THE STATE OF AUSTRALIA'S BIRDS **2009**

Restoring Woodland Habitats for Birds

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Birds Australia
CONSERVATION THROUGH KNOWLEDGE

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Restoring Woodland Habitats for Birds

The State of Australia's Birds reports are overviews of the status of Australia's birds, the threats they face and the conservation actions taken. This seventh annual report focuses on revegetation for woodland birds, particularly those in agricultural landscapes. Australia's woodlands—especially in the temperate south-eastern and south-western wheat and sheep belts—are among the most extensively cleared, fragmented and severely degraded habitats on the continent. And Australia's woodland birds, including many species generally regarded as common and widespread, are declining at an alarming rate.

The challenge is huge. There are very real concerns that the current scale and nature of revegetation projects will not be sufficient to save woodland bird species at the most risk, particularly those with special habitat requirements. Many plantings are homogeneous stands of trees, which have been set in place for the purpose of carbon credits, salinity or erosion control; all of which may provide only limited benefits to biodiversity. But responses to this challenge are beginning to become visible in many rural areas, as landowners and local communities grow increasingly active in taking up the shovel, often in partnership with organisations which are increasingly ambitious about the scale at which to tackle this problem.

This publication examines some of the issues facing current revegetation enterprises, and makes some key recommendations on how they can be improved to enhance biodiversity outcomes. We are faced with an enormous task, but the clear messages are that revegetation helps, that these projects have the potential to draw communities together and unite them in a common cause to protect their natural heritage, and that every tree and every shrub added to the landscape will improve the lot of one of our most well-loved but imperiled groups of birds.

This publication concentrates on issues facing the revegetation of Australia's temperate and subtropical woodlands; particularly those that, historically, have overlapped with areas of intensive agriculture. There are a multitude of issues and a vast array of literature on this subject, and no attempt has been made at exhaustive coverage. The publication merely introduces some of the key themes relevant to woodland birds.

KEY POINTS

Native vegetation clearance

Vegetation clearance is a major cause of past, current and predicted future losses of biodiversity for most groups of terrestrial plants and animals throughout the world. Loss, fragmentation and degradation of native vegetation are the greatest threats to biodiversity in Australia. This must cease, except where there are compelling reasons to lose further native vegetation for particular land uses.

Presently, the rate of habitat loss for birds remains unacceptably high. Australia is still undergoing annual net losses of habitat, despite efforts to restore and revegetate. While this continues, we cannot meet our international obligations to protect our biodiversity.

Revegetation

Revegetation is not currently occurring at the scale required to halt biodiversity loss in the southern temperate woodlands. However, all revegetation, on whatever scale, has some value for biodiversity, since it adds incrementally to the amount of vegetation cover.

The remaining native vegetation is not representative of the proportions of vegetation that existed 200 years ago. The habitats on the least productive soils and on rocky ridges and steep gorges are better represented than habitats in more productive parts of the landscape.

Around 30–35 per cent of the landscape across all habitats needs to be covered by relatively natural vegetation to maintain sustainable populations of most species of woodland birds in agricultural regions.

Revegetation should include areas of low fertilizer use, where native grasses and forbs can survive and ground ecosystems can re-establish.

Where possible, revegetation should be located around existing remnant (and dead) trees with hollows; this will protect isolated trees and increase the habitat value and nesting opportunities for more bird species.

Revegetation can provide breeding habitat which is complementary to remnant vegetation in woodland landscapes.

Many birds utilise revegetation—but not all do. A number of declining woodland bird species respond most strongly to remnant native vegetation cover rather than revegetated cover.

Regrowth

Active revegetation can be expensive and labour intensive, and opportunities for passive revegetation should be explored as a way of augmenting this activity. Further study of the relative benefits of passive regeneration to birds is required in the southern agricultural regions. Regrowth vegetation offers potentially valuable habitat for wildlife, including threatened species.

Spatial attributes

The spatial attributes of plantings matter. Large, compact patches of native vegetation are of more value to birds than small, thin strips of vegetation. Isolated strip plantings support significantly lower bird species richness than block plantings or intersecting linear plantings.

If revegetation programs are going to provide habitats in which declining bird species can breed, then the patches need to be at least 10–100 ha in size, and preferably close to other patches of woodland vegetation.

Stepping stones (e.g. scattered paddock trees) may be as effective as continuous corridors for facilitating movement of some species between habitat patches. The evidence suggests that stepping stones need to be no more than 100 m apart to ensure that the majority of species will be willing to move between them, and that both stepping stones and corridors should not extend for more than 1 km before connecting to another habitat patch (preferably at least 10 ha in size).

Riparian areas and watercourses are particularly important to wildlife. Restoration of these areas may require changes in agricultural practices, such as excluding stock.

The landscape matrix is also important. The bird diversity at a given site is a function of the type and quality of the habitat present, coupled with the nature of the landscape surrounding the site.

Single patches of vegetation are not sufficient on their own to support viable populations. Many species move between different parts of the landscape on a daily or seasonal basis, and migratory species move at even larger scales. The conservation status of woodland species depends on the overall network of habitat available to support the population.

Heterogeneity

Much revegetation has come about for reasons other than enhancing or protecting biodiversity, e.g. shelter for stock, combating salinity, or reducing erosion—but there is a widespread assumption that these plantings will also carry benefits for biodiversity. This is not always true. Planting for biodiversity requires heterogeneity of structure and of the species being planted. These requirements for heterogeneity apply from the smallest patch to the scale of landscapes.

Birds do better in revegetation which is heterogeneous: plantings of multiple different native species, with multiple age classes and varied patch dynamics, attract a greater diversity and abundance of bird species.

In the long term, natural disturbance regimes, such as fire and flood, may need to be managed in revegetated areas in order to maintain habitat for biodiversity.

A mix of habitats is required in order to conserve a region's bird fauna. Restoration activities should provide a mosaic of habitats and microhabitats to meet the array of species' requirements, and use the existing patches of native vegetation as building blocks for regional-level restoration activities.

Understanding the microhabitat needs of individual species may help in designing new habitats that will better cater for specific species. In the absence of such information, maximising the structural and floristic heterogeneity of future revegetation should maximise the number of species likely to benefit.

Homogeneous plantings of trees will result in long-lasting structural problems in the trees themselves, which may reduce the lasting benefits for biodiversity.

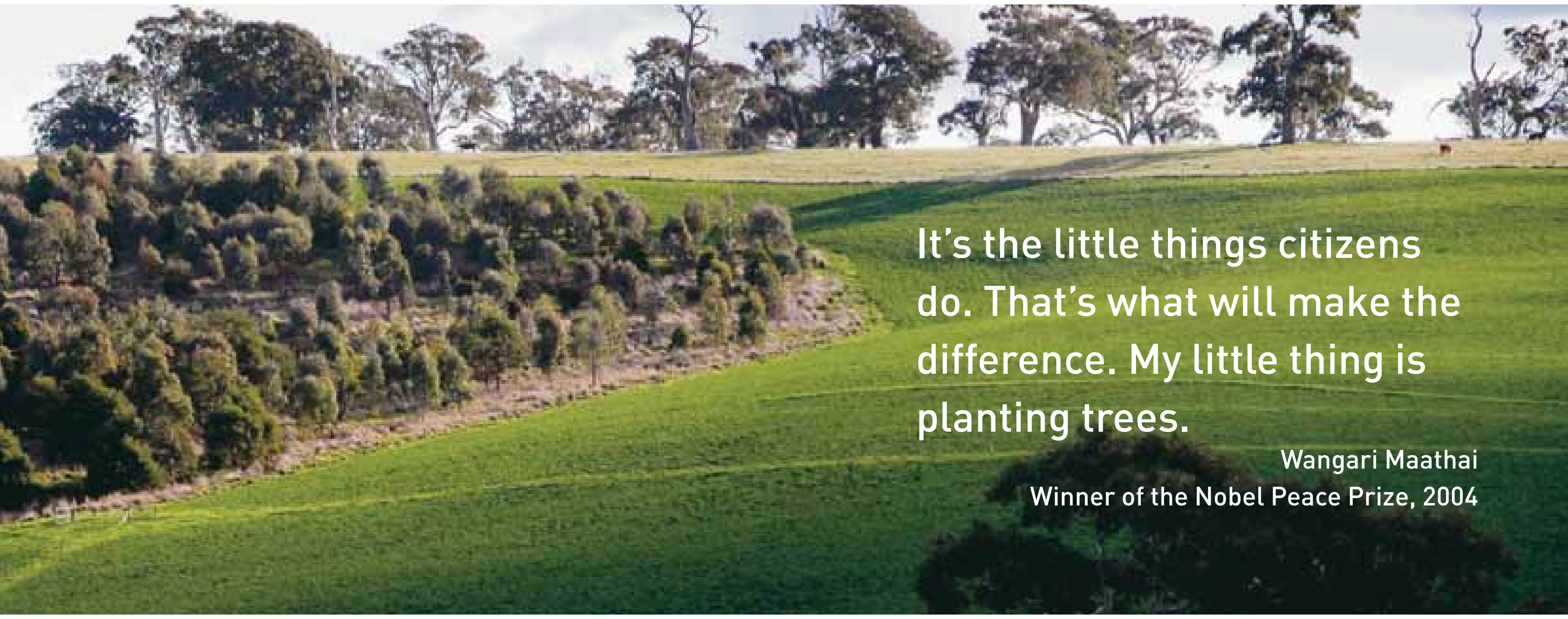
Composite provenancing is a new approach to sourcing seed for regeneration, and could provide a future adaptive potential for mimicking natural gene flow and evolutionary dynamics.

Extinction debt

Extinction debt is a major challenge for biodiversity conservation and one of the major reasons for embarking on large-scale restoration works. For instance, broad-scale clearance of native vegetation ceased in the Mount Lofty Ranges of South Australia in the 1980s, but the distributions and abundances of a wide range of bird species continue to decline.

When there is little remaining native vegetation, bird population sizes are small and vulnerable to other perturbations (e.g. droughts, fire, and demographics), and over time, those populations decline and eventually disappear.

The longer the delay in reinstating significant areas of habitats, the smaller the eventual legacy will be for future generations.



Bigger is better, but small patches of revegetation are important for facilitating movement.
Photo by **Glenn Ehmke**

Introduction

Australia's birds—and biodiversity in general—face a series of major threats: habitat destruction and degradation, global climate change, changes to disturbance regimes (e.g. fire and water), dysfunction of biological interactions (e.g. predation, competition, herbivory and diseases from invasive species), and over-exploitation (Auld and Keith 2009). In isolation, these threats are a serious challenge, but they also interact synergistically, and so, their effects are compounded and magnified. For example, climate change will exacerbate the threats posed by habitat destruction and fragmentation by restricting the options birds have for moving to more suitable patches of habitat, and in some cases by eliminating these options altogether. Climate change will also increase the threats from drought and fire, particularly in southern Australia. Positive feedback loops of interacting threats are causing a rapid and accelerating loss of ecosystem resilience (defined here as the ability of a system to absorb and recover from disturbance while retaining the same basic function and structure).

Our temperate and subtropical woodlands are severely fragmented and degraded by historical and ongoing clearing and land use. Many of the species inhabiting these woodlands are facing the spectre of 'extinction debt', which means that historical habitat loss has trapped populations in isolated and small fragments where they are more vulnerable to disturbances, and subject to local extinctions over time. Fragmentation also means that habitats have more edges, which cause further degradation through increased predation, competition for resources and introgression of diseases. Progressive loss of mature trees means decreasing availability of nest sites and food. And threats at the patch level are also highly interactive; for instance, edge effects, habitat simplification from grazing, and introduced predators and weeds, can all combine to increase nest predation (Ford et al. 2001).

Historic losses of woodland vegetation communities have been severe. It is still difficult to get meaningful estimates of overall clearance rates by vegetation type, but some examples will illustrate the extent of the problem:

- In the 18 million hectare Western Australian wheat belt, only 10 per cent of the native vegetation cover remains on average; and in many places, the cover is as low as 3 per cent (Smith 2008).
- The Statewide Land Cover and Trees Study (SLATS) stated that the average annual tree clearing rate in Queensland for the 2003–2004 period was 482,000 ha per year; down from a peak measured clearing rate in the 1999–2000 period of 758,000 ha per year; and 13 per cent lower than the previous period (2002–2003) of 554,000 ha (DNRM 2006).
- Clearing of remnant vegetation for agriculture accounted for 96 per cent of clearing in Queensland during 2003–2004.
- Around half of Victoria's native vegetation has been cleared since settlement, including 80 per cent of the original cover on private land, and the figures are higher for the flatter agricultural regions (DSE 2008).

Vegetation clearance has been concentrated on flatter land with more fertile soils. Species such as Bush Stone-curlew, Barking Owl, Swift Parrot, Regent Honeyeater, Grey-crowned Babbler, Hooded Robin and Jacky Winter, which historically inhabited woodlands in these areas, have lost the greatest proportion of their original habitat, and are now mostly found hanging on in small, degraded remnants and in sub-optimal habitats.

The simple lack of habitat, as a consequence of past vegetation clearance, is therefore a major problem for our woodland birds, but so is the ongoing loss and degradation of habitat. Broadscale clearing is slowly being halted in parts of Australia, with recent legislation in Queensland to bring a halt to broadscale clearing of remnant vegetation for agriculture from 2007 a notable example, but incremental losses continue to eat away at our woodland remnants.

In many parts of Australia, clearance of native vegetation remains an ongoing threat to biodiversity. In New South Wales from 1997–2005, permits were issued to legally clear some 640,000 ha of native vegetation, i.e. 80,000 ha per year. The NSW auditor general estimated that in 2005, 75,000 ha was cleared, of which 45,000 ha was cleared legally, and 30,000 ha illegally. To put this in perspective, this is about a 1 km–wide strip of vegetation from Melbourne to Adelaide, every year. Estimates of the amount of revegetation occurring are difficult to interpret, although the rapidly improving technology will give reliable estimates of this in the future. However, as at 2009, the areas of habitat being re-established each year are vastly less than the amounts still being cleared. Furthermore, areas that are revegetated will take decades to centuries to develop into the type of ecosystems that were cleared.

Bird populations in Australia's agricultural regions are consequently suffering serious declines. Recher (1999) reviewed the state of Australia's avifauna and predicted that, unless management changed substantially, the country would lose half of its terrestrial avifauna over the next century. And sure enough, in 2009 a landmark study has detailed the regional collapse of an avifauna in the box and ironbark forests and woodlands of northern Victoria (Mac Nally et al. 2009). Of course, stopping vegetation clearance is not in itself sufficient to stop biodiversity loss. The threats to our avifauna are many, complex and varied, and there is no doubt that they will continue to intensify for the foreseeable future with human population pressure and global climate change.

There is a growing recognition that our national reserve system is inadequate to protect our biodiversity, because it is not sufficiently extensive to provide a buffer for ecosystems against large-scale disturbances such as fire and climate change, and is not sufficiently comprehensive and connected to accommodate large-scale movements of organisms, such as migration and dispersal of animals. There are also a large number of organisms not adequately represented, or not represented at all, in the existing system. So our attention turns increasingly to augmenting and connecting the reserve system by rehabilitating and protecting key areas on private land.

In response to the plight of woodland birds, there has been an increasing urgency of calls for revegetation in south-eastern and south-western Australia. Many organisations, communities and individuals are now working on programs of revegetation to protect biodiversity, particularly in agricultural landscapes, where most of the historical clearing has occurred and where the sharpest biodiversity declines are being observed. This work is occurring at many spatial scales and across a variety of land tenures. At the largest scale, several initiatives are underway to connect landscapes across hundreds and even thousands of kilometres. Two of these

initiatives—Habitat 141 and Gondwana Link—are discussed in this report.

