A slow unpicking of the landscape thread? Changes in tropical savanna birds on a gradient of habitat modification over 12 years of monitoring

A.S. Kutt [1,2,3]

1. School of Ecosystem and Forest Sciences, University of Melbourne, Victoria 3010, AUSTRALIA
2. School of Natural Sciences, University of Tasmania, Hobart, Tasmania 7005, AUSTRALIA
3. Research Institute for the Environment and Livelihoods, Casuarina campus, Charles Darwin University, Darwin, Northern Territory, 0810 AUSTRALIA.

Author for correspondence: alexanderkutt@gmail.com

Date: July 30, 2025

Target: EMU Austral Ornithology

Abstract (250)

In south-eastern Australia, land clearing has been extensive, resulting in an avifauna that has been significantly depleted. In northern Australia, land clearing is less but increasing. In this study, I examined the change in bird composition in a Queensland tropical savanna woodland where some land clearing has commenced. The data were collected from 60 sites sampled seven times between 2004 and 2016. I used a range of multivariate and non-parametric methods to examine the variation in species composition over the three categories of habitat modification, and years of survey. 21 899 bird records, representing 116 species were recorded. The was a significant difference in species composition across years, habitat modification and the interaction though marginal tests for environmental variables (green and non-green fractional cover, preceding 12-month rainfall, and Yellow-throated Miner *Manorina flavigula* abundance) indicated a low of explanatory power (45%). Forty-eight species were recorded in significantly different abundances across the three habitat modification categories (22 more abundant in intact vegetation, 12 in thinned, and 14 in cleared) and 53 species were recorded in significantly different abundances over the seven years of survey. Species associated with cleared sites were the Zebra Finch *Taeniopygia castanotis*, Budgerigar *Melopsittacus undulatus*, Nankeen Kestrel *Falco cenchroides*, with intact sites, Grey Shrike-thrush *Colluricincla harmonica*, Crested Bellbird *Oreoica gutturalis*, Striped Honeyeater *Plectorhyncha lanceolata* and thinned sites, Jacky Winter *Microeca fascinans* and Brown Treecreeper *Climacteris picumnus*. This study indicated that in largely intact tropical savanna landscape, small scale modifications can result in significant changes to the bird community.

Introduction

Despite being the single most significant threat to biodiversity globally (Tilman *et al.* 2017), land clearing for agriculture continues at a depressingly high rate in Australia, and especially in the state of Queensland (Reside *et al.* 2017). This clearing is predominantly broad scale and often including pasture improvement using exotic perennial grasses, targeted clearing of productive areas such as alluvial floodplains for crops, or selective the removal of a proportion of the canopy or understory (i.e., thinning) to promote grass growth (Walker and Weston 1990). The extent of clearing at both a local scale and regional can have small to significant impacts on the fauna (Tilman *et al.* 2017); and in the case of birds - a functionally diverse component of woodlands and forests - the effects can be substantial (Hannah *et al.* 2007; Martin and McIntye 2007). In southern and eastern Australia, land clearing has been extensive, and resulting in an avifauna that has been significantly depleted and therefore much less resilient to extended periods of climate extremes (Bennett *et al.* 2014). As a consequence, the subtropical and temperate woodland bird community in these areas, has been proposed for listing as a threatened ecological community under national legislation (Fraser *et al.* 2019).

The time lag to species decline and extinction after substantial landscape change, is long and can be commence many decades prior to the depletion of species becoming manifest (Liao *et al.* 2022). In Australia, the ongoing loss and fragmentation of woodlands and forests is linked to the regional loss of species (Ford *et al.* 2009) and the reconfiguration of both the bird community and vegetation has promoted a change in such as the dominance and despotism of hyper-aggressive colonising avifauna that continue to promote the reduction of functional groups such as small-bodied birds (Maron *et al.* 2013). In areas where the clearing for pastoralism is still limited, there is evidence that small scale disturbance can initiate changes in the avifauna (Kutt and Fisher 2011), that could signal the commencement of a longer term impact on birds (Hannah *et al.* 2007).

In this study, I examined the change in bird composition in a tropical savanna woodland in sites sampled over multiple years, and representing a gradient of habitat modification from clearing, thinning and intact vegetation. What is notable in this study is that the landscape is predominantly uncleared, unlike other parts of eastern Australia; however,

clearing in Queensland continues to cumulatively increase. I investigated a very simple question: what the change in the bird community (composition and species abundances) in response to both habitat modification and over the 12-year period of survey. Articulating how species and communities change in the initial phase of habitat modification is important for planning, managing, and mitigating the long-term negative effects of these changes, especially in the context of overarching climate change.

Methods

Study Area

The study area is situated in the Desert Uplands bioregion in central-north Queensland (Fig. 1). The vegetation of the region consists of predominantly *Eucalyptus, Corymbia* and *Acacia* woodlands, open grasslands and ephemeral lakes (DERM 2012). The region is within the southern more arid area of Australia's tropical savannas, with a long term (1912-2023) mean annual rainfall of 473 mm (Uanda Station, Bureau of Meteorology 2020). The dominant land use is cattle grazing, and vegetation clearing in the Desert Uplands bioregion is estimated to be 7.4%, largely within the Jericho, Bogie River Hills and Prairie – Torrens Creek sub-regions (the latter sub-region being the location of this study) (Queensland Department of Environment and Science 2022).

The study was undertaken across four properties (Kalleroo, Penrice, Timaru and Woura Park stations) located within a 50 km radius of Torrens Creek (20°48'S, 145°00'E) (Fig. 1). Sixty sites were selected for sampling reflecting three habitat modification types – predominantly cleared of native vegetation, thinned native vegetation, and intact native vegetation (hereafter cleared, thinned and intact). All sites sampled in this study were in a single broad vegetation unit (1: 1,000,000) *Eucalyptus populnea* (poplar box) and *E. melanophloia* (silver-leaved ironbark) or *E. whitei* (White's ironbark) dry woodlands to open woodlands on sandplains or depositional plains.The three habitat modification types including the thinning method is described in Tassicker *et al*. (2006). The details of the survey periods, and treatment breakdown across the properties is provided in Supplementary Material 2 and 3.

Bird surveys

The bird surveys were undertaken seven times between 2004 and 2016, with no data collected in 2007, 2009-2012 and 2015. All surveys were conducted in the dry season between May and October, the exact timing dictated by access due to prevailing weather and permission from property managers. Sixty sites were sampled in 2004 and 2005 before Kalleroo managers revoked permission to access the property; therefore 50 sites were sampled in the remaining years. One site at Kalleroo could not be accessed in 2005.

The bird surveys were undertaken within a 1 ha site (Perry *et al.* 2016). In each site, 8 x 10-minute meandering diurnal bird census were conducted over a four-day period. Two counts were undertaken at each site on each of the four days: one in the morning between dawn and the three hours after dawn and the other after this period and before dusk. All birds seen and heard within the site were recorded, though species flying over the site were not recorded unless they were interacting with the site (i.e., hunting, Perry *et al.* 2012).

As there were no consistent site-based habitat data collected at each site except for 2004 and 2005, I used seasonal fractional cover and rainfall as environmental predictors. Fractional cover is the estimated proportion of bare ground (i.e., soil), green (i.e., photosynthetic vegetation in the ground, shrub, and tree layer) and dry (i.e., non-photosynthetic vegetation, litter, logs and tree branches) cover, within each pixel. For this project, we used the twelve-month seasonal Landsat composite product, which selects representative pixels through the determination of the medoid (multi-dimensional equivalent of the median) of three months (a season) of fractional cover imagery (Joint Remote Sensing Research Program 2021). For further details on this compositing method see Flood (2013). The product was extracted via the VegMachine™ API (Beutel *et al.* 2019), which now uses an updated version of fractional cover products (Joint Remote Sensing Research Program and Department of Environment and Science 2022).

Monthly (and therefore annual) rainfall data were extracted from the Bureau of Meteorology monthly gridded rainfall dataset (http://www.bom.gov.au/climate/averages/climatology/monthly-rainfall-metadata.shtml). The grids are generated using statistical or optimal interpolation which is basically a form of least squares regression applied in two dimensions (Daley 1993).

