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Is revegetation good for biodiversity?

THIS PUBLICATION IS PRODUCED BY THE NATIVE VEGETATION AND BIODIVERSITY R&D PROGRAM

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David Salt and David Lindenmayer

Published by: Land & Water Australia
Postal address: GPO Box 2182, Canberra ACT 2601
Office location: L1, The Phoenix
86 Northbourne Avenue, Braddon ACT
Tel: (02) 6263 6000
Fax: (02) 6263 6099
E-mail: Land&WaterAustralia@lwa.gov.au
Web: <www.lwa.gov.au>

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Product code: PN21580
ISBNs: 978-1-921544-04-0 (hard copy)
978-1-921544-05-7 (electronic)

Photos: Front cover landscape and back cover: courtesy of Greening Australia Capital Region. Sugar Glider: Bruce Thomson
Design: Angel Ink
Print: Paragon Printers
September 2008

When it comes to restoring the natural values of our agricultural landscapes, revegetation with native plants would have to be one of the more common approaches employed.

This technical note presents a summary of a recent review of the scientific literature carried out by Nicky Munro, David Lindenmayer and Joern Fischer from the Fenner School of Environment and Society at the Australian National University (ANU). The three ecologists are investigating how you manage agricultural landscapes to look after its biodiversity, and were interested in reviewing what the current state of knowledge is on revegetation and its use by native animals. Their review also sought to identify any significant gaps in our understanding.

They looked at 27 studies (22 of which examined birds) and found that while revegetation provides habitat for many species of birds and some arboreal marsupials, it is far from being a substitute for remnant vegetation, at least in the medium term (several decades).

Species richness of birds was greater in revegetated areas that were large, wide, structurally complex, old and near remnant vegetation. Bats, small terrestrial mammals, reptiles and amphibians did not appear to benefit significantly from revegetation in the short term.

The findings of their review are presented in: Munro, N.T., Lindenmayer, D.B. & Fischer, J. 2007, 'Faunal response to revegetation in agricultural areas of Australia: A review', *Ecological Management & Restoration*, vol. 8, pp. 199–207.

Photo courtesy of Greening Australia Capital Region.

Native revegetation and biodiversity

What do we really know?

Planting native vegetation is one of our most common responses to the problem of declining biodiversity in agricultural landscapes. Of course, there are a variety of other environmental reasons why you might establish native vegetation. For example, lowering the water table and providing shelter for stock, but bringing back native animals and plants is one major reason we plant native vegetation.

However, the scientific evidence demonstrating the value of native revegetation for native wildlife is surprisingly thin and there is much that we still have to learn about its real benefits. Which is not to say that native revegetation is bad for native animals, just that there is not a lot of science or experience to guide us on what's the best way to do it and what the medium and long-term benefits for biodiversity will be. What information is available, however, suggests the relationship between native revegetation and biodiversity is a complex one and that it changes over different scales of time and space.

Reviewing what's known

Quantifying the value of native revegetation for biodiversity isn't easy, and this isn't the first time ecologists have attempted to bring together the available evidence from a range of studies. Two reviews back in 1999 (Ryan, 1999 and Kimber et al., 1999) both concluded that revegetated sites provided habitat for a range of bird species. However, the majority of these were generalist or edge species (e.g. superb fairy wrens), and birds with specialised needs (e.g. brown tree creepers) were not provided for by revegetation. At the time of these reviews, birds were almost the only animals being examined in terms of what was using native revegetation.