More often than not, revegetation programs are driven by purposes other than biodiversity conservation and the benefits of them to birds are secondary. A common motto is 'plant trees and the birds will come'. That is not always the case. Plantings that do not have biodiversity conservation as their core purpose—such as plantations for carbon storage—are often monocultures of same-age trees, which can have minimal benefits for birds and other wildlife. Even when biodiversity protection or ecosystem function is the primary stated reason for revegetation, the benefits may be questionable. For example, some revegetation projects may measure their targets in terms of the number of hectares planted and while they may satisfy such criteria, there is no measure or guarantee of benefits to wildlife. And where such projects do have biodiversity benefits, the lack of quantitative monitoring, due to an emphasis on spatial targets, means that we may learn very little about the biodiversity benefits of these efforts.

On the other hand, effective revegetation does not only benefit birds; restoring native vegetation cover is integral not only for combating salinity and reducing erosion, but also to maintain nutrient recycling and rebuild other natural ecosystem services that have collapsed with the loss of native woodlands—the alternative is desertification and irredeemable biodiversity loss.

One of our most pressing problems is that the scale of the restoration does not match the scale of the problem. Revegetation is time-consuming and often labour-intensive and expensive. In this report, Geoff Barrett and his colleagues describe a revegetation project in the Holbrook catchment in New South Wales, where $2 million was spent and managed to add 2 per cent vegetation to the catchment. But rather than being a cause for despair, such figures should act as a spur to increase the scale and ambition of our efforts.

We should acknowledge that in some pockets of agricultural Australia, revegetation is nothing new. Landholders in the Wallatin and O'Brien Creek catchments of the Western Australia's Central Wheatbelt have planted 1,750 ha of woody perennial vegetation in the catchments from the 1920s to 2006, adding 4.6 per cent further cover to the 9.4 per cent cover of uncleared remnants (Smith 2008)—this decades-long effort points to the amount of work that is truly required to make a significant difference through revegetation. Much of the vegetation in woodland remnants is stressed, or will become so before much of the current crop of revegetation has become suitable as habitat, so it will not be able to divert a crisis of habitat quality and availability in the coming years. A strategic view over a decadal time scale, along with an ambitious geographical scale, is essential if we are to provide a buffer to our threatened and declining woodland birds. "The problem is a complex one of scheduling and placement, and its optimisation presents major theoretical and analytical challenges" (Mac Nally 2008).

The purpose of this report is to illustrate some of the benefits that have accrued for birds from past and ongoing revegetation efforts, to show that we can provide new habitats for woodland birds, and to warn that an ad hoc approach to revegetation (without detailed consideration of the needs of fauna) may ultimately fail to deliver suitable habitats to support the most sensitive species. Future work needs to plan for the reconstruction of habitat features that are used by different species of woodland birds; the scale of this habitat reconstruction needs to be significantly increased; new habitats need to mimic natural systems (with floristic and structural diversity and heterogeneity), and they must be self-sustaining and resilient to climate change. A new approach to repairing cleared and damaged landscapes is gradually gathering momentum, and some of the underlying principles and required approaches are explored in this publication.

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Opposite page, left: Small woodland birds such as the Red-capped Robin favour farms with many elliptical plantings (see page 10). Photo by **Chris Tzaros**

Opposite page, middle: Planting trees too close together will result in structural problems in the trees themselves, which may require thinning (see page 13). Photo by **Dean Ingwersen**

Left: The Splendid Fairy-wren is one of several species observed using revegetation in the WA Wheatbelt to facilitate movement between patches (see page 6). Photo by **Ashley Herrod**

Above: Reducing the damage caused by stock to river banks and streamside vegetation is a key challenge for many revegetation projects. Photo by **Chris Tzaros**

Conserving a region's bird fauna is a complex challenge

By Andrew M. Fisher, Charles Sturt University

The Bathurst landscape in the Central Tablelands of NSW comprises a range of land uses, including farming, forestry, urban uses and nature conservation. Although the area retains around 50 per cent native vegetation cover, this coverage is by no means uniform, both in terms of plant species composition and its location within the landscape. This is the result of a complex interplay between soil, topography, climate and land-use factors. The distribution and abundance of bird species within this landscape is correspondingly complex. Analysis of 116 species recorded across 39 sites over two-and-a-half years revealed seven main groupings of bird species (Fisher 2001a):

- species associated with open woodland
- species associated with degraded woodland
- species associated with riparian strips in agricultural land
- species associated with dense forest
- species associated with dense understorey
- species that were sparsely distributed or with narrow habitat requirements
- widespread species.

This study demonstrated that the bird fauna present at a given site is a function of the type and quality of the habitat present, coupled with the nature of the landscape surrounding the site. For example, riparian strips within cleared and grazed farmland were used by woodland and forest bird species only, in spite of the lack of understorey vegetation (Fisher & Goldney 1997). But where riparian strips were set within remnant vegetation, they were used by a number of additional bird species (e.g. Azure Kingfisher and Rufous Fantail).

Patches of native forest within softwood plantations were shown to provide valuable habitat for native bird species (Fisher & Goldney 1998). The mean occurrence index (a measure of the number of times a species was recorded at a site) was positively correlated with patch area, but negatively correlated with the perimeter–area ratio. This implies that large, compact patches of native forest are of more value to birds than small, thin strips of vegetation. Mean occurrence index also decreased with increasing remnant degradation.

Within woodland sites along a gradient of time since regeneration, there was a clearly discernable successional sequence in terms of bird species recorded (Fisher 2001b). Species characteristic of open areas (e.g. Willie Wagtail) were associated with early-regeneration sites. As regeneration advanced, ground-foraging species (e.g. Speckled Warbler) that retreat to shrub cover became apparent, as did shrub feeders (e.g. Rufous Whistler) and open canopy species (e.g. Striated Thornbill). At the most established sites, the species mix included those requiring mature understorey (e.g. Golden Whistler), along with the trunk-feeding White-throated Treecreeper.

The key message arising from this work is that a mix of habitats is required in order to conserve a region's bird fauna. Whilst area plays a role in determining the suitability of a patch of native vegetation for birds, landscape context has a critical influence on the habitat value of a given site. This underscores the requirement for habitat restoration activities to provide a mosaic of habitats and microhabitats to meet the array of species' requirements, as well as the use of existing patches of native vegetation as the building blocks for regional level restoration activities.

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Above: The Azure Kingfisher is one species more likely to be found in riparian strips planted within remnants. Photo by **Chris Tzaros**

Birds and farmland revegetation in Western Australia

Patrick Smith, CSIRO Sustainable Ecosystems, Perth

In recent years, CSIRO has been researching biodiversity values of farmland revegetation and woody perennial farming systems such as oil mallees and saltbush in Western Australia. A synthesis of the results from these studies suggests the following three key points for birds:

1. Many birds utilise farmland revegetation—but not all do

Like all biota, birds express preferences for different types of habitat. Some species show broad preferences, while others have narrow requirements. Farmland revegetation should be considered as just another type (or class) of habitat. Some species will happily utilise it regularly, others may utilise it reluctantly under some circumstances, yet others may not utilise it at all. Typically, we find that on average around two-thirds of the bird species we find in remnant bush in an agricultural landscape will also be found in the revegetation in that same landscape—though some species are found regularly, and some species are found rarely. About a third of the species found in remnant bush in agricultural landscapes are never seen in revegetation in the same landscape.

Close inspection of bird activity reveals that there are two main things that birds are doing in the revegetation.

Firstly, there is a set of birds that appear to use revegetation chiefly as cover when moving about within the agricultural landscape. These species do not typically stop within the revegetation to browse or feed, but pass through—or immediately above—the plantings, making use of the cover provided by the vegetation. Species we have noted doing this include Galah, Grey Fantail, Grey Butcherbird, Grey Shrike-thrush, New Holland Honeyeater, Regent Parrot and Splendid Fairy-wren. Of course, this does not mean these species never utilise any food resource within revegetation, it simply means that our results to date suggest that mostly they are just passing through.

Secondly, we have observed many species using the revegetation as a food resource, spending time in the plantings browsing for insects, nectar or seeds amongst the canopy or on the ground. Often, these species are the common farmland species—e.g., Australian Ringneck, Stubble Quail, Common Bronzewing and Willie Wagtail—but other species more often associated with remnant bush are also observed, for example, Red-capped Robin, Red Wattlebird, Inland Thornbill, Yellow-rumped Thornbill, Striated Pardalote, Brown Honeyeater, Yellow-plumed Honeyeater, Singing Honeyeater and Weebill.

2. Vegetation characteristics may be more important to birds than the size or location of the patch

One of the perhaps surprising results to come out of our work is the suggestion that birds may not be as fussy about the size and location of a patch of revegetation as they are about the quality of the habitat that the patch provides. Considering revegetation as just another class of habitat, it appears that birds show a distinct preference for higher quality revegetation, but do not mind if it is close to bush or isolated from bush, or if the vegetation is in long narrow belts or large continuous blocks. Our results show clearly that there is greater bird species diversity and greater bird species abundance in mixed-species revegetation than there are in monocultures of oil mallees, saltbush or other tree or shrub species. The diversity and abundance of birds in various types of plantings tended to be the same, regardless of whether the patches were adjacent to bush or isolated, or if they were long narrow belts or more extensive blocks.

As well as the plant species diversity within revegetation, the habitat quality of a planting is also affected by its age and by management. Some aspects of quality habitat only develop with age (e.g. canopy height, tree hollows, accumulated litter and woody debris) and others can be affected by management (e.g. presence of livestock or rabbits destroying understorey and preventing regeneration).

3. Reconnecting isolated patches of bush with revegetation works

The final key point is that, from WA, we now have evidence that recreating habitat networks at the landscape scale has a positive effect on bird diversity within small patches. We have compared bird survey results from the Kellerberrin area in 1995 with surveys done in 2004 and 2005. We found that small (on average, 15 ha) formerly isolated patches of remnant vegetation that were reintegrated into habitat networks by revegetation corridors during the 1990s had a significantly greater diversity of bird species in 2004 and 2005 than they did in 1995. Overall species numbers in these reconnected remnants increased by over 22 per cent and most species (57 per cent) were observed more frequently in these remnants in 2004 and 2005 than they were in 1995. Over the same period, the bird diversity fell by 22 per cent in a set of larger isolated remnants (on average, 25 ha) that were not reconnected. And, in a third set of even larger remnants (on average, 92 ha) that have always been part of extensive habitat networks, while the bird diversity did not change overall, a large majority of species (73 per cent) in these remnants was observed less frequently in 2004 and 2005 than in 1995. The return of many bird species to small remnant patches from which they were absent 10 years earlier is a positive outcome and a strong endorsement for revegetation activities. At the same time, the results show us that even the bird communities in 'better off' parts of our agricultural landscapes are still under threat—so let's keep that revegetation coming.

Further information

www.csiro.au/people/Patrick.Smith.html

Above: The Western Australian Wheatbelt: one of the most extensively cleared regions in the country. Photo by **Dean Ingwersen**

Below: Woody debris is a key component for retention in both remnant and revegetation sites. Ground foraging insectivorous birds, among the most threatened group in Australia's woodlands, rely on this substrate for a healthy supply of prey. Photo by **Chris Tzaros**

Woodland bird breeding in revegetation sites in the greater ACT region

By Suzi Bond, Julian Reid, (Fenner School of Environment and Society, Australian National University) and Nicki Taws (Greening Australia)

Vesk et al. (2008) query whether early stages of woodland revegetation provide breeding habitat for woodland birds. The senior author surveyed landbird breeding activity in 20 wooded sites in the spring of 2003 (three visits to each site) in the region between Canberra and Boorowa. The 20 sites varied in size from 0.4 to 9 ha, and they were stratified according to four age classes of revegetation and a fifth class of small patches of remnant woodland that served as controls; there were four sites in each class. The time since planting of the four revegetation classes averaged 6, 8.5, 11 and 13 years. A broader study of over 100 revegetated sites in the same region had shown that woodland birds begin to colonise revegetation three to four years after planting (Taws 2007).

Some 111 bird species were recorded across the 60 surveys at 20 sites, with 62 woodland and 49 non-woodland species (classified by Reid 2000). The number of all landbird and woodland species recorded attempting to breed generally increased from the youngest age class of revegetation, to older classes, to remnant woodland. This result was significant for all birds (Figure 1a) and near the margin of significance for woodland species. Hollow-nesting species were responsible for the increased number of species breeding in remnant patches, relative to older age revegetation classes. And, with obligate hollow nesters removed from the data, across classes there was little difference in the number of breeding species except for in the youngest revegetation (Figure 1b). There were remnant trees with hollows in about half of the revegetation sites, which explains the breeding attempts of some hollow-nesting species in those revegetation classes; thus, we recommend that sites selected for revegetation should aim to include old remnant eucalypts where possible. There was no difference in the number of species nesting in revegetation where eucalypts dominated the planting versus wattle-dominated sites.

What was most striking about the breeding results was the low degree of overlap between species showing signs of nesting in revegetation and those in remnant woodland. Of the 43 landbird species detected attempting to breed, 27 were in revegetation and 24 were in remnants with only 8 species in common. This result suggests that revegetation provides novel nesting opportunities for birds in the region, generally not provided by remnant patches of woodland (and vice versa of course).

Two species listed in NSW as Vulnerable (Superb Parrot and Brown Treecreeper) and one declining species (Jacky Winter) were only found nesting in remnant woodland, while one Vulnerable (Diamond Firetail) and three declining species (Southern Whiteface, Rufous Whistler and Dusky Woodswallow) were detected breeding only in revegetation in this study; again there was no overlap in species identity. A sixth declining species (Red-capped Robin) has nested in revegetation at another site in the broader study (Bond & Taws 2006). Other declining species recorded in the 16 revegetation sites used in this study were Scarlet Robin and Crested Shrike-tit, as were the Vulnerable Speckled Warbler and Hooded Robin. A further 16 species have been recorded nesting in revegetation across the broader survey, bringing the total to 45 species, of which 32 species are woodland-dependent (after Reid 2000).

A wide range of woodland-dependent and other species utilise revegetation in the greater ACT region, including many species of conservation significance. Of these, a substantial proportion is now known to have attempted to breed in revegetation, and we are confident that ultimately many species will be found to breed in revegetation successfully. Those species dependent on hollows for nesting will not be able to breed in replanted trees and vegetation for many years, unless hollows are deliberately provided (Vesk et al. 2008). The lists of species recorded breeding in revegetation versus remnant woodland in this study were highly complementary, indicating that actively growing, regenerating woodland—including revegetation—probably has a vital role to play in our attempts to conserve the full range of bird species in agricultural landscapes. Our results suggest that, where possible, revegetation should be located around existing remnant (and dead) trees with hollows, since this activity will serve to protect isolated trees and increase the habitat value and nesting opportunities for a fuller range of bird species.

Mean species richness of all landbirds (a) and landbirds that are not obligate hollow nesters (b) showing strong evidence of nesting activity over entire sites across four age classes of revegetation and similar-sized woodland remnants (with 1 standard error).

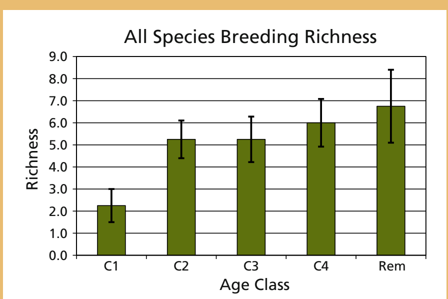

Figure 1a

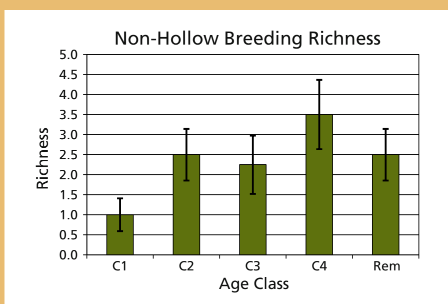

Figure 1b

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Above: The declining Dusky Woodswallow has found new opportunities for nesting in revegetation in the ACT. Photo by **Chris Tzaros**

Revegetation in rural landscapes: will it help woodland bird communities 'recover'?

