Comparing changes in the abundance of woodland birds in the Hunter Region of New South Wales

Mike Newman

72 Axiom Way, Acton Park, Tasmania 7170, Australia omgnewman@bigpond.com

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Birdata records suggest that many woodland and other birds have experienced serious decreases in the Hunter Region during the last two decades. These include species such as the Superb Fairy-wren *Malurus cyaneus*, which, however, remains widespread and abundant. Others, like the Jacky Winter *Microeca fascinans,* are becoming increasingly uncommon. Reliable estimation of the population trajectories of uncommon species is compromised by a lack of sufficient records in short-duration surveys. This difficulty is addressed in this paper by combining the results of surveys of different duration in order to increase the number of records. A screening process involving comparison of the rates of decrease with a benchmark species, the Superb Fairy-wren, has highlighted species of concern which require more detailed analysis.

Of 17 Hunter Region woodland birds, ten species decreased monotonically at rates that were statistically significantly more rapid than the rate for the Superb Fairy-wren: up to 2.7 times greater in the case of the Pallid Cuckoo *Heteroscenes pallidus*. The rates of decrease in the Superb Fairy-wren and six other species were statistically significantly different from the rates for the ten species showing greater decline. In general, uncommon species were decreasing more rapidly than common species. Not all species fitted the pattern of monotonic decline; examples being the Dusky Woodswallow *Artamus cyanopterus* and the Spiny-cheeked Honeyeater *Acanthagenys rufogularis*. The latter has recently established a presence in the Hunter Region.

Potential causes of population decrease include land clearing, excessive fragmentation of remnant woodland and drier conditions resulting from climate change. It is speculated that uncommon species may decrease more rapidly because they are less adaptable, having specialized ecological requirements, and diminished ability to disperse.

INTRODUCTION

A key purpose of Birdata is to identify changes in bird populations. For this purpose, Reporting Rates (RR), are used as a measure of the abundance of a species (Clarke *et al*. 1999). Inspection of Birdata RRs suggests that many species are rapidly disappearing from the Hunter Region's landscape. However, the extent to which the apparent trends are affected by changes in data collection procedures is unclear. For instance, during the past two decades technological and social changes have influenced where, and how, people watch birds, complicating interpretation. This paper provides insights into the changes in Hunter Region bird populations by comparing the rates at which different species have altered.

Contributors to Birdata are encouraged to use standard survey methods, ideally 2-ha surveys, where an area of 2 ha is surveyed for 20 minutes and short bird lists are generated. However, many Birdata participants prefer to survey larger areas for extended periods of time, generating longer bird lists than from 2-ha surveys. While 2-ha survey data have advantages for determining changes in common species such as the Superb Fairy-wren *Malurus cyaneus* (Hunter Region RR 42.4% from 2-ha surveys), there are seldom sufficient records for meaningful analysis of uncommon species, such as Pallid Cuckoo *Heteroscenes pallidus* (Hunter Region RR 2.1% from 2-ha surveys), necessitating the use of records from other survey types. Unfortunately, combining the results of different types of surveys introduces bias, complicating the analysis of trends. The approach adopted in this paper is based on the proposition that if all species experience the same annual bias, differences in their relative rates of change will provide an indication of how the status of individual species are changing. This will provide insights into the ability of species to adapt to environmental changes in the Hunter Region. The Superb Fairy-wren is used as a benchmark for comparing the status of other woodland species.

METHODS

The analysis in this paper is based on the results of three types of Birdata survey:

- 2-ha surveys – an area of 2 ha is searched for a period of 20 min. The 2-ha survey is BLA's preferred method because both the area searched and the survey duration are standardised.
- 500-m surveys – birds are recorded within an area not exceeding 500 m radius. Duration is not constrained, although participants are encouraged to complete surveys during one day.
- 5-km surveys – birds are recorded within an area not exceeding 5 km radius with completion encouraged within one day.

During August 2020 I extracted the annual RRs for Hunter Region from the Birdata portal (General Birdata program) for a combination of the three survey types for 22 species for the period 1999 to 2019 (1999 was the first full year of the New Atlas of Australian Birds; Barrett *et al*. 2003).

The Superb Fairy-wren was selected as the basis for comparison because it is frequently recorded and well distributed across the Hunter Region. Woodland birds with ranges similar to the Superb Fairy-wren (unless otherwise stated) and representing a range of life-style traits (e.g. resident and migratory) and foraging guilds (e.g. ground, bark and foliage gleaning) were chosen otherwise randomly for comparison. The mean RRs for the 21-year period 1999 to 2019 varied widely among the selected species.

Decadal changes in the annual RR (i.e. the extent to which a species decreased during a ten-year period were calculated from the slope and intercept of the linear regression equation of the annual RR trend (See **Figure 1** in the Results section). The 95% confidence intervals (not shown) indicated errors of 4 and 9% for the 2010 estimates of the Superb Fairy-wren and the Jacky Winter *Microeca fascinans*, respectively. In instances where linear regression models were deemed unsuitable, temporal trends were evaluated as three-year moving average values.