The background error correlation and variance form the most important elements of statistical interpolation, which are determined from interstation correlations for each month, across the climatology period 1981 to 2010. For a given realisation, the observation increment is spread out according to the spatial structure of the respective background error variance for that month. This means that the level of accuracy is expected to be better in data dense areas and degrade to those defined by the background error variance in areas of data sparseness. To effectively account for low network density in parts of Australia, two passes of the statistical interpolation technique are applied (Glowacki *et al.* 2012). See Evans *et al.* (2020) for full details of the analysis approach.

I used the mean seasonal fractional cover for the 12-month period (i.e., the mean of the four three-month data periods) directly prior to each bird survey calculated for a 500 m radius surrounding each survey site. Rainfall is the total monthly rainfall for the survey site, again for the 12-month period prior to the bird survey.

Analysis

For each site and for each survey, I was able to derive total species richness and total abundance of all birds, and abundance of each species. Abundance data were calculated as the total number of birds of each species recorded during each site surveys (i.e., total of eight counts), rather than any calculation of absolute density. Previous studies have demonstrated that measures of relative abundance provide patterns of population trends proportional to those derived from estimates of absolute abundance (Hopkins and Kennedy 2004; Slade and Blair 2000). The scientific and common names, and taxonomic order for birds tabulated, follow the BirdLife Australia working list of Australian birds version 4.1 (BirdLife 2022).

I examined the pattern in the bird composition via several multivariate methods. In the first instance I constructed a site by species abundance array, forth-root transformed the data and then created a Bray-Curtis resemblance (similarity) matrix. I then examined the variation in bird composition across the survey years and habitat modification treatments (and their interaction) via multivariate analysis using the PERMANOVA in PRIMER v7.0.13 (Anderson *et al.* 2008). PERMANOVA is a distance-based, non-parametric, multivariate

analysis of variance that calculates a pseudo *F*-statistic and associated *P*-value by means of permutations, rather than relying on normal-theory tables (Anderson *et al.* 2008).

Secondly, I examined the relationship between these variables and the bird composition using the multivariate regression routine DISTILM in PERMANOVA. This routine uses distance–based redundancy analysis (dbRDA) and performs a constrained ordination and multivariate multiple regression to find linear combinations predictor variables (Anderson *et al.* 2008). I used the best subsets selection procedure in DistLM and Akaike's Information Criterion (AIC) as the selection criterion and examined the percentage variation explained for the fitted model and the total variation.

Thirdly, I undertook a constrained canonical analysis of principle coordinates (CAP) for species composition across habitat types (in this instance, using species abundance averaged across the years in each habitat modification type) to find the strongest axes of species correlation through the multivariate cloud that best characterises *a priori* habitat group differences (Anderson *et al.* 2008). This method also measures agreement between *a priori* habitat modification categories species composition. I also fitted species as vectors to the multivariate ordination via Pearson rank correlations, and I truncated the vectors to those with a correlation >0.6. I overlaid four environmental predictor variables as vectors: fractional green and non-green cover, rainfall and Yellow-throated Miner *Manorina flavigula* abundance. Fractional bare cover was excluded as it was strongly negatively correlated to both green (R= -0.69) and non-green cover (R= -0.74). I used the abundance of Yellow-throated Miners *Manorina flavigula* recorded at each site as this species is known to influence bird community composition, particularly small-bodied birds in northern Queensland (Kutt *et al.* 2012c). I used rainfall as many birds in semi-arid and arid region have a strong association (i.e., presence or abundance) with antecedent rainfall (Kutt and Kern 2023).

Finally I examined if there was any significant variation in species abundance across the habitat modification categories using the Kruskal-Wallis non-parametric analysis of variance in Statistica version 13.5.0.17 (TIBCO Software Inc 2018). Given the large number of samples and species I chose a more conservative significance level of 0.01. I also examined the variation across years, and again, because of the large number of samples

and categories (i.e., seven years), I used Mood's median test which is a special and more moderate case of Pearson's Chi-squared test. This non-parametric test compares data above or below the median, and then examines the observed and expected frequencies (TIBCO Software Inc 2018).

I tabulated the average abundance (and standard error) for all species for each year and habitat modification category separately, and then indicated which species demonstrated significant variation across each category, and which species were only recorded in a single year or habitat modification category, and which were recorded in all categories.

Results

This study recorded a total of 21,899 birds representing 116 species from the 389 sites over the seven years of sampling. The most frequently recorded species were Weebill *Smicrornis brevirostris* (n=341 sites), Singing Honeyeater *Gavicalis virescens* (n=296), Rufous Whistler *Pachycephala rufiventris* (n=282), Striated Pardalote *Pardalotus striatus* (n=282) and Yellow-throated Miner *Manorina flavigula* (n=265). The most abundantly recorded species were Weebill (n=3263 records), Budgerigar *Melopsittacus undulatus* (n=1400), Variegated Fairy-wren *Malurus lamberti* (n=1161), Zebra Finch *Taeniopygia castanotis* (n=1090) and Yellow-throated Miner (n= 872). Twelve bird species were only recorded once, and 10 of these were only via a single record. Considering the distribution of species across the habitat modification categories, 23 species were only recorded in a single category, while 70 species were recorded in all three; for years, this breakdown was 15 and 48 respectively.

The highest mean site species abundance and richness was in the intact vegetation (59.4 ± 2.1 and 19.7 ± 0.4 respectively) and lowest in the cleared vegetation (48.9 ± 6.4 and 14.4 ± 0.5) (Fig. 2, Table 1). The highest mean site species abundance was recorded in 2005 (85.8 ± 12.1) and the lowest in 2008 (38.7 ± 2.9) and the highest mean site species richness was in 2014 (20.1 ± 0.7) and the lowest in 2008 (13.8 ± 0.8) (Fig. 3, Supplementary Table 1).

The PERMANOVA results indicated that there was a significant difference in species composition across years (df = 6, Pseudo-F = 6.94, P(perm) = 0.001), habitat modification

(df = 2, Pseudo-F = 25.4, P(perm) = 0.001) and the interaction (df = 20, Pseudo-F = 2.43, P(perm) = 0.001). The larger Pseudo-F (a measure of effect size) for habitat modification suggest this is a stronger effect than year.

The DistLM marginal test for the habitat modification treatment indicated that for the four variables tested, all were in the best subset (residual df = 58, AIC = 400.6) and the total percentage of the variation explained was moderate (R^2 = 36.3%). The marginal tests for each variable and proportion explained was also small: fractional green (Pseudo-F = 14.6, P = 0.001, Proportion = 20.1%), fractional non-green (Pseudo-F = 4.6, P = 0.001, Proportion = 7.3%), rainfall (Pseudo-F = 5.06, P = 0.001, Proportion = 8.0%) and Yellow-throated Miner abundance (Pseudo-F = 6.63, P = 0.001, Proportion = 10.3%).

The CAP indicated that there was strong separation in species composition across the habitats, and the assessment of classification veracity indicated that 83.6% were correct and 16.7% were mis-classified. The thinned treatment had the lowest classification success (70.0%). The vector fitting (Fig. 4) indicated that species such as Zebra Finch *Taeniopygia castanotis*, Budgerigar *Melopsittacus undulatus*, Little Button-quail *Turnix velox*, Crimson Chat *Epthianura tricolor*, Nankeen Kestrel *Falco cenchroides* were positively correlated with the cleared sites, Grey Shrike-thrush *Colluricincla harmonica*, Crested Bellbird *Oreoica gutturalis*, Striped Honeyeater *Plectorhyncha lanceolata* were positively correlated with the intact sites, and Jacky Winter *Microeca fascinans* and Brown Treecreeper *Climacteris picumnus* positively correlated with the thinned sites (Fig. 4). Fractional cover green and non-green were positively correlated with the intact sites, and rainfall and Yellow-throated Miner were positively correlated with the thinned sites (Fig. 4).