By Rohan Clarke, Greg Holland, Alistair Stewart and Andrew F. Bennett, Landscape Ecology Research Group, School of Life and Environmental Sciences, Deakin University

A drive through many rural landscapes reveals visible signs of change: ribbons of green extending along drainage lines and creeks, stands of young trees growing along the boundaries or across corners of paddocks and patches and plantations of trees which add complexity to cleared farmland. Revegetation is being carried out in many regions for a variety of reasons: to provide shelterbelts for stock; to reduce or prevent soil erosion; to combat the threat of salinity; to stabilise river banks and improve aquatic environments; or to create a more pleasant environment in which to live and work. A common expectation is that such revegetation will also be of benefit to native wildlife.

What are the benefits of revegetation? Which species benefit? How do wildlife respond to different types of revegetation? Will revegetation in cleared landscapes 'bring back' species, or will it simply assist species that are still surviving in farmland? These kinds of questions are being addressed in a study at Deakin University investigating the landscape-scale benefits of revegetation for birds in the Glenelg Hopkins catchment in south-western Victoria.

Why study at a landscape-scale? For most bird species, single patches of vegetation are not sufficient on their own to support viable populations. Many species move between different parts of the landscape on a daily or seasonal basis, and migratory species move at even larger scales. The conservation status of woodland species depends on the overall network of habitat available to support the population. The landscape is also an appropriate scale for managing and restoring rural environments. Land managers deal with issues such as the most effective location and pattern for vegetation, the effects of different types of land uses, and setting goals for the overall amount of vegetation in a region.

We selected 43 landscapes, each 8 km^2 in size (800 ha) to represent:

- landscapes cleared of native forest and woodland
- landscapes with *increasing* amounts of revegetation
- landscapes with *decreasing* amounts of remnant vegetation
- landscapes with both remnants and revegetation

Many of these landscapes also have scattered trees in farm paddocks, typically large River Red Gums that occur at a rate of 5 or more trees per 15 ha. Birds were systematically surveyed at 12 sites in each landscape, with sites stratified among areas of remnant native vegetation, revegetation, pasture with scattered trees, open farm paddocks and wetlands. Work on this project is still underway, but some fascinating results are emerging.

The number of species (species richness) of woodland birds in these farm landscapes is most strongly influenced by the total amount of wooded vegetation (Figure 1).

- Species richness *decreases* as remnant native vegetation is lost from farm landscapes.
- Species richness *increases* as the amount of revegetation in the landscape increases.

For the same overall amount of vegetation, landscapes with remnant vegetation or a mix of remnant and revegetation have more species than a landscape with revegetation alone.

This has several important implications:

1. It demonstrates that revegetation of farm landscapes is beneficial for woodland birds, since a wide range of species is being recorded.
2. It shows that revegetation does assist in reversing the detrimental effects of the loss of native vegetation. As revegetation is added to cleared farm landscapes, the bird community gradually 'recovers', with new species attracted back into the landscape.
3. It highlights the collective benefits of individual revegetation actions. Each planting has value because they each add incrementally to the landscape's total wooded cover in the landscape—the main driver of species richness.
4. It emphasises the paramount importance of protecting remnant native vegetation, because landscapes with remnant vegetation support a higher number of species than those with revegetation alone. Further, remnant vegetation provides resources that are scarce in younger revegetation, and supports species that depend on mature trees (e.g. White-throated Treecreeper and Varied Sittella).

Revegetation and restoration in farm landscapes involve a long-term commitment. It will take decades for trees to grow and for the full benefits to bird communities and the wider environment to be appreciated fully. It is also an investment in the future of our communities and the generations of Australians to come.

As revegetation is added to cleared farm landscapes, bird communities begin to recover. Photo by **Rohan Clarke**

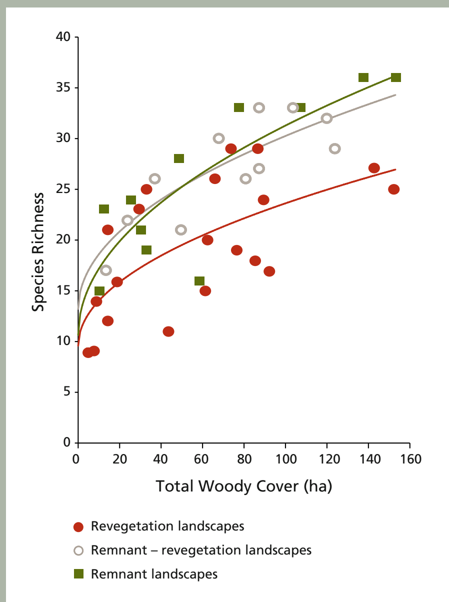

Figure 1. Number of species of woodland birds in relation to area of wooded vegetation for farm landscapes (8 km^2) in western Victoria. Curves represent the modeled relationship for landscapes in which the wooded vegetation is remnant native vegetation (green), revegetation (red) and a mix of both remnants and revegetation (grey).

Revegetation and birds in New South Wales

Rebirding the landscape

By Geoff Barrett, David Freudenberger, Alex Drew, Jacqui Stol and Nick Nicholls, CSIRO Sustainable Ecosystems

With almost a quarter of birds in New South Wales declining, attention continues to focus on finding ways to balance the competing interests of production and conservation. Planting native trees and shrubs has been proposed as a way to restore biodiversity in agricultural landscapes, yet mostly occurs as dispersed, immature stands at a scale well below that required for maintaining biodiversity. Also, the primary objective of such plantings is usually to address issues such as carbon sequestration, salinity and erosion control. Community expectations that such revegetation works have significant biodiversity benefits are unlikely to be satisfied. There is also the question of whether revegetated sites are functioning properly or creating ecological traps where, for example, birds fail to persist and breed.

We present a case study of a tree planting program initiated by the Holbrook Landcare Group in southern NSW. Less than 20% of the original tree cover remains in the region, and on the lower slopes the figure is closer to 1%. The landscape is dominated by annual grazing pastures, mixed exotic and native pastures, and cropping. In 1990, the Holbrook Landcare Group commissioned a survey of tree health across their catchment and discovered that half of the large paddock trees were dying from insect attack. Following research suggesting that birds will remove 50–70% of the insects from a tree canopy, they initiated the 'Rebirding the Landscape' revegetation program with the aim of drawing birds back onto farms and reducing eucalypt dieback. Over $2 million were spent and 2,000 ha of the catchment (2%) was revegetated. Of this, 800 ha were environmental plantings, using local trees and shrubs. CSIRO Sustainable Ecosystems assessed the value of the environmental plantings for birds, and whether the health of the paddock trees improved following the planting of younger trees nearby. Birds were surveyed over three years (2004–2006) in 12 young planted sites (2–3 years old), and compared with adjacent paddock sites and six remnant woodland sites. Birds were also captured and banded to establish whether they were reoccurring in the sites.

Bird diversity

Of 69 woodland bird species recorded, 70% occurred in the planted sites, challenging the view that planted habitat in agricultural landscapes is usually of poor quality. Of all woodland bird species, 86% were recorded in the remnant woodland sites and 49% were recorded in the paddock sites (these sites included paddock trees). The increased diversity of birds in planted sites relative to paddock sites was mostly due to understorey species such as Superb Fairy-wren and Red-browed Finch, supporting research that links habitat structure with bird diversity. Ground-foraging insectivorous woodland birds were under-represented in the plantings. Interestingly, this study links the absence of ground insectivores to a lack of native forb diversity (wildflowers). While there is likely to be a direct link as wildflowers attract insects, the absence of wildflowers in planted sites reflects our current inability to reconstruct the woodland ground ecosystem within planted sites. This is largely a legacy of intensive agriculture and prolonged fertilizer use prior to planting, which has removed the forb seedbank and michorrizal fungi essential to the establishment of wildflowers.

Persistence and breeding

Our results challenge the view that revegetated sites are ecological traps in which birds fail to persist and breed. The proportion of mist-netted birds recaptured was similar in both planted (15%) and remnant woodland sites (16%). Shrub-dependent species such as the Superb Fairy-wren and Red-browed Finch were actually more likely to be recaptured in planted sites, suggesting that the increased volume of low, dense vegetation cover made these sites preferable to remnant woodland. Of 35 woodland bird species checked for brood patches in planted sites, 69% showed breeding activity, slightly higher than the 63% showing breeding activity in remnant woodland sites.

Ecosystem services

What of the dying paddock trees? Over the short monitoring period a 50% increase in bird activity in paddock trees occurred within the planted sites, compared to a 30% increase in paddock trees in the adjacent paddock (200–300 m away). Also, we observed a 6% increase in the health of canopies of paddock trees occurring within revegetated sites, but no change in the health of the paddock trees outside the planted sites. In another demonstration of ecosystem services provided by birds in planted sites, 31 bird species were observed flying from planted sites into adjacent pasture and crops to forage. There was an average of 50 forays by individual birds into the production matrix per 100 m of fence line per day, with 30% of forays extending beyond 25 m. This compares with around 80 forays per 100 m of fence line per day from the remnant woodland sites. Pest insects such as caterpillars, beetles and grasshoppers were predated during these forays.

There are few examples of the successful reconstruction of whole ecosystems, and perhaps our expectation to see the full complement of woodland birds in the Holbrook planted sites one day is unrealistic. Rather, such planted sites may remain as different transitional states providing, for example, unique habitat such as dense shrubby cover but lacking native wildflowers. This study demonstrates the value of planted native trees and shrubs to birds, but also shows our inability to reconstruct ground-layer habitats. If the loss of ground-foraging insectivorous woodland birds is to be halted, landscapes will need to include areas of low fertilizer use where the native grasses and forbs can survive and ground ecosystems can re-establish.

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Above: Intensive agriculture and prolonged fertilizer use removes the forb seedbank and michorrizal fungi essential to the establishment of wildflowers. Photo by **Glenn Ehmke**

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Revegetation and birds: insights from large-scale, long-term work on the South West Slopes of New South Wales

By David Lindenmayer, Ross Cunningham, Mason Crane, Damian Michael, Rebecca Montague-Drake, Christopher Macgregor and Rachel Muntz, Fenner School of Environment and Society, Australian National University, Canberra

Major vegetation restoration programs have commenced in many parts of Australia to tackle problems, such as salinity and soil erosion, that resulted from landscape modification and agricultural development. Substantial funding has been dedicated to revegetation projects nationwide, including significant initiatives administered by federal and state governments. Although these initiatives are based on the belief that revegetation projects will benefit biodiversity, evidence for the effectiveness of these programs remains scarce. The few studies to date have focused on small-scale, site-level plantings; larger-scale farm-level benefits have rarely been examined. Moreover, although most planting efforts occur in landscapes that also support remnant vegetation, the conservation benefits arising from the cumulative effects of planted and remnant vegetation are poorly known.

Major studies of birds

Since 2001, we have been conducting a series of ambitious large-scale projects aimed at improving our understanding of the biodiversity values of replanted areas on the South West Slopes of New South Wales—the most extensively modified bioregion in the state. The study is based on repeated surveys of vertebrates at 184 field sites on 46 farms across the Murray and Murrumbidgee catchments. These farms were divided into six different categories depending on the amount of planting and levels of remnant vegetation in landscapes. This allowed conclusions about the relative biodiversity value of plantings compared to remnant vegetation for various species. We also compared the effectiveness for biodiversity of different types of plantings. For example, we compared bird occurrence at intersections of strip plantings, within isolated linear plantings, and within block plantings of various sizes.

Results to date

Woodland remnants and replanting

We found over 15 species of native birds responded positively to replanted areas on farms. However, by far the strongest responses for birds were seen for the joint effect of a range of different remnant native vegetation attributes occuring on a farm: large blocks of woodland remnants, the number of scattered paddock trees, and the amount of native grassland. Most bird species of conservation concern in woodland environments were strongly associated with these key native vegetation attributes; Brown Treecreeper was a good example. Unfortunately, the majority of these taxa were absent or rare within plantings. It may take many years before farm plantings support habitat attributes that make them suitable for some species of conservation concern.

Whilst the value of remnant native vegetation on a farm for bird species richness was three times that of replanted vegetation, replantings often added an average of 3.5 bird species that might otherwise have not occurred on a farm. It appears that small-bodied woodland birds were those most likely to be recruited to farms when replanted areas were added to the portfolio of vegetation assets on a property. Two examples were Red-capped Robin and Buff-rumped Thornbill; both were more likely to occur on farms characterised by many plantings, in particular many large, elliptical or block-shaped plantings.

We identified an important interaction effect on bird species richness between planted native vegetation and remnant native vegetation. Plantings added more taxa to overall species richness when a farm had low levels of remnant native vegetation than when levels of remnant native vegetation were high.

Planting geometry

In our study of the geometry of plantings, we found no significant difference in species richness between intersections of plantings and block plantings. However, intersections had higher species richness than isolated linear strips. We also found strong evidence that the bird assemblages inhabiting block plantings were significantly different from linear strips and intersections. Several individual species of birds, including Grey Shrike-thrush and Red Wattlebird, most often occupied block plantings and least often occupied isolated strip plantings.

General conclusions

Our research to date has indicated that replanted areas can make an important contribution to on-farm bird conservation and some species clearly benefit from them. However, others (including a number of declining taxa of conservation concern) respond most strongly to remnant native vegetation rather than revegetation. Conservation efforts for these species might be best focused on farms that already exhibit high levels of native vegetation cover.

Another key finding is that the attributes of plantings matter. Isolated strip plantings support significantly lower bird species richness than block plantings or intersecting linear plantings.

Finally, the responses of reptiles and mammals to replantings have been markedly different to those we have quantified for birds. Clearly, birds are not indicators for other vertebrate groups. As an example, hotspots for reptile biota are rocky outcrops—habitats largely unused by birds. We believe that it is best to focus management on particular species or sets of taxa rather than assuming that birds will be surrogates for other groups.

Acknowledgments

Our work was funded by The Natural Heritage Trust, Land and Water Australia, the Australian Research Council and the Murray Catchment Management Authority. Our surveys could not have been completed without the assistance and dedication of volunteers from the Canberra Ornithologists Group.

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Far left: Replanted area at Burnbank near Ladysmith on the South West Slopes of New South Wales. This area supports a range of bird species of conservation concern including the Hooded Robin, Flame Robin and Speckled Warbler. Photo by **David Lindenmayer**

Left: Intersecting areas of replanted vegetation and native vegetation near Ladysmith on the South West Slopes of New South Wales. Photo by **David Lindenmayer**

Disproportional clearance of better quality land

Consequences for ecological processes and revegetation strategies

By David Paton, School of Earth and Environmental Sciences, University of Adelaide

Across Australia's arable areas, native vegetation clearing has been extensive. For many areas, around 90 per cent of the native vegetation has been lost. Areas with better quality soils, higher moisture and gentle topography are more suitable for European agriculture and consequently have been more extensively cleared. In some areas, less than 2 per cent of the native vegetation remains. This remaining native vegetation is not representative of the proportions of vegetation that originally existed: those habitats on the least productive soils (nutrient-poor sands), rocky ridges and steep gorges are proportionately better represented.

