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Prepared for Squadron Energy

# Bird and Bat Monitoring 2022-23 Biennial Report

## Boco Rock Wind Farm

Southern Tablelands, NSW

August 2024

Project Number: 230699

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# Document verification

| | |
|---|---|
| Project Title: | Boco Rock Wind Farm |
| Project Number: | 230699 |
| Project File Name: | Monitoring 2022-2023 Biennial Report Final v1.1 20240812 |

| Revision | Date | Prepared by | Approved by |
|---|---|---|---|
| Final V1.1 | 12/08/2024 | Bianca Heinze (minor edits) | Bianca Heinze |
| Final V1.0 | 25/07/2024 | Stella O'Dwyer<br>Bianca Heinze | Deb Frazer (nominated expert) |
| Draft V1.0 | 2/07/2024 | Stella O'Dwyer | Bianca Heinze |

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# Acronyms and Abbreviations

| | |
|---|---|
| AWS | Automatic weather station |
| BBMP | Bird and Bat Management Plan |
| BC Act | *Biodiversity Conservation Act 2016* (NSW) |
| BOM | Australian Bureau of Meteorology |
| BRWF | Boco Rock Wind Farm |
| CE | Critically endangered |
| Cth | Commonwealth |
| E | Endangered |
| EEC | Endangered ecological community – as defined under relevant law applying to the proposal |
| EPBC Act | *Environment Protection and Biodiversity Conservation Act 1999* (Cwth) |
| GIS | Geographic information system |
| ha | hectares |
| HD | high detection |
| km | kilometres |
| LGA | Local government area |
| m | metres |
| TEC | Threatened ecological community |
| V | Vulnerable |

# Executive summary

The Boco Rock Wind Farm (BRWF) is located on the Southern Tablelands of New South Wales (NSW), approximately 10 km south-west of the town of Nimmitabel. There are 67 operational turbines. Implementation of an adaptive Bird and Bat Management Plan (BBMP) forms part of the conditions of project approval.

As outlined in BBAMP V2.0 (NGH 2023), this Biennial Report is for the 2022-2023 survey period. Note a new monitoring method was begun in November 2023 in line with BBAMP V2.0. The results from the new methods are to be reported separately. This Biennial Report is supplementary to the *Summary Results Report 2015-2023* which was prepared in October 2023 to accompany the application to update the plan (BBAMP V2.0). This report has the complete set of results for the 2022-2023 reporting period for surveys undertaken under BBMP V1.3, which span January 2022 to October 2023.

Mortality surveys in between January 2022 – October 2023 resulted in 12 carcass/feather scatter finds. There were nine bird carcasses/feather scatters: two in 2022 and seven in 2023 from common and secure species including Eurasian Skylark (introduced), Australian Magpie and Nankeen Kestrel. Four carcasses of White-striped Freetail Bat were found: two in 2022 and two in 2023. No threatened species or waterbird carcasses were found.

The annual mortality estimate for bats is 15 in 2022 and 15 in 2023 (median). The annual mortality estimate for birds is 21 in 2022 and 55 in 2023 (median). These estimates are within the range previously calculated for Boco Rock WF, noting that the period for 2023 was 10 months rather than the usual 12 months.

A total of 215 bird utilisation surveys (BUS) were undertaken in January 2022 – October 2023 with an average survey coverage on 98%; well above the required 80% for robust statistical analysis. Species richness at BRWF in 2022 was 81 (the 2nd highest yet recorded) and 66 in 2023. Species abundance was 793 (2022) and 636 (2023); within the range of previous results.

As with previous years, results from Anabat data do not reflect bat mortalities, i.e. the most frequently recorded microbats by Anabat ('other' species such as *Vespadelus* spp.) do not correlate with frequently found microbat carcasses (White-striped Freetail Bat). Of particular note, Large Bent-winged Bat continues to be recorded utilising the site but is not found during carcass searches.

In conclusion, results from mortality, bird and anabat monitoring were broadly consistent with expectations given results of previous years and continue to support the conclusions of *Summary Results Report 2015-2023*, including that Boco Rock WF does not pose a significant threat to local bird and bat populations.

# 1. Introduction

## 1.1. Background

The Boco Rock Wind Farm (BRWF) is located on the Southern Tablelands of New South Wales (NSW), approximately 10 km south-west of the town of Nimmitabel. BRWF Stage 1 commenced operation in December 2014. Conditions of project approval by NSW Department of Planning (now Department of Planning& Environment, DPE) included an ongoing monitoring and management program to evaluate the operational impact of the wind farm to bird and bat species; an adaptive Bird and Bat Management Plan. Version 1 of the plan became operational in 2015 (BBMP V1.3); an updated plan (BBAMP V2.0) became operational in November 2023.

