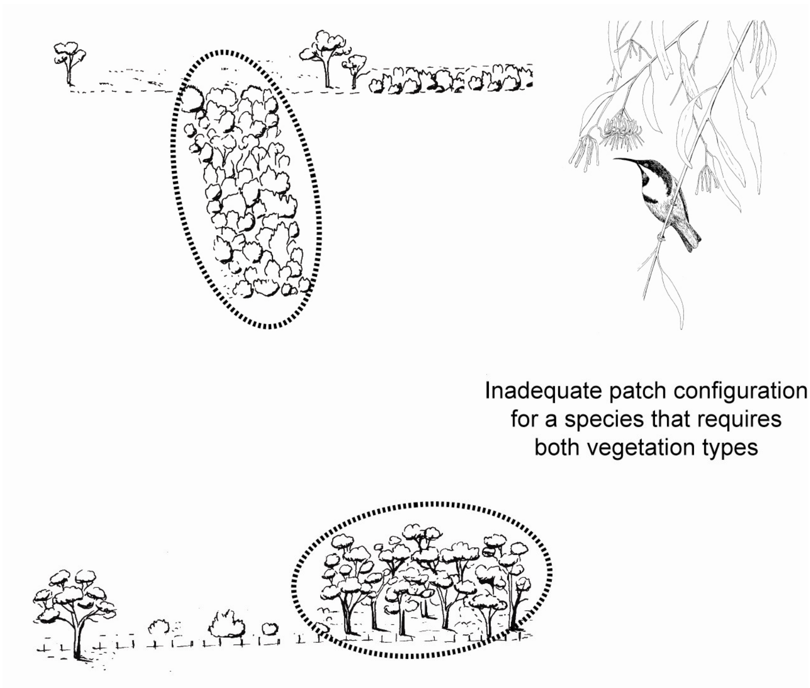

Figure 19: Hypothetical environment with patches of shrubland (short vegetation) and woodland (tall vegetation) resources required for a honeyeater, but fragmented into isolated patches – the range of the honeyeater is circled, showing that the configuration is inadequate.

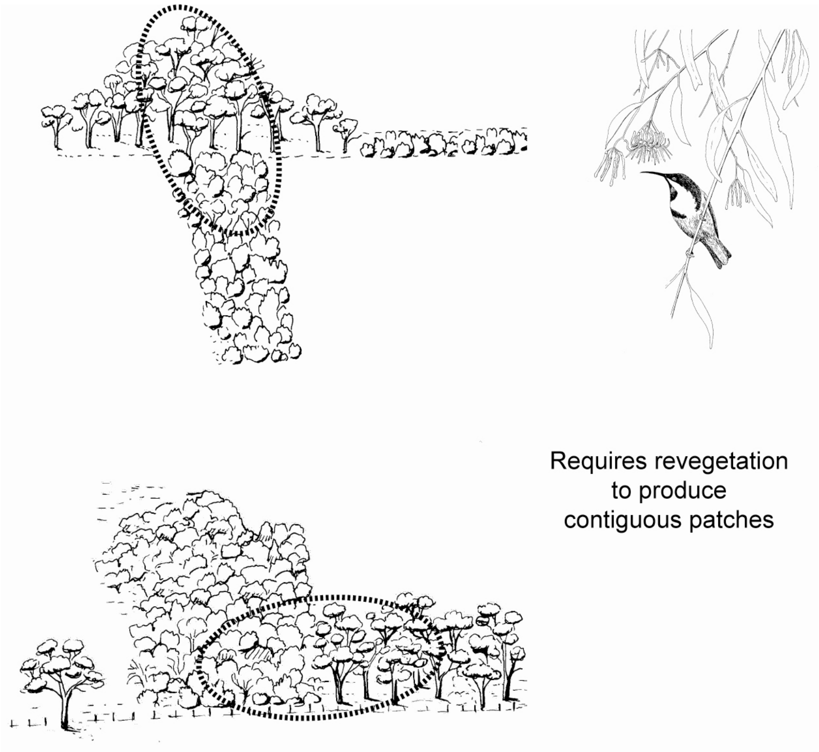

Figure 20: Revegetation to provide additional habitat of the missing vegetation type adjacent to remnant patches is needed if the honeyeater is limited in its movements to the circled areas.

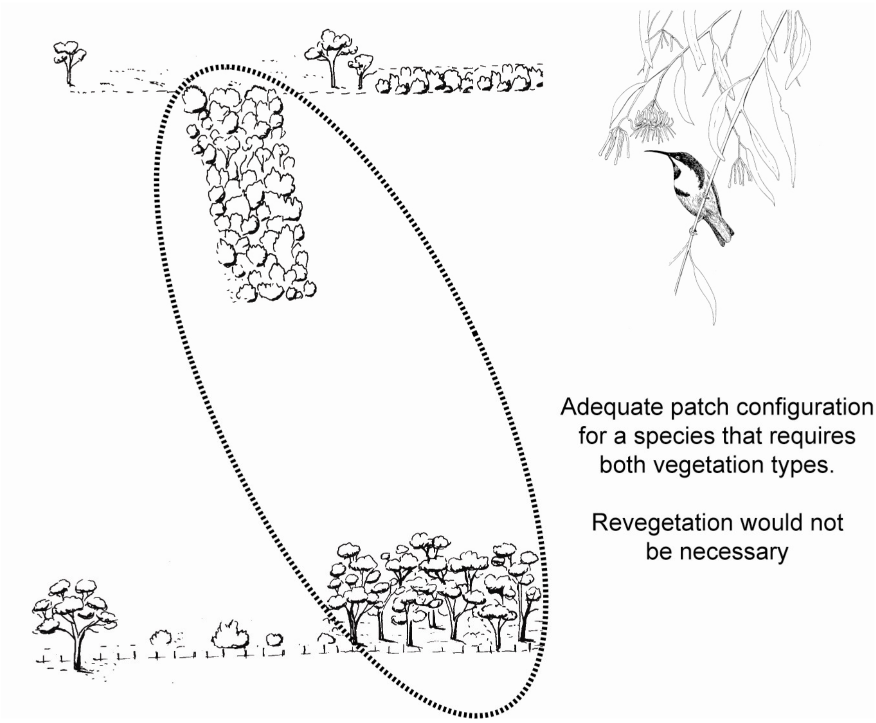

Figure 21: Revegetation to extend patches is not necessary for this honeyeater species assuming that movement between the patches is not restricted.

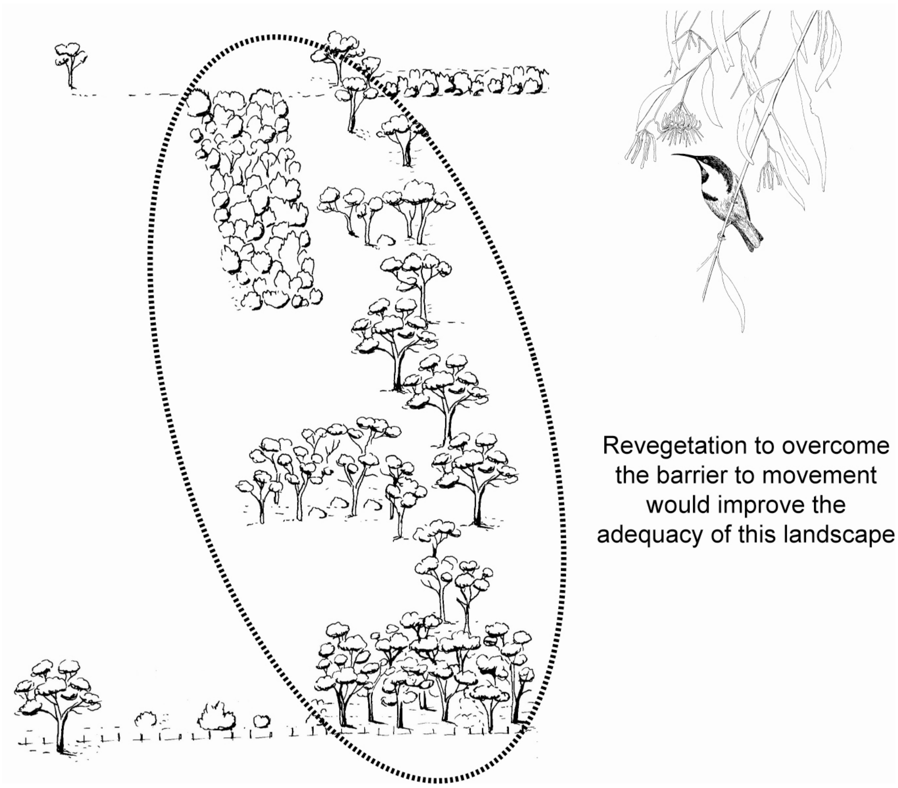

Figure 22: Revegetation (trees in centre of ellipse) to overcome the barrier to movement would improve adequacy of this landscape, if the species of interest is not willing to cross open land between patches.

This is an issue of connectivity associated with the requirements of an individual, as opposed to connectivity at a population scale. Management of the matrix is frequently the most efficient way of addressing such problems, because it is a characteristic of the matrix itself that creates the problem.

CONNECTIVITY AND THE ROLE OF RESTORATION

Connectivity is one of the most misunderstood processes in ecology. Connectivity is a functional characteristic of the landscape not solely a physical one. It has two aspects:

- structure - connections between habitats that enhance the likelihood a species can move between them (eg corridors and stepping stones) and
- function – the likelihood that propagules of an organism can move from one place to another.

The only time this is solely represented by physical structures is when there are absolute barriers to movement. This certainly happens but it is NOT the norm. Most of the time movement is reduced by changes in the landscape but not stopped entirely. Therefore, connectivity can be affected by not only the structural characteristics of the landscape but also by the number of propagules a species is producing, which is dependent on the quality of the habitat.

An example – the White-browed Babbler. In the WA wheatbelt the quality of the habitat for White-browed Babblers was dependent on two things (Figure 23):

- the configuration of the patch – groups living in linear strips (top group) were less productive than those living in a remnant (bottom group)
- the diversity of foliage cover – groups in shrublands that had been grazed and therefore had less complexity in vegetation cover were less productive (bottom group).

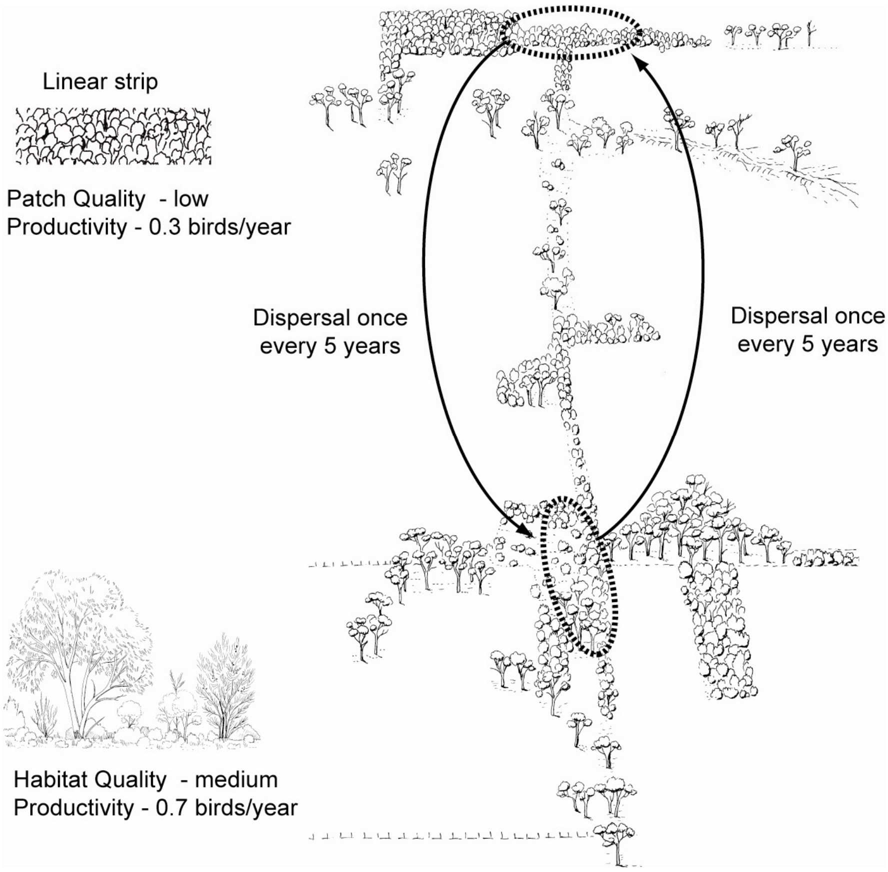

Figure 23: Productivity and dispersal of White-browed Babblers in habitat patches of different quality (linear strip - upper ellipse - vs grazed remnant patch - lower ellipse).

The frequency of dispersal for these two groups was estimated to be only one individual every 5 years. The frequency of dispersal between these two groups is determined by:

- the probability that a dispersing individual will end up in the other territory, which is a function on the vegetation between them and the number of potential dispersal routes the individual may take (this probability can be asymmetrical between two groups because of the latter component).
- the number of dispersing individuals that can be generated by the group.

Now if we alter the quality of these two territories, the first (top) by revegetating to generate a patch instead of a linear strip, the second (bottom) by restoring the vegetation structure, then connectivity between these groups is altered (Figure 24). The physical connections between these two patches of vegetation have not been altered, only the quality of the habitat patches themselves. The effect this has is to increase the number of individuals each group produces that may make the attempt to disperse.

The important consequences for landscape restoration:

- connectivity in a landscape can change without vegetation clearance, through the decline in the quality of remnant habitat
- conversely connectivity can be improved within landscapes by restoring the quality of the remaining habitat - this has the additional benefit of increasing the likely persistence of the individuals in each remnant.

This is dependent on there being no absolute barriers to dispersal (ie. dispersal probability is >0), and as the probability of dispersal tends toward zero the effectiveness of improving productivity will probably decline dramatically as the small increase in the number of dispersers will be far out weighed by the unlikely event of a successful dispersal.

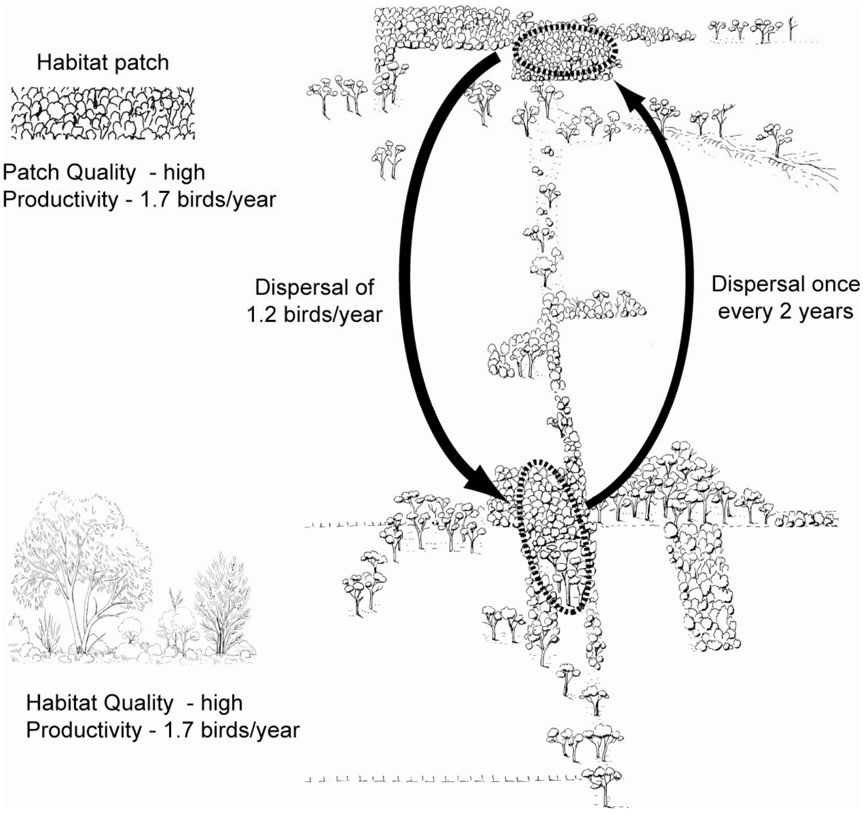

Figure 24: Productivity and dispersal of White-browed Babblers in habitat patches restored to enhance quality (linear strip - upper ellipse - changed to patch vs grazed remnant patch with added understorey - lower ellipse).

A FOCAL SPECIES APPROACH TO CONNECTIVITY

When we need to change the structural connectivity in the landscape what do we need to do? The answer to this question is – it depends on the species for which you are trying to restore the landscape. Some examples (Figure 25):

- Pardalote – may need little more than improving the number of scattered trees across cleared areas - this could be viewed as making the matrix more suitable for dispersal (softening) or each tree could be seen as a stepping stone
- Hooded Robin – may prefer a more continuous line of trees across the cleared area – a 'corridor'
- Bandicoot – prefers continuous dense shrub vegetation for protection.

Three species, three different types of connection. This issue lies in when you want to improve connectivity for all of these species. You then need to consider which of these options may meet the needs for more than one species. Clearly the requirements for the Hooded Robin will be adequate for the Pardalote, and if these bird species are willing to travel within shrub communities then the Bandicoot becomes the most demanding species and its requirements become the focus of the reconstruction.

This is the focal species approach to determine restoration priorities. Find the most demanding species for the limitation in question and use their requirements to meet the needs of all species.

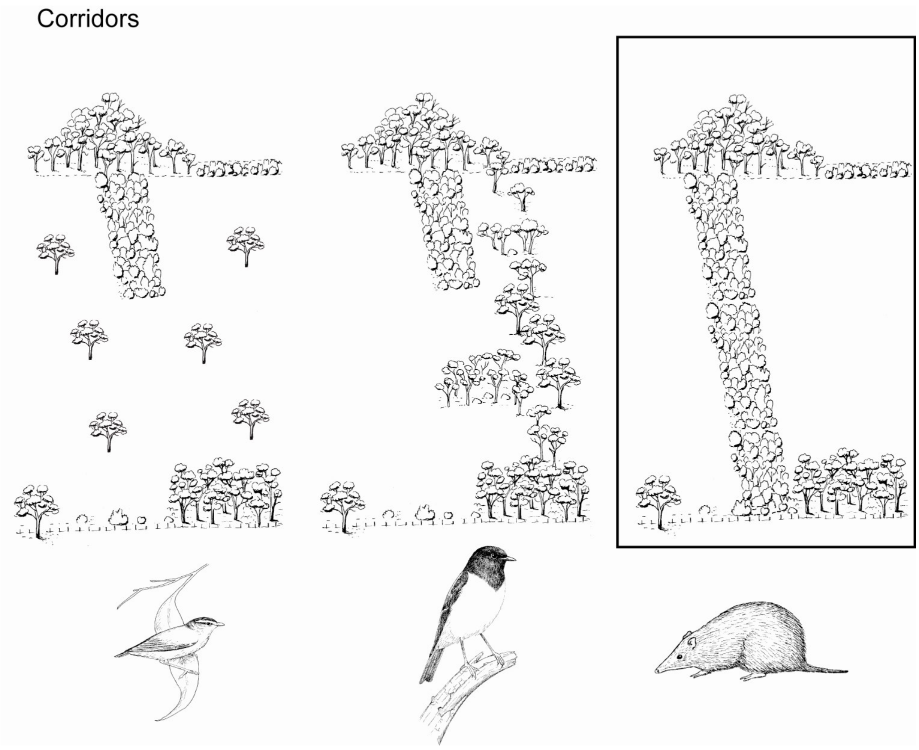

Figure 25: Restoring 'connectivity' depends on a species needs: from left to right – scattered trees for Pardalote, continuous line of trees for Hooded Robin, continuous dense shrubby vegetation for Bandicoot.

Clear objectives are an essential part of any program of change, without them there is no direction. It is not essential that these initial objectives are perfect, because as we go through the process and gain a better understanding of the system we are dealing with they can be refined.

The next stage is to work out why the landscape is inadequate for our targets. To do this we need to know what scales the species operates at. Issues such as habitat heterogeneity and connectivity are species specific and scale dependent. Without knowing the appropriate scales we can never determine what the real issues are.

Once we have an understanding of the problems we need to look at all the options for a solution. If the problem is connectivity can this be addressed by improving the quality of the existing remnants or changing the way the matrix is managed, or does it require some form of structural connection? If it requires a connection is this a stepping stone or a corridor? If a corridor, what type of corridor?

Considering all of these issues means that we can identify the easiest, cheapest and least risky options and it also allows us to look for options to meet the needs for multiple targets with a single action.

