



LONG-TERM TRENDS IN ACT WOODLAND BIRDS 1998–2019

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Abstract

A major analysis of twenty-one years of systematic bird monitoring data was undertaken by the Canberra Ornithologists Group (COG) in collaboration with the ACT Government and the Australian National University (ANU). Guided by the Project Team and Dr Rayner this analysis looked at long-term trends in: (i) species richness, (ii) individual land-based birds, and (iii) 12 bird groups of interest across the ACT. This report outlines significant trends and key results for the ACT woodland bird community; a list of Conservation Priority Species has been compiled and presented.

From 1998 to 2019, survey data were collected at 142 woodland sites in 15 woodland locations across the ACT. Data for 168 individual bird species were interrogated for analysis, and long-term modelling was possible for 164 species. This included land-based birds (129 species) and water-based birds (39 species), however, this report focusses on land-based birds only.

The analysis revealed no significant change in species richness through time, or across woodland bird monitoring locations. Of the 129 land-based species analysed, 56 species had statistically significant trends in reporting rate; 32 species showed long-term decline and 24 species showed long-term increase. There are some unexpected results, such as declining trends for some species that are regarded as common.

Of the 12 bird groups analysed, 7 groups showed statistically significant changes through time. There was a significant increase in the reporting rate of large-bodied birds, and birds associated with degraded woodland communities. There was a significant decrease in the reporting rate of small-bodied birds, canopy feeders, ACT woodland-dependent birds, and ACT species of conservation concern.

Although no statistical analysis was performed on the relationship between various population indices and weather, an inspection of annual weather records suggests a role of climate and weather in shaping ACT woodland bird population reduction and growth. The woodland analysis includes survey data from periods of drought (1998 to 2009) and significant rainfall (2010 to 2012), which may have been the drivers of short-term change in reporting rates for some species. Weather-related responses of individual species were not consistent.

This report validates widespread concern for ACT woodland-dependent birds as a vulnerable community group. It raises conservation concern for small-bodied birds, particularly insectivores and canopy feeders. It is argued that declining common birds (both migratory and resident) require ongoing assessment in terms of monitoring their population status and their habitat extent and condition. Increasing numbers of large-bodied birds, and species associated with degraded woodland communities, have implications for urban planning into greenfield sites and buffer areas.

Lastly, this report serves as a support tool for land managers through the identification of Conservation Priority Species that arguably require immediate protection and conservation attention. In some cases, strategic restoration planning to improve woodland condition and arrest current rates of decline may be necessary to avoid future local extirpation events.

1. Background

1.1. The Woodland Bird Monitoring Project

The primary aim of the Woodland Bird Monitoring Project was to develop a statistically robust monitoring program to measure the abundance of birds through time at grassy woodland locations in the ACT (see Cunningham 2003 and Bounds *et al.* 2010). A priority feature of the sampling design was to establish survey sites on-reserve and off-reserve to assess the effectiveness of the ACT reserve network for conserving woodland birds (see Rayner *et al.* 2014).

COG has implemented the Woodland Bird Monitoring Project since 1995, commencing at Mulligans Flat Nature Reserve (then leasehold land). Locations have been added to the Project since its inception, including 5 locations in 1998, and 9 locations between 2000 and 2005. In total, there are 142 monitoring sites, nested within 15 broad ACT locations (Appendix A), all occurring in Yellow Box-Blakely's Red Gum grassy woodland — a critically endangered ecological community. All survey locations are in peri-urban Canberra and include ACT Nature Reserves, rural leasehold properties, and quasi-conservation areas not in the ACT reserve system (Commonwealth Department of Defence land). Four locations have changed tenure during the survey period, from leasehold to Nature Reserve.

A core purpose of the Woodland Bird Monitoring Project is to provide recommendations for land management based on monitoring results. Survey data from the Woodland Bird Monitoring Project have been analysed on several occasions previously, examining trends in reporting rate for a range of bird species. Previous reports published on the [COG website](#), including Bounds *et al.* 2010 and Taws *et al.* 2012, provide additional background information and site details. A Ten-year Analysis of bird survey data (1998 to 2008) was undertaken in 2009 (Bounds *et al.* 2010) and multiple project reports have been published in COG's journal *Canberra Bird Notes*, available on the [COG website](#).

This report presents major results from the analysis of survey data collected over the period March 1998 to September 2019; a period of twenty-one years and six months. The intention was to undertake an analysis once the majority of survey locations had at least 20 years of monitoring data.



Goorooyarroo Nature Reserve - view to Gungahlin suburbs

1.2. Scope of the Analysis

Questions for the analysis were developed by the Project Team and focussed on long-term trends in woodland bird detections. This investigated:

- **changes in species richness** to broadly assess community condition
- **individual species trends** to assess conservation status of woodland birds, and
- **composite trends for bird groups of special interest** to inform targeted conservation work.

It should be noted that the overall focus of the analysis, as determined by the Project Team, was on questions of conservation management relevance. It is not based on pure ecological criteria, which an academic study might focus on. This is particularly relevant to the analysis of bird groups outlined later in this report. The Project Team also considered it important to look at the analysis results in the context of weather patterns experienced during the analysis period, therefore supporting weather data are provided in Appendix B, and discussed where relevant.

The analysis was constrained by available time and funding for a professional analyst. Suggested questions for future projects using this dataset are presented in the Conclusion/Recommendation section of this report. An exhaustive report of statistical outputs is not presented here, and further interpretation of results may be undertaken.



Newline Quarry woodland

2. Methods

2.1. Bird Surveys

Bird survey data are collected on sites of 50-metre radius (*c* 0.8 hectares) within grassy woodlands. Ten of the 15 survey locations have 9 sites each, one has 8 sites, and 3 locations have 6 to 7 sites (Table 1). All survey locations are categorised into low, medium, and high habitat structure (*sensu* Bounds *et al.* 2010) to allow for an overall representation of the location. Mulligans Flat Nature Reserve surveys commenced in 1995 with 24 sites; these sites were selected to represent three habitat types: grassy woodland on flats, dry forest on low ridges, and areas at the ecotone of these communities.

Bird surveys are undertaken seasonally, with 4 surveys per year at each site. Each quarterly survey period varied slightly prior to 2003, when it was standardised to a 9-day survey window capturing two weekends at the end of March, June and September, and the end of November/beginning of December. While not encouraged, surveys can be undertaken within a week either side of the quarterly survey window. This gives the survey coordinators and teams some flexibility, many of whom have undertaken the surveys at their sites since establishment.

Surveys are carried out in the early part of the morning, with a 10-minute observation period at each site. All surveys are undertaken by experienced observers in fair weather. The species and number of birds (seen or heard) is recorded. Birds seen or heard up to 100 metres outside the site are also recorded (i.e. 50 to 100 metres from the centre of the site), however, only bird data collected inside the 50-metre radius sites were statistically analysed for this report.



Restless Flycatcher

2.2. Survey Sites

Survey locations and their management histories in this report (Table 1) are described in detail in the Ten-year Analysis Report (Bounds *et al.* 2010).

Table 1. Locations and date range of woodland bird survey data included in analysis, 1998-2019. "NR" is *Nature Reserve*.

* indicates sites managed primarily by Department of Defence.

Location	Number of sites	Survey period
Hall Common/Gold Creek (grazed leasehold) (HAL)	9	2000 to 2019
Mulligans Flat NR (MUL)	24	1998 to 2019
Goorooyarroo NR – North (GOO)	9	1998 to 2019
Goorooyarroo NR – South (GOS)	9	2004 to 2019
Mt Majura NR (MAJ)	9	1998 to 2019
Mt Ainslie NR/Campbell Park (CMP)	9	2003 to 2019
Symonston (Callum Brae NR/Isaacs Ridge NR) (SYM)	9	6 sites: 1998 to 2019 3 sites: 2004 to 2019
Jerrabomberra West NR (JER)	7	2006 to 2019
Red Hill NR (RED)	9	1998 to 2019
Kama NR (KAM)	9	2005 to 2019
Tuggeranong Hill NR (TUG)	7	2000 to 2019
Newline Quarry woodland* (NLQ)	9	2000 to 2019
Majura Training Area (MJF)*	8	1998 to 2000 2004 to 2019
Castle Hill (grazed leasehold) (CAS)	9	1998 to 2019
Naas Valley (grazed leasehold) (NAS)	6	2004 to 2019

2.3. Bird Groups

The Project Team identified 12 bird groups (below) of conservation interest to be analysed for long-term change. Collectively, groups included 125 species, and their allocation is shown in Appendix C. The method used for allocation is defined below. All bird species are allocated to at least one bird group, and bird species can be allocated to more than one bird group.

1. ACT woodland-dependent species: 48 species

There was no standard list of ACT bird species regarded as 'dependent on woodlands' to use as the basis for analysis. The Project Team considered various criteria for determining the species for this group, and individuals in the Project Team developed their own lists, some with criteria stricter than others. This included definitions of 'woodland conservation dependency', 'substantial dependency on woodlands', and 'not living outside woodland structure'. After the Project Team considered various approaches, it was agreed to base this group on a strict premise, 'if woodlands were removed these species would not occur'.

2. South-east woodland-dependent species: 49 species

This group was adopted from Fraser *et al.* (2019) and includes species considered part of the woodland bird community for the temperate south-east mainland eco-region of Australia by 70% of ornithological experts. Of six eco-regional variants, the 'south-east woodland-dependent' group was the most relevant to the ACT region, but differs from the 'ACT woodland-dependent' group determined by the Project Team (above). For example, the 'south-east woodland-dependent' group includes a number of species that occur in ACT forest (dry and wet) structures as well as ACT grassy woodlands (e.g. Brown Thornbill, Spotted Pardalote, White-browed Scrub-wren, White-eared Honeyeater and White-throated Treecreeper), which did not meet strict criteria for 'ACT woodland-dependent'.

3. Degraded woodland community: 10 species

This group was also adopted from Fraser *et al.* (2019). All but one species in this group (Pied Butcherbird) are common in the ACT. The 9 species common in the ACT are not habitat specialists and are generally tolerant of the ACT's urban related environments, e.g. Australian Magpie, Galah, Noisy Miner. The Pied Butcherbird is uncommon in the ACT but is increasing, and considered at the margin of its distribution, the core range being further inland in more open, agricultural, and drier habitats.

4. ACT threatened species: 11 species

This group comprised species listed as threatened under ACT legislation (*Nature Conservation Act 2014*) that were recorded in the Woodland Bird Monitoring Project. Of these, five species are also listed under Commonwealth legislation (*Environment Protection & Biodiversity Conservation Act 1999*).

5. Species of conservation concern: 14 species

This group is based on the local bird knowledge of the Project Team. The group includes some bird species on the ACT threatened list, particularly resident/sedentary species, and others considered to be in very low abundance, thought to be declining, and/or possibly at risk of moving into a threatened category.

6. Canopy feeding species: 24 species

The Project Team considered various criteria for the canopy feeding group. Reference was made to habitat assessment criteria based on structural elements developed for assessing habitat at monitoring sites by Alison Rowell (Rowell 2004; Bounds *et al.* 2010). It was decided to use vegetation structure over two metres as 'canopy'. This could include tall shrubs such as acacias, tall eucalypt re-growth, small and large trees. Birds were allocated based on their primary (but not exclusive) use of this structure for foraging.

7. Mid-storey feeding species: 3 species

This category is defined as species which use up to two metres of the shrub and eucalypt layer, based on Alison Rowell's habitat assessment criteria (Rowell 2004). Few species fit this category with only 3 species identified to primarily use the mid-storey for foraging: Buff-rumped Thornbill, Dusky Woodswallow, and Yellow Thornbill.

8. Ground feeding species: 17 species

The Project Team determined the criteria for the ground feeding group based on ground-layer substrates, such as grasses (short and tall), leaf litter, low-lying debris, forbs and very low shrubs. The ground feeding group includes some birds in low abundance or of conservation concern, such as three robins and two native finches. Only one large-bodied bird was included in this group: White-winged Chough.

9. Woody weed frequent species: 16 species

This group is known to occupy woody weed structures for food, shelter, or nesting as determined by the local knowledge of the Project Team. Common woody weeds found in ACT woodlands include Sweet Briar/Briar Rose, Blackberry, Hawthorn, African Boxthorn, Cotoneaster, and Firethorns. Birds in this group include a mix of 10 small-bodied species (e.g. finches and wrens) and 6 large-bodied species.

10. Small woody weed frequent species: 10 species

This group comprises the 10 small-bodied species (< 70 g) of birds from the 'woody weed frequent' group. Woody weeds may have an important function for small birds in the absence of native shrubs. At some woodland sites, woody weeds are the only or predominant "shrubs", and their removal has implications for the protection and conservation of cover-dependent birds.

11. Small-bodied species: 74 species, and (12) Large-bodied species: 52 species

Birds were analysed as either small-bodied (< 70 g) or large-bodied (> 70 g) based on body mass measured in grams. The 70 g cut-off reflects the body size of Noisy Miners (71 g). Additional cut-offs were tested (50 g and 100 g), but effects of body size were robust to these small variations in classification. The 70 g class showed the clearest difference in group response.

2.4. Data Analysis

For the analysis, trends in *Species Richness* are derived from the number of species detected at each bird survey, whilst trends in *Individual Species Reporting Rate* (hereafter *Individual Species*) are derived from the detection (presence/absence) of an individual species at each bird survey thereby adjusting for any differences in survey effort between years. The reporting rate is the number of surveys in which a species was recorded out of the total number of surveys for that season. The effect on *Species Richness* and *Individual Species* of the following factors was modelled:

- **Time** – the effect of each year spanning 1998 to 2019 (21 years)
- **Location** – representing the 15 locations at which bird surveys took place, and
- **Site** – representing the 142 survey sites, nested within *Location*.

All survey data were checked to ensure that 'true-zero' observations were included; that is, those surveys in which no birds were observed. All water-based bird species (39 species) were omitted from analysis because site locations do not adequately represent their habitat. Survey effort was consistent across all seasons through time, such that trend profiles for migratory birds are robust to detection bias and presented in this report.

Below, the methods for calculating Individual Species Trends, Rates of Change, and Composite Trends for Bird Groups are outlined. Readers seeking further details of analysis may contact COG, see the [COG website](#) for email contact.



Weebill

2.4.1. Individual Species Trends

Detections for individual species were used to model the trends of birds through time. Both generalised additive models (GAM), and generalised additive mixed models (GAMM), were fitted to individual species detections data, providing a smoothed (non-linear) trend line. To test whether there was an overall increase or decrease in detections of individual species from 1998 to 2019, generalised linear models (GLM), and generalised linear mixed models (GLMM), were fitted to individual species detections, providing a straight (linear) trend line.

Interpreting Trend Plots

Adopting the method of Bounds *et al.* (2010), plots for individual species show both non-linear and linear trends with associated confidence intervals (indicating significance of the trend pattern), as well as the raw data. Plot elements should be interpreted as follows (see Figure 1):

1. mean reporting rate in each quarter-yearly survey (thin black line)
2. smoothed *GAM/M* trend line showing short-term change in reporting rate (purple line)
3. 95% confidence intervals of the smoothed trend (purple shading)
4. sections of significant rate of change in the smoothed fit (positive is blue, negative is red)
5. predicted straight *GLM/M* trend line fit (green dashed line)
6. 95% confidence intervals of the linear trend (green shade)
7. P-values of the *GAMM* and *GLMM* indicating trend significance ($P < 0.05$ is significant), and
8. a representation of survey effort in each quarter-yearly survey (red bars below main plot); the maximum number of surveys conducted in a quarter was 236.

For all plots, predicted trends for individual species detections were transformed from their original scale of proportions (0 – 1) to percentages (0 – 100). The percent scale (y-axis) should be interpreted as the mean percent of surveys in which a species is predicted to be present. When reporting significant trends in Individual Species only the straight *GLM/M* trend line fit is referred to.

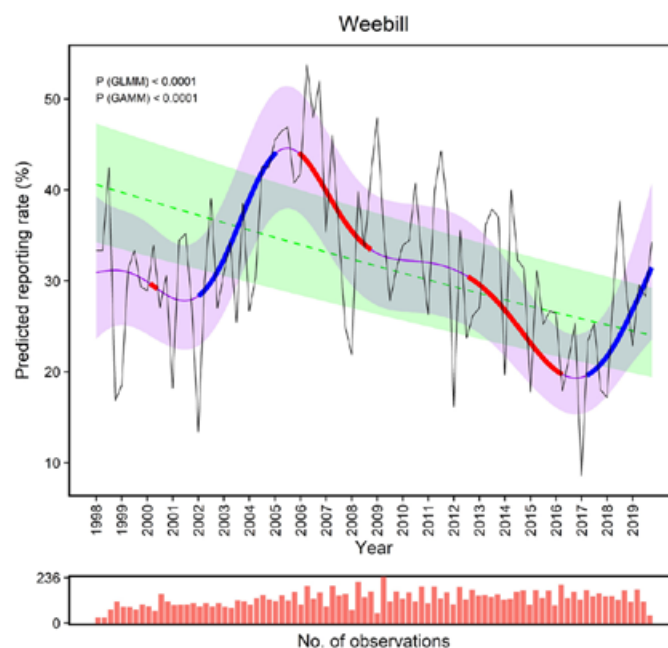


Figure 1. Example *Trend Plot* for interpreting individual species results.

2.4.2. Rate of Change (ROC)

For each species reporting rate fit, the time in which there was significant increase or decrease in the rate of change (ROC) in the smoothed trend was determined by calculating the first derivative and its associated point-wise confidence intervals. Values were calculated for each quarter year, and only significant values were plotted.

Interpreting ROC Plots

To visualise increases and decreases in the rate of change for multiple species, including bird groups, “ROC plots” were created. As per *Individual Species Trend Plots*, sections of significant rate of change in the smoothed fit are shown in blue for positive change and in red for negative change (Figure 2).

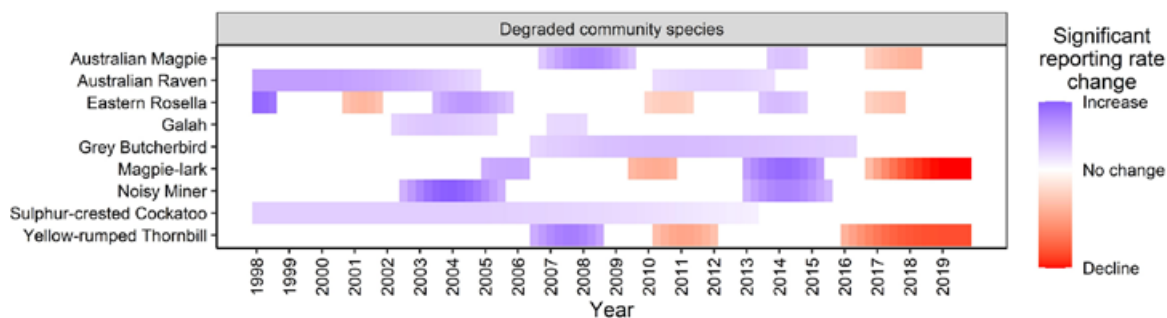


Figure 2. Example *ROC Plot* for interpreting significant periods of change across multiple species

2.4.3. Composite Trends for Bird Groups

To test whether birds of a particular grouping ($n = 12$, described above) showed common linear trends from 1998 to 2019, a guilds analysis was conducted on linear trend results from the individual species analysis described above. To do this, a new variable representing the time-effect (i.e. trend) for each species was fitted against the two-level factor (included or not) for each bird group.