As outlined in BBAMP V2.0 (NGH 2023), this Biennial Report is for the 2022-2023 survey period. Note a new monitoring method was begun in November 2023 in line with BBAMP V2.0. The results from the new methods are to be reported separately.

## 1.2. Objectives of the Biennial Report

This Biennial Report is supplementary to the *Summary Results Report 2015-2023* which was prepared in October 2023 to accompany the application to update the plan (BBAMP V2.0). This report has the complete set of results for the 2022-2023 reporting period for surveys undertaken under BBMP V1.3, which span January 2022 to October 2023.

The reporting requirements to be met herein are detailed in the BBMP V1.3. In summary, annual reports are to:

- Summarise the results of monitoring (January 2022 – October 2023).
- Provide quantitative of mortality and bird surveys including an annual mortality estimate.

This report will not identify trends, highlight species at risk and provide recommendations as these matters were addressed in the *Summary Results Report 2015-2023*. The outcome of that report was the updated BBAMP V2.0.

## 1.3. Structure of the Biennial Report

Each section of the report outlines the survey method, effort and results of a monitoring method. Details and raw results are provided in appendices. Results from the interim November 2023 – April 2024 period are reported in Appendix C.4.

# 2. Carcass searches

## 2.1. Survey method & effort

Carcass searches during January 2022 – October 2023 were conducted in accordance with the BBMP V1.3. Mortality surveys were completed monthly within two different search areas:

1. High detectability zone at all 67 turbines every month (pulsed), and
2. Extended zone at 20 turbines per month

The carcass searches included 1608 high detectability searches & 240 extended zone searches each year: 1872 from January to December 2022, 1560 from January to October 2023. Data from the carcass searches were analysed and reported on by Symbolix (see Appendix C). Refer to Section 6.1 of BBMP V1.3 (NGH 2017) for detailed carcass search methodologies.

### 2.1.1. Limitations

Quarter 1 of the 2022 period recorded higher rainfall and warm weather, leading to prolific vegetation growth on site. This was notable in the extended zones, making carcass searches throughout 2022 difficult due to limited visibility. In March 2022 (end of 1st quarter), the hardstand areas of turbines were sprayed to remove vegetation and improve visibility for carcass detection. Thick vegetation continued to be reported as a hinderance to carcass detectability in extended zones.. The land manager was able to manage vegetation in the extended zones in late 2022 and coupled with reduced rainfall in early 2023, vegetation density was not impacting carcass detectability and search efforts in 2023.

## 2.2. Survey results

The detailed mortality survey results for January 2022 to October 2023 are given in Appendix A. The location of each carcass found is shown in the map in Appendix D1.1.

### Summary

Mortality surveys in between January 2022 – October 2023 resulted in 12 carcass/feather scatter finds. The monthly distribution of carcass finds is shown in below (see

Table 2-1). The highest number (2) of carcasses was found in February 2022 and March 2023 (first quarter). The total number of carcasses for the 22 month period was 12; 4 in 2022 and 8 in 2023 (to October).

No carcasses were found in 9 out of 12 months in 2022; 4 of 10 months in 2023. Locations of carcass finds are shown in Appendix A (see map in D1.2). No waterbirds or threatened species were found during mortality surveys during January 2022 – October 2023.

Table 2-1 Monthly distribution of carcasses/feather scatters found at BRWF (January 2022 – October 2023)

| Survey period | Number of carcass finds | |
|---|---|---|
| | 2022 | 2023 |
| January | 0 | 1 |
| February | 2 | 0 |
| March | 1 | 2 |
| April | 0 | 0 |
| May | 0 | 0 |
| June | 0 | 1 |
| July | 0 | 0 |
| August | 0 | 2 |
| September | 0 | 1 |
| October | 0 | 1 |
| November | 1 | n/a |
| December | 0 | n/a |
| Total | 4 | 8 |

### 2.2.1. Birds

Across all years of monitoring (January 2015 - October 2023), the top three bird species found in mortality surveys are:

1. Eurasian Skylark (15 or 22% of the total bird finds)
2. Australian Magpie (10 or 14% total bird finds)
3. Nankeen Kestrel (8 or 11% total bird finds)

All three are common, secure species. The data from this reporting period is consistent with results of previous years; bird carcasses were found from six species including: Eurasian Skylark (2), Common Starling (2), Raven sp (1), Australian Magpie (1), Nankeen Kestrel (1) and Stubble Quail (1).

Table 2-2 shows the species identified from carcasses/feather scatters along with the number. There were a total of eight bird carcasses/feather scatters: two in 2022 and six in 2023.