In the Mount Lofty Ranges, this extensive and disproportionate clearance of better quality areas may affect a range of ecological processes. For example, most of the native shrub species in the remaining vegetation flower during the winter and spring. These plants are exploited by a variety of honeyeaters that congregate in these remnants during winter and early spring. But when the flowering ceases in these areas, most of the honeyeaters must vacate and find alternative resources in the region. Knowledge of the plant communities that once existed on the better quality land indicate that Silver Banksia (*Banksia marginata)*, several eucalypts, including South Australian Blue Gum (*Eucalyptus leucoxylon*), Grey Box (*E. microcarpa*) and Peppermint Box (*E. odorata*), and the mistletoe *Amyema miquelii* provided nectar resources for honeyeaters during this period. Since these resources have been more extensively cleared, many of the departing honeyeaters struggle to find food during summer and autumn, and their abundance across the region declines. By next winter when they move back into the reserves, their population sizes are inadequate to fully service the plants that flower during winter and early spring. Many of these plant species fail to set a full complement of seeds and this may ultimately reduce their ability to replace themselves in the future.

A simple solution to this imbalance between summer–autumn refuges, honeyeaters, and the pollination of winter and spring-flowering plants would be to re-establish areas of native vegetation on the better quality lands that include plants that flower during summer and autumn.

The distances over which honeyeaters have been detected moving in the Mount Lofty Ranges region ranged from 1 km to over 100 km, with more than 10 per cent of the detected movements exceeding 20 km (Figure 1). Clearly, these honeyeaters are capable of moving through heavily cleared landscapes, but their movements may be greater now than in the past. Given their apparent ease of movement, the re-establishment of summer and autumn habitats may not need to be juxtaposed on the areas used in winter, and a regional approach to recovering this system can be adopted.

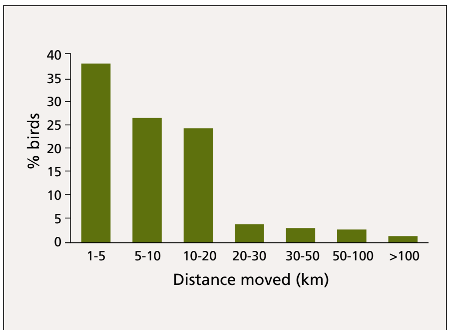

Figure 1. Frequency distribution of distances moved by honeyeaters in the Mt Lofty region of South Australia, based on 356 detected movements of banded birds.

Revegetation and birds in the Tungkillo area

By David Paton, Daniel Rogers and Wendy Harris

Revegetation programs in the Mount Lofty Ranges region in South Australia have been underway for nearly 30 years. Much of the initial revegetation was driven by a need to provide shelter belts, reduce erosion and reduce risks of dryland salinisation (where underlying saline groundwater approaches the surface). Nearly all forms of revegetation—irrespective of their primary purpose—have been promoted as providing a biodiversity benefit as well. Relatively little effort, however, has been put into monitoring the biodiversity gains from these initial revegetation programs.

The Tungkillo area within the Mount Lofty Ranges has been extensively cleared. Only 803 ha of native vegetation remain within this 206 km² area, equivalent to 3.9 per cent remnancy. Most patches of

remnant vegetation are small, often isolated from other patches of native vegetated, and—except for a few larger blocks on poor soils—exist as long, narrow roadside strips. A significant amount of revegetation has been taking place within this area—775 ha of revegetation works had commenced by 2000. The vast majority of these revegetated patches, however, are small, usually less than 10 ha, and nearly half are less than 1 ha. Most of the large patches (those larger than 20 ha) of revegetation within the area are agroforestry plantings involving only one or a few tree species. These new patches of vegetation are also often linear in shape and distant from patches of remnant native vegetation. Much of the revegetation has taken place on the tops of hills or along gullies in areas that were least suited for grazing, since these were the areas that property owners were willing to set aside, or at greatest risk of significant environmental damage such as erosion.

The revegetated patches also differed floristically and structurally from remnant native vegetation. Revegetated plots consisted mainly of dense plantings of a few tree species, often planted in rows or linear arrays, a few metres apart. Most of these plants were of the same age. Even 'passive' regeneration, where areas adjacent to remnant trees or patches of vegetation were fenced off from grazing by stock, usually resulted in dense even-aged groves of eucalypt saplings. Such regeneration is probably not natural, in that the saplings were re-establishing on areas that had been altered by grazing (at least), and the areas had no other substantive plants with which the seedlings would have had to compete. In comparison, remnant vegetation in the area had a greater diversity of tree and understorey plant species (Figure 2).

The eucalypts that dominated the natural woodlands were at much lower densities, varied in size or age, and had different shapes to those establishing in revegetated plots. The most notable difference was that the trees in remnant vegetation often had substantial lateral branches, often within a few metres of the ground, with the trees having breadth and depth and a spreading crown of foliage. Many of these trees had canopy diameters as wide as they were tall. Within the revegetation plots, the eucalypts had no lateral branches, had a poplar-like shape with canopy diameters many times less than their height. Trees develop their lateral branches when their growing points or apical meristems are at that height. So, even if the saplings within the revegetation plots are thinned out now, they will not produce the lateral branches and spreading canopies typical of the natural woodlands.

These glaring differences in habitat floristics and structure were correlated with marked differences in the structure of the avian communities that inhabited the different vegetation types. In general, revegetated plots supported fewer birds and fewer species of birds compared with similar plots in remnant native vegetation (Figure 3).

Although the 'passive' regeneration areas had higher bird use than the other forms of revegetation, this bird use was largely due to the birds using the few large spreading remnant trees that existed prior to the areas being set aside for regeneration. Furthermore, few of the birds using these revegetated areas were species of woodland birds that were considered to be declining. Of the 20 declining species recorded, 16 were recorded using only 1–3 of the 12 revegetation areas that were studied, and then not regularly, and usually only where these abutted a patch of remnant vegetation. The only species recorded at half or more of the revegetation areas were Australian Magpie, Crimson Rosella, Galah, Little Raven, Red Wattlebird and White-plumed Honeyeater. These are mainly species that use open areas with scattered trees and are abundant and widespread in the Tungkillo area. Some of these bird species are considered pests to various agricultural or horticultural pursuits.

Clearly, the revegetation that has taken place in the Tungkillo area provides little benefit to the vast majority of woodland birds. This conclusion is not unexpected, since the vast majority of revegetation projects list biodiversity gains as a relatively low priority. The conclusion that the biodiversity gains are poor may be premature, because these revegetated patches may in time develop habitat features suitable for some of the declining species.

However, there are other reasons to suggest they will provide limited respite for biodiversity losses. First, the vast majority of the patches that have been revegetated are isolated from other patches, thus, even if these new habitats were suitable, many of the smaller woodland bird species may not be able to regularly or efficiently access them. Second, and more importantly, most of the revegetation patches are too small to meet the home range requirements of individuals or pairs of declining species, irrespective of the quality of the habitat. At best, the revegetation efforts in the Tungkillo area may facilitate movements of birds through the landscape, but they are not going to be sufficient in area for the birds to access adequate resources throughout the year, establish home ranges, and breed. If revegetation programs are going to provide habitats in which the declining species can breed, then the patches need to be substantially larger in area, perhaps of the order of 10–100 ha or more; and close to other patches of woodland vegetation.

Above left: Native vegetation in the Tungkillo area illustrating the structural diversity and hetero-geneity of native woodlands. Photo by **Wendy Harris**

Below left: Passive regeneration of Red Gum (*Eucalyptus camaldulensis*) following the exclusion of stock, illustrating that a dense stand of similar-aged plants lacking lateral branches can develop. Photo by **David Paton**

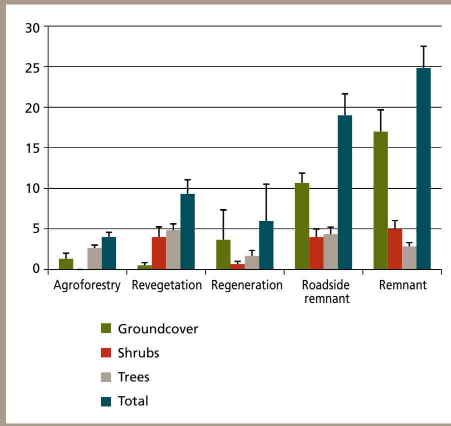

Figure 2. Differences in plant species richness for various types of re-vegetation and for remnant vegetation within the Tungkillo area of South Australia.

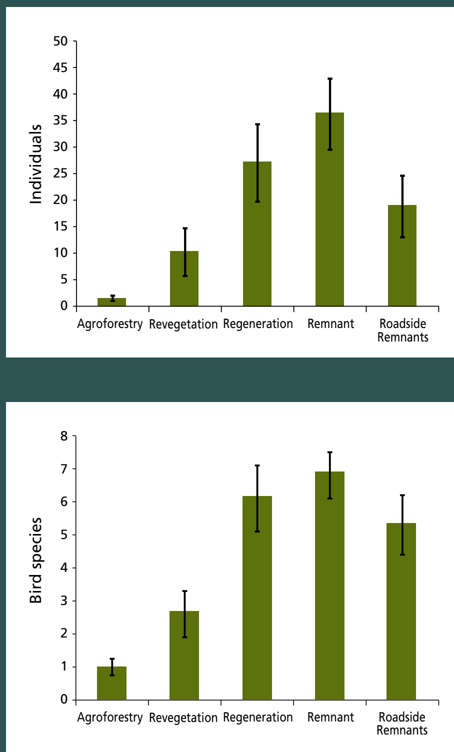

Figure 3. Mean (± se) total bird abundance (top) and species richness (bottom) for five vegetation types surveyed in the Tungkillo region. Surveys were conducted on 50 m x 20 m plots for three 40-minute periods during autumn and winter 1999. Number of plots per habitat type ranged from 3–6.

Bird use of the Monarto plantations: insights from a study of home ranges

By David Paton, Joel Allan, Daniel Rogers, Phil Northeast

In the late 1970s, there were plans to establish a satellite city at Monarto, about 70 km east of Adelaide, on the eastern flank of the Mount Lofty Ranges. As part of the development, substantial areas of cleared land were revegetated, in an effort to ameliorate the environment, reduce dust and make the area more attractive for human habitation.

This has been the largest revegetation program conducted in South Australia, with some 600,000 plants established on 1850 ha of land within an area of about 160 km². In all, some 250 species of trees and large shrubs were used, including local species of eucalypts (e.g. *Eucalyptus leucoxylon, E. calycogona, E. porosa, E. odorata*), *Callitris preissii, Allocasuarina verticillata* and *Melaleuca lanceolata*, plus a wide range of eucalypts from other parts of the country, particularly species from south-western Australia, mostly having natural distributions between Albany, Esperance and Kalgoorlie. The trees and large shrubs were planted as small saplings 4–6 m apart in contour rows that were also 4–6 m apart. Although the intention was to subsequently plant an understorey of shrubs, plans for the proposed satellite city were shelved, and the shrubs were never added. Despite this, a shrub layer of mainly chenopods, such as *Rhagodia crassifolia* and *Enchylaena tomentosa*, is slowly establishing. Within this region, around 2000 ha of remnant vegetation still remained (Figure 1).

In all, 92 species of native birds have been recorded using the revegetated habitats in the Monarto area, including 40 species that are considered to be declining. This is equivalent to 89 per cent of the avifauna that would be expected to use woodland habitats in this region. Of these species, 53 are recorded regularly in the revegetated areas, with banded individuals from 25 species being recaptured or resighted—often repeatedly—over periods spanning 1 year to 10 years (Figure 2). These indicate regular and repeated use of revegetated areas—if not residency—for many species.

A total of 28 species have also bred in the Monarto plantations, including species of conservation concern, such as Restless Flycatcher, Hooded Robin, Rufous Whistler and Diamond Firetail. Of the 28 species, four were only able to breed in revegetated areas following the provision of nest boxes, including the introduced Common Starling and the Australian Owlet-nightjar.

The Hooded Robin and Red-capped Robin are known to reside entirely within revegetated areas at Monarto, with home ranges varying from 3.6–8.4 ha and 12.1–18.4 ha respectively (Northeast 2007). Not all areas of revegetation within a patch were used by either species (Figure 3), suggesting that the suitability of the revegetation for them varied within a patch. Other species—such as the Australian Owlet-nightjar, Superb Fairy-wren and Diamond Firetail—usually included at least a small amount of remnant vegetation

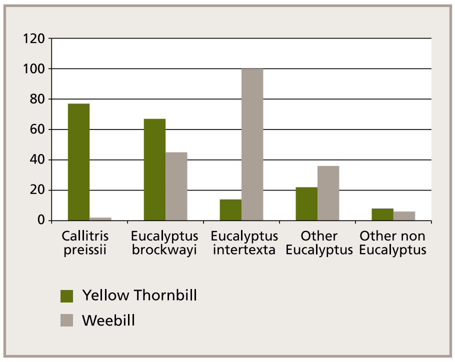

Figure 6. Use of different trees by Weebills and Yellow Thornbills in revegetation areas at Monarto

within their home ranges, suggesting that the revegetation did not provide all their needs. Owlet-nightjars regularly used nest boxes erected within the revegetation but also used natural hollows provided in remnant vegetation for daytime roosting. Eight radio-collared Owlet-nightjars, however, had nocturnal foraging ranges of 2 ha–29 ha that were predominantly in revegetation (65–100 per cent of nocturnal fixes) (Hlava 2005).

The Varied Sittella, Restless Flycatcher and Brown-headed Honeyeater all had much larger home ranges than those of robins and wrens, with one group of

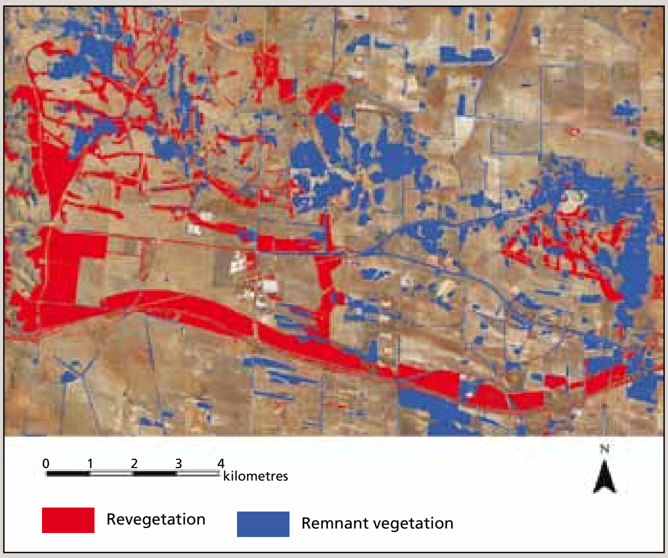

Figure 1. Distribution of revegetation (red) and remnant (blue) over a 160 km² area near Monarto.

Interval (years)	Species
1–2	Peaceful Dove, Spotted Pardalote
2–3	Australian Owlet-nightjar, Brown Treecreeper, Red-capped Robin, Red Wattlebird
3–4	Australian Ringneck, Chestnut-rumped Thornbill, Silvereye, Singing Honeyeater, Variegated Fairy-wren, White-plumed Honeyeater
4–5	Diamond Firetail, Golden Whistler, Hooded Robin, Varied Sittella, Yellow-plumed Honeyeater
5–6	Grey Shrike-thrush, Rufous Whistler
6–7	
7–8	Brown-headed Honeyeater, Superb Fairy-wren, Yellow-rumped Thornbill
8–9	New Holland Honeyeater
9–10	Spiny-cheeked Honeyeater, White-browed Babbler, Yellow Thornbill

Figure 2. Maximum intervals between original banding and recapture for 25 species of birds using revegetated areas in the Monarto area.

Facing page, top: High planting densities following direct seeding programs in the Mt Lofty Ranges. Photo by **David Paton**

This page: Though occupying the same area, Weebills *(left)* and Yellow Thornbills *(right)* have distinct habitat preferences: Weebills prefer trees with more open canopies, while Yellow Thornbill prefer dense canopy cover. Photos by **Chris Tzaros**

Varied Sittellas using an area in excess of 200 ha during a two-week period (Figure 4). The home range of a Restless Flycatcher and Brown-headed Honeyeater in the same area were 185 ha and 66 ha, respectively. Such species are unlikely to benefit from revegetation unless large patches are planted.