Interpreting Effects Plots

Summary effect size plots, showing the magnitude of change for individual bird species, are provided. For individual species and bird groups, only species that have shown significant change through time are plotted. Plot elements should be interpreted as follows (Figure 3):

1. a decreasing trend is displayed left of the neutral (dotted) line
2. an increasing trend is displayed right of the neutral (dotted) line
3. the size of the dots represents the relative reporting rate of each species over all surveys, i.e. species with larger points are reported more often than species with smaller points, and
4. lines through the points are confidence intervals, which indicate how reliable the mean effect size is (the longer the line, the more variable or sparse the data are).

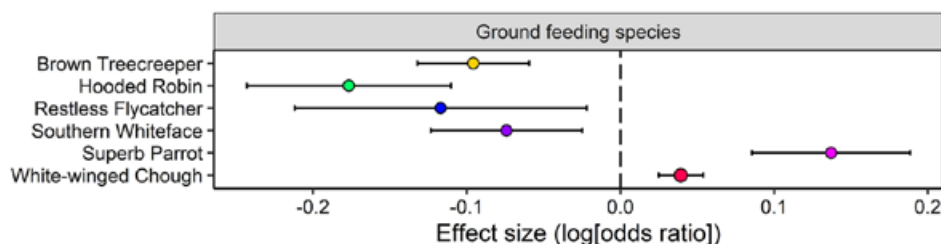


Figure 3. Example *Effects Plot* for interpreting bird group results. Note: colours are for contrast only.

3. Results and Discussion

The analysis incorporated 10,728 surveys undertaken at 142 sites between 1998 and 2019. The number of bird surveys completed per site ranges from 52 to 92 over the observation period (Appendix D). Bird data for 129 land-based woodland bird species (water-based birds excluded) were analysed.

3.1. Species Richness

The analysis showed no significant change in species richness from 1998 to 2019 across woodland bird monitoring sites (Figure 4). There were significant (but small: average 1–2 species) decreases in species richness from 1999 to 2001 and from 2015 to 2019, possibly reflecting significantly drier than average years (Appendix B).

When additional years of data are analysed, it will be interesting to see if the downward trend from 2015 to 2019 continues or not, noting that 2020 had significantly higher than average rainfall (Appendix B) and may signal a positive change in patterns.

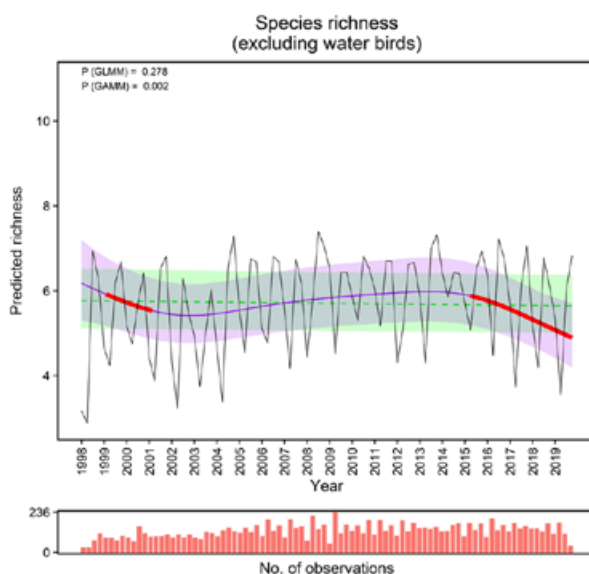


Figure 4. Trend in species richness at 15 woodland locations from 1998 to 2019

3.2. Individual Species

Long-term trends in reporting rate were calculated for 129 land-based woodland species, of which 73 species showed no significant trend pattern, and are not individually discussed. In some cases, non-significant trend results may be due to limitations of the project sampling design. For example, no raptors showed statistically significant trends, likely because the within-site (50 m) survey methodology is not effective for measuring the abundance of raptors (a more targeted sampling design is needed).

Significant trends – either an increase or decrease – were observed for 56 species (see Table 2 below and Appendix E). Table 2 provides an overview of significant trend patterns, and linear effects were plotted on one large effects plot in order of magnitude from greatest decrease to greatest increase (Figure 5). To visualise whether decreases or increases in the rate of change of the non-linear (smoothed) trends were correlated across several species, the rates of change were plotted on a ROC Plot, provided in Appendix F.

3.2.1. Decreasers

Thirty-two species showed a statistically significant decrease in reporting rate over the analysis period (Table 2). Twenty-eight are native species, and include seasonal migrants¹, residents, and a range of sizes of birds (21 small-bodied: < 70 g, and 7 large-bodied: > 70 g). Some of these birds are thought by observers to have declined at some woodland sites or occur in very low numbers at sites (e.g. White-plumed Honeyeater, Southern Whiteface, Crested Shrike-tit). However, the long-term decline of some species was unexpected to the Project Team, including the following 16 species generally regarded as common:

- | | | |
|----------------------|---------------------------|-------------------------|
| ■ Tree Martin | ■ Striated Thornbill | ■ Western Gerygone |
| ■ Fuscous Honeyeater | ■ Weebill | ■ Striated Pardalote |
| ■ Pallid Cuckoo | ■ Yellow-rumped Thornbill | ■ Leaden Flycatcher |
| ■ Dollarbird | ■ Rufous Whistler | ■ Buff-rumped Thornbill |
| ■ Superb Fairy-wren | ■ Willie Wagtail | ■ Grey Fantail. |
| ■ Mistletoebird | | |

3.2.2. Increases

Of the 24 species that showed increasing trends (Table 2) most are common, large-bodied birds, adapted to urban environments (i.e. habitat generalists). However, the list of increasers does include 5 small-bodied birds that occur in ACT lowland and mountain forests, as well as woodland habitats (i.e. not strictly woodland-dependent); for example, Golden Whistler, White-eared Honeyeater, and Brown Thornbill.

3.2.3. Consistent linear changes

Species that showed steady, consistent decreases over every year in the analysis period were:

- | | | |
|-----------------------|--------------------|--------------------|
| ■ Hooded Robin | ■ Pallid Cuckoo | ■ Grey Currawong |
| ■ Tree Martin | ■ Dollarbird | ■ Western Gerygone |
| ■ Restless Flycatcher | ■ Rufous Whistler. | |

Species that showed steady, consistent increases over every year in the analysis period were:

- | | | |
|--------------------|--------------------------|-----------------------|
| ■ Rainbow Lorikeet | ■ Gang-gang Cockatoo | ■ White-winged Chough |
| ■ Satin Bowerbird | ■ Australian King-Parrot | ■ Crimson Rosella |
| ■ Little Corella | ■ Australian Raven. | |

¹ *Seasonal migrant* refers to a species that has constant and regular movements, moves into the ACT over the spring and summer months (for breeding), and moves out of the ACT for the cooler months to other locations, e.g. north, coastal. This is distinct from an *altitudinal migrant*, which moves within the local area, breeds in upland forests, and moves to lower and milder altitudes in autumn/winter (including to lowland woodlands).

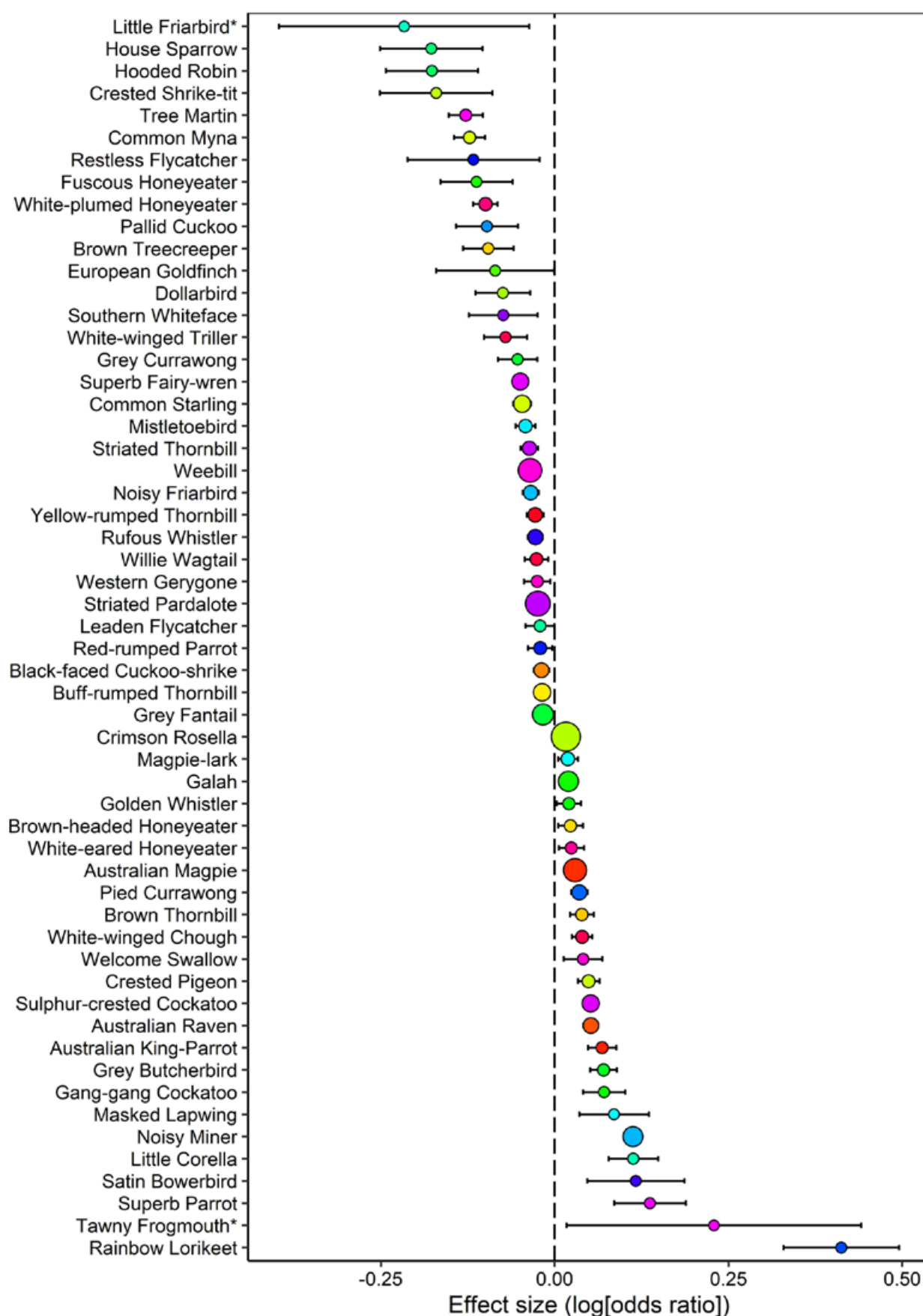


Figure 5. Summary *Effects Plot* showing the magnitude of change in the occurrence of individual bird species that have shown a significant trend pattern. Species marked with an asterisk (*) were rare with fewer than 10 detections over the analysis period.

Table 2. Trend summary for individual species that showed significant change over the analysis period (1998–2019). Species marked with an asterisk (*) show consistent significant inter-annual trend effects, i.e. significant annual decrease or increase in every year of the analysis period. Mean site-level reporting rate (RR) is presented for the first year (1998) and last year (2019) of the analysis to provide indication of linear change through time.

Species name	No. Records	1998 RR (%)	2019 RR (%)	P value	Trend description
DECREASERS <i>Greatest to least</i>					
Little Friarbird	7	0.25	0.00	0.008	Seasonal. Very low RR, most years with no records. Significant decline over the analysis period.
House Sparrow	89	0.23	0.01	< 0.001	Low RR. Significant decline over the analysis period, few records in the last 10 years.
Hooded Robin*	74	0.62	0.02	< 0.001	Low RR declining to very low. Significant steady decline 1998–2014 after which there were no records.
Crested Shrike-tit	44	0.66	0.02	< 0.001	Low RR. Slight peak in 2006, then significant decline 2007–2013 after which there were no records.
Tree Martin*	1,439	2.8	0.20	< 0.001	Seasonal. Medium RR declining to low. Significant decline 1998–2011. Still declining after this but at a less significant rate.
Common Myna	1,171	3.10	0.24	< 0.001	Medium RR declining to low. Significant decline 1999–2002, then increase to a slight peak in 2006, followed by significant decline to 2012. Small increase 2014–2016, then another decline from 2018. Overall downward trend.
Restless Flycatcher*	17	0.36	0.03	0.016	Low RR, more than half the years with no records. Significant decline over the analysis period.
Fuscous Honeyeater	265	1.12	0.11	< 0.001	Seasonal. Low RR. Significant decline 1999–2002. Small increase 2004–2006 followed by significant decline 2009–2010 and ongoing slow decline since.
White-plumed Honeyeater	1,723	5.48	0.71	< 0.001	Medium RR declining to low. Significant decline 1998–2002 then slight increase 2003–2005. Further significant declines 2007–2009 and 2012–2015. Still declining after this but at a less significant rate.
Pallid Cuckoo*	77	1.44	0.19	< 0.001	Seasonal. Low RR. Significant steady decline over the analysis period.
Brown Treecreeper	222	0.36	0.05	< 0.001	Low RR declining to very low. Significant decline from 2011 onwards.
European Goldfinch	59	0.29	0.05	0.048	Sparse observations. Slow marginally significant decrease over the analysis period.
Dollarbird*	127	1.20	0.25	< 0.001	Seasonal. Low RR declining to very low. Significant steady decline over the analysis period.

Table 2 — continued

Species name	No. Records	1998 RR (%)	2019 RR (%)	P value	Trend description
Southern Whiteface	178	0.46	0.10	0.003	Low RR. Significant decline 2009–2014.
White-winged Triller	241	2.44	0.56	< 0.001	Seasonal. Medium-low RR. Significant decline 1998–2000. Small but significant increase in 2010–2011 followed by decline 2013–2014.
Grey Currawong*	201	1.12	0.37	< 0.001	Low RR declining to very low. Significant steady decline over the analysis period.
Superb Fairy-wren	6,535	14.28	5.57	< 0.001	Medium RR. Significant decline 2000–2006, significant increase 2008–2011 followed by significant decline 2013–2019 to give an overall declining trend.
Common Starling	9,547	12.15	4.91	< 0.001	Medium RR. Two periods of significant declines; 1999–2002 and 2010–2012, each followed by 2 years of significant increase; 2003–2005 and 2013–2015. Overall downward trend.
Mistletoebird	900	6.53	2.81	< 0.001	Seasonal. Medium RR. Significant declines in 2000–2001 and 2014–2019 give an overall declining trend.
Striated Thornbill	3,519	6.24	3.00	< 0.001	Medium RR declining to low. Significant decline in 2005–2008 followed by a small but significant increase 2010–2012 then another decline 2014–2017.
Weebill	8,949	40.58	24.49	< 0.001	High RR with large fluctuations. A significant increase in 2002–2005 followed by two periods of significant decline 2006–2009 and 2012–2016, then a significant increase 2017–2019. Overall declining trend.
Noisy Friarbird	1,786	11.70	6.03	< 0.001	Seasonal. Medium RR. Significant decline 1998–2002, followed by significant increase 2004–2006, then ongoing declines, significant in 2009–2011 and 2016–2019.
Yellow-rumped Thornbill	3,941	10.23	5.94	< 0.001	Medium RR. Significant increase 2006–2008 followed by significant declines 2010–2012 and 2016–2019, with an overall declining trend.
Rufous Whistler*	1,631	10.14	5.91	< 0.001	Seasonal. Medium RR. Significant steady decline across the analysis period.
Willie Wagtail	730	3.66	2.15	0.003	Medium to low RR. Significant decline 1998–2002. Non-significant downward trend since.
Western Gerygone*	440	2.33	1.39	0.009	Seasonal. Low RR. Significant steady decline over analysis period.
Striated Pardalote	8,866	42.15	30.45	< 0.001	High RR. A significant increase 1998–2000, followed by a short but significant decline 2001–2002. Another increase 2003–2005 then a significant decline 2010–2013. Overall declining trend.

Table 2 — continued

Species name	No. Records	1998 RR (%)	2019 RR (%)	P value	Trend description
Leaden Flycatcher	386	2.34	1.52	0.048	Seasonal. Low RR. Significant decline 1998–2002.
Red-rumped Parrot	2,143	1.74	1.13	0.019	Low RR. Significant decline 1998–2006.
Black-faced Cuckoo-shrike	1,657	12.42	8.66	< 0.001	Seasonal. Medium RR. Two periods of significant decline; 1998–2002 and 2015–2019.
Buff-rumped Thornbill	7,199	12.14	8.64	< 0.001	Medium RR. Two periods of significant decline; 2000–2002 and 2014–2019.
Grey Fantail	5,088	26.35	20.11	< 0.001	Seasonal. High RR. Significant decline 1998–2000, significant increase 2009–2012, followed by another decline 2013–2016.
INCREASERS <i>Greatest to least</i>					
Rainbow Lorikeet*	285	0.00	0.64	< 0.001	Low RR. First records not until 2008 but significant increase since then.
Tawny Frogmouth	7	0.00	0.24	0.034	Very low RR. First records in 2013. Significant increase since then.
Superb Parrot	168	0.02	0.30	< 0.001	Seasonal. Low RR. First records in 2005 and a significant increase from then until 2012.
Satin Bowerbird*	44	0.01	0.14	0.001	Low RR. First records in 2000 then sporadic until 2011. Significant increase over the period 2000–2019.
Little Corella*	376	0.12	1.24	< 0.001	Low RR. Significant steady increase from first records in 1999 to 2019.
Noisy Miner	7,985	2.97	24.49	< 0.001	Low RR increasing to high. Two periods of significant increase 2002–2008 and 2012–2016 giving a strong upward trend.
Masked Lapwing	250	0.00	0.02	0.001	Very low RR. Significant increase 2007–2010.
Gang-gang Cockatoo*	342	0.07	0.30	< 0.001	Low RR. Slight but significant increase in RR over the analysis period.
Grey Butcherbird	443	1.07	4.51	< 0.001	Low RR increasing to medium. Significant steady increase 2004–2019.
Australian King-Parrot*	1,036	0.39	1.60	< 0.001	Low RR. Significant steady increase over the analysis period.
Australian Raven*	2,528	6.12	16.26	< 0.001	Medium RR. Significant steep increase over the analysis period.
Sulphur-crested Cockatoo	4,576	7.08	18.39	< 0.001	Medium RR. Significant steady increase 1998–2013. Still increasing to 2019 but non-significant.
Crested Pigeon	1,259	1.93	5.20	< 0.001	Low RR increasing to medium. Significant increases 2002–2005 and 2006–2009 to a peak, then significant decrease 2010–2013 before another significant increase 2014–2018.

