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Avifaunal Community Composition in a Tropical Forest Corridor: A Case Study from the Atherton Tableland, North Queensland

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Avifaunal Community Composition in a Tropical Forest Corridor: A Case Study from the Atherton Tableland, North Queensland

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Abstract

Bird communities in tropical forest ecosystems are highly threatened by habitat loss and fragmentation. Replanted corridors connecting isolated forest remnants are a popular method of ameliorating certain negative impacts of habitat fragmentation. Such linkages can theoretically facilitate greater dispersal, increase gene flow, and reduce the risk of local extinctions in forest birds. However, relatively few studies have examined the utilization of reforested corridors by birds, and little hard data exists to support claims that this type of resource and time intensive project is the best use of often scarce funding for conservation.

This study examined the avifaunal community present in the Lakes Corridor, located on the Atherton Tableland in northeast Queensland, Australia. Point counts were conducted at multiple sites during April 2016 to determine the range and abundance of species utilizing this 18 year old corridor. Reference sites in the two large forest fragments which it connects were also surveyed in order to provide a comparison between community composition in regrowth and remnants. Results were compared with data from two past studies of a similar nature at the same location, thereby showing change over time associated with the maturation of corridor vegetation.

The Lakes Corridor was found to support similar species richness and a greater abundance of individuals than remnant forest. However, community composition varied between the two habitats, driven primarily by differences in the abundance of certain foraging guilds and the absence of many endemic species in the corridor. Although the corridor shows promise for increasing connectivity for many rainforest birds, questions remain about its effectiveness for certain species of particular conservation concern.

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1.0 Introduction

1.1 Habitat fragmentation

Habitat fragmentation, the process by which patches of native vegetation are isolated through changes in surrounding land cover associated with human activity, is among the leading threats to biodiversity in tropical ecosystems (Tucker 2000, Whitmore 1997). Although fragmentation impacts virtually all taxa in one way or another, particular attention has been paid to population dynamics of vertebrate animals. Numerous studies in wet tropical forests have shown that many bird species experience increased mortality, significant population declines, and even local extinction in habitat remnants isolated by fragmentation (e.g. Ferraz et al. 2007, Korfanta et al. 2012, Watson et al. 2004). Because wet tropical forests around the world are known for their extraordinarily high levels of endemism and diversity of birds, along with many other taxa of animals and plants, the loss of species in these regions is particularly concerning. Tropical rainforests are additionally characterized by unparalleled structural complexity and high rates of mutualism and symbiosis between plants and their pollinators (Laurance and Bierregaard 1997), meaning that the local extinction of a single species or a slight change in community composition can have far-reaching effects throughout the entire ecosystem. For these reasons, habitat fragmentation is of special concern in the tropics.

The processes through which habitat fragmentation can threaten bird communities are numerous, diverse, and may vary substantially from site to site (Crome 1997). At the species level, isolation of populations within small fragments can result in inbreeding depression, which reduces viability and may increase the likelihood of local extinction (Mills and Smouse 1994). Furthermore, isolation in habitat fragments can hinder the ability of many forest bird species to undertake a variety of important movements, from traveling to find mates (Norris and Stutchbury 2001) to locating temporally-shifting fruit resources (Vergara and Armesto 2009). At the landscape level, physical processes collectively known as ‘edge effects’ have a broad range of impacts on the structure of vegetation and the composition of bird communities (Collinge 1996, Laurance et al. 2007, Dale et al. 2000). Taken together, an exhaustive collection of studies and research indicates that habitat fragmentation is detrimental to the survival of natural avifaunal communities in tropical rainforest.

1.2 Habitat corridors

The development of habitat corridors is one of the most popular and widely implemented strategies for improving connectivity in fragmented landscapes. Hilty et al. (2006) define a corridor as “any space identifiable by species using it that facilitates the movement of animals or plants over time between two or more patches of otherwise disjunct habitat” (p. 90). It is important to recognize that habitat corridors address only some of the challenges faced by birds in fragmented tropical ecosystems; while improving connectivity can facilitate increased movement between isolated forest remnants, edge effects remain a serious concern.

Because deforestation is the leading global cause of fragmentation in wet tropical forests (Haddad et al. 2015, Pereira et al. 2010), corridor creation in these landscapes relies on the protection or reestablishment of native forest vegetation. In cases where forest cover has already been lost and restoration is required, several techniques may be utilized. These include permitting vegetation regrowth through natural regeneration or planting seedlings of target species (Lamb et al. 1997). Each of these methods have both advantages and disadvantages. Natural regeneration is relatively inexpensive and can therefore be implemented over large areas, but numerous obstacles such as competition from exotic vegetation and lack of native propagules in the soil seedbank often result in delayed or incomplete forest recovery (Erskine 2002). Planting seedlings of target rainforest tree species, although expensive and requiring a major time commitment in the form of ongoing management, generally results in more rapid development of closed canopy forest of desirable structural and species composition (Kanowski et al. 2003). Therefore, when revegetating corridors which are relatively small in area and are designed to facilitate movement of forest interior bird species, the latter approach is favored.