From the entire suite of birds recorded, the Kruskal-Wallis non-parametric one-way analysis of variance (ANOVA) indicated that 48 species were recorded in significantly different abundances across the three habitat modification categories (22 more abundant in intact vegetation, 12 in thinned, and 14 in cleared). Examples of species that were more abundant in different habitat modification categories included Striped Honeyeater *Plectorhyncha lanceolata*, Spiny-cheeked Honeyeater *Acanthagenys rufogularis*, Grey-crowned Babbler *Pomatostomus temporalis*, Rufous Whistler *Pachycephala rufiventris*, Double-barred Finch *Taeniopygia bichenovii* (intact vegetation), Yellow-throated Miner

Manorina flavigula, Weebill *Smicrornis brevirostris*, Jacky Winter *Microeca fascinans* (thinned vegetation), Crested Pigeon *Ocyphaps lophotes,* Nankeen Kestrel *Falco cenchroides*, Galah *Eolophus roseicapilla*, Crimson Chat *Epthianura tricolor* and Zebra Finch *Taeniopygia castanotis* (cleared vegetation) (Table 1).

For years of survey, 53 species were recorded in significantly different abundances, and examples included Peaceful Dove *Geopelia placida* in 2014, Horsfield's Bronze-Cuckoo *Chalcites basalis* in 2006, Little Button-quail *Turnix velox* in 2005, Cockatiel *Nymphicus hollandicus* in 2014, Rainbow Lorikeet *Trichoglossus moluccanus* in 2013, Red-backed Fairy-wren *Malurus melanocephalus* in 2016, Rufous-throated Honeyeater *Conopophila rufogularis* in 2014, Yellow-throated Miner *Manorina flavigula* in 2006, White-browed Woodswallow *Artamus superciliosus* in 2016 and Mistletoebird *Dicaeum hirundinaceum* in 2013 (Supplementary Material 1).

Discussion

The clearing of native vegetation in many parts of the world, including central and south-eastern Australia, have caused a substantial past and continuing disarray of bird communities and species (Berryman *et al.* 2024; Thomson *et al.* 2015). The primary cause of bird community decline in Australia is land clearing associated with agriculture (Lindenmayer 2022). In this study I examined the pattern of bird species in a series of sites (sampled over multiple years), reflecting the preliminary stages of more extensive land clearing that has already occurred elsewhere in Australia. In general, there were clear differences in species composition, abundance and species richness across the cleared and intact tropical savanna woodlands, and a more muted differences with the thinned vegetation. The concept of land clearing thresholds for the prevention of species decline and local extirpation have been well articulated (McAlpine *et al.* 2002), yet the attrition of native vegetation continues in a dispiritingly substantial manner on many land tenures with little effective legislative oversight (Ward *et al.* 2019).

This data spanned a 12-year period, though I only sampled the birds at each site on seven occasions. The differences in bird abundance and species richness in each year of sampling was variable, and seemingly demonstrated very little association with overall rainfall. The variation in composition was largely driven by the degree of habitat

modification, more so than annual sampling variation, reflected also by the correlation of different bird communities with fraction cover green and non-green. A group of sites (largely the thinned treatment) demonstrated some relationship with higher rainfall, a function of the subtle rainfall gradient in the property locations (north to south). The pattern in bird variation across the sites was similar to the initial sampling (Kutt *et al.* 2012b; Tassicker *et al.* 2006), and this immutability reflects the lack of on-going clearing, or stark changes in management which can deplete bird communities (Dorrough *et al.* 2012). However many patterns of change do not manifest without multi-decadal monitoring (Lindenmayer *et al.* 2022).

There were clear differences in composition between the intact and thinned vegetation in comparison to the cleared sites (including a higher green and non-green fractional cover), and woodland bird species susceptible to habitat fragmentation (i.e., Striped Honeyeater, Crested Bellbird, Brown Treecreeper, Rufous Whistler, Grey-crowned Babbler) were more abundant (Maron *et al.* 2011). A large proportion of the variation in composition remained unexplained (63.7% in the DistLM analysis), which suggest more localised site based mechanisms were not captured by the four environmental variables examined; these could be subtle aspect of productivity, and plant and habitat resources unable to be recorded by remotely sensed metrics (Montague-Drake *et al.* 2009). Despite this, the mechanisms for these species decline in eastern Australia, caused by more substantial habitat loss and fragmentation, include reduced dispersal and higher nest predation and then reduced breeding leading to local extirpation (Ford *et al.* 2009) In addition there is strong evidence now that simplification of the vegetation structure and Noisy Miner *Manorina melanocephala* despotism is a significant threat (Thomson *et al.* 2015). One aspect of the thinned vegetation sites is the presence of Yellow-throated Miners in higher abundances. This species, like the Noisy Miner, can become more abundant and hyperaggressive when vegetation is cleared or thinned, which enhances behavioural traits that facilitate small bird persecution or exclusion (Kutt *et al.* 2012c).

The number of species recorded in all the three habitat modification categories was high (59% of all species recorded) and those recorded over the 7 years of survey, in only a single category were mainly in either the intact vegetation (12 species) or cleared vegetation (9 species). This suggests that despite some habitat modification across the

four properties sampled, the small extent of clearing allows for the persistence of a considerable proportion of the woodland bird species in this landscape. This contrasts with sites sampled in an identical manner (i.e., bird census method) in tropical savanna woodlands, at the southern end of the Desert Uplands bioregion, and with a greater extent of landscape modification and fragmentation (Hannah *et al.* 2007); bird species richness in cleared sites were substantially reduced (8.1 species per site compared to this study 14.4) whereas species richness in intact sites was remarkably coincident (19.9 species versus 19.8 in this study). The contrast in species in each habitat modification category was typical of those occurring in different abundances in treed or largely treeless habitats, such as woodland dependent birds (i.e., species in Meliphagidae, Pachycephalidae, Acanthizidae) and species associated with grasslands and bare ground (i.e., Crested Pigeon, Ground Cuckoo Shrike, Crimson Chat, Horsfield Bushlark, Zebra Finch) (Barrett *et al.* 1994).

In this study there was no clear pattern in the change in species over years of survey, though I did not measure fine scale site-based resources that would interact with annual weather patterns to influence changing species abundance over time. There were clear low points (i.e., 2008) and peaks (i.e., 2015, 2014) in total bird species and abundance, and as such I could not pinpoint any correlative cause. Woodland bird assemblages in Australia can be highly variable from year to year (Maron *et al.* 2005), and these patterns can be driven by extreme climatic events (Bennett *et al.* 2014), associated resource pulses or declines (Collett *et al.* 2022) as well as seasonal regional or continental migration patterns (Chan 2001). Of the 116 species recorded, 70 were recorded in all years and 23 in just a single year, suggesting a degree of stability in the bird assemblage present across all sites. However the species that influenced the peak and trough years included resource tracking honeyeaters (i.e., Brown, Black, Rufous-throated, White-plumed and White-throated Honeyeaters, and the Crimson Chat), small granivores with distinct pulses of abundance (i.e., Little Button-quail, Galah, Budgerigar, Zebra and Double-barred Finch in 2005) and seasonal migrants such as the Rainbow Bee-eater, Sacred Kingfisher, Red-capped Robin, woodswallow species). These patterns of annual change are typical of tropical savanna woodlands (Kutt *et al.* 2012a; Woinarski *et al.* 2000; Woinarski and Tidemann 1991).

Changes in the vertebrate fauna of tropical savannas in northern Australia are evident, and especially so in the mammal fauna (Fisher *et al.* 2014). The data for bird assemblages seem to suggest more resilience to environmental change (Woinarski *et al.* 2012), though there is likely a geographical effect; in some areas of north-eastern Australia where overgrazing has significantly altered intact vegetation (i.e., permanently altered the ground cover, and removed the shrub layer), the avifauna can also be depleted (Kutt and Fisher 2011). In this study I have demonstrated that, where changes in land cover have recently commenced there are significant site-based changes in the bird community, but not necessarily changes in the avifauna across the wider landscape. Given the increase in extreme weather events driven by climate change, which can effect species occurrence and abundance (Connell *et al.* 2022) and cause confounding or interacting patterns in concert with land use change (Oliver and Morecroft 2014), monitoring bird pattern and causes for any observed change over time is important. The sites described in this study were last sampled in 2016, and surveys have been discontinued. Long term monitoring is a critical action for improved landscape management and conservation (Lindenmayer *et al.* 2022); extension, enhancement or even recasting of long term research, such as those presented here, should be ongoing, and include more specific focus on biological mechanisms for species variation, and the effects of climate change.