Table 2 — continued

Species name	No. Records	1998 RR (%)	2019 RR (%)	P value	Trend description
Welcome Swallow	569	0.56	1.30	0.004	Low RR. Significant increase 2009–2013 then significant decline 2015–2019. Overall subtle, significant increase across the analysis period, most likely due to rainfall response.
White-winged Chough*	3,613	2.26	5.01	< 0.001	Low RR increasing to medium. Significant steady increase over the analysis period.
Brown Thornbill	760	1.58	3.52	< 0.001	Low RR. Steady until small but significant increase 2008–2012.
Pied Currawong	2,319	4.74	9.48	< 0.001	Low to medium RR. Steady until a small but significant increase 2012–2015, then small but significant decrease 2017–2018.
Australian Magpie	6,884	23.96	36.79	< 0.001	Medium RR increasing to high. Steady then significant increases in 2006–2010 and 2014 followed by significant decline 2016–2019. Overall significant linear increase across the analysis period.
White-eared Honeyeater	429	1.81	2.96	0.010	Mostly seasonal. Low to medium RR. Small but significant increase 2006–2009, small but significant decrease 2014–2017. Overall slightly increasing trend.
Brown-headed Honeyeater	1,251	1.49	2.38	0.013	Low RR. Slight increase, (significant only in 2012) through to a peak in 2014, significant decrease 2016–2019. Overall subtle, significant linear increase across the analysis period.
Golden Whistler	484	2.43	3.68	0.024	Mostly seasonal. Low to medium RR with two peaks, 2003 and 2013. Significant changes before and after these peaks, but an overall increasing trend.
Galah	6,453	17.16	23.90	< 0.001	Medium RR increasing to high. An initial significant decline 1998–2000, followed by significant increases between 2002–2008 and an ongoing upward trend.
Magpie-lark	1,411	3.39	4.98	0.008	Low RR increasing to medium. Slightly increasing trend overall with two peaks in 2008 and 2016 with significant changes before and after these peaks.
Crimson Rosella*	14,130	43.16	51.62	< 0.001	High RR. Significant steady increase over the analysis period.

3.2.4. Increasers of interest

Increases in these species are of ecological relevance: a substantial increase in the resident Noisy Miner, and colonisation in recent decades by Rainbow Lorikeet and Little Corella.

Noisy Miner

Noisy Miners showed a significant six-fold increase in reporting rate over the analysis period. This species is an aggressive, medium-sized, colonial honeyeater known to exclude or suppress small birds. There is widespread concern about these impacts, with culling programs implemented across many areas of the Australian temperate zone. Further research is needed to inform Noisy Miner management programs in the ACT.

Rainbow Lorikeet

Rainbow Lorikeets showed a significant increase in the analysis. This is a nectar-feeding parrot typically associated with coastal habitats, and first observed in the ACT around 1986 (Canberra Ornithologists Group). In many parts of Australia, Rainbow Lorikeets are considered an invasive species and, while their reporting rate is low in the ACT, its increase is consistent and statistically reliable.

Little Corella

Little Corellas showed a slight but steady and significant increase in reporting rate over the analysis period. This is a ground feeding, flock species of cockatoo that is very common in open, inland habitats, and has been increasing in the ACT since around 1990 (Canberra Ornithologists Group).

3.2.5. Decreasers of interest

Two small, canopy feeding honeyeaters which have a wide distribution/range outside the ACT are highlighted. The White-plumed Honeyeater is a resident breeder in ACT lowland woodland, and the Fuscous Honeyeater a breeder in mid-altitude woodland.

White-plumed Honeyeater

White-plumed Honeyeater showed an overall decrease of concern. Before 2002, there is a strong decline, and a more gradual decline in the trend since then, to a low level of abundance (Appendix E). This is a widely distributed honeyeater, common along inland river systems. In the ACT, they have been considered a fairly common species, largely sedentary, resident in woodlands as well as parklands with mature eucalypts. The species has been thought by observers to have reduced in numbers or disappeared from some woodland sites, and the analysis result confirms this.

Fuscous Honeyeater

Fuscous Honeyeater showed an overall decrease, with a very low reporting rate since 2011 (Appendix E). The decline is of concern, particularly as the species' core ACT habitat is in the southern half of the ACT where it breeds, at mid-altitude open woodlands in valleys and on footslopes. This area was impacted by bushfires in 2003 and 2020. Some seasonal movement is known in cooler months to ACT peri-urban woodlands where there are nectar sources.

Table 4 has further examples of species with significant decreases.

3.2.6. Reporting rate change and weather

The end of the Millennium Drought (2009) with a period of significantly higher than average rainfall (2010–2012) was a notable event in the analysis period, but most ACT bird species did not show a sustained population-level response (Appendix E).

Some species showed a significant increase in reporting rate from 2010 to 2012 despite decreasing overall over the period 1998 to 2019, such as Grey Fantail, Striated Thornbill, Superb Fairy-wren and White-winged Triller. This could be explained as a positive short-term response to the higher than average rainfall over those years, although seasonal and monthly rainfall was variable (Appendix B). For others, like the Brown Treecreeper and Crested Shrike-tit, their long-term decline was not interrupted by the breaking of the drought.

For the increaser species, there are some species which showed a significant reporting rate increase over the years 2010 to 2012, for example Noisy Miner, Brown Thornbill, Golden Whistler, Pied Currawong and Welcome Swallow, due to a short-term response presumably related to the higher rainfall over that period. The reporting rates of Crested Pigeon and Magpie-lark decreased temporarily at the breaking of the drought, then continued to increase in subsequent years.

Brown-headed Honeyeater, a species showing a small overall increase over the period 1998 to 2019, showed a slight increase in reporting rate during the Millennium Drought, a more significant increase over 2011 to 2012, with a marked decline from 2016, a drier period. This suggests the species is stable overall at ACT woodland sites and appears to tolerate drier conditions; perhaps indicating it is less dependent on nectar sources than other honeyeaters.

3.2.7. Seasonal migrants

The only seasonal (or partial) migrants that showed a significant increase are Welcome Swallow and Superb Parrot. Twelve seasonal migrants (see below) showed decreases; of which 11 are common species that breed in ACT woodlands (excludes Little Friarbird). Trends in seasonal migrants are variable and not clearly explained by local weather.

- Rufous Whistler
- Leaden Flycatcher
- Dollarbird
- Mistletoebird
- Tree Martin
- Pallid Cuckoo
- Noisy Friarbird
- Little Friarbird
- Black-faced Cuckoo-shrike
- White-winged Triller
- Western Gerygone
- Grey Fantail.



Brown-headed Honeyeater

3.2.8. Resident species

Of the 22 resident species that showed a significant increase, 18 are large-bodied species. Of the small-bodied species, two are altitudinal migrants in the ACT (Golden Whistler, White-eared Honeyeater). Weebill and Buff-rumped Thornbill are examples of small, resident species that showed a significant variation, but an overall decrease, in their reporting rates. Significant drops in the reporting rate of Buff-rumped Thornbill appeared to coincide with drier than average periods (e.g. 2000–2003 and 2014–2019), whereas changes in the reporting rate for Weebill do not appear weather-related. The large-bodied Grey Currawong showed a decreasing trend. This species is resident in woodlands. They are at some woodland sites in fairly low numbers, as breeding pairs.

3.2.9. Non-native species

No non-native species were found to have increasing trends. Of the 7 non-native species, 4 showed significant decreases: House Sparrow, Common Myna, European Goldfinch and Common Starling. The remaining 3 are marginal woodland species. Although records are few, the Common Blackbird showed a decline with a positive response with the breaking of the Millennium Drought.

3.3. Bird Groups

Seven bird groups showed significant trends over the analysis period (Figure 6). This included:

- an increase in large-bodied birds, and birds associated with degraded woodland communities, and
- a decrease in small-bodied birds, canopy feeders, south-east Australian woodland birds, ACT woodland-dependent birds, and ACT species of conservation concern.

There was no collective trend in threatened species, ground feeders, or birds associated with woody weeds (all species or small-bodied species). Models did not converge for mid-storey feeders due to sparse data. Additional information showing the magnitude of (significant) change for individual species in a bird group is provided in Appendix G.

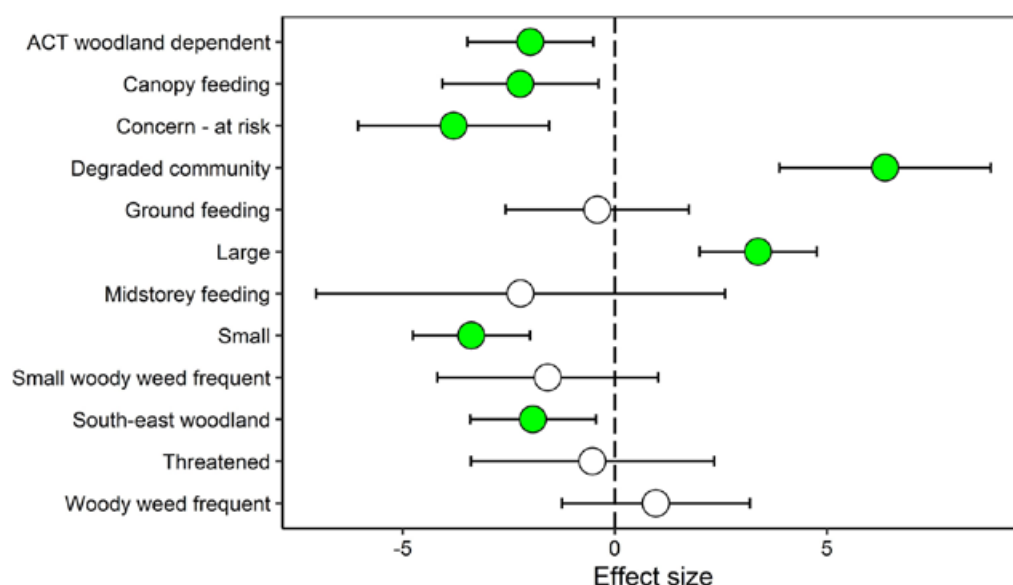


Figure 6. *Effect size plot* for bird groups of interest. Points to the right of the zero line represent that species in that group have collectively increased over time (1998 to 2019), and points to the left of the zero line represent that species in that group have collectively decreased over the time. Bird group trends that are statistically significant are shown in green.



Kama Nature Reserve woodland in autumn

3.3.1. ACT woodland-dependent species

For this group (48 species; Appendix C), a decrease in reporting rate was statistically significant (Figure 6). A similar result was observed for the south-east Australian woodland group (49 species) despite allocation differences for 29 species. Of the 48 species in the ACT woodland-dependent group, 25 species showed a significant trend. Of these 25 species, 21 showed decreases, and 4 showed increases (Brown-headed Honeyeater, Grey Butcherbird, Noisy Miner and Superb Parrot).

3.3.2. Degraded woodland community

This group showed a significant increase across ACT woodland monitoring sites (Figure 6). Of the 10 species in the degraded woodland community group, 2 (Eastern Rosella and Pied Butcherbird) did not show any significant trend. Seven species showed a significant increase, and the Yellow-rumped Thornbill (a small-bodied bird) was the only species that showed a decrease (Appendix G). A general increase in birds associated with a degraded woodland bird community across the analysis period may be indicative of degradation or simplification of important woodland bird habitats. Investigations into woodland condition within the monitoring survey extent could assist land managers in determining if and where restoration action is needed.

3.3.3. Canopy feeding species

The significant decrease in canopy feeders (Figure 6) as a collective was unexpected; there were no obvious indications to observers prior to the analysis. The canopy feeding group (24 species) includes insectivores and nectar feeders, and one specialist feeder (Mistletoebird). Species in this group were various sized honeyeaters, resident and seasonal species, and a range of common species (Figure 7). Despite this mixture, however, rates of change among canopy feeders showed some similarity through time, with multiple group members showing higher reporting rates in 2003–2004 and lower reporting rates since 2015 (Figure 8).

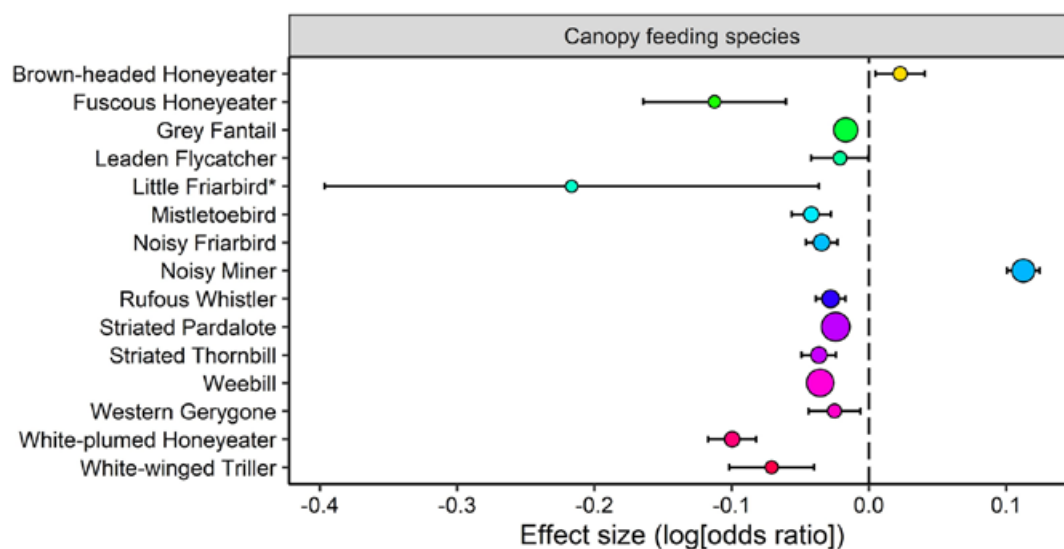


Figure 7. *Effects Plot*: Significant trends in canopy feeding species

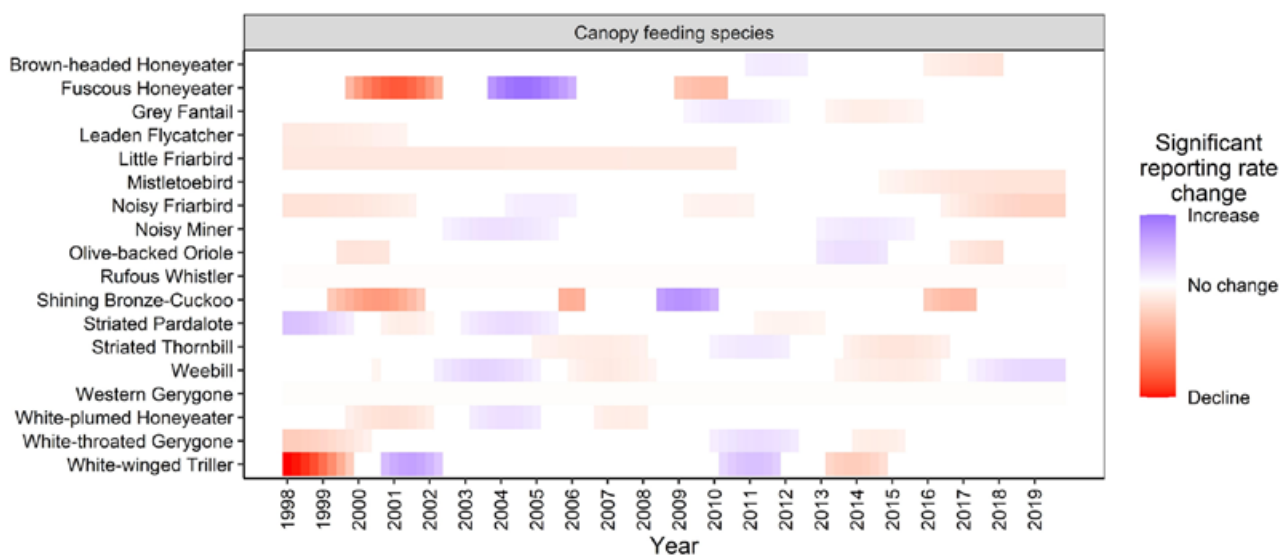


Figure 8. *ROC Plot*: Periods of significant reporting rate change for canopy feeding species

3.3.4. Ground feeding species

Ground feeders (17 species) comprised mostly small-bodied birds and showed no significant collective change in reporting rates (Figures 6, 9). Previous analyses (Bounds *et al.* 2010), and anecdotal information, suggest ground feeders may be of conservation concern. This was based on factors such as increasing weather variability, overgrazing by native herbivores, deterioration of ground layer quality and diversity, and weeds invasion. Furthermore, a number of ground feeding species showed declining trends in previous analyses, or have very low numbers in the ACT region. With an additional 10 years of data, ground feeders as a collective appear relatively stable.

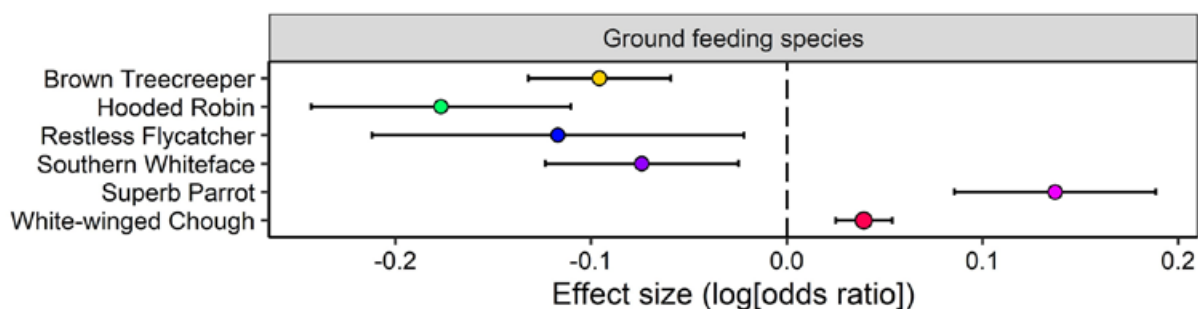


Figure 9. *Effects Plot*: Significant trends in ground feeding species

3.3.5. Woody weed frequent species

Woody weed frequent birds (16 species) showed no significant collective trend (Appendix G). Among the small woody weed frequent birds, 4 were decreasing: European Goldfinch (non-native), Red-rumped Parrot, Southern Whiteface, and Superb Fairy-wren. Where the removal of woody weeds is deemed necessary, land managers should first determine whether the area is occupied by any of the native declining species and, where present, additional measures (e.g. staged or supplementary habitat plantings) should be undertaken to mitigate potential negative impacts of habitat removal.

