20 Years of Rainforest Restoration

A case-study of rainforest restoration activities on an abandoned paddock adjacent to Dorrigo National Park

JALIIGIRR Biodiversity Alliance

Case-study summary

This case-study documents and assesses rainforest restoration activities undertaken in an abandoned paddock adjacent to Dorrigo National Park over a 20-year period between 1996 and 2016. Restoration works occurred on three sites (REGEN 1, REGEN 2 and REGEN 3) totalling 12ha in area. This case-study will focus on revegetation activities in REGEN 1, and will assess restoration success, barriers to restoration and future directions.

Dorrigo National Park Bush Regeneration Project

Site history

Vegetation clearing has been widespread on the Dorrigo Plateau in northern New South Wales. The rainforest communities that once existed on the rich plateau basalts are now restricted to isolated gullies or areas not suitable for agriculture, and many of the remaining remnants are affected by grazing and weed invasion. Dorrigo National Park is the most significant remnant of this previous vegetation, and the park protects temperate rainforest and provides refuge for sub-tropical rainforest.

In 1975 the National Parks and Wildlife Service gained control of three abandoned paddocks along Dome Rd, adjacent to Dorrigo National Park. These paddocks had previously been leased out for grazing by the Dorrigo Park Community Trust to generate income for the upkeep of facilities in the park. The paddocks were mostly cleared, with only occasional remnant trees (*Acacia melanoxylon, Doryphora sassafras* and *Acmena smithii*). Pasture areas were dominated by kikuyu (*Pennisetum clandestinum*) and small leaf privet (*Ligustrum sinense*) regrowth.

Restoration goals

The original vegetation, and the target community for the restoration project, was sub-tropical rainforest dominated by *Sloanea woollsii, Argyrodendron actinophyllum, Ficus watkinsiana, Dendrocnide excelsa, Orites excelsa* and *Planchonella australis* (Floyd (1990) STRf Suballiance No. 7).

Restoration activities

In early 1997 the largest site (REGEN 1 – 6ha) was cleared of small leaf privet (*Ligustrum sinense*), deep ripped, fenced and then planted with 17,500 tube-stock (13,500 *Acacia melanoxylon*, 4,000 mixed rainforest species) through the Greening Australia Farm Forestry Project. A further 4,000 *A. melanoxylon* and 1,500 mixed rainforest species were planted in 1999 to cover seedling mortality.

Dorrigo National Park Bush Regeneration Project Sites: Left – REGEN 1, Right – REGEN 2 and 3 (Photo 1973).

In 2005, two additional sites (REGEN 2 and REGEN 3 – 6ha total) were cleared of small leaf privet. This work was followed up with an application (spray) of metsulfuron methyl (BrushOff ™) in 2006 and 2007 to kill any remaining small leaf privet seedlings. Woody weeds under remnant trees were stem injected with 100% Glyphosate. In mid-2007 the site was fenced

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with 900mm hinge joint and barbed wire to reduce browsing by native and introduced animals.

Revegetation methods used

Two different revegetation methods were trialled in REGEN 1. These methods were:

- Single species, *Acacia melanoxylon* planting at 2m x 2m spacing (13,500 plants across 5ha).
- Mixed species rainforest island plantings (26 islands at 20m x 20m) at two densities, 1m x 1m and 2m x 2m (4,000 plants across a total of 1ha).

Fertilising of each tree was undertaken 2-3 weeks after planting. Trees were further protected from grazing and exposure through the use of either cardboard milk cartons or plastic sleeve tree guards.

Initial plantings following the clearing of small leaf privet (January 1998).

Rainforest restoration models

The planting techniques trialled at REGEN 1 are examples of two approaches to rainforest reafforestation that were commonly used in the late 1990's (see Goosem and Tucker 1995; Kooyman 1996).

Framework Model: The framework model utilises a number of hardy, fast growing rainforest pioneers to quickly "capture" a site, and outcompete aggressive ground-layer species that may act as a barrier to regeneration. These framework species then act as a catalyst for on-going rainforest recruitment and the building of species diversity by attracting seed dispersing animals to the site (Goosem and Tucker 1995). The framework method is only recommended when a seed source is nearby, as external seed inputs are needed to build species diversity over time.

The single species *Acacia melanoxylon* planting in REGEN 1 is an example of a simplified variation of the framework model. Most framework plantings include multiple rainforest pioneer species (typically 4 – 20) with some diversity of fruit types and life forms included in the initial species mix. Although the *A. melanoxylon* planting had limited species diversity, the close (2m) spacing resulted in a closed canopy after approximately 4 years and provides frost protection and shading across the site.

