Use of reforested rainforest by arboreal marsupials on the Atherton Tablelands, North-Eastern Australia – a preliminary assessment

Steven Zachar[A], *John Grant*[B], *John Winter*[C] and *Mark McCaffrey*[D]

[A]Loyola University Chicago, Illinois, USA

[B]Mail Bag 71, Yungaburra Qld 4884, Australia

[C]College of Science and Engineering, James Cook University, Cairns Qld 4870, Australia. Email: jw.winter@bigpond.com

[D]14 Pine Street, Millaa Millaa Qld 4886, Australia

Abstract

Conservation efforts over the past two decades have restored some of the tropical rainforest cover in the fragmented landscape of the Atherton Tableland, north Queensland. This study is the first to systematically assess whether or not endemic arboreal mammal species are colonizing revegetated areas. We measured their use by five target arboreal marsupials: Lumholtz's Tree-Kangaroo, Coppery Brushtail Possum, Green Ringtail Possum, Herbert River Ringtail Possum, and Lemuroid Ringtail Possum. Using spotlights, we conducted five surveys in each of 10 sites on the Atherton Tablelands in both restored and remnant reference plots.

Statistical power was low due to few observations so assessing differences between experimental (replanted) and control (remnant) plots was not possible. However, Lumholtz's Tree Kangaroos, Coppery Brushtails, and Green Ringtails were observed permanently inhabiting replanted sites, including one, not adjacent to remnant rainforest. Herbert River Ringtails and Lemuroid Ringtails were, as expected, restricted to the two higher altitude sites and occurred in remnant rainforest. The Herbert River Ringtail occurred in the replanted forest at both sites, whereas the one observation of a Lemuroid Ringtail was on the edge of a replanted site that was closely bracketed by remnant forest.

Findings from this study support revegetation projects throughout the Atherton Tablelands based on their successful uses by arboreal marsupials for habitat.

Copyright all content: © 2017, Zachar *et al*. This is an open access article distributed under the terms of the *Creative Commons Attribution License*, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Handling editor: Steve Murphy and Don Franklin

Citation: [author(s)]. 2017. [title]. *North Queensland Naturalist* 47: 21-27.

Introduction

The Atherton Tableland is an upland tropical plateau in north-eastern Australia at elevations between 600 and 900 m. A high proportion of it was covered by tropical rainforest growing on basalt, much of which has been cleared for agriculture leaving a landscape of fragmented patches and narrow linear strips of rainforest. It is bordered by ranges to the east and west which still retain their original rainforest, albeit much of it selectively logged. Logging ceased in the continuous forests when the area was declared the Wet Tropics of Queensland World Heritage Site in 1988. The upland rainforests of the Wet Tropics bioregion contain a high proportion of endemic species with the highest concentration within the Atherton Uplands sub-region (Williams 2006).

Efforts to retain and restore biodiversity within the fragmented landscape of the Atherton Tableland have primarily focused on tree plantings, actively encouraged since the late 1980s (Catterall *et*. *al*. 2008). Funding for tree planting schemes has come from government and private sources, but there has been no formal requirement to assess whether these schemes contribute to the biodiversity of the region (Kanowski *et*. *al*. 2008). In order to keep attracting funding there is a need to demonstrate that the native fauna of the rainforest, particularly species endemic to the Wet Tropics bioregion, is colonising the replantings.

Conservation Volunteers Australia (CVA) as part of their "Building Resilient Environments" campaign, wished to assess the effects of its revegetation projects which aim to connect many remnant tropical rainforest plots with replanted corridors. Although six studies have assessed the use of replantings by birds and small ground dwelling mammals (Tucker 2001, 2008; Jensen 2005; Freeman *et al.* 2009; Nomura *et al.* 2009; Tucker & Simmonds 2009), none have assessed their use by arboreal mammals.

Our study aimed to examine the use of rainforest replantings by arboreal marsupials capable of being detected by spotlighting. They included three specialist rainforest ringtail possums endemic to the Wet Tropics – Green Ringtail Possum (*Pseudochirops archeri*), Herbert River Ringtail Possum (*Pseudochirulus herbertensis*), and Lemuroid Ringtail Possum (*Hemibelideus lemuroides*), the Coppery Brushtail Possum (*Trichosurus vulpecula johnstonii*), an endemic subspecies, and the endemic Lumholtz's Tree-Kangaroo (*Dendrolagus lumholtzi*) (Van Dyck & Strahan 2008).