3.3.6. ACT Threatened species

Birds listed as threatened in the ACT (11 species; Table 3) did not show a consistent collective trend (Figure 10). The analysis showed 4 threatened species with statistically significant trends: 3 with decreasing reporting rates (Brown Treecreeper, Hooded Robin and White-winged Triller) and one with an increasing reporting rate, Superb Parrot. It is worth noting that the Superb Parrot and White-winged Triller are highly mobile species, and seasonal breeding migrants (or partial migrants) in the ACT. Their numbers are likely influenced by seasonal conditions within and outside of the ACT.

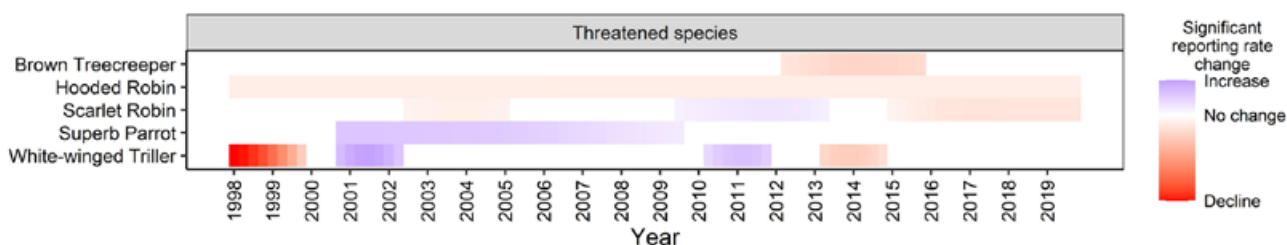


Figure 10. *ROC Plot*: Periods of significant reporting rate change for threatened species

Table 3. ACT threatened species, their listing source, and trend result. Species with significant trends are shown in bold. Asterisk (*) indicate rare species that are not resident in ACT woodlands.

Species	Listing	Trend
Brown Treecreeper	ACT	Decrease
Hooded Robin	ACT	Decrease
Little Eagle	ACT	No trend detected
Painted Honeyeater*	Commonwealth and ACT	n/a
Rainbow Bee-eater	Commonwealth and ACT	No trend detected
Regent Honeyeater*	Commonwealth and ACT	No trend detected
Scarlet Robin	ACT	No trend detected
Superb Parrot	Commonwealth and ACT	Increase
Swift Parrot*	Commonwealth and ACT	No trend detected
Varied Sittella	ACT	No trend detected
White-winged Triller	ACT	Decrease

Brown Treecreeper & Hooded Robin

Brown Treecreeper and Hooded Robin are flagship woodland-dependent species and ACT listed threatened species, in very low abundance in ACT woodlands, and have disappeared over time from peri-urban woodland sites. These species have been in steady decline as shown in previous analyses (Bounds *et al.* 2010, Bounds 2007). This analysis confirms significant, steady, ongoing declines. These species appear unable to take advantage of and recover with what would typically be considered favourable weather conditions (e.g. higher rainfall periods), possibly due to their now very small sub-populations and factors relating to habitat loss and fragmentation. The ROC Plot result (Figure 10) for Hooded Robin is of note; a consistent, small decline over every year in the analysis.



Superb Parrot

Superb Parrot

Superb Parrot showed a significant increasing trend (Figure 10, Table 3) driven by a jump in reporting rates from 2005 to 2012 (Figure 11). While their reporting rate remains below 1% on woodland sites, this trend corresponds to increased sightings of the species across Canberra, from small numbers known historically to breed around northern ACT. At the present time, there are at least two breeding colonies established in ACT peri-urban woodland. Local research on Superb Parrots suggests their increasing trend may be climate related.

Scarlet Robin

Scarlet Robin did not show a statistically significant trend. However, for Scarlet Robin short-term changes in reporting rate appear to reflect wetter and drier periods; i.e. decrease over the Millennium Drought to 2008, and some recovery to 2014 coinciding with higher rainfall over 2010 to 2012 (Figure 11). As such, the species appears to have some ability to recover their abundance over a breeding season following high rainfall.

Of concern is the marked decrease in reporting rate of Scarlet Robin since 2014 (mostly drier than normal years), to the lowest reporting rate in 21 years of woodland monitoring. The Scarlet Robin was listed as an ACT threatened species in 2015, based on COG's Ten-year analysis (Bounds *et al.* 2010) and other supporting data, which showed a gradual, steady decline.

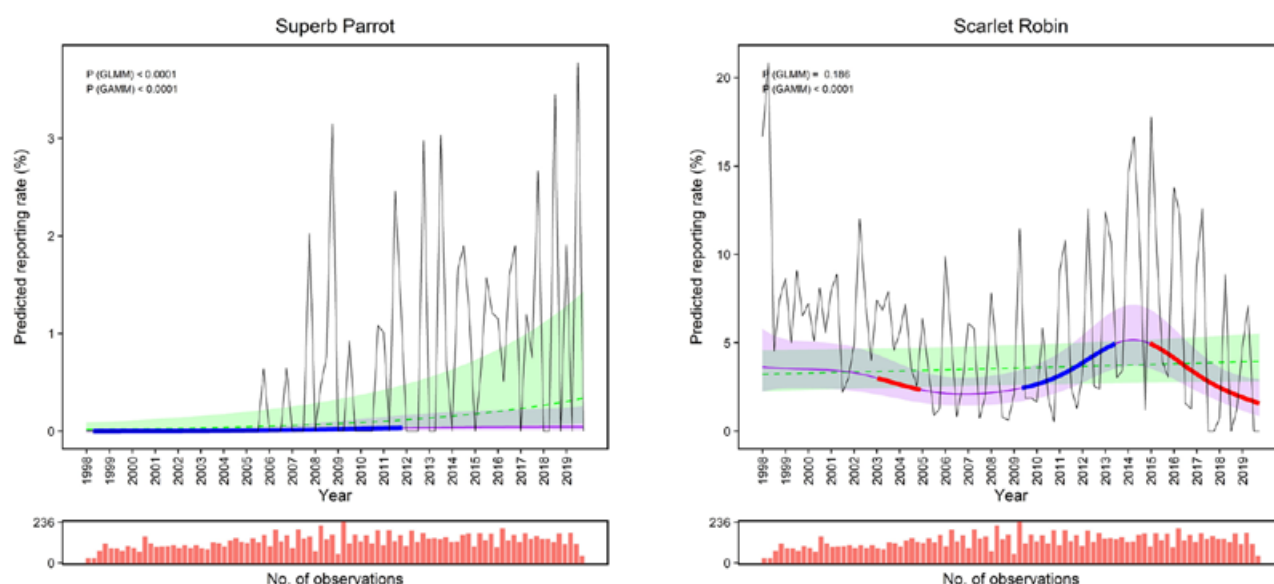


Figure 11. Species trend plots for the Superb Parrot and Scarlet Robin

3.3.7. Species of conservation concern

The result for this group (14 species) is a significant collective decrease, and the effect size is the largest of the declining bird groups (Figure 6). The 8 species with significant trends showed decreases (Table 4). A further 5 species showed large confidence intervals, reflecting low abundance/sparse data. Eleven species (including the 8 decliners) showed variable periods of change (Figure 12). However, Hooded Robin, Restless Flycatcher and Tree Martin all showed consistent declines in every year of the analysis. Five species in this group that are of interest to bird observers due either to their patchy distribution or infrequent detection are Southern Whiteface, Diamond Firetail, Double-barred Finch, Jacky Winter and Flame Robin.

Table 4. Species of concern (at risk) and their trend results. Species with significant trends are shown in bold. Asterisk (*) indicate rare species and/or sparse data.

Species	Trend
Brown Treecreeper	Decrease
Crested Shrike-tit*	Decrease
Diamond Firetail	No trend detected
Double-barred Finch	No trend detected
Flame Robin*	No trend detected
Hooded Robin	Decrease
Jacky Winter *	No trend detected
Mistletoebird	Decrease
Painted Button-quail *	No trend detected
Restless Flycatcher	Decrease
Scarlet Robin	No trend detected
Southern Whiteface	Decrease
Tree Martin	Decrease
White-plumed Honeyeater	Decrease

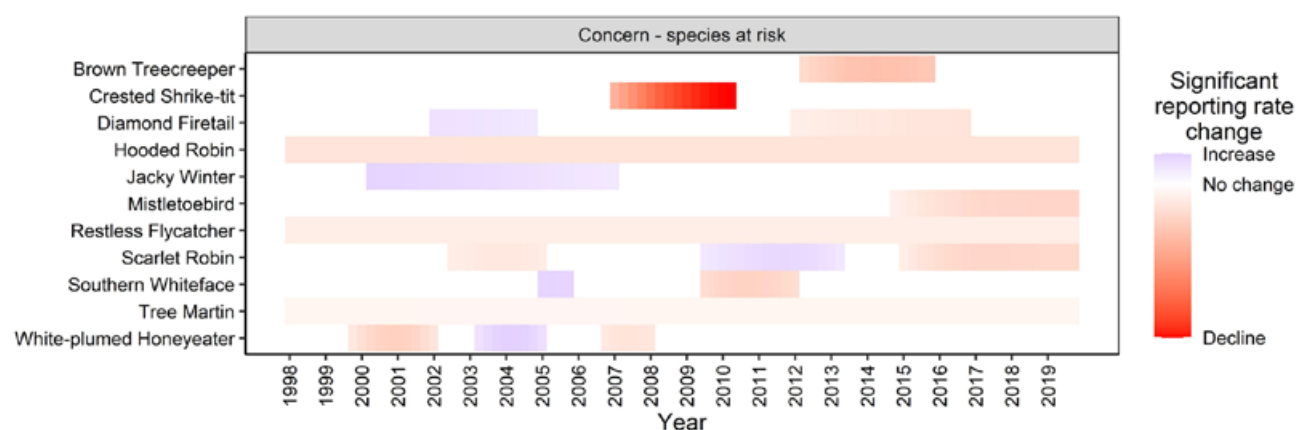


Figure 12. ROC Plot: Periods of significant reporting rate change for species of concern

Southern Whiteface

Southern Whiteface showed very low reporting rates, a small but significant decrease in trend overall, and a wide range in the confidence interval, reflecting the very low numbers at woodland sites. Southern Whiteface is a ground feeder, usually recorded in open sites, grassy rocky sites and woodland/grassland margins, where grasses are short or sparse. The species can be associated with woody weeds.

Diamond Firetail

Diamond Firetail showed a significant decrease from 2012 to 2017, corresponding with the end of a wetter period and start of a drier period. The species is resident and typically recorded in small groups, infrequently at particular locations, and probably moves around to take advantage of seed sources. Weed cover (e.g. in high rainfall periods), loss of favoured native grasses, or overgrazing by native herbivores may be influencing factors in their decline.

Double-barred Finch

Double-barred Finch are recorded infrequently and at only a few woodland sites. They occur in small, localised groups in some reserves and urban/rural edge sites. They have some association with woody weeds. Overgrazing and extended dry periods may be limiting their numbers and distribution.

Jacky Winter

Jacky Winter showed no detectable long-term trend. This is a seasonal species in low abundance at woodland sites. The ROC Plot (Figure 12) showed a significant rate of change (increase) during the Millennium Drought from 2000 to 2007; possibly indicating birds moving further east from drier areas inland.

Flame Robin

Flame Robin showed no detectable long-term trend. There is very low abundance of this altitudinal migrant species, occurring at a few woodland sites, generally in cooler months. Flame Robins have been identified as a species potentially affected by climate change.

3.4. Conservation Priority Species

The Project Team has compiled a list of Conservation Priority Species in ACT woodlands and assigned a management **priority ranking** (high or low) to each based on an assessment of significant statistical results collectively. The purpose of this list is to support land managers in conservation and restoration planning for woodland birds. To be considered a Conservation Priority Species, a species had to meet ALL THREE (3) of the following criteria:

1. a significant decliner (Table 2), and
2. an ACT woodland-dependent bird species (Page 4, Figure 6), and
3. (i) a consistent, every-year decliner (Page 10, Table 2)
(ii) a canopy feeder (Page 5, Figure 6), and/or
(iii) a small-bodied bird (Page 6, Figure 6).

The **priority ranking** takes account of these criteria and the local knowledge and expertise of the Project Team, and relates to the ACT region only.



Fuscous Honeyeater

Table 5. Species prioritised for conservation attention in the ACT due to concerning long-term status and trait-based vulnerability (i.e. small-bodied and/or canopy feeder). *Reminder: Canopy feeders feed primarily, but not exclusively, in the canopy.*

Species	RR trend	Consistent decline	Canopy feeder	Small-bodied	Priority ranking	Notes on ecology and trend pattern
Brown Treecreeper	Low-very low			✓	High	Mainly ground feeder of insects, also taken from crevices/bark in trees. Reliant on dead & fallen timber. Hollow nester. Requires well connected habitats/patches. No longer resident breeding groups at woodland sites. Rare/uncommon in rural areas.
Buff-rumped Thornbill	Medium			✓	Low	Abundant flock species in good quality woodland structures/habitats. Insect feeder, utilises lower/mid-storey and ground, including eucalypt re-growth.
Dollarbird	Low-very low	✓			High	Seasonal, long distance migrant from areas in Asia and PNG. Canopy and aerial feeder/hawker of insects. Nests in tree hollows, often dead trees.
Fuscous Honeyeater	Low		✓	✓	High	Moves seasonally between mid-altitude and lowland woodlands in ACT. Widely distributed in SE Aust. woodlands. Nectar feeder in eucalypts, shrubs. Takes insects in absence of nectar. Core ACT habitat impacted by bushfires 2003 and 2020.
Grey Currawong	Low-very low	✓			High	Widespread species. In ACT occurs in low numbers/pairs, in woodlands. Takes insects, fruits/berries, probes bark/litter. Records in COG Area of Interest (AOI) show slow decline from 1991 (Canberra Ornithologists Group).
Grey Fantail	High		✓	✓	Low	Mostly migratory/seasonal. Occurs in habitats of varying structures/quality. Insect feeder, taken in flight.
Hooded Robin	Low-very low	✓		✓	High	Mainly ground feeder of insects. Requires large, undisturbed, well connected patches/habitats. No longer resident breeding groups at woodland sites. Rare/uncommon in rural areas.
Leaden Flycatcher	Low		✓	✓	Low	Seasonal species. Occurs in good quality woodland habitats with large eucalypts, open forest. Insect feeder, in trees and in flight amongst treetops.

Table 5 — continued

Species	RR trend	Consistent decline	Canopy feeder	Small-bodied	Priority ranking	Notes on ecology and trend pattern
Little Friarbird	Very low		✓		Low	Very sparse data, marginal ACT species, core range outside ACT.
Mistletoebird	Medium		✓	✓	Low	Seasonal species, some overwinter. Feeds largely on mistletoe fruits, and insects. Tree health decline is possible factor (loss of/reduced mistletoes, herbivores/possums).
Noisy Friarbird	Medium		✓		Low	Seasonal, migratory species. Insects and nectar feeder.
Restless Flycatcher	Low	✓		✓	High	Widely distributed species. Mainly hawks insects on or from the ground. Tolerates open treed habitats, farmlands and riverine.
Rufous Whistler	Medium	✓	✓	✓	Low	Seasonal migratory species. Occurs in good quality woodland habitats with large eucalypts. Insect feeder in trees and shrubs layer.
Southern Whiteface	Low			✓	Low	Ground feeder, on insects and seeds. Some disturbance tolerance, occurs in modified habitats and farmlands. Prefers areas of short grass, patchy ground layer.
Striated Pardalote	High		✓	✓	Low	Widely distributed species. Feeds on tree frequenting insects, including lerps. Disturbance tolerant, occurs in degraded, treed habitats, and fragmented patches.
Tree Martin	Medium-low	✓		✓	High	Seasonal migrant, some overwinter. Hawks insects from or between trees and aerial. Tolerates open treed habitats. Nests in small hollows in eucalypts.
Weebill	High		✓	✓	Low	Lerp and insect feeder, mostly taken from outer foliage of eucalypts. Abundant at woodland sites of varying quality/structure. Utilises eucalypt re-growth.
Western Gerygone	Low	✓	✓	✓	Low	Seasonal migratory species. Small insect feeder, usually in outer foliage. Occurs in better quality woodland habitats. Widespread species, more common further inland.

Species	RR trend	Consistent decline	Canopy feeder	Small-bodied	Priority ranking	Notes on ecology and trend pattern
White-plumed Honeyeater	Medium-low		✓	✓	Low	Widely distributed species in woodland structures and riverine habitats. In ACT, occurs in woodlands, in treed urban/reserve edge green strips, and parklands with mature eucalypts. Insects and nectar feeder.
White-winged Triller	Medium-low		✓	✓	Low	Widespread, mobile, irruptive species, numbers vary seasonally. Insect feeder, including on or close to the ground.

Notes on some declining species in Table 2 list, not included as Conservation Priority Species in Table 5:

- Crested Shrike-tit (RR low, never a common woodland species, uncommon/rare in ACT forest habitats).
- Striated Thornbill (RR medium declining to low, flock and canopy feeding species, not woodland-dependent, also forest species).
- Pallid Cuckoo (RR low, is a consistent decliner, not woodland-dependent, is a widespread species more common inland in open habitats).



Hooded Robin

4. Conclusions & Recommendations

This report provides a timely update on the conservation status of ACT woodland birds. Here, long-term woodland bird population trends have been elicited from the Woodland Bird Monitoring Project database, and interpreted with expert knowledge, to provide an overview of desirable and undesirable changes to woodland avifauna. Further, this report serves as a support tool for conservation land managers through the identification of Conservation Priority Species that arguably require immediate protection and conservation attention. In some cases, strategic restoration planning to improve woodland condition and arrest current rates of decline may be necessary to avoid future local extirpation events. Below, the authors call attention to some key conclusions from the analysis.

The increase of large-bodied bird species, and the strong, unabated increase in aggressive species like Noisy Miner and Rainbow Lorikeet, are important considerations for the management of woodland-dependent birds. This is particularly relevant in the consideration and planning of conservation buffers — including their size and nature — at the interface of new urban and greenfield developments. It is likely that high-functioning conservation buffers will be needed to minimise the intrusion and dominance of large and/or aggressive, urban-tolerant bird species in nature reserves and rural woodland habitats.

There were three important new findings from the analysis:

1. Observed declines were expected for some species (e.g. White-plumed Honeyeater, Southern Whiteface, Crested Shrike-tit), but there were a number of additional species showing declines that were unexpected to the Project Team (e.g. Fuscous Honeyeater, Mistletoebird). Similarly, some species regarded as fairly common or abundant, showed long-term downward trends, (e.g. Rufous Whistler, Weebill, Yellow-rumped Thornbill, Superb Fairy-wren), albeit only small declines in some cases (e.g. Leaden Flycatcher, Red-rumped Parrot). Declining groups were not restricted to native species with 4 of the 7 introduced species showing a decrease (the other 3 showing no trend).
2. A significant collective decline in canopy feeders was unexpected and warrants further investigation. Possible drivers of decline in this bird group include eucalypt dieback and crown condition, climate-related habitat effects (e.g. nectar availability), and overabundant canopy browsers such as possums.
3. Before the analysis, it was thought by the Project Team that ground feeders may be the group of most concern, given previous analyses and factors such as increasing periods of drought, variable rainfall, overgrazing by native herbivores, deterioration of ground layer habitat condition and plant diversity, and weeds invasion. However, the ground feeders group did not show a collective trend.