CONCLUSIONS

Habitat restoration should be planned with consideration to the following steps:

- have clear objectives before attempting restoration for fauna
- determine the appropriate scales for the faunal targets, so that we can ascertain why the landscape is inadequate and
- look at all the options for addressing a landscape limitation.

This process should allow us in many situations to meet the needs of multiple targets with each activity.

For further reading see Lindenmayer *et al.* (2007).

SEED PROVENANCE AND OTHER SEED SOURCING ISSUES

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REVEGETATION TARGETS

Like many other regions in the world, degraded Australian landscapes are now the focus of intensive broad-scale restoration programs. In Victoria, restoration (revegetation) targets from natural resource management plans add up to many thousands of hectares (Table 6).

Table 6: Planned revegetation targets from CMA revegetation and salinity management plans

CMA	Salinity Target (ha)	Total Target (ha)	Overall Goal and Time-frame
Corangamite	9 310	102 000	Increase native cover to 30% by 2030
Glenelg-Hopkins	25 523	197 109	Increase native cover of depleted communities to 15% by 2030
Goulburn Broken	?	117 952	Increase native cover to 15% by 2030
Mallee	5 000	?	
North Central	21 235	225 000	Increase native cover to 20% by 2020
Port Phillip	?	156 420	Increase native cover to 30% in 30 yrs
Wimmera	17 300	?	
West Gippsland	?	55 081	Extent of increase by 2050

In 2004, Greening Australia nationally:

- Planted >2.1 million seedlings
- Direct seeded 3,300 km of treeline
- Collected 3,665 kg of native seed

In 2005, the Ballarat seed bank in the Corangamite CMA (Victoria) was holding 2.5 tonnes of seed.

Associated with these large restoration targets are a number of issues relating to the sustainability of seed collection as well as the quality, quantity and location of seed sources. Seed collection for revegetation in Australia is primarily guided by the perceived requirement to source locally to preclude concerns associated with local adaptation as well as outbreeding depression in small remnant populations that remain in the landscape.

Studies show that for some species limited seed is produced in small remnants found in degraded landscapes. In addition, this seed can be genetically compromised and show low germination and poor seedling fitness which may affect restoration efforts.

There is a need to maximise restoration success through:
- deploying correct germplasm (genetic) considering
- provenance
- seed quality
- enhancing symbiotic interactions (ecological)
- rhizobial-legume interactions.

SEED PROVENANCE

How far can we move seed? This needs to be decided on a species by species basis.

Acacia acinacea (Gold Dust Wattle) study example:
- key revegetation species across southern Australia (nitrogen fixer, adds structural complexity to communities)
- provenance study to assess issues associated with seed movement through revegetation programs across south-eastern Australia
- broad range across Murray-Darling Basin
- two observed “ecotypes”.

The study was to determine whether there was any genetic basis for the two observed ecotypes, since this adds considerably to restoration costs if seed is to be kept separate.

Thirty-four populations were assessed for:
- quantitative variation – growth & fitness trial
- molecular variation – amplified fragment length polymorphism (AFLP)
- chromosomal variation.

Sampling included seed supplied by regional seed banks collected under current guidelines (Figure 26). Guidelines recommend that seed be collected from as many healthy plants distributed across natural populations as possible.

Morphological studies of *Acacia acinacea* showed that West Hume populations were highly differentiated from the remaining populations (Figure 27) mainly based on weakly ridged stems and mid-shape, hirsute leaves.

The rest of the populations could be separated into three groups (Figure 28). Group 1 were tall with strong apical branching, Group 2 were shorter with strong basal branching and Bendigo plants were shortest with little stem branching. The differences between Group 1 and Group 2 may reflect differences in habit with both prostrate and upright forms being noted by experienced field collectors.

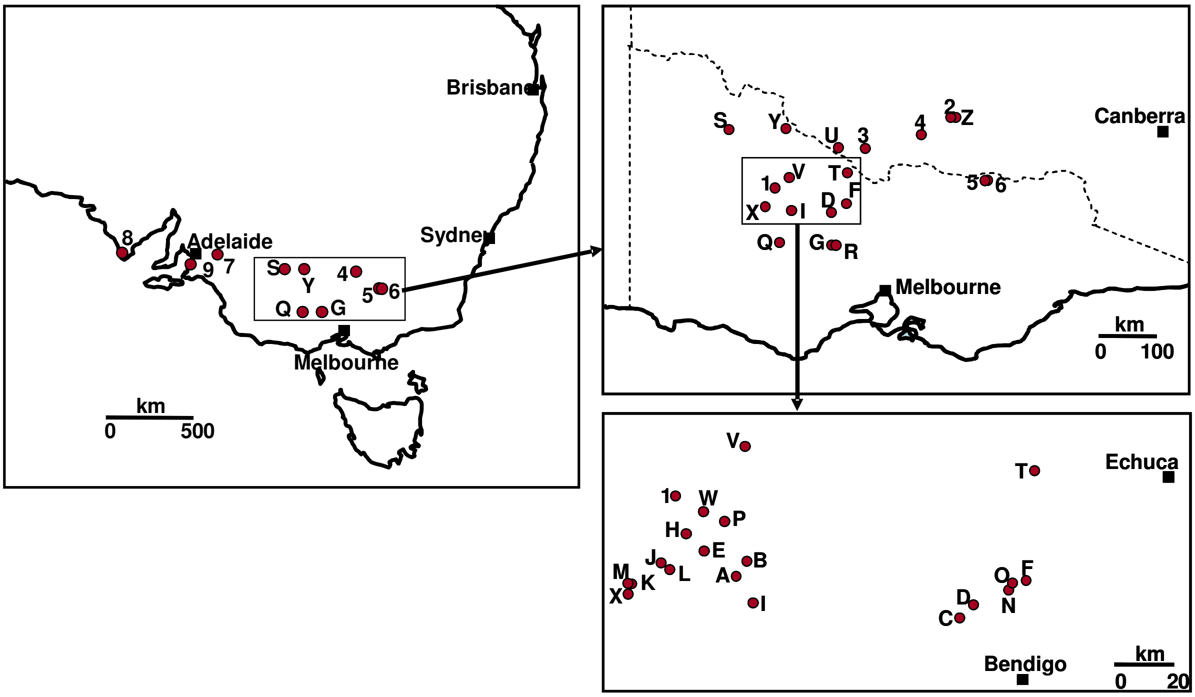


Figure 26: Collection sites for *Acacia acinacea* seed.

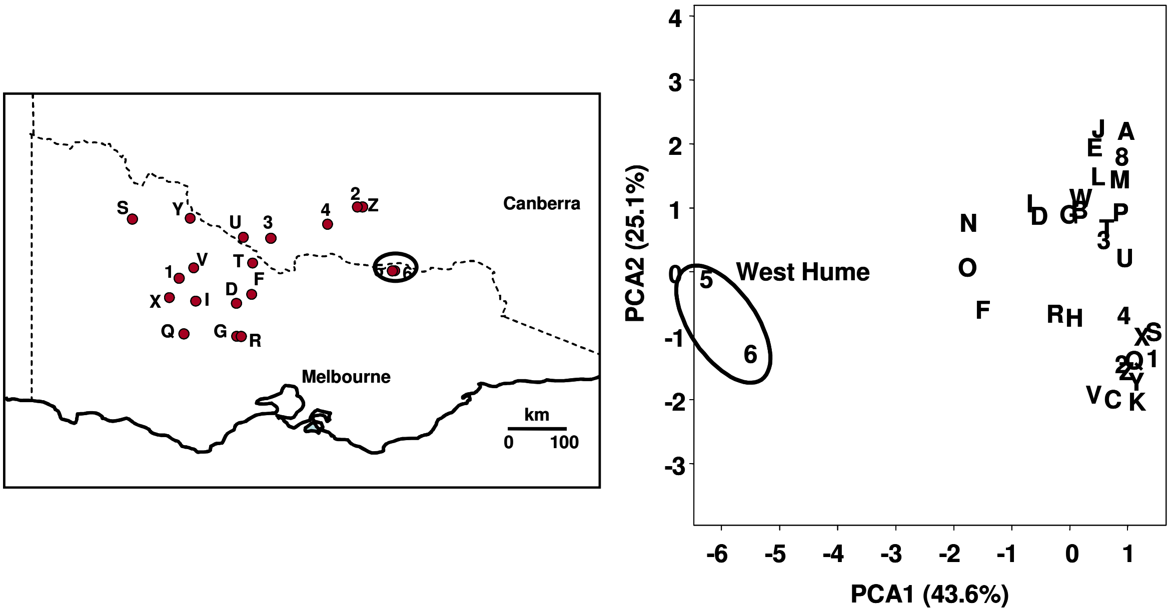


Figure 27: Principal components analysis of six quantitative traits for all *Acacia acinacea* populations showing the difference in the West Hume population.

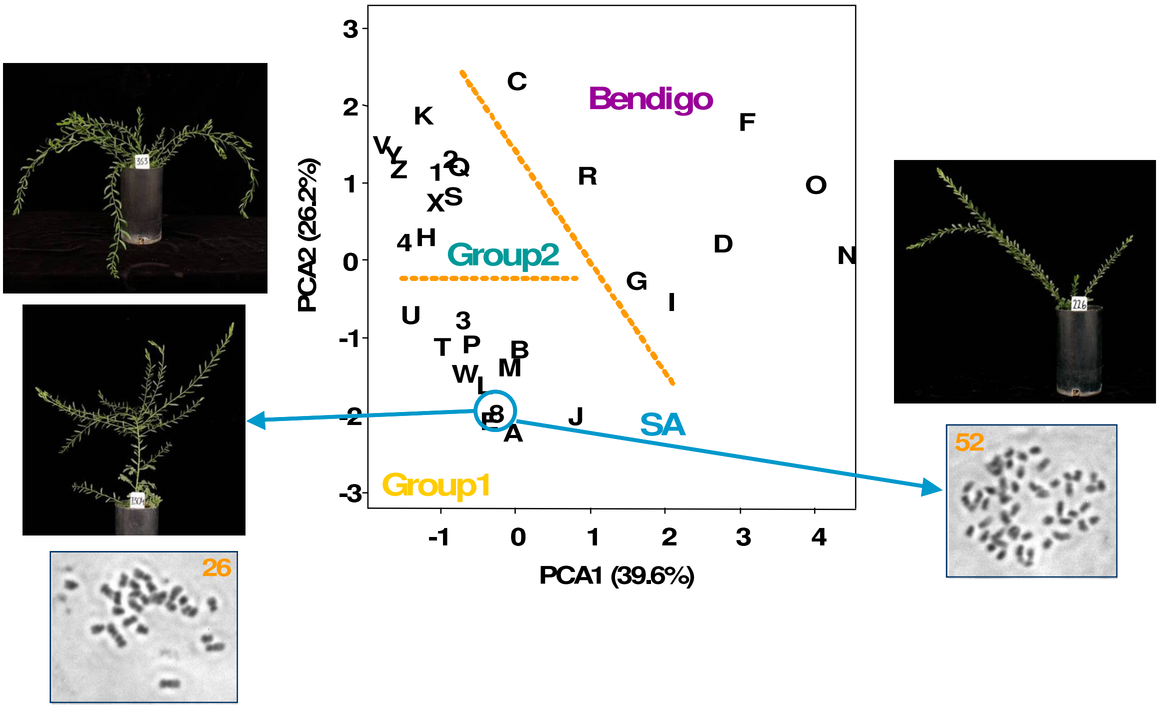


Figure 28: Principal components analysis of six quantitative traits for all *Acacia acinacea* populations except West Hume; broken lines are indicative of separate groups; plant habits of each group are pictured.

A principal co-ordinate representation of genetic relatedness identified that the West Hume sites (5 and 6) and Port Lincoln, SA (8) were different to the other populations (Figure 29) and that some differentiation was also apparent in the remaining population groups.

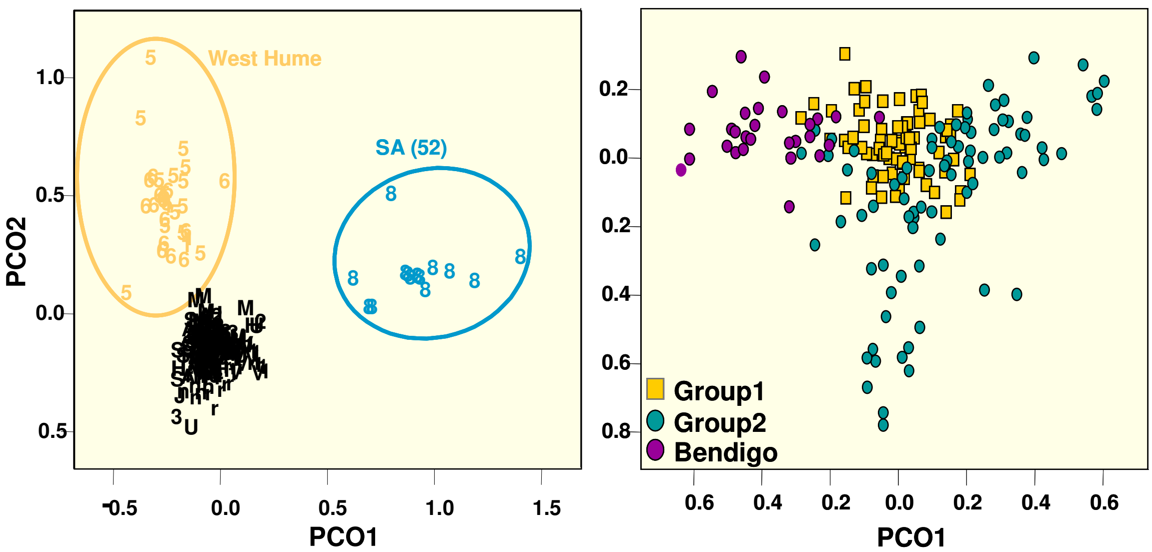


Figure 29: Principal co-ordinate representation of relatedness based on AFLP markers among all *Acacia acinacea* individuals (left) and among individuals of the three groups only (right).

When sites from Group 1 alone were compared, the Medlyns (J) population was more allied to the Gunbower (U) and Deni098 (3) populations, which were over 100 km away rather than with Moliagul (A) and TottingtonA (M) which were within 30 km (Figure 30).

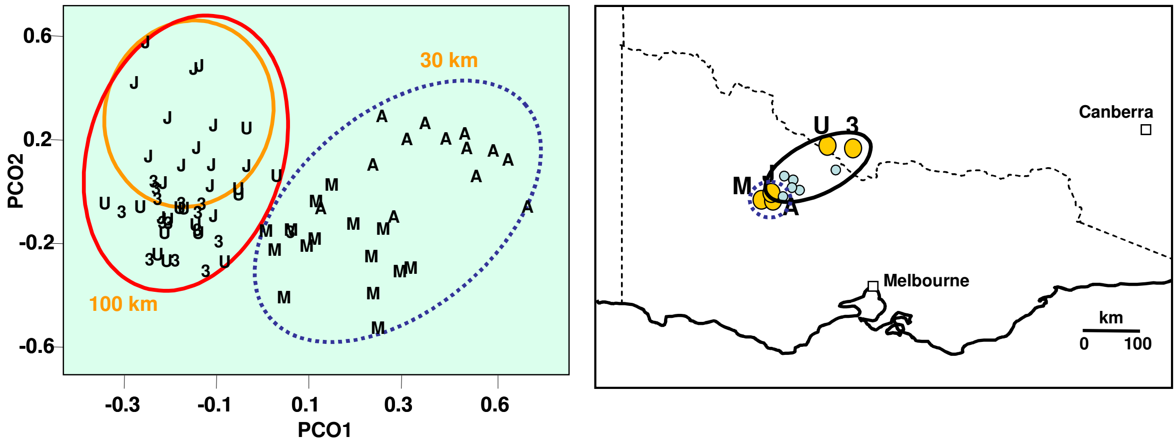


Figure 30: Principal co-ordinate representation of relatedness based on AFLP markers among Group 1 individuals (left) and the spatial distribution of those populations in Victoria (right); individuals in J were genetically more allied to U and 3 than to M and A even though J, M and A are spatially closest in the landscape.

Differentiation among the Group 2 populations was stronger with Berrigan (4) being clearly distinct to all of those remaining (Figure 31) despite being situated spatially within the collection zone of this group. Most of the Sea Lake (S), Yando (V) and Yeungroon (1) individuals formed one cluster while Urana (2) and Berrimal (H) formed another (Figure 31).

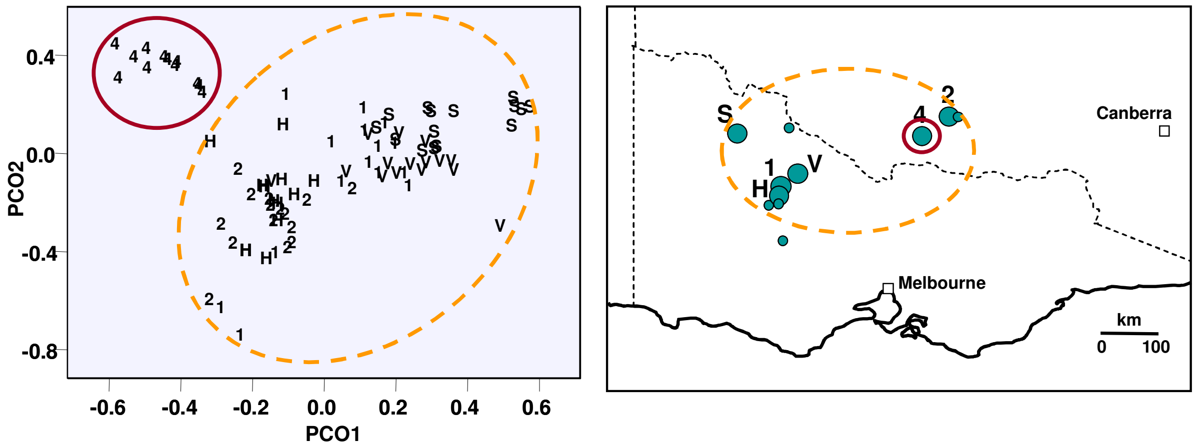


Figure 31: Principal co-ordinate representation of relatedness based on AFLP markers among Group 2 individuals (left) and the spatial distribution of those populations in Victoria (right).

These two examples indicate that location is not always a good predictor of genetic relatedness. The study revealed that several groups with distinctive genetic traits exist within the widely distributed *A. acinacea*, highlighting our poor understanding of most key revegetation species.

IMPLICATIONS FOR REVEGETATION

How does this affect revegetation? An understanding of genetic structure, for example, can be fundamental when determining the range over which seed should be moved. The Bendigo group of *A. acinacea*, which was morphologically distinct and had higher levels of genetic diversity than the other groups, was also geographically localised suggesting that genetic and/or ecological boundaries are present. Accordingly, these populations should be maintained as an entity and seed movement restricted to within its natural geographic range.

A further consideration for deploying Bendigo seed (which is tetraploid) is whether contact between this tetraploid and other diploid populations will result in hybridisation creating sterile triploid offspring, compromising both the long-term viability of both revegetation and extant populations.

The other populations of *A. acinacea* were divided into two groups (Group 1 and Group 2) that appear to reflect differences in habit. Both of these groups are common and widespread throughout the study region, and anecdotally can occur within 50 m of each other, yet remain morphologically distinct. Combining seed of these two groups for revegetation is not recommended since we are able to demonstrate morphological and genetic divergence between them.

In Group 1 and Group 2 populations, local adaptation and outbreeding depression may be important considerations for deploying seed across the region, particularly since genetic relatedness within these two groups has highlighted that population genetic structure is complex and not readily predicted by geographic distribution (for example some populations located over 200 km apart were more genetically allied than those located only 50 km apart).

For most key revegetation species it is likely that we will need to rely on integrated studies of current genetic structure such as in the *A. acinacea* example to provide a useful framework upon which to base seed sourcing decisions. Genetic variability is not necessarily apparent through plant morphology. Such undetectable differences are particularly critical for long-lived species where recruitment failure brought about by the mixing of different ploidy levels may not become apparent for some years.

PROVIDENCE FOR MORE RESTRICTED SPECIES

Arachnorchis concolor and *A. pilotensis* are rare and endangered orchids that occur on the Victorian/NSW border (eg Figure 32). A study in collaboration with NSW NPWS and Albury City Council has produced genetic relatedness 'maps' to assist species management within and among populations of each of these orchid species. Management can include hand-pollinations and germplasm movement.

The genetic map for *A. concolor* (Figure 33) indicates that most of the C/W plants are more closely related to each other than to the other populations[1]. Given this, and the large geographic disjunction between the populations, movement between these two groups is not recommended. Within the remaining populations, however, germplasm can probably be moved.

[1] Data for this study has since been reviewed and will be published in the Australian Journal of Botany in 2008.