Due to the relatively slow growth of plantings into mature trees and the long-term successional trajectory of primary tropical rainforest, research on the ultimate success of habitat corridors has been limited. Nonetheless, several preliminary studies indicate that forest bird species respond positively to increased connectivity. In a highly fragmented tropical forest landscape in Costa Rica, tracking research has revealed that a forest specialist bird species preferentially travels through riparian forest corridors to move between patches of remnant forest (Gillies and St. Clair 2008). Data on understory birds present in habitat fragments in Amazonian rainforest demonstrate that corridor connectivity is important in maintaining community composition, particularly among insectivorous species (Martensen 2008). Additionally, an exhaustive review on the utility of corridors concluded that a majority of studies support the assertion that habitat corridors improve connectivity and benefit faunal communities, including those of tropical birds, while cautioning that "generalizations about the biological value of corridors will remain elusive because of the species-specific nature of the problem" (Beier and Noss 1998, p. 1249).

Opposite these studies supporting the effectiveness of habitat corridors for conserving tropical forest avifauna, other research highlights troubling obstacles to their success. Of particular relevance to revegetated forest corridors, one review found that among multiple studies in a variety of tropical forests, full recovery of bird communities had not occurred even in sites that had been revegetated for over twenty years (Dunn 2004). Although habitat and trophic generalist bird species respond quickly and often occupy revegetated sites within several years, primary forest specialists and local endemics are unlikely to utilize replantings for a much longer period of time (Catterall et al. 2012). These species may never be able to move through a corridor if it is too narrow and subject to edge effects across its entire width (Hilty et al. 2006). Finally, corridors that draw birds into suboptimal habitats in which they come into detrimental contact with humans are likely to be counterproductive (Simberloff and Cox 1987, Tucker 2000). Given these challenges, ongoing, long-term monitoring of individual corridor projects is clearly needed to assess their benefits.

1.3 The Atherton Tableland

Situated in the Wet Tropics Bioregion of Northeast Queensland, Australia, the Atherton Tableland is an ideal landscape in which to conduct this type of long-term monitoring. Located at 17°S and separated from the coast by the Bellenden Ker Range, the Tableland ranges from 600-900m elevation and consists of basaltic and metamorphic soils (Warburton 1997). While the region once supported continuous rainforest, forest clearing, primarily for agricultural purposes, has resulted in a modern landscape consisting of isolated fragments of primary forest surrounded by pasture land (Grimbacher et al. 2008).

In the past two decades, local interest in restoration of native ecosystems has been on the rise, and several community-based reforestation programs have been established (Lamb et al. 1997). Scientific monitoring of the development of floral and faunal communities in replanted sites (e.g. Jansen 2005, Tucker and Simmons 2009) provides valuable baseline data for assessing the effectiveness of these corridors. Additionally, research on the vegetation structure and community composition of secondary forest habitats on the Tableland indicates likely trajectories of replanted rainforest corridors (Freeman 2015, Catterall et al. 2012). The wealth of local scientific knowledge about secondary forest habitats and replanted corridors on the Atherton Tableland make it an excellent region for ongoing research on forest bird communities in a fragmented landscape. The aim of this study is to build on data collected over the past eighteen years in one reforested corridor, in order to assess the change in avifaunal community composition over time and to determine whether rainforest specialist bird species are able to utilize this habitat to move between isolated forest remnants.

2.0 Methods

2.1 Study Site

Located at the northeast corner of the Atherton Tableland, Crater Lakes National Park consists of two units, one encompassing Lake Eacham and the other Lake Barrine (see Figure 1). The two lakes, separated by several kilometers, are each surrounded by a large remnant (>500ha) of type 1B complex mesophyll vine forest (Breeden 1999). The area is underlain by rich volcanic soils and receives an annual average rainfall of 1444mm (Malcolm et al. 1999). Beginning in 1998, community volunteers working under the guidance of the North Johnstone and Lake Eacham Landcare Association planted 14,000 tree saplings over two years, thereby establishing the 1.5km-long Lakes Corridor connecting Lake Barrine and Lake Eacham (Stewart 2008). The replanting was strategically planned to incorporate several small remnant patches of vegetation, including a badly eroded gully of mature acacia regrowth and a strip of surviving riparian vegetation along Maroobi Creek (Austin 1998). In the eighteen years since its initial planting, two research projects have examined the bird species present in the Lakes Corridor, providing valuable baseline data for ongoing, long-term monitoring (Austin 1998, Stewart 2008).

In order to assess changes over time in the avifaunal community of the corridor, five study sites were selected along its length (see Figures 2 and 3). Sites C1 and C2 are located in replanted stands near the south end of the corridor, where active management has resulted in an overstory dominated by rainforest tree species and little to no growth of grass and weeds in the understory. Sites C3 and C4 fall within the acacia regrowth gully in the center of the corridor. The habitat here is characterized by a taller canopy of very large, old growth acacias, with younger acacias and rainforest saplings beginning to take over the open understory. Site C5, near the north end of the corridor, encompasses riparian vegetation on the south side of Maroobi Creek where the overstory is patchy and grass dominates beneath the canopy. Four of these sites (C1, C3, C4, and C5) correspond to sites surveyed by Austin (1998) and Stewart (2008).

Eight additional sites were established in forest remnants at either end of the Lakes Corridor in order to compare avifaunal communities in mature rainforest with those of the corridor. In the forest surrounding Lake Eacham, sites E1 and E2 are on gently sloping topography to the south and east of the lake. Site E3 is in the gully formed by Wright's Creek, where a permanent source of water results in a warm, wet microclimate. Site E4 is in the far northeast corner of the forest fragment around Lake Eacham, approximately 100m from the south end of the Lakes Corridor. At Lake Barrine, sites B1 and B2 are located on flat topography between the Gillies Highway and the northeast side of the lake. Site B3 in the bottom of a densely vegetated gully along a stream flowing out of the northeast corner of the lake, and site B4 is situated on a slope along the east side of the lake.