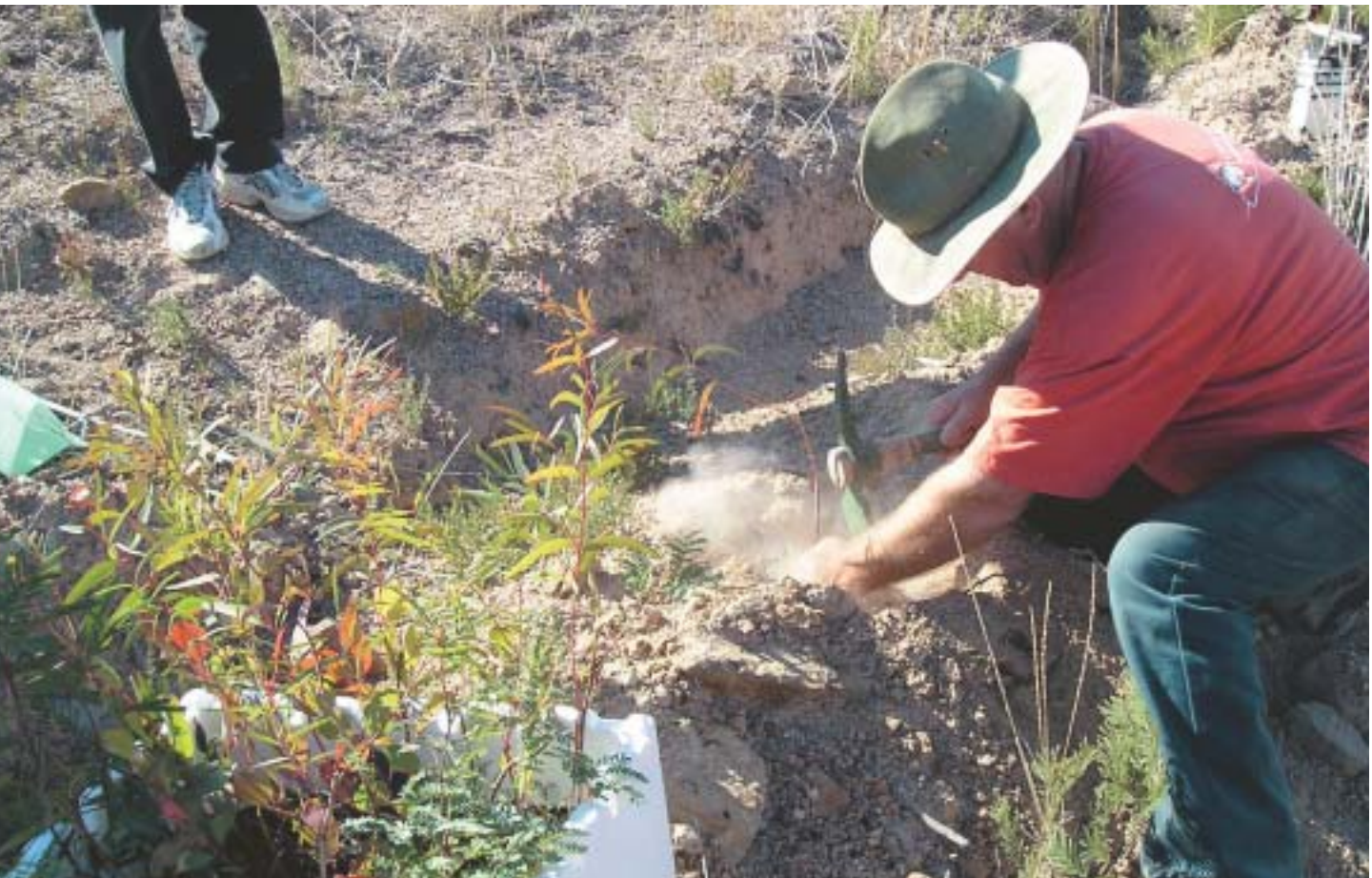


Photo courtesy of Greening Australia Capital Region.

The ANU review was undertaken in 2007 and considered the significant number of studies that have been conducted in recent years. It focussed on the use of revegetation by fauna in Australian agricultural landscapes and the effectiveness of different revegetation strategies. It looked at studies done in plantings of woody vegetation (excluding grasslands) in areas where woody vegetation previously occurred, and where the planted vegetation is native to Australia (but not necessarily local). They excluded industrial-scale plantations, and focussed their review on small-scale farm and community plantings.

In an effort to better distinguish between different approaches to revegetation, the ecologists defined plantings as either 'simple tree plantings' or 'ecological restoration plantings'. Simple tree plantings include windbreaks, community plantings, woodlots and other farm plantings that are structurally simple. Ecological restoration plantings, on the other hand, aim to re-create the vegetation communities present before land clearing. These restoration plantings are usually more structurally and floristically diverse than the simple plantings. They're also much less common.

After trawling through the scientific literature, Munro and colleagues came up with 29 articles describing 27 studies on faunal response to revegetation in Australian agricultural areas. As with earlier reviews, most of the studies examined birds as a response variable (22 studies). However, several studies looked beyond birds. There were four to six studies for each of the following groups: arboreal marsupials, small terrestrial mammals, bats, reptiles, amphibians and invertebrates.

Many studies compared plantings to reference sites such as nearby patches of remnant vegetation (22 studies) or cleared farmland (15 studies). More studies examined simple tree plantings than ecological restoration plantings, although six compared these two revegetation types.

So, what did the review find? The reviewers presented their findings for the different animal groups and different revegetation approaches. As you'd expect, the results were most comprehensive for birds.

Photo Bruce Thomson.

Birds

First the good news; compared with open farmland — revegetation typically supported more bird species, more woodland/forest dependent species and more declining species (species whose numbers have been recorded as declining over time).