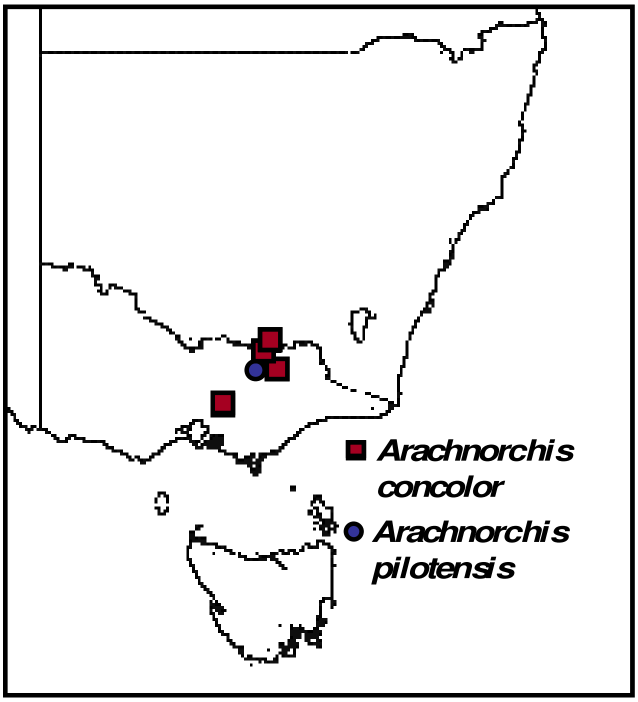


Figure 32: Distribution of *Arachnorchis* species sites.

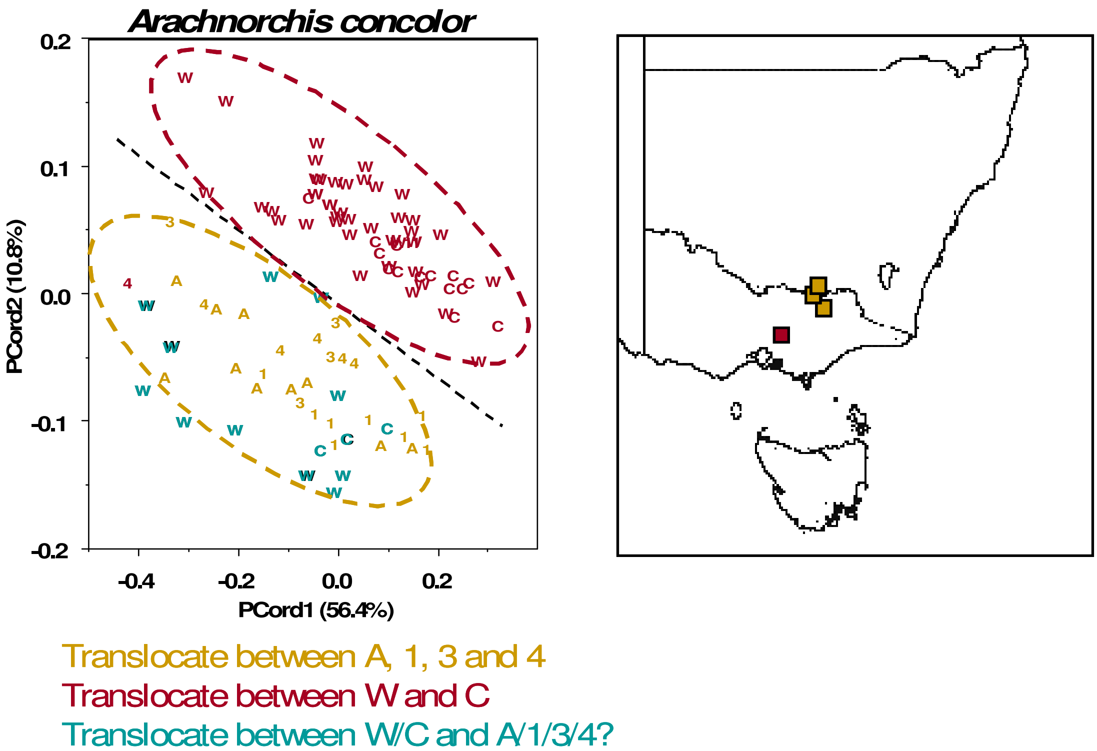


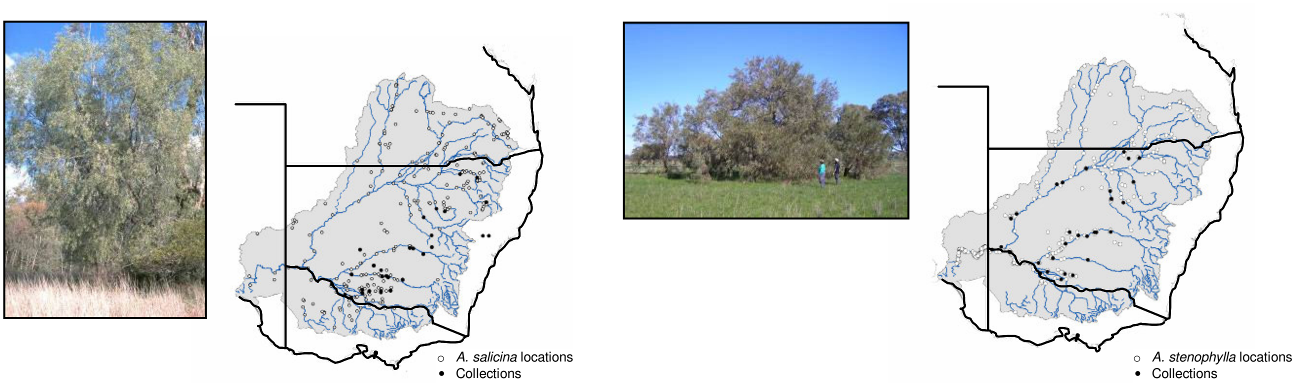
Figure 33: Genetic relatedness map of *Arachnorchis concolor* plants.

SEED AND SYMBIONT PROVENANCE

Geography is not always a good predictor of provenance. How fussy should we be about provenance given the current and expected rate of environmental change? The more genetic diversity, the more opportunity for vegetation to adapt to changing conditions.

"Using Plant-Soil Interactions to Optimise Revegetation Strategies" is a project being conducted through the NSW Environment Trust to develop a better understanding of seed and symbiont provenance for two *Acacia* species across NSW (Figure 34):

- largest study of its type in Australia with a very broad geographic scale
- two host species (30 pops X 30 plants) and associated symbionts (30 sites X 30 isolates each host species).



Acacia salicina ***Acacia stenophylla***

Figure 34: *Acacia* species involved and their collection sites (dark dots)

SEED QUALITY

The viability of plant populations in remnants can be limited by many factors including pollinator limitation, genetic variation, inbreeding depression, microbial associations, seed predation, herbivory, disturbance regimes and microclimate. Alterations to Australian landscapes have fundamentally changed patterns and processes through:

- less habitat - smaller patches, various shapes
- smaller populations - fewer mates, fewer pollinators
- increased isolation between patches - limited gene exchange (pollen and seed)
- changes to habitat 'health' - above and below ground e.g. weeds, loss of symbionts.

There is a flow-on effect to seed quality within remnant vegetation. The response is affected by a species' reproductive strategy:

- self-incompatible species: fewer mates = poor seed set
- self-compatible species: related mates = elevated inbreeding
- mixed-mating: changes in abundance = hybridisation.

Self-incompatible species – poor seed set

A large study has assessed genetic and ecological constraints to population persistence of *Acacia dealbata* in fragmented landscapes. Fertilization success was found to be a major reproduction constraint, particularly in small populations and probably reflects a self-incompatible reproductive strategy. Smaller *A. dealbata* populations consistently produce significantly less seed. Larger populations have higher success rate (p=0.004), presumably because more mates are available (Figure 35).

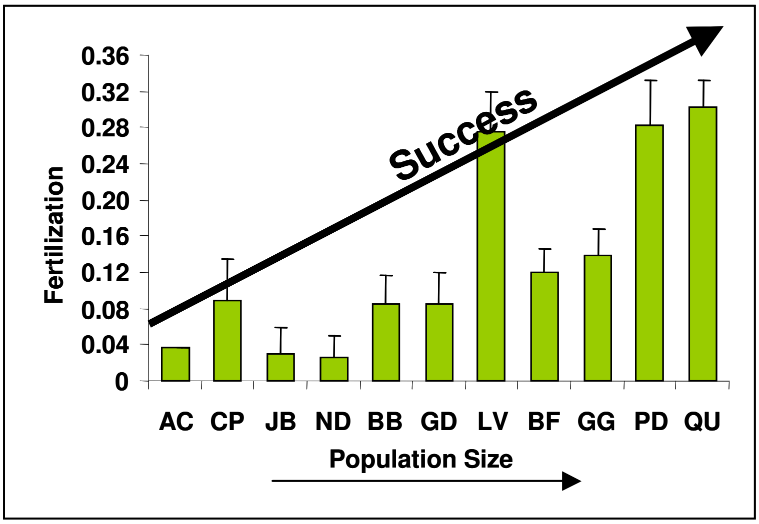


Figure 35: In fragmented landscapes, fertilization success in *Acacia dealbata* increases with population size.

Another study of a self-incompatible species (*Rutidosis leptorrhynchoides*, Button Wrinklewort) show that the number of S-alleles (representing genetic diversity) increase with population size and that seed set rises correspondingly with the number of S-alleles (Figure 36).

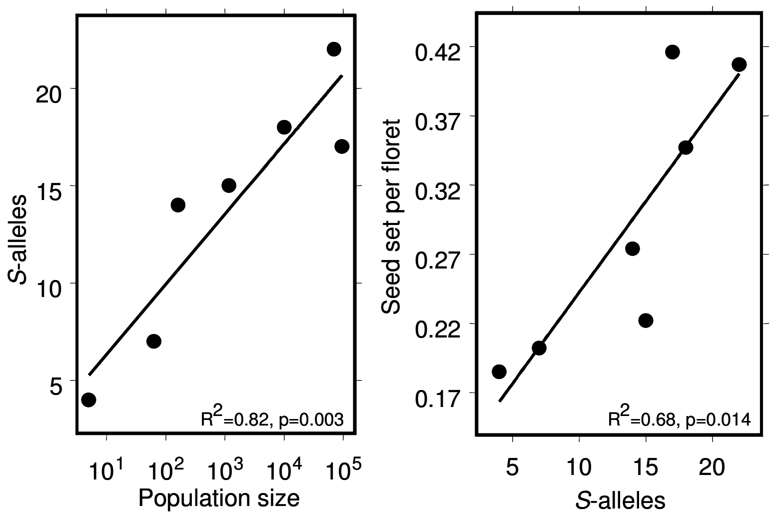


Figure 36: Relationship between population size, number of S-alleles and seed set in *Rutidosis leptorrhynchoides*.

Self-compatible species - inbreeding

Swainsona sericea (Silky Swainson-pea) is a threatened herb species with small fragmented populations. A study to assess inbreeding showed that seed was set in most years but this was confounded by drought and polyploidy. Progeny fitness effects (2n=128 populations) suggest that inbreeding is occurring. Individuals from larger populations have taller progeny (p=0.007) and produce more stems (p=0.037) than those from populations with fewer individuals (Figure 37). The net effect is decreased seedling fitness associated with poor growth.

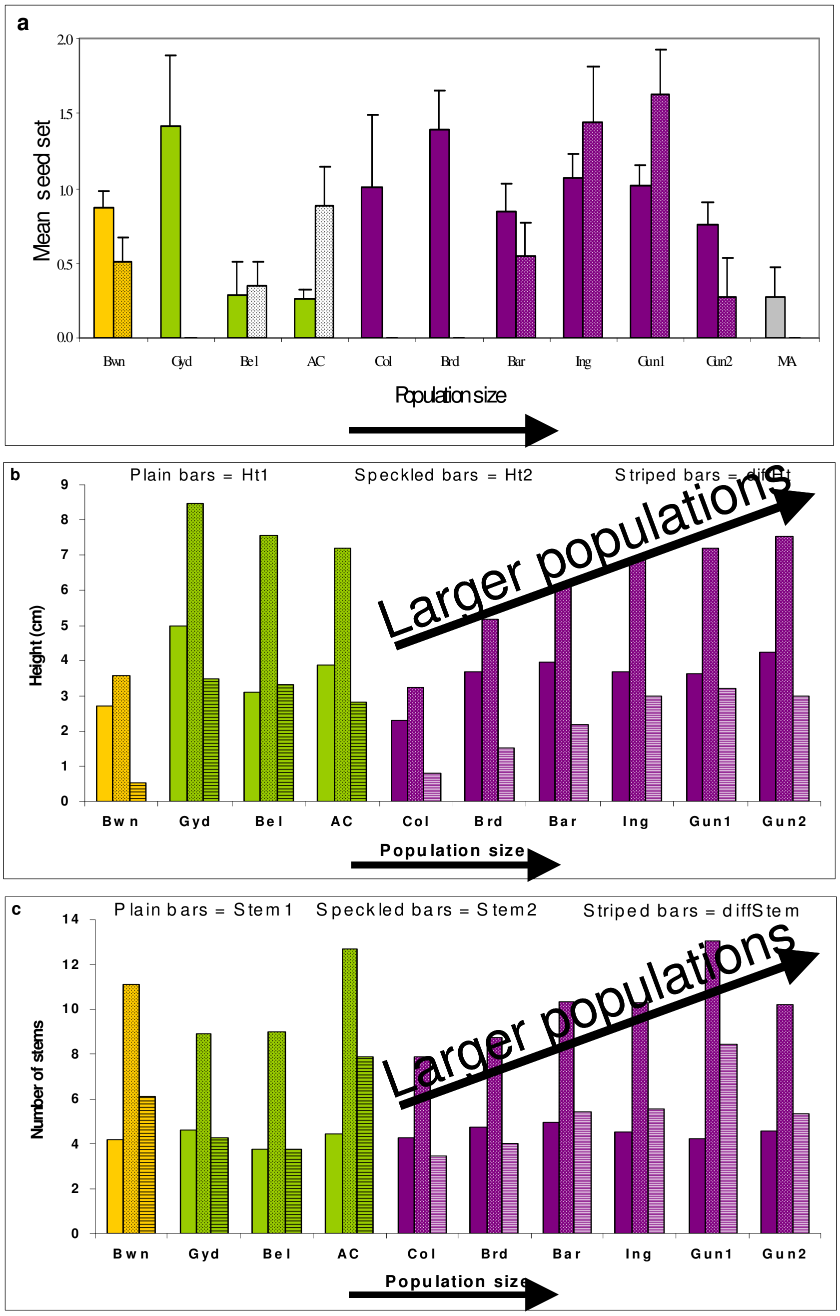


Figure 37: Relationship between population size and number of stems, height and mean seed set of *Swainsona sericea*.

Why is seedling survival so poor? One theory is that the amount of inbreeding that occurs within a population could be important. In small populations that consist of closely related individuals inbreeding depression can occur and this can result in less seed being produced, seedlings taking longer to germinate and those seedlings that do germinate don't survive.

Studies of *Swainsona recta* (Small Purple-pea) show that inbreeding is much more likely in smaller populations than larger populations (Figure 38). This graph shows how related plants are within a population on the left axis and essentially the higher the value, the more inbred the population is. Along the bottom axis we have population size. If we plot the level of relatedness within a population against its size we see that the plants in the small populations are highly related while in large populations this is much less of an issue.

And when we look at individuals from these different populations grown under glasshouse conditions we can clearly see why seedling survival in the small sites is so poor (Figure 38).

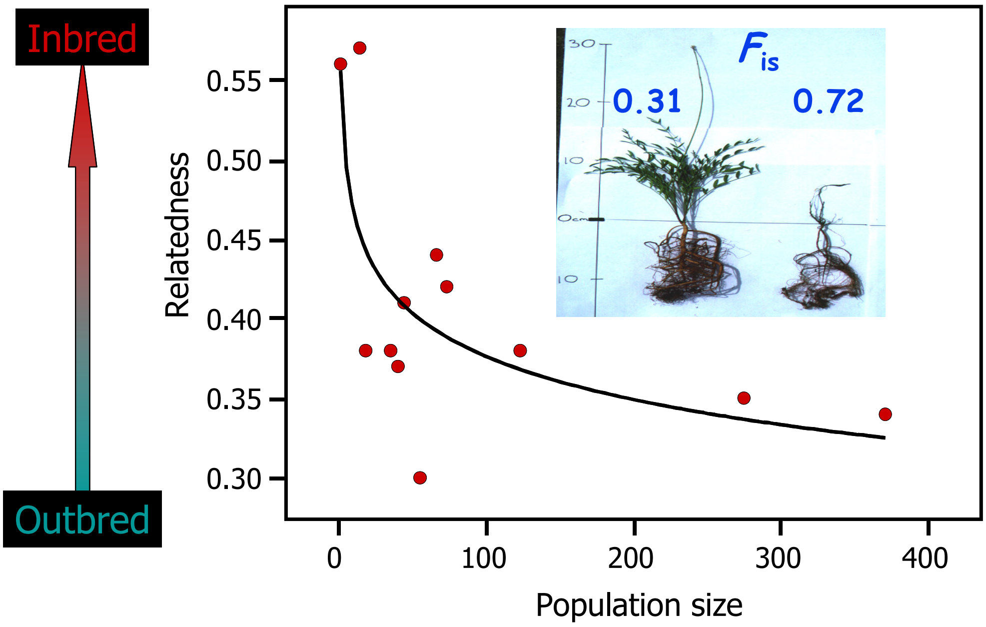


Figure 38: Relationship between population size of *Swainsona recta* and genetic relatedness; picture shows difference in growth between plants grown from seed from large population (left) and a small population (right).

Hybridisation in *Eucalyptus aggregata*

Eucalyptus aggregata is a woodland tree found in the south-east tablelands. It is insect pollinated and has mixed mating. It is highly herbivore resistant. *E. aggregata* is known to hybridise with *E. viminalis* and *E. rubida*.

Seedlings of *E. aggregata* from degraded sites have unusual morphology (Figure 39). It was found that the % hybridisation of *E. aggregata* with either *E. viminalis* or *E. rubida* increased with decreasing population size (Figure 40). Hybridisation rates were different depending on the proportion of eucalypt species at each site (Figure 41).

Figure 39: Morphological leaf variation in *E. aggregata*

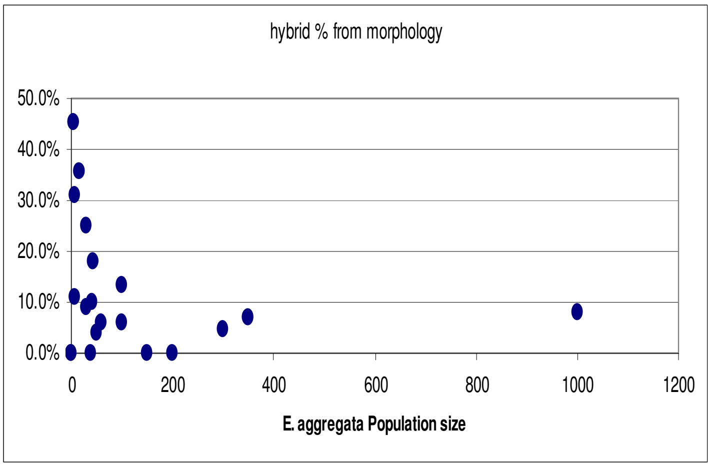


Figure 40: Relationship between *E. aggregata* population size and hybrid production.

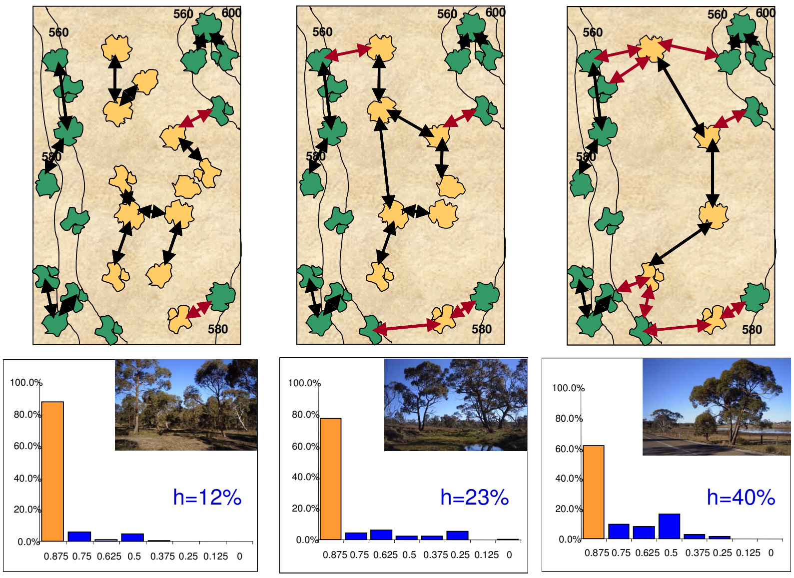


Figure 41: Hybridisation rates vary according to the proportion of each eucalypt species in the remnant.