Figure 1. The location of Lake Barrine and Lake Eacham within the Atherton Tableland, Northeast Queensland, Australia.

Figure 2. The location of study sites within the Lakes Corridor.

Figure 3. Photos of selected survey sites showing differences in vegetation structure. Top left: overlooking Site C3 in the acacia regrowth gully note extreme soil erosion. Top right: Site C5 near Maroobi Creek at the north end of the corridor, note open canopy and grassy understory. Bottom left: rainforest replanting between Sites C1 and C2, note closed canopy and relatively open understory. Bottom right: Site E1, note closed canopy and extremely dense understory typical of mature remnant forest.

2.2 Bird Surveys

Bird communities were assessed by conducting point counts during April 2016. Each survey consisted of a 20-minute count during which every individual bird detected within 20 meters in all directions was recorded. The presence of other species detected outside of the 20m circle was recorded but their abundance was not estimated. All surveys were conducted between 6:30am and 9:30am, coinciding with the daily period of maximum bird activity. The order in which individual sites were surveyed each morning was systematically rotated, thereby controlling for bias caused by time of day. Every effort was made to avoid surveying in inclement weather which might have disrupted bird activity or detectability, although given time constraints some surveys were conducted in light drizzle or moderate breeze. Weather conditions during each survey were recorded. Sites B1-B4 and E1-E4 were each surveyed five times and sites C1-C5 were each surveyed ten times.

2.3 Analysis

In order to facilitate comparisons between remnant primary forest at Lake Eacham and Lake Barrine, and secondary regrowth within the Lakes Corridor, species richness and abundance of individuals were calculated for each survey site. Diversity of species at each site was determined using Shannon's diversity index. Differences in multivariate avifaunal community composition between each site were quantified using Sorenson's dissimilarity index (based on abundance of each species at each site). A nonmetric multidimensional scaling analysis was performed on this distance matrix, resulting in a two-dimensional ordination diagram in which distance between each site is proportional to total community difference (McCune and Grace 2002).

Bird communities were further classified and analyzed by foraging guild. All species were assigned to one of eight primary foraging groups – frugivore, frugivore/insectivore, gleaning insectivore, granivore, leaf litter insectivore, nectarivore/insectivore, omnivore, and perching insectivore – based on classifications from past studies (Stewart 2008, Quakenbush 1995) and ecological descriptions from published literature (Pizzey and Knight 2012, Simpson and Day 2010). The abundance of each foraging guild was calculated at every site and the averages of corridor and remnant sites compared. Richness and average abundance of Wet Tropics endemic bird species abundance was also calculated and compared between corridor and remnant sites.

Change over time in the avifaunal community composition at sites within the corridor was assessed through the ongoing monitoring of certain indicator species surveyed during past studies. Austin (1998) assigned seventeen bird species to one of five vagility groups (A-E) based on their presence or absence in the corridor during during its initial year of replanting (see Appendix 1). Vagility refers to a species' adaptability to new environments and its potential for mobility in disturbed habitats, and is considered an important indicator of survival in fragmented landscapes (Laurance 1990). During baseline monitoring of the bird community at the Lakes Corridor, vagility groups were determined by the number of sites within the corridor at which species were detected, with Group A occurring only in remnant forest at either end and Group E occupying all sites throughout the corridor (Austin 1998). Because survey sites for my study corresponded roughly to locations surveyed by Austin and Stewart, comparing the number of sites occupied by species of each vagility group and their relative abundance provided an accurate assessment of change over time.

3.0 Results

3.1 Species richness, abundance, and diversity

A total of 62 species were recorded during surveys, including those detected both inside and outside of count circles (see Appendix 1). 12 species were recorded in count circles in one or both remnants that were not present in the corridor, and 15 species were detected in the corridor but not in either remnant. The average species richness of corridor sites was higher than sites in remnant forest, as was the average number of individual birds detected per survey (see Table 1). Species diversity, however, averaged slightly higher in remnant sites than in corridor sites.

Survey site	Species richness	Average # individuals per survey	Shannon's diversity index
B1	36	6.6	2.6478
B2	33	5.6	2.6512
B3	28	8	2.6184
B4	33	7.6	2.5734
E1	33	8.8	2.5552
E2	41	13.2	2.8356
E3	31	12	2.5919
E4	34	13	2.8382
Remnant average	33.6	9.4 (± 2.98)	2.6610
C1	41	29.6	2.0617
C2	36	11.7	2.1241
C3	37	12.5	2.6934
C4	39	9.8	2.9522
C5	39	7.1	2.7086
Corridor average	38.4	14.1 (± 8.89)	2.5080

Table 1. Summary statistics for all survey sites. Species richness is derived from all detections both inside and outside the 20m count circle; average number of individuals (± 1SD) per survey and diversity indices are derived from in-circle data only. Remnant average refers to all sites at Lake Barrine and Lake Eacham.

3.2 NMS ordination of sites

Overall avifaunal community composition differed between sites in the corridor and remnant habitats (see Figure 4). Sites C1-C5 were more widely scattered in ordination space than sites E1-E4 or B1-B4, indicating a relatively greater diversity of community composition within the corridor than the remnants. C1 and C2 were substantially different than all other sites, but C3, C4, and C5 were fairly close in composition to sites in remnant forests. Interestingly, among sites in remnant habitat, those at Lake Eacham formed a distinct cluster separate from those at Lake Barrine.