### 2.2.2. Bats

Across all years of monitoring (2015-October 2023), most carcasses found have been from two bat species:

1. White-striped Freetail Bat (60 or 73% of the total bat finds January 2015 to October 2023)
2. Gould's Wattled Bat (15 or 18% total bat finds)

Between January 2022 and October 2023, there were four bat carcasses found from one species: White-striped Freetail Bat.

Both are common, secure species. The data from the current reporting period is in keeping with previous years. Between January 2022 and October 2023, there were four bat carcasses found from one species: White-striped Freetail Bat.

Table 2-2 shows that two bat carcasses were found in 2022 and in 2023.

Table 2-2 Species and number of carcasses found during mortality surveys at BRWF (January 2022 – October 2023)

| Common name | Species name | No. found 2022 | No. found 2023 | Species at risk of turbine collision? |
|---|---|---|---|---|
| | **Birds** | | | |
| Australian Magpie | *Cracticus tibicen* | | 1 | No |
| Common Starling | *Sturnus vulgaris* | 1 | 1 | No |
| Eurasian Skylark | *Alauda arvensis* | 1 | 1 | No |
| Nankeen Kestrel | *Falco cenchroides* | | 1 | Yes |
| Raven sp. | | | 1 | No |
| Stubble Quail | *Coturnix pectoralis* | | 1 | No |
| ***Total birds*** | | **2** | **6** | |
| | **Bats** | | | |
| White-striped Freetail Bat | *Austronomus australis* | 2 | 2 | Yes |
| ***Total bats*** | | **2** | **2** | |

### 2.2.3. Location and status of finds

Table 2-3 summarises the carcass search results. It can be seen from Table 2-3 that the majority of carcasses were found in the high detectability (core) zone; only one carcass was located in the extended zone in September 2023. No threatened species were detected during the carcass searches between January 2022 and October 2023.

Table 2-3 Summary of mortality survey results by date for BRWF (January 2022 – October 2023)

| Turbine ID | Date | Common name | Threatened (Yes/No) | Found during monthly survey? | Survey zone |
|---|---|---|---|---|---|
| 54 | 13/02/2022 | White-striped Freetail Bat | No | Yes | Core |
| 59 | 13/02/2022 | White-striped Freetail Bat | No | Yes | Core |
| 5 | 4/03/2022 | Common Starling | No | Yes | Core |
| 17 | 27/11/2022 | Eurasian Skylark | No | Yes | Core |
| 62 | 15/01/2023 | Nankeen Kestrel | No | Yes | Core |
| 59 | 12/03/2023 | White-striped Freetail Bat | No | Yes | Core |
| 58 | 12/03/2023 | White-striped Freetail Bat | No | Yes | Core |
| 50 | 26/06/2023 | Stubble Quail | No | Yes | Core |
| 51 | 25/08/2023 | Australian Magpie | No | Yes | Core |
| 5 | 25/08/2023 | Common Starling | No | Yes | Core |
| 1 | 28/09/2023 | Eurasian Skylark | No | Yes | Ext. |
| 1 | 25/10/2023 | Raven sp. | No | Yes | Core |

## 2.3. Analysis: mortality estimates

As per previous years, an estimate of overall annual mortality was derived by a Monte-Carlo simulation model (Hull and Muir 2010 in Symbolix 2024) by Symbolix for each year of monitoring and is presented in Table 2-4. The data for this reporting period has been analysed in two separate reports (refer to Appendix C for both statistical mortality reports).

Table 2-4 Annual mortality estimates for birds and bats at BRWF 2015 - October 2023 ( * indicates analysis for 10-month period only)

| Carcass type | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | Oct 2023* |
|---|---|---|---|---|---|---|---|---|---|
| Bat | 160 | 138 | 129 | 63 | 27 | 8 | 55 | 15 | 15 |
| Bird | 115 | 88 | 131 | 118 | 76 | 151 | 40 | 21 | 55 |

The cumulative Y1-9 estimate (January 2015 to October 2023) analysed for both bats and birds. Over this time period, a total of 74 bats were found. The resulting (median) estimate of total mortality is 465 bat individuals lost over the nine years. Over this time period, a total of 63 birds were found. The resulting (median) estimate of total mortality is 395 individuals lost over the nine years.

### 2.3.1. Anomalies

The period for 2023 was 10 months rather than the usual 12 months; mortality monitoring was undertaken in the other two months under BBAMP V2.0 but this will be reported on separately. The median mortality estimate results (15; 15) for bats are within the range previously found (8-160) and no anomalies have been detected. The 2023 median mortality estimate for birds (55) are within the existing range (40-151). The 2022 median mortality estimate for birds (21) is lower than the range; this may be because fewer birds were lost or because detectability was lower than expected during some of the time (refer to Section 2.1.1).