REVEGETATION AS A SEED SOURCE?

People often ask whether they can use their revegetation as a seed source. In many cases, the answer is probably no given that collections of restored sites may not have included enough genetic diversity to prevent inbreeding and poor quality seed. The CSIRO is currently assessing this with a key revegetation species in Victoria, *Allocasuarina verticillata*. This study will assess genetic structure and diversity, mating system, reproductive output and progeny fitness of different remnant types across the Corangamite catchment (Figure 42).

Seed from small isolated populations and revegetation sites produce much fewer germinants than the other two remnant types (Table 7). This suggests that while some of this seed can be used for revegetation, it should not be the sole seed source.

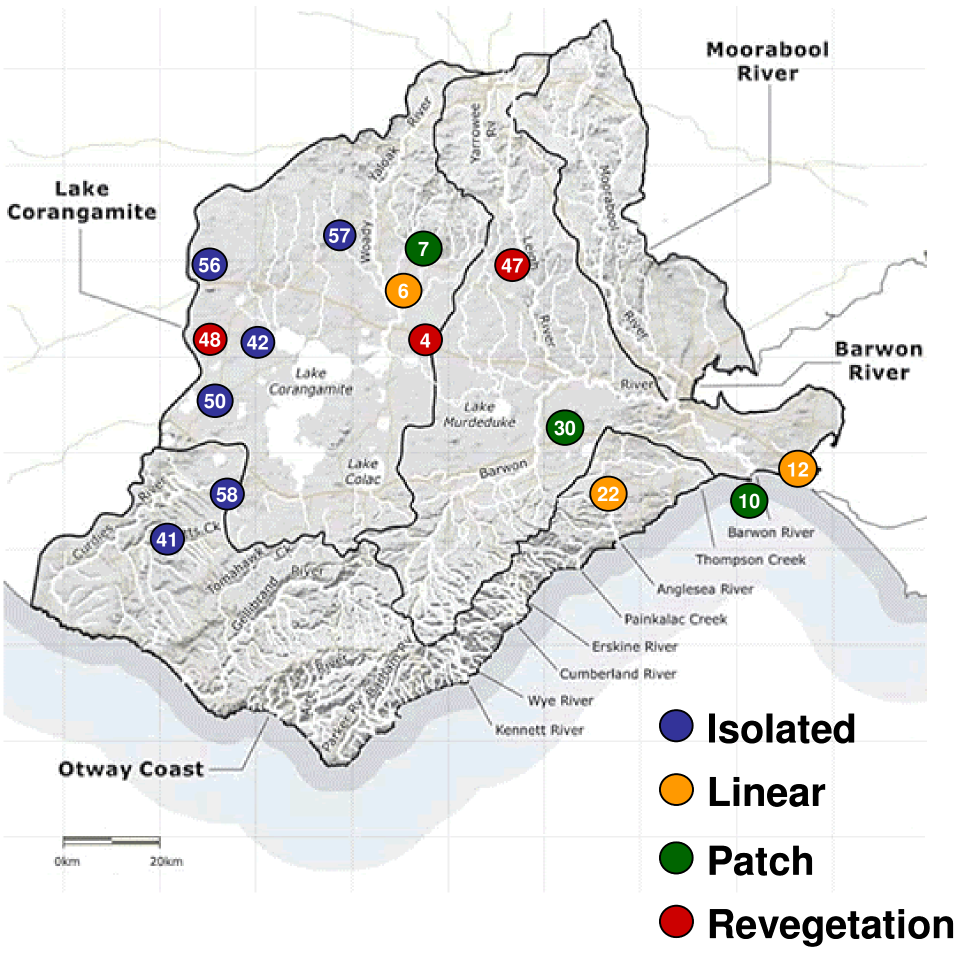


Figure 42: Collection details of *Allocasuarina verticillata* populations in the Corangamite CMA

Table 7: The differences in germination and the number of days between germination of *Allocasuarina verticillata* seeds from the different remnant and revegetation types studied. Numbers in brackets exclude zero values.

Type	Population	% Germination	Mean Days
Isolated	41	5.0	18.7
	42	38.8	17.0
	50	21.7	15.5
	58	23.8	15.5
	56	0.0	0.0
	57	0.0	0.0
Mean		*14.9 (22.3)*	*11.1 (16.7)*
Linear	6	23.8	17.6
	12	18.8	16.2
	22	18.3	16.1
Mean		*20.3*	*16.7*
Patch	7	12.5	18.1
	10	29.0	17.3
	30	20.5	16.6
Mean		*20.7*	*17.3*
Revegetation	4	17.1	18.6
	47	18.1	18.6
	48	6.3	20.1
Mean		*13.8*	*19.1*

PROVENANCE, A TAXONOMIC PERSPECTIVE: ACACIA *AND* EUCALYPTUS

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HOW DO PROVENANCE AND TAXONOMY RELATE TO RESTORATION PROJECTS?

Provenance is the location in which seed is collected. Taxonomy is the systematic classification of plants. Provenance describes and guides where seed is collected from, whereas taxonomy helps to name what was collected.

As a general rule:

- collect local seed (or cuttings) for revegetation (local provenance)
- note the micro-habitat and where things grow and
- make sure it is not a weed (check taxonomy).

Why? Much work is still required with plant classification in South Australia. Many species are poorly defined, and many plant taxa remain undescribed. Consequently plant lists and distribution maps for areas that are used to guide restoration can be wrong, poor or out of date.

Every block of the landscape has a list of native plants, how they are arranged and change over time is open to debate. 'Local' species are constantly disappearing over time. A major effort is required to preserve local provenances of species before they are lost (even if these species may be common elsewhere).

DISJUNCT AND RARE OCCURRENCES

Most areas of South Australia have disjunct or rare species that may be common interstate. These populations need attention if we are to conserve their potentially different local genetics. They may not have distinct species names from the species main populations as such, but could be considered to be unique.

Future study could show that some populations from non-local areas are distinct enough to receive new species names. If seeds or plants are bought from a nursery or supplier, the species name may be correct, but the origin of the material may have been far away. You may be planting a weed with the "correct" species name. Therefore, the last thing you should do is obtain seed or plants from interstate or distant populations! Habitat restorers should always keep the potential complexity of the vegetation in mind.

Examples of rare or disjunct species

The following species are all rare or in small disconnected populations far from their main distribution:

Acacia

- *A. genistifolia* – only one plant is known from a roadside between Clare and Burra, the species is common in the Eastern States.
- *A. glandulicarpa* - several plants are known to occur near Bordertown and around one hundred plants are known from a distant population near Burra. The ability of this species to sucker possibly enabled it to withstand grazing pressure from stock.

Melaleuca

- *M. cuticularis* - occurs in a few saline swamps on Kangaroo Island where it is under threat from hybridising out with the common *M. halmaturorum* which encircles it. This species is common in Western Australia.

Eucalyptus

- *E. globulus* subspecies *bicostata* - a small group of trees recently discovered on a hill near Burra, (though possibly one of the first trees painted in a landscape from South Australia). The large size of some of the trees indicates their substantial age. Also occurs in Victoria and New South Wales. Plants of this species from interstate are becoming weedy in the Southern Loftys. The planting of *E. globulus* plantations in South Australia could also compromise the local population's seed integrity if planted too close.
- *E. sideroxylon* - one large tree on hillside near Yunta. Possible hybrids of nearby mature eucalypts may indicate age.
- *E. dalrympleana* - an example of a disjunct taxon requiring further study with its eastern populations. Restricted to high rainfall areas of the Onkaparinga Valley, Norton Summit, Kuitpo & Parawa. Potentially threatened by any drop in rainfall, can hybridise with *E. viminalis* (so seed viability should be considered).

Discoveries of disjunct/rare occurrences of obvious trees and shrubs are still being made! Much work is still needed for more obscure or poorly collected groups such as orchids, grasses and herbs etc.

Scattered distributions

Many species can have scattered distributions and may not appear on maps or species lists! Revegetators should consider putting a variety of odd plants in their plantings if they are local, instead of just the normal large numbers of a few common species. For example *Eucalyptus diversifolia* - normally considered a common coastal species associated with recent or old coastlines - has scattered occurrences in the Mt. Lofty Ranges in places like Mt. Bold, Black Hill and Clare.

NATIVE AND WEEDY SPECIES

The situation of species both native and weedy is likely to become worse in the future, and probably already exists with interstate/non-local material being planted because it has the "correct name". Molecular fingerprinting of populations may be needed to help unravel some of these problems in the future if no diagnostic physiological characters can be used, although it is not cheap. Some research has also begun examining if "super weeds" are evolving from hybrids between the same or similar species.

Examples of "weedy natives":

Acacia cyclops - native to Western Australia and the west coast of South Australia. Populations from Yorke Peninsula and Kangaroo Island have at times been thought to be natural, though now seem more likely to be weedy. There is also the possibility that some populations could be both weedy and natural (or that they have interbred). Further studies are required to resolve this matter, though the species is spreading rapidly in central and eastern South Australia and needs to be controlled.

Acacia paradoxa - there are at least 2 morphological forms (and intermediates) of *A. paradoxa* in South Australia. A robust spined and round phylloded form from Kangaroo Island and southern Fleurieu Peninsula, and a narrow phylloded form from the Mt Crawford and north. This species was extensively used as a spiny hedge in early settlement and seed from Kangaroo Island was reported being brought to the mainland. Hybrids have possibly formed and spread - it may be possible to study what is native and what is weedy with morphological and molecular studies.

Acacia trineura - native to the Bordertown area in South Australia where a few plants still occur. Becoming weedy in the Monarto area where it is spreading from the city landscape plantings.

Acacia longifolia - there are two recognised subspecies of *A. longifolia* occurring in South Australia, - subspecies *sophorae* is native and predominantly occurs in coastal areas, while subsp. *longifolia* has been commonly planted and has become an aggressive weed in many areas. Just to complicate matters, subsp. *sophorae* has also been planted and is spreading into areas where it did not historically occur. It also appears that the two subspecies may be hybridising into a "super-weed". Possibly the hybrid or a variant of one of the subspecies has been selected for and propagated in plant nurseries due to its vigour and ease of propagation (nurseries only sell & distribute what they can grow).

SPECIES COMPLEXES AND REGIONAL VARIATION

I hope revegetators don't just get a simple species list for a location and source the plants or seed from wherever they can get them, but they do! A species can often exhibit substantial regional variation, it may be so variable that it cannot be adequately named, or it may encounter other related species in different parts of its range and share genetic material. *Acacia* and *Eucalyptus* have many examples of this as follows.

Acacia

A. acinacea - a few years back the names *A. rotundifolia* and *A. acinacea* were used. However a revision found that what was called *A. acinacea* was in fact *A. triquetra* (a coastal species) and that *A. rotundifolia* was part of the variable *A. acinacea* complex (growing from the Flinders Ranges to New South Wales), so till further study, it should be included within *A. acinacea*. This species comprises of a taxon with densely hairy phyllodes and tightly coiled pods that can be seen near Eudunda; a taxon with round glossy green phyllodes that can be seen in the Aldinga Scrub, and a narrow oblong phylloded taxon that suckers which can be see seen in the Adelaide Hills and the Southeast near Bordertown. In places these taxa grade into each other, so consideration should be given to what form of *A. acinacea* is local.

A. brachybotrya - typical *A. brachybotrya* occurs from north of the Murray River south to near Bordertown and has hairs on its phyllodes that stand at 90 degrees. A taxon with appressed hooked hairs occurs in the higher rainfall areas in SA's Southeast, Southern Lofty's, Kangaroo Island, Yorke & Eyre Peninsula's, (it also hybridises with *A. argyrophylla* on Yorke Peninsula). A taxon with tomentose hairs on its phyllodes occurs on western Eyre Peninsula.

A. pycnantha - the taxon occurring in the Flinders Ranges and Northern Lofty's tends to have narrow falcate phyllodes and form a slender small tree. The taxon from much of the Southern Lofty's and Southeast has broad phyllodes and can grow into a substantial tree. There is also a small shrubby taxon from eastern Kangaroo Island.

A. calamifolia & *A. euthycarpa* - *A. calamifolia* can be distinguished by its pods with strong constrictions between the seeds, and occurs in the Flinders Ranges south to near Saddleworth. *A. euthycarpa* is now considered to be a distinct species with straight-sided pods and round to flat phyllodes. It occurs across Eyre Peninsula, the Southern Lofty's, the Murraylands and Southeast. *A. euthycarpa* has three or more taxa embedded within it - a pendulous taxon from the Gawler Ranges, a more widespread terete-phylloded taxon with green-grey phyllodes (which can withstand seasonally waterlogged soils on Kangaroo Island), and a flat-phylloded taxon which can grow into a small tree (examples can be seen near Saunders Creek).

A. retinodes, *A. provincialis* and *A. uncifolia* - an example of three species from distinct habitats that were previously confused under the name *A. retinodes*. I have had reports of the wetland species being planted on dry hillsides and coastal dunes with the subsequent underperformance and death of the plantings. The wetland species was commonly grown in nurseries and had the “correct” name for the plant list for the area.

A. retinodes is a moderately long lived species that occurs from Mt Bryan south to Cape Jervis. It grows on hills and slopes (away from water), develops into an upright tree, has a single flowering period from December till February, black rough bark and suckers.

A. provincialis (commonly called *A. retinodes* for over the last hundred years) typically lives for 10-20 years, occurs from Mt Crawford south through the Fleurieu Peninsula and Kangaroo Island, then from the Glenelg River and Grampians east to near Melbourne. It is largely restricted to moist valleys, watercourses and swamps. It can develop into an open shrub or small tree, has a spring-summer flowering peak, but can flower throughout the year, has smooth grey bark and does not sucker.

A. uncifolia is moderately long-lived and has a disjunct distribution from Waitpinga Beach, Kangaroo Island, Torquay to Geelong and Wilson's Promontory and King and Flinders Islands in Bass Strait. It grows on coastal dunes or sand over limestone, develops into a dense shrub or small tree, has a spring to late summer flowering peak but can flower throughout the year. Its bark is smooth, grey and suckers.

Eucalyptus

E. leucoxylon – SA Blue Gum - a good example of a complex species that is mostly divided into several subspecies. One problem is that some lists and maps only distinguish it to the species, not subspecies level. To make matters more complex (and locally more unique) many of the subspecies grade into each other.

E. leucoxlon subsp. *leucoxylon* occurs in a small area in the southern Flinders Ranges, through most of the Southern Lofty Ranges, Kangaroo Island and in the lower Southeast. The area near Monarto has a large flowered but small leaved tree that has received no formal status (it is included for the time being under subsp. *leucoxylon*). This is probably the origin of the *E. leucoxylon* '*rosea'* tree that is commonly sold in nurseries around Australia, and is commonly planted in Adelaide gardens. Where *E. leucoxylon* and *E. porosa* come into contact, hybrids between the two are fairly common.

E. leucoxylon subsp. *pruinosa* occurs from the Southern Flinders south to near Gawler and Angaston, then from near Kingston and Bordertown.

E. leucoxylon subsp. *stephaniae* occurs from near Meningie to north of Bordertown.

E. leucoxylon subsp. *megalocarpa* occurs from near Robe south to Port MacDonnell.

E. petiolaris from Eyre Peninsula is considered distinct enough to be considered a separate species (it was previously treated as a subspecies). It commonly has yellow flowers, but is distinct in having juvenile leaves with petioles.

DON'T FORGET MICROHABITATS!

It is not unusual to find localised areas or small microhabitats with different vegetation to the general area. Again consider the possible complexity of an area. For example, near Mt Beevor a rocky hilltop with mallee species might be composed of *Eucalyptus odorata*, *E. incrassata*, *E. phenax* subsp. *phenax*, *Melaleuca acuminata* and *Callistemon teretifolius* surrounded by tall woodland of *E. leucoxylon* subsp. *leucoxylon* and *E. fasciculosa*. While south of Naracoorte, a remnant block of vegetation of dunes and swales with mallee species and heath might be composed of *Eucalyptus arenacea*, *E. wimmerensis*, *E incrassata*, surrounded by *E. leucoxylon* subsp. *pruinosa* and *E. microcarpa* woodland.

MATTERS WORTH DEBATING OR THINKING ABOUT

If seed viability is low, or diminishes in small remnant populations, should there be a programme of bringing together separate remnant populations to form viable seeding populations or regional living seed banks/plantations? How local should this be? What would be the limits of this? This could be a revegetation strategy, though the plantings would not be natural, and lack the balance of mixed plantings.

CHANGING COMMUNITY PERCEPTIONS ON RESTORATION PLANNING AND MANAGEMENT

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COMMUNITY PERCEPTION OF RESTORATION

The community's perception of habitat restoration is often limited to 'tree planting' exercises only. Whilst putting all our efforts into revegetation our existing patches of bushland continue to degrade. It is pointless creating new 'habitat' if we can't even look after what we've currently got. Revegetation can be useful in the long term but has minimal to no ecological value in the short term.

Generally community perceptions include one or all of the following:

- planting trees
- shelter belts
- corridors
- revegetation of previously cropped land
- manipulation of past revegetation
- removing weeds from existing bushland
- putting up bird/bat boxes.

In the right context, all of these are useful.

It is critical to understand a community's perception. How do we advance community perception? Are they willing to have their perceptions change? Some people are happy to plant trees, others just to kill weeds. Each person may require a different approach to be used. Most are 'sponges' that will soak up information.

COMMUNITY EXPECTATIONS AND UNDERSTANDING

What does the community expect to get out of their project: a feel good exercise or a genuine contribution to biodiversity conservation? Stop global warming by planting trees?

Most people get their understanding from looking at common media. Most people want to do something useful, but have no idea how to do it and don't know where to start – the message they get is that you go out and plant a tree for a day. Maybe that is all they have time for. Is this so bad? It depends on the context of the project. Maybe they need to be directed to another project.

HOW DO WE ADVANCE COMMUNITY PERCEPTION?

We need to know what is the context of a community project and why WE are involved. We should be able to provide expert advice on a subject that the average citizen does not understand or at least we can find expert advice if we are not sure ourselves.

Is it a funded project? Does it need co-ordination across a large area? Does the community understand why the project is being done? Experts, advisers and project officers etc need to communicate clearly with community members to find out the answers to these questions, then develop a relationship based on trust. Communication needs to be clear, engaging, and inclusive and help people to see themselves as part of the landscape (health, recreation, resources etc). Our landscape is truly unique in Australia; it actually defines who we are.

Don't over commit community members or yourself - everyone knows the burnout situation. This can be a fast way of losing a project. Expectations of achievements must be realistic.

PRIORITISING EFFORTS; RESTORATION TO REVEGETATION

In prioritising efforts:

- identify what is the expected outcome (context) of the project - can it be improved to gain greater ecological outcomes?
- convey ecological theory to the community – it should be easily understood but not be oversimplified
- not everyone will understand or accept ecological objectives – work most with those who want to understand and will be most productive
- use basic biodiversity conservation principles (many resource materials are well known to practitioners but less so in the wider community)
- existing vegetation provides ecological function, revegetation provides fewer ecological benefits (in the short term) so the priority is to protect what is left first (both common and threatened species)
- remove/manage threats from existing bushland eg weeds, cats, foxes (taking care not to have off-target impacts) and follow up
- allow natural processes to happen, eg let an area become 'messy' with fallen timber, give bushland time to regenerate – overall, natural regeneration is ecologically and economically more effective and efficient than 'revegetation'
- do not be in a rush to put a human stamp on an area
- revegetation should be the last consideration (eg useful for targeting threatened species or if working in an area previously cropped or with improved pasture), although often for the community it is the first thing to be done – this community perception should be changed for more effective restoration planning and management.

REVEGETATION – GENERAL PRINCIPLES FOR RESTORATION

If revegetation is to be done, the following general principles should be incorporated where relevant:

- bigger is better, in blocks not strips
- look for connectivity within the landscape

- if buffering remnant vegetation, don't revegetate right up to the remnant – leave a space so that they can merge together
- use local species (communities need to be advised about the risks associated with using other species if planting in response to expected climate change, but this is very specialised advice).

Implementing the cautionary approach:

- the community should stick to what is readily accepted by the ecological community using basic biodiversity principles unless it is clear that an experimental approach is being taken
- collect seeds locally
- don't plant into remnant vegetation – if possible wait about 4-5 years before you revegetate – sometimes the site will regenerate through ecological processes
- don't make too many changes too quickly – observe what is present, facilitate natural processes to occur and monitor
- don't become a threatening process yourself!