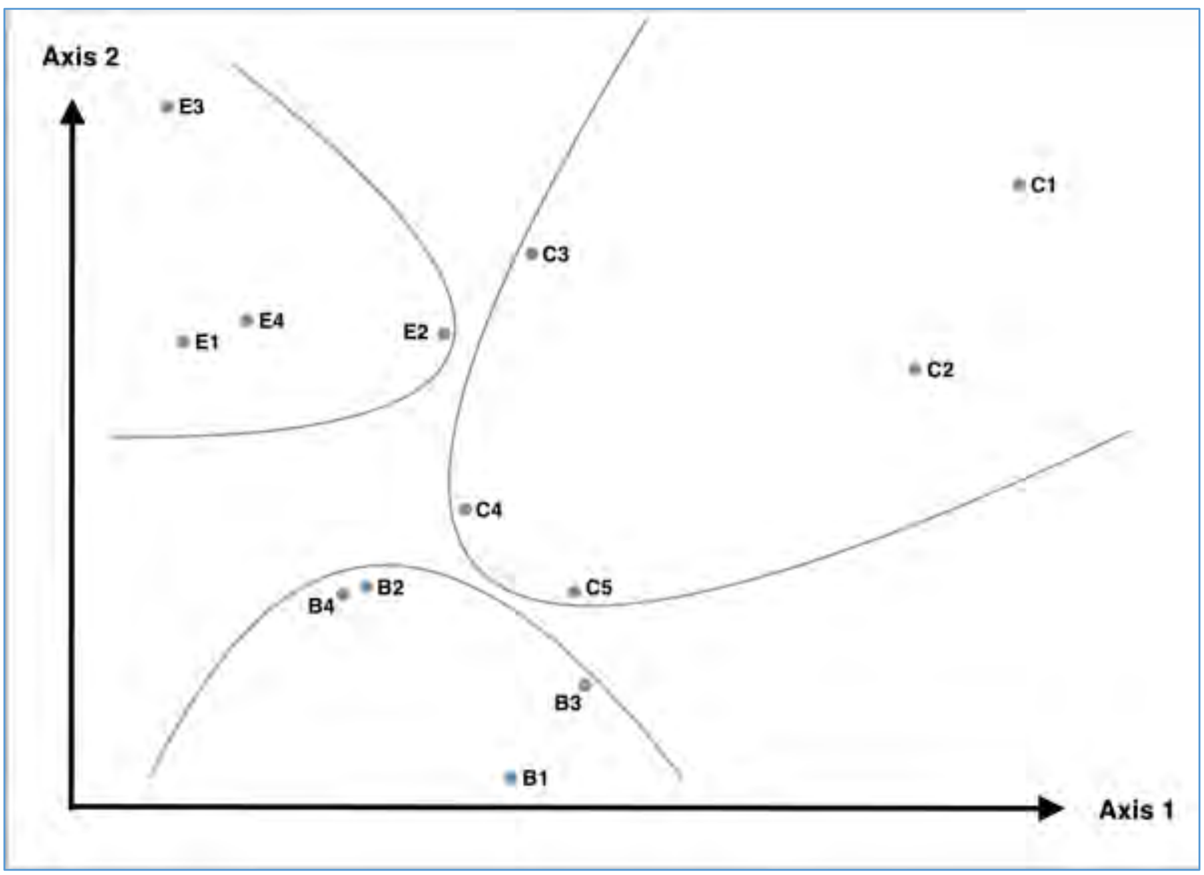

Figure 4. Nonmetric multidimensional scaling ordination diagram of bird communities at all study sites. Distances in ordination space are proportional to differences between Sorenson's Dissimilarity Index for each site. Axis 1 and Axis 2 are synthetic variables that minimize stress in multivariate similarity among thirteen sites.

3.3 Vagility groups

Species with greater vagility tended to occupy more sites within the corridor than those in lower vagility groups (see Table 2). Among Group A species (least vagile), no individuals were detected during any surveys at sites within the corridor despite their presence at low densities in remnant forest. Group B species were found at three of five corridor sites, and Group C species at four. Groups D and E occupied all five sites within the corridor. Abundance of individuals also tended to be greater among higher vagility groups, both in the remnants and the corridor.

Table 2. Occurrence and abundance of bird species according to vagility group at remnant and corridor sites. Vagility groups were adopted from Austin (1998). See Appendix 1 for species within each group.

Site	**Average # individuals per survey (± 1SD)**				
	Group A	**Group B**	**Group C**	**Group D**	**Group E**
Remnant	0.125 (±0.32)	0.15 (±0.31)	0.18 (±0.27)	0.43 (±0.53)	0.53 (±0.5)
C1	0 (±0)	0.1 (±0.2)	0 (±0)	0.1 (±0.1)	0.533 (±0.49)
C2	0 (±0)	0.025 (±0.05)	0.033 (±0.06)	0.033 (±0.06)	0.433 (±0.26)
C3	0 (±0)	0.075 (±0.15)	0.066 (±0.06)	0.033 (±0.42)	0.9 (±0.89)
C4	0 (±0)	0.025 (±0.05	0.166 (±0.21)	0.467 (±0.40)	0.58 (±0.37)
C5	0 (±0)	0 (±0)	0.166 (±0.15)	0.233 (±0.40)	0.35 (±0.25)

3.4 Foraging guilds

Differences were observed between corridor and remnant sites in the abundance of certain foraging guilds (see Figure 5). Frugivores, leaf litter insectivores, and perching insectivores in particular composed a much higher proportion of individuals detected at Lake Eacham and Lake Barrine than in the corridor. Birds belonging to the nectarivore/insectivore group, on the other hand, were more numerous in corridor sites than in remnant sites. Due to small sample sizes, Rank-Sum Tests performed comparing averages between the corridor and the remnant did not return statistically significant differences for any foraging guild.