Acknowledgements

I am grateful for the help of landholders in granting us access to their properties at Woura Park, Timaru, Penrice and Kalleroo, and the many people who assisted in the surveys, from the Australian CSIRO and Queensland Department of Environment and Science. This project was supported by the Queensland Government and the Australian Government (CSIRO, National Heritage Trust, Tropical Savanna Cooperative Research Centre, TERN). All surveys were conducted under the Queensland Government Scientific Purposes Permit number WITK04645707.

References

Anderson, M.J., Clarke, K.R., and Gorley, R.N. (2008) 'PERMANOVA+ for Primer. Guide to Software and Statistical Methods.' (University of Auckland and PRIMER-E Ltd: Plymouth UK)

Barrett, G.W., Ford, H.A., and Recher, H.F. (1994) Conservation of woodland birds in a fragmented rural landscape. *Pacific Conservation Biology* **1**(3), 245-256.

Bennett, J.M., Nimmo, D.G., Clarke, R.H., Thomson, J.R., Cheers, G., Horrocks, G.F.B., Hall, M., Radford, J.Q., Bennett, A.F., and Mac Nally, R. (2014) Resistance and resilience: can the abrupt end of extreme drought reverse avifaunal collapse? *Diversity and Distributions* **20**(11), 1321-1332.

Berryman, A.J., Butchart S. H. M., Jackson M. V., Legge S. M., Olah G., Thomas J., Woinarski J. C. Z., and Garnett, S.T. (2024) Trends and patterns in the extinction risk of Australia's birds over three decades. *Emu - Austral Ornithology* **124**(1), 55-67.

Beutel, T.S., Trevithick, R., Scarth, P., and Tindall, D. (2019) VegMachine.net. Online land cover analysis for the Australian rangelands. *The Rangeland Journal* **41**(4), 355-362.

BirdLife (2022) The BirdLife Australia Working List of Australian Birds; Version 4.1. In '.' (Ed. B Australia): Downloaded from http://www.birdlife.org.au/documents/BWL-BirdLife_Australia_Working_List_v4.1.xlsx.)

Bureau of Meteorology (2020) 'Average annual, seasonal and monthly rainfall. Available at http://www.bom.gov.au/climate/data/index.shtml [Verified 09 October 2020].'

Chan, K. (2001) Partial migration in Australian landbirds: a review. *Emu* **101**(4), 281-292.

Collett, S.J., Crewe, T.L., Radford, I.J., Garnett, S.T., and Campbell, H.A. (2022) Sympatric finches increase trophic and spatiotemporal partitioning to enable coexistence through periods of low resource availability. *Functional Ecology* **36**(9), 2138-2151.

Connell, J., Hall, M.A., Nimmo, D.G., Watson, S.J., and Clarke, M.F. (2022) Fire, drought and flooding rains: The effect of climatic extremes on bird species' responses to time since fire. *Diversity and Distributions* **28**(3), 417-438.

Daley, R. (1993) 'Atmospheric Data Analysis.' (Cambridge University Press, UK)

DERM (2012) 'Biodiversity Planning Assessment, Desert Uplands Bioregion Landscape Expert Panel Report, Central West Region.' (Department of Environment and Resource Management, Queensland Government: Brisbane)

Dorrough, J., McIntyre, S., Brown, G., Stol, J., Barrett, G., and Brown, A. (2012) Differential responses of plants, reptiles and birds to grazing management, fertilizer and tree clearing. *Austral Ecology* **37**(5), 569-582.

Evans, A., Jones, D., Smalley, R., and Lellyett, S. (2020) An enhanced gridded rainfall analysis scheme for Australia. *Australian Bureau of Meteorology* **66**, 55-67.

Fisher, D.O., .Johnson, C.N., Lawes, M.J., Fritz, S.A., McCallum, H., Blomberg, S.P., VanDerWal, J., Abbott, B., Frank, A., Legge, S., Letnic, M., Thomas, C.R., Fisher, A., Gordon, I.J., and Kutt, A.S. (2014) The current decline of tropical marsupials in Australia: is history repeating? *Global Ecology and Biogeography* **23**(2), 181-190.

Flood, N. (2013) Seasonal Composite Landsat TM/ETM+ Images Using the Medoid (a Multi-Dimensional Median). *Remote Sensing* **5**(12), 6481-6500.

Ford, H.A., Walters, J.R., Cooper, C.B., Debus, S.J.S., and Doerr, V.A.J. (2009) Extinction debt or habitat change? – Ongoing losses of woodland birds in north-eastern New South Wales, Australia. *Biological Conservation* **142**(12), 3182-3190.

Fraser, H., Simmonds, J.S., Kutt, A.S., and Maron, M. (2019) Systematic definition of threatened fauna communities is critical to their conservation. *Diversity and Distributions* **25**(3), 462-477.

Glowacki, T.J., Xiao, Y., and Steinle, P. (2012) Mesoscale surface analysis system for the Australian domain: Design issues, development status, and system validation. *Weather and Forecasting* **27**(1), 141-157.

Hannah, D., Woinarski, J.C.Z., Catterall, C.P., McCosker, J.C., Thurgate, N.Y., and Fensham, R.J. (2007) Impacts of clearing, fragmentation and disturbance on the bird fauna of Eucalypt savanna woodlands in central Queensland, Australia. *Austral Ecology* **32**(3), 261-276. [In English]

Hopkins, H.L., and Kennedy, M.L. (2004) An assessment of indices of relative and absolute abundance for monitoring populations of small mammals. *Wildlife Society Bulletin* **32**(4), 1289-1296.

Joint Remote Sensing Research Program (2021) 'Seasonal fractional cover - Landsat, JRSRP algorithm, Australia coverage. Dataset. Version 1.0. https://portal.tern.org.au/metadata/TERN.' (The University of Queensland, Indooroopilly, Queensland, Australia)

Joint Remote Sensing Research Program and Department of Environment and Science (2022) 'Seasonal fractional cover - Landsat, JRSRP algorithm Version 3.0, Australia coverage. Version 3.0. Dataset. https://portal.tern.org.au/metadata/TERN ' (The University of Queensland, Indooroopilly, Queensland, Australia)

Kutt, A.S., and Fisher, A. (2011) Increased grazing and dominance of an exotic pasture (*Bothriochloa pertusa*) affects vertebrate fauna species composition, abundance and habitat in savanna woodland. *The Rangeland Journal* **33**(1), 49-58.

Kutt, A.S., and Kern, P.L. (2023) Birds on the Edge: Spatial and temporal patterns in the bird community recorded at a conservation reserve on a bioregion woodland-grassland boundary in central Queensland. *Australian Field Ornithology* **40**, 130-149.

Kutt, A.S., Perkins, G.C., Colman, N., Vanderduys, E.P., and Perry, J.J. (2012a) Temporal variation in a savanna bird assemblage: what changes over 5 years? *Emu* **112**(1), 32-38.

Kutt, A.S., Vanderduys, E.P., Ferguson, D., and Mathieson, M. (2012b) Effect of small-scale woodland clearing and thinning on vertebrate fauna in a largely intact tropical savanna mosaic. *Wildlife Research* **39**(4), 366-373.

Kutt, A.S., Vanderduys, E.P., Perry, J.J., and Perkins, G.C. (2012c) Do miners (*Manorina* spp.) affect bird assemblages in continuous savanna woodlands in north-eastern Australia? *Austral Ecology* **37**(7), 779-788.

Liao, Z., Peng, S., and Chen, Y. (2022) Half-millennium evidence suggests that extinction debts of global vertebrates started in the Second Industrial Revolution. *Communications Biology* **5**(1), 1311.

Lindenmayer, D. (2022) Birds on farms: a review of factors influencing bird occurrence in the temperate woodlands of south-eastern Australia. *Emu - Austral Ornithology* **122**, 238-254.