Drought and rainfall are generally considered important determinants of bird distribution and abundance, especially for small passerines. From this analysis, it appears some species (e.g. Scarlet Robin) responded positively to increased rainfall, while others (e.g. Hooded Robin) showed no response at all. Without a more tailored analysis, it is unclear if (or how) weather affects woodland bird reporting rates. It is plausible, however, that species occurring only at low densities, or in fragmented populations, lack the means to exploit favourable weather to recover their numbers.

The analysis confirms a focus on small birds as a conservation priority is valid. There may be a need to consider the nomination of some species as *Threatened* (Vulnerable status) under the ACT *Nature Conservation Act 2014*, such as those considered 'High' priority in Table 5 (e.g. Tree Martin, Fuscous Honeyeater), or the upgrading of some species already listed as *Threatened* (e.g. Hooded Robin). Additional supporting data, or further analysis, may be needed to underpin a strong case for new threatened species nominations. In the interim, all species named as 'Conservation Priority Species' (Table 5) should form part of a formalised 'Watching Brief' that implies ongoing species assessment in terms of their population status and their habitat extent and condition.

4.1. Future work

Further exploration of results presented here could be undertaken, as well as new projects with questions arising from, or based on, this report. Future work using COG's Woodland Bird Monitoring Project database, dependent on available funding, resources and priorities, could include:

- Targeted analysis of species of interest, including species of concern, which may warrant nomination for listing as *Threatened*. This should be driven by clear questions (e.g. *What do we need to know about species X?*). Action Plans produced by the ACT Government may provide some guidance.
- Analysis of landscape-scale woodland change and associated bird responses. This could include:
 - Assessing whether habitats critical to the maintenance of woodland bird diversity are being maintained.
 - Analysing how woodland birds are responding to ongoing urbanisation and reservation (an update of Rayner *et al.* 2014).
 - Investigating the relationship between dieback and woodland bird abundance, density and distribution.
- Examination of the impacts of dominant avian competitors on vulnerable woodland birds that would include a description of Noisy Miner colonisation dynamics across the ACT.
- An analysis of site-based species occurrence and community composition, which may be influenced by site-related attributes such as patch size, patch connectivity, habitat structure, land tenure, grazing regimes, the urban context, or other geographical factors.
- A case study of Mulligans Flat and Goorooyarroo Nature Reserves where survey data are available from 1995, before/after and within/outside the predator-proof Sanctuary.
- Identification of climate-sensitive species, based on research on how woodland birds are responding to weather variability and broad-scale climate signals.

Readers are encouraged to explore reports from other woodland bird monitoring projects in the region to position the results of this project in the broader context of temperate woodland bird conservation. For example, the Cowra Woodland Birds Program (CWBP) conducts regular bird surveys in woodlands in the Cowra area north of Canberra, and 17 years of data have recently been analysed (Reid & Nicholls 2020).

Finally, this report has been prepared to enable COG to publish key results, and for the consideration of a journal article for peer-reviewed publication.

4.2. Actions Recommended

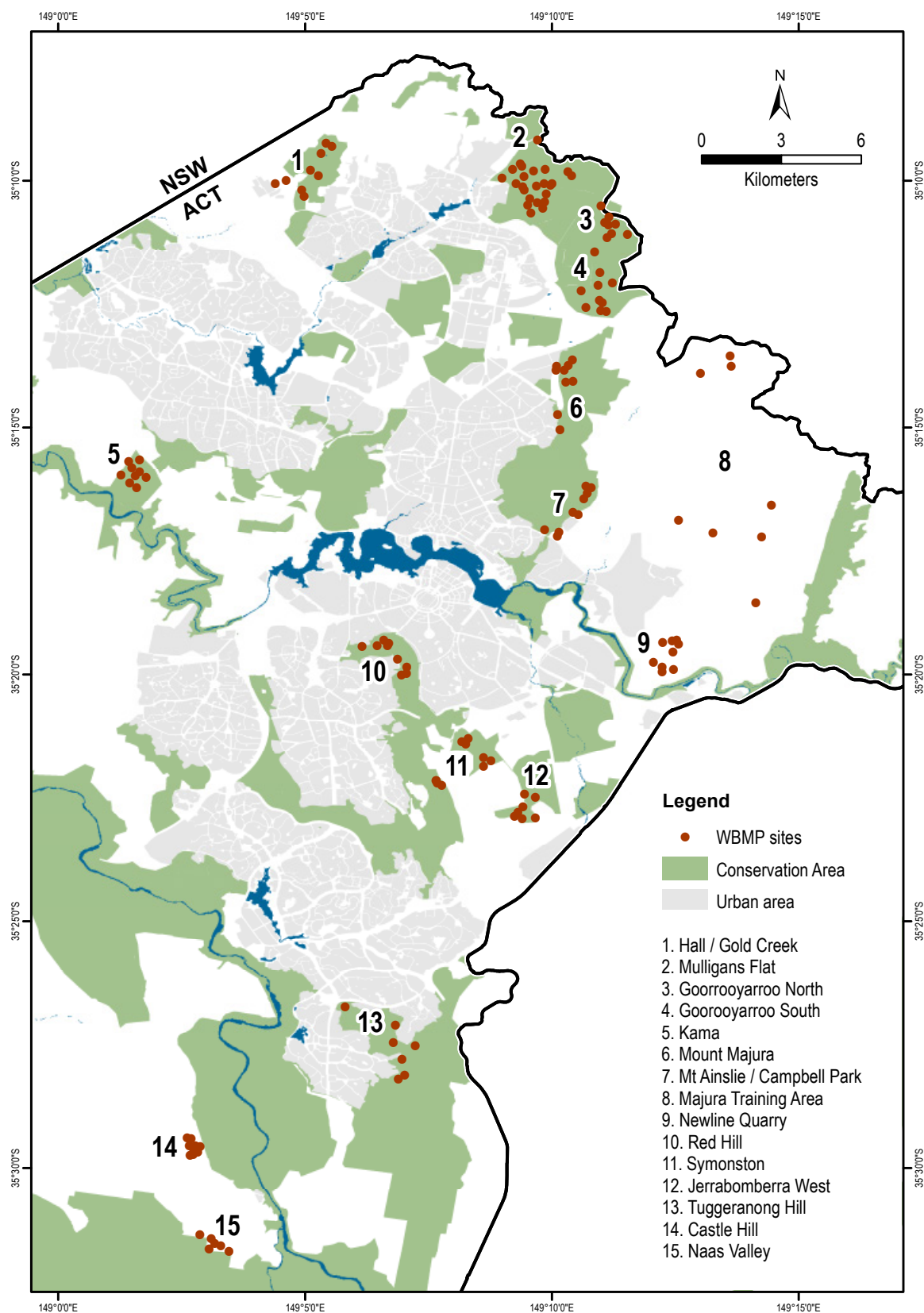
1. Continue the survey program and consider a future trend analysis.
 - Most suitable at the 30-year milestone (1998 to 2028).
 - With an emerging pattern of drier years since 2015, there is great interest and, in some cases, concern for what trends will emerge in the next decade and whether some unexpected decliners might recover. Monitoring should continue to determine when/if populations will plateau and how this influences the conservation status of species.
2. Consider publishing results presented in this report in a peer-reviewed journal to enhance the dissemination of key findings and reach a wider scientific audience.
3. Seek funding/resources to undertake further analysis or research projects with a focus on Conservation Priority Species and their primary threatening processes.

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Appendices

Appendix A: Map of survey locations



Appendix B: Weather data from the analysis period

It is important to look at results presented here in the context of weather data. Rainfall data, annual and monthly actual and long-term annual averages, were obtained from the Bureau of Meteorology website, 'Climate Data Online' (www.bom.gov.au/climate), for the Canberra Airport weather station.

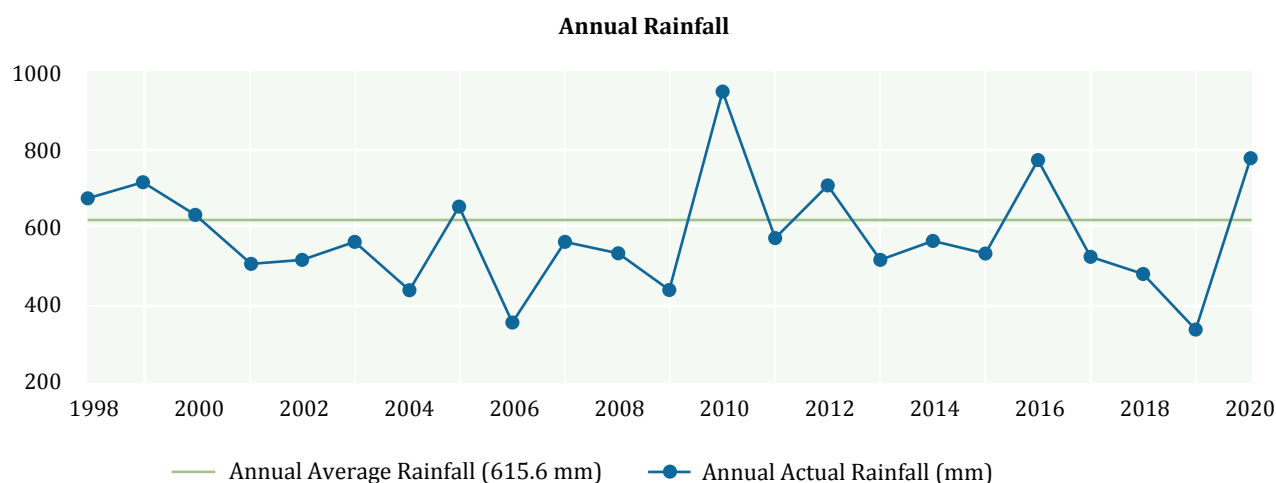


Figure B1. Total annual rainfall and average annual rainfall over the analysis period

The years 1998 to 2008 are within a period generally referred to as the Millennium Drought, notable by below average annual rainfall in most years. Note that four of the years in the data analysed from 1998 to 2008 had annual rainfall well below the average (2001, 2002, 2004, 2006). In that period, there was also more variable rainfall in the spring months (compared with the long-term averages). Spring rainfall is a factor that influences successful bird breeding; indeed the spring or warmer months are critical breeding months for most birds.

The year 2005 had slightly more rainfall than average, after four years of below average rainfall, but notably, 2005 had a third more than the average spring rainfall. COG's Ten-Year Analysis showed some increase in abundance, of both resident and migrant species, as a result of that good spring rainfall event within a generally drier decade (Bounds *et al.* 2010).

Annual rainfall was above average, or close to the average, from 2010 to 2016, but has been below average over the following years, 2017 to 2019. Rainfall on a monthly or seasonal basis has also been quite variable over the years 2010 to 2019.

- 2010 had a third more annual rainfall than the annual average total.
- The equivalent of a year's average rainfall occurred over six months from September 2010 to February 2011, peaking in December 2010 at 198 mm for that month — these are months important for bird breeding.
- The five months from November 2011 to March 2012 had a significant increase in total rainfall, almost equivalent to the average annual rainfall, peaking in the month of March at 197 mm.
- 2012 had above average annual rainfall, 693 mm; spring rainfall was below average and variable.
- 2013, 2014 and 2015 had annual rainfall below average (533 mm, 568 mm and 545 mm respectively — compared with average 616 mm), and rainfall in the warmer months was variable.
- Over two months December 2014 and January 2015, rainfall total was significant at 199 mm, almost a third of a year's average rainfall for these two months.
- 2016 had significantly higher total annual rainfall at 788 mm, with the spring months September to December recording significantly more than the usual averages.
- 2017, 2018 and 2019 had significantly below average rainfall, with 2019 (358 mm) the driest year since 1982, with only 58% of the long-term average rainfall (616 mm).

Although not in the analysis period, 2020 had annual rainfall significantly higher than average at 790 mm, a similar level to 2016. Monthly rainfall was quite variable in 2020, most of the late autumn/early winter months were drier than average, but the four late winter/spring months (August to November) had very good rainfall of just over 50% of the annual total rainfall.

It is noted that in the last few months of 2019 and first month of 2020, following a widespread drought period across eastern Australia, there were catastrophic bushfires, particularly in forests all along the Great Dividing Range and the south coast of NSW. These very significant climate-related events occurred just after the analysis period and would be relevant to future analysis.

- In the SE region, the Tallaganda National Park to the SE of the ACT, rural lands around Braidwood, large areas of national parks to the east and forests as far as the sea were burnt.
- In the ACT, 80% of the Namadgi NP was burnt, much of it severely, but most of the higher, western edge of the park, mainly wet forests and alpine habitat, was not burnt.
- Much of the high country to the south and SW of the ACT was also burnt.
- Most of one woodland location, Newline, was burnt in a local outbreak.



Noisy Friarbird

Appendix C: Allocation of species to bird groups

The table below shows for each species their inclusion (1) or exclusion (0) from the 12 bird groups of interest, as identified by the Project Team.

Species	ACT woodland-dependent	South-east woodland bird	Degraded community bird	Threatened species	Conservation concern	Canopy feeders	Mid-storey feeders	Ground feeders	Woody weed frequent	Woody weed + small	Body mass: small	Body mass: large
Australasian Pipit	0	0	0	0	0	0	0	0	0	0	1	0
Australian Hobby	0	0	0	0	0	0	0	0	0	0	0	1
Australian King-Parrot	0	0	0	0	0	0	0	0	1	0	0	1
Australian Magpie	0	0	1	0	0	0	0	0	0	0	0	1
Australian Owlet-nightjar	1	1	0	0	0	0	0	1	0	0	1	0
Australian Raven	0	0	1	0	0	0	0	0	0	0	0	1
Black-faced Cuckoo-shrike	0	0	0	0	0	0	0	0	0	0	0	1
Black-shouldered Kite	0	0	0	0	0	0	0	0	0	0	0	1
Brown Falcon	0	0	0	0	0	0	0	0	0	0	0	1
Brown Goshawk	0	0	0	0	0	0	0	0	0	0	0	1
Brown Quail	0	0	0	0	0	0	0	0	0	0	0	1
Brown Songlark	0	0	0	0	0	0	0	0	0	0	1	0
Brown Thornbill	0	1	0	0	0	0	0	0	0	0	1	0
Brown Treecreeper	1	1	0	1	1	0	0	1	0	0	1	0
Brown-headed Honeyeater	1	1	0	0	0	1	0	0	0	0	1	0
Brush Cuckoo	0	0	0	0	0	0	0	0	0	0	1	0
Buff-rumped Thornbill	1	1	0	0	0	0	1	0	0	0	1	0
Cicadabird	0	0	0	0	0	0	0	0	0	0	1	0
Collared Sparrowhawk	0	0	0	0	0	0	0	0	0	0	0	1
Common Blackbird	0	0	0	0	0	0	0	0	0	0	0	1
Common Bronzewing	0	1	0	0	0	0	0	0	0	0	0	1
Common Myna	0	0	0	0	0	0	0	0	0	0	0	1
Common Starling	0	0	0	0	0	0	0	0	0	0	0	1
Crested Pigeon	0	0	0	0	0	0	0	0	0	0	0	1
Crested Shrike-tit	0	1	0	0	1	0	0	0	0	0	1	0
Crimson Rosella	0	0	0	0	0	0	0	0	0	0	0	1
Diamond Firetail	1	1	0	0	1	0	0	1	1	1	1	0
Dollarbird	1	0	0	0	0	0	0	0	0	0	0	1
Double-barred Finch	1	0	0	0	1	0	0	1	1	1	1	0

Species	ACT woodland-dependent	South-east woodland bird	Degraded community bird	Threatened species	Conservation concern	Canopy feeders	Mid-storey feeders	Ground feeders	Woody weed frequent	Woody weed + small	Body mass: small	Body mass: large
Dusky Woodswallow	1	1	0	0	0	0	1	0	0	0	1	0
Eastern Rosella	0	0	1	0	0	0	0	0	0	0	0	1
Eastern Spinebill	0	1	0	0	0	0	0	0	0	0	1	0
Eastern Yellow Robin	0	1	0	0	0	0	0	0	0	0	1	0
European Goldfinch	0	0	0	0	0	0	0	0	1	1	1	0
European Greenfinch	0	0	0	0	0	0	0	0	1	1	1	0
Fairy Martin	0	0	0	0	0	0	0	0	0	0	1	0
Fan-tailed Cuckoo	0	0	0	0	0	0	0	0	0	0	1	0
Flame Robin	1	0	0	0	1	0	0	1	0	0	1	0
Fuscous Honeyeater	1	1	0	0	0	1	0	0	0	0	1	0
Galah	0	0	1	0	0	0	0	0	1	0	0	1
Gang-gang Cockatoo	0	0	0	0	0	0	0	0	1	0	0	1
Golden Whistler	0	1	0	0	0	0	0	0	0	0	1	0
Grey Butcherbird	1	0	1	0	0	0	0	0	0	0	0	1
Grey Currawong	1	0	0	0	0	0	0	0	0	0	0	1
Grey Fantail	1	1	0	0	0	1	0	0	0	0	1	0
Grey Shrike-thrush	1	1	0	0	0	0	0	0	0	0	1	0
Hooded Robin	1	1	0	1	1	0	0	1	0	0	1	0
Horsfield's Bronze-Cuckoo	1	1	0	0	0	1	0	0	0	0	1	0
House Sparrow	0	0	0	0	0	0	0	0	0	0	1	0
Jacky Winter	1	1	0	0	1	0	0	1	0	0	1	0
Laughing Kookaburra	0	0	0	0	0	0	0	0	0	0	0	1
Leaden Flycatcher	1	1	0	0	0	1	0	0	0	0	1	0
Little Corella	0	0	0	0	0	0	0	0	1	0	0	1
Little Eagle	0	0	0	1	0	0	0	0	0	0	0	1
Little Friarbird	1	1	0	0	0	1	0	0	0	0	1	0
Little Lorikeet	1	1	0	0	0	1	0	0	0	0	1	0
Little Raven	0	0	0	0	0	0	0	0	0	0	0	1
Long-billed Corella	0	0	0	0	0	0	0	0	0	0	0	1
Magpie-lark	0	0	1	0	0	0	0	0	0	0	0	1
Masked Lapwing	0	0	0	0	0	0	0	0	0	0	0	1
Masked Woodswallow	1	0	0	0	0	1	0	0	0	0	1	0
Mistletoebird	1	1	0	0	1	1	0	0	0	0	1	0