Maximum Diversity Model: The maximum diversity model includes a diverse mix of mature phase rainforest species with a smaller proportion of fast growing early successional species. By including these mature phase species in the original planting there is less reliance on ongoing seed dispersal to build diversity over time. This in-built diversity makes the maximum diversity model suitable for more isolated locations where seed dispersal may be limited.

The mixed species rainforest islands planted throughout REGEN 1 are examples of the maximum diversity model. A total of 26 different species were included in each of these plantings, and mixed species islands were spread throughout the *A. melanoxylon* planting to attract seed dispersing animals across the entire site.

Although these later successional species are generally slower growing, plantings that include a greater diversity of mature phase species often start to resemble the structure and diversity of a mature rainforest after as little as 5 – 10 years (Catterall et al. 2004).

Assessing restoration success

Plant survival

Seedling losses due to frost were high within the first 18 months, with 29% of the acacias and 37% of the mixed rainforest species needing replacement. These plants were replaced through a follow-up planting program in 1998-9. After this time limited planting has taken place on the site.

Plant losses continued across the site after the initial replanting in 1999, with the mixed species plots suffering the highest losses. Plot diversity is now greatly reduced in most of the mixed species plots and many of the rainforest islands are now

hard to differentiate from the pure acacia planting.

Aerial view looking north-west of revegetation area in REGEN 1. Photo taken in 2007 – Tim Scanlon.

Natural regeneration and recruitment rates

Long-term restoration success requires the re-establishment of the natural processes of seed dispersal and recruitment to the site. To assess levels of natural regeneration, 5 monitoring plots ($25m^2$) were established in the acacia planting and mixed species plots, in 2007. Additional monitoring plots were also established under remnant large *Acacia melanoxylon* trees, within adjacent areas of intact rainforest, and in areas dominated by small leaf privet (*Ligustrum sinense*). Within each of these plots native seedling abundance (<30cm in height), canopy cover (%) and living ground cover (%) were recorded.

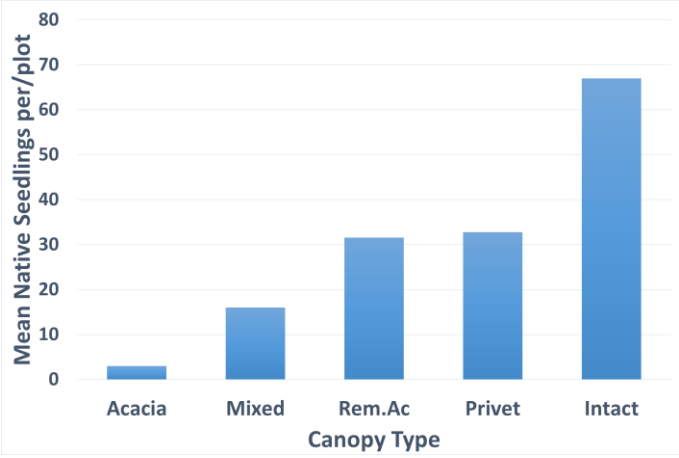

*Figure 1: Mean native seedling regeneration under acacia plantings (**Acacia**), mixed rainforest plantings (**Mixed**), remnant mature Acacia (**Rem. Ac.**), stands of small leaf privet (**Privet**) and intact rainforest (**Intact**).*

Although replication was limited, the monitoring undertaken in 2007 shows distinct differences in all three variables across the five canopy types.

Native seedlings were uncommon under the pure *Acacia melanoxylon* planting (mean number of seedlings per plot = 3). Mixed species plots had an average of 16 seedlings per plot, while remnant acacias and stands of privet had an average of 32 and 33 seedlings respectively. By contrast, plots within intact rainforest had an average of 67 seedlings per plot from 18 different rainforest species.

Barriers to regeneration

Competition from exotic grasses and ground layer species creates a significant barrier to the germination and recruitment of seedlings of native rainforest species. Most rainforest restoration projects aim to overcome this barrier by establishing plants on the site to outcompete these ground layer species. Ground cover levels of exotic grasses will often decrease when canopy cover increases, and the establishment of dense canopy cover is a goal of most revegetation projects. The opening up of the ground layer in turn promotes the germination and establishment of many rainforest seedlings.

Canopy Cover: Mixed species rainforest plantings had a higher level of canopy cover compared to the *Acacia melanoxylon* planting (48% vs 27%). Canopy cover was higher again under stands of privet (62% cover) and intact rainforest (82% cover).