Lindenmayer, D.B., Lavery, T., and Scheele, B.C. (2022) Why We Need to Invest in Large-Scale, Long-Term Monitoring Programs in Landscape Ecology and Conservation Biology. *Current Landscape Ecology Reports* **7**(4), 137-146.

Maron, M., Grey, M.J., Catterall, C.P., Major, R.E., Oliver, D.L., Clarke, M.F., Loyn, R.H., Mac Nally, R., Davidson, I., and Thomson, J.R. (2013) Avifaunal disarray due to a single despotic species. *Diversity and Distributions* **19**(12), 1468-1479.

Maron, M., Lill, A., Watson, D.M., and Mac Nally, R. (2005) Temporal variation in bird assemblages: How representative is a one-year snapshot? *Austral Ecology* **30**(4), 383-394.

Maron, M., Main A., Bowen M., Howes A., Kath J., Pillette C., and McAlpine, C.A. (2011) Relative influence of habitat modification and interspecific competition on woodland bird assemblages in eastern Australia. *Emu - Austral Ornithology* **111**(1), 40-51.

Martin, T.G., and McIntye, S. (2007) Impacts of livestock grazing and tree clearing on birds of woodland and riparian habitats. *Conservation Biology* **21**(2), 504-514.

McAlpine, C.A., Fensham, R.J., and Temple-Smith, D.E. (2002) Biodiversity conservation and vegetation clearing in Queensland: principles and thresholds. *The Rangeland Journal* **24**(1), 36-55.

Montague-Drake, R.M., Lindenmayer, D.B., and Cunningham, R.B. (2009) Factors affecting site occupancy by woodland bird species of conservation concern. *Biological Conservation* **142**(12), 2896-2903.

Oliver, T.H., and Morecroft, M.D. (2014) Interactions between climate change and land use change on biodiversity: attribution problems, risks, and opportunities. *WIREs Climate Change* **5**(3), 317-335.

Perry, J.J., Kutt, A.S., Perkins, G.C., Vanderduys, E.P., and Colman, N.J. (2012) A bird survey method for Australian tropical savannas. *Emu* **112**(3), 261-266.

Perry, J.J., Vanderduys, E.P., and Kutt, A.S. (2016) Shifting fire regimes from late to early dry-season fires to abate greenhouse emissions does not completely equate with terrestrial vertebrate biodiversity co-benefits on Cape York Peninsula, Australia. *International Journal of Wildland Fire* **25**(7), 742-752.

Queensland Department of Environment and Science (2022) Statewide Landcover and Trees Study – Methodology Overview v1.1. Queensland Government, Brisbane.

Reside, A.E., Beher, J., Cosgrove, A.J., Evans, M.C., Seabrook, L., Silcock, J.L., Wenger, A.S., and Maron, M. (2017) Ecological consequences of land clearing and policy reform in Queensland. *Pacific Conservation Biology* **23**(3), 219-230.

Slade, N.A., and Blair, S.M. (2000) An empirical test of using counts of individuals captured as indices of population size. *Journal of Mammalogy* **81**(4), 1035-1045.

Tassicker, A.L., Kutt, A.S., Vanderduys, E., and Mangru, S. (2006) The effects of vegetation structure on the birds in a tropical savanna woodland in north-eastern Australia. *Rangeland Journal* **28**(2), 139-152. [In English]

Thomson, J.R., Maron, M., Grey, M.J., Catterall, C.P., Major, R.E., Oliver, D.L., Clarke, M.F., Loyn, R.H., Davidson, I., Ingwersen, D., Robinson, D., Kutt, A., MacDonald, M.A., and Mac Nally, R. (2015) Avifaunal disarray: quantifying models of the occurrence and ecological effects of a despotic bird species. *Diversity and Distributions* **21**(4), 451-464.

TIBCO Software Inc (2018) 'Statistica (data analysis software system), version 13.5.0.17 Available from: http://statistica.io.' In (TIBCO Software Inc: Palo Alto, CA, USA;)

Tilman, D., Clark, M., Williams, D.R., Kimmel, K., Polasky, S., and Packer, C. (2017) Future threats to biodiversity and pathways to their prevention. *Nature* **546**(7656), 73-81.

Walker, B., and Weston, E. (1990) Pasture development in Queensland–a success story. *Tropical Grasslands* **24**(4), 257-268.

Ward, M.S., Simmonds, J.S., Reside, A.E., Watson, J.E.M., Rhodes, J.R., Possingham, H.P., Trezise, J., Fletcher, R., File, L., and Taylor, M. (2019) Lots of loss with little scrutiny: The attrition of habitat critical for threatened species in Australia. *Conservation Science and Practice* **1**(11), e117.

Woinarski, J.C., Connors, G., and Franklin, D.C. (2000) Thinking honeyeater: nectar maps for the Northern Territory, Australia. *Pacific Conservation Biology* **6**, 61-80.

Woinarski, J.C.Z., Fisher, A., Armstrong, M., Brennan, K., Griffiths, A.D., Hill, B., Choy, J.L., Milne, D., Stewart, A., Young, S., Ward, S., Winderlich, S., and Ziembicki, M. (2012) Monitoring indicates greater resilience for birds than for mammals in Kakadu National Park, northern Australia. *Wildlife Research* **39**(5), 397-407.

Woinarski, J.C.Z., and Tidemann, S.C. (1991) The Bird Fauna of a Deciduous Woodland in the Wet-Dry Tropics of Northern Australia. *Wildlife Research* **18**(4), 479-500.

Figure 1. The location of the properties where the bird surveys were undertaken in this study. The grey shaded are indicates intact vegetation and the white areas, cleared. Areas that are thinned are included within the grey shaded areas, as they still represent intact vegetation in the mapping product used for this figure.

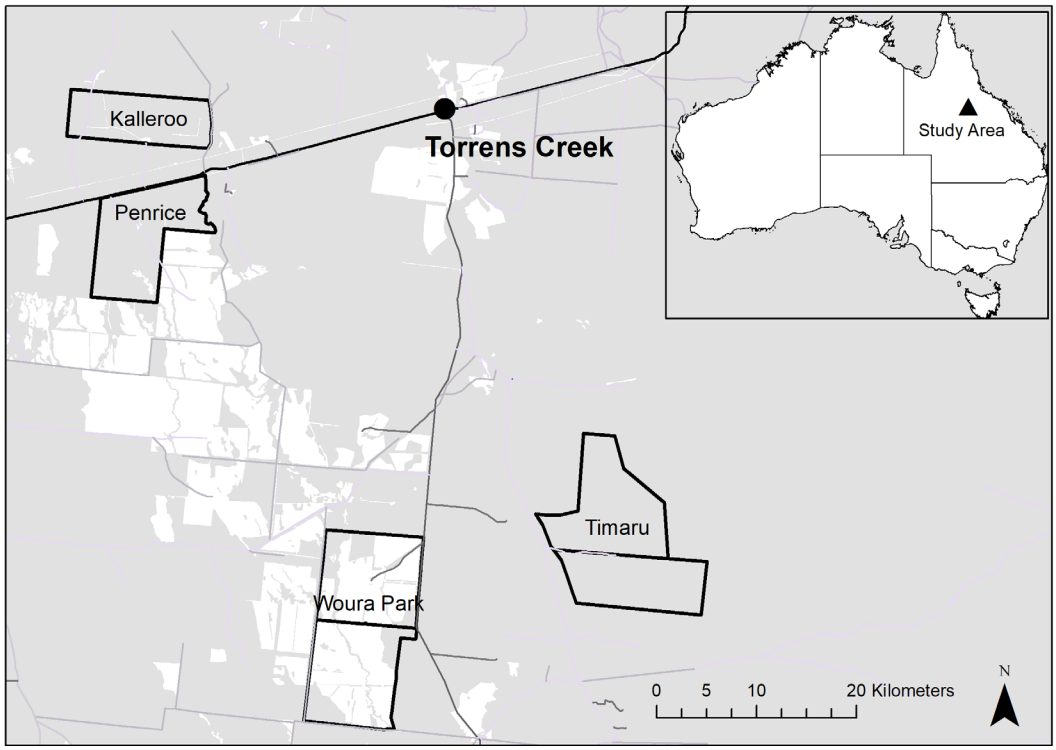

Figure 2. The mean (and standard error) for bird abundance and species richness per survey for each habitat modification class across all years of survey.