Maintaining momentum:

- encourage open, honest and frank discussion – if an answer to a question is not known, say so; build trust and respect so that constructive criticism, if needed, is not a problem
- ensure the community knows what it is getting into and advise realistic timelines – false expectations lead to disappointment and failure
- encourage the community (if they want to) to learn common species as this motivates and helps develop observation skills
- be prepared to learn from community members (eg by working in the field with them)
- provide the community group with some easy wins and celebrate them, eg photo-points, developing plant and animal/bird/bat identification skills.

CONCLUSIONS

The following summarises an approach to engaging the community in restoration projects rather than just a 'tree-planting exercise':

- first priority is always biodiversity conservation
- develop a credible relationship with the community group and gain their trust
- always protect and manage existing remnant vegetation before undertaking revegetation
- implement broadly accepted ecological principles
- celebrate successful outcomes with the community.

INTERVENTION OR REGENERATION: TO PLANT OR NOT TO PLANT?

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REVEGETATION OR BUSHLAND MANAGEMENT?

Interested people deal with degraded vegetation of varying types and carry out revegetation for a range of different needs, not just for habitat restoration. Farmers, for example, want shelter for their stock, salinity control and landcare benefits which revegetation can play an active part in.

If we are aiming for biodiversity conservation however, there is not enough emphasis on managing existing bushland. The ‘Bush for Life’ program began in 1994, through Trees For Life, to increase the focus on bushland management. The Bush for Life program is about letting the bush regenerate itself, with some assistance, over a long period of time. It was not the perfect program but we continue to learn everyday from our members who are out on-ground.

We have to engage the broader community to carry out bushland management. There are around 10 000 members in Trees for Life. We train about 600 people in bush regeneration techniques, but around 6 000 people would be better to meet the demands of our degraded bushland. The success will depend on the efforts that volunteers put in and that depends on the time gaps they have in their life. A small percentage of participants become highly trained.

TO PLANT OR NOT TO PLANT

‘To plant or not to plant’ needs to be assessed on a site-by-site basis given the context of the location you are working in. Most landholders do not have the skills to manage biodiversity on their property. There is a shortfall of trained practitioners who can assist with management issues.

The management “continuum”: cropped or ploughed land is at one end of a spectrum (degraded) with good bushland containing few weed species at the other end (intact). At the most degraded end of the scale, it is fairly easy to undertake revegetation, especially if there are landcare objectives (eg erosion control etc). Revegetation to achieve biodiversity objectives is a more complex issue that requires specific design and placement.

Good bushland can be looked after by relatively few people more efficiently, as long as the right strategies are in place (just fencing bushland is not enough). The more difficult areas to manage are the areas that fall in between (patches with degraded vegetation). Such areas might be where trees have been removed leaving parts of the understorey (eg grasslands that were grassy woodlands), or where the understorey has been grazed out of a woodland.

The areas that are semi-degraded are harder to look after and this is where revegetation might come in. The main question to decide if revegetation is appropriate in this context is "will recruitment occur if all threatening processes have been alleviated?" This question needs to be asked periodically for the duration of a project to allow for changing conditions.

Threat abatement should occur first, to allow for regeneration to occur naturally. Threat abatement can include removal of stock grazing, rabbit control work, weed management (eg using herbicides, slashing and/or manual removal). Threat abatement activities will enable work to be completed elsewhere on the properties.

Revegetation should be a last resort but may be appropriate in some contexts. Examples include:

- where disturbance has created a highly modified environment (eg extensive areas damaged by rabbit warrens)
- buffering exposed sites - eg buffering lone Sheoaks in a windswept landscape with more planted trees is threat abatement in itself
- planting into previously cropped areas
- eroded sand blow-outs
- amenity and for the 'management of landholders' (eg where the landholder insists that they want to do revegetation – to keep good will and develop momentum and education, sometimes it is better to find areas to plant initially).

So semi-degraded bushland/grassland areas should not be revegetated initially, only after a period of time has passed to assess the regenerative potential once threat abatement has occurred. Revegetation may then be used to add missing elements (key species that have not regenerated or have become locally extinct).

FRAMEWORK FOR DECISION-MAKING

Year one

1. Ascertain site history (eg grazing, cropping, wood cutting etc).
2. Site assessment (species present, threats).
3. Plan and set objectives.
4. Set up a monitoring program.
5. Undertake threat abatement activities.

Subsequent years

1. Wait, re-assess the situation periodically.
2. Adjust management regime as necessary to meet objectives (this may then require some revegetation).
3. Review plan and assess objectives.
4. Continue threat abatement.
5. Continue monitoring and re-assess periodically.

For simple monitoring, photo points can be inspiring to people. The community must be involved, as all of these rehabilitation/revegetation actions require a labour force. There must be a learning pathway and encouragement given along the way to show people the benefits of their work and to keep them motivated.

Property Example 1

Ascertain site history

Degraded Sheoak grassy woodland at Palmer, bought in 2001. The property had been conservatively grazed and hence quite a few native species were left, but mainly in an open grassy state that looked quite degraded (Figure 43).

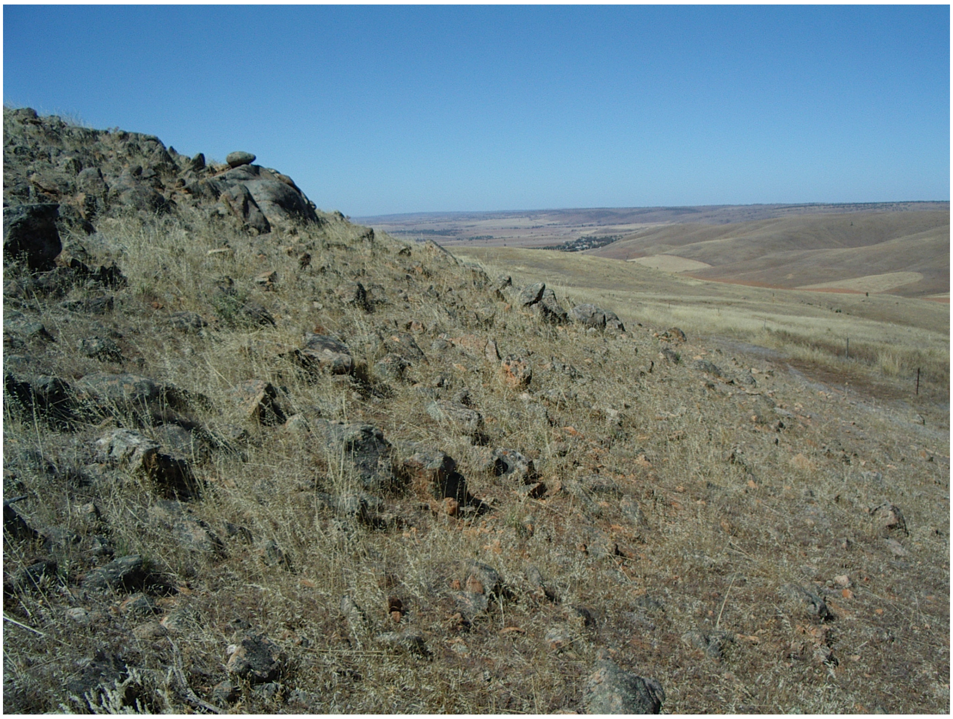

Figure 43: Property at Palmer with varying extent of native grassland areas

Site assessment

Initially, the landholder wanted to revegetate all of the property to a more natural state because he assumed there was nothing of value there. A site assessment showed a good number of remnant species present, especially away from water-points and thus there was good potential for regeneration.

Plan and set objectives

Increase native plant diversity. Large-scale revegetation was discouraged, but stock were removed across the property to promote regeneration instead. One area of cropped land was planted – direct seeded in 2002 – and some amenity planting occurred near buildings. Intervention was needed – but properly controlled.

Set up a monitoring program

Photos were taken periodically and the site was viewed by technical experts to assess species changes.

Undertake threat abatement activities

Emphasis was put on weed and rabbit control rather than revegetation.

Reassessment

Enough regeneration has occurred as a result of threat abatement activities that the landholder has felt discouraged from any further revegetation without undertaking a good site assessment first.

Property Example 2

Ascertain site history

Eleven hectares at Palmer, partially cropped, but most of the property was used for rough grazing.

Site assessment

Rabbits were a big problem!

Plan and set objectives

The initial objective was to control threats – rabbits as a priority, then to rehabilitate, trialling revegetation on the most disturbed areas.

Set up a monitoring program

Photographs were taken at photopoints.

Undertake threat abatement activities

Rehabilitation began eight years ago. The rabbits were eliminated and the areas monitored.

Reassessment

Trial revegetation occurred over old rabbit warrens and on the cropped areas. Ten species from local seed sources were planted. Surprisingly, thirteen species (including many native grasses) have also regenerated naturally over the eight years (Figure 44). This proves that given time, many systems will start to bounce back.

Future management will encourage further natural regeneration, improve revegetation structure (eg through thinning areas that are too dense) and add missing elements.

Figure 44: Unexpected natural regeneration has added diversity to this revegetation site at Palmer.

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MONITORING AND EVALUATION

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WHAT IS MONITORING AND EVALUATION?

Monitoring is to observe a situation for any changes that may occur over time. *Evaluation* involves making judgments about the merit or worth of something.

> *'Monitoring is essential if progress in a project is to be evaluated'*
> (Lake 2001 p. 111).

There are many and varied things that can be monitored. These include, but are not limited to: vegetation, structure, cover, native species, exotic species, functional groups, soil nutrients, water quality, hydrology etc. It is therefore important to relate monitoring and evaluation to the specific goal/s of the (restoration) work.

MONITORING AND EVALUATION PRINCIPLES

Krebs (1999 p. 2) outlined some key rules relating to experimental design that are worthy of note:

Rule 1 – Not everything that can be measured should be.
Rule 2 - Develop clear objectives.
Rule 3 - Collect data that will achieve your objectives.

Hobbs and Norton (1996 p. 94) suggest a number of key processes in restoration. Many are directly related to monitoring and evaluation, namely:

- develop project goals
- develop easily observable measures of success
- monitor key system variables
- assess progress of restoration relative to goals and
- adjust procedures if necessary.

MEASURABLE ECOLOGICAL ATTRIBUTES

Ecological attributes measured in restoration-*type* projects include:

- species diversity and abundance
- richness, abundance and evenness of distribution
- structure of vegetation or other organisms and

- ecological processes and function.

Most measures are across one trophic level (eg birds, tree species diversity) but should be done across several depending on how much information is needed.

Species Diversity and Abundance

To measure species richness in plant communities, various approaches to the sampling problem have been suggested by Krebs (1999 pp. 412-423): ‘jackknife’ estimates; ‘bootstrap’ procedures; ‘rarefaction’ methods and species area curve estimates.

Examples:

- using species area curves to measure species diversity - see Heard and Channon (1997)
- measuring flora diversity (in plantations) - see Wang *et al.* (2004)
- measuring vegetation structure (in alpine areas) – see McDougall (2001)
- measuring vegetation structure (in grasslands) – see Reseigh *et al.* (2007).

Ecological processes

Ecological processes include nutrient cycling, biological interactions, seed dispersal and pollination. For an example of measuring ecological processes (soil changes) see Wilson (2002).

APPROACHES TO EVALUATION

Effective project evaluation requires more than simply monitoring. Approaches to evaluation of data associated with projects include direct comparison, attribute analysis and trajectory analysis. For an example of evaluation (of the restoration of a grassy woodland) using trajectory analysis see Wilkins *et al.* (2003).

Practical constraints on monitoring and evaluation projects include:

- the need for long-term commitment
- the cost is usually high and
- monitoring requires records of observations, data and the testing of hypotheses.

NATIVE VEGETATION ACT 1991

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HISTORY OF CLEARANCE CONTROLS IN SA

The major steps in the development of native vegetation clearance controls that occurred in South Australia from 1974 are listed in Table 8.

SIGNIFICANT ENVIRONMENTAL BENEFIT (SEB) OFFSETS

General principles/policies include:

- the establishment of an SEB only applies when clearance consent is granted or where avoidance of native vegetation clearance under an exemption is not possible and
- must replace like with like, unless a better outcome is identified.

SEB priorities are to:

- protect and manage existing blocks of native vegetation
- restore areas degraded by land use history or re-establish native vegetation on cleared land
- achieve offset on the site of clearance, adjacent land or same region of the state *or* through a payment into the Native Vegetation Fund – to be used for the same outcome
- achieve a higher value offset for any higher value vegetation cleared eg offset from two times the area cleared up to ten times the area cleared (2:1 - 10:1) depending on vegetation value.

Mining operations may gain a discount if the mine site is rehabilitated post mining to an ecological standard. Payments to the Native Vegetation Fund are based on land value plus a management cost.

NATIVE VEGETATION COUNCIL FUNCTIONS

The functions of the Native Vegetation Council include:

- preservation, enhancement and management of existing native vegetation
- the re-establishment of native vegetation:
  - through the use of SEB payments into the Native Vegetation Fund and
  - by providing for the protection of voluntary revegetation works

- research into the preservation, enhancement and management of both existing native vegetation and the re-establishment of native vegetation on cleared land.

The Native Vegetation Council has delegated some decision-making:

- mining issues have been delegated to PIRSA - Mineral Resources Division
- outsourced/third party data collection possible by NVC accredited consultants
- landholders assisted with processing applications.

Table 8: Summary of the development of clearance controls in South Australia.

Year	Development
1974	Interdepartmental committee formed to review vegetation clearance in SA
1981	Voluntary controls (Heritage Agreements) introduced
1983	*Planning Act 1982* – controlled change of land use – no compensation
1985	*Native Vegetation Management Act 1985* – including 'compensation' entitlement
1991	*Native Vegetation Act 1991* – controls tightened – no compensation entitlement
1999	Major review of legislation
2003	Act and Regulations amended ○ end of broadacre clearance for farming (intact stratum) ○ clearance conditional on achieving a significant environmental benefit (SEB) to offset clearance impacts ○ legislation binds the crown and mining operations – SEB required ○ increased penalties for illegal clearance ($100,000 or $2,500/ha fine, penalties paid into the Native Vegetation Fund, - where conviction recorded, NVC must initiate civil action to 'make good' the clearance) ○ other enforcement options including expiation notices and make good orders for minor clearance ○ revegetation encouraged (voluntary protection under agreement now provided for, through registration on property title)
2004	Better relationships with landholders - initiative implemented to encourage landholders to value and afford improved biodiversity outcomes, including: ○ reduced red tape for minor clearance (eg lopping of branches) – potentially no SEB requirements ○ increased flexibility ○ to allow some clearance at variance with principles possible subject to SEB ○ capacity for landowners to use accredited consultants for assessment ○ increased support for landholders to develop positive outcomes (eg regrowth management)
2007	Review identifying potential amendments to Act and Regulations (yet to be considered by Parliament): ○ SEB possible outside region of vegetation clearance, subject to Native Vegetation Council endorsement ○ exemption for expansion of cemeteries (recognised potential impacts on important remnants)
2007	Review of the administration of the legislation – improved linkages with the Development and NRM Acts.

FUTURE DIRECTIONS

A communication program is being developed, with some regional meetings held in 2006 and more to be done in 2007. Looking to NRM Boards to help define priorities and value add to regional biodiversity conservation via SEB works.

No policy yet on whether areas that are being managed for a biodiversity outcome with the use of public grant funds can also be used as SEB offset areas (concern regarding “double dipping”) from the Native Vegetation Council – this is currently up to funding bodies to decide.

Guidelines for mining SEB offsets have been completed; ‘scattered tree’ issues are still being finalised[2].

Miscellaneous amendments to the legislation are out for consultation (at the time of writing). It is a process of ongoing development – particularly the interaction with other legislation through a review of the administration of the legislation due to be completed by July 2007.

Further information on the Native Vegetation Act 1991 and Native Vegetation Council available from the following website: http://www.dwlbc.sa.gov.au/native/index.html.

[2] The development of the guidelines were in progress at the time of the workshop but have now been finalised – see http://www.dwlbc.sa.gov.au/native/index.html

CASE STUDY 1 - BANGHAM VEGETATION LINKS PROJECT

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BACKGROUND

The Greater Bangham District lies between Naracoorte and Bordertown in the South East of SA. It is predominantly grazing country with some cropping.

The Bangham Vegetation Links project forms part of the Upper South East Dryland Salinity and Flood Management Program. The project began in 2005 with an on-ground works budget of $400 000. The general aim was to protect and improve biodiversity in the area.

Most landholders in the Upper South East are eligible for biodiversity stewardship payments under a "Project Levy – Biodiversity Offset Scheme". Landholders in three disjunct areas known as "Zone D" however are not eligible (Figure 45).

The Bangham Vegetation Links project originally came about to offer financial incentives for biodiversity conservation to landholders in Zone D in recognition that there are high conservation assets in that area. The funding is tied to the same "rules" as the Biodiversity Offset Scheme.

COMMUNITY PARTICIPATION

In order to seek community input into the development of the project, a steering committee was formed with representation from local Agricultural Bureaux, South Australian Farmers Federation (SAFF), Birds Australia, DEH, DWLBC, PIRSA, the SE NRM Board, indigenous groups and the general community. The resulting committee was made up of six community members and three agency staff and was run with the support of Rural Solutions SA staff.

The Steering Committee commenced in April 2005. This group was involved in all decision making for the structure and functioning of the project.

"Tell Me and I May Forget, Show Me and I May Remember,

INVOLVE ME AND I WILL UNDERSTAND"

Through meeting with the steering committee, the project staff could build capacity of local landholders, build rapport/respect in the community, establish links within the community and obtain regional knowledge and intelligence.

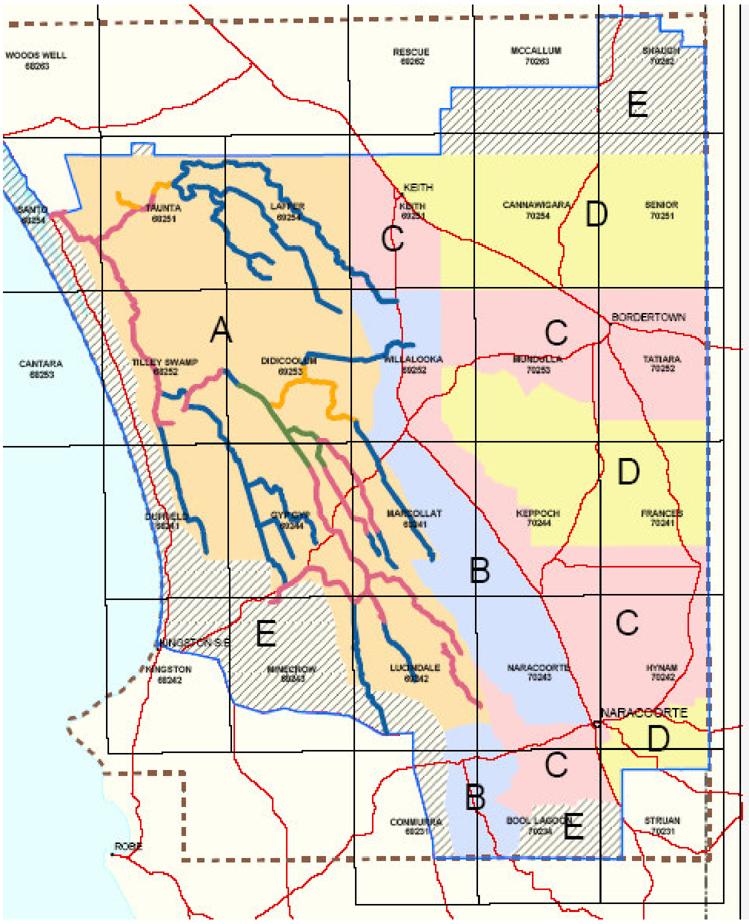

Figure 45: Zones A to E of the Upper South East Dryland Salinity and Flood Management Program – Zone D encompasses the Bangham District (yellow, centre right).

REGIONAL PRIORITISATION

The Steering Committee helped to identify the major threats to biodiversity within the Greater Bangham District including:

- stock grazing of native vegetation
- fragmentation
- lack of financial and labour resources of landholders to manage native vegetation assets.

The central area of Zone D (ie the Greater Bangham District) was targeted to provide financial incentives to private landholders. The area was chosen due to the extent of core areas present as remnant vegetation of which 5% was in the reserve system and 46% in Heritage Agreement areas (Figure 46). The remainder of vegetation (around 6 000 hectares) occurred on private land and was targeted for improved protection and management.

The vegetation in the Bangham district is primarily *Eucalyptus* woodlands, scrubs and mallee and areas with Native Pine (*Callitris*).

