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Rainforest restoration: approaches, costs and biodiversity outcomes

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Rainforests have a complex structure and support a diverse suite of plants and animals, attributes lost on conversion to pasture. Rainforest restoration includes activities such as the rehabilitation of degraded remnants, the reforestation of cleared land (photos left and centre) and the management of weedy regrowth (photo, right). All of these activities aim to assist the recovery of rainforest biodiversity.

The last few decades have seen considerable investment in rainforest restoration (including remnant rehabilitation, tree planting and regrowth management) in tropical and subtropical Australia. In recent years, research has helped us understand the value of restoration projects for biodiversity.

In this fact sheet, we discuss the following issues.

- **What approaches have been used to achieve rainforest restoration?**
- **What are the costs of these approaches?**
- **What are the outcomes for biodiversity?**
- **How might 'biodiversity-friendly' rainforest plantings be designed and maintained?**

Rainforests and biodiversity

Rainforests cover less than 1% of Australia, relics of the vast forests that once occupied much of the continent. Yet they still support a high proportion of Australia's native species.

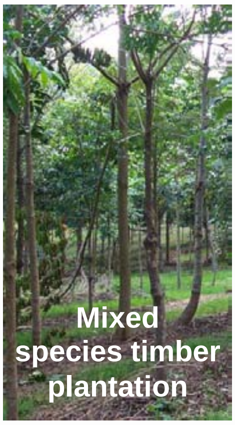
Following European settlement, tropical and subtropical rainforests on fertile soils were extensively cleared for agriculture. Most remaining rainforest is now protected from further clearing, but smaller remnants often support reduced populations of rainforest animals and are subject to disturbance and invasion by exotic species. Regenerative processes such as seed dispersal have been altered, and the long-term future of biodiversity in many remnant rainforests is uncertain.

Rainforest restoration

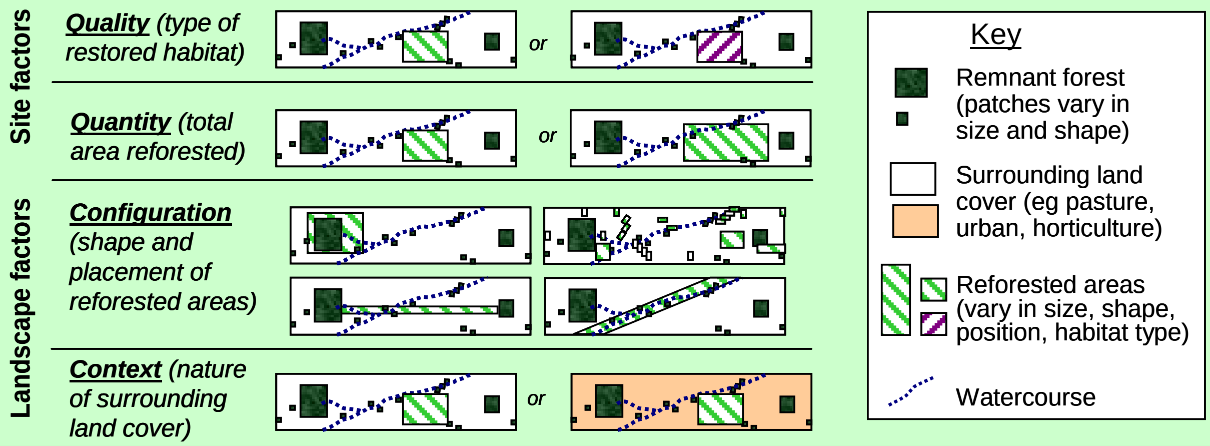
In recent decades, there has been increasing effort to rehabilitate degraded rainforest remnants and to re-establish rainforest on cleared land. A wide variety of tree planting designs have been trialled, from monoculture and mixed species timber plantations to diverse 'ecological restoration' plantings (see below). At the same time, regrowth forests have developed spontaneously on larger areas of retired farmland, particularly in subtropical Australia. Even when dominated by introduced trees, regrowth forests can support native fauna and flora, including the seedlings of rainforest trees. Active management of this regrowth can further promote the regeneration of rainforest plants.

Approaches to re-establishing rainforest on cleared land

The following table summarises the typical characteristics of different approaches to rainforest re-establishment. In practice, there are many variants, and different approaches can be combined at the landscape scale (for example, spatial mosaics of timber and restoration plantings).

	 Monoculture timber plantation	 Mixed species timber plantation	 Ecological restoration planting	 Regrowth (from dispersed seeds)
Species planted:	1 species	2-10 species	20-50 species	No planting
Planting density:	1,000 stems/ha	1,000 stems/ha	2,500-5,000 stems/ha	No planting
Cost per hectare (AUD):	$4,000	$8,000	$30,000	$0-$10,000 (if managed)
Objectives:	Timber, also rehabilitation of degraded land	Timber, also rehabilitation of degraded land, biodiversity	Biodiversity, water quality, rehabilitation of degraded land	Varies. Regrowth can be managed to improve biodiversity outcomes
Management:	Initial intensive weed control, thinning and pruning of trees	Initial intensive weed control, thinning and pruning of trees	Initial intensive weed control, maintenance weed control	Includes weed control (intensive and maintenance)

The outcomes of reforestation projects for biodiversity are affected by a range of factors operating at both site and landscape scales



What factors influence the outcomes of reforestation for biodiversity?