Methods

Five replanted rainforest sites were selected in the southern Atherton Tablelands and paired with nearby patches of remnant forest (Table 1, Fig. 1) within known ranges of Wet Tropics' arboreal marsupials (Williams 2006; Van Dyck & Strahan 2008).

Spotlighting within rainforest as opposed to along an edge is considered ineffectual, whereas along the edge (including wider tracks through it) can work well (Russell 1980). To further appraise this, a pilot spotlighting study was undertaken between April and July of 2010, during which 21 transects were conducted, six edge and five interior at Malanda Falls Conservation Park and five edge and five interior at Winfield Park. All arboreal mammals recorded, 13 Coppery Brushtails and one Lumholtz's Tree-kangaroo, were along the edge transects (Grant 2010). Consequently, we restricted sampling in our study to edge transects. Five surveys of each of the ten sites were then conducted on 17 nights between 2 and 22 November, 2010 between 7:45 and 11:00pm. A survey involved spotlighting the forest canopy for mammal eye-shine by SZ and MM using 30 watt spotlights with red filter along 300 m edge transects of each site from 5-10 m outside the forest edge to give a good visual angle of the forest canopy. Where a continuous 300 m edge survey was not possible, multiple sections adding up to 300 m were surveyed. Where interior footpaths at Fig Tree Close and Seamark Rd sites were used, only one side of the forest edge was surveyed. Sites were entered from outside of the transect boundaries to avoid any pre-disturbances to the target species.

Sites were visited at least once at the beginning, middle, and end of the evening survey period. No site was surveyed twice on the same night, and paired remnant/replanted forest sites were surveyed as close together in time as possible under similar environmental conditions. Survey times ranged between 20 and 40 minutes, depending on the number of sightings, difficulty of terrain, spatial layout of transect, and visibility limitations due to weather and foliage density. Only sightings within 5 m of the forest edge, defined as an average end of the outermost tree foliage, were used for the census. All other wildlife sightings outside of the site or sample time were recorded as opportunistic data. Weather observations were recorded prior to each transect start, using a Pocket Weather Tracker to determine temperature, humidity, and wind-speed. Surveys could not be performed on nights with very heavy rainfall, as spotlighting became extremely difficult with limited visibility.

Mammals were initially spotted by eye-shine and identified using binoculars. Lumholtz's Tree-kangaroos were also recorded from their distinct escape sounds – rustling in tree, loud thud as they jumped to ground, then heavy thumping, heavier than that made by pademelons, as they bounded away.

Table 1. Study site pairs.
Regional Ecosystems (RE) – 7.8.2a = Upland complex mesophyll vine forest on basalt in very wet rainfall zone; 7.8.4a = Highland complex notophyll vine forest on basalt in the cloudy wet zone; 7.12.16a = Upland simple notophyll vine forest on granite or rhyolite in the cloudy wet zone (Sattler and Williams 1999).

Pair	Remnant Forest	Replanted Forest	Connection to remnant forest
A	Malanda Falls Env. Park (17°21'13" S, 145°35'11" E) Elevation: 738-772 m Type: RE 7.8.2a	Malanda Falls Env. Park (17°21'17" S, 145°35'04" E) Elevation: 727-747 m Planted 1994, Age: 16 yrs	Abutting
B	Malanda State High School (17°21'27" S, 145°35'30" E) Elevation: 765-768 m Type: RE 7.8.2a	Williams'/Upper Barron Rd. (17°22'38" S, 145°33'03" E) Elevation: 772-775 m Planted 1996, age: > 14 yrs	Isolated in narrow riparian strip
C	Fig Tree Close/Freeman's (17°20'26" S, 145°37'32" E) Elevation: 730-741 m Type: RE 7.8.2a	Winfield Park (17°20'21" S, 145°37'29" E) Elevation: 714-722 m Planted 1992, age: 18 yrs	Across river with 6-10 m canopy gap
D	Kenny Rd./Swann's (17°28"06' S, 145°32'10" E) Elevation: 874-896 m Type: RE 7.12.16a	Kenny Rd./Swann's (17°28'01" S, 145°32'07" E) Elevation: 847-897 m Planted 1997,age: 13 yrs	Between substantial remnant forest areas
E	Seamark Rd./Hudson's (17°26'22" S, 145°32'01" E) Elevation: 900-920 m Type: RE 7.8.4a	Seamark Rd./Hudson's (17°28'02" S, 145°31'59" E) Elevation: 869-874 m Planted 2006-7, age: 3-4 yrs	Between extensive remnant forest 160 m apart