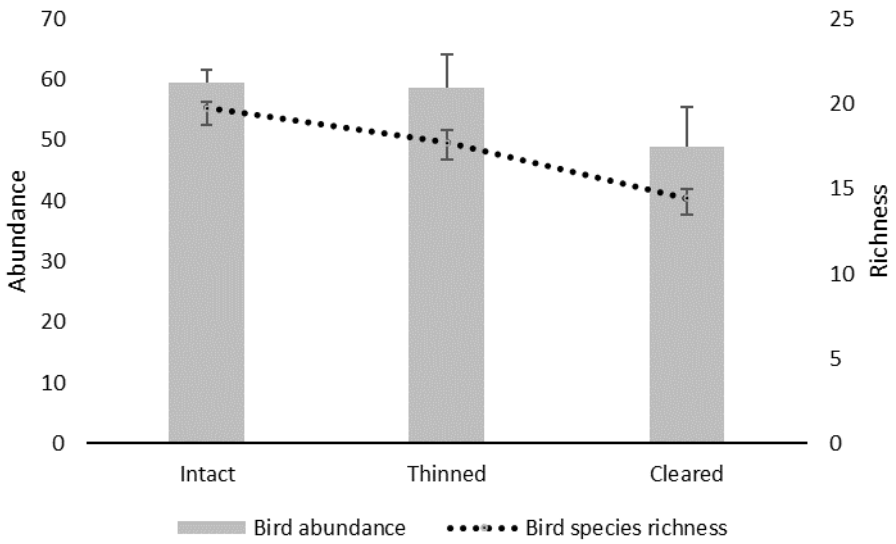

Figure 3. The mean (and standard error) for bird abundance and species richness for each year of survey across all sites combined. The average rainfall for each year across all sites is also presented.

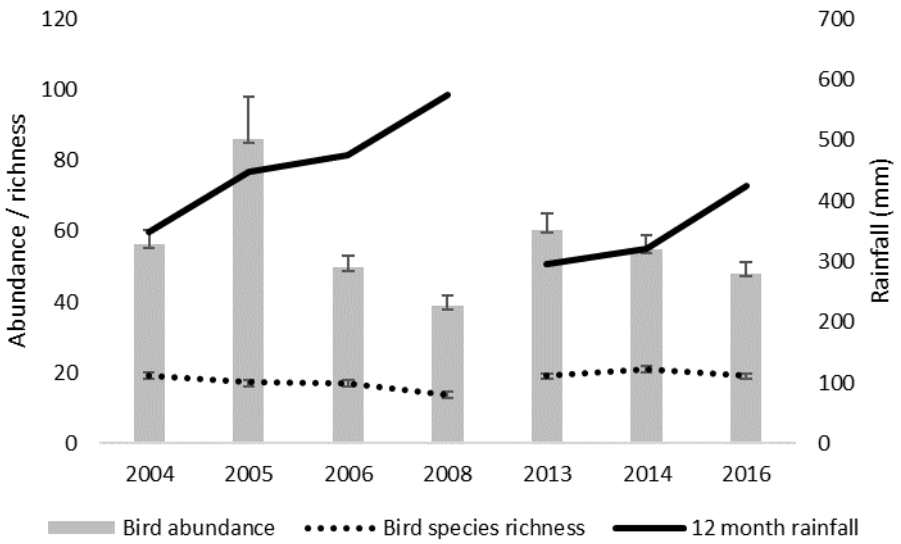

Figure 4. Spearman rank correlations of bird species (R>0.6) and four environmental vectors (inclusive of one despotic bird species) overlain on the constrained canonical analysis of principle ordination of the bird composition for each habitat modification treatment (all years combined).

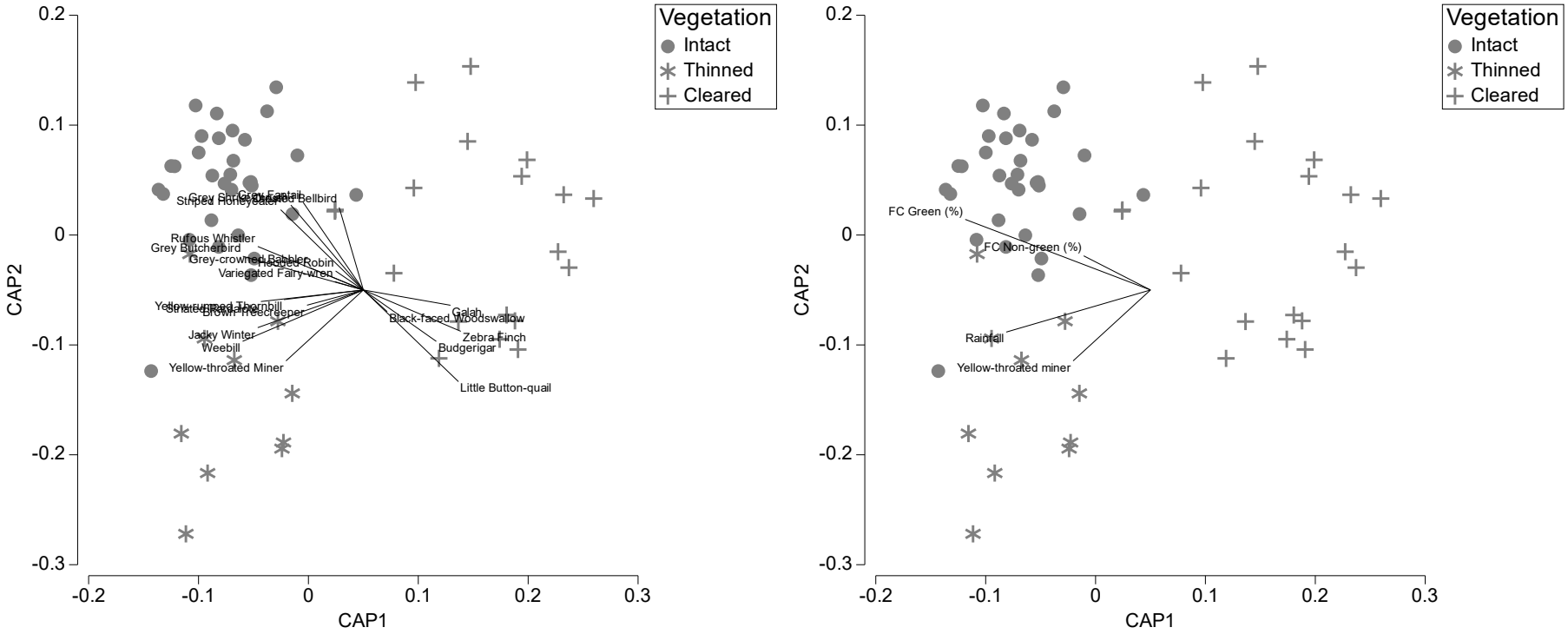

Table 1. The mean (and standard error) of bird abundance and species richness, and each species, recorded across all surveys, for each of the habitat modification classes. The P indicates where there is a significant difference in the surveys, tested via the Kruskal-Wallis non-parametric analysis of variance. **H** is the test statistic and where the P value is <0.01 the highest mean is in **bold** and grey-shaded**,** and the second highest mean is just grey-shaded. The **Freq** column indicates if a species was recorded in a single habitat modification type (S) or all types (A).