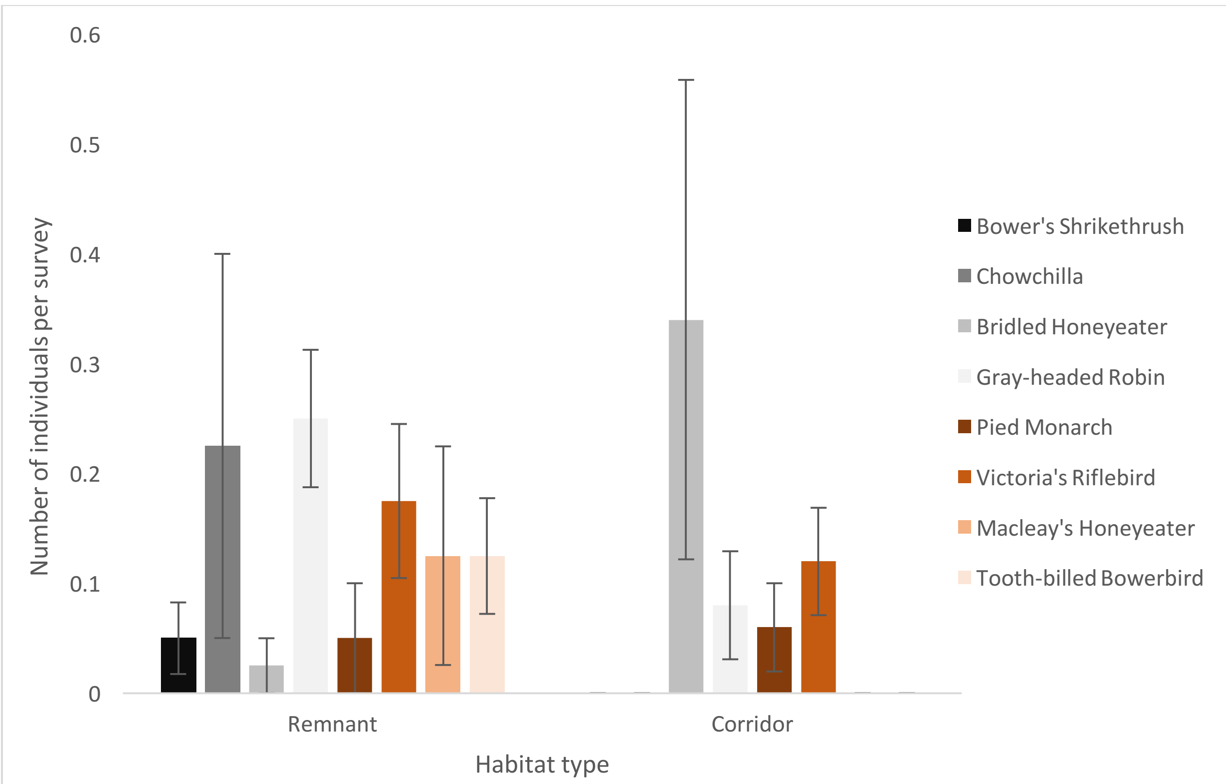

Figure 5. Abundance of Wet Tropics endemic bird species in survey sites, grouped by site type. Error bars are ± 1SD.

3.5 Endemic species

A total of eight Wet Tropics endemic bird species were detected in-circle at one or more survey sites (see Figure 6). Four species (Bridled Honeyeater, Pied Monarch, Gray-headed Robin, and Victoria's Riflebird) were detected at sites both in the corridor and in the remnants, while four additional species (Bower's Shrikethrush, Chowchilla, Macleay's Honeyeater, and Tooth-billed Bowerbird) were detected only during surveys in remnant forest. Of those endemics found in both habitats, Gray-headed Robin and Victoria's Riflebird were more abundant (although not significantly so) at Lake Eacham and Lake Barrine. Pied Monarch was marginally more abundant at corridor sites, and Bridled Honeyeater was significantly more abundant in the corridor than in remnant forest (Rank-Sum test, n_1=5, n_2=8, T=21.5).