The rates of decline of individual species were compared with the Superb Fairy-wren, the benchmark species, by testing whether the slope of the variation in the occurrence of that species was statistically different from that of the Superb Fairy-wren. The probability *p* of this difference was calculated using StatPlus:mac, AnalystSoft Inc. - statistical analysis program for macOS. Version v7.3.

To evaluate the possibility that annual RR trends were affected by variations in the number of surveys and types (see **Figure 7** in Results section) the 500-m and 5-km survey records for each species were adjusted to an equivalent number of 2-ha records using the ratios of their mean annual RR with the 2-ha RR. This allowed a 2-ha equivalent annual RR to be calculated for each species and the trend of the adjusted values to be compared with the uncorrected trend. No correction was made for variations in survey duration, which is not standardized in 500-m and 5-km Birdata surveys.

RESULTS

The RRs of the Superb Fairy-wren and many other species of the Hunter Region have decreased over the past 20 years. In most cases these decreases are explained by a linear model as shown for the Superb Fairy-wren and three other species in **Figure 1**.

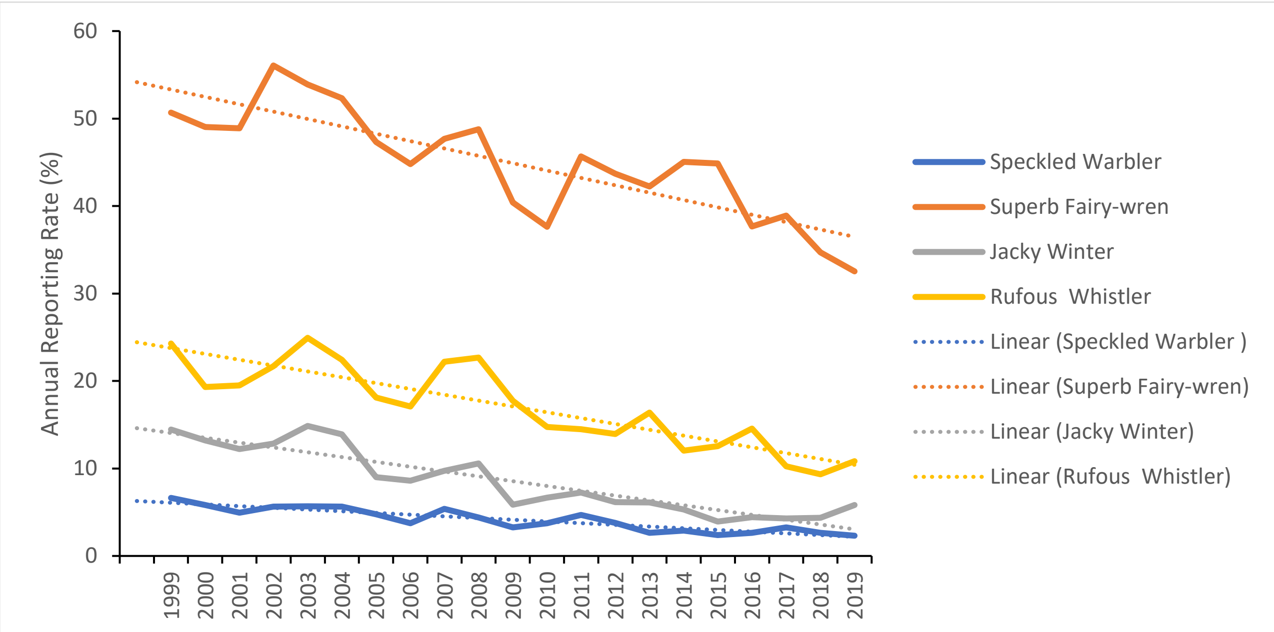

Figure 1. Variation in annual reporting rate of Superb Fairy-wren, Rufous Whistler, Jacky Winter and Speckled Warbler for the period 1999 to 2019 based on the combined results of Birdata 2-ha, 500-m and 5-km surveys.

The temporal trends of 17 of the 22 species evaluated were described by linear regression models with high values of the correlation coefficient r and statistically significant negative slopes $p<0.05$ (**Table 1**).

Table 1. Summary of population change statistics for 22 species of woodland birds with extensive distributions in the Hunter Region of NSW. Analysis based on the annual reporting rates for combined 2-ha, 500-m and 5-km Birdata surveys for the 21-year period 1999 to 2019.