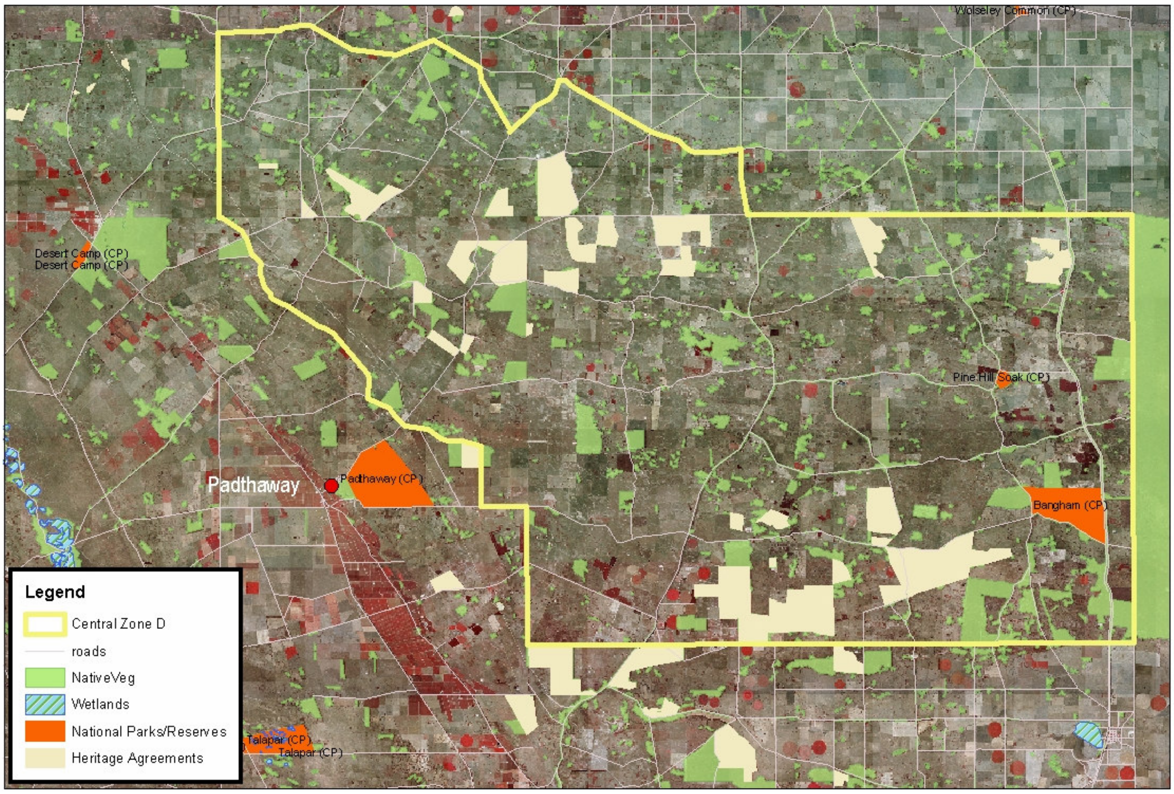

Figure 46: Vegetation cover and tenure in the central Zone D area (Greater Bangham District) – with Little Desert National Park (Vic) adjoining (at right).

ASSESSMENT METHODOLOGY

The process of engaging landholders to apply for incentive funding is as follows:

- expressions of interest sought through targeted mail-out and print media
- interested landholder's properties visited by technical staff
- 'Bushland Condition Monitoring' (modified from the Nature Conservation Society of SA) undertaken for each vegetation community at each site
- input data into SABAT database (SA Biological Assessment Tool, which utilises Microsoft Access and ArcMap)
- calculation of Biodiversity Significance Index (BSI) (through SABAT) for each site

What is a Biodiversity Significance Index (BSI)?

The BSI is a score out of 100 that values patches of vegetation based on landscape context (LC), habitat condition (HC) and conservation significance (CS) of the vegetation type.

The total BSI score is out of 100 = [(CS+LC)*HC]/200.

Landscape Context (LC)

LC takes into account: adjacency to other remnant vegetation; connectivity with other remnant vegetation; the area : perimeter ratio of the patch; percent vegetation in 1.5 km radius (calculated automatically from data layers in ArcMap).

Habitat Condition (HC)

Bushland Condition Monitoring methodology (modified by the Nature Conservation Society of SA specially for the Upper SE Program) is utilised to quantify plant species and structural diversity, weed abundance and native plant recruitment

Conservation Significance (CS)

The vegetation community type is weighted by its regional conservation significance as based on information in the Biodiversity Plan for the South East of SA (Croft *et al.* 1999).

PROJECT INCENTIVES

The following incentives were offered to landholders who's applications were successful:

- stewardship funding calculated at $10/BSI score/hectare
- plus fencing incentives (for new and upgrading of existing fencelines).

The average result was $50/ha/year (for 15 years – includes fencing and stewardship incentives). This involves:

- funding to be paid in instalments over 5 years (on signing of a Management Agreement then at Yr 1, Yr 3 and Yr 5) and
- regular monitoring over the initial 15 years (landowner completes annual monitoring forms as a minimum).

PROJECT MANAGEMENT AGREEMENT PLANS

The Management Agreement is a legal covenant between the Minister and the landholder - on title in perpetuity. The management plan is for a 15 year period and identifies:

- objectives
- conservation values
- threats
- priority management strategies
- requirements
- conditions.

The management expectations revolve primarily around stock exclusion or strategic grazing management and pest animal and plant control.

PROJECT OUTCOMES

The value of initial expressions of interest exceeded expectations. Additional funds of $800 000 were sought and approved through DWLBC. The area covered by the project was also expanded in order to include some threatened vegetation types in nearby areas.

Stage 1 of the project has resulted in over 1 000 ha of remnant vegetation under legal agreement. Over $700 000 in stewardship and fencing incentives have been approved.

Stage two of the project (in 2007) will value add to Stage 1 outcomes and target threatened vegetation communities over a larger project area.

CHALLENGES AHEAD

The following have been identified as future issues for the Bangham Vegetation Links project:

- sourcing follow-up funding for monitoring vegetation condition and project outcomes
- providing on-going technical support for landholders with management agreements
- maintenance of landholder motivation to manage sites and
- access to funding for regional animal and plant control programs to value-add to project outcomes.

ACKNOWLEDGEMENTS

The Author wishes to acknowledge the following for the support, funding and/or development of the Bangham Vegetation Links project:

- Upper South East Dryland Salinity and Flood Management Program
- Department for Water, Land and Biodiversity Conservation
- National Action Plan for Salinity and Water Quality
- Bangham Vegetation Links Steering Committee and associated organisations
- Rural Solutions SA and
- participating landholders.

CASE STUDY 2 - LARGE-SCALE REVEGETATION AT MORELLA

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BACKGROUND

We are told there is a need to think big, to achieve more restoration at a landscape scale and that the situation is urgent. Morella is the site of one of the few projects in South Australia where large-scale revegetation has been achieved in a short time frame.

Morella is located in the Upper South East region near Salt Creek (half way down the Coorong between Meningie and Kingston). It is situated between the Coorong National Park and Martin Washpool Conservation Park.

Morella Station was a 2370 hectare private grazing property. It contains an 800 hectare natural wetland basin at the terminal end of the Tilley Swamp watercourse and connects to the sea via Salt Creek. In 1998, Morella was purchased by the State Government of SA, through Primary Industries and Resources SA. The purchase allowed the wetland basin to be utilised as a pondage basin for drainage waters under the Upper South East Dryland Salinity and Flood Management Program.

After purchase, approximately 535 hectares of land surrounding the wetland basin was designated for stock removal and native revegetation in three ‘stages’ (Figure 47).

PROJECT MANAGEMENT AND FUNDING

The Upper South East Dryland Salinity and Flood Management Program Implementation Group and the Coorong and District Local Action Planning (LAP) Group set project objectives and guided management. Direct project management and implementation was my responsibility through Rural Solutions SA.

Management funding came from the State Government (ie PIRSA, through the “Salt to Success” program) and on-ground works funding came from the Natural Heritage Trust (through the Coorong & District LAP Program).

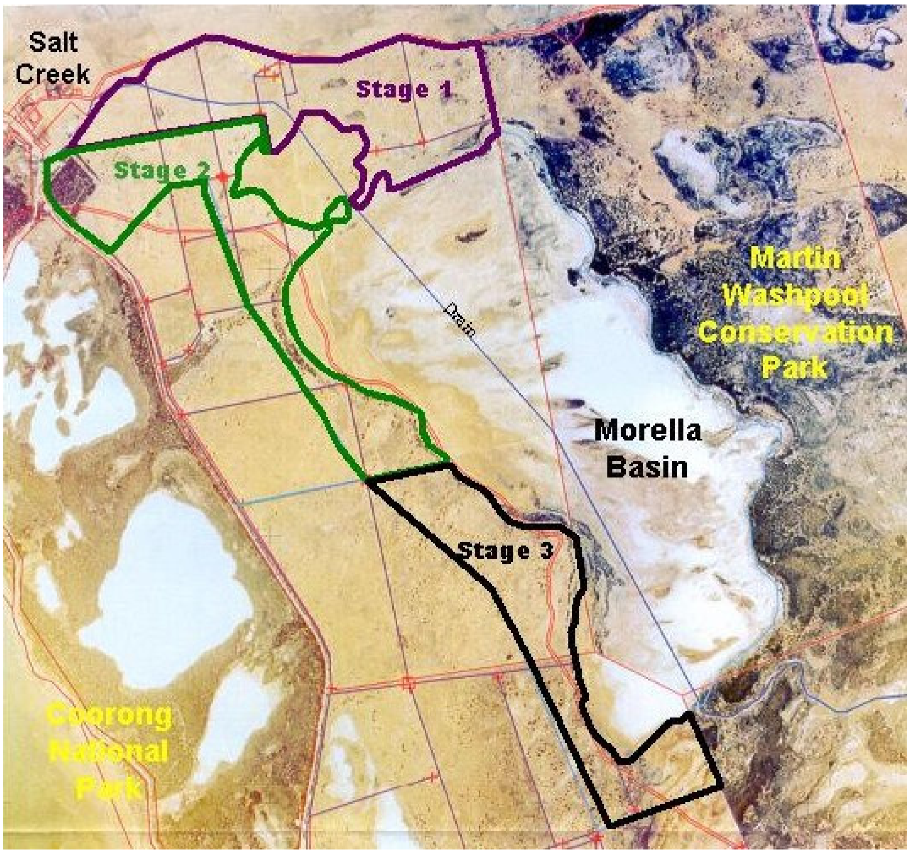

Figure 47: The 535 hectare area around Morella Basin revegetated in three 'Stages' – Stage 1 in 2001, Stage 2 in 2002 and Stage 3 in 2003.

PROJECT GOALS

Goals for the revegetation and site management were general and can be summarised as:

- water quality protection
- control potential soil erosion
- provide a filter for run off
- utilise excess groundwater recharge
- weed suppression
- protect and regenerate remnant vegetation
- create wildlife habitat and
- create a wildlife corridor between the two parks to either side.

The goals were not detailed to describe which fauna species were the target for habitat or the corridor. It was assumed that if as many plant species from the original vegetation community as possible were included in the revegetation program, that this would provide for whatever fauna were present to utilise it.

SITE ASSESSMENT

The situation in 1998

In 1998, prior to stock removal, the site contained predominantly scattered Pink Gum (*Eucalyptus fasciculosa*), Blue Gum (*E. leucoxylon*) and Coastal Mallee (*E. diversifolia*) over pasture. The wetland basin supported a fringe of Tea Tree (*Melaleuca halmaturorum*), Red Gum (*E. camaldulensis*) and some samphire.

Defining landforms

The first step was to map different landforms that the vegetation types grew on. This was done manually in the field (in the days before using a GPS unit was common!) by drawing onto an overlay on an aerial photograph (Figure 48). Landforms/areas mapped were:

- mature vegetation patches (no revegetation needed)
- sandy flats and depressions
- loamy clay flats (not inundated)
- wet clay flats/fringes of basin
- ridges and slopes
- very stony ridge tops.

At the same time, areas where practical issues were of concern could also be mapped or noted (eg where infrastructure needed to be removed; where tracks were to be left open, where revegetation was to be excluded, water sources, general weed distribution etc).

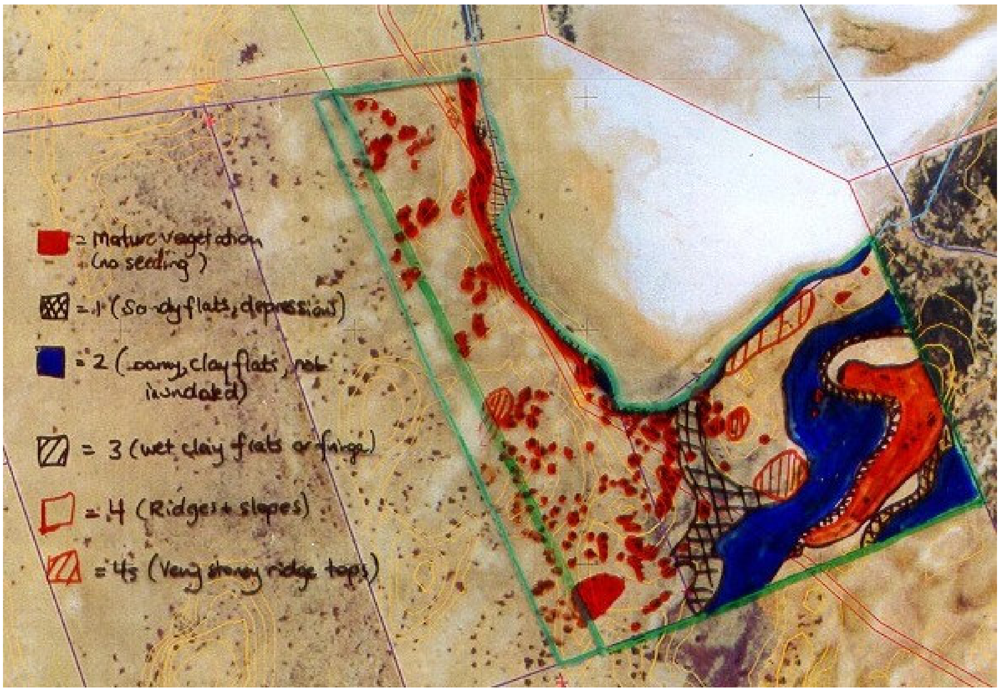

Figure 48: Example of initial mapping of landforms and other features in the Stage 3 revegetation section of Morella.

Defining pre-European vegetation types

The second step of the project was to define what the pre-European vegetation on each landform would have been (this was at a time before pre-European mapping had been completed by DEH). Vegetation types were determined by looking at remnant vegetation on-site and nearby; using the Martin Washpool CP species list (from Department for Environment and Heritage) and talking to local revegetation contractors. The vegetation types recognised at the beginning of the project were:

- Costal Mallee (*E. diversifolia*) scrubland
- Pink Gum (*E. fasciculosa*) and SA Blue Gum (*E. leucoxylon*) woodland
- Red Gum (*E. camaldulensis*) grassy woodland and
- Saltwater Paperbark/Small-leaved Honey Myrte (*Melaleuca halmaturorum*/*brevifolia*) shrubland.

LOGISTICAL CONTEXT AND IMPLEMENTATION

The revegetation was carried out on accessible areas over three years from 2001 to 2003. The logistical context of the revegetation at Morella included the following considerations:

- very large scale of on-ground works required
- uncertain and limited funding
- relatively remote location (no contractors close by)
- challenging rocky/sandy/wet terrain
- dodgy water sources (both quality and access were poor)
- very limited management time available for project manager.

The logistical limitations therefore impacted as follows on implementation and outcomes:

- machine direct seeding was chosen for all of the initial revegetation establishment due to its economy, efficiency and low labour requirements
- the contract for the direct seeding was put out to tender – the tender was won by a local business who were not necessarily the cheapest but offered a wealth of experience and who therefore could do the job with minimal supervision and management input after initial consultation
- aerial spraying (rather than ground rig spraying) was sometimes undertaken over large areas because of rocky terrain and scale issues
- some very rocky areas were not revegetated due to inaccessibility
- sandy rises posed erosion risk problems due to blanket spraying and some small blow-out areas had to be re-done with speedlings due to failure of direct seeding in the first attempt
- some wet clay flats and fringes of the basin were too waterlogged for machinery access and were not effectively revegetated – a lesson learned early on was that *Melaleuca* regenerated well on the wet flats and so no revegetation action was needed
- volunteer labour was generally not used (only some seed collection in the first year by a MOW-camp prisoner group) due to lack of time to supervise inexperienced workers

- very little formal baseline monitoring was carried out (four official photo-points with bird surveys and general plant observations only).

Machinery used

Two seeding machines were used. The direct seeder for rocky soils had a V-blade (that suffered much damage!) and was pulled by a tractor. The direct seeder for sandy soils had a normal circular scalping disc and was pulled by a 4-wheeler motorbike.

Seed and species

Local seeds of 32 species were collected and sown. Observations showed that 24 species established successfully from the direct seeding. Of those, the most successful included: *Acacia* (5 species), *Eucalyptus* (4), *Allocasuarina* (4), *Melaleuca* (3), *Adriana quadripartita*; *Callistemon rugulosus*; *Dodonaea viscosa*; *Kunzea pomifera* and *Olearia axillaris*.

Some species that generally failed to germinate or survive were: *Banksia marginata*, *Banksia ornata*; *Bursaria spinosa*; *Hakea vittata*, *Hakea rugosa*; *Kennedia prostrata*, *Leptospermum myrsinoides*, *Leptospermum continentale*; *Leucopogon parviflorus* and *Xanthorrhoea caespitosa*.

Weed Control

The weed spectrum in 1998 consisted mainly of the following:

- herbaceous broadleaves - Horehound, Salvation Jane, Primrose, Thistles
- woody weeds - African Boxthorn
- perennial grasses - Phalaris, Tall Wheat Grass, Kikuyu, Veldt Grass
- annual grasses - Silvergrass, Brome Grass etc

Weed control for each section commenced two years prior to revegetation (focusing on killing broadleaf and perennial species and spray-topping annual grasses). In the year of revegetation a total knock-down herbicide was blanket sprayed after the break of season and then in a 1.5 m wide strip at the time of seeding. The latter spray incorporated a very low rate of residual herbicide (sprayed from the direct seeding machine ahead of the soil-scalping blade/disc).

In the winter one year after seeding, a blanket over-spray was carried out using aerial application over the revegetated area. The herbicides used were a special mix involving low rates of both glyphosate and residual herbicide.

Pest Control

The following pest control activities were undertaken as required:

- introduced conical and round snails (baited aerially in Spring)
- Red-legged Earth Mite (sprayed aerially after seeding)
- Rabbits & Foxes (baited/fumigated yearly)

Although deer invaded the site in latter years but control needs to be addressed at a regional scale, so no specific on-site control was undertaken.

RESULTS

The direct seeding was generally successful in terms of creating perennial cover (Figure 49) (only 6% of the revegetated area failed and had to be redone). Growth has been excellent, as can be seen via Stage 1 photo-point monitoring (Figure 50 and Figure 51).

In 2005, the revegetated area was transferred to the park network under Department for Environment and Heritage management. “Martin Washpool Conservation Park - Morella Basin” was ‘born’ for the cost of $270 000 (Figure 52).

Are weeds suppressed?

No formal baseline monitoring, general observations only showed that in 2007 there were approximately 54 weed species were present with variable weed cover. Older areas of dense revegetation seem to have less broadleaf weed cover, so it does appear that some suppression has occurred, although this may also be due to other control methods being used. Ongoing control of proclaimed weeds by Authorised Officers included targeted spraying of proclaimed weeds and dissemination of biological control agents for Horehound and Salvation Jane.

Figure 49: Stage 1 revegetation in the foreground at 3.5 years old (showing drain connection from Morella Basin at rear to Salt Creek).

Figure 50: Photopoint in Stage 1 area of Morella just prior to revegetation in June 2001.

Figure 51: Same photopoint in Stage 1 area of Morella in January 2006 (4.5 years old).

Figure 52: In 2005, the revegetated area became annexed to Martin Washpool Conservation Park.

Is water quality protected?

The revegetation has resulted in good perennial cover that presumably is reducing groundwater recharge compared to the previous state with predominantly annual pasture. No erosion is evident now (sandy soils were stabilised) and water-monitoring studies in the basin detect no chemical pollution.

Have the remnant plants regenerated?

Anecdotal records show that regeneration of 91% of the species originally on the property has occurred to varying extent. Sixteen new species (not in revegetation mix and not originally at the site) have been found to have regenerated in the seven years since stock removal, including: herbs; daisies; lilies/sedges; grasses; climbers/twiners; mistletoes; mat plants; low shrubs and trees.

Has species diversity increased?