Common name	Scientific Name	Intact	Thinned	Cleared	H	P	Freq
Bird abundance		**59.446 ± 2.106**	58.618 ± 5.542	48.918 ± 6.459	35.7	<0.001	
Bird species richness		**19.75 ± 0.376**	17.709 ± 0.745	14.436 ± 0.552	54.1	<0.001	
Emu	*Dromaius novaehollandiae*	0.017 ± 0.010	0.272 ± 0.171	0.045 ± 0.023			A
Brown Quail	*Synoicus ypsilophorus*	0.058 ± 0.041		0.027 ± 0.027			
Squatter Pigeon	*Geophaps scripta*	0.214 ± 0.119	0.163 ± 0.129	0.009 ± 0.009			A
Common Bronzewing	*Phaps chalcoptera*	0.383 ± 0.066	0.163 ± 0.081	0.254 ± 0.083			A
Crested Pigeon	*Ocyphaps lophotes*	0.147 ± 0.033	0.236 ± 0.089	**0.336 ± 0.064**	11.6	<0.01	A
Diamond Dove	*Geopelia cuneata*	0.142 ± 0.075	**0.290 ± 0.128**	0.027 ± 0.020	12.6	<0.01	A
Peaceful Dove	*Geopelia placida*	**0.517 ± 0.055**	0.181 ± 0.073	0.136 ± 0.035	33.1	<0.001	A
Bar-shouldered Dove	*Geopelia humeralis*	**0.209 ± 0.032**		0.027 ± 0.015	26.0	<0.001	
Australian Owlet-nightjar	*Aegotheles cristatus*	**0.160 ± 0.026**	0.018 ± 0.018	0.009 ± 0.009	21.2	<0.001	
Pheasant Coucal	*Centropus phasianinus*	0.008 ± 0.006					S
Channel-billed Cuckoo	*Scythrops novaehollandiae*	0.004 ± 0.004	0.018 ± 0.018				
Horsfield's Bronze-Cuckoo	*Chalcites basalis*	0.031 ± 0.011	0.018 ± 0.018	0.136 ± 0.047			
Black-eared Cuckoo	*Chalcites osculans*	0.008 ± 0.008					S
Shining Bronze-Cuckoo	*Chalcites lucidus*	0.008 ± 0.006		0.009 ± 0.009			
Brush Cuckoo	*Cacomantis variolosus*	0.013 ± 0.007					S
Pallid Cuckoo	*Heteroscenes pallidus*	0.049 ± 0.015	**0.181 ± 0.058**	0.018 ± 0.012	16.1	<0.001	A
Australian Bustard	*Ardeotis australis*	0.013 ± 0.007	0.018 ± 0.018	**0.136 ± 0.041**	18.0	<0.001	A
White-necked Heron	*Ardea pacifica*			0.009 ± 0.009			S
Painted Button-quail	*Turnix varius*	0.049 ± 0.027					S
Red-chested Button-quail	*Turnix pyrrhothorax*		0.018 ± 0.018				S
Little Button-quail	*Turnix velox*	0.174 ± 0.041	0.400 ± 0.167	0.581 ± 0.160			A
Black-breasted Buzzard	*Hamirostra melanosternon*	0.017 ± 0.010	0.018 ± 0.018	0.018 ± 0.012			A
Square-tailed Kite	*Lophoictinia isura*	0.004 ± 0.004					S
Wedge-tailed Eagle	*Aquila audax*	0.022 ± 0.009	**0.218 ± 0.076**	0.109 ± 0.032	18.1	<0.001	A
Little Eagle	*Hieraaetus morphnoides*			0.009 ± 0.009			S
Spotted Harrier	*Circus assimilis*		0.018 ± 0.018	0.036 ± 0.022			
Brown Goshawk	*Accipiter fasciatus*	0.017 ± 0.008	0.036 ± 0.025	0.018 ± 0.012			A

Common name	Scientific Name	Intact	Thinned	Cleared	H	P	Freq
Collared Sparrowhawk	*Accipiter cirrocephalus*	0.013 ± 0.007	0.018 ± 0.018	0.009 ± 0.009			A
Whistling Kite	*Haliastur sphenurus*	0.013 ± 0.007	0.018 ± 0.018	0.027 ± 0.015			A
Black Kite	*Milvus migrans*	0.026 ± 0.010	0.072 ± 0.043	0.063 ± 0.026			A
Rainbow Bee-eater	*Merops ornatus*	0.357 ± 0.086	0.163 ± 0.096	0.181 ± 0.086			A
Oriental Dollarbird	*Eurystomus orientalis*	0.004 ± 0.004					S
Forest Kingfisher	*Todiramphus macleayii*	0.004 ± 0.004	0.018 ± 0.018				
Sacred Kingfisher	*Todiramphus sanctus*	0.022 ± 0.011	0.018 ± 0.018				
Red-backed Kingfisher	*Todiramphus pyrrhopygius*	0.071 ± 0.019	0.072 ± 0.050	0.145 ± 0.051			A
Laughing Kookaburra	*Dacelo novaeguineae*	0.013 ± 0.007					S
Blue-winged Kookaburra	*Dacelo leachii*	0.075 ± 0.017	**0.163 ± 0.050**	0.018 ± 0.012	11.7	<0.01	A
Nankeen Kestrel	*Falco cenchroides*	0.008 ± 0.006	0.036 ± 0.036	**0.127 ± 0.036**	20.5	<0.001	A
Australian Hobby	*Falco longipennis*			**0.036 ± 0.017**	10.2	<0.01	S
Brown Falcon	*Falco berigora*	0.209 ± 0.031	0.127 ± 0.045	**0.354 ± 0.054**	10.0	<0.01	A
Peregrine Falcon	*Falco peregrinus*	0.004 ± 0.004					S
Cockatiel	*Nymphicus hollandicus*	0.205 ± 0.065	0.763 ± 0.220	**1.372 ± 0.521**	29.9	<0.001	A
Red-tailed Black-Cockatoo	*Calyptorhynchus banksii*	0.035 ± 0.022		0.027 ± 0.015			
Galah	*Eolophus roseicapilla*	0.133 ± 0.037	0.272 ± 0.105	**3.663 ± 2.042**	68.4	<0.001	A
Sulphur-crested Cockatoo	*Cacatua galerita*	0.026 ± 0.012	0.036 ± 0.025	0.036 ± 0.017			A
Pale-headed Rosella	*Platycercus adscitus*	**0.660 ± 0.082**	0.600 ± 0.133	0.327 ± 0.086	12.0	<0.01	A
Rainbow Lorikeet	*Trichoglossus moluccanus*	**0.638 ± 0.156**	0.163 ± 0.050	0.136 ± 0.055	22.6	<0.001	A
Scaly-breasted Lorikeet	*Trichoglossus chlorolepidotus*	0.031 ± 0.019					S
Budgerigar	*Melopsittacus undulatus*	1.549 ± 0.688	4.236 ± 2.734	**7.454 ± 2.826**	65.9	<0.001	A
Red-winged Parrot	*Aprosmictus erythropterus*	0.406 ± 0.055	0.618 ± 0.188	0.363 ± 0.132			A
Spotted Bowerbird	*Chlamydera maculata*	0.208 ± 0.042	**0.254 ± 0.140**	0.036 ± 0.029	12.9	<0.01	A
Brown Treecreeper	*Climacteris picumnus*	**1.062 ± 0.155**	0.890 ± 0.181	0.027 ± 0.015	62.9	<0.001	A
Variegated Fairy-wren	*Malurus lamberti*	3.312 ± 0.334	3.636 ± 0.803	1.990 ± 0.304			A
Red-backed Fairy-wren	*Malurus melanocephalus*	0.401 ± 0.125	1.109 ± 0.552	**1.145 ± 0.305**	11.3	<0.01	A
White-winged Fairy-wren	*Malurus leucopterus*			0.045 ± 0.029			S
Brown Honeyeater	*Lichmera indistincta*	0.089 ± 0.056	0.018 ± 0.018				
Blue-faced Honeyeater	*Entomyzon cyanotis*	0.035 ± 0.012	0.054 ± 0.03	0.018 ± 0.012			A
White-throated Honeyeater	*Melithreptus albogularis*	0.008 ± 0.008	0.018 ± 0.018				
Striped Honeyeater	*Plectorhyncha lanceolata*	**0.531 ± 0.056**	0.272 ± 0.083	0.072 ± 0.028	40.6	<0.001	A
Little Friarbird	*Philemon citreogularis*	**0.968 ± 0.105**	0.818 ± 0.192	0.281 ± 0.087	30.2	<0.001	A
Noisy Friarbird	*Philemon corniculatus*	**0.553 ± 0.205**	0.018 ± 0.018	0.036 ± 0.017	26.1	<0.001	A
Black Honeyeater	*Sugomel nigrum*		0.018 ± 0.018				S