Common Name	Scientific Name	Mean Annual RR (%)	Decadal Decrease RR (%)	Correlation Coefficient r
Superb Fairy-wren	*Malurus cyaneus*	42.4	15.3	0.84
Willie Wagtail	*Rhipidura leucophrys*	35.8	15.2	0.64
Grey Fantail	*Rhipidura rufifrons*	35.8	17.1	0.88
Magpie-lark	*Grallina cyanoleuca*	34.7	AM[1]	
Eastern Yellow Robin	*Eopsaltria australis*	23.2	13.8	0.68
Golden Whistler	*Pachycephala pectoralis*	22.7	13.2	0.60
Grey Shrike-thrush	*Colluricincla harmonica*	20.9	22.8	0.91
Eastern Spinebill	*Acanthorhynchus tenuirostris*	20.5	16.1	0.70
Red-browed Finch	*Neochmia temporalis*	19.6	25.9	0.89
White-throated Treecreeper	*Cormobates leucophaea*	18.2	15.6	0.84
Double-barred Finch	*Taeniopygia bichenovii*	15.4	30.0	0.72
Rufous Whistler	*Pachycephala rufiventris*	15.3	26.7	0.88
White-naped Honeyeater	*Melithreptus lunatus*	8.1	AM[1]	
Jacky Winter	*Microeca fascinans*	7.5	37.7	0.92
White-throated Gerygone	*Gerygone olivacea*	7.4	37.3	0.91
White-breasted Woodswallow	*Artamus leucorynchus*	5.8	AM[1]	
Speckled Warbler	*Pyrrholaemus sagittatus*	3.8	31.0	0.91
Varied Sittella	*Daphoenositta chrysoptera*	3.3	34.0	0.77
Dusky Woodswallow	*Artamus cyanopterus*	3.1	AM[1]	
Eastern Shrike-tit	*Falcunculus frontatus*	3.0	36.1	0.73
Pallid Cuckoo	*Heteroscenes pallidus*	2.1	43.0	0.81
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	1.4	NA[2]	

AM[1] – Better described by an alternative non-linear model
NA[2] - Not applicable because of the anomalous expansion of the Spiny-cheeked Honeyeater; see **Figure 6**.

Comparison of rates of population decrease

The decadal rates of decrease of 17 species are compared in **Figure 2**. Rates of decrease ranged from 13% for the Golden Whistler *Pachycephala pectoralis* to 43% for the Pallid Cuckoo. The rates of decadal decrease of seven species were in the range 13 to 17%. These rates were not significantly different from the rate of decrease of the Superb Fairy-wren, the most frequently recorded species. Ten other species decreased at decadal rates in the range 23% (Grey Shrike-thrush *Colluricincla harmonica*) to 43% (Pallid Cuckoo).

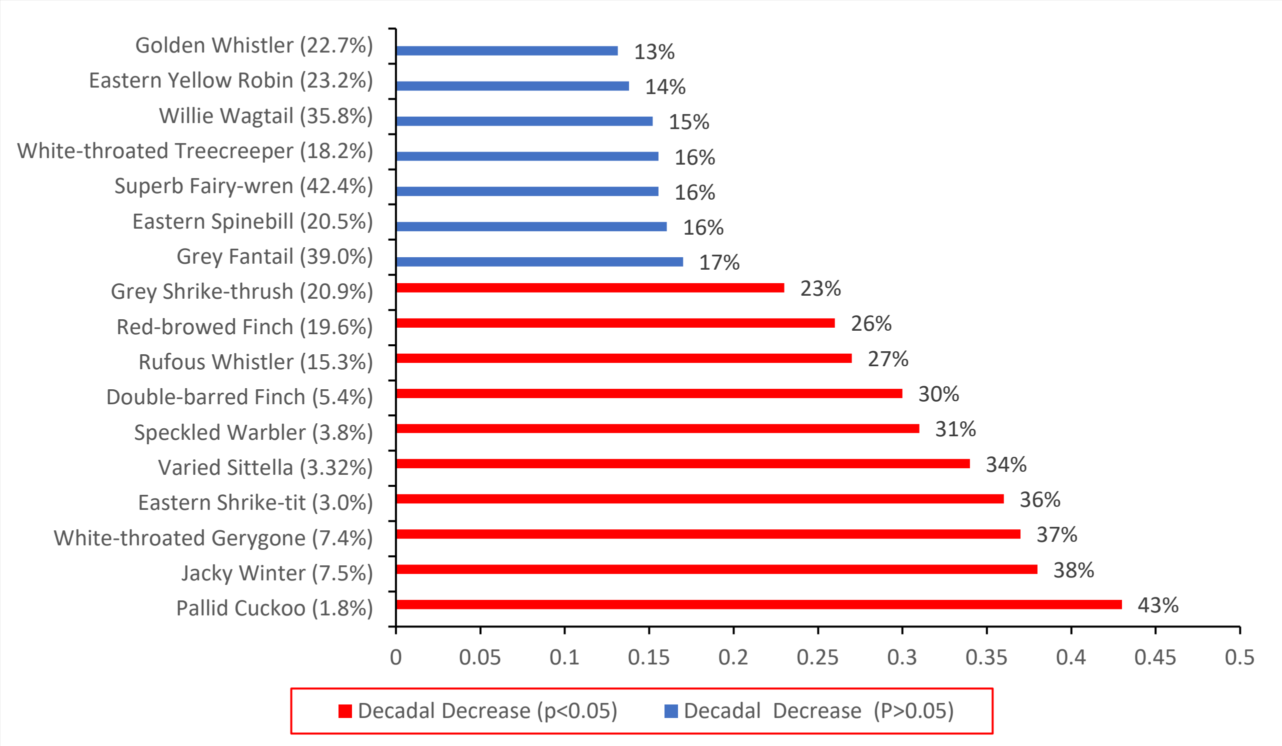

Figure 2. Comparison of the decadal decreases in the annual reporting rates of 17 species (the mean annual reporting rate of each species is shown in parentheses) of woodland birds in the Hunter Region for the period 1999 to 2019 based on the combined results of 2-ha, 500-m and 5-km surveys. The red bars indicate species which decreased at rates significantly different from the Superb Fairy-wren (p<0.05).