# 3. Bird Utilisation Surveys

## 3.1. Survey method & effort

The Bird Utilisations Surveys (BUS) completed from January 2022 till October 2023 were in accordance with BBMP V1.3 (2017). BUS surveys are completed monthly. Each month, ten locations are selected for survey (120 bird utilisation surveys during a 12-month reporting period).

There are three stratification layers in the design: grassland/pasture impact sites ('grassland' sites, grassland/pasture control sites ('control' sites) and woodland sites. The three stratification layers are independent of each other. The strata are defined as follows:

- Grassland impact: grassland/pasture habitat within 500 m radius of a turbine
- Grassland control: grassland/pasture habitat greater than 500 m from a turbine
- Woodland: woodland habitat where it is available to survey; sites are generally between 500 m and two kilometres from a turbine, with the closest being around 300 m (these are along woodland edges) and the furthest site 2.7 km distant. There are no woodland control sites

Although attempts have been made to sample similar habitat in the grassland impact and grassland control sites, there are notable differences in the bird habitat available at the two. The majority of the grassland impact sites are heavily cleared pasture areas while the control sites are more diverse grassland within patchy mosaics of scattered trees or woodland. Also, many grassland impact sites are at the highest points in the landscape and are barren and exposed. Control sites occupy a range of landscape positions and generally include more shelter. These differences reflect the selection of high elevations and more open sites for turbine placement (and therefore impact sites) compared to the random selection of control sites.

### 3.1.1. Limitations on statistical analysis

Aspects of survey roll-out place some limitations of analysis and use of data. Some of these issues have been discussed previously (e.g. 2016 Annual Report, NGH 2017c) and will continue to be a caveat on interpretation of results throughout the program.

In 2015 at commencement of monitoring, all bird utilisation survey sites were randomly generated using a GIS system and then located in the field. This resulted in some sites which were difficult to access, and some grassland control sites where the habitat was more of a woodland matrix than grassland. These sites were dropped (e.g. due to access issues) or moved (i.e. to better represent the target habitat stratum) in 2016. The legacy of this change is an apparent marked decline in species richness of control sites from 2015 to 2016, reflecting the move from heterogeneous treed habitat to the homogeneous grassland habitat that occurs in the grassland impact site. When this is accounted for in analysis, there is no obvious change in species mix at control sites across the years.

In 2016, in an attempt to even up total sites surveyed in each strata for the year, grassland impact site surveys were not undertaken in October and November. This skews the grassland fourth quarter (October, November, December) species richness counts for that year, showing an apparently much lower species richness in the fourth quarter of 2016 than 2015 and 2017.

In 2021, wet weather reduced survey coverage such that 14 BUS (out of 120 planned surveys) were not able to be completed due to adverse weather, which impacted December surveys in particular; missing two entire strata for that month (grassland impact and woodland). This has shown as a slight decline in species richness in the two impact zones compared to the control.

These limitations do not affect the ability of the data to be analysed to meet the objectives of the program and were accounted for during statistical analysis by Symbolix Pty Ltd.

## 3.2. Survey results

Table 3-1 shows the number of surveys per stratum at BRWF from January 2022 to October 2023. A total of 215 bird utilisation surveys were undertaken with 73 sites in grassland control, 73 in grassland impact and 69 in woodland. The 2022 BUS survey effort (January – December 2022) achieved 97% survey coverage overall (116 from 120 survey sites), while the 2023 survey effort (January – October 2023) achieved 99% coverage (99 from 100 survey sites). This is a combined average survey coverage of 98% (215 from 220 survey sites). Refer to maps in Appendix D1.3 for bird utilisation survey locations.

Table 3-1 Number of Surveys per stratification layer each month and in total at BRWF (January 2022 – April 2023)

| Survey Period | Grassland Control | Grassland Impact | Woodland | Total |
|---|---|---|---|---|
| **2022** | | | | |
| January | 4 | 3 | 3 | 10 |
| February | 4 | 3 | 3 | 10 |
| March | 3 | 4 | 3 | 10 |