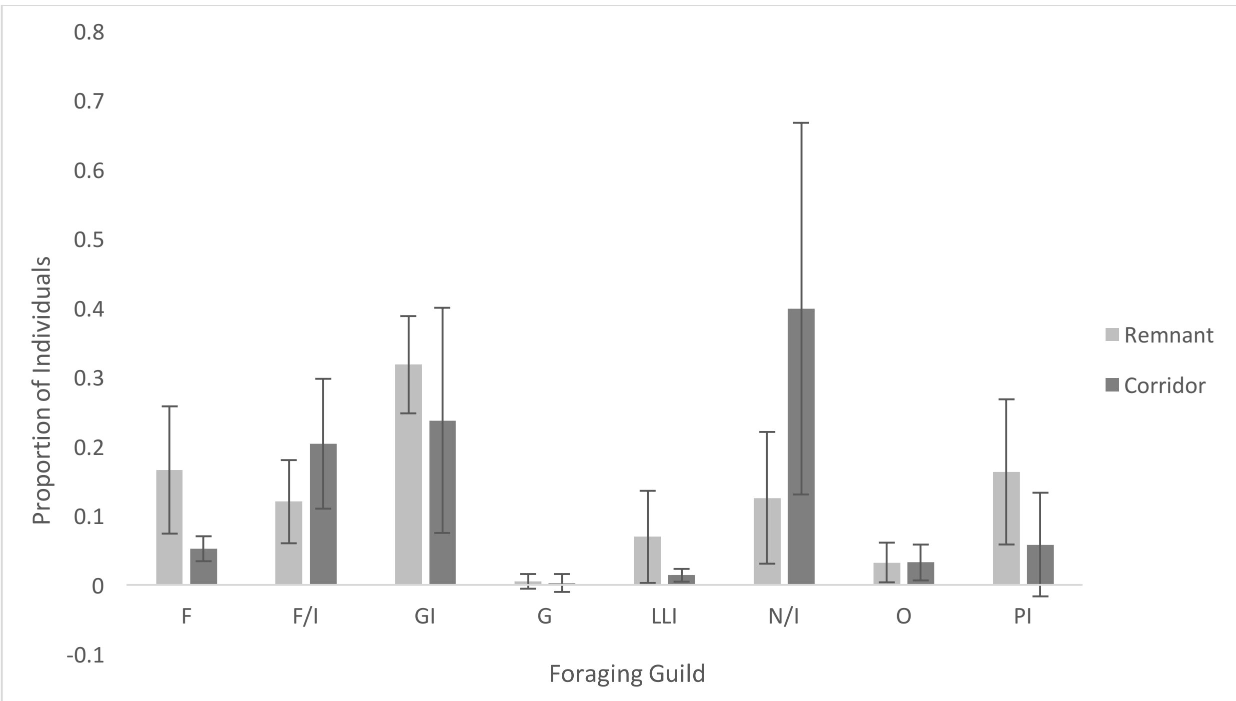

Figure 6. Proportion of birds in remnant and corridor habitats composed of each foraging guild. Error bars are ± 1SD.

4.0 Discussion

Although the Lakes Corridor is occupied by an equivalent number of bird species and a higher density of individuals than forest surrounding Lake Eacham and Lake Barrine, a multitude of metrics demonstrate that avifaunal community composition in the reforested corridor differs substantially from that in adjoining remnants. Other studies have found similar patterns when comparing remnant habitats to replanted forest (e.g. Catterall et al. 2012, Dunn 2004). Examining the ways in which avifaunal communities in the Lakes Corridor differ from those at Lake Barrine and Lake Eacham, and how they have changed over time, can yield important information on the successes and failures of this type of conservation strategy.

4.1 Foraging Guilds

When bird communities were broken down into foraging guilds, clear differences emerged between remnant forest and corridor replantings (see Figure 6). The abundance of leaf litter insectivores was much higher at sites around Lake Barrine and Lake Eacham, indicating that the corridor does not yet provide appropriate habitat for many bird species that forage for invertebrates on the forest floor. A number of factors may be partially responsible for the lack of leaf litter insectivores in the corridor. Differences in temperature, moisture and composition of soil and leaf litter have been demonstrated to penetrate at least 30 meters from the edge of tropical forest fragments (Turton and Freiburger 1997), and these microclimatic edge effects impact diversity, richness, and abundance of forest floor insects (Grimbacher et al. 2006). Because the Lakes Corridor is a relatively narrow strip of forest vegetation, such edge effects are likely to influence habitat suitability for leaf litter insectivores across much of its width, even when vegetation composition and structure resemble that of mature rainforest. Many species of leaf litter insectivores may be further limited in their use of replanted corridors due to elements of their behavioral ecology; for example, some members of this guild have small clutch sizes and are therefore slow to colonize new habitat (Frith et al. 1997). Although additional behavioral research is needed on a species-by-species basis to ascertain the factors limiting corridor use by leaf litter insectivores, my findings augment a multitude of other studies (e.g. Bierregaard Jr. and Stouffer 1997, Fagan et al. 2016, Sigel et al. 2010) indicating that this foraging guild is among the most sensitive to habitat fragmentation and the least likely to occupy secondary forest vegetation.

The reduction in frugivores in the corridor as compared to remnant forest is another noteworthy result. Frugivorous bird species are seed dispersers for a variety of plant species in tropical forests and are therefore important for the ecological functioning of these ecosystems (Sankamethawee et al. 2011, Mack and Wright 2005). Other research has indicated that members of this foraging guild will readily utilize forest corridors (Jansen 2005), so it is surprising that relatively few frugivores were detected during surveys at the Lakes Corridor (see Figure 6). This is at least partially explicable by the lack of mature, fruiting trees such as the large figs (*Ficus sp.*) that were ubiquitous in remnant forest around Lake Barrine and Lake Eacham. The low abundance of frugivores in the corridor suggests that the ‘framework strategy’ outlined by Lamb (1997), in which fruit-bearing primary successional tree species are planted in order to attract frugivorous birds and thereby accelerate colonization by a full complement of rainforest flora, may have failed in this case. Encouragingly, unlike understory insectivores, many species of frugivore are highly mobile (Moran and

Catterall 2014) that are and should therefore colonize the Lakes Corridor if an incentive is provided for them to do so (see Conclusion).