Results

A total of 60 target marsupials sightings were made during sampling, 23 in remnant rainforests and 37 in replanted sites (Table 2). In addition 67 opportunistic sightings of target species were made, 34 in remnant rainforest sites and 33 in replanted sites (Table 2). Although statistical power was too low, due to few sites and observations, to assess differences between experimental (replanted) and control (remnant) sites Coppery Brushtails appeared to show a preference for replanted sites over remnant sites.

Other mammals observed in and around replanted sites included a Striped Possum (*Dactylopsila trivirgata)* at Kenny Rd, four Long-nosed Bandicoots (*Perameles nasuta*) – one at each of Williams' and Kenny Rd and two at Seamark Rd, two Red-legged Pademelons (*Thylogale stigmatica*) – one each at Seamark Rd and, Malanda Falls, and a Giant White-tailed Rat (*Uromys caudimaculatus*) at Winfield Park.

Discussion

The southern section of the Atherton Tablelands within which this study took place was originally rainforest, much of it on high fertility basalt soils, 96% of which of which along with the adjacent Evelyn Tableland was cleared for agricultural purposes by the 1980s (Winter *et al.* 1987). Since the early 1980s forest rehabilitation commenced, notably by the community group Trees for the Evelyn and Atherton Tablelands (TREAT) in association with Queensland Parks and Wildlife Service to encourage landholders to plant native trees (www.treat.net.au). It has also become an important area in the study of restoration ecology (e.g. Catterall *et al.* 2008). From a wildlife perspective an aim of the replantings is to enhance isolated remnant patches, the larger of which

Figure 1. Sampling sites.
Site pairs - A Malanda Falls; B Malanda High School & Williams'; C Fig Tree Close & Winfield Park; D Kenny Road; E Seamark Road. Remnant = circle, replanted = diamond. Imagery from Google Earth Pro.

Table 2. Sightings of species at sites, surveyed and opportunistic.
CB = Coppery Brushtail Possum; GR = Green Ringtail Possum; HRR = Herbert River Ringtail Possum; LR = Lemuroid Ringtail Possum; TK = Lumholtz's Tree-Kangaroo.

Remnant forest	CB	GR	HRR	LR	TK	Replanted forest	CB	GR	HRR	LR	TK	Total
Sampled												
Malanda Falls	3	0	0	0	1	Malanda Falls	4	2	0	0	0	10
Malanda School	0	0	0	0	0	Williams	8	0	0	0	0	8
Fig Tree Close	3	0	0	0	0	Winfield Park	10	0	0	0	1	14
Kenny Rd	3	0	0	1	1	Kenny Rd	8	0	0	0	0	13
Seamark Rd	6	1	0	2	2	Seamark Rd	0	3	0	0	1	15
Total	15	1	0	3	4		30	5	0	0	2	60
Opportunistic												
Malanda Falls	5	0	0	0	0	Malanda Falls	2	0	0	0	0	7
Malanda School	1	0	0	0	0	Williams	13	1	0	0	1	16
Fig Tree Close	6	0	0	0	0	Winfield Park	1	0	0	0	0	7
Kenny Rd	4	1	5	4	2	Kenny Rd	3	1	2	0	0	24
Seamark Rd	0	4	0	0	2	Seamark Rd	1	1	2	3	2	15
Total	16	5	5	4	4		20	3	4	3	3	67
Grand total	31	6	5	7	8		50	8	4	3	5	127

support populations of endemic species, and provide connecting corridors. For example, extensive areas of prime habitat of Lumholtz's Tree-kangaroo is restricted to the Herberton Range to the west of the Tablelands, but large remnants in the Yungaburra area and at the head of the North Johnstone and Barron Rivers play an important role in maintaining populations in the surrounding modified landscape of the Tablelands (Kanowski *et al.* 2003). Maintaining and improving both remnant patches and establishing connectivity between them will help maintain the genetic diversity of this tree-kangaroo (Bowyer *et al.* 2002) and enable tree-kangaroos to recolonise the fragmented landscape following droughts, cyclones or other catastrophes (Kanowski *et al.* 2003).