| Survey Period | Grassland Control | Grassland Impact | Woodland | Total |
|---|---|---|---|---|
| ***1st quarter totals*** | **11** | **10** | **9** | **30** |
| April | 3 | 1 | 3 | 7 |
| May | 3 | 4 | 3 | 10 |
| June | 3 | 3 | 3 | 9 |
| ***2nd quarter totals*** | **9** | **8** | **9** | **26** |
| July | 3 | 3 | 4 | 10 |
| August | 3 | 4 | 3 | 10 |
| September | 3 | 3 | 4 | 10 |
| ***3rd quarter totals*** | **9** | **10** | **11** | **30** |
| October | 4 | 4 | 2 | 10 |
| November | 5 | 5 | 0 | 10 |
| December | 3 | 3 | 4 | 10 |
| ***4th quarter totals*** | **12** | **12** | **6** | **30** |
| **2023** | | | | |
| January | 4 | 3 | 3 | 10 |
| February | 4 | 3 | 3 | 10 |
| March | 3 | 3 | 3 | 9 |
| ***1st quarter totals*** | **11** | **9** | **9** | **29** |
| April | 3 | 3 | 4 | 10 |
| May | 2 | 4 | 4 | 10 |
| June | 3 | 3 | 4 | 10 |
| ***2nd quarter totals*** | **8** | **10** | **12** | **30** |
| July | 4 | 3 | 3 | 10 |
| August | 3 | 4 | 3 | 10 |
| September | 3 | 3 | 4 | 10 |
| ***3rd quarter totals*** | **10** | **10** | **10** | **30** |
| October | 3 | 4 | 3 | 10 |
| ***4th quarter totals*** | **3** | **4** | **3** | **10** |
| ***Total*** | ***73*** | ***73*** | ***69*** | ***215*** |

### 3.2.1. Species richness

Species richness is the count of the number of species in an area. There were 81 species recorded in 2022 and 66 species recorded in 2023 during BUS only. Note: analysis by Symbolix uses only BUS data. This is within the range previously recorded (59-89), with 2022 the 2nd highest species richness over the nine years of monitoring.

Table 3-2 Species richness each year of BUS monitoring (January 2015 - October 2023)

| Year | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|
| Species richness | 89 | 75 | 73 | 69 | 65 | 66 | 59 | 81 | 66 |

Overall richness is higher in woodland than grassland BUS sites. Woodland richness has remained fairly constant over the last five years (accounting for seasonal variation). Richness in grassland sites is also generally stable. Refer to Appendix C.2. for more statistical detail from Symbolix.

### 3.2.2. Species abundance & diversity

Species abundance is the number of individuals per species. Note that aural observations are given a count of one individual. Abundance in 2022 was 793 (observations) and 636 in 2023 (for 10 months) - Table 3-3. This shows a change from a downward trend over the past years of monitoring; along with more species of birds, more individual birds were recorded in 2022 and 2023.

Table 3-3 Species abundance each year of BUS monitoring (January 2015 - October 2023)

| Year | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | *2022* | *2023* |
|---|---|---|---|---|---|---|---|---|---|
| No. observations | 1729 | 1283 | 1051 | 948 | 801 | 719 | 665 | *793* | *636* |

Eurasian Skylark was consistently one of the most common species observed during grassland BUS surveys between 2015-2023 along with a fairly consistent mix of Common Starling, Sulphur-crested Cockatoo, Little Raven and Australian Magpie. Species abundance in woodland was more varied over time. Auditory and visual count charts for most common species by year and strata are given in Appendix C.2.

### Diversity

Due to high variation in results year to year (refer to Figure 3-1), it is difficult to identify any clear trends in Shannon diversity (Symbolix, 2024b). However, overall results indicate that diversity is fairly stable in the woodland (accounting for seasonal variation) and grassland sites.

## Species mix

The most pronounced shift in species mix over time occurs in grassland control sites between 2015 and 2017, which are already discussed occurred because of changes to control sites. Overall, species mix in grassland control and impact are variable year to year yet show a similar pattern between strata (Figure 3-2). The species mix in woodland is distinct from grassland and shows less variation year to year. In all strata, the species mix has been fairly stable (with the exception above). Most pertinently, there is no evidence of changes in the grassland stratum that aren't mirrored by changes in the control.