4.2 Endemic species

Habitat corridors are often designed and/or justified to conserve threatened or endemic species (Hilty et al. 2006). Because the Wet Tropics is home to a disproportionately large number of endemic species, which tend to be concentrated in the uplands and highlands (Williams et al. 2010), conservation projects in the region are often geared toward maintaining or increasing populations of these species. It is therefore concerning that only half as many endemic bird species were detected in the Lakes Corridor as in adjoining forest remnants (see Figure 5), a ratio distinctly at odds with the overall trend of slightly higher species richness at corridor sites (see Table 1). Among those species never detected in the corridor, the Chowchilla is considered very vulnerable to the anticipated effects of climate change, due to its very high exposure and sensitivity to climate change, while the Bower's Shrikethrush isn't much better off, rating highly exposed and highly vulnerable (Franklin et al. 2014). Unfortunately, the same reasons for which the Chowchilla is so vulnerable to climate change – specialized diet and foraging substrate in a single habitat type (Garnett et al. 2014) – are also likely to preclude it from using replanted forest corridors that do not fully resemble mature rainforest (see Discussion, section 4.1).

Even for those Wet Tropics endemics with more generalized diet and foraging habits, an evolutionary history of speciation in cool, moist refugia during past glacial maxima has resulted in adaptation to rainforest habitats (Williams et al. 2010). Other research has shown that regionally endemic rainforest-obligate bird species are less tolerant of regrowth vegetation and are less likely to occupy replanted sites (Catterall et al. 2012, Freeman 2015), mirroring the pattern detected in my study. There are exceptions to this rule; Bridled Honeyeaters were far more numerous in the Lakes Corridor than at Lake Eacham or Lake Barrine (see Figure 5), likely reflecting their diet generalization and perhaps their foraging on ubiquitous flowering trees present throughout the corridor. Nonetheless, many endemic birds of the Wet Tropics are expected to suffer serious population declines and even extinction as a result of projected climate change (Li et al 2009, Hilbert et al. 2004). Given the ecological and environmental constraints faced by these species, it seems unlikely that projects such as the Lakes Corridor will ultimately make much of a difference.

4.3 Change over time: corridor colonization by non-vagile species

The gradual expansion of species with low vagility, as established by Austin (1998), into additional sites within the Lakes Corridor indicates that vegetation structure continues to mature and habitat characteristics are increasingly favorable for non-mobile, rainforest adapted species (see Table 2). During baseline monitoring as the corridor was initially being planted in 1998, species belonging to Group E were detected at all sites, Group D at most but not all sites along the length of the corridor, and Group C only in sites near the ends of the corridor. Groups A and B were absent from all sites within the corridor and occurred only in remnant forest adjoining either end (Austin 1998). In a follow-up study ten years later, Stewart (2008) found that a majority of the vagility groups had expanded into regrowth vegetation within the Lakes Corridor. Several species from Group B that were absent in 1998, including Orange-footed Scrubfowl and Spotted Catbird, had colonized multiple sites. While Group C was found at only two sites, both Groups D and E were present in increased abundance throughout the length of the corridor (Stewart 2008).

My results reveal that meaningful but limited progress has been made over the past eight years. Groups D and E continue to occupy all corridor sites at similar densities to remnant forest, indicating that less vagile bird species can easily traverse the length of the corridor between Lake Barrine and Lake Eacham. Group C now occupies four out of five corridor sites, including those in the middle, which represents a substantial increase from past surveys. Group B is also present at four sites in the corridor, and the same species found to have increased by Stewart (2008) showed additional density increases and colonization of new sites. Group A, on the other hand, continues to be absent from any sites in the Lakes Corridor, indicating that it does not yet provide appropriate habitat for species with highly limited dispersal and adaptation. This result is not surprising, given that both species belonging to Group A are leaf litter insectivores (see Discussion, section 4.1).

4.4 Experimental limitations

Although this study provides valuable data on the avian community of the Lakes Corridor and its change over time, it was limited in scope and should not be viewed as comprehensive. All surveys were conducted during a four-week period after the breeding season had ended for most species; additional point counts throughout the year would likely detect more individuals vocalizing on territory. The limited sample size of my study design (five sites in the Lakes Corridor and four each at Lake Barrine and Lake Eacham), meant that although I am confident in my assessment of the birds present in this particular corridor, conclusions about avian use of revegetated tropical forest corridors in general are limited. Finally, although single-observer audio-visual surveys are a widely accepted technique for determining presence/absence and abundance of birds (Wu and Yang 2008, Volpato et al. 2009), it is likely that I overestimated the abundance of vocally conspicuous species and underestimated that of small, ground-dwelling birds. An integrated approach involving point counts, mist-netting, and remote camera traps would provide a less biased snapshot of the avifaunal community in the Lakes Corridor and at Lake Barrine and Lake Eacham.

5.0 Conclusion

The Lakes Corridor offers a unique opportunity to gather meaningful data on faunal use of a replanted tropical forest corridor. In the 18 years since its initial replanting, the avifaunal community present in the Lakes Corridor has undergone major changes. The corridor now supports similar species richness and a greater abundance of individual birds than the remnant forests at Lake Barrine and Lake Eacham which it was designed to connect. Community composition remains altered, however, and several of the species which are not yet utilizing corridor habitat are those of conservation concern, endemics, or both. Given the predicted loss of climate space for many of these species resulting from anticipated climate change, their ability to move between Lake Eacham and Lake Barrine may ultimately be irrelevant. On the other hand, reforested corridors connecting lowland habitat to and upland refugial areas may prove to be critical for the survival of some species, and information from the Lakes Corridor is likely to factor into the design and implementation of these projects. These implications make ongoing monitoring of the avifaunal community at this site, with an emphasis on endemic species, important for future conservation work. Finally, conservation projects such as the Lakes Corridor should not be judged as failures because they lack a handful of species of conservation concern. Many other rainforest birds clearly utilize this linkage, and given the threats facing a wide variety of the Wet Tropics' avifauna, increasing habitat connectivity is never a bad thing. In an era of ever-increasing stress on natural communities, the importance of keeping common species common should not be overlooked.