Then the qualification: Typically, revegetation did not support the bird richness or composition characteristic of remnant vegetation. However, the authors believe this might be a reflection of the fact that most revegetation simply hasn't had enough time to develop the structural diversity commonly present in remnant vegetation. It's been shown that revegetation does not approximate the floristic and structural diversity of remnants in the first few decades after establishment (that's decades, not years).

Structural diversity and complexity is important to many native birds. Several studies observed that bird species richness was higher in complex revegetation than in simple revegetation. Unfortunately, the value of these findings is greatly reduced because most of these studies did not measure complexity directly.

The age of the revegetation is believed to be an important factor. Structural complexity of revegetation, as measured by the cover or abundance of a number of vegetation attributes, increases with age. Possibly because of this increased complexity, as well as increased time for recolonisation, bird species richness also tends to increase with the age of revegetation. Common bird species can recolonise revegetation within two to three years, and many declining and uncommon birds after eight years.

However, some bird species, such as bark foragers, had not recolonised revegetation in northern New South Wales after 50 years. One study noted that guilds such as grain-, nectar- and fruit-eating birds and bark gleaners were absent or uncommon in 25-year-old simple tree plantings.

And what about the **use of local native plants** (as opposed to non-local native vegetation, e.g. like gums from another state)? Some people believe that local native plants are the only way to go, while others believe it's overstated. Recent revegetation guides suggest that planting local plant species should benefit local fauna but this aspect of revegetation was only implicitly tested in one study in which it was found that the diversity of woodland birds was greater if local native plants were established, and conversely, exotic birds were more diverse if exotic trees were planted.

Results on **the size of the revegetation** were mixed. Only two studies investigated the response of birds to planting area. One found no correlation between bird species richness and simple tree planting area. Another found that bird species richness and abundance had a strong positive response to patch size. These studies differed in their ranges of patch sizes and complexity, with the former being small simple eucalypt plantings (1.5 to 10.5 hectares), and the latter including large ecological restoration plantings (<5 to >1000 hectares).

Then there's **the aspect of shape**. Several studies identified width of revegetation as being positively correlated with bird species richness or richness of forest/woodland birds.

The **landscape context** of the revegetation is believed to be very important. Unfortunately, it has been little studied. One study found that adjacency to remnant vegetation increased the abundance of some birds in simple tree plantings, but overall differences between isolated plantings and those adjacent to remnant vegetation were relatively small. Another study compared birds in revegetation in two landscapes differing in vegetation cover — variegated and cleared — and found no difference in the total numbers of bird species in each landscape.

Recent work by the ANU group (see Cunningham et al., 2008) demonstrated that bird richness was greater where the total area of both remnants and revegetation was greater. Also, the effect of plantings was greater on farms with little remnant vegetation, than on farms with more remnant vegetation (see Box on opposite page).

Photo courtesy of Greening Australia Capital Region.

Revegetation, remnant vegetation and farmland birds

There are several studies that demonstrate that remnant patches of native vegetation provide better habitat for native animals than native revegetation but few that examine the value of revegetation in combination with remnant vegetation on farms. Cunningham et al. (2008) did exactly that for birds and their findings make interesting reading.

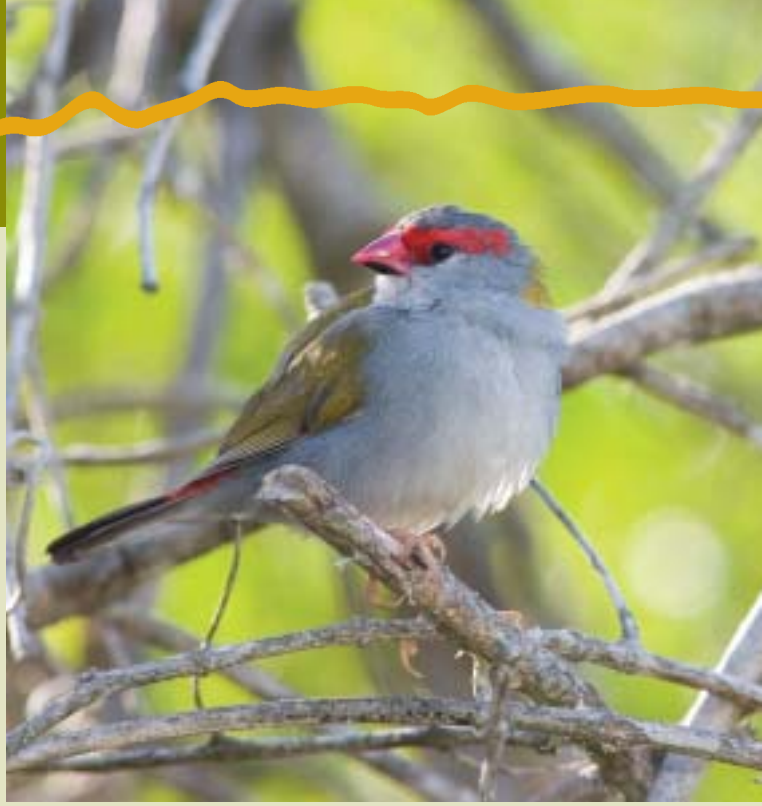
They studied grazing and cropping properties in the southern half of the south west slopes of New South Wales, a region that has been the target of extensive native planting programs over the past two decades. They compared farms with plantings to farms without plantings, over a range of different landscapes looking at a variety of factors (relating the abundance and diversity of birds to how much remnant vegetation and revegetation were present).