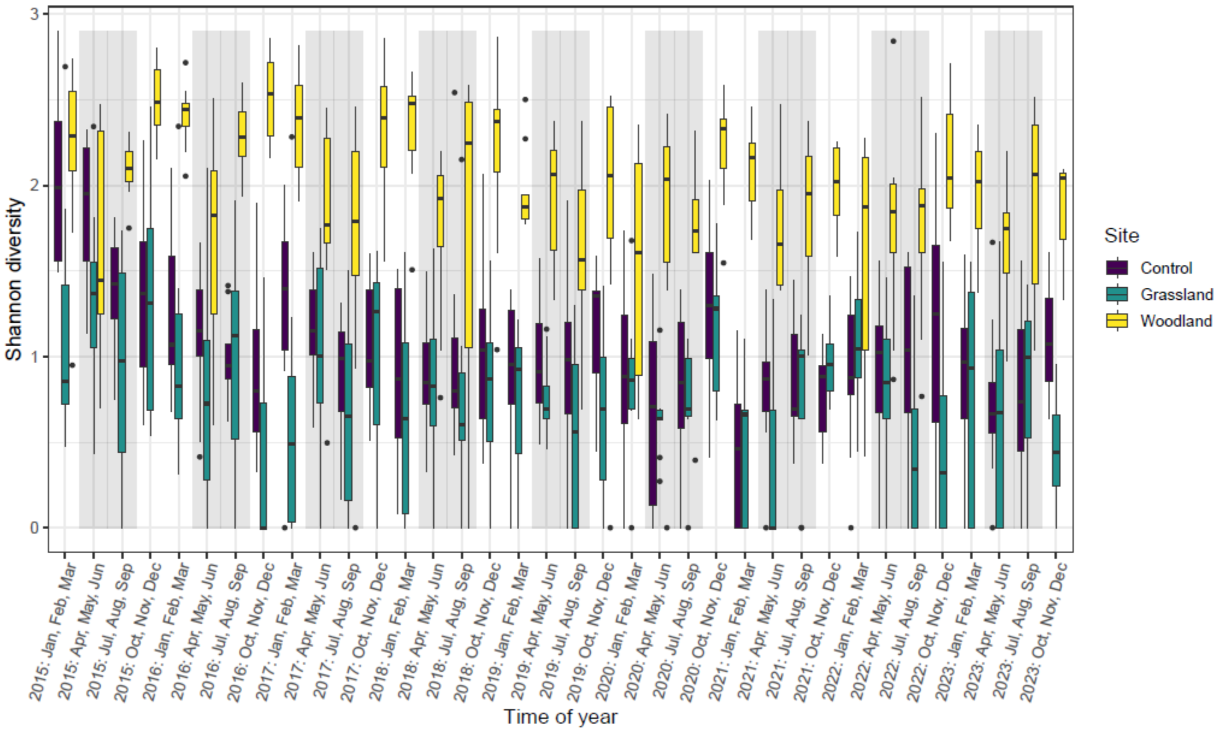


Figure 3-1 Distribution of Shannon diversity per survey, by site and time of year (Symbolix 2024b)