In 1998 it was estimated (from personal observations and comparisons with adjacent grazed land) that 35 native plant species were probably present. In 2007 there were at least 64 native plant species present:

- 35 originally present as remnants
- 16 species new from natural regeneration processes and
- 13 new, introduced via revegetation.

In 2007, native life-form diversity (taking abundance into account) was still 'very poor' to 'poor' however (when measured at the 900 m^2 quadrat scale using Bushland Condition Monitoring methods of NCSSA) due to the majority of native plants present being tree and shrub life-forms. At the landscape-scale, diversity has increased due to the introduction of new species via regeneration and revegetation.

Has new wildlife habitat been created?

Anecdotal observations and some monitoring show that the wildlife at Morella has changed since 1998.

Mammals

Western Grey Kangaroos are now more common throughout the property. Common Wombats (rated Rare in SA) were previously not present on the revegetated section of the property but were utilising most of the area by 2007 (as evidenced by scats and many new burrows dug throughout the Stage 1, 2 and 3 areas).

Birds

Seasonal monitoring by Mark de Jong[3] and Karina Mercer[4] shows 75 native bird species have visited or utilised the revegetated area since 2001, including 6 of concern in SA: Beautiful Firetail; Southern Emu-wren; Shy Heathwren; Rufous Bristlebird; Purple-gaped Honeyeater and Blue-winged Parrot.

Native bird diversity has increased over time (Figure 53 and Figure 54) and composition of species appears to have changed (Figure 55 and Figure 56):

- there appears to be 7 species that prefer open habitats which have been observed less frequently in the revegetated areas as the revegetation has aged (including Richard's Pipit, Australian Magpie, White-fronted Chat, Yellow-rumped Thornbill and Blue-winged Parrot) and
- around 17 species generally found in shrubby habitats and woodlands have been observed more frequently and in greater numbers in the revegetation area over time (including Superb Fairy Wren, Thornbills, Silvereye, Honeyeaters, Bronzewings, Beautiful Firetail, Grey Shrike-thrush and Grey Fantail).

There is evidence of several bird species nesting in the revegetation area, so they are not all just visitors.

The 'missing' bird species compared to remnant vegetation nearby include bark feeders, ground-pouncers, upper-canopy foliage feeders and leaf-litter 'lovers' (eg Varied Sittella, White-eared Honeyeater, Robins, Spotted Pardalote, Malleefowl) – this is to be expected because the revegetation area has not matured enough to support the correct habitat elements.

Is it a wildlife corridor?

The answer to this question is not known, because the appropriate monitoring has not been carried out.

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[3] Senior Environmental Officer, South Eastern Water Conservation and Drainage Board
[4] Environmental Consultant, Rural Solutions SA

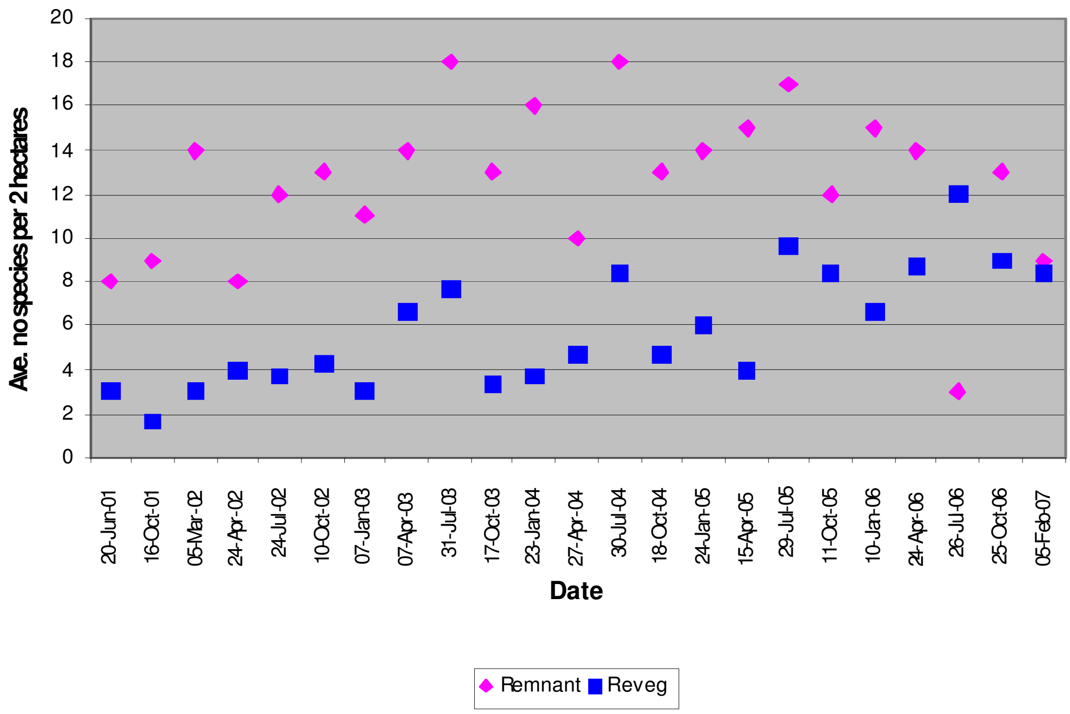

Figure 53: Average native bird species richness found (per 2 ha sampling site) in remnant woodland (1 site) and revegetation (3 sites) in Stage 1 at Morella over six years of monitoring (data courtesy M. de Jong, 23 sampling dates).

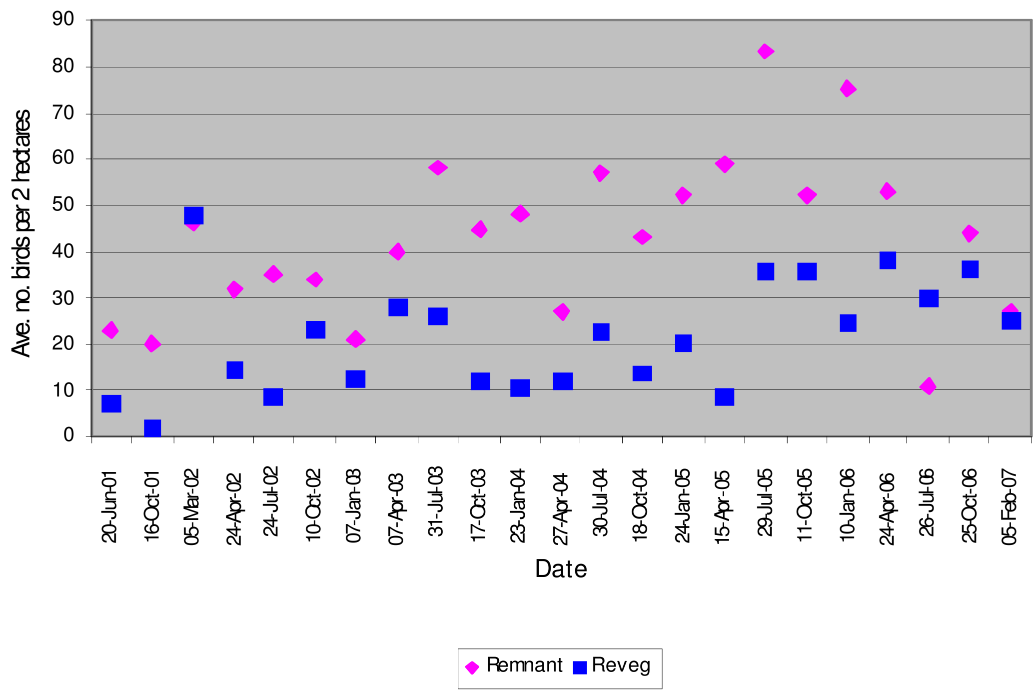

Figure 54: Average native bird abundance found (per 2 hectare sampling site) in remnant woodland (1 site) and revegetation (3 sites) in Stage 1 at Morella over six years of monitoring (data courtesy M. de Jong, 23 sampling dates).

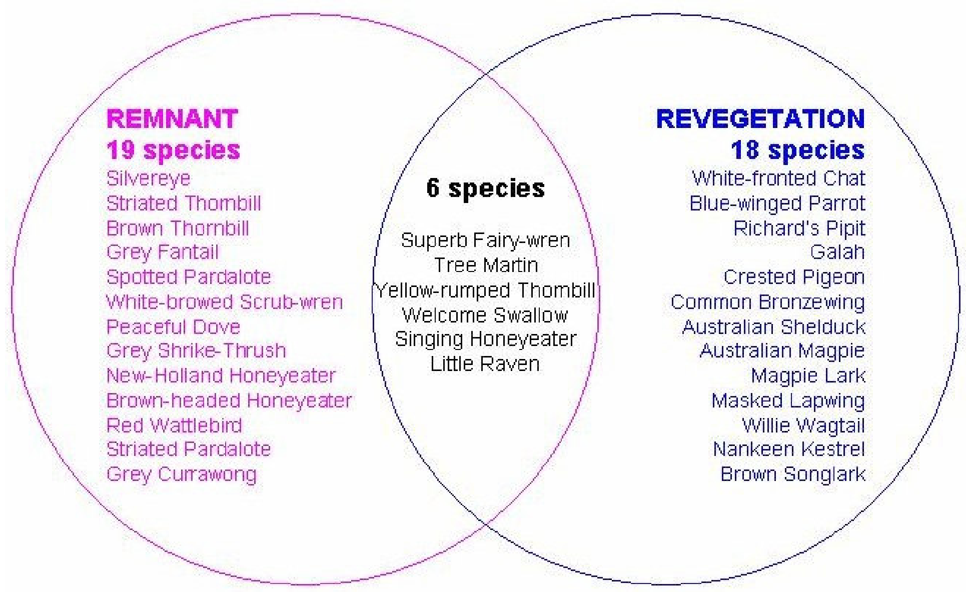

Figure 55: Composition of bird species in remnant (1 site sampled) versus revegetation sites (3 sites sampled) (overlap shows species present in both sites) in the first year of revegetation (4 sampling dates, 2001-2002).

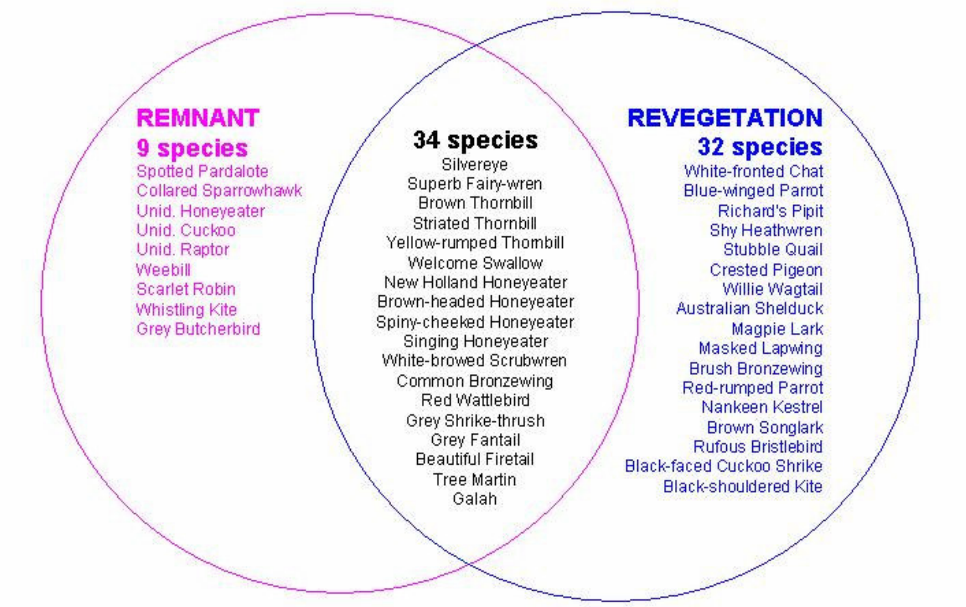

Figure 56: Composition of the majority of bird species in remnant (1 site) versus revegetation (3 sites) (overlap shows species present in both site types) for the six-year monitoring period (23 sampling dates, 2001-2007).

LESSONS LEARNED

Many lessons have been learned about carrying out such a large-scale revegetation project. The following are some of the more important considerations.

Project management

Clarifying objectives in more detail (eg using Specific, Measurable, Achievable, Realistic and Time-bound goals) at the beginning would help guide decision-making and monitoring.

Individual passionate champions need to be involved to drive such a project and maintain long-term records for follow up evaluation.

Habitat structure and biodiversity objectives

It is easy to achieve good native plant cover that will give some benefits, but are the species and structure the best that could be achieved for habitat and a self-sustaining system?

It is worthwhile to take time in not only investigating pre-European vegetation types but also which fauna might be target species for habitat (to help set specific goals and tailor revegetation structure). For example the flats which were originally targeted for *Melaleuca* revegetation at Morella are likely to be good feeding grounds for Common Wombats (and also Red-necked Wallaby) and therefore are better left as open grassy areas. The presence of these species and habitat requirements were not appreciated at the beginning of the project as there was very little survey information readily available at that time. It was by pure chance that many flats were too wet to be seeded and hence have remained relatively open. This example highlights the importance of understanding specific habitat goals and tailoring revegetation to suit but also that lack of data (or the knowledge of where that data is) can sometimes limit how much practitioners can plan.

The large scale of the project incorporated the vagaries of topography and therefore microclimate and the variable results that ensued with direct seeding (unintentionally) helped with achieving heterogeneity/patchiness in revegetation structure.

On-going pest plant and animal control is essential to encourage the system in a direction towards a more natural state.

Using herbicides

Aerial applications of sprays for large-scale weed control are very effective and generally very accurate, but risk must be assessed and caution used because of the potential of damage with spray drift (and risks with any off-label use).

Monitoring and evaluation

Scientific monitoring was a low priority - the baseline situation at Morella was therefore not captured systematically. A baseline however is essential in order to understand subsequent changes (even if it is just general observations that are properly documented). On-going monitoring and evaluation are extremely expensive, but also essential if the worth of such a project is to be determined and to learn about the impacts (both positive and negative).

ACKNOWLEDGEMENTS

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Thanks to Mark de Jong (Environmental Officer, South East Water Conservation and Drainage Board) and Karina Mercer (Environmental Consultant, Rural Solutions SA) who provided bird-monitoring data and photo-point images.

CASE STUDY 3 - RECOVERING KANGAROO ISLAND'S FRAGMENTED LANDSCAPES

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PLANNING FOR THE RECOVERY OF THREATENED PLANT SPECIES

The Kangaroo Island Nationally Threatened Plant project commenced in February 2002. The first 12 months of the project's life was focussed on developing a recovery plan for the 15 nationally threatened plant species found on the island. This involved both a literature search and a field assessment to determine the distribution and abundance of each plant species and to identify the processes threatening their future existence.

A prioritisation process was then completed to determine which management actions would produce the greatest benefit for Kangaroo Island's nationally threatened flora. This process identified five nationally threatened plant species that were both endemic to Kangaroo Island and at risk of extinction in the foreseeable future:

- Small-flowered Daisy-bush (*Olearia microdisca*) – Critically Endangered
- Beyeria Bush-pea (*Pultenaea insularis*) - Critically Endangered
- Kangaroo Island Turpentine Bush (*Beyeria subtecta*) - Endangered
- Kangaroo Island Phebalium (*Leionema equestre*) - Endangered
- MacGillivray (*Spyridium eriocephalum* var. *glabrisepalum*) - Endangered.

At this point in the development of the recovery plan it also became clear that these five species had quite a few things in common. All five species are understorey plants that depend upon a common mallee community dominated by Narrow-leaved Mallee (*Eucalyptus cneorifolia*). In addition both the critical habitat and the potential habitat of all five species is restricted to a relatively small section of eastern Kangaroo Island. This 'critical zone' (Figure 57) consists of approximately 60,000 ha of mostly agricultural land with fragmented remnant vegetation, much of which is experiencing a slow and steady decline in both diversity and structure.

The identification of the 'critical zone' ultimately led the recovery planning process for threatened species conservation on Kangaroo Island from a 'multi-species' approach to an 'area' or 'landscape-based' approach.

Implementation of recovery actions under the plan began in July 2003 and has primarily involved tackling four key threatening processes affecting the 'critical zone' landscape. In the short term, three threatening processes have been targeted for action in the 'critical zone': inappropriate fire regimes; inappropriate grazing regimes and invasion by environmental weeds.

The project has attempted to both develop and implement management actions to address these issues on a landscape scale.

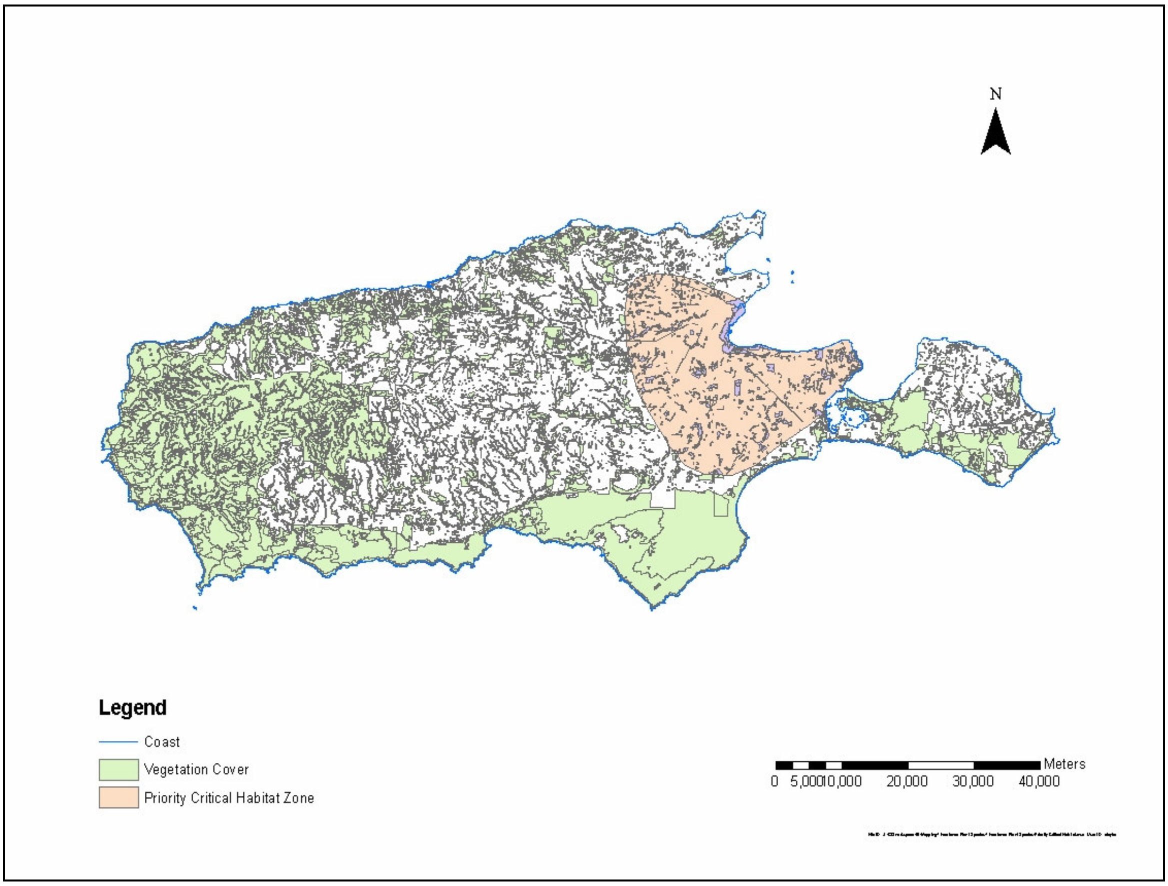

Figure 57: Priority Critical Habitat Zone on Kangaroo Island for 5 threatened plant species.

ADDRESSING FRAGMENTATION

While vegetation communities of this area may be improved in the short term by actions such as weed and herbivore control, the long-term survival of biodiversity in this area is dependent on addressing a fourth underlying impediment to landscape recovery - the limited and fragmented nature of the remaining habitat in the landscape. Only 11.9% of the landscape is covered in remnant vegetation and it is found in scattered patches (Figure 58) that are not self-sustaining.

In theory, the solution to the issue of habitat loss and fragmentation is simple: just go and restore habitat. However, in reality producing diverse, self-sustaining habitats resembling pre-European ecosystems has proven to be an exceptionally difficult task, particularly given that healthy Narrow-leaved Mallee communities typically have very diverse heath understorey.

NATIVE HERBIVORE GRAZING

The majority of potential restoration sites within the 'critical zone' are subject to high levels of grazing by native herbivores (typically Kangaroo Island Kangaroo, Tammar Wallaby and/or Brush-tailed Possum). In the past, guarding small planting areas with conventional tree guards has been used to protect seedlings. To restore large areas however, this option is simply not viable.