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7.0 Appendices

Appendix 1: All species detected during bird surveys, including those detected inside and outside count circles. Foraging guilds were adapted from Stewart (2008) and Quakenbush (1995), and supplemented with information from Pizzey and Knight (2012).

Species	Average # individuals inside circle per survey			Foraging guild	Vagility group
	Barrine	Eacham	Corridor		
Australian Brushturkey	**0.1**	**0.15**	**0.06**	O	D
Orange-footed Scrubfowl	**0**	**0.35**	**0.06**	O	B
White-headed Pigeon	**0**	**0**	**0.04**	F	-
Brown Cuckoo-Dove	**0**	**0.15**	**0.04**	F	-
Emerald Dove	**0.05**	**0.05**	**0.02**	F	-
Peaceful Dove	**0**	**0.1**	**0**	G	-
Bar-shouldered Dove	**0**	**0**	**0.04**	G	-
Wompoo Fruit-Dove	**0.15**	**0.4**	**0**	F	-
Superb Fruit-Dove	**0**	**0.15**	**0**	F	-
Fan-tailed Cuckoo	**0.05**	**0**	**0**	GI	-
Shining Bronze-Cuckoo	**0**	**0.05**	**0**	GI	-
Laughing Kookaburra	**0**	**0**	**0.08**	O	-
Rainbow Bee-eater	**0.05**	**0.05**	**0**	PI	-
Sulphur-crested Cockatoo	**0**	**0.05**	**0.16**	F	-
Australian King-Parrot	**0**	**0.7**	**0.1**	F	-
Crimson Rosella	**0**	**0**	**0.02**	F	-
Double-eyed Fig-Parrot	**0**	**0.1**	**0**	F	-
Rainbow Lorikeet	**0**	**0.1**	**3.76**	N/F	-
Scaly-breasted Lorikeet	**0**	**0**	**0.26**	N/F	-
Spotted Catbird	**0.3**	**0**	**0.12**	F	B
Tooth-billed Bowerbird	**0.15**	**0.1**	**0**	F	-
White-throated Treecreeper	**0.05**	**0.7**	**0.14**	GI	D
Eastern Spinebill	**0.05**	**0.05**	**0**	N/I	-
Lewin's Honeyeater	**0.85**	**0.65**	**0.74**	N/I	E
Bridled Honeyeater	**0**	**0.05**	**0.34**	N/I	-
Dusky Honeyeater	**0.05**	**0.1**	**0.24**	N/I	-
Scarlet Honeyeater	**0.15**	**0.05**	**0.2**	N/I	-
Macleay's Honeyeater	**0.25**	**0**	**0**	N/I	-
Helmeted Friarbird	**0**	**0**	**0.1**	N/I	C
Yellow-throated Scrubwren	**0**	**0.5**	**0.06**	LLI	A
White-browed Scrubwren	**0**	**0**	**0.16**	GI	-

Large-billed Scrubwren	**0.2**	**0.9**	**0.76**	GI	E
Fairy Gerygone	**0**	**0**	**0.24**	GI	-
Brown Gerygone	**0.7**	**1.5**	**0.96**	GI	E
Chowchilla	**0.45**	**0**	**0**	LLI	B
Eastern Whipbird	**0.2**	**0.15**	**0.14**	LLI	E
Yellow-breasted Boatbill	**0.25**	**0.15**	**0.04**	PI	-
Black Butcherbird	**0**	**0**	**0.12**	O	-
Australian Magpie	**0**	**0**	**0**	O	-
Pied Currawong	**0**	**0**	**0.1**	O	-
Barred Cuckoo-Shrike	**0**	**0**	**0.06**	F/I	-
White-bellied Cuckoo-Shrike	**0**	**0**	**0.06**	F/I	-
Varied Triller	**0**	**0**	**0.02**	GI	-
Cicadabird	**0.05**	**0**	**0.02**	GI	-
Little Shrikethrush	**0.2**	**0.15**	**0.52**	GI	E
Bower's Shrikethrush	**0**	**0.1**	**0**	GI	B
Little/Bower's Shrikethrush	**0**	**0.1**	**0**	GI	-
Golden Whistler	**0.3**	**0.5**	**0.24**	GI	E
Australasian Figbird	**0**	**0.4**	**0.12**	F	-
Spangled Drongo	**0**	**0**	**0.04**	O	-
Rufous Fantail	**0**	**0.05**	**0.06**	PI	-
Gray Fantail	**0.1**	**0.35**	**0.14**	PI	-
White-eared Monarch	**0**	**0**	**0**	GI	-
Black-faced Monarch	**0**	**0**	**0.04**	GI	-
Spectacled Monarch	**0.2**	**0.1**	**0.2**	GI	-
Pale Yellow Robin	**0.45**	**1.1**	**0.5**	PI	D
Pied Monarch	**0.1**	**0**	**0.06**	GI	-
Magpie-lark	**0**	**0**	**0**	O	C
Victoria's Riflebird	**0.35**	**0**	**0.12**	F	-
Gray-headed Robin	**0.3**	**0.2**	**0.08**	PI	C
Silver-eye	**0.45**	**0.85**	**2.48**	F/I	-
Mistletoebird	**0.4**	**0.55**	**0.28**	F/I	-