The pattern of use of revegetated areas by birds, however, varies greatly within patches, with some areas supporting many more species than others (Figure 5). This suggests that there is a suite of features, probably floristic and structural, that will influence the use of revegetation areas by various birds, and that restoring the birds to heavily cleared landscapes is not as easy as simply planting plants. Individual species are likely to respond to different floristic and structural features and these features need to be considered in future revegetation programs. For example, Weebill and Yellow Thornbill use the same range of tree species but show distinct preferences: Yellow Thornbill prefers trees with relatively dense canopies and Weebill prefers those with more open canopies (Figure 6, facing page). Thus, the presence of either bird species in a patch of revegetation may depend on the species that are planted. Often, other bird species show little overlap in their home ranges, indicating that they are responding to different features of the revegetation. Even within the home ranges of birds, there are areas of higher use and lower use. Understanding the microhabitat needs of individual species may help in designing new habitats that will better cater for a given species; for nearly all species the important characteristics are not known. In the absence of such information, maximising the structural and floristic heterogeneity of future revegetation is a good default which should maximise the number of species likely to benefit.

In summary, the substantial positive avian responses to the Monarto plantations provides strong evidence that if suitable additional habitat is re-established and at appropriate scales, then predicted losses of woodland bird species could be prevented.

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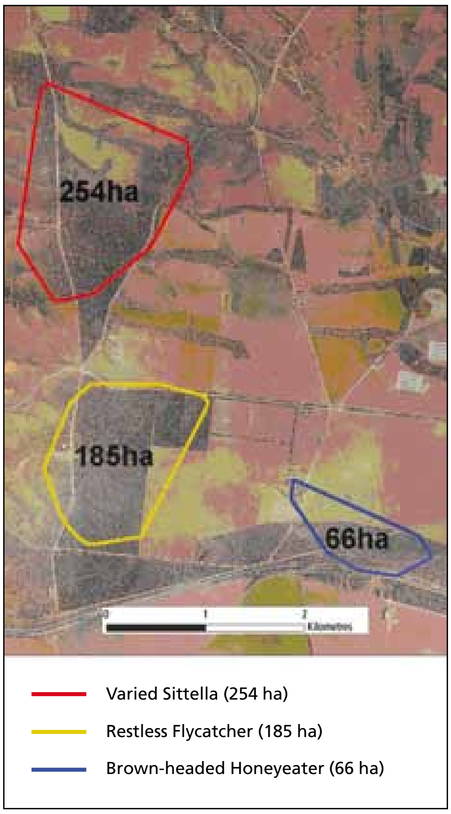

Figure 4. Home ranges for Varied Sittella, Restless Flycatcher and Brown-headed Honeyeater at Monarto.

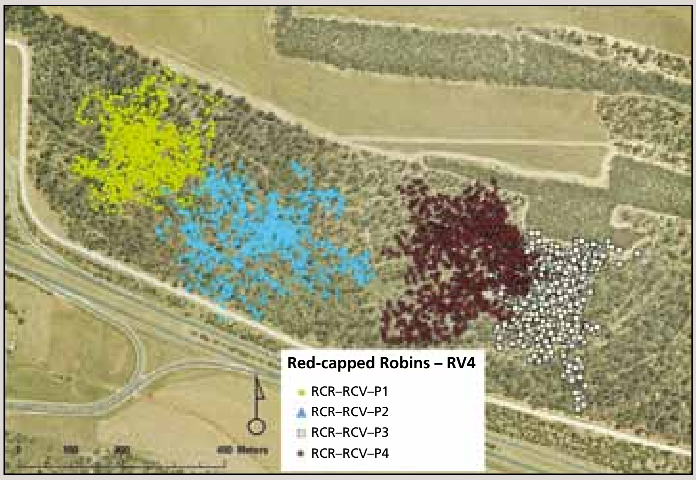

Figure 3. Home ranges of the 4 pairs of Red-capped Robins using a 60 ha area of revegetation at Monarto (from Northeast 2007).

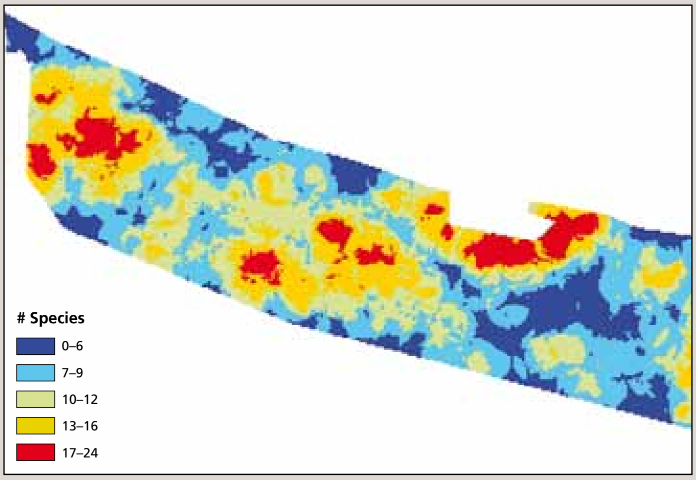

Figure 5. Variation in species richness within a 60-ha patch of revegetation at Monarto, showing that within this patch some areas are attracting and supporting more species than other areas. Data are based on recording and mapping with a GPS the locations and numbers of each species of bird over a *ca* 60ha area of revegetation at Monarto, repeated on 13 separate occasions: 5 in autumn, 4 in winter and 4 in spring.

Composite provenancing of seed for restoration: progressing the 'local is best' paradigm for seed sourcing

By Andrew Lowe, Australian Centre for Evolutionary Biology & Biodiversity, University of Adelaide

The use of local seed is widely advocated for restoration, and is based on the premise that locally sourced seed will be the best adapted for restoration projects (e.g. McKay et al. 2005; O'Brien et al. 2007). Despite evidence for local adaptation, a 'local is best' sourcing practice misses two important points that may be seriously impacting on restoration outcomes, particularly resilience in the face of future environmental changes. This paper discusses the issues and suggests a new and improved approach to seed sourcing—composite provenancing (sourcing of seed from multiple locations).

The first potential problem with 'local is best' recommendations is that there is a serious risk of encouraging the establishment of populations that will not harbour sufficient evolutionary potential for future environmental change (i.e. establish genetic 'ghettos' (Moritz 1999). In addition, strict adherence to 'local is best' protocols may encourage the selection of inbred or genetically depauperate seed sources, when genetically healthier sources further afield may produce a better restoration result. This may serve to perpetuate the number of small inbred populations across highly degraded landscapes that are unlikely to persist in the long term.

The second issue is that the particular environmental conditions that drive local adaptation can change very rapidly. The environment is continually changing at different rates and scales, from annual to 1000 and 100,000–year time scales (Wilkinson 2001). The most notable recent environmental change has been the emergence from the last ice age about 10,000 years ago, when the atmosphere was significantly cooler and drier than it is today. Following post-glacial warming, species (and their genes) have redistributed across the landscape, some over thousands of kilometres and at exceptionally rapid rates (Lowe et al. 2006). In addition, recent anthropogenic influences are expected to have dramatically changed selection pressures, for example, variability in temperature and rainfall distribution associated with anthropogenically forced climate change, and other environmental changes due to habitat fragmentation, increased salinity, irrigation, and heavy metal deposition. In the face of rapidly changing environments it is pertinent to ask how 'local environments' should be defined in contemporary landscapes, especially for long-lived species such as trees (Wilkinson 2001). In many regions of the world the conditions under which a 200-year-old tree was established are now very different to those existing today, and it could be legitimately argued that source material from more distant (geographically and ecologically) populations may harbour adaptations that more closely match the environment of the focal restoration site today.

So, can we improve the selection of seed provenances to maximise evolutionary potential in restoration plantings? Can we facilitate long-term adaptive responses to contemporary and future selection pressures (Moritz 1999; McKay et al. 2005)? In answering these questions, it is informative to note two main processes: the redistribution of standing genetic adaptations (through gene flow); and the evolution of new adaptive variants that have allowed species to keep pace with environmental change naturally. The answer to provenance selection for future adaptive potential surely then lies in mimicking these natural gene flow and evolutionary dynamics.

For some species, gene flow via pollen and seed has been documented to occur over tens, and in some cases hundreds of kilometres (Bacles et al. 2006; Nathan 2006), but many species are now limited in their capacity to disperse propagules (both pollen and seed), following habitat alteration and fragmentation. Gene flow in most species is leptokurtic, with most propagules dispersing proximally, but with a significant proportion moving over longer distances (Figure 1, opposite). To simulate gene flow during a restoration program, it would be necessary to restore populations using a mixture of material sampled at different distances from the focal site, a practice defined here as composite provenancing. This 'composite provenance' would be predominantly composed of locally sourced material, taken from genetically healthy stock, but would also incorporate proximate and ecogeographically matched sources. In addition, a smaller proportion of material (somewhere between 10 per cent and 30 per cent, depending on the inferred gene flow dynamics of the species) should be comprised of material from much further afield.

Whilst this composite provenancing approach may risk introducing some maladapted germplasm, it crucially provides an opportunity for redistribution of preadapted genes and the evolution of new adaptive gene combinations through mixture of stocks, a key driver of evolution. For restoration plantings, we need to initiate plantings that will allow natural selection to act to produce a suitable and adaptively fit restored stand.

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Seed sourced from a range of locations may provide more adaptive capacity. Photo by **Chris Tzaros**

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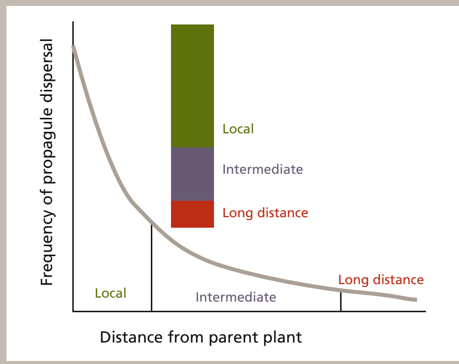


Figure 1. Recommended proportion of stock sourced from local, intermediate and long distance sources, following natural gene flow dispersal kernel.

Species–area relationships and woodland birds

By Jim Radford (Bush Heritage Australia, Deakin University, Melbourne) and Andrew Bennett (Deakin University, Melbourne)

All else being equal, more species occur in larger patches of bush. This simple and seemingly self-evident generalisation is the practical expression of species–area theory, the long-established relationship between species richness and area that underpins modern conservation planning.

Species–area relationships result from many interacting factors, especially as larger areas are sampled. Larger areas satisfy the minimum area requirements for more species. Larger areas generally support larger populations of individual species, which are less likely to suffer local extinctions due to chance fluctuations, human disturbances or intermittent declines in breeding success (e.g. during drought). In other words, larger populations are more resilient. Therefore, larger areas are more likely to support viable populations of more species. Further, larger areas usually include a greater variety of landforms, soils, topographical gradients and natural disturbance histories (e.g. fire), which produce a diversity of habitat types and a commensurate increase in faunal species richness.

Species–area relationships have been well-documented for a wide range of taxa—including birds—in relation to individual patches of habitat. But what happens when species–area relationships are examined at larger spatial scales? At the landscape scale? Perhaps not surprisingly, it appears that similar principles apply. As the amount of habitat for a given faunal group (such as woodland-dependent birds) increases within a landscape, species richness also increases, but with diminishing rates of increase as the landscape reaches its maximum carrying capacity (Radford et al. 2005) (Figure 2). More habitat equates to larger populations, which are more widely distributed across the landscape (that is, they occur at more locations) and have a greater capacity to withstand environmental shocks (e.g. drought, fire, 'nectar drought'), and human impacts.

Recent research in agricultural landscapes in northern Victoria suggests that for many species of woodland birds, the frequency of occurrence in wooded habitat is also positively correlated with the overall amount of woodland in the landscape (Radford & Bennett 2007). That is, the population density in remnant woodland is lower in landscapes with less woodland overall (there is a disproportionate decrease in occurrence compared with the decrease in wooded habitat). However, variation does occur between species in the type of relationship between population size and the total extent of wooded habitat in the landscape. For example, White-plumed Honeyeater maintains a relatively constant density in remnant woodland as the landscape-level extent of woodland decreases, but Grey Shrike-thrush shows a sharp decline in occurrence in landscapes with fewer than 10 per cent remnant native vegetation (Figures 3a & 3b).

Our research suggests that around 30–35 per cent of the landscape needs to be covered by relatively natural vegetation to maintain sustainable populations of most species of woodland birds in agricultural regions. Other factors, such as vegetation condition, diversity of vegetation types, inter-specific interactions (e.g. those of Noisy Miner, and of exotic predators) and habitat connectivity will also influence the abundance of individual species and species richness, but the overall amount of wooded habitat appears to be the predominant driving factor. In many agricultural regions throughout Australia, the extent of remnant native vegetation is well below this level (e.g. in the South West Slopes of NSW, Mount Lofty Ranges in SA, the northern plains of Vic., and the Wheatbelt Region in WA).

The legacy of such extensive clearing is shown by an increasing number of local extinctions and threatened species, declining populations and previously 'common' species becoming scarce. Restorative action is required if we are to prevent the widespread collapse of populations and the incremental loss of species from agricultural regions. There is no universal answer as to the best way to increase the amount of habitat. Revegetation to buffer existing remnants, filling in gaps in linear vegetation, establishing stepping stones and creating new patches of vegetation will each be appropriate in different situations. Local knowledge is required to decide on the best approach on a case-by-case basis.

Associated actions will also be necessary in many landscapes. Such actions include restoring existing remnant vegetation to improve habitat quality, eradicating feral predators and competitors, and controlling 'problem' native species. All of these are important elements in any recovery strategy; however, these actions alone are unlikely to be enough to bring back many species from the brink of local extinction. Substantial increases in the landscape-level extent of native vegetation are essential to restoring sustainable landscapes.

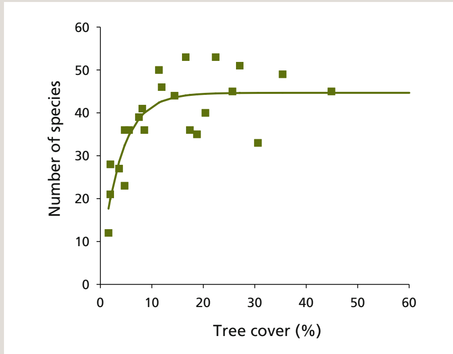


Figure 2. The relationship between the number of woodland bird species and the amount of tree cover in 100 km² landscapes in northern Victoria. Squares are observed values and the solid line represents the 'average' number of woodland species per landscape.