Common name	Scientific Name	Intact	Thinned	Cleared	H	P	Freq
Rufous-throated Honeyeater	*Conopophila rufogularis*	0.133 ± 0.062	0.127 ± 0.082	0.009 ± 0.009			A
Crimson Chat	*Epthianura tricolor*	0.022 ± 0.014	0.018 ± 0.018	**0.672 ± 0.242**	18.4	<0.001	A
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	**1.294 ± 0.157**	0.327 ± 0.082	0.145 ± 0.042	56.1	<0.001	A
Singing Honeyeater	*Gavicalis virescens*	1.848 ± 0.124	1.945 ± 0.289	1.590 ± 0.160			A
White-plumed Honeyeater	*Ptilotula penicillata*	0.044 ± 0.025	0.145 ± 0.128				
Grey-fronted Honeyeater	*Ptilotula plumula*	**2.500 ± 0.447**	0.436 ± 0.157	0.072 ± 0.035	43.7	<0.001	A
Yellow-throated Miner	*Manorina flavigula*	2.151 ± 0.270	**4.745 ± 0.808**	1.172 ± 0.149	33.8	<0.001	A
Red-browed Pardalote	*Pardalotus rubricatus*	0.044 ± 0.015	0.09 ± 0.046	0.054 ± 0.021			A
Striated Pardalote	*Pardalotus striatus*	2.674 ± 0.174	**2.818 ± 0.488**	0.836 ± 0.144	72.2	<0.001	A
White-throated Gerygone	*Gerygone olivacea*	0.058 ± 0.016	0.018 ± 0.018	0.009 ± 0.009			A
Western Gerygone	*Gerygone fusca*	**0.205 ± 0.034**		0.045 ± 0.019	18.1	<0.001	
Weebill	*Smicrornis brevirostris*	9.607 ± 0.527	**12.236 ± 1.258**	3.981 ± 0.513	68.3	<0.001	A
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	**2.370 ± 0.234**	2.309 ± 0.924	0.790 ± 0.215	32.1	<0.001	A
Inland Thornbill	*Acanthiza apicalis*	**0.763 ± 0.121**		0.190 ± 0.075	29.2	<0.001	
Buff-rumped Thornbill	*Acanthiza reguloides*	0.062 ± 0.035		0.018 ± 0.012			
Grey-crowned Babbler	*Pomatostomus temporalis*	**1.437 ± 0.156**	0.909 ± 0.279	0.681 ± 0.174	29.5	<0.001	A
Varied Sittella	*Daphoenositta chrysoptera*	0.955 ± 0.139	0.563 ± 0.197	0.381 ± 0.118			A
Olive-backed Oriole	*Oriolus sagittatus*	0.080 ± 0.019	0.145 ± 0.047	0.045 ± 0.019			A
Crested Bellbird	*Oreoica gutturalis*	**1.053 ± 0.067**	0.527 ± 0.072	0.600 ± 0.067	29.2	<0.001	A
Rufous Whistler	*Pachycephala rufiventris*	**2.642 ± 0.165**	1.618 ± 0.274	0.745 ± 0.144	89.7	<0.001	A
Grey Shrike-thrush	*Colluricincla harmonica*	**0.825 ± 0.077**	0.236 ± 0.085	0.136 ± 0.041	66.4	<0.001	A
Ground Cuckoo-shrike	*Coracina maxima*	0.031 ± 0.013	0.036 ± 0.025	**0.227 ± 0.069**	16.7	<0.001	A
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	0.651 ± 0.098	0.454 ± 0.089	0.654 ± 0.134			A
White-bellied Cuckoo-shrike	*Coracina papuensis*	0.062 ± 0.020		0.009 ± 0.009			
White-winged Triller	*Lalage tricolor*	0.241 ± 0.058	0.272 ± 0.117	0.427 ± 0.140			A
Australian Magpie	*Gymnorhina tibicen*	0.633 ± 0.054	0.527 ± 0.077	0.790 ± 0.078			A
Pied Butcherbird	*Cracticus nigrogularis*	0.647 ± 0.047	0.818 ± 0.183	0.763 ± 0.084			A
Grey Butcherbird	*Cracticus torquatus*	**0.982 ± 0.066**	0.781 ± 0.120	0.245 ± 0.043	72.5	<0.001	A
Masked Woodswallow	*Artamus personatus*	0.424 ± 0.250		0.118 ± 0.038			
White-browed Woodswallow	*Artamus superciliosus*	0.044 ± 0.017		0.036 ± 0.022			
Dusky Woodswallow	*Artamus cyanopterus*	0.004 ± 0.004					S
Black-faced Woodswallow	*Artamus cinereus*	1.120 ± 0.226	**1.600 ± 0.771**	1.554 ± 0.247	10.5	<0.01	A
Little Woodswallow	*Artamus minor*	0.348 ± 0.092	0.436 ± 0.255	0.136 ± 0.047			A
White-breasted Woodswallow	*Artamus leucorynchus*	0.598 ± 0.277		0.036 ± 0.025			
Willie Wagtail	*Rhipidura leucophrys*	0.549 ± 0.067	0.800 ± 0.174	0.718 ± 0.102			A

Common name	Scientific Name	Intact	Thinned	Cleared	H	P	Freq
Grey Fantail	*Rhipidura albiscapa*	**0.750 ± 0.080**	0.163 ± 0.085	0.227 ± 0.070	43.4	<0.001	A
Leaden Flycatcher	*Myiagra rubecula*	0.022 ± 0.011					S
Restless Flycatcher	*Myiagra inquieta*	0.031 ± 0.014		0.009 ± 0.009			
Magpie-lark	*Grallina cyanoleuca*	0.165 ± 0.046	**0.509 ± 0.106**	0.472 ± 0.164	26.5	<0.001	A
Torresian Crow	*Corvus orru*	0.228 ± 0.051	0.309 ± 0.130	0.682 ± 0.260			A
Apostlebird	*Struthidea cinerea*	1.504 ± 0.394	1.200 ± 0.631	0.154 ± 0.101			A
Red-capped Robin	*Petroica goodenovii*	0.017 ± 0.008		0.063 ± 0.047			
Jacky Winter	*Microeca fascinans*	0.897 ± 0.097	**1.072 ± 0.244**	0.118 ± 0.051	53.4	<0.001	A
Hooded Robin	*Melanodryas cucullata*	**0.308 ± 0.084**		0.009 ± 0.009	16.2	<0.001	
Horsfield's Bushlark	*Mirafra javanica*			**0.063 ± 0.029**	12.8	<0.01	S
Brown Songlark	*Cincloramphus cruralis*	0.004 ± 0.004		0.009 ± 0.009			
Rufous Songlark	*Cincloramphus mathewsi*	0.151 ± 0.038	0.200 ± 0.098	0.254 ± 0.091			A
Tawny Grassbird	*Cincloramphus timoriensis*			0.009 ± 0.009			S
Fairy Martin	*Petrochelidon ariel*			0.009 ± 0.009			S
Silvereye	*Zosterops lateralis*	0.008 ± 0.008					S
Mistletoebird	*Dicaeum hirundinaceum*	0.419 ± 0.090	**0.763 ± 0.204**	0.072 ± 0.024	19.5	<0.001	A
Plum-headed Finch	*Neochmia modesta*			0.345 ± 0.345			S
Zebra Finch	*Taeniopygia castanotis*	0.718 ± 0.283	1.254 ± 0.685	**7.818 ± 2.741**	38.4	<0.001	A
Double-barred Finch	*Taeniopygia bichenovii*	**3.053 ± 0.375**	1.363 ± 0.465	0.600 ± 0.256	50.3	<0.001	A
Australasian Pipit	*Anthus novaeseelandiae*			**0.063 ± 0.034**	10.2	<0.01	S