Species with non-linear Reporting Rate trajectories

The Dusky Woodswallow *Artamus cyanopterus* and White-breasted Woodswallow *A. leucorynchus* were among six species whose temporal trends were better described by non-linear relationships. The annual RR of the Dusky Woodswallow (**Figure 3**) varied in a complex manner, with peak occurrences in the periods 2001-07 and 2016-19. This is in contrast to the monotonic decreases exhibited by the Superb Fairy-wren and many other woodland species (**Figure 1**). The variation in the annual RR of White-breasted Woodswallow, a near-coastal species, was also complex (**Figure 3**). The trends in the RRs of the two Woodswallow species were similar between 2009 and 2019, but not in the previous decade.

The annual RR trends of the Magpie-lark *Grallina cyanoleuca* and White-naped Honeyeater *Melithreptus lunatus* differed from the linear trends of the Superb Fairy-wren and many other woodland species (**Figure 1**). Both species decreased between 1999 and 2010, before partially recovering during the following decade (**Figure 4**).

Figure 3. Variation in annual reporting rate of Dusky and White-breasted Woodswallows in the Hunter Region for the period 1999 to 2019 based on the combined results of Birdata 2-ha, 500-m and 5-km surveys. (Trend lines based on 3-year moving average.)

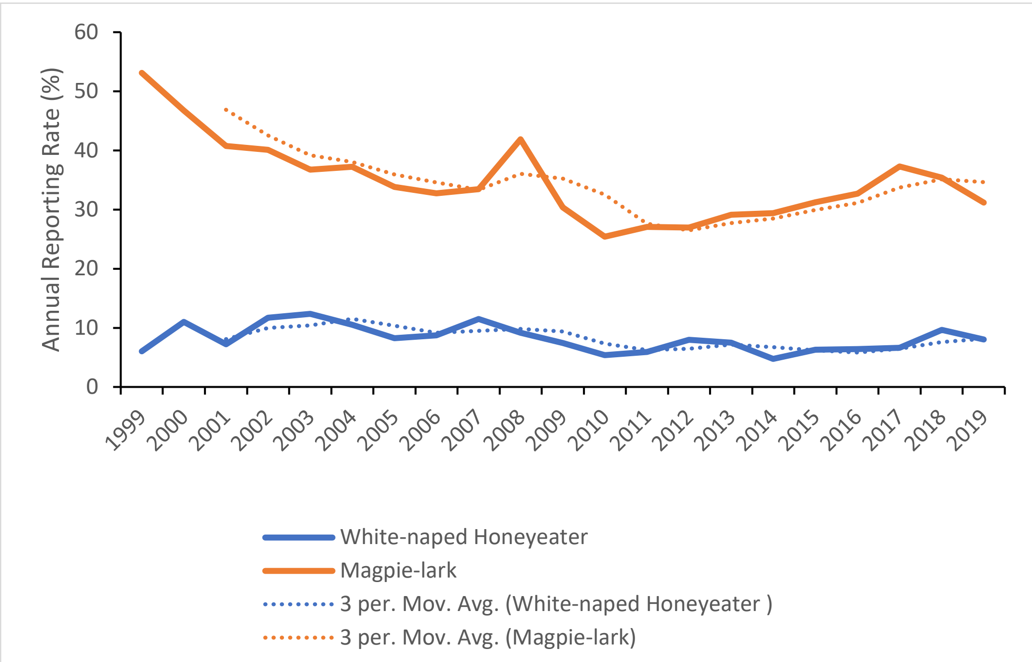

Figure 4. Variation in annual reporting rate of Magpie-lark and White-naped Honeyeater in the Hunter Region for the period 1999 to 2019 based on the combined results of Birdata 2-ha, 500-m and 5-km surveys. (Trend lines based on 3-year moving averages\.)

Although the Pallid Cuckoo was assessed in **Table 1** and **Figure 2** using a linear trend, its decrease occurred between 2000 and 2014. Since then, the annual RR has slightly increased (**Figure 5**).