The biodiversity outcomes of re-establishing rainforest at any site will depend on:

- **site factors** (physical conditions and characteristics of the revegetation);
- **patch size** (the area of continuous vegetation); and
- **landscape factors** (the relationships of the revegetation with surrounding areas).

How can trees make a forest?

At the **site level**, important decisions about planting designs for reforestation include the number and kinds of species planted and the stocking rate (plant density). These will determine **habitat quality** (suitability for rainforest-dependent species). Restoration plantings contain many more tree species than timber plantations and are more densely planted. They are more similar to rainforests in plant species composition and structural complexity, and support more of the animal species that depend on rainforest habitats.

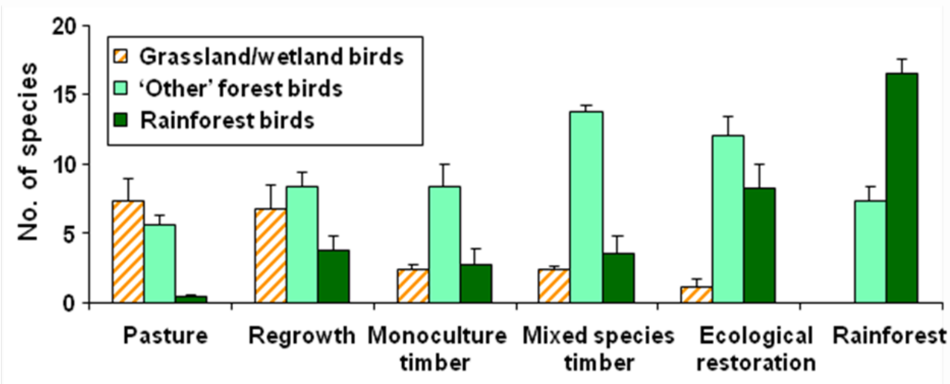
For example, in North Queensland (see graph, below), the number of rainforest-dependent bird species in decade-old restoration plantings averaged about half of that typically found in intact rainforest, compared with around 25% in timber plantations and regrowth. However, birds of grassland or wetland habitats showed the reverse pattern.

The importance of patch size

Biodiversity in reforested areas will also depend on the **quantity** of habitat (the patch size). Most reforestation projects have been no more than a few hectares in area (with many less than one hectare). Even if they are planted in a manner that will produce high habitat quality, such small areas cannot sustain all of the species found in intact rainforest habitat. Furthermore, edge effects (changes caused by the penetration of light, wind. heat and other factors) reduce the habitat quality of small patches.

Bird species that depend on rainforest disappear from pasture: increases in their number indicate successful restoration, with the reverse for grassland/wetland birds.

Each bar shows the average number of species recorded at 5-10 sites, from four hours of survey effort in 0.3 ha per site. 'Rainforest' birds are species typically associated with intact rainforest, while other forest birds also or exclusively use eucalypt forests. Data are from sites in North Queensland (Source: Catterall *et al.* 2004).



The bigger picture

The biodiversity outcomes of reforestation at any site also depend on landscape-scale factors such as the **configuration** (e.g. the number shape, and arrangement) of reforested areas and their **context** (e.g. the type of surrounding habitat).

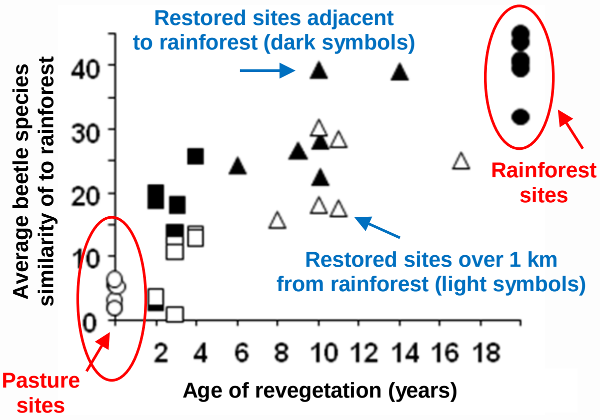
Many restored rainforest areas are riparian corridors (narrow strips along creeks). Riparian restoration helps improve water quality and in-stream habitats. Reforested corridors that link remnants can also help rainforest-dependent species to move between them.

But the main value of corridors for most species may simply be the additional habitat area that they provide in the landscape.

On the downside, narrow corridors may be dominated by edge effects (including weed invasion). Plantings whose shape is more compact and consolidated will have a larger proportion of their area located away from edges, and therefore will be less disturbed.

Proximity to remnant rainforest is another aspect of configuration that affects biodiversity outcomes, especially for species with limited capacity for long-distance movement.

Distance from intact rainforest affects the recovery rate of fauna in restored sites



Data from North Queensland.
Source: Grimbacher *et al.* 2007.