They found that over 70% of the bird response they observed could be explained by three factors:

- attributes of remnant native vegetation (native grassland, scattered paddock trees, patches of remnant native woodland);
- presence or absence of planted native trees, and
- the size and shape of tree plantings.

In terms of the number of bird species, remnant native vegetation was found to be much more important than tree planting. There are typically three times more species associated with remnant vegetation than tree plantings. Farms with high values for remnant native vegetation were those most likely to support declining or vulnerable species, although some individual species of conservation concern occurred on farms with large plantings.

They found that there was an important interaction effect between remnant native vegetation and planted native vegetation on bird species richness. Plantings added more taxa to overall species richness when a farm had a low remnant native-vegetation index than when values for this index were high.



Red-browed finch. Photo Bruce Thomson.

The study also identified interesting patterns for a number of high profile declining woodland birds. For example, several studies have raised concerns about the decline of the brown treecreeper and highlighted problems with the dispersal ability of the species. This analysis identified a strong positive relationship between the remnant native-vegetation index and the probability of occurrence of the brown treecreeper. Conversely, the species was less likely to occur on farms with plantings.

Perhaps the negative planting result was an outcome of the limited quantities of dead timber and hence suitable foraging habitat for the brown treecreeper in planted areas. This accords with knowledge of the habitat requirements of the species, such as its preference for areas with large quantities of fallen timber. Two tentative conclusions from these findings are that (1) conservation efforts for the species might be best focused on farms that already exhibit high levels of native-vegetation cover (where birds are more likely to occur) and (2) it may take many years before farm plantings support the kinds of attributes that make such areas suitable for the brown treecreeper.

Results for a suite of bird species of conservation importance indicate that:

1. remnant native vegetation on farms is critical for many declining bird species (such as the brown treecreeper, diamond firetail, hooded robin and crested shrike-tit),

2. plantings provide suitable habitats for some species (such as the scarlet robin and rufous whistler) and may potentially offset the loss of remnant native vegetation, but
3. for other species, plantings may not offset such losses of native vegetation, at least not for decades into the future.

And what does this mean for farm management and bird biodiversity? For improved bird conservation, you should account for the cumulative and complementary contributions of many components of remnant native-vegetation cover (e.g. scattered paddock trees and fallen timber) as well as areas of restored native vegetation.

And what about prioritising vegetation management? For most farms and most bird species, biodiversity management should focus first on conserving and enhancing existing areas of remnant native vegetation and second on planting. This recommendation is based on the relative contribution these sets of features make to bird species richness and the occurrence of particular species of woodland birds that are declining and that can occur on a farm.

These findings are contained in the paper Cunningham, R.B., Lindenmayer, D.B., Crane, M., Michael, D., MacGregor, C., Montague-Drake, R. & Fischer, J. 2008, 'The combined effects of remnant vegetation and tree planting on farmland birds', *Conservation Biology*, DOI: 10.1111/j.1523-1739.2008.00924.x

Photo Bruce Thomson.

Arboreal marsupials

It's not difficult to appreciate that cleared farmland provides almost no habitat for arboreal (tree-dwelling) marsupials. Although revegetation can sometimes provide habitat for arboreal marsupials, this group is typically far more abundant in remnant vegetation. Studies of arboreal marsupials have shown that some members of this group can recolonise revegetated areas if hollows (a key resource) are present or provided (e.g. nestboxes).