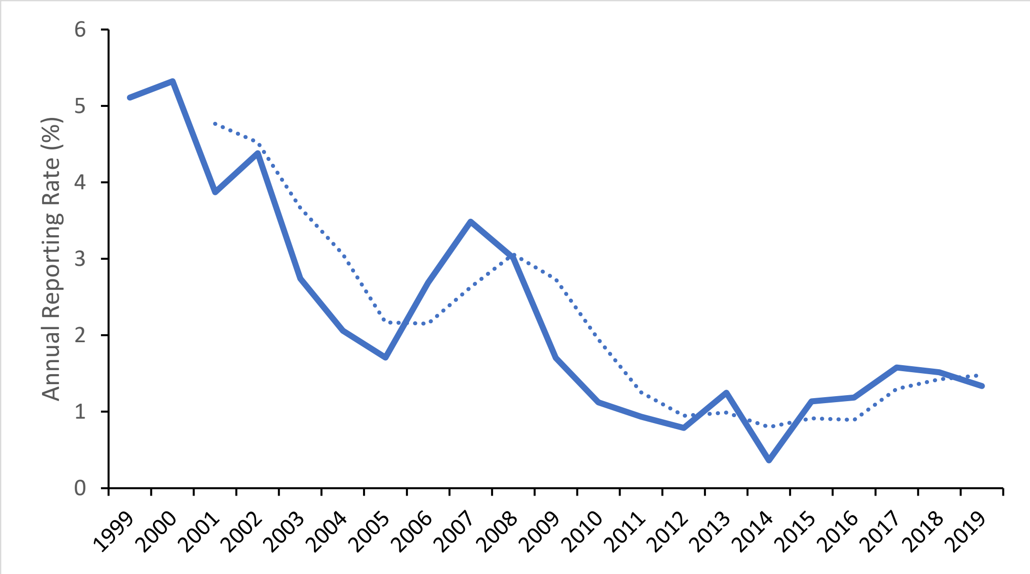

Figure 5. Variation in annual reporting rate of Pallid Cuckoo in the Hunter Region for the period 1999 to 2019 based on the combined results of Birdata 2-ha, 500-m and 5-km surveys. (Trend line based on 3-year moving averages.)

The Spiny-cheeked Honeyeater *Acanthagenys rufogularis* was first recorded regularly in the Hunter Region in 1999. Since then, its population has expanded increasingly rapidly (**Figure 6**) in contrast to all the other species which have decreased.

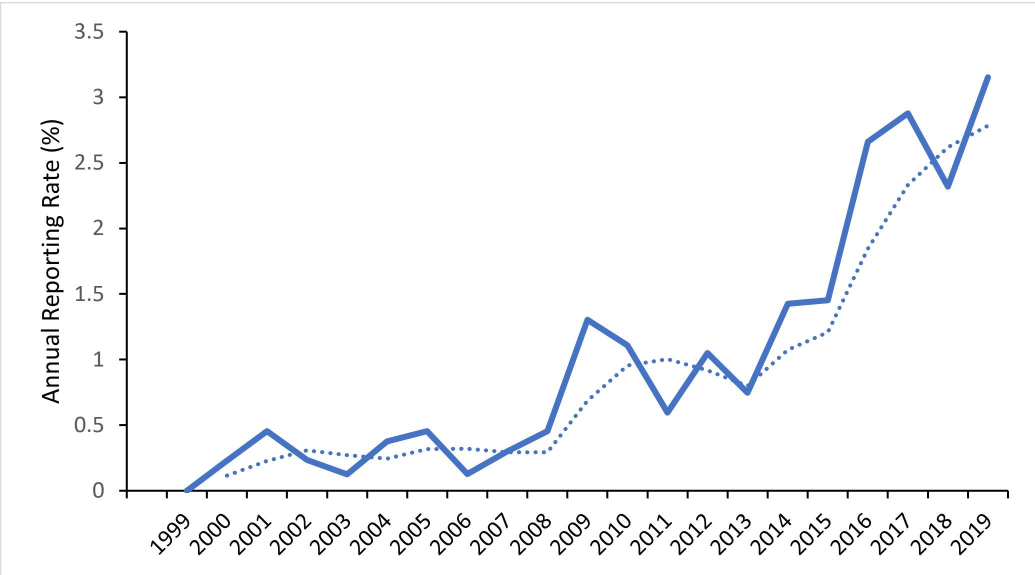

Figure 6. Variation in annual reporting rate of Spiny-cheeked Honeyeater in the Hunter Region for the period 1999 to 2019 based on the combined results of Birdata 2-ha, 500-m and 5-km surveys. (Trend line based on 3-year moving averages).

Correction for variation in survey type

There were large annual differences in the number and type of survey, as shown in **Figure 7**. Three phases of data collection are apparent. During the period of field work for the New Atlas (1999-2001) there was a relatively high proportion of 5-km surveys. When Birdata entered the bird-monitoring phase in 2002, the number of 2-ha and 5-km surveys decreased, but the number of 500-m surveys remained relatively stable. This situation persisted until 2008. During the next decade the number of surveys increased, ultimately by a factor of five, and predominantly involved increased numbers of 2-ha and 500-m surveys.

To assess how these variations in survey numbers and survey types were affecting the annual RR trends, the RR of three species were adjusted to their 2-ha-equivalent RR, as outlined in the Methods section. In each case the adjusted decadal decrease in RR was lower: Superb Fairy-wren 16% to 13%;

Rufous Whistler 27% to 24%; Jacky Winter 36% to 33%. Thus, variation in survey type between years seems to lead to only a small over-estimation of the rates of population decrease (in the relative percentage range 10 to 20%).