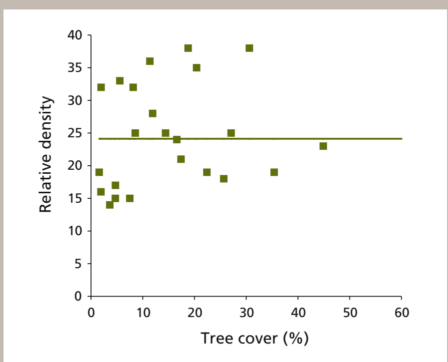


Figure 3a

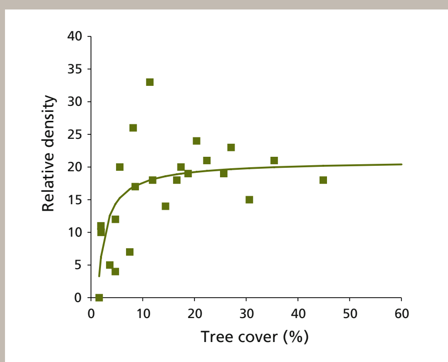
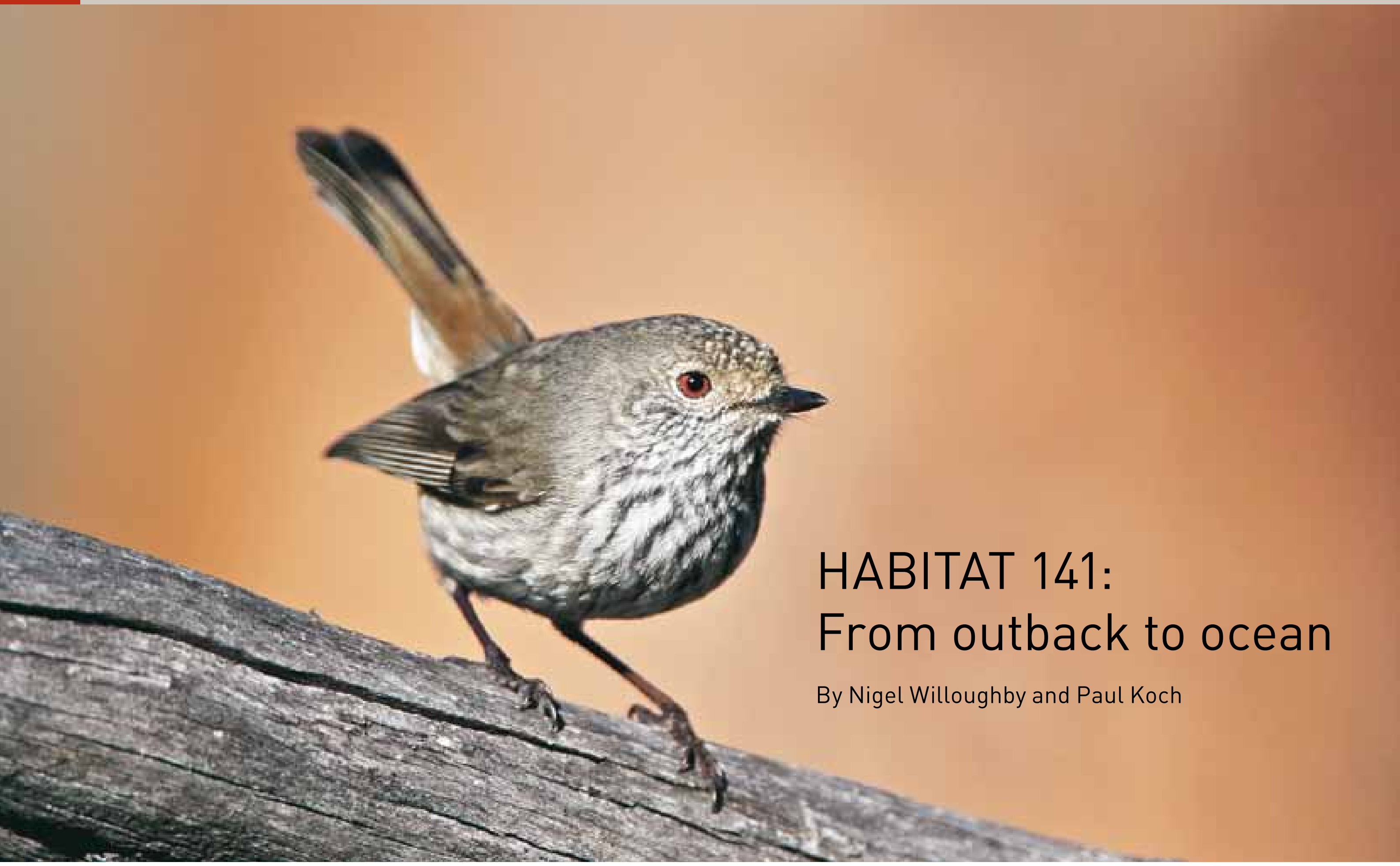


Figure 3b

Figure 3a & 3b. The relationship between the relative density of White-plumed Honeyeaters (left) and Grey Shrike-thrushes (right) and the amount of tree cover in 100 km² landscapes in northern Victoria. Squares are observed values and the lines represent 'average' density per landscape.



HABITAT 141: From outback to ocean

By Nigel Willoughby and Paul Koch

Habitat 141 is a 50-year initiative aimed at protecting, restoring and reconnecting the landscapes straddling the SA–Vic. border, stretching 700 km along the 141st longitudinal meridian to the NSW rangelands (Figure 1, opposite). The Habitat 141 region is one of very few places in southern Australia where extensive wilderness areas form a series of stepping stones from the southernmost coastal areas through to the arid zone; yet these areas are surrounded by some of the most highly modified and fragmented ecosystems in Australia. Furthermore, the ecosystems associated with more fertile soils (typically gum woodlands and grassy ecosystems that provide critical habitats for woodland birds and other flora and fauna) have been disproportionately cleared for agriculture. In addition to existing threats to wildlife such as habitat fragmentation, invasive species and altered stream flows, there is an ever more pressing need to anticipate and respond to the emerging threat of climate change.

Habitat 141 aims to maintain and restore functional ecosystems that can support their full complement of species across this vast series of landscapes through well planned, long term and carefully monitored action involving an alliance of government and non-government organisations across three states (SA, Vic. and NSW). Habitat 141 uses the Conservation Action Planning (CAP) process developed by The Nature Conservancy to set long term goals, and adaptively manage conservation and restoration projects as conditions change and new information becomes available.

Rather than attempt a single conservation plan across the entire region and a diversity of ecosystems, the region has been divided into a series of planning 'zones' and the CAP applied at that scale. This provides a better alignment to some of the regional management authorities responsible for different parts of the region. The initial phase of the CAP process involves the following steps:

- Identifying 5–8 broad conservation assets (species, communities or ecosystems) that collectively represent the biodiversity of the region.
- Identifying 3–5 key ecological threats to each asset and assessing the current and desired status of each asset.
- Ranking the threatening processes for each ecosystem.
- Identifying conservation goals and strategies to abate critical threats and enhance asset viability.
- Identifying key performance indicators to measure the effectiveness of the strategic actions that are implemented.

Selection of assets on which to initially focus attention is a complex process: the following example illustrates an approach using knowledge of birds to determine priorities for restoring mallee habitats in South Australia. Setting priorities is necessary to maximise the likelihood of securing a significant biodiversity outcome given the limited conservation funding that is currently available.

Using knowledge of birds to set restoration priorities in mallee habitats

Five steps have been used to set priorities for restoring the Murray Mallee region of South Australia immediately south of the Murray River:

- Building an understanding of the vegetation types and their environmental determinants.
- Determining groups of species that have similar states and trajectories, based on an understanding of the ecology of those species and the possible drivers of that state and trajectory.
- Landscape-specific land use histories that document the nature, extent and timing of major land use changes.
- Assessing and synthesising the information to set conservation goals.
- Taking appropriate targeted action.

1. Vegetation types and their environmental settings

There are two major land systems in the Murray Mallee areas immediately south of the River Murray in South Australia. These are often referred to as the 'Woorinen Formation' and 'Lowan Sands'. The Lowan Sands have infertile soils and are less developed for agriculture than the Woorinen formation. In South Australia 85% of the Woorinen Formation has been cleared and converted to crops and pasture. Within the Woorinen Formation, there are three main landforms, each with a characteristic vegetation type: (1) Loamy Sands Mallee is found in areas with deep sand and supports a patchily dense shrub layer; (2) Woorinen Sands Mallee is found on shallow sand characterised by an understorey of *Triodia*; and (3) Woorinen Mallee is found on red-brown sandy loam soil with calcrete development throughout the soil profile and a very open understorey. All three vegetation types support an open mallee eucalypt overstorey.

2. Landscape response groups: identifying groups of birds with similar states and trajectories

Based on the region's bird species, four distinct landscape response groups can be distinguished. Three of these groups closely match the three vegetation types, while the fourth group is more generalist and uses a range of vegetation types. Birds associated with Loamy Sands Mallee are now restricted to one or two small localities within the study area. This group includes Southern Scrub-robin, Shy Heathwren, Inland Thornbill, Purple-gaped Honeyeater and Gilbert's Whistler. Birds associated with Woorinen Sands Mallee are now extinct within the study area. This group includes Red-lored Whistler, Striated Grasswren and Mallee Emu-wren. A group of birds associated with the Woorinen Mallee remains widespread across the study area, including Restless Flycatcher, Hooded Robin, Brown Treecreeper, Varied Sittella and Yellow-rumped Thornbill. A final group is more generalist and shows a similar distribution to the Loamy Sands Mallee group but is slightly more widespread, also occurring in Woorinen Mallee, and includes Malleefowl, Chestnut Quail-thrush and Crested Bellbird.

3. Land-use history

The land-use history is mainly used to inform development of the vegetation types and their environmental setting and the landscape response groups. For example, in some landscapes close to the Murray River clearance occurred very early (1850s onwards) whereas in areas further away from the river clearance only started when the railway went through in the 1910s. Even then, clearance was slower in some areas than others, leaving some landscapes within the Woorinen formation around 80% cleared while others are around 98% cleared. Further, different clearance on different landforms within the mallee corresponds to levels of calcrete development in the soil profile: in some areas the dunes were targeted for clearance, leaving these areas as priorities for current restoration attempts.

4. Synthesis

Figure 2 provides an appraisal of the state of the four bird response groups that use the Woorinen Formation. The characteristic bird species of the Woorinen Sands Mallee have been lost from the area, and therefore are currently a low priority for restoration efforts. In contrast, the species characteristic of Woorinen Mallee remain widespread, and therefore are also a lower priority for restoration. However, the characteristic species of the Loamy Sands Mallee vegetation type have been lost from the majority of the study area, while the generalists are showing a similar if slightly more desirable response to date. Thus, restoration priorities are focused on the Loamy Sands Mallee vegetation types, where prompt action may prevent those species from disappearing. This synthesis is really a hypothesis about how our restoration efforts are best targeted within parts of the mallee.

5. Targeted on-ground action to address priorities

Based on this initial assessment, using a combination of ecological theory and knowledge of local ecology, a clear restoration priority has been established. Funding has been secured to begin the restoration of areas of deep sands that support the Loamy Sands Mallee within the Woorinen Formation—initially focusing around the localities that still support the characteristic species. Planning for the on-ground restoration—which includes revegetation works and monitoring against expected outcomes—has been undertaken by the Woorinen Recovery Team with representation from the SA Department for Environment and Heritage, the Murray Mallee Local Action Planning Association, Greening Australia SA and the SA Murray–Darling Basin Natural Resources Management Board. Time (and monitoring) will tell whether the on-ground works and additional habitat will arrest the declining trajectory for this system.

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Inland Thornbill *(opposite)* and Southern Scrub-robin *(right)* are both associated with Loamy Sands Mallee vegetation and restricted to only a few locations within the Habitat 141 region. Photos by **Dean Ingwersen**

Figure 1. The Habitat 141 region.

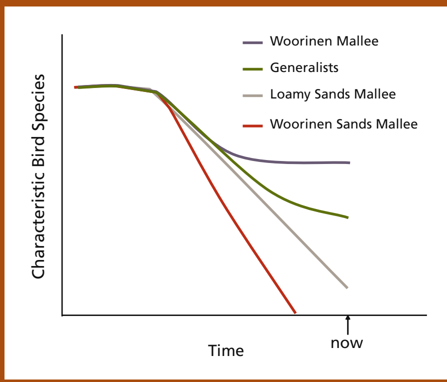

Figure 2. Hypothesised response of the bird species characteristic of the main Woorinen Formation vegetation types

The populations of most species in the area have decreased due to clearance of habitat. However, some groups of species have disappeared completely while others remain relatively widespread. Identifying which groups are responding to the recent landscape history with similar trajectories is a key component for setting priorities.

Connectivity Conservation in Action: Gondwana Link, Western Australia

By Angela Sanders, Paula Deegan and Sandy Gilmore

In Gondwana Link, a number of groups are collaborating to protect, manage and restore bushland across the south-west corner of Western Australia, in Australia's only global biodiversity hotspot. The vision involves reconnecting habitat across a 1,000 km pathway, from the wet karri forests of the south-west corner to the woodlands and mallee bordering the Nullarbor Plain.

An important area for achieving this vision is between the Stirling Range and Fitzgerald River National Parks (Fitz–Stirling Operational Area), where Bush Heritage Australia and Greening Australia—with funding from The Nature Conservancy—are purchasing properties to protect and restore the most ecologically critical linkages.

Since the project's inception in 2002, five properties have been acquired; 5,900 ha is being managed for conservation and some 1,250 ha has been replanted with native species (Figure 1). Using a combination of innovative conservation strategies and the best land restoration experience available, the project is reconnecting and revegetating a vast network of private and public land. Over the last decade or so, there has been steady development and trial of restoration technologies geared towards expanding the scale of the works.

Today the Gondwana Link project is collating information on habitat requirements for the resident, nomadic, dispersing and migratory bird species that have been recorded in the area (some 120 taxa) to help with inclusion of fauna-specific habitat requirements in planning; in the past the focus has mainly been on getting trees back into the landscape. A suite of target or representative species is chosen for each site, so their habitat requirements can then be added to conditions such as slope, soils and previous land use history to help formulate a site-specific restoration plan. There are limitations imposed by seed availability and techniques for germination, but as knowledge and techniques improve, it is expected that the species available to the site plans will increase.

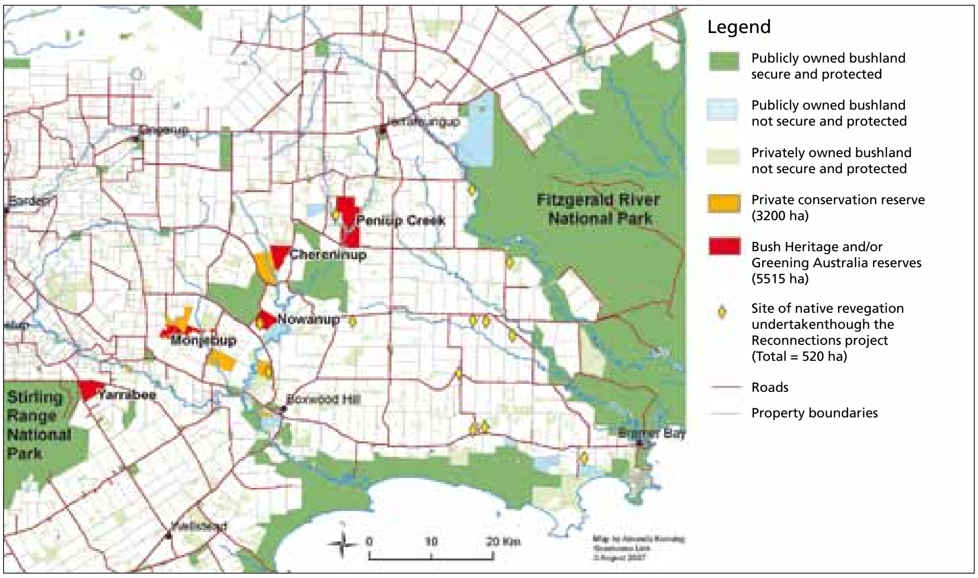

Figure 1. Status of remaining vegetation in the Fitz-Stirling Operational Area, August 2007.

Some progress has already been made: observations of the 13 honeyeater species that occur in the area have identified plants from the family Proteaceae as being the most visited (43%), followed by Myrtaceae (35%). Planning to restore proteaceous heath on some of the deep, infertile sands that were cleared for agriculture is now in its early stages. Once established, they will need management to exclude diseases such as *Phytophthora cinnamomi*. Microhabitat is also being considered, with the inclusion of short-lived woody species that will provide litter and logs for ground-foraging species. Piles of rocks, mallee roots and soil within paddocks are left in place. Prickly shrubs are included to provide safe nesting sites for birds, and work is ongoing to refine techniques for re-establishing sedges as a source of food and nesting material. Dense thickets of *Gastrolobium* species—highly toxic to exotic species but not to native animals—are also included.