The five target arboreal marsupials of our pilot study are known to exhibit a differential response to altitude, rainfall gradients, geology and fragmentation of their habitat, which affects the expected results at the sites sampled. The Lemuroid Ringtail is the most sensitive to patch size and width resulting in local extinctions (Pahl *et al*. 1988; Laurance 1990; Laurance & Laurance 1996, 1999; Laurance & Goosem 2008). It is not known from narrow riparian strips of forest and is considered to require corridors of primary forest at least 200 m in width (Laurance & Laurance 1999), and is the most restricted to higher altitudes (Winter 1984; Kanowski *et al*. 2001). The Herbert River Ringtail is also not expected to occur in drier sites and those below 800 m elevation (Winter 1984; Kanowski *et al*. 2001). The Coppery Brushtail and Green Ringtail are the least affected by rainfall and altitude and would be expected to occur at all sites sampled (Winter 1984). Likewise, Lumholtz's Tree-kangaroo is know to occur throughout the area sampled (Newell 1999; Kanowski *et al.* 2003)

Of the three species known to occur throughout the sampling area the Coppery Brushtail was the most commonly seen in both remnant and replanted sites (Table 2). It is the species least affected by fragmentation and least specialised in its diet (Pahl *et al.* 1988; Laurance 1990). It occurs in a wide range of habitat on the Atherton Tablelands – rainforest, eucalypt woodland, grassland and suburban and is the possum most frequently recorded as a road-kill (Winter database). Observations of adults with young at Williams' site, in a six kilometre riparian strip, less than 100 m wide and consisting mostly of replanting and 1.8 km across open paddock to the nearest patch of remnant forest 30 hectares in size (Fig. 1B), strongly suggests that breeding individuals are inhabiting replanted sites and not just visiting to feed.

Green Ringtails occurred in both types of site at all altitudes. The species is able to cope with fragmentation, as it sleeps on exposed tree branches rather than in tree hollows (Pahl *et al.* 1988; Laurance 1990; Van Dyck & Strahan 2008) and are capable of crossing open ground – two records of individuals seen at night crossing roads between a forest fragment and open grassy paddocks (A Freeman pers. obs. 2/3/2009). Their presence at Williams' site and casual observations at sites not included in the study again strongly suggest they also reside in replanted forest.

Tree-kangaroos were seen in both types of forest at all altitudes (Table 2). They are capable of crossing open ground between forest patches - one was watched crossing open grassy paddocks at Glendenning Rd during the day at least 1.5 km from the nearest large patch of rainforest (Winter pers. obs. 3/12/1990). However, they have relatively sedentary habits (Newell 1999) and are likely to reside in a replanting providing it contains trees large enough for day time roosting - >c.5m in height, a size reached within about 5 years – for example at Williams' site.

The two species restricted to altitudes above 800m were seen only at the two higher altitude sites – Kenny Rd and Seamark Rd. Herbert River Ringtails were not observed during sampling periods in either type of forest, but were seen opportunistically in both types (Table 2). Unlike the Green Ringtail they require den hollows or large epiphytic ferns as day-time shelters. They also have a more restricted altitudinal range and moisture gradient than the Green Ringtails (Winter 1984).

Lemuroid Ringtails were observed only in remnant forest at the two higher altitude sites, Kenny Rd and Seamark Rd, during sampling periods. Observations in replanted sites were restricted to opportunistic sightings on two nights at Seamark Rd. The replanting here were part of a 120 m wide regenerating habitat between extensive areas of remnant forest 160 m apart (Fig, 1E).