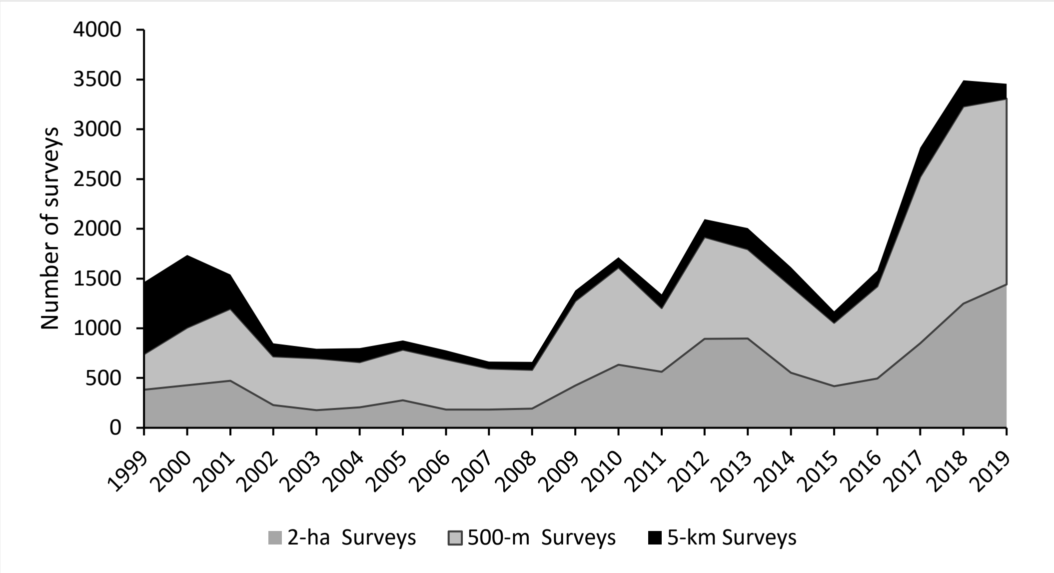

Figure 7. Variation in the number and proportion of 2-ha, 500-m and 5-km surveys conducted annually in the Hunter Region between 1999 and 2019.

DISCUSSION

The 21-year decrease in the annual RR of the Superb-Fairy wren equates to a decadal decrease of 16%. However, this decrease is subject to numerous sources of bias, which if corrected for might adjust the magnitude of that value. In addition to differences in survey type and duration, other factors to consider are annual variations in the representation of different habitat types, and the uneven distribution of survey activity across the Hunter Region. Sources of such bias include species-specific projects (e.g. Rufous Scrub-bird studies in the Gloucester Tops which commenced in 2010 (Newman *et al*. 2014), more intensive monitoring of areas near to where people live, and birdwatchers being attracted to areas of higher avian diversity.

The similarity in the 21-year RR trends of the Superb Fairy-wren and a number of other woodland birds with similar Hunter Region ranges was an expectation of this study, which compares changes in the RR rates of these species to the Superb Fairy-wren. Combining the results of 2-ha, 500-m and 5-km surveys enabled conclusions to be drawn about changes in the status of less common species, such as the Jacky Winter, Speckled Warbler *Pyrrholaemus sagittatus* and Pallid Cuckoo, by increasing the number and hence statistical power of their records (there were insufficient records of these species to draw meaningful conclusions using only 2-ha survey data).

Small woodland birds, including the Superb Fairy-wren, typically have generation times of three to four years (Bird *et al*. 2020). For these species, a sustained decrease in RR lasting two decades (i.e. about six generation times) is an indication that their populations are unstable at the landscape scale. It is normal for bird populations to experience short-term fluctuations in abundance (Newton 2013), but with a periodicity less than three generation times.

Species with sustained linear decreases in Reporting Rate

For seven of the 17 species showing long-term linear decrease in RR, their decadal declines were in the range 13 to 17%. These rates were not statistically different from that of the Superb Fairy-wren, the benchmark species. All seven species were frequently recorded, with mean RRs in the range 18% to 42%. They included species from a range of avian families, which adopt a variety of different foraging styles and have different ecological requirements.

The RRs for the other ten species decreased more rapidly, and at rates that were statistically significantly different from the Superb Fairy-wren. The Pallid Cuckoo, the species with the greatest change in RR, was decreasing in RR 2.7 times more rapidly than the Superb Fairy-wren. It also was the species with the lowest mean RR for the 21-year period. This exemplifies the tendency for the more rapidly decreasing species to be those which were already less common initially.

The shared long-term monotonic decrease in RR suggests that there is an environmental factor (or factors) which adversely affects all 17 species, but that some species are more impacted than others. Land clearing and increasing fragmentation of remnant vegetation are obvious possibilities, as is climate change, involving a tendency to increasingly dry and hotter conditions during the last two decades (Ehmke *et al*. 2015). It is beyond the scope of this paper to provide detailed explanations of the impact of these factors on individual species. The following discussion is limited to some generic possibilities.

Increasing fragmentation of remnant vegetation would be expected to have greater impact on the dispersal of species with specialized habitat preferences, providing a possible explanation of the higher rates of decrease found for species such as the Speckled Warbler. Mobile, opportunistic species, which exploit locally variable food resources (e.g. honeyeaters seeking flowering trees), might be less impacted. This could explain why the less common White-naped Honeyeater shows similar population resilience (i.e. has a similar decadal decrease) to more common species, such as the Superb Fairy-wren, but with different population dynamics.

Ecological specialization is another factor which may cause species to decrease their environmental resilience and be uncommon. For example, ground-feeding specialists such as the Red-browed Finch *Neochmia temporalis* and Double-barred Finch *Taeniopygia bichenovii*, as well as the Speckled Warbler, are all uncommon and decreasing more rapidly than the more common species.