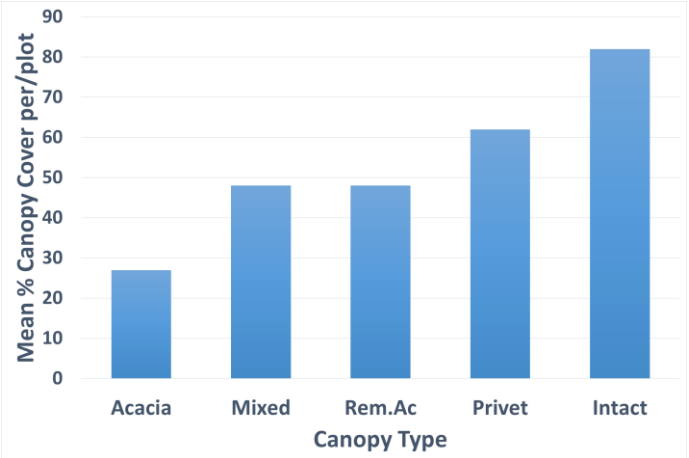

*Figure 2: Mean % canopy cover under acacia plantings (**Acacia**), mixed rainforest plantings (**Mixed**), remnant mature acacia (**Rem. Ac.**), stands of small leaf privet (**Privet**) and intact rainforest (**Intact**).*

Living Ground Cover: Levels of living ground cover were directly related to the mean percentage canopy cover in the monitoring plots. Acacia plantings after 10 years of growth still had high levels of living ground cover (73%) with the exotic grass, kikuyu (*Pennisetum clandestinum*), dominating most sites. Mixed species plots and remnant acacias had similar levels of living ground cover (30% and 25%), as did stands of privet and intact rainforest (both 9% cover).

Monitoring plots with high levels of canopy cover and low levels of living ground cover consistently had the highest number of regenerating native seedlings across all of the monitoring plots.

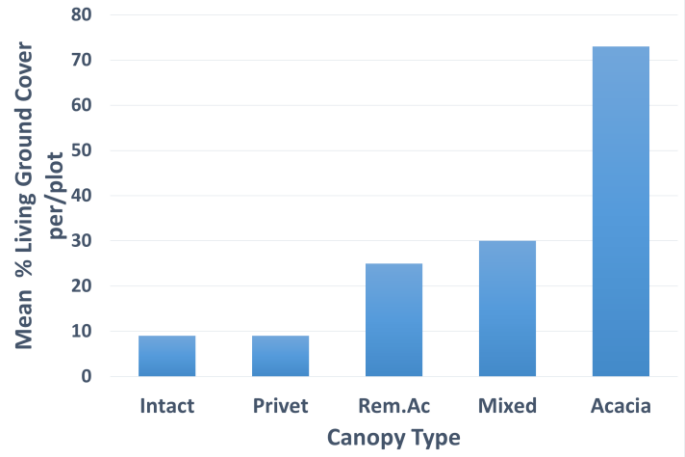

*Figure 3: Mean % living ground cover under acacia plantings (**Acacia**), mixed rainforest plantings (**Mixed**), remnant mature acacia (**Rem. Ac.**), stands of small leaf privet (**Privet**) and intact rainforest (**Intact**).*

Persistence of Kikuyu: Assessment at 10 years post planting showed many areas under the acacia canopy to be dominated by kikuyu. Any areas that were not dominated by kikuyu had dense native ground covers due to the relatively high light levels under the acacia canopy.

Dense kikuyu ground cover under 10 year old Acacia melanoxylon in REGEN 1.

It is likely that the use of a single pioneer species across the site has exacerbated this issue, as canopy cover levels for *A. melanoxylon* would typically peak 3-5 years after planting. Similar declines in canopy cover have been noted for several other rainforest pioneers (e.g. bleeding heart, macaranga and sarsparilla) in north Queensland revegetation trials (Freebody 2007). Other studies suggest that plantings that include a higher proportion of mid- to late- successional species, and a more diverse mix of species, are more likely to avoid this decline in canopy cover over time due to their more complex canopy architecture (Florentine & Westbroooke 2004, Freebody 2007).

Spread of Tradescantia: Tradescantia (*Tradescantia fluminensis*) has recently spread to cover approximately 20% of the site. This weed can form a dense and thick (40cm) ground cover that prevents most native recruitment. Tradescantia is also tolerant of some shade and is likely to persist at the site until canopy cover reaches a level similar to those found in the remnant rainforest (>70%). On-going control of this species will be required if its spread is to be limited.