Reforestation research reports state that it takes at least 10 years before a planting can be structurally

comparable to rainforest sites (Catterall *et*. *al*. 2008; Nomura *et al.* 2009). However, substantial elements of rainforest vertebrate fauna can colonise replantings at an earlier stage. Bird studies in two narrow replanted corridors, containing patches of remnant forest, found that a suite of generalised rainforest birds were using three-year-old replanting, but lacked specialised rainforest species with low mobility (Jensen 2005) and that 4-7 year-old-plantings were more similar to remnant patches in birds species than younger plantings (Freeman *et al.* 2009). Likewise, a suite of small mammal rainforest species in seven-year replantings was similar to that in remanant reference sites (Nomura *et al.* 2009).

In this study all five target species were recorded in the youngest replanting, 3-4 year-old at Seamark Rd. However, no point in the replanting was more than 80 m from extensive remnant forest, within the distance an individual could access the replanting nightly. Replanting at other sites were 13-18 years old and two of these – Williams' and Winfield Park - were sufficiently isolated from remnant forest to suggest that the Coppery Brushtail, Green Ringtail and Lumholtz's Tree-kangaroo could be resident within the remnant forest.

In conclusion, this preliminary study has shown that the suite of rainforest arboreal mammals sampled will enter rainforest replantings and that three of them - Coppery Brushtail, Green Ringtail and Lumholtz's Tree-kangaroo – may be capable of residing in 13-18 year-old replantings. Undoubtedly colonisation of replantings by arboreal mammals occurs more readily if adjacent to areas of extensive remnant forest, for example at Seamark Rd site, or in corridors containing patches of remnant forest. Further studies are required to determine the ability of these arboreal species to colonise strictly isolated replantings and the ability of the species to cross unforested ground.

As noted in Catterall *et. al.* (2008), the field of restoration ecology has yet to reach a stage where it can provide clear predictions of the consequences of reforestation projects and their impact on biodiversity levels. Because many tropical rainforest endemics have sensitive habitat-requirements and currently exist in limited fragmented ranges (Catterall *et*. *al*. 2008), they are especially susceptible to the negative effects of imminent global climate change. However, this pilot study demonstrates that four of five arboreal marsupials endemic to the Atherton Tablelands are indeed using revegetation plots in the area. This indicates that reforestation is a helpful strategy for the conservation of rainforest arboreal marsupials in a fragmented landscape.

Acknowledgements

This project was a small part of a larger study on biodiversity within rainforest revegetation headed by Associate Professor Carla Catterall, Centre for Innovative Conservation Strategies, Griffith University. We would like to thank both Carla Catterall and John Kanowski, also of the centre, for their major input into the design of this study and Don Franklin for statistical advice. Others we wish to thank include David Hudson and Alice Crabtree of Conservation Volunteers Australia-Cairns for organizing project logistics, travel, and accommodation; Tony Cummings, SIT-Cairns academic director, for transportation, research instruments, and supplies; Mike Stott and Sarah Offner, Wet Tropics Management Authority, GIS technical officers, for their mapping expertise; Chris and Sue Oakley, Malanda Falls Caravan Park, for their hospitality; Kylie Freebody, Tablelands Regional Council, for providing dates of tree plantings; and to all of the study site landholders: Amanda and Alistair Freeman, Dave and Robyn Hudson; Principle Elizabeth Schwink at Malanda State High School, Roy Swann and Marilyn Stirk, and Geordie and Fay Williams.

References

Bowyer JC, Newell GR, Eldridge MDB. 2002. Genetic effects of habitat contraction on Lumholtz's tree-kangaroo (*Dendrolagus lumholtzi*) in the Australian Wet Tropics. *Conservation Genetics* 3: 59-67.

Catterall CP, Kanowski J, Wardell-Johnson GW. 2008. Biodiversity and new forests: Interacting processes, prospects and pitfalls of rainforest restoration. In *Living in a Dynamic Tropical Forest Landscape*, eds NE Stork, S M Turton, pp. 510-525. Blackwell Publishing Ltd: Victoria.

Freeman AND, Freeman AB, Burchill S. 2009. Bird use of revegetated sites along a creek connecting rainforest remnants. *Emu* 109: 331-338.

Grant JD. 2010. Preliminary investigation of arboreal marsupial use of reforested plots on the Atherton Tablelands (pp. 1-4). A report for Conservation Volunteers Australia, Cairns office.