For migratory species (e.g. Rufous Whistler *Pachycephala rufiventris* and Pallid Cuckoo), factors outside the Hunter Region may contribute to, or determine, regional population changes, thus explaining why some migrant species have population trajectories that are distinct from resident species.

Species with non-linear decrease in Reporting Rate

The non-linear variation of the annual RR of the Dusky Woodswallow suggests that the factors causing variations in its population size are different from those affecting the Superb Fairy-wren and the other woodland birds with decreasing linear RR trends. This proposition is supported by evidence of a strong northern seasonal movement along the east of Australia involving a shift between summer and winter population centres (Griffieon & Clarke 2002). Hence, although Dusky Woodswallow breed and occur throughout the year in the Hunter Region (Stuart 1993 – 2018), a large proportion of the Region's records may involve non-resident birds. Interestingly, the RR trend of the White-breasted Woodswallow, a summer visitor with a near-coastal distribution (Williams 2019), has also increased strongly during the last decade. As the RRs of both species, which forage insects on the wing, have increased during the last decade it is possible that recent conditions in the Hunter Region have favoured them.

In the case of the Pallid Cuckoo, it appears that the steep decrease in annual RR experienced in the first decade of this study has been arrested and that the species' status in the Hunter Region is now relatively stable, although less common than formerly. This is another example of a species with a complex migratory pattern (Griffieon & Clarke 2002) for which the Hunter Region is not core habitat (Newman 2019). Hence, external factors may have caused its status in the Hunter Region to change.

The Magpie-lark and White-naped Honeyeater are examples of species with populations that appear relatively stable, although subject to medium-term fluctuations. The resilience of these species may be associated with their life-style traits. For instance, the White-naped Honeyeater may be differentiated from other woodland species by its mobility as it seeks out and opportunistically exploits flowering gum and other food resources. Cursory inspection of Hunter Region Birdata records suggests that other honeyeater species may have similar RR profiles. Thus, the possible benefits from mobility warrant future investigation. Although requiring trees for nest sites, the Magpie-lark predominantly inhabits open areas, which may explain the difference between its population dynamics and species more heavily dependent on woodland habitat.

The Spiny-cheeked Honeyeater provides a rare example of a woodland bird which is increasing in the Hunter Region. It was first recorded in 2000 and the annual RRs have increased rapidly since that time. Two decades later, the annual RR continues to increase, probably associated with an ongoing extension of its range within the Hunter Region (Williams 2020).

Combining survey types

Interpretation of Hunter Region Birdata is complicated by many forms of bias, as outlined previously. Fortunately, annual variations in the numbers of surveys and the proportion of different survey types has small impact on the relative rates of change in annual RR between species when survey types are combined. The superior correlations for uncorrected RR trends (i.e. higher r values) suggest that the loss of statistical power (fewer records) outweighs the advantage of correction. This is an important conclusion, providing confidence in the approach used in this study in which the results of combined survey types were used to screen regional Birdata and identify species seriously impacted by environmental change.

Future directions

The approach used in this analysis only provides an indication of which species are most at risk. It is a screening process to identify priorities for future investigations. It is probable that the rates of decrease reported are somewhat over-estimated as shown when the 2-ha-equivalent survey correction was applied for three of the species. It is therefore important that the data are reassessed to eliminate biases in the raw results used for this analysis. The approach used by Ehmke *et al*. (2015) applying methods developed by Cunningham & Olsen (2009) should provide more accurate estimates for data-rich species, including the Superb Fairy-wren, the benchmark species in this study. The relative rates of decrease established in the present study can then be used to revise the estimates for less common species although it is possible that some species will prove to be too data deficient for detailed modelling. It is expected that the re-assessment will confirm the present conclusion, namely that many of the Hunter's woodland birds have decreased. A previous State of Australia's Birds assessment (Ehmke *et al.* 2015) indicated widespread decreases in the status of Australia's woodland birds.

The question is whether the more sophisticated analysis will substantially alter the present findings. The rates of decrease in RR from this study are cause for serious concern. The IUCN Red List process used in the Action Plan for Australian Birds (Garnett *et al*. 2011) considers species with decreases exceeding 30% in three generation times (e.g. c. 10 years for small woodland birds) to be vulnerable when the decreases are ongoing and their causes are uncertain. On the above basis, seven of the 17 species assessed in this study, i.e. those species which have decadal RR decreases of 30% relative or greater, might be considered regionally vulnerable. This concern is exacerbated by the fact that the linear declines in many of these species in NSW potentially extend back to at least 1986 (e.g. see trends for Jacky Winter, Varied Sittella *Daphoenositta chrysoptera* and Eastern Shrike-tit *Falcunculus frontatus* in Cooper *et al*. 2020).

This analysis evaluated a diverse range of species that are widely distributed in the Hunter Region and which are representative of a number of foraging guilds. The analysis should be expanded to include habitat specialists (e.g. rainforest species) and species with limited distribution ranges. For habitat specialists there may be advantages in restricting the analysis to the core range of the species and in using a reference species which is abundant within that particular habitat.

Woodland birds appear to be particularly vulnerable in the Hunter Region. Improved understanding of the life-style traits of species with relatively stable populations (e.g. White-naped Honeyeater) may provide insights into how woodland habitats can be better managed to halt, and ideally reverse, the decline of the less resilient species.