Species	ACT woodland-dependent	South-east woodland bird	Degraded community bird	Threatened species	Conservation concern	Canopy feeders	Mid-storey feeders	Ground feeders	Woody weed frequent	Woody weed + small	Body mass: small	Body mass: large
Musk Lorikeet	0	0	0	0	0	0	0	0	0	0	1	0
Nankeen Kestrel	0	0	0	0	0	0	0	0	0	0	0	1
Noisy Friarbird	1	1	0	0	0	1	0	0	0	0	0	1
Noisy Miner	1	0	1	0	0	1	0	0	0	0	0	1
Olive-backed Oriole	1	1	0	0	0	1	0	0	0	0	0	1
Painted Button-quail	1	1	0	0	1	0	0	1	0	0	0	1
Pallid Cuckoo	0	0	0	0	0	0	0	0	0	0	0	1
Peaceful Dove	0	0	0	0	0	0	0	0	0	0	1	0
Peregrine Falcon	0	0	0	0	0	0	0	0	0	0	0	1
Pied Butcherbird	0	0	1	0	0	0	0	0	0	0	0	1
Pied Currawong	0	0	0	0	0	0	0	0	1	0	0	1
Rainbow Bee-eater	0	0	0	1	0	0	0	0	0	0	1	0
Rainbow Lorikeet	0	0	0	0	0	0	0	0	0	0	0	1
Red Wattlebird	0	0	0	0	0	0	0	0	0	0	0	1
Red-browed Finch	0	1	0	0	0	0	0	0	1	1	1	0
Red-capped Robin	1	1	0	0	0	0	0	1	0	0	1	0
Red-rumped Parrot	0	0	0	0	0	0	0	0	1	1	1	0
Restless Flycatcher	1	1	0	0	1	0	0	1	0	0	1	0
Rock Dove	0	0	0	0	0	0	0	0	0	0	0	1
Rose Robin	0	0	0	0	0	0	0	0	0	0	1	0
Rufous Fantail	0	0	0	0	0	0	0	0	0	0	1	0
Rufous Songlark	1	0	0	0	0	0	0	1	0	0	1	0
Rufous Whistler	1	1	0	0	0	1	0	0	0	0	1	0
Sacred Kingfisher	1	1	0	0	0	0	0	1	0	0	1	0
Satin Bowerbird	0	0	0	0	0	0	0	0	0	0	0	1
Satin Flycatcher	0	0	0	0	0	0	0	0	0	0	1	0
Scarlet Robin	1	1	0	1	1	0	0	1	0	0	1	0
Shining Bronze-Cuckoo	1	1	0	0	0	1	0	0	0	0	1	0
Silvereye	0	0	0	0	0	0	0	0	1	1	1	0
Southern Boobook	0	1	0	0	0	0	0	0	0	0	0	1
Southern Whiteface	1	1	0	0	1	0	0	1	1	1	1	0
Speckled Warbler	1	1	0	0	0	0	0	1	1	1	1	0
Spotted Pardalote	0	1	0	0	0	0	0	0	0	0	1	0

Species	ACT woodland-dependent	South-east woodland bird	Degraded community bird	Threatened species	Conservation concern	Canopy feeders	Mid-storey feeders	Ground feeders	Woody weed frequent	Woody weed + small	Body mass: small	Body mass: large
Striated Pardalote	1	0	0	0	0	1	0	0	0	0	1	0
Striated Thornbill	0	1	0	0	0	1	0	0	0	0	1	0
Stubble Quail	0	0	0	0	0	0	0	0	0	0	0	1
Sulphur-crested Cockatoo	0	0	1	0	0	0	0	0	0	0	0	1
Superb Fairy-wren	0	0	0	0	0	0	0	0	1	1	1	0
Superb Parrot	1	0	0	1	0	0	0	1	0	0	0	1
Swift Parrot	1	1	0	1	0	1	0	0	0	0	1	0
Tawny Frogmouth	0	0	0	0	0	0	0	0	0	0	0	1
Tree Martin	1	0	0	0	1	0	0	0	0	0	1	0
Varied Sittella	1	1	0	1	0	1	0	0	0	0	1	0
Wedge-tailed Eagle	0	0	0	0	0	0	0	0	0	0	0	1
Weebill	1	1	0	0	0	1	0	0	0	0	1	0
Welcome Swallow	0	0	0	0	0	0	0	0	0	0	1	0
Western Gerygone	1	1	0	0	0	1	0	0	0	0	1	0
Whistling Kite	0	0	0	0	0	0	0	0	0	0	0	1
White-browed Scrubwren	0	1	0	0	0	0	0	0	1	1	1	0
White-browed Woodswallow	1	0	0	0	0	1	0	0	0	0	1	0
White-eared Honeyeater	0	1	0	0	0	0	0	0	0	0	1	0
White-naped Honeyeater	0	1	0	0	0	0	0	0	0	0	1	0
White-plumed Honeyeater	1	0	0	0	1	1	0	0	0	0	1	0
White-throated Gerygone	1	1	0	0	0	1	0	0	0	0	1	0
White-throated Needle-tail	0	0	0	0	0	0	0	0	0	0	0	1
White-throated Treecreeper	0	1	0	0	0	0	0	0	0	0	1	0
White-winged Chough	1	0	0	0	0	0	0	1	0	0	0	1
White-winged Triller	1	1	0	1	0	1	0	0	0	0	1	0
Willie Wagtail	0	0	0	0	0	0	0	0	0	0	1	0
Yellow Thornbill	1	1	0	0	0	0	1	0	0	0	1	0
Yellow-faced Honeyeater	0	1	0	0	0	0	0	0	0	0	1	0
Yellow-rumped Thornbill	0	0	1	0	0	0	0	0	0	0	1	0
Yellow-tailed Black-Cockatoo	0	0	0	0	0	0	0	0	0	0	0	1

Appendix D: Distribution of surveys in the Woodland Bird Monitoring Project

The table below shows the distribution of survey effort during the observation period (1998–2019) of the COG Woodland Bird Monitoring Project. Each cell shows the number of surveys undertaken per year; lighter green indicates fewer surveys, darker green indicates more surveys.

Site ID	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
CAS.101	3	7	7	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	92
CAS.102	3	7	7	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	92
CAS.103	3	7	7	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	90
CAS.104	3	7	7	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	91
CAS.105	3	7	7	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	92
CAS.106	3	7	7	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	92
CAS.107	3	7	7	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	3	3	90
CAS.108	3	7	7	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	3	3	90
CAS.109	3	7	7	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	92
CMP.1201						3	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	3	65
CMP.1202						3	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	3	65
CMP.1203						3	4	4	4	4	4	3	4	3	4	4	4	4	4	4	4	3	64
CMP.1204						3	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	3	65
CMP.1205						3	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	3	65
CMP.1206						3	3	4	4	4	4	3	4	3	4	4	4	4	4	4	4	3	63
CMP.1207						3	4	4	4	4	4	3	4	3	4	4	4	4	4	4	4	3	64
CMP.1208						3	4	4	4	4	4	3	4	3	4	4	4	4	4	4	4	3	64
CMP.1209						3	4	4	4	4	4	3	4	3	4	4	4	4	4	4	4	3	64
G00.201	2	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	4	4	4	3	84
G00.202	2	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	4	4	4	3	84
G00.203	2	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	4	4	4	3	84
G00.204	2	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	4	4	4	3	84
G00.205	2	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	4	4	4	3	84
G00.206	2	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	4	4	4	3	84
G00.207	2	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	4	4	4	3	84
G00.208	2	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	4	4	4	3	84
G00.209	2	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	4	4	4	3	84
GOS.1301							4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	63
GOS.1302							4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	63
GOS.1303							4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	3	62
GOS.1304							4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	3	62

Site ID	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
GOS.1305							4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	3	62
GOS.1306							4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	3	62
GOS.1307							4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	63
GOS.1308							4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	63
GOS.1309							4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	63
HAL.1101			3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	78
HAL.1102			3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	78
HAL.1103			3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	2	76
HAL.1104			3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	2	76
HAL.1105			3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	2	76
HAL.1106			3	4	4	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	3	2	74
HAL.1107			3	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	3	2	75
HAL.1108			3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	2	76
HAL.1109			3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	2	76
JER.1601									1	4	4	4	4	4	4	4	4	4	4	4	4	3	52
JER.1602									1	4	4	4	4	4	4	4	4	4	4	4	4	3	52
JER.1603									1	4	4	4	4	4	4	4	4	4	4	4	4	3	52
JER.1604									1	4	4	4	4	4	4	4	4	4	4	4	4	3	52
JER.1605									1	4	4	4	4	4	4	4	4	4	4	4	4	3	52
JER.1606									1	4	4	4	4	4	4	4	4	4	4	4	4	3	52
JER.1607									1	4	4	4	4	4	4	4	4	4	4	4	4	3	52
KAM.1501								1	4	4	4	4	4	4	4	4	4	4	4	4	4	3	56
KAM.1502								1	4	4	4	4	4	4	4	4	4	4	4	4	4	3	56
KAM.1503								1	4	4	4	4	4	4	4	4	4	4	4	4	4	3	56
KAM.1504								1	4	4	4	4	4	4	4	4	4	4	4	4	4	3	56
KAM.1505								1	4	4	4	4	4	4	4	4	4	4	4	4	4	3	56
KAM.1506								1	4	4	4	4	4	4	4	4	4	4	4	4	4	3	56
KAM.1507								1	4	4	4	4	4	4	4	4	4	4	4	4	4	3	56
KAM.1508								1	4	4	4	4	4	4	4	4	4	4	4	4	4	3	56
KAM.1509								1	4	4	4	4	4	4	4	4	4	4	4	4	4	3	56
MAJ.301	2	4	4	4	3	3	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	83
MAJ.302	2	4	4	4	3	3	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	84
MAJ.303	2	4	4	4	3	2	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	83
MAJ.304	2	4	4	4	3	3	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	84
MAJ.305	2	4	4	4	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	83
MAJ.306	2	4	4	4	3	3	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	84
MAJ.307	2	4	4	4	3	3	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	84

Site ID	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
MAJ.308	2	4	4	4	3	3	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	84
MAJ.309	2	4	4	4	3	3	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	84
MJF.401	1	3	4				1	5	4	4	4	4	4	4	4	4	4	4	4	4	4	3	69
MJF.402	1	3	4				1	5	4	4	4	4	4	4	4	4	4	4	4	4	4	3	69
MJF.403	1	3	4				1	5	4	4	4	4	4	3	4	4	4	4	4	4	4	3	68
MJF.404	1	3	4				1	5	4	4	4	4	4	3	4	4	4	4	4	4	4	3	68
MJF.407	1	3	4				1	5	4	4	4	4	4	4	4	4	4	4	4	4	4	3	69
MJF.408	1	3	4				1	5	4	4	4	4	4	4	4	4	4	4	4	4	4	3	69
MJF.409	1	3	4				1	5	4	4	4	4	4	4	4	4	4	4	3	4	4	3	68
MJF.410	1	2	4				1	5	4	4	4	4	4	4	4	4	4	4	4	4	2		63
MUL.501	5	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	3	87
MUL.502	5	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	87
MUL.503	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	88
MUL.504	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	88
MUL.505	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	88
MUL.506	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	88
MUL.507	5	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	3	87
MUL.508	5	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	86
MUL.509	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	88
MUL.510	5	4	4	3	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	3	86
MUL.511	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	88
MUL.512	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	88
MUL.513	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	88
MUL.514	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	88
MUL.515	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	88
MUL.516	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	88
MUL.517	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	88
MUL.518	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	88
MUL.519	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	88
MUL.520	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	88
MUL.521	5	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	87
MUL.522	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	88
MUL.523	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	88
MUL.524	5	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	3	87
NAS.1401							3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	62
NAS.1402							3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	62
NAS.1403							3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	62

Site ID	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
NAS.1404							3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	62
NAS.1405							3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	62
NAS.1406							3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	62
NLQ.801			3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	78
NLQ.802			3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	78
NLQ.803			3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	78
NLQ.804			3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	78
NLQ.805			3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	78
NLQ.806			3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	78
NLQ.807			3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	78
NLQ.808			3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	78
NLQ.809			3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	78
RED.601	2	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	86
RED.602	2	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	86
RED.603	2	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	86
RED.604	2	4	4	4	5	3	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	83
RED.605	2	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	86
RED.606	2	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	86
RED.607	2	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	86
RED.608	2	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	86
RED.609	2	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	86
SYM.701	2	4	4	5	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	3	87
SYM.702	2	4	4	5	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	3	87
SYM.703	2	4	4	5	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	3	87
SYM.704	2	4	4	5	4	4	4	4	5	3	3	3	4	4	2		2	4	4	4	3	3	75
SYM.705	2	4	4	5	4	4	4	4	5	3	3	3	4	4	2		2	4	4	4	3	3	75
SYM.706	2	4	4	5	4	3	4	4	5	1	3	3	4	4	2		2	4	4	4	3	3	72
SYM.713							3	4	5	3	4	4	4	4	4	4	4	4	4	4	4	3	62
SYM.714							3	4	5	3	4	4	4	4	4	4	4	4	4	4	4	3	62
SYM.715							3	4	5	3	4	4	4	4	4	4	4	4	4	4	4	3	62
TUG.1001			3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	78
TUG.1002			3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	78
TUG.1003			3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	78
TUG.1004			3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	77
TUG.1005			3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4	4	3	77
TUG.1006			3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	78
TUG.1007			3	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	3	77

Appendix E: Individual species trend plots

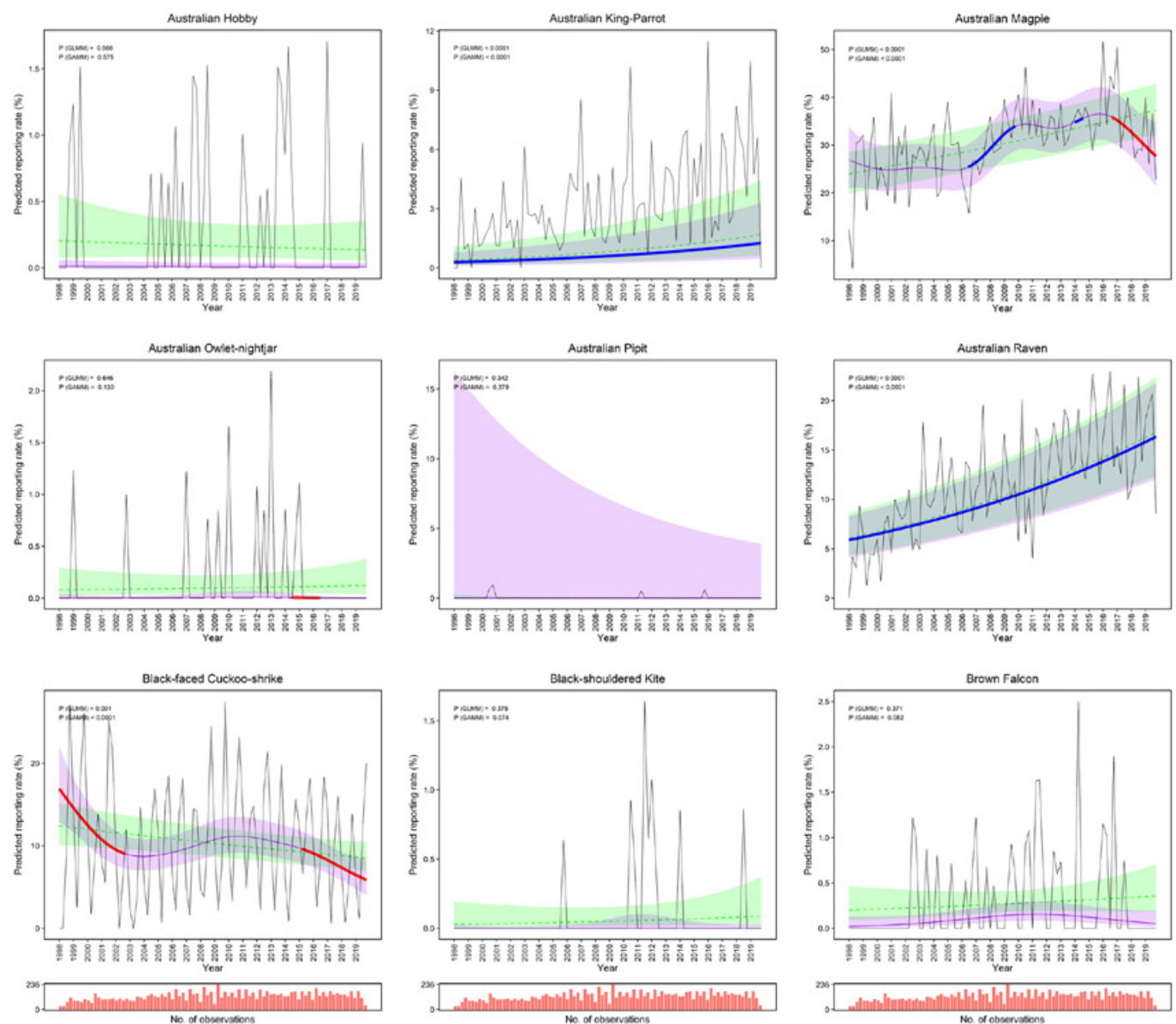
Trends in detections for individual species through time.