Jensen A. 2005. Avian use of restoration plantings along a creek linking rainforest patches on the Atherton Tablelands, North Queensland. *Restoration Ecology* 13: 275-283.

Kanowski J, Catterall CP, Harrison DA. 2008. Monitoring the outcomes of reforestation for biodiversity conservation. In *Living in a Dynamic Tropical Forest Landscape*, eds NE Stork, SM Turton, pp. 527-536. Blackwell Publishing Ltd: Victoria.

Kanowski J, Winter JW, Simmons T, Tucker NIJ. 2003. Conservation strategy for Lumholtz's tree-kangaroo on the Atherton Tablelands. *Ecological Management and Restoration* 4: 220-221.

Kanowski J, Hopkins MS, March H, Winter JW. 2001. Ecological correlates of folivore abundance in north Queensland rainforests. *Wildlife Research* 28: 1-8.

Laurance WF. 1990. Comparative responses of five arboreal marsupials to tropical forest fragmentation. *Journal of Mammalogy* 71: 641-653.

Laurance WF, Goosem M. 2008. Impacts of habitat fragmentation and linear clearings on Australian rainforest biota. In *Living in a Dynamic Tropical Forest Landscape*, eds NE Stork, SM Turton, pp. 295-306. Blackwell Publishing Ltd: Victoria.

Laurance WF, Laurance SGW. 1996. Responses of five arboreal marsupials to recent selective logging in tropical Australia. *Biotropica* 28: 310-322.

Laurance SG, Laurance WF. 1999. Tropical wildlife corridors: use of linear rainforest remnants by arboreal mammals. *Biological Conservation* 91: 231-239.

Newell GR. 1999. Home range and habitat use by Lumholtz's tree-kangaroo (*Dendrolagus lumholtzi*) within a rainforest fragment in north Queensland. *Wildlife Research* 26: 129-145.

Nomura H, Kobori H, Winter JW. 2009. Evaluation of conservation corridors created in the Wet Tropics World Heritage Area by assessing small mammal assemblages in North Queensland, Australia. *Journal of Environmental Information Science* 37: 21-30.

Pahl LI, Winter JW, Heinsohn G. 1988. Variation in responses of arboreal marsupials to fragmentation of tropical rainforest in north eastern Australia. *Biological Conservation* 46: 71-82.

Russell R. 1980. *Spotlight on Possums*. Queensland University Press: Brisbane.

Sattler P, Williams R. (eds) 1999. *The Conservation Status of Queensland's Bioregional Ecosystems*. Environmental Protection Agency: Brisbane.

Tucker NIJ. 2001. Wildlife colonization on restored tropical lands: What can it do, how con we hasten it and what can we expect? In *Forest Restoration for Wildlife Conservation*, eds S Elliott, J Kerby, D Blakesley, K Hardwicke, K Woods, V Anusarnsunthorn, pp. 279-295. International Tropical Timber Organisation and the Forest Restoration Research Unit, Chiang Mai University: Thailand.

Tucker N. 2008. Restoration in North Queensland: Recent advances in the science and practice of tropical rainforest restoration. In *Living in a Dynamic Tropical Forest Landscape*, eds NE Stork, SM Turton, pp. 485-493. Blackwell Publishing Ltd: Victoria.

Tucker NIJ, Simmonds T. 2009. Restoring a rainforest habitat linkage in north Queensland: Donaghy's Corridor. *Ecological Management & Restoration* 10: 98-112.

Van Dyck S, Strahan R. 2008. *Mammals of Australia*. Reed New Holland: Sydney.

Williams SE. 2006. *Vertebrates of the Wet Tropics Rainforests of Australia: Species Distributions and Biodiversity*. Cooperative Research Centre for Tropical Rainforest Ecology and Management: Cairns.

Winter JW. 1984. Conservation studies of tropical rainforest possums. In *Possums and Gliders*, eds AP Smith, ID Hume, pp. 469-481. Australian Mammal Society: Sydney.

Winter JW, Bell FC, Pahl LI, Atherton RG. 1987. Rainforest clearfelling in northeastern Australia. *Proceedings of the Royal Society of Queensland* 98: 41-57.