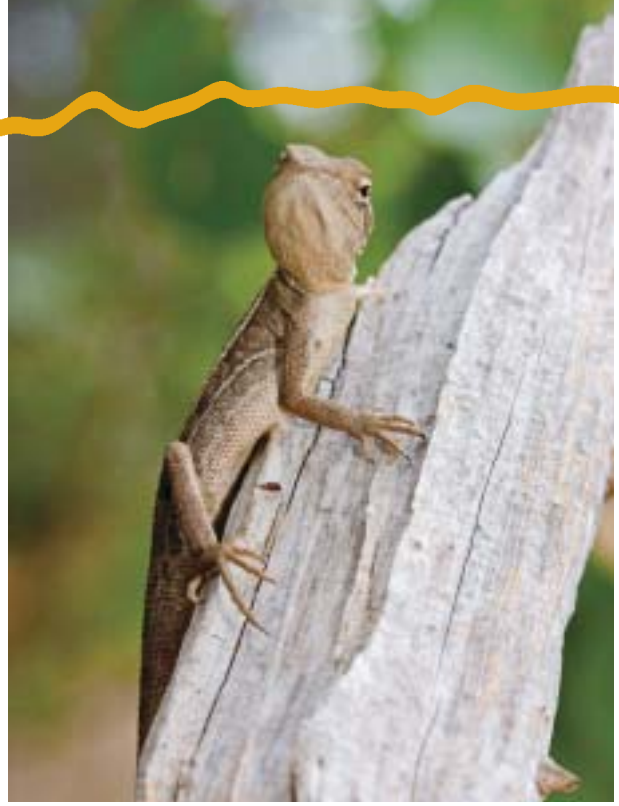
Nadeem Sammakay.

Older revegetation sites contain more arboreal marsupials than young sites. The older areas of revegetation in that study were 20–25 years old, and so were unlikely to provide nesting hollows — hence it is unclear why these older sites contained more arboreal marsupials. One study found that arboreal marsupials were more abundant in relatively large revegetation sites (>5 hectares), but did not respond to planting width (where a narrow site was <50 metres wide).

Another study found that farms and landscapes with many revegetation plantings supported a lower abundance of arboreal marsupials. This was attributed to those farms supporting less remnant vegetation than farms and landscapes with few plantings.

Small native terrestrial mammals

Two of four studies examining small native terrestrial mammals had sufficient data to indicate the value of revegetation as habitat. In one study, southern brown bandicoots and bush rats were observed, but both occurred only in remnant vegetation and not in simple tree plantings. In the other, the echidna was ubiquitous, and three species (bush rat, swamp rat and agile antechinus) were more abundant in remnant vegetation than simple tree plantings. Habitat complexity of plantings (as measured by the number of stratas including ground cover elements) explained most variability in native mammal richness.



Photos this page Bruce Thomson.

Bats

Three studies monitored bats in revegetation and they found greater bat foraging activity in remnant vegetation than in revegetation. One of these studies found greater species richness in remnant vegetation, while another didn't.

There were also mixed responses when bat activity in cleared farmland was compared to that in revegetation. Two studies found no differences between revegetation of any size and cleared farmland, whereas the other found more bat activity in cleared farmland compared to an isolated simple tree planting, but less compared to a planting near a remnant.

One study found more bat activity in older revegetation than in younger revegetation, but the other two did not.

Bats appeared to be insensitive to revegetation size and width as well as to the amount of vegetation cover in the landscape.

Reptiles

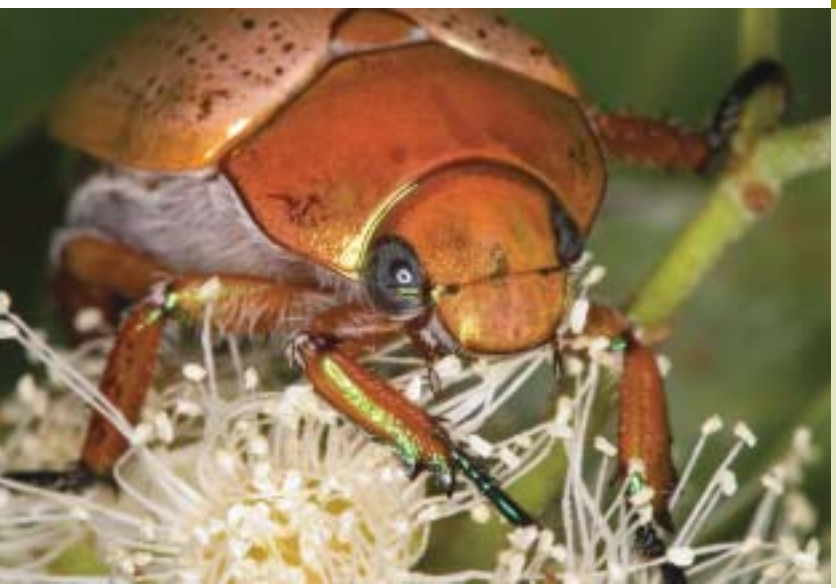
Typically, remnant vegetation contained more reptile species and higher abundances than revegetation, and revegetation supported more species than cleared farmland.