Restoration plans also take into account year-round nectar sources and provision of nest sites and nest materials. Restoration of cleared farmland on the Peniup Creek and Corner Farm property purchased in 2007 will involve specialised biodiverse plantings for carbon sequestration as well as planting for habitat restoration.

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www.gondwanalink.org

Using birds to measure habitat restoration success

Birds are one of the chosen indicators of habitat restoration success. To monitor them we are using the 'bird minutes' methodology to estimate population densities (Gilmore, in prep). This method uses an index of bird activity (called 'bird minutes metric') to estimate the number of individuals present. It enables valid estimates of community parameters including species composition, species richness, energy consumption and diversity indices. This method is being used across the Fitz–Stirling Operational Area. However, it is early days for bird monitoring, since the oldest patch of restored habitat is only a few years old.

In winter 2003, around 60 ha of the 900 ha Chereninup property was revegetated using seedlings and direct seeding techniques. Around 42 kg of seed (about 42 million seeds) from 50 species were used. The revegetation has now grown to form 'shrubland' that will eventually become woodland and mallee heath. The land was cleared in the late 1980s and was used to grow cereal crops and sheep: at the time of purchase, it supported mainly grassland species like Stubble Quail and Australasian Pipit. The growth of native perennial vegetation has seen a decrease in these species, and an increase in nectarivores and insectivores.

These changes reflect three variables: the antecedent climate, changes in the structure and resources provided by the restored vegetation at the site, and the surrounding vegetation. Nectarivores such as the Tawny-crowned Honeyeater are increasing in number as mallee eucalypts and other shrubs start to flower. Ground-feeding insectivores, such as the Southern Scrub-robin, are now utilising the increased decomposing litter, which is feeding more invertebrates. Upper stratum–feeding insectivores such as the Weebill are starting to appear as a stratified complex vegetation structure develops. A turnover of foraging guilds is occurring as ground-feeding granivores are replaced by species that feed more on arboreal seed stores.

Species richness and total populations are increasing rapidly—as is expected in the early growth phase—but this will taper off as the restored vegetation approaches its site-based equilibrium biomass and rates of turnover of energy and nutrients (see Figure 2). This point cannot be predicted at present, but the birds will help us identify the equilibrium state for this site.

Surveys are also being carried out in undisturbed bushland and providing data that we

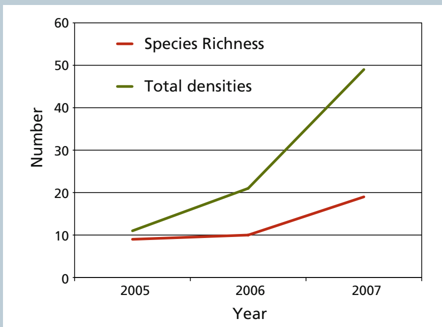

Figure 2. Bird species richness and total densities (birds/10 ha) for Chereninup 2003 revegetation

can use to compare with those from restored areas. The data will eventually highlight species that are missing from equivalent restored areas. If we can link the differences to local habitat condition, we will be able to adjust restoration techniques. We can never restore habitats exactly as they were prior to clearing, but our aim is to establish a self-generating renewal trend that will lead to close replication of the original habitats with the passage of time.

Regrowth: 'woody weed' or opportunity?

By Martine Maron, Michiala Bowen and Clive McAlpine, The University of Queensland

In southern Australia, habitat restoration on cleared land typically requires replanting, which can be labour-intensive and expensive, especially over large areas. But in the subtropical inland, many types of woody vegetation will re-grow on cleared land if it is not constantly cultivated. Although this woody regrowth is the bane of many farmers' existence, it also represents an important opportunity for passive landscape restoration.

Michiala Bowen recently completed her PhD comparing woodland bird communities in a replicated chronosequence of subtropical regrowth forests dominated by brigalow (*Acacia harpophylla*), and the University of Queensland is hosting an ongoing project in partnership with several regional Natural Resource Management (NRM) organisations to quantify the value of brigalow regrowth to fauna. Both projects are showing that regrowth vegetation provides valuable habitat for wildlife, including threatened species. However, until recently there have been no controls on clearing regrowth in Queensland, and little incentive for landholders to retain and manage it for biodiversity.

Although the floristic diversity of regrowth vegetation is less than that of remnant vegetation, and the structure is denser, over time the habitat value of regrowth for birds converges with that of remnant vegetation. Bowen found that species richness of woodland birds in regrowth reached that of remnant habitat within 30–50 years. Resources that are more common in older stands—such as mistletoes—were significant drivers of species richness, and are important for many species, including Painted Honeyeater. However, the dense structure of young brigalow regrowth also provides habitat for shrub-dependent birds such as fairy-wrens. The context of brigalow vegetation patches was also important for bird species richness, with more woodland-dependent birds occurring in less modified landscapes, and the converse for generalist species.

Many species considered sensitive to landscape modification in southern Australia were also sensitive to patch context, and preferred remnant to regrowth habitat, in the Brigalow Belt. However, several species—such as the Eastern Yellow Robin—also occupied regrowth habitats, suggesting that these species may respond positively to landscape restoration through targeted retention of brigalow regrowth. A few species that are declining in more southern woodlands—such as the Grey-crowned Babbler—are still common in southern Queensland, highlighting the opportunity for pre-emptive conservation efforts targeting these species in Queensland. Considering the massive efforts taking place to restore habitat for Grey-crowned Babbler in Victoria and New South Wales, the potential to harness passive restoration to maintain secure populations is surely a significant advantage that should not be lost.

Regrowth may be particularly important in highly modified landscapes, where the area of remnant habitat may be insufficient to support viable plant and animal communities without some form of restoration. Bowen found that the amount of remnant and old (> 30 years) regrowth in the landscape did have an important positive influence on the number of woodland bird species and species' abundance, suggesting that regrowth is making an important contribution to landscape recovery. Landscape-level requirements for woody vegetation cover of around 10% to maintain woodland bird richness have recently been identified in Victorian woodlands, and there is evidence of similar thresholds (~18%) in southern Queensland. Throughout much of the region, regrowth vegetation is a significant component of total vegetation cover, and so is important in maintaining cover above this threshold value. In landscapes with vegetation cover below the threshold, the effort required to increase vegetation cover by even a few per cent may be prohibitive if relying on active revegetation, but passive restoration through retention of regrowth provides a significant opportunity to achieve significant gains at the landscape scale.

Targeting the retention of regrowth towards increasing the size of and reducing the isolation of remnant brigalow patches will produce the greatest biodiversity benefits. Brigalow regrowth stands will need to be retained for at least 30 years and probably longer to maintain viable woodland bird communities. For this to happen on a regional scale, brigalow regrowth needs to be given greater recognition for potential biodiversity benefits, either within a legislative framework or by incentive schemes to promote the long-term persistence of regrowth habitat within the landscape. This year, the Queensland government has announced a moratorium on the clearing of regrowth of endangered vegetation types while a comprehensive policy on regrowth management is developed. The outcomes of their decision will shape the future of the landscapes of the Brigalow Belt.

The benefits of retaining regrowth vegetation on farms go beyond biodiversity.
Lynelle and Warren Urquhart have a mixed farming property at Moonie, north of Goondiwindi, and 36% of their property is protected as a nature refuge. A significant amount of the vegetation is in the form of 100 m–wide brigalow remnant or regrowth shadelines bordering their paddocks. Aside from the abundant wildlife supported by these areas, the Urquharts report a cooling effect of the shadelines in summer and wind speed reduction year round, which benefits their crops and pasture and all animals (stock and native). And the day when retaining managed regrowth will earn saleable carbon credits for landowners seems to be nearing.

Further reading

www.uq.edu.au/brigalow

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Above: Painted Honeyeater is one potential beneficiary when stands of regrowth reach maturity and carry resources such as mistletoes. Photo by Chris Tzaros

Restoring woodlands in the Mount Lofty Ranges region

By David Paton

The Mount Lofty Ranges region, near Adelaide, is listed by the federal government as one of 10 biodiversity 'hot spots'. The listing is due in part to the fact that woodland systems of this region are isolated from other similar woodland systems in eastern Australia; such that much of the biota is distinct. But the listing also reflects concern for the imminent losses of species—particularly birds—from the region.

The Mount Lofty Ranges and the adjacent plains have been extensively cleared of native vegetation. Less than 10% of the original vegetative cover remains, with disproportionately more of the native vegetation lost from the better quality soils. Broad-scale clearance of native vegetation ceased in the 1980s but the distributions and abundances of a wide range of bird species continue to decline. This ongoing loss of biodiversity is expected, and is known as an 'extinction debt'. Extinction debt is linked to the amount of remaining native habitat: when little native vegetation remains, population sizes are small and vulnerable to other perturbations (e.g. droughts and fire); and over time, those populations decline and eventually disappear.

Ford and Howe (1980) were the first to draw attention to the lack of habitat in the Mount Lofty Ranges region. Based on the amount of native vegetation that remained (about 10%), they predicted that some 35–50 of the 115 woodland bird species that occupied the Mount Lofty Ranges region prior to European settlement could be expected to become regionally extinct. In fact, losses could be higher because (1) the data on which the predictions were based assumed that the number of species found in different-sized areas of habitat had reached equilibrium, (2) much of the remaining vegetation was on poor quality soils and thus not representative of the range of productive habitats in the region, and (3) nearly all areas were disturbed and likely to continue to lose condition. Given this, perhaps as many as half of the woodland bird species in the Mount Lofty Ranges region could disappear. An important conclusion from these analyses is that simply managing the remaining 10% of native vegetation will not be sufficient to maintain the complement of species.

These dire predictions of losses of woodland bird species are supported by evidence: 10 bird species are already regionally extinct; and at least another 60 species continue to decline since broadacre vegetation ceased in the 1980s. These declining species have not yet disappeared, however, and if suitable habitat can be reinstated quickly, there is a chance that not all of them will be lost. Since woodland habitats take time to reconstruct, the window of opportunity to prevent the extent of these bird losses is now. The longer the delay in reinstating significant areas of habitats, the smaller the eventual legacy will be for future generations.

Presently, various government and non-government organisations are involved in revegetation programs in the Mount Lofty Ranges region. Often, these revegetation efforts are not implemented for biodiversity improvement, but for slightly different purposes ranging from reducing erosion to capturing carbon. In many cases, only a few of the plant species that would normally exist are planted, and no consideration is given to the habitat needs of the declining fauna. Revegetation programs often claim that if plants are planted then the fauna will also benefit. In many cases, however, they fail to provide adequate habitat features to secure benefits for the most threatened species. An often overlooked factor is that many declining bird species require large areas just to support a single pair. For some, more than 100 ha of suitable habitat is needed to successfully support breeding, and often this needs to include some of the habitats that existed on the better quality soils and have been disproportionately cleared.

At present, farming land set aside for revegetation is often poorer quality land, since this has the least impact on overall farm income. Such a strategy is unlikely to provide the large patches of vegetation or areas with better quality soils. A program of revegetating whole farms would allow large patches of woodland to be re-established, better meeting the needs of some of the bird species, and allowing some of the woodland systems found on the better quality soils to be reconstructed. A potential funding mechanism would be to pay farmers to slowly revegetate their farms. Such a scheme has other benefits, such as keeping farming families in rural communities. Keeping farmers on their land secures their corporate knowledge (about their properties) to aid in reconstruction efforts. Under this scheme, the whole farm would not be immediately restored, but restored in stages, with the farmer shifting to new areas of the farm once initial restoration works and plantings are completed. During this interim phase the rest of the property would still be farmed.

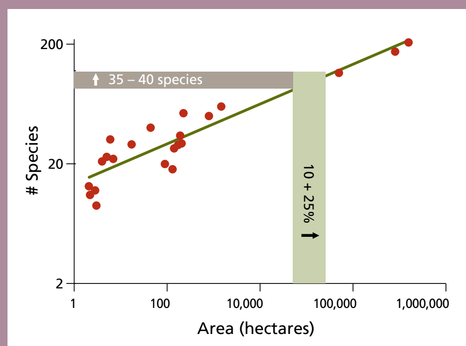

Figure 1. If an additional 150,000 ha of new woodland is established, this could save 35–40 species from extinction.

An increasing level of financial support would be provided as more of the farm was removed from agricultural production.

In South Australia there are examples of whole farms being set aside for restoration. One property, 'Para Woodland', was donated to South Australia by Elizabeth Law-Smith; and with some additional land purchased by the state government, 300 ha of good quality farming land has been set aside for restoration near Gawler, north-east of Adelaide. The property is managed by the Nature Foundation SA and the state government's Department for Environment and Heritage. A further donation from the original landowner of $120,000 per annum until 2030 will be used to fund the restoration works across the farm. The property has been divided into a series of 10 management units based on topography, soil type and agricultural use (grazing versus cropping), and baseline surveys have been established. The likely habitats that were formerly present on each unit will now be slowly reinstated, concentrating on one or two units at a time. Another 300 ha property, 'Cygnet Park Sanctuary', was purchased by Jack May and Hilary Johnson and set aside for restoration. More than 50 ha of the farm has been replanted with more than 100 plant species, with differences in pre-planting treatments and planting densities and arrangements, and a focus on re-establishing populations of several threatened plant species. SA Water has begun re-establishing woodland habitats over an area of 400 ha of cleared farmland around the Mount Bold and Clarendon Weir catchment in the Mount Lofty Ranges region. Although the primary driver here is to improve water quality, the new habitats being developed are heterogeneous because of the diversity of soils, topographies, plants and planting densities being used, and so are likely to produce habitats capable of supporting some declining species.

These examples suggest that putting back woodland habitats at the scale of individual farms is possible, but how much habitat is required to prevent the loss of most species from the Mount Lofty Ranges region?

The best available science suggests that we can avoid the ongoing extinction debt (that is, loss of species from a region) by increasing the native vegetation cover to around 30–35 per cent. The need to do this is recognised by the South Australian government's 'No Species Loss' policy, and planning for the establishment of four broad 'NatureLinks' across the state. These NatureLinks, however, do not have targets. One of those regions is known as the Cape Borda to Barossa NatureLink, which covers Kangaroo Island and the Mount Lofty Ranges region. For the Mount Lofty Ranges region, the Adelaide and Mount Lofty Ranges Natural Resource Management (AMLR NRM) plan has a stated target (ratified by both state and federal governments) to reinstate native vegetation to 30 per cent cover across the region to prevent further species loss. Given the current amounts of native vegetation, an additional 150,000 ha of new woodland habitats need to be re-established across the region to reach this target. This is a substantial area of new habitat, but if reinstated is predicted to prevent 35–40 woodland bird species from disappearing from the region (Figure 1, opposite). The AMLR NRM plan also states that initial priority will be given to habitat reconstruction on the disproportionately cleared better quality land, and to programs that aim to reconstruct large areas of habitat (at least 20 ha).

To meet the target in a timely fashion, significant growth in the capacity to do the on-ground work (that is, the number of trained people) is required, as well as the knowledge of how to reconstruct woodland habitats that are resilient, are self-sustaining, and meet the habitat needs of declining fauna. However, there is no need to wait for this knowledge to be accumulated before starting, since the most efficient way of increasing knowledge is to use an adaptive management approach and learn by doing. Since woodlands take considerable time to mature (perhaps 100 years or more) this learning process is long-term and intergenerational, and the outcomes of different trials established now might be measured in one or two generations' time.

Reconstructing 150,000 ha of woodland habitats will transform the appearance of the Mount Lofty Ranges region (Figure 2), but successful delivery will depend on transforming community attitudes about the use of land for environmental purposes. This echoes the situation facing the ailing River Murray system, where over-extraction of water has led to significant environmental degradation, yet there remains considerable reluctance to return water. For the Mount Lofty Ranges region, over-clearance of native vegetation is the fundamental threat to the region's biodiversity, and that threat can only be addressed by giving back a substantial amount of cleared land for habitat reconstruction.