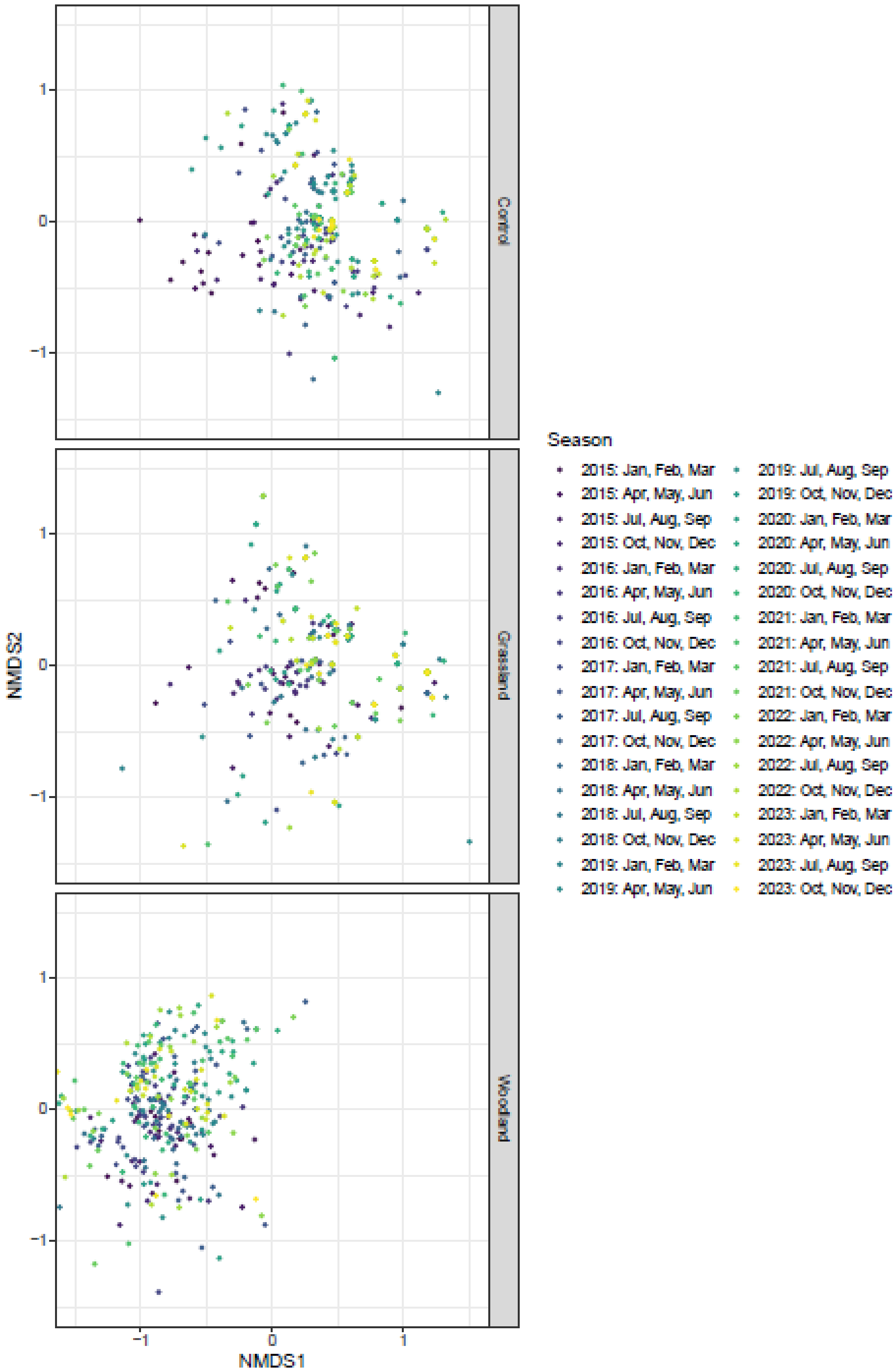


Figure 3-2 Ordination plots grouped by season and site, with distance based upon presence/absence (Symbolix 2024b)

### 3.2.3. Trend modelling

Trend modelling shows that (Symbolix, 2024b):

- Increased rainfall is associated with increased Shannon diversity.
- Shannon diversity is decreasing over time in all stratum; site type (control, impact, woodland) is not a determining factor.
- Species diversity and richness increase with distance from turbine.

### 3.2.4. Control-impact comparisons

Table 3-4 shows the species richness for each year of monitoring separated into strata. For 2022, species richness in the grassland control stratum was 33; the highest since 2018. In 2023, it was 19; the lowest recorded. This is likely to have been influenced by exclusion of November and December in the survey, with spring and summer typically being the busiest for birds at Boco Rock.

Species richness in the grassland impact stratum was 16 for 2022 and 19 in 2023. These are within the range of previous results (11-40). Species richness in the woodland stratum in 2022 was 62, the highest recorded since 2015 while in 2023 species richness in the woodland stratum was the lowest ever recorded on site at 50. Again this result would have been influenced by surveys concluding in October.

Table 3-4 Species richness by each year of monitoring (2015-2023) for each stratum

| | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|
| Grassland control | 63 | 36 | 30 | 35 | 28 | 26 | 24 | 33 | 19 |
| Grassland impact | 40 | 29 | 28 | 21 | 14 | 19 | 11 | 16 | 19 |
| Woodland | 66 | 58 | 58 | 53 | 53 | 52 | 55 | 62 | 50 |

### Analysis

Results showed a decrease in diversity and abundance not attributed to the wind farm, with factors like rainfall and distance from turbines correlating with diversity (Symbolix, 2024b). There is no evidence of an impact on bird populations caused by the operation of BRWF (Symbolix, 2024b).

### 3.2.5. Threatened species

During BUS surveys and opportunistically, 25 counts of seven threatened species were recorded. As for previous years, the most frequently recorded threatened species was Scarlet Robin *Petroica boodang*, with eleven records. Refer to Table 3-5 for threatened species records.

Table 3-5 Threatened species recorded during BUS surveys at BRWF (January – October 2023)