One study found mixed responses depending on the species of reptile, and whether they were rainforest dependent, or habitat generalists.

In the south west slopes of New South Wales, reptile abundance and species-richness were not affected by revegetation age, width or size. One study found that reptiles were less abundant on farms with many revegetation plantings than on farms with little revegetation. Reptiles were, however, correlated with the amount of remnant vegetation cover on a farm.

Amphibians

Amphibians exhibited a mixed response to revegetation. One study found that frogs were present in ponds with water regardless of vegetation type (remnant, revegetation or cleared farmland); another found more frogs in remnants than in revegetation and cleared farmland, and no difference between the latter two.



Invertebrates

Four studies on invertebrates found more taxa in remnant vegetation than in simple tree plantings. However, the studies found different responses of invertebrates to revegetation compared with cleared farmland.

One found more ant species in 6-year-old simple tree plantings than on cleared farmland, whereas another study found no difference. Two studies found highly variable responses by different invertebrate orders.

One study found that grasshoppers were much more abundant in cleared farmland than revegetation or remnants; beetles and ants were reasonably abundant in all vegetation types (cleared farmland, revegetation, remnants); amphipods (litter hoppers) were abundant only in vegetation of high floristic diversity (remnant forest, regenerating forest and floristically rich ecological restoration plantings), with very low numbers in cleared farmland and monoculture revegetation.

One study found that the composition of ants in an ecological restoration planting of a mined site approached that in a remnant forest sooner than that in a simple tree planting. Ant richness increased in both revegetation plots over a 14-year period, and the composition approached that of remnant forests in both revegetation types.

Photo above Bruce Thomson. Photo at right Jim Donaldson.

The attributes of your revegetation

Beyond observations on different animal groups, the studies being reviewed also had something to say about the effect of different types of revegetation.

Size: While it's known that the size of remnant patches in fragmented landscapes is significant (i.e. the bigger the patch size, the more species of birds, arboreal marsupials and reptiles you're likely to find), the effect of patch size has been poorly researched in revegetation studies. Larger patches of revegetation may benefit some faunal groups such as birds and bats however the effect of patch size on other faunal groups is largely unknown.

Shape (width): Bird species richness is generally higher in relatively wide plantings.

Age: Birds and arboreal marsupials appear to increase in richness and abundance with increased revegetation age, but bats, reptiles and invertebrates do not.

Most revegetation plantings examined in this review were young (mostly under 30 years). Some key resources such as large logs, dead trees, tree hollows, or ground cover complexity take longer than this to develop), whereas others may be independent of revegetation age (e.g. water availability, rocks).

Faunal composition also may change in revegetation over time. Young revegetated mine sites in south west Western Australia contained competitive colonising species or generalist species of mammal, bird and ant; then as the vegetation matured, a new suite of species took advantage of the changes in structure at the site.

In Queensland, bird guilds in simple tree plantings became more like those in selectively logged forest over time.

Structural complexity and floristic diversity: Structurally complex revegetation typically supports more fauna species and a different faunal composition than structurally simpler revegetation. Some attributes of complexity are particularly important to some faunal groups. For example, amphibians and reptiles respond predominantly to complexity in the ground layer, and small terrestrial mammals respond to complexity in the mid- and understorey layer.

Similarly, the presence of old trees in a eucalypt plantation can significantly increase bird diversity and abundance.

Vegetation that is floristically diverse may contain more animal species than monocultures, even if vegetation structure is similar. Plantings established for ecological restoration generally exhibit greater floristic and structural diversity than simple tree plantings, and typically support higher faunal diversity.

Adjacency to remnant vegetation: Adjacency to remnant vegetation can increase the use of revegetation by birds. Less mobile species such as mammals are less likely to inhabit planted vegetation than highly mobile animals such as birds. One study found that plantings close to remnants had higher numbers of rainforest plants dispersed by birds, small mammals and wind, than distant sites, indicating that adjacency may benefit plants as well as animals.

Vegetation cover in the landscape: The amount of overstorey vegetation cover in the landscape has been identified as a key variable determining the presence of birds at revegetated sites. Birds, arboreal marsupials and reptiles are also more likely to inhabit revegetation when remnant cover is high.