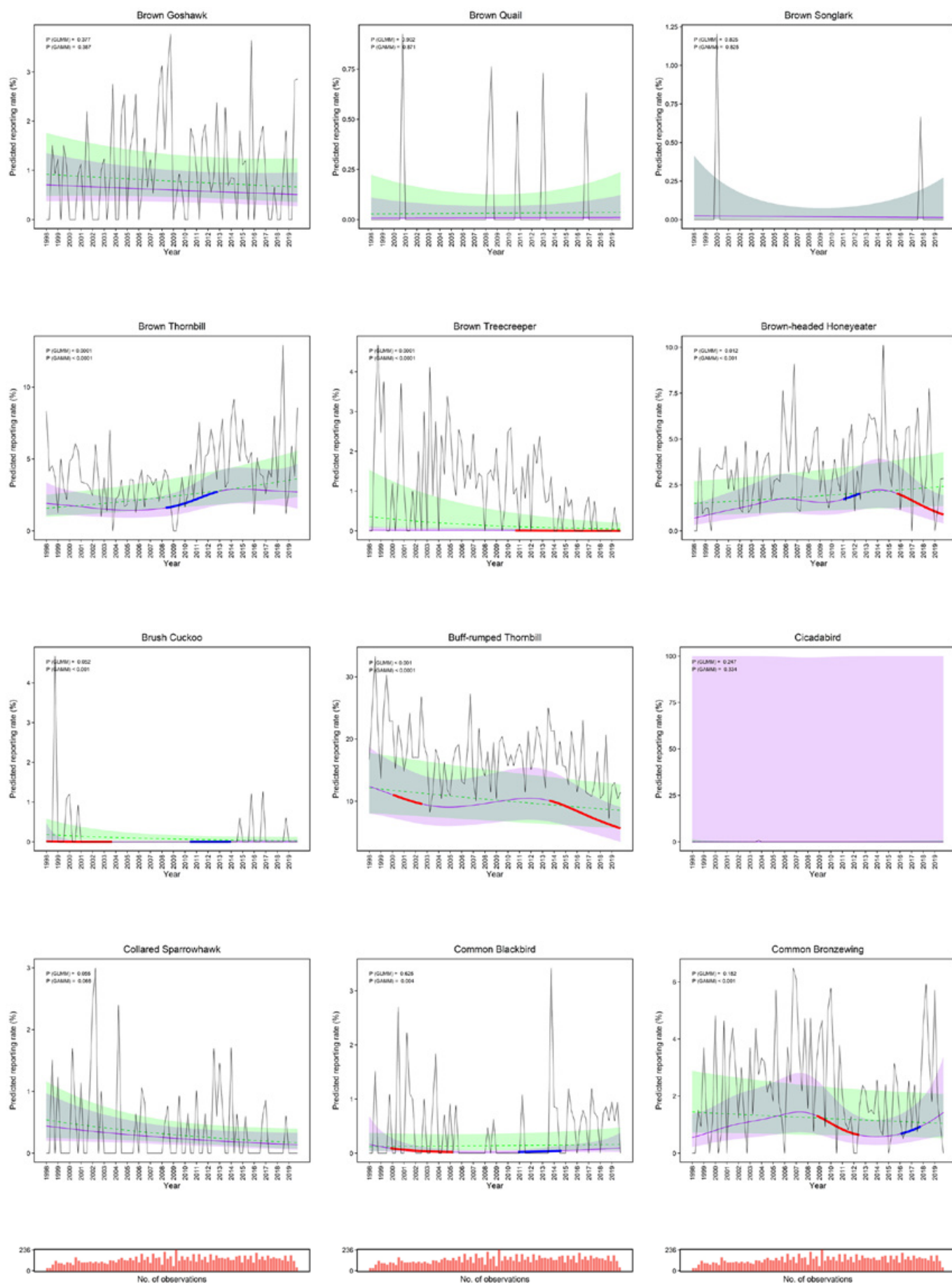
Interpreting Trend Plots

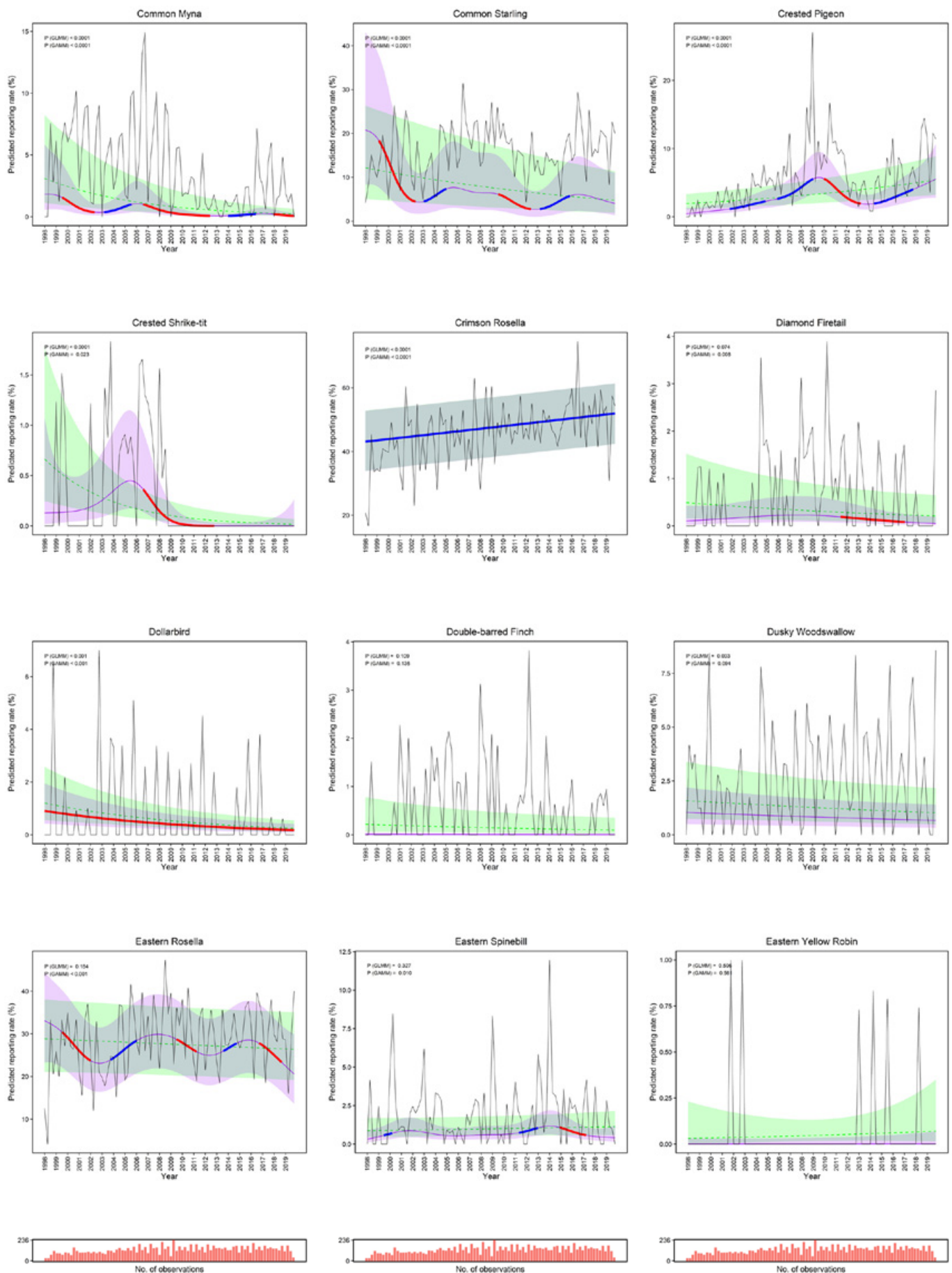
Plots for individual species show both non-linear and linear trends with associated confidence intervals. The percent scale (y-axis) should be interpreted as the mean percent of surveys in which a species is predicted to be present. Plot elements should be interpreted as follows:

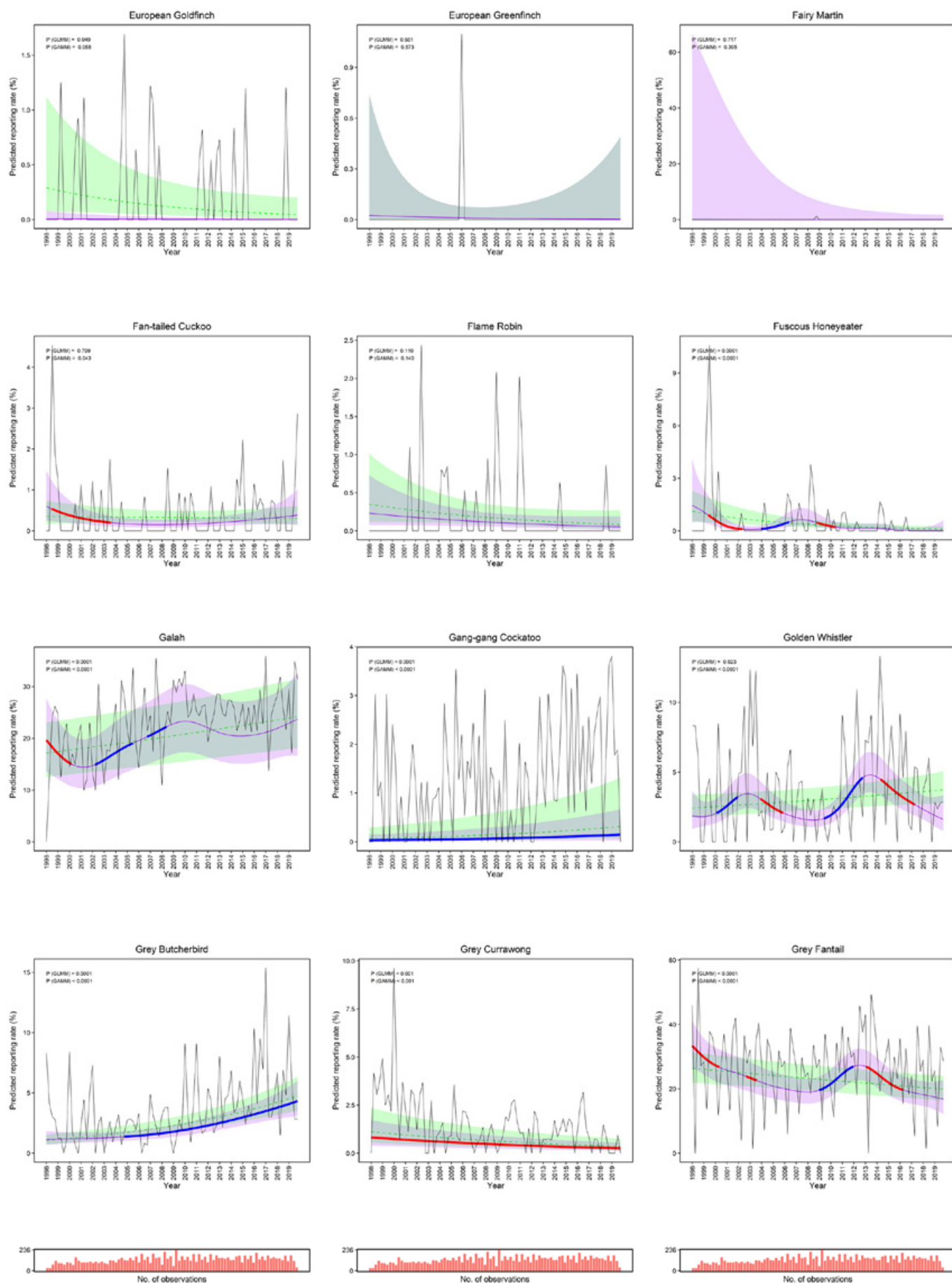
1. mean reporting rate in each quarter-yearly survey (thin black line)
2. smoothed *GAM/M* trend line showing short-term change in reporting rate (purple line)
3. 95% confidence intervals of the smoothed trend (purple shading)
4. sections of significant rate of change in the smoothed fit (positive is blue, negative is red)
5. predicted straight *GLM/M* trend line fit (green dashed line)
6. 95% confidence intervals of the linear trend (green shade)
7. P-values of the *GAMM* and *GLMM* indicating trend significance ($P < 0.05$ is significant), and
8. a representation of survey effort in each quarter-yearly survey (red bars below main plot)

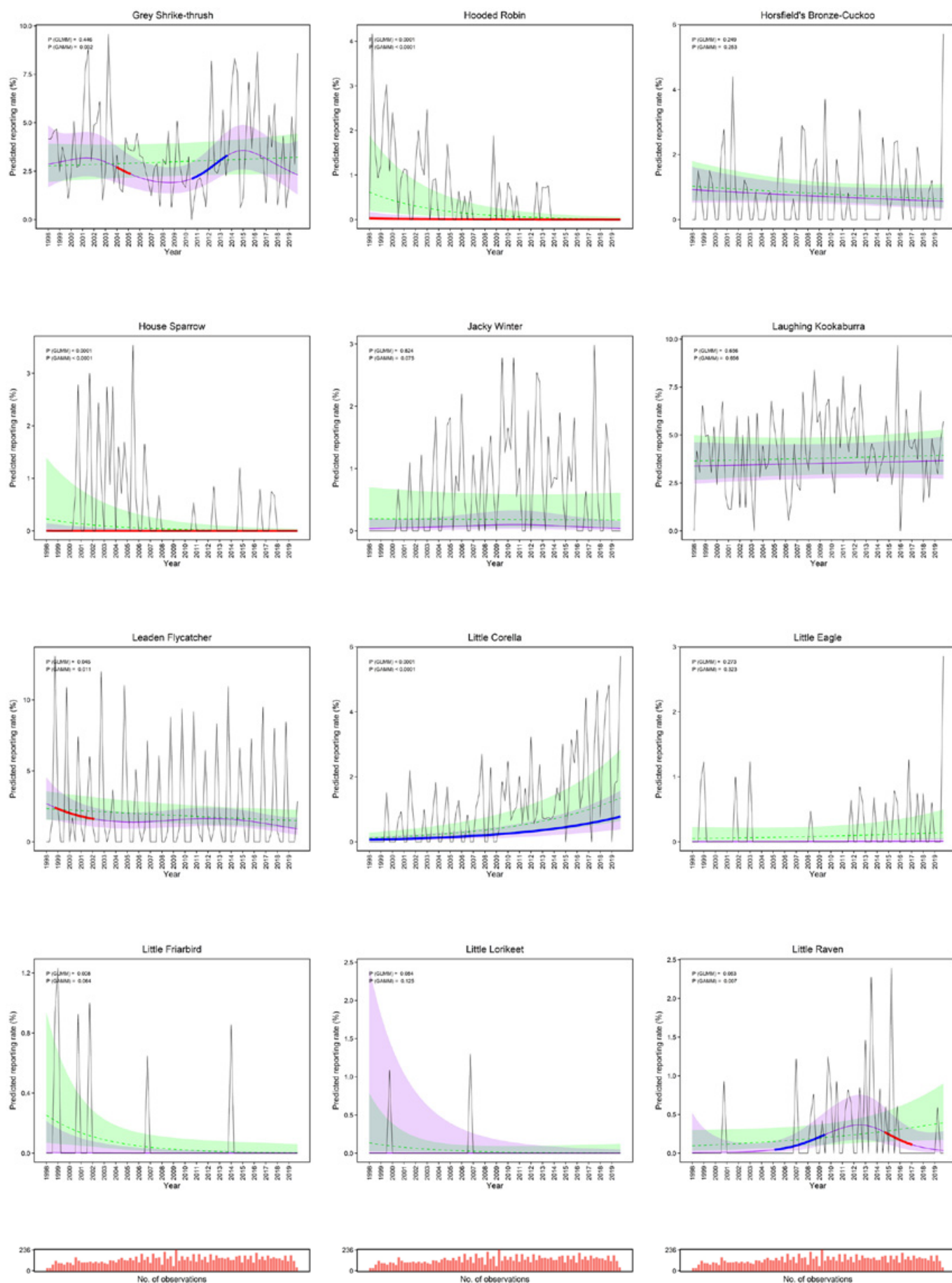
Note: Four rare species shown in Appendix E (Regent Honeyeater, Scarlet Honeyeater, White-bellied Cuckoo-Shrike, Zebra Finch), are not included in Appendix C (groups analysis); because of their rarity it was not possible/appropriate to assign to groups.