In conjunction with a local fencing contractor, the project has developed and trialled two fence designs that have since been used at multiple restoration sites (Figure 59).

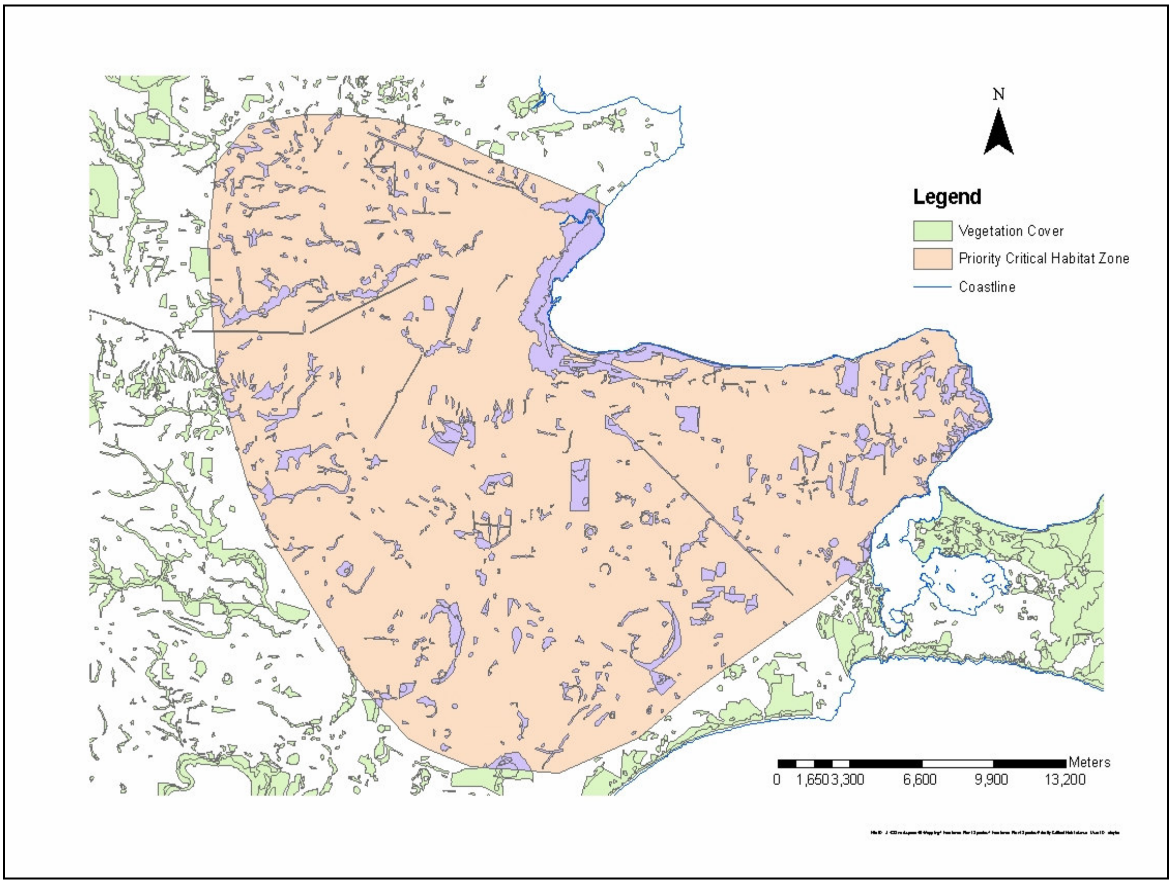

Figure 58: Map showing the fragmented nature of the remnant vegetation in the "Critical Zone".

WEED CONTROL ISSUES

The importance of effective weed control in habitat restoration was highlighted in the first restoration trial completed as part of this project in 2004. A number of different native plant species (including one nationally threatened species) were planted in a paddock that had been used primarily for grazing over the last 50 to 70 years. Four types of site management were trialled: ripping vs dense planting vs weed control vs no treatment and survival of the plants were monitored.

Of the four treatments, plants subject to one weed control treatment (spot spraying of weeds within 0.5 m of the native plant seedling) were much more likely to survive the first 12 months and were much larger in size. This conclusion led to a number of follow up trials (the majority of which are still in progress) to determine the best way to suppress weed invasion at a restoration site. Methods tested include high density planting with native plant species (as a way of outcompeting weed species), intensive pre-treatment of sites (to exhaust seedbanks prior to planting) and the use of jute matting to suppress weed growth in key areas.

Figure 59: Fencing design to exclude native herbivores

HABITAT STRUCTURE

Anecdotal evidence suggests that the structure of Narrow-leaved Mallee communities (particularly the overstorey) plays a key role in determining plant diversity in that ecosystem. Establishing plant structure in early restoration work in the early phase of the project was done on a 'gut feel' basis with mixed results. In order to improve that process two techniques are currently being tested:

- understorey structure has been measured in existing diverse habitat in 5 m x 5 m plots and the composition of these plots re-established in key locations within the restoration site and
- overstorey structure has been also measured at diverse remnant sites using a Global Positioning System and this template has been overlain and pegged at restoration sites to create a more appropriate overstorey planting pattern.

LAND AVAILABILITY

In order to achieve outcomes at a landscape scale, large areas of land will need to be restored, which requires the co-operation of multiple landholders. The Kangaroo Island Threatened Plant Project has approached a number of interested landholders in the critical zone and found them very supportive. The project currently has 6 areas to undertake restoration works totalling over 300 ha and this will hopefully increase as more land owners become aware of the program.

PLANTING CAPACITY

Large-scale restoration activities require large numbers of tubestock. Facilities to propagate tubestock on Kangaroo Island are limited and the cost of purchasing tubestock from outside sources is prohibitive. The project in conjunction with a supportive landholder has constructed facilities large enough to propagate 60 000 tubestock in any given year, greatly increasing the capacity of the project.

The Kangaroo Island Threatened Plant Project has enlisted the support of volunteers in planting tubestock. This has developed into an annual planting festival involving both planting activities and educational activities over a four-day period each July.

APPENDIX A: WORKSHOP PROGRAM

Habitat Restoration Workshop

GUEST SPEAKERS *(continued)*

Andrew Allanson (TFL) has been involved in Trees For Life's Bush For Life program since it's inception in 1994. This program involves the community (via Trees for Life members) in managing remnant bushland on Local Government reserves, Heritage Agreements and other private properties containing bushland.

Jodie Reseigh (RSSA) is from a farming family growing up in the South East of South Australia, and plays an active role in the family property at Murray Bridge. Jodie has an honours degree in Applied Science from the University of South Australia and a PhD from the University of New England, which looked at relationships between agricultural management and grassy vegetation near Armidale on the Northern Tablelands of NSW. Jodie joined Rural Solutions SA in late 2004 working on many varied projects throughout the state including monitoring and evaluation of on-ground works.

Craig Whisson (DWLBC) as with many others graduates in a similar position joined the Department of Environment and Planning in 1982, the role involved providing advice to landowners and the Native Vegetation Advisory Committee on voluntary Heritage Agreements. That job expanded and took on a whole new perspective with the introduction of the vegetation clearance legislation in 1983 to include the assessment of applications to clear native vegetation. He is currently employed within DWLBC as the Executive Officer to the Native Vegetation Council.

Donna Bartsch (RSSA), a Senior Environmental Consultant with Rural Solutions SA. She has over eight years experience in Natural Resource Management industry in the South East region of SA. She has extensive experience in implementation and delivery of devolved grant schemes and more recently market-based tools to engage rural community in natural resource management activities.

Zita Stokes (RSSA), a Senior Environmental Consultant for Rural Solutions SA, has worked for 11 years on promoting revegetation and vegetation management through consultancies, managing incentive schemes and general community extension in the South East region. Currently based at Mt Barker Natural Resources Centre working through DWLBC to support ecological restoration planning with DEH across SA

Dave Taylor (DEH), originally from NSW working for State Forests NSW. Working as the Threatened Plant Project Officer on Kangaroo Island for the last 5 years tinkering with habitat restoration for approximately 3.5 of those years and have a definite tendency to bite off more than he can chew (a necessary trait amongst habitat restorers).

FURTHER INFORMATION

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Government of South Australia
Department of Water, Land and Biodiversity Conservation

Land and Biodiversity Services

Native Vegetation Council

Improving Biodiversity Outcomes of Restoration Works:

Habitat Resoration Workshop

WHERE:
Charles Hawker Centre
Waite Road
Urrbrae

WHEN:
12–13 April 2007

REGISTRATION:
8.30 am

Habitat Restoration Workshop

Government of South Australia
Department of Water, Land and Biodiversity Conservation

DAY ONE

Workshop Theme 1:
Theoretical frameworks underpinning on-ground works

Registration: 8.30 am – 9.00 am

Introduction 9.00 am

Indigenous Welcome 9.00 am – 9.10 am
Georgina Williams

Opening Speeches 9.10 am – 9.20 am
Rob Freeman – Chief Executive, DWLBC
John Roger – Chairperson, NVC

Workshop Outline 9.20 am – 9.30 am

Presentations

9.30 am – 10.00 am
Habitat Restoration
Speaker: David Paton (Adelaide University)

10.00 am – 10. 30 am
Targeted Goal Setting for Landscape Restoration Outcomes
Speaker: Andrew West (DEH)

10.30 am –11.00 am
Modelling Biodiversity Priorities at a Sub- Regional Scale: The Northern Murray Mallee Project.
Speaker: Nigel Willoughby (DEH)

Morning Tea: 11.00 am – 11.20 am

11.20 am –11.45 am *Group Discussions*
Divide participants into small groups to discuss issues from previous speakers and compile top 5 questions for examination in following panel discussion

11.45 am – 12.30 pm *Questions for presenters*
Panel discussion of questions derived in small group session

Lunch: 12.30 pm – 1.15 pm

APPENDIX A: WORKSHOP PROGRAM

GUEST SPEAKERS

Georgina Williams (Senior Kaurna Woman), most recent recovery work over the past decade has been the development of the concepts and the vision of *'coming home'* to the spirit of the land of the Kaurna peoples; renewing her clan and other Kaurna peoples' clans to our spirit of place, beginning with the recovery of the law/lore story, Tjirbruki (Tjilbruke), and his ancestral Dreaming, Munaintya, of law and law in the land. In particular, at Warriparinga, in the development of an interactive history project, the Kaurna Living Cultural Centre Project.

David Paton (Adelaide University), is an ecologist at the University of Adelaide with broad interests in ecological management and restoration. He has been monitoring birds and their resources in the Coorong on and off since the 1980s, documenting responses of flora and fauna to drought and fire in Ngarkat since 1990, and looking at the ecology and management of declining woodland birds in the Mt Lofty Ranges and in the remnant and revegetation areas of Monarto.

Andrew West (DEH), started working for DEH as a Natural Resource Management Officer in the SE from 1996, as State Bushcare Coordinator from 1997, Bush Management Adviser in MLR from 1999, Ecologist - Threatened Species and Ecological Communities from 2003, and from 2006 took up position as the Ecologist - Ecological Restoration.

Nigel Willoughby (DEH), studied *Melithreptus* honeyeaters in the Mount Lofty Ranges from 2000-2004, has been grappling with the question of how to plan to conserve biodiversity for most of the last eight years, first as biodiversity planner for Kangaroo Island, then with a species focus during the *Melithreptus* study and now as restoration ecologist for the SA Murray-Darling Basin

Presentations

1.15 pm – 1.45 pm
Habitat Restoration for Fauna Outcomes
Speaker: Peter Cale (DEH)

Workshop Theme 2: Habitat Restoration Technical directions

1.45 pm – 2.15 pm
Seed provenance: Issues and considerations
Speaker: Linda Broadhurst (CSIRO)
Issues relating to provenance and restoration success

2.15 pm – 2.45 pm
Speaker: Martin O'Leary (DEH)
Provenance, a taxonomic perspective: Eucalyptus / Acacia

Afternoon Tea 2.45 pm – 3.00 pm

3.00 pm – 3.25 pm
Divide participants into small groups to discuss issues from previous speakers and compile top 5 questions for examination in following panel discussion

3.25 pm – 4.10 pm
Panel discussion of questions derived in small group session

4.10 pm
Summary of major issues and brief introduction for tomorrow's session

Day Close

DAY TWO

Workshop Theme 2: Habitat Restoration Technical directions

Registration: 8.30 am – 9.00 am

Introduction 9.00 am

Presentations

9.00 am – 9.30 am
Changing community perceptions on restoration planning and management
Speaker: Peter Tucker (RSSA)

9.30 am – 10.00 am Intervention or regeneration
Speaker: Andrew Allanson (TFL)
Discussion of where and what level of intervention is ecologically appropriate to meet the best outcomes

10.00 am – 10.30 am
Monitoring and Evaluation
Speaker: Jodie Reseigh (RSSA)

Morning Tea: 10.30 am – 10.50 am

10.50 am – 11.10 am
Native Vegetation Legislation
Speaker: Craig Whisson (DWLBC)

11.10 am – 11.35 am *Group Discussions*
Divide participants into small groups to discuss issues from previous speakers and compile top 5 questions for examination in following panel discussion

11.35 am – 12.20 pm *Questions for presenters*
Panel discussion of questions derived in small group session

Lunch: 12.20 pm – 1.00 pm

1.00pm – 2.30pm Case Studies

Bangham Vegetation Links
Speaker: Donna Bartsch (DWLBC/RSSA)

Morella
Speaker: Zita Stokes (DWLBC/RSSA)

Cygnet River
Speaker: Dave Taylor (DEH)

Afternoon Tea 2.30 pm – 2.45 pm

2.45 pm – 3.10 pm *Group Discussions*
Divide participants into small groups to discuss issues from previous speakers and compile top 5 questions for examination in following panel discussion

3.10 pm – 3.55 pm
Questions for presenters

Panel discussion of questions derived in small group session

3.55 pm – 4.15 pm
Summary of Day 2

4.15 pm – 4.30 pm
Where to from here

Close

Peter Cale (DEH), did his degree and PhD in WA on landscape scale conservation issues in collaboration with CSIRO and has worked since then on Rivercare issues and research based programs delivering information to the community on landscape management.
Peter is currently Ecologist for Threatened Mallee Birds Recovery Program, which seeks to use birds as a focus for the management of Mallee systems within the SA MDB

Linda Broadhurst (CSIRO) is the group leader for the Conservation and Restoration sub-program at CSIRO Plant Industry. Her research is directed towards improving the restoration of highly degraded Australian landscapes through a better understanding of the scale and importance of seed and symbiont provenance, the effects of seed quality on restoration success and how vegetation fragmentation influences seed quality, population persistence and gene flow.

Martin O'Leary (DEH), has worked for the last 20 years at the State Herbarium being involved with the curation of the *Acacia* and *Myrtaceae* collections, general plant identifications, advice to the public, and collection trips around the state and parts of Australia.
Recently he has described several new species of *Acacia*, and has just published a study of *Acacia retinodes*, together with the closely related *Acacia uncifolia* and *Acacia provincialis*.

Peter Tucker (RSSA) recently moved to Rural Solutions SA, Environmental Design and Management Team based at Struan in the South East where he is working with landholders and other stakeholders to protect & manage remnant vegetation.
Peter previously spent 8 years with Trees For Life's Bush For Life program assisting volunteers, community groups and landholders with limited time to manage bushland with particular emphasis on bushland weeds.

APPENDIX B: WORKSHOP AUDIENCE

Key stakeholders from across South Australia were invited to represent a cross section of agencies, regions and levels of expertise. The representation of a broad range of stakeholders was to ensure that key issues and questions, from policy through to planning and implementation, would be raised during group discussions.

Agencies and groups represented were:

Adelaide and Mt Lofty Ranges NRM Board

Botanic Gardens of Adelaide

Burnside City Council

City of Marion

City of Tea Tree Gully

CSIRO Plant Industry

Conservation Council of SA

University of Adelaide

Department for Environment and Heritage

Department of Water, Land and Biodiversity Conservation

Department of Defence

Department of Environment and Conservation

Electranet

Forestry SA

Greening Australia Ltd

Greening Australia SA

Kangaroo Island NRM Board

Land and Water Australia

Local Action Planning Groups

Native Vegetation Council

Nature Conservation Society of SA

Northern and Yorke NRM Board

Landcare Groups

Primary Industries and Resources SA – Forestry

Private Contractors

Community

Rural Solutions SA

SA Murray Darling Basin NRM Board

SA Water Corporation

Trees for Life

Wilderness Society

GLOSSARY

Aquatic ecosystem — The stream channel, lake or estuary bed, water, and/or biotic communities, and the habitat features that occur therein.

Aquatic habitat — Environments characterised by the presence of standing or flowing water.

Basin — The area drained by a major river and its tributaries.

Benchmark condition — Points of reference from which change can be measured.

Biological diversity (biodiversity) — The variety of life forms: the different life forms including plants, animals and micro-organisms, the genes they contain and the *ecosystems (see below)* they form. It is usually considered at three levels — genetic diversity, species diversity and ecosystem diversity.

Biota — All of the organisms at a particular locality.

Buffer zone — A neutral area that separates and minimises interactions between zones whose management objectives are significantly different or in conflict (e.g. a vegetated riparian zone can act as a buffer to protect the water quality and streams from adjacent land uses).

Catchment — That area of land determined by topographic features within which rainfall will contribute to runoff at a particular point.

DEH — Department for Environment and Heritage (Government of South Australia).

Diversity — The distribution and abundance of different kinds of plant and animal species and communities in a specified area.

Dryland salinity — The process whereby salts stored below the surface of the ground are brought close to the surface by the rising watertable. The accumulation of salt degrades the upper soil profile, with impacts on agriculture, infrastructure and the environment.

DWLBC — Department of Water, Land and Biodiversity Conservation (Government of South Australia).

Ecological processes — All biological, physical or chemical processes that maintain an ecosystem.

Ecological values — The habitats, natural ecological processes and biodiversity of ecosystems.

Ecology — The study of the relationships between living organisms and their environment.

Ecosystem — Any system in which there is an interdependence upon, and interaction between, living organisms and their immediate physical, chemical and biological environment.

Ecosystem services — All biological, physical or chemical processes that maintain ecosystems and biodiversity and provide inputs and waste treatment services that support human activities.

Erosion — Natural breakdown and movement of soil and rock by water, wind or ice. The process may be accelerated by human activities.

Groundwater — *See underground water.*

Habitat — The natural place or type of site in which an animal or plant, or communities of plants and animals, lives.

Hydrology — The study of the characteristics, occurrence, movement and utilisation of water on and below the Earth's surface and within its atmosphere.

Indigenous species — A species that occurs naturally in the area referred to.

Infrastructure — Artificial lakes; dams or reservoirs; embankments, walls, channels or other works; buildings or structures; or pipes, machinery or other equipment.

MLR — Mount Lofty Ranges.

Model — A conceptual or mathematical means of understanding elements of the real world which allows for predictions of outcomes given certain conditions. Examples include estimating storm runoff, assessing the impacts of dams or predicting ecological response to environmental change.

Monitoring — (1) The repeated measurement of parameters to assess the current status and changes over time of the parameters measured. (2) Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, animals, and other living things.

Native species — Any animal and plant species originally in Australia.

Natural resources — Soil; water resources; geological features and landscapes; native vegetation, native animals and other native organisms; ecosystems.

NRM — Natural Resources Management**.** All activities that involve the use or development of natural resources and/or that impact on the state and condition of natural resources, whether positively or negatively.

NHT — Natural Heritage Trust.

Pasture — Grassland used for the production of grazing animals such as sheep and cattle.

PIRSA —Primary Industries and Resources South Australia (Government of South Australia).

Population — (1) For the purposes of natural resource planning, the set of individuals of the same species that occurs within the natural resource of interest. (2) An aggregate of interbreeding individuals of a biological species within a specified location.

Recharge— The rainfall, streamflow, irrigation, etc. that infiltrates into an aquifer.

Riparian — Of, pertaining to, or situated or dwelling on the bank of a river or other water body.

Taxa — General term for a group identified by taxonomy, which is the science of describing, naming and classifying organisms.

Threatened species — Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Watercourse — A river, creek or other natural watercourse (whether modified or not) and includes: a dam or reservoir that collects water flowing in a watercourse; a lake through which water flows; a channel (but not a channel declared by regulation to be excluded from the this definition) into which the water of a watercourse has been diverted; and part of a watercourse.

Wetlands — Defined by the Act as a swamp or marsh and includes any land that is seasonally inundated with water. This definition encompasses a number of concepts that are more specifically described in the definition used in the Ramsar Convention on Wetlands of International Importance. This describes wetlands as areas of permanent or periodic to intermittent inundation, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tides does not exceed six metres.

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