Comparisons with mine site rehabilitation

Revegetated mine sites provide an interesting parallel to revegetated areas in agricultural landscapes. Now days these types of revegetation are usually complex plantings however in the early times of mine site rehabilitation they were mainly simple. It's the contextual position of revegetated mine sites (which are usually surrounded by native vegetation) that makes them of so much interest. That's very different to revegetation in agricultural areas (where the farm revegetation is often isolated). Revegetated mine sites can therefore provide important information on the faunal use of revegetation in the absence of issues related to isolation, landscape cover or gap-crossing.

Revegetated mine sites show successional trends in bird species, beginning with generalist taxa. Recolonisation of revegetated mine sites appears to be quite rapid taking around six years for birds. In four to six years it's been shown that reptile species richness may resemble that of low quality remnant vegetation. Many invertebrate orders had similar species richness to surrounding unmined forest within seven years; native small mammals recolonised sandmined forests within eight years; and many birds were breeding in revegetated sites within ten years. Birds that did not breed in the revegetated sites had requirements for features not yet available in the sites, such as tree hollows.

Older rehabilitation sites sometimes contain very little understorey vegetation, whereas more recent sites contained an understorey plant species richness and diversity comparable to unmined forests. The older sites contained very low bird species richness and densities, whereas the recent sites with understorey support bird species richness and densities similar to those in unmined forest. These studies have emphasised the benefits of developing an understorey in the plantings (where an understorey originally occurred).

Does revegetation play a role at the scale of the landscape?

Research has shown that fragments of remnant vegetation of all sizes and shapes have significant conservation value, both as habitat and as stepping stones through the landscape. This notion may extend to revegetation, despite the lower faunal use compared to remnants. Revegetation may also help buffer adjacent remnants from climatic extremes and other degrading processes, and may stabilise key ecological processes in agricultural landscapes (e.g. by reducing water tables).

A repeated finding has been that the real value lies in the remnant vegetation. At a landscape scale, there may be negative consequences for fauna if remnant vegetation is replaced with revegetation. However, if revegetation is situated on already cleared farmland it's likely it will have a positive effect.