CONCLUSIONS

Comparing the relative rates of change in RRs has been demonstrated to be a valuable method of screening regional Birdata to identify changes in the status of individual species and highlight those most at risk. The approach is a powerful tool to assist local communities to understand and advocate for the conservation of local bird communities, a need recently highlighted in a recent forum article (Garnett 2020). The approach used here successfully combined 2-ha, 500-m and 5-km survey data to increase the number of records of uncommon species (e.g. Jacky Winter, Speckled Warbler and Pallid Cuckoo).

This analysis suggests that the RRs of the Superb Fairy-wren and many other woodland species have decreased alarmingly throughout the last two decades. Land clearing, excessive fragmentation of remnant woodland habitat and climate change are potential causes of the observed decreases. In general, the species which decreased most rapidly were already uncommon. It is tentatively suggested that such species are less versatile, have specialised ecological requirements and limited dispersal capability (Newman 2018). Inevitably, there will be species for which there are insufficient data to draw statistically confident conclusions concerning their status. In such instance species-specific studies will be required, as exemplified by the Rufous Scrub-bird monitoring project (Newman *et al*. 2014).

It is ironic that the species potentially at greatest environmental risk are less common and hence data deficient. A future challenge is to calibrate the relative rates of RR change identified in this paper in order to generate absolute estimates. This will require detailed modelling to correct the biases in the raw RRs of abundant species such as the Superb Fairy-wren, the base-line species used in this analysis. The use of standardised Birdata survey methods (e.g. 2-ha surveys only) is an important feature of such analysis (Cunningham & Olsen 2009; Emke *et al*. 2015). However, as demonstrated in this paper there are advantages in drawing on data from a range of survey types in order to understand the dynamics of diverse bird populations.

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As indicated by Garnett (2020), local groups must take ownership of the results of their field studies, including understanding the implications of their work; ultimately applying their findings to the conservation of local bird populations. This can only occur if they receive the generous support of professional experts, which I have received in preparing this paper.

REFERENCES

Barrett, G., Silcocks, A., Barry, S., Cunningham, R. and Poulter, R.E. (2003). 'The New Atlas of Australian Birds'. (Royal Australasian Ornithologists Union: Melbourne.)

Bird, J.P., Martin, R., Akçakaya, H.R., Gilroy, J., Burfield, I.J., Garnett, S.T., Symes, A., Taylor, J., Şekercioğlu, Ç.H. and Butchart, S.H. (2020). Generation lengths of the world's birds and their implications for extinction risk. *Conservation Biology* DOI: 10.1111/cobi.13486.

Clarke, M.F., Griffieon, P. and Lyon, R.H. (1999). Where do all the bush birds go? Supplement to *Wing Span* 9, Number 4.

Cooper, R.M., McAllan, I.A.W., Brandis, C.C.P. and Curtis, B.R. (2020). 'An Atlas of the Birds of NSW and the ACT, Volume 3'. (New South Wales Bird Atlassers Inc.: Woolgoolga, NSW.)

Cunningham, R. and Olsen, P. (2009). A statistical methodology for tracking long-term change in reporting rates of birds from volunteer-collected presence-absence data. *Biodiversity Conservation* **18**: 1305-27.

Ehmke, G., Cunningham, R., O'Connor, J., Garnett, S.T., Lau, J. and Herman, K. (2015). 'The State of Australia's Birds 2015: Headline Trends for Terrestrial Birds'. (BirdLife Australia: Carlton, Vic.)

Garnett, S.T., Szabo, J.K. and Dutson, G. (2011). The action plan for Australian Birds 2010. (CSIRO Publishing: Collingwood, Australia.)

Garnett, S.T. (2020). Towards protection of locally significant species. *Emu* **120**: 100-101.

Griffieon, P.A. and Clarke, M.F. (2002). Large scale bird-movement patterns evident in eastern Australia atlas data. *Emu* **102**: 99-125.

Newman, M., Stuart, A. and Hill, F. (2014). Rufous Scrub-bird *Atrichornis rufescens* monitoring at the extremities of the species' range in New South Wales (2010-2012). *Australian Field Ornithology* **31**: 77-98.

Newman, M. (2018). Winners and Losers – Changes in bird population on removing cattle from woodland near Paterson, NSW. *The Whistler* **12**: 7-15.

Newman, M. (2019). Why is the Pallid Cuckoo declining in the Hunter Region, but relatively stable in Tasmania? *The Whistler* **13**: 69-80.

Newton, I. (2013). 'Bird Populations.' *The New Naturalist Library* **124**. (William Collins, London, UK.)

Stuart, A. (Ed.) (1993-2018) Hunter Region of New South Wales Annual Bird Report Numbers 1 to 25 (1993-2017). (Hunter Bird Observers Club Inc.: New Lambton, NSW.)

Williams, D. (2019). Hunter Region of New South Wales Annual Bird Report Number 26 (2018). (Hunter Bird Observers Club Inc.: New Lambton, NSW.)

Williams, D. (2020). Expansion in the range of the Spiny-cheeked Honeyeater in the Hunter Valley – an example of the use of time-variant maps to study Hunter Region species. *The Whistler* **14**: 46-47.