For example, a study in North Queensland found that ecological restoration sites between two and 18 years old were more rapidly colonised by rainforest beetles if they were located adjacent to intact rainforest, than if they were located more than one kilometre from rainforest (see graph, above).

Finally, **context** (surrounding habitat) will make a difference. For example, restored rainforest patches that are surrounded by woodland (widely-spaced trees) will be less isolated and exposed to edge effects than those within pasture.

Design of 'biodiversity-friendly' reforestation projects

Achieving rapid recovery of biodiversity

For the reasons outlined above, reforestation projects should be most likely to rapidly acquire a more rainforest-like biota if they are designed to:

- consist of many species of trees, shrubs and other plant life forms;
- resemble rainforest in their physical structure and complexity; and
- be large in area.

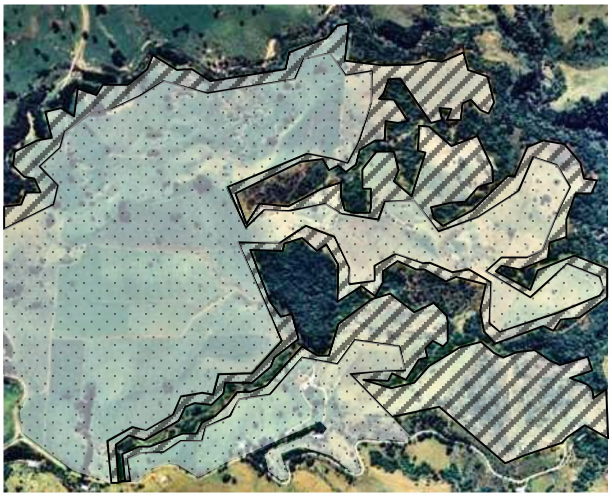
Ecological restoration planting as commonly practiced in Australia produces habitats that meet the first two criteria, and which often support a variety of rainforest animals within five to ten years of establishment. However, these techniques are expensive and have been restricted to relatively small areas.

Reforested areas that are close to intact rainforest or within landscapes that contain a lot of rainforest are likely to gain diversity most rapidly. In contrast, restored rainforest that is far from any other forest will gain new species more slowly, but on the other hand will add more diversity to the landscape and can itself act as a source of new colonisers for surrounding areas.

Timber vs. biodiversity: trade-off or synergy?

Some landholders have sought both biodiversity and financial benefits by establishing mixed-species timber plantations. However, recent research has found that these plantations provide no more benefit to rainforest biota than do monoculture plantations, at least in their first decade of growth (see *References and further reading*). This is due to trade-offs in the planting designs needed for maximising timber production versus biodiversity within a replanted site.

To maximise wood production, a few tree species chosen for their timber quality are planted at low density, thinned and pruned, with understorey growth suppressed. In contrast, maximising biodiversity requires a high plant diversity, density and structural complexity.



Landscape-scale approach to meeting biodiversity and timber objectives from reforestation. In this hypothetical example, 25% of the plantation estate has been allocated to restoration plantings (striped areas), mostly along creek corridors and buffers around remnants, but also as larger areas to consolidate native forest. The balance is monoculture timber plantations (dots).

Timber plus biodiversity opportunities

Design and management at the landscape scale may get around this problem. For example, a restoration/ monoculture patchwork is expected to have better biodiversity outcomes across a whole plantation than uniform mixed timber. And it may be cheaper: based on available costing, an area of 25% timber monoculture and 75% restoration planting would have a similar total establishment cost to mixed species timber planting over the entire area.

Mixed species cabinet timber plantation, comprised of a few tree species established at wide spacing; their rainforest biodiversity value is relatively low.

Future rainforest restoration

How much is enough and who pays?

Despite tens of millions of dollars already having been spent, only about 1% of previously-cleared rainforest in tropical and subtropical Australia has been replanted with rainforest trees (although larger areas of spontaneous weedy regrowth occur in the subtropics). Larger-scale reforestation is needed for the long-term persistence of rainforest biodiversity.

Plantings to restore biodiversity have been limited to small areas because of high cost and low financial return. However, prospects for financing restoration plantings are improving, as markets develop for:

- ‘offsets’ to compensate for the clearing of native vegetation;
- environmentally-certified forest products; and
- carbon sequestration.

Recent work has shown that ecological restoration plantings are effective at sequestering carbon (see *References and further reading*).

How can it be done better?

Emerging alternative approaches that may ultimately reduce reforestation costs include direct seeding and management of natural regeneration. Knowledge is improving, but there is still much to be learnt about how to cost-effectively rebuild rainforest biodiversity.

To enable better advice to be given to future restorers of rainforest, we need to learn more from current efforts, and to identify past mistakes and avoid repeating them. The development of improved techniques requires a collaborative effort involving both researchers and restoration practitioners, to combine:

- a more experimental approach to restoration activities; together with
- longer term monitoring of the outcomes.

Methods for documenting and monitoring the outcomes of reforestation activities have recently been developed (see *References and further reading*). However, experimental approaches are still scarce, and more creative efforts are needed over larger areas.

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Photos: T. Reis

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