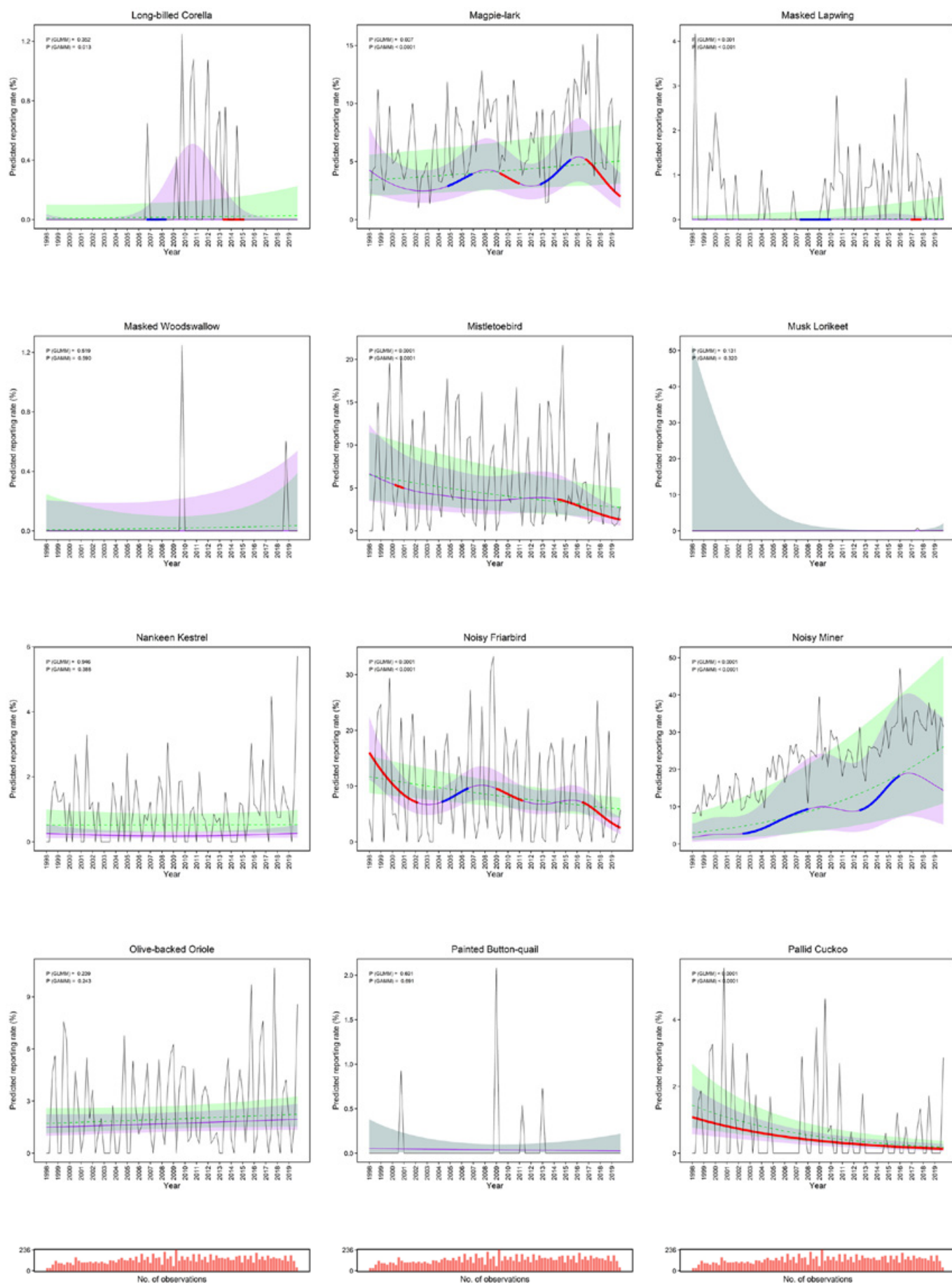


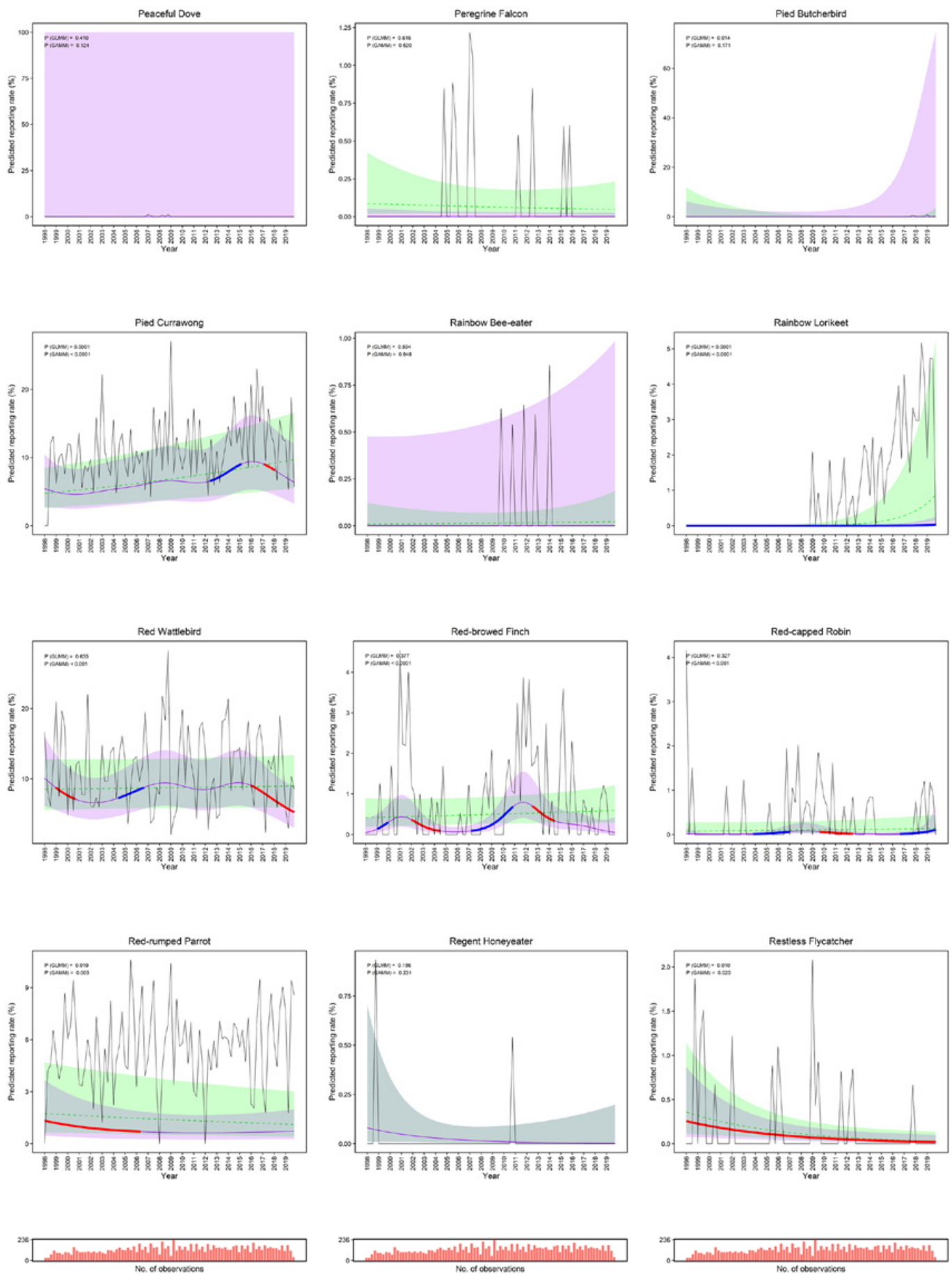


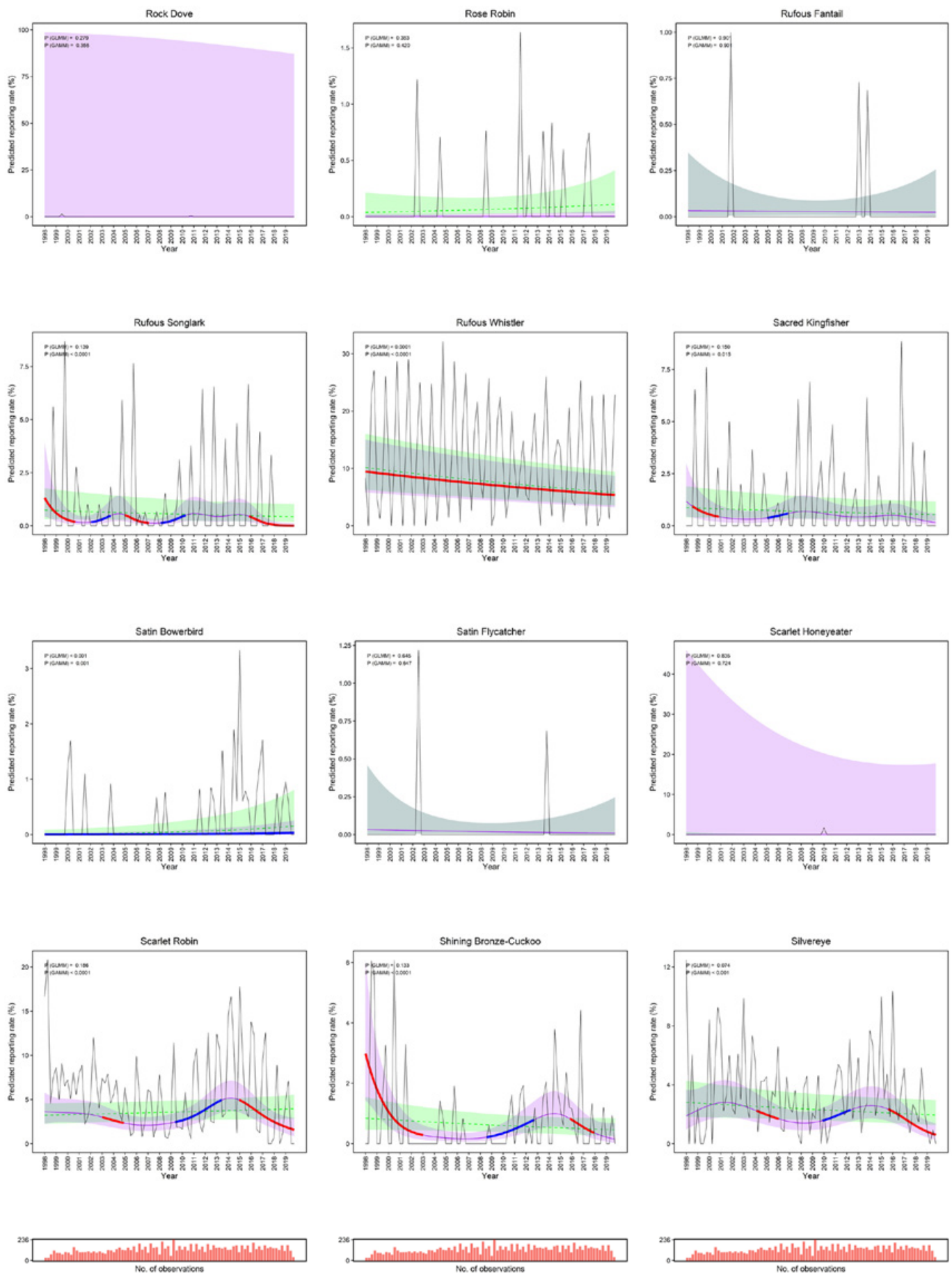


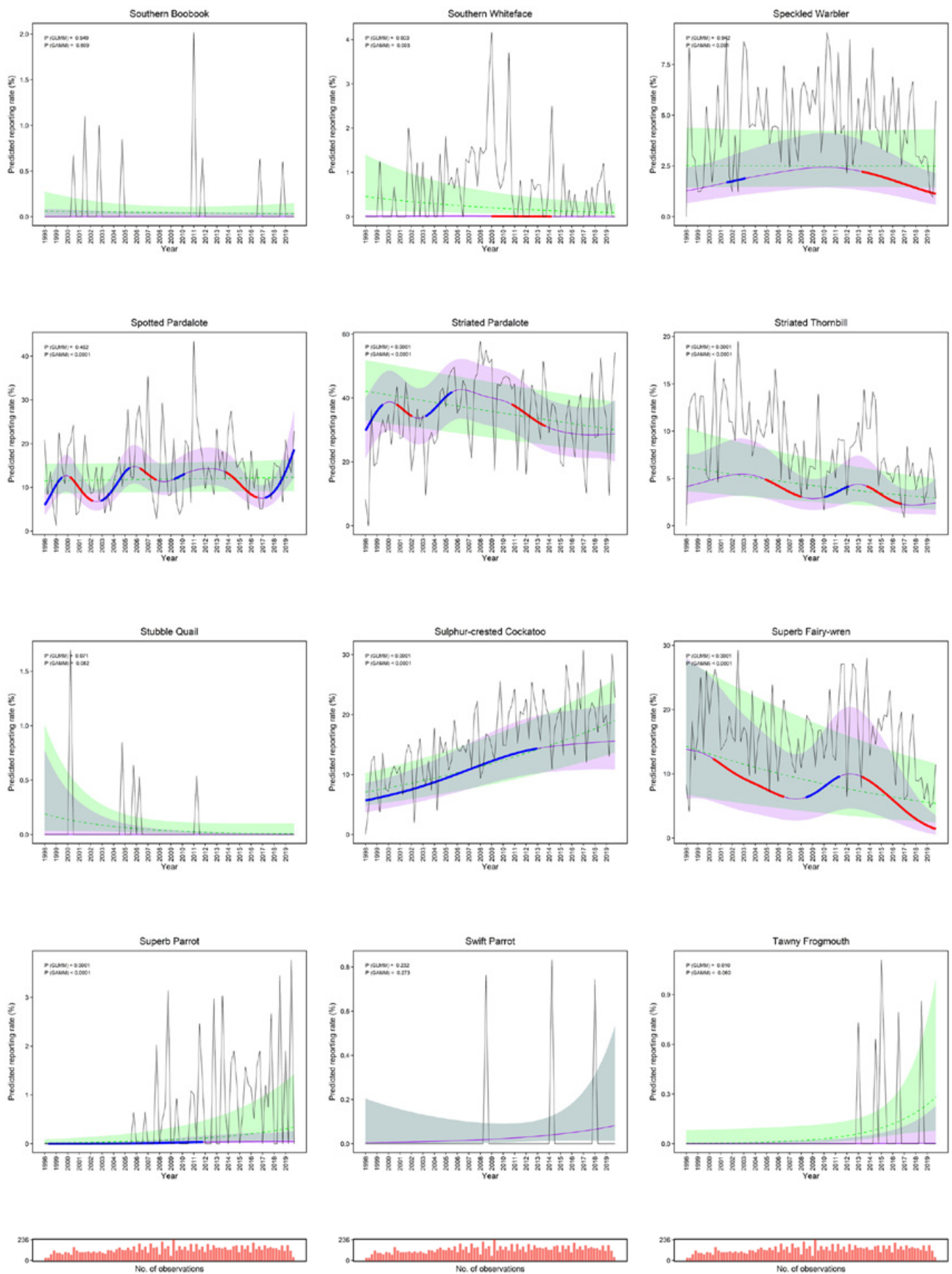


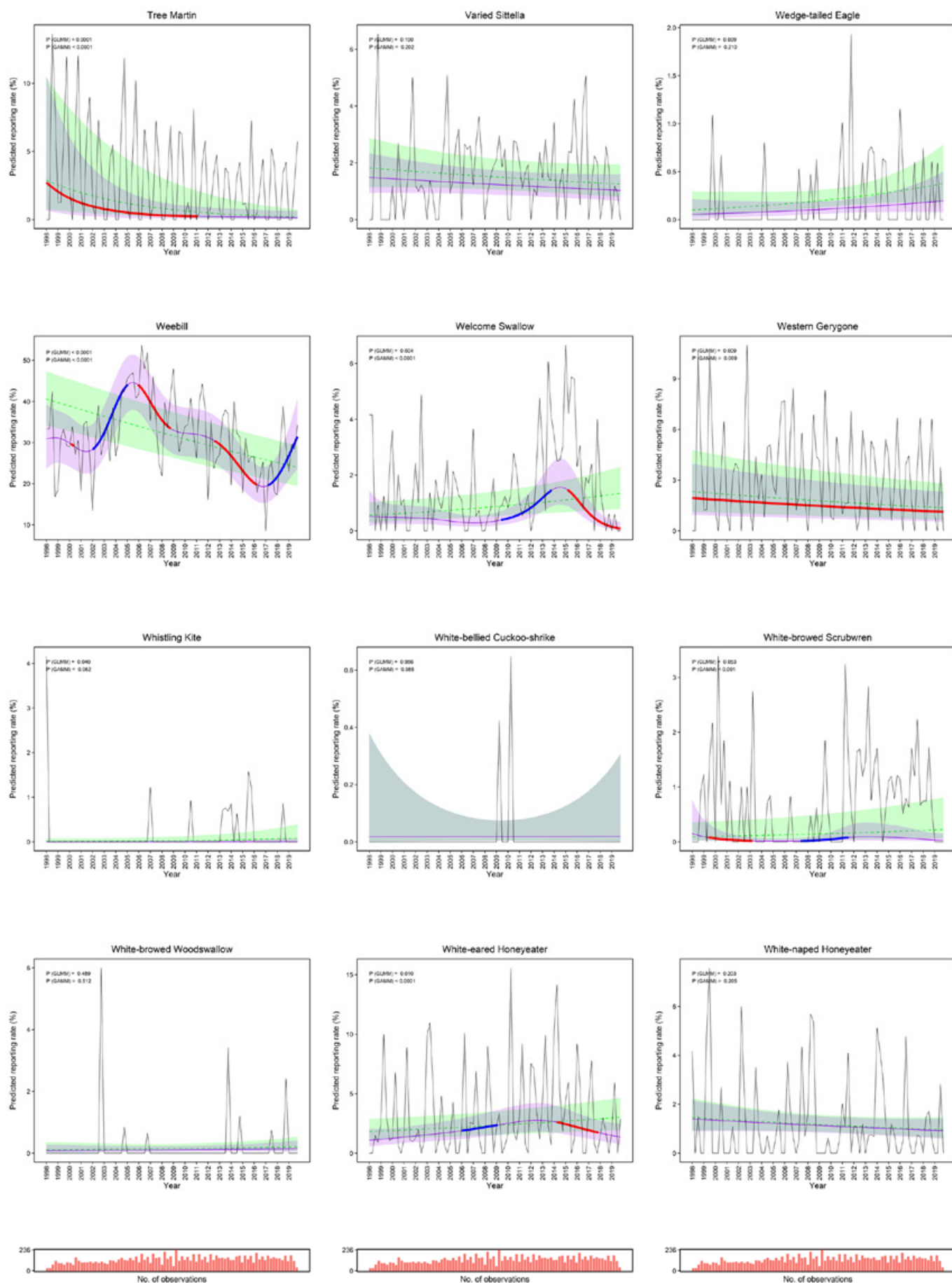


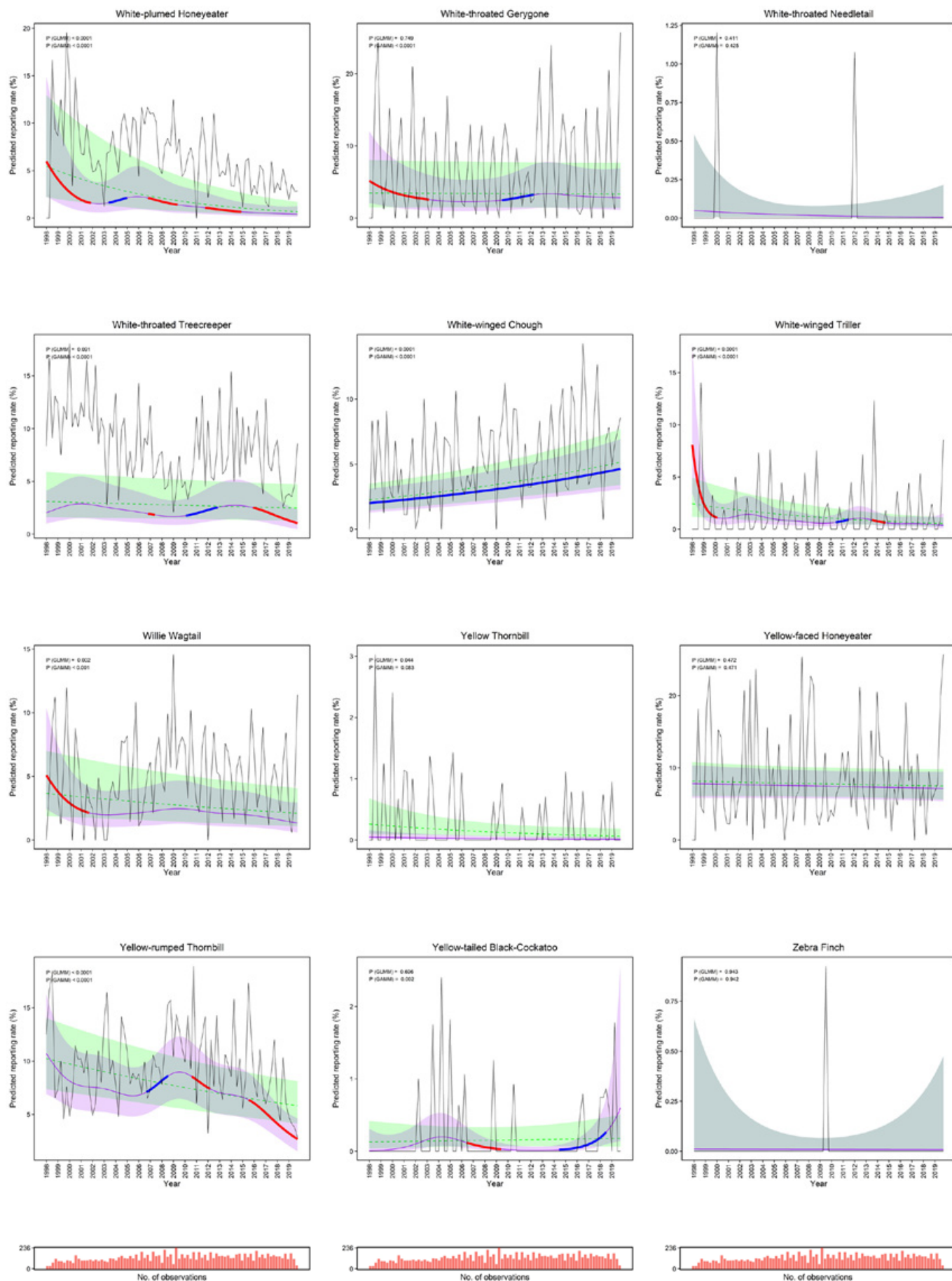












Appendix F: All species Rate of Change Plot

Significant increases (blue) and decreases (red) in the rate of change of the smoothed trends for individual species. Values were calculated for each quarter year. Only significant values were plotted.



Appendix G: Effect Plots for Individual Species within Bird Groups

Summary Effect Size plots, showing the magnitude of change in reporting rate for individual bird species arranged by bird groups. The relevant bird group is named at the top of each plot (shaded grey). Groups showing significant, collective, long-term change have a bold black border.