One of the great challenges for delivering significant amounts of new habitat will be securing significant long-term funding. Usually, governments allocate funds to programs for periods of one to three years, and rarely over longer time periods. Changes in priorities and changes in government often result in significant shifts of funding from one to another environmental program, and do not provide secure long-term funding. Although payments for carbon sequestration in plantings provides an opportunity to re-establish woodland habitats, the diverse plantings that provide heterogeneous habitats for fauna are more costly to construct and audit, so the carbon market might encourage only basic plantings that fail to address the needs of critical fauna. Given the amount of new habitat that is required within this region to prevent species loss, any plantings for carbon offsets should be multi-purpose and consider biodiversity outcomes and not just be about carbon sequestration. The price of carbon may also fluctuate, so this is not a secure funding mechanism.

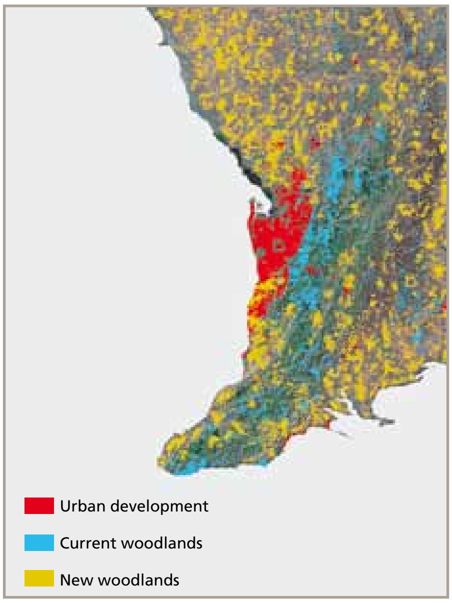

Figure 2. The Mount Lofty Ranges region near Adelaide
The Challenge: re-establish 150,000 ha (shown schematically) of new habitat to prevent imminent species loss.

The University of Adelaide recently offered an alternative strategy for securing some long-term funding. The University of Adelaide owns Glenthorne Farm, a 208 ha property in the southern suburbs of Adelaide, and proposed to develop a third of this farm for housing and to place the net income from that development into a trust fund, with the annual income used to help fund woodland system restoration in the Mount Lofty Ranges region over a long period. Woodland habitats would be re-established on the rest of the property and these would form an important educational resource and provide a visible connection between urban communities and the broader need for habitat re-establishment across the region. The university's goal was to establish a trust fund of around $100 million, making a potential annual income of around $5 million available to help the state deliver the 150,000 ha of habitat across the Mount Lofty Ranges region. Unfortunately, despite significant support from the community, the state government decided not to approve this proposal. Alternative funding sources including sponsorships and tax-deductible donations are now being explored to establish a substantially smaller trust fund.

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Photo by **Dean Ingwersen**

Using the Atlas project to assess the value of revegetation to birds

Revegetation for biodiversity conservation is costly to the community and will take many years to counter the effects of vegetation clearance. Therefore it stands to reason that we would want to know if our revegetation patches are providing habitat for birds in the short term and if there is some measurable improvement in biodiversity at the larger scales of catchments over decades. The advent of more structured atlassing by our network of volunteers, and improvements in data analysis techniques, gives us increasing power to assess population trends for a broad suite of birds in many regions. An increase in fixed-site monitoring using standardised methods (e.g. the 20 minute, 2 ha survey) has added to the value of Birds Australia's Atlas data. Some of this work takes place as part of Birds Australia projects which monitor birds in revegetation.

Lurg Threatened Bird Search

The Lurg Threatened Bird Search takes place annually to help monitor the success of a landscape restoration project in north-eastern Victoria (the Regent Honeyeater Project). The revegetation project has been active since 1996 and has planted and improved over 1,000 ha of woodland habitat to date. Since 2005, there has been annual bird monitoring using Atlas methods.

To date, no Regent Honeyeaters have turned up in the revegetation landscape. However, the project is showing benefits for another threatened Victorian bird: the Grey-crowned Babbler has increased in the Atlas survey plots. This result is supported by the surveys carried out in the Lurg district since 1997 by Friends of the Grey-crowned Babbler. They've shown that both the number of individuals and the number of babbler groups have nearly doubled over that period. Groups are colonising and regularly using habitat in the newly revegetated areas established on many of the properties in the district.

The early results of the surveys show that two of the four most commonly recorded species in revegetated sites are the Noisy Miner and White-plumed Honeyeater, both of which are known to aggressively exclude smaller insectivorous species. This may be a common feature of the early stages of revegetation projects, especially where the ground covering of shrubs is insufficient to provide protection for smaller species.

Cowra Woodland Birds Program

Birds Australia Southern NSW and ACT Group (BASNA) commenced the Cowra Woodland Birds Program in 2001, in response to local landholders' concerns about noticeable declines in local woodland birds. Our aim: to reverse the decline of woodland birds in the region. Projects have focused on (i) scientific research to improve knowledge of woodland bird patterns and habitat requirements and (ii) on-ground habitat restoration to improve bird habitat. We've had the direct participation of the local landholders and land managers, Cowra Shire Council, Lachlan Catchment Management Authority, Australian Nation University and other birding groups.

Our major initiative is quarterly bird monitoring surveys across more than 60 sites. We use the Atlas 20 minute, 2 ha counts, recording the numbers of each species. Like many agricultural regions of southern Australia, Cowra has had several decades of landcare-style revegetation programs. We have insufficient data to analyse individual revegetation sites but, to see how birds are going in the district, we analysed six years of data from autumn 2002. The pervasive decline in the species richness and abundance of woodland-dependent birds is of grave concern. Most threatened and declining species were detected too infrequently to be modelled individually, but their general decline can be assumed, given their membership in the woodland-dependent group, and most that could be modelled showed evidence of decline.

We are resolved to continue monitoring because the power of analyses will increase with time, and from this we will continue to provide evidence for the success or otherwise of revegetation in this part of Australia's temperate woodlands. Meanwhile, it seems logical that there needs to be a greater focus on and investment in restoration/rehabilitation activities, by increasing the area of woodland habitat (revegetation) and improving the condition (suitability) of existing woodland habitat. Recent advances in direct-seeding technology demonstrate that this method works in the Cowra Shire (Geeves et al. 2008),

and so the rate of revegetation could be dramatically increased.

Our bird and habitat surveys over the past six years have shown us which sites are better for woodland birds. Based on these observations and those from similar studies into woodland bird conservation in south-eastern Australia, we can make the following recommendations for landholders interested in reversing the decline in woodland birds.

- Fence off rivers, creeks and other remnants; and manage grazing on these sites. Creeks and rivers have been shown to be very important and contain critical resources for many species, particularly during dryer periods.
- Increase the amount of native vegetation on farms. It has been shown by numerous studies that total vegetation cover across a landscape has significant impact on bird species diversity.
- Increase the size of small remnants (to >10 ha) through revegetation and fencing (with grazing management) to encourage natural regeneration. The larger remnants are likely to be more resilient to disturbance in the long term and contain more resources for a range of fauna species.
- Increase the width of narrow plantings and thin linear remnants (e.g. narrow roadside verges) to at least 30 m and five rows of revegetation. More woodland bird species can coexist in broad strips of native vegetation.
- Encourage increased cover of native ground covers and woody shrubs (especially *Callitris* spp., *Acacia* spp.), except in high quality native grassy woodlands. A diversity of layers (grasses, shrubs, high shrubs, trees) in bushland provides habitat for a range of species for nesting, foraging and cover from predators and pest native species, such as Noisy Miner. In addition, when undertaking restoration, promote horizontal patchiness within both overstorey and understorey vegetation layers as some birds, for example fairy-wrens and finches prefer dense cover and larger birds such as Grey-crowned Babblers require more open habitat. This will tend to occur naturally if direct seeding is used.
- Increase the amount of fallen timber, rocks and leaf litter. This provides habitat for insects, spiders, small reptiles and other bird food. It also provides cover and nesting habitat for a range of ground nesting birds such as Painted Button-quail, Speckled Warbler and Bush Stone-curlew. This is why it is important to discourage the removal of fallen timber from woodland remnants.

Left: The Lurg district, where a massive volunteer effort in landscape revegetation is starting to pay dividends to threatened woodland birds. Photo by **Dean Ingwersen**

Figure 1. Survey sites in the Cowra district.

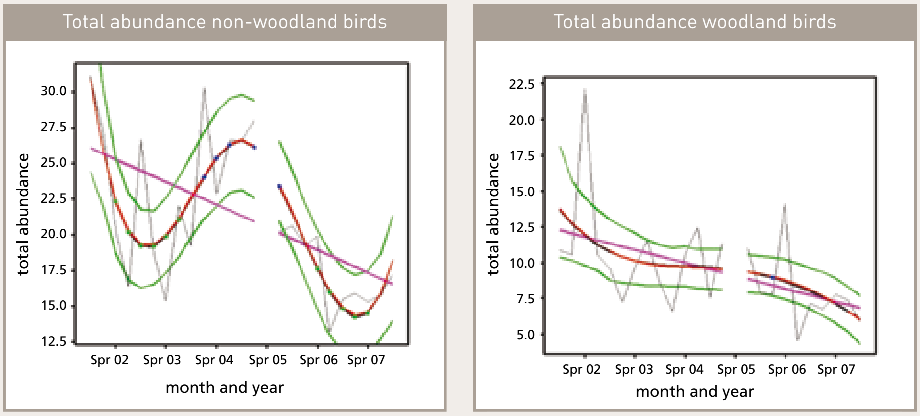

Figure 2. Trends in the total abundance of non-woodland and woodland bird species found in the Cowra district, 2002–2007 (from Reid and Cunningham 2008).

- Connect remnants to other woodland areas using corridors, patches of vegetation (which act as stepping stones) or by protecting existing paddock trees and where possible replanting paddock trees.
- Increase the use of native pastures as many native species such as Diamond Firetail forage on native grass seed.
- Protect woodland remnants from fertiliser and pesticide drift as both can impact on understorey plant diversity and can delay regeneration of native species.
- Protect native vegetation along roadsides and travelling stock routes and manage them appropriately, as these are often the only habitat links for birds and a range of other fauna across cleared productive land.

(Adapted from Reid and Cunningham 2008.)

Assessing revegetation projects for biodiversity outcomes

The major vehicle for funding revegetation for biodiversity conservation in Australia, the federal government's Caring for Our Country program, has specific and measurable targets as part of its first business plan (2009–2010). Under the national investment priority 'Biodiversity and natural icons' the business plan's primary target is "to increase by at least 400,000 ha, over the next two years, the area of native habitat and vegetation that is managed to reduce critical threats to biodiversity and enhance the condition, connectivity and resilience of habitats and landscapes in priority regions." The five-year outcome for Caring for Our Country under this investment priority is for 1 million ha to be managed in this way. The Monitoring, Evaluation, Reporting and Improvement (MERI) strategy associated with the program is geared specifically to measuring the performance of funded projects against the targets: the target and outcome is therefore measured in hectares managed, rather than in the effects of any such management on biodiversity.

The lack of any requirement to monitor for—or conduct research into—the effects of on-ground works on biodiversity is a serious deficiency in the program. It also means there is no direct resourcing of these critical activities under Caring for Our Country. The federal government has recently shifted to an ecosystem-scale approach to biodiversity conservation, which is laudable, but if this approach does not include monitoring of the effects on all biota of efforts, for example, to restore landscapes, there is no guarantee that ecosystems are in fact being protected or rehabilitated, and opportunities to adaptively manage these new systems are lost. Coupled with a shift away from funding work on threatened species, this lack of effective monitoring could spell trouble for Australia's many vulnerable woodland bird species.

In Australia there are currently no national monitoring and reporting procedures for collecting data on revegetation, either to assess the outcomes of monitoring projects or resource condition itself. Despite a large investment in revegetation efforts over many years, we cannot accurately assess where or how this investment has been directed, and there is no comprehensive national baseline dataset which can be referred to for assessing revegetation priorities, methods or effectiveness of investment (Atyeo & Thackway 2009).

Hopefully, emerging mapping and monitoring technologies and the development of national-scale programs for monitoring resource condition will go some way to addressing problems with the lack of national baseline and ongoing data collection. For example, the Bureau of Rural Sciences (BRS) have been developing an information system for collecting and reporting data on revegetation, the Collaborative Australian Revegetation and Restoration Information System (CARRIS). The BRS is also producing a revegetation field manual and a report on the State of Australia's Vegetation 2009, which should be available in early 2010 (Atyeo & Thackway 2009).

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The Bush Stone-curlew (*above right*, photo by **Ashley Herrod**) and Painted Button-quail (*below right*, photo by **Chris Tzaros**) are two ground-nesting species which will benefit from retention of fallen timber and woody debris.

RECONNECT *with* THE BUSH

A Birds Australia campaign

Recognising that large-scale loss of connectivity is one of the main drivers of the decline in bird diversity, Birds Australia has chosen the phrase 'Reconnect (with) the Bush' to promote this important conservation message. The phrase also acknowledges that people must be engaged if we are to reconnect effectively the landscape.

What do we mean by 'connectivity'?

When we advocate connectivity for birds, we mean functional connectivity. Functional connectivity means several things. It means that birds have enough resources of the right kinds within their reach. It also means that gene flow is not impeded between different parts of a species' range. Finally, it means that populations are not impeded from shifting over large distances at a decadal time scale, which might be important in adapting to climate change. All of these things are essential to achieve healthy and resilient bird populations.

What constitutes connectivity?

Rarely is functional connectivity the same thing as having an unbroken line of trees from one 'habitat patch' to another. Typically, such 'structural connectivity' is not as important as the total amount and suitability of habitat in a landscape

for achieving functional connectivity. Most bird species are highly mobile and can move between habitat patches and use the intervening habitat, especially when it is hospitable—for example, paddock trees or grassy paddock margins. The retention and improvement of habitat extent and quality is, in general, of much greater importance to achieving functional connectivity for birds than a structural connection in the form of a corridor of trees. So, for instance, offset approaches that allow clearing of scattered trees across large areas in return for a small area of revegetation are likely to erode regional connectivity.

In advocating connectivity as a theme for our conservation focus, Birds Australia emphasises the value of large-scale connectivity. Achieving this means that there are sequences of landscapes, running across hundreds or even thousands of kilometres, which contain enough suitable habitat to promote resilient bird populations. For long-distance migrants, it means that migratory pathways have adequate stopover points where birds can access necessary resources and rest in a safe place. It also means temporal connectivity for example, complementary food resources that become available at different times of the year, or in different years, must all be available and accessible to the birds that need them. So, the disproportionate loss of certain types of eucalypt woodlands, for example, must be redressed to maximise temporal resource connectivity.

What actions support increased regional-scale connectivity?

The single factor of overwhelming importance for bird conservation is the amount of suitable habitat available to them. Thus, the greatest threat is the loss of suitable habitat, which continues through the processes of degradation, clearing (often incremental) and loss of condition and vigour of remnant habitat of remnant habitat. Habitat is not just large areas of native vegetation—for many species there is habitat in the many small natural features embedded in farming, industrial and urban landscapes. The recent focus on planning for strings of healthy natural landscapes spanning hundreds of kilometres in significant regional and multi-regional restoration projects (e.g. Habitat 141 and Gondwana Link) exemplifies the sort of planning approach needed to achieve large-scale connectivity. But the single most important action is to avoid further losses of habitat, not just from large-scale clearing and degradation—which continues in some parts of Australia—but from the incremental losses of small remnants, wetlands and natural habitat components that add up to a significant impact on our birds.

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Cover photo:
Brown-headed Honeyeater in Grey Box. Photo by **Dean Ingwersen**

Back cover: Yellow Box *(Eucalyptus melliodora)*. Photo by **Ashley Herrod**