Tradescantia fluminensis is an emerging weed in the REGEN 1 site (Photo: Harry Rose).

Future directions

Supplementary planting

While the levels of canopy cover under the mature acacias may have been insufficient to outcompete many ground layer weeds, is has provided protection from frost and climatic extremes. Many rainforest species that would not have survived on the site initially could now be planted to increase diversity, canopy cover and habitat values across the site. When considering the existing island plantings, and natural

rainforest recruits, as little as 1000 plants across the 6ha site may be sufficient to boost diversity and density.

Acacia control

A lack of recruitment under acacia dominated plantings has been found in several mature (5-17 years) north Queensland plantings (Freebody 2007, and see Hopkins 1990). Thinning of one third of the acacia canopy was trialled at one of these sites and led to a significant increase in native rainforest recruitment. A similar method could be trialled at little cost across the acacia plantings in REGEN 1.

Reducing ground layer competition

In 2007 all kikuyu and ground layer herbs and grasses were controlled in several 10m x 10m trial plots across REGEN 1. Although these plots have never had return monitoring, several can still be located and qualitative assessments would suggest that rainforest seedling recruitment has increased in these plots in response to the more open ground layer. Kikuyu re-establishment has also been limited in these plots, suggesting that light levels are sufficient to prevent re-establishment, but not low enough to outcompete this species. This strategy could be further trialled across the site either separately, or in conjunction with the thinning of acacias.

Ground layer control plot. Photo taken in 2008, one month after control. Prior to control, plot had 90% living ground cover. This photo also shows substantial thinning in the lower portion of the acacia canopy.

Alternatives to planting

Planting costs

Rainforest plantings can quickly capture a bare site and stimulate on-going natural regeneration but this change comes at a substantial cost. A hectare planted with 2000 tube-stock without tree guards, mulch mats or fertiliser costs $16,000. Many sites will also require plant protection from wallaby browsing, and growth rates are improved with the use of mulch mats. This can increase the cost of a 2000 tube-stock, 1ha planting, from $16,000 to $36,000. These figures also don't include on-going weed control, replacement planting, and tree guard removal which can add an additional $20,000 per hectare over the first 5 years of establishment (See Catterall and Kanowski 2010, for an assessment of alternative rainforest restoration approaches).

Dense rainforest plantings are effective, but can cost up to $56,000 per hectare to establish.

Management of woody regrowth

An alternative to tree planting is the management of woody regrowth. Unassisted woody regrowth can kick-start rainforest restoration in a similar way to a "framework" planting (See Jaliigirr/Griffith University Factsheet – *The Role of Woody Weeds in Rainforest Restoration*). Costs of this approach are substantially cheaper (unassisted - $0, managed - $3-5,000 per/ha per/year) and have the potential to improve biodiversity values over large areas of land.

Non-native species such as wild tobacco (*Solanum mauritianum*) and small leaf privet (*Ligustrum sinense*) grow readily across the site and can be used to stimulate natural recruitment to the site and provide cover to native seedlings. Their judicious use and on-going management could provide a cost effective alternative to broad-scale planting.

Further Reading

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Goosem S. and Tucker N. I. J. (1995) Repairing the rainforest: Theory and practice of rainforest reestablishment in North Queensland's Wet Tropics. Wet Tropics Management Authority, Cairns.

Griffith University Environmental Futures Research Institute *Materials for Environmental Managers* reports. Online access to several relevant reports on rainforest restoration. Accessible at: https://www.griffith.edu.au/environment-planning-architecture/environmental-futures-research-institute/publications/materials-for-environmental-managers

Hopkins M.S. (1990) Disturbance – the forest transformer. In: *Australian Tropical Rainforests – Science, Values, Meaning* (eds L.J. Webb & J. Kikkawa), pp. 40-52. CSIRO, Melbourne.

Kooyman R. (1996) Growing rainforest: Rainforest restoration and regeneration, Recommendations for the humid subtropical region of northern NSW and south-east Qld. Greening Australia, Brisbane.

For more information on the Jaliigirr Biodiversity Alliance go to:

http://www.greateasternranges.org.au/our-partners/ger-regional-partnerships/jalliigirr-biodiversity-alliance/

Acknowledgements: Content by Craig Stehn. Background on restoration activities by Tim Scanlon (NPWS)
Photos: Craig Stehn, unless otherwise attributed.

Australian Government | National Landcare Programme

The Jaliigirr **Healthy Catchments = Productive Catchments** project is supported through funding from the Australian Government's National Landcare Programme

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