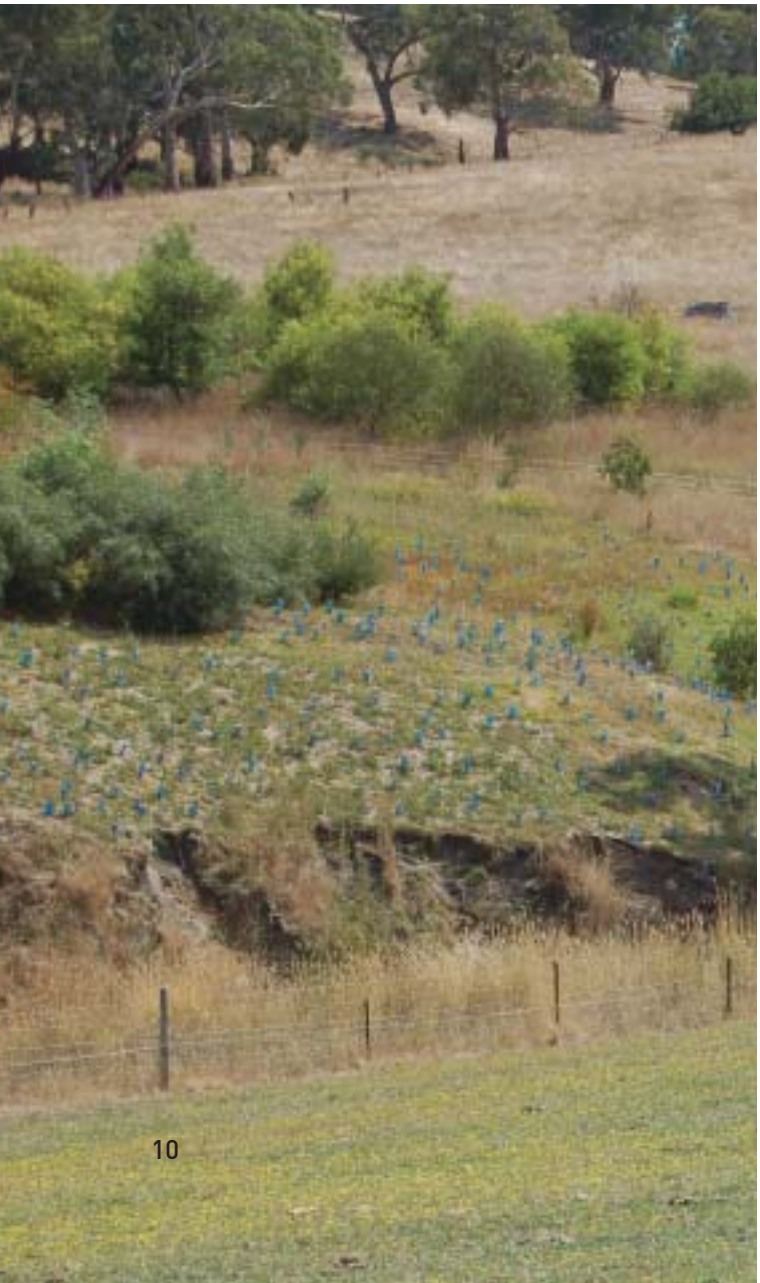


Photo at left Roger Charlton. Photo below Nadeem Samnakay

Knowledge gaps

The researchers at the Fenner School were aware that many research projects involving revegetation are written up as reports or unpublished theses that are not widely available. To maximise accessibility of findings to other researchers, they suggest publication in peer-reviewed journals.

There is also a need for scientists to more clearly explain site attributes of revegetation — in particular age, size, isolation, and structural complexity and floristic diversity. Much of this basic information was unavailable in the reviewed articles. Clear and consistent information can provide future opportunities for systematic reviews or meta-analyses.

The ecologists also recommended that research should target the following areas:

- long-term trends and successional changes in revegetation including the development of key structural features and their effect on fauna;
- comparisons of different types of revegetation including analyses of potential trade-offs between quantity and quality of revegetation at the landscape scale;
- the faunal composition changes in revegetation over time and with different site attributes;
- the response by terrestrial mammals to revegetation;
- the resource needs of reptiles, amphibians and bats which could be provided by revegetation;
- the conservation value of revegetation for declining or threatened fauna;
- the value to wildlife of revegetation in riparian compared to non-riparian areas; and
- what are the cumulative effects on biodiversity of both plantings and remnant vegetation on a farm.

Photo courtesy of Greening Australia Capital Region.

Progress to date

In addition to providing us new information on the value of revegetation for native animals, the review undertaken by the ANU ecologists also reveals much that we still need to learn. To begin with, it's apparent that most of the research has focused on the value of revegetation for birds, but there isn't much information on other faunal groups and on threatened and declining taxa.

Most research has focused on simple measures of species richness and abundance but faunal composition would provide valuable information on the benefits of revegetation to fauna.

Establishment of ecological restoration plantings is a relatively new practice. It is logical to study both ecological restoration plantings (as an example of the best revegetation currently conducted) and simple tree plantings (as the most common form of revegetation). Differences between these forms of revegetation can provide insights into the conservation capacity of revegetation under both a best-case scenario and the current scenario of mostly simple tree plantings.

The value of revegetation to fauna is rarely put into a landscape context. This context is important because patch-scale research provides information on the local faunal richness (alpha diversity), but it is the landscape faunal richness (beta diversity) that is often of greatest conservation concern.

Most studies have not examined underlying processes involved in faunal use of revegetation. The review by the researchers at the Fenner School found only one study which explored this issue — and that was on the use of revegetation by birds for breeding. To date, no research has been conducted on processes such as competition or predation in revegetation.

The faunal response to revegetation studied to date is mostly short-term because revegetation has become common only in recent decades. As revegetation ages, and incorporates more features such as logs and leaf litter, its value to wildlife may increase. Ongoing studies will be required to assess the long-term benefits of revegetation.

The key points

While revegetation provides habitat for many species of birds and some species of arboreal marsupials, it is far from being a substitute for remnant vegetation. The priority element within any landscape is the remnant vegetation.

Species richness of birds was greater in revegetated areas that were large, wide, structurally complex, old and nearer to remnant vegetation. Bats, small terrestrial mammals, reptiles and amphibians did not appear to benefit significantly from revegetation in the short term.

While the science on this topic is growing, there are still key information gaps on the faunal response to:

(i) revegetation as it ages;

(ii) different structural complexities of revegetation;

(iii) revegetation that is composed of indigenous versus non-indigenous plant species; and

(iv) revegetation that is in riparian versus non-riparian locations.

In addition, little is known on the value of revegetation for declining or threatened fauna, or of the composition of fauna in revegetation. There is a need to better understand the balance between quantity of revegetation in the landscape, and the quality or complexity of revegetation at the patch scale.

Based on current evidence, the review recommended that:

- continued high priority be given to retaining and managing remnant vegetation in the landscape;
- any revegetation efforts focus on the creation of patches that are large, wide and structurally complex to maximise the benefits to fauna.

Useful references for further reading

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Photo opposite Bruce Thomson. Photo this page Roger Charlton. Back cover photo courtesy of Greening Australia Capital Region.

This report is published by Land & Water Australia through the Native Vegetation and Biodiversity R&D program.

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