| Date | Common Name | Scientific Name | Easting | Northing | NSW Listing | EPBC Listing |
|---|---|---|---|---|---|---|
| 14/02/2022 | Scarlet Robin | *Petroica boodang* | 685063 | 5940153 | V | |
| 5/04/2022 | Scarlet Robin | *Petroica boodang* | 685524 | 5939471 | V | |
| 29/05/2022 | Gang-gang Cockatoo | *Callocephalon fimbriatum* | 685463 | 5939221 | E | E |
| 29/05/2022 | Scarlet Robin | *Petroica boodang* | 685463 | 5939221 | V | |
| 15/06/2022 | Scarlet Robin | *Petroica boodang* | 685603 | 5939302 | V | |
| 5/07/2022 | Diamond Firetail | *Stagonopleura guttata* | 684942 | 5940091 | V | |
| 5/07/2022 | Scarlet Robin | *Petroica boodang* | 684942 | 5940091 | V | |
| 5/07/2022 | Speckled Warbler | *Chthonicola sagittata* | 684942 | 5940091 | V | |
| 20/09/2022 | Scarlet Robin | *Petroica boodang* | 692299 | 5951227 | V | |
| 28/10/2022 | Dusky Woodswallow | *Artamus cyanopterus* | 692260 | 5951978 | V | |
| 9/12/2022 | Brown Treecreeper | *Climacteris picumnus* | 685969 | 5938280 | V | V |
| 9/12/2022 | Diamond Firetail | *Stagonopleura guttata* | 685969 | 5938280 | V | V |
| 9/12/2022 | Dusky Woodswallow | *Artamus cyanopterus* | 685969 | 5938280 | V | |
| 9/12/2022 | Hooded Robin | *Melanodryas cucullata* | 685969 | 5938280 | E | E |
| 9/12/2022 | Scarlet Robin | *Petroica boodang* | 684662 | 5938927 | V | |
| 9/12/2022 | Speckled Warbler | *Chthonicola sagittata* | 684662 | 5938927 | V | |
| 18/02/2023 | Scarlet Robin | *Petroica boodang* | 685524 | 5939471 | V | |
| 13/03/2023 | Scarlet Robin | *Petroica boodang* | 684942 | 5940091 | V | |
| 2/04/2023 | Brown Treecreeper | *Climacteris picumnus* | 685969 | 5938280 | V | V |
| 2/04/2023 | Scarlet Robin | *Petroica boodang* | 684638 | 5938677 | V | |
| 28/06/2023 | Diamond Firetail | *Stagonopleura guttata* | 688991 | 5949894 | V | V |
| 30/07/2023 | Scarlet Robin | *Petroica boodang* | 692299 | 5951227 | V | |
| 26/08/2023 | Gang-gang | *Callocephalon* | 684580 | 5939238 | E | E |

| Date | Common Name | Scientific Name | Easting | Northing | NSW Listing | EPBC Listing |
|---|---|---|---|---|---|---|
| | Cockatoo | *fimbriatum* | | | | |
| 26/09/2023 | Dusky Woodswallow | *Artamus cyanopterus* | 685698 | 5939244 | V | |
| 26/09/2023 | Speckled Warbler | *Chthonicola sagittata* | 685698 | 5939244 | V | |

# 4. Microbat surveys

## 4.1. Survey method & effort

Passive overnight Anabat surveys were undertaken seven times from January 2022 to October 2023 (refer to Table 4-2 below). Four Anabat detectors were placed in the same location each survey cycle for four consecutive nights, with a focus on survey coverage of the most relevant season for microbat survey (March-May and September-November for species of interest such as the migratory Large Bent-winged Bat and White-striped Freetail Bat), as well as a winter survey. Survey locations have been selected based on the two habitat types at BRWF (woodland and grassland) and have been used for the past seven years (Table 4-1).

Table 4-1 Anabat sites used for each quarterly survey at BRWF (2015 to date)

| Anabat site | Stratification | Description | Nearest turbine |
|---|---|---|---|
| AE-1 | Control | Open grassland near Avon Lake Road > 500 m from turbines | 34, 35 |
| AE-2 | Impact | Open grassland between turbines 49 & 50 (< than 500 m distance from turbines) | 49, 50 |
| AE-3 | Impact | Two rows of trees meeting < 500 m from turbine. No woodland occurs within 500 m of turbines, so this is the densest vegetation. | 25 |
| AE-4 | Control | Woodland > 500 m from turbines | 35, 37 |

The detectors were programmed to commence operation approximately 30 minutes before dusk and to cease approximately 30 minutes after dawn. Anabat survey effort for the reporting period is shown in Table 4-2. Results were analysed by consultant bat expert Glenn Hoye of Flight by Night Bat Surveys.

Table 4-2 Microbat (Anabat) survey effort at BRWF (January 2022 – October 2023)

| Reporting quarter | Date | Effort |
|---|---|---|
| **2022** | | |
| 1st quarter | 1-4 March 2022 | 4 units for 4 nights; 16 survey nights. |

| Reporting quarter | Date | Effort |
|---|---|---|
| 2nd quarter | 13-16 June 2022 | 4 units for 4 nights; 16 survey nights. |
| 3rd quarter | 19-22 September 2022 | 4 units for 4 nights; 16 survey nights. |
| 4th quarter | 8-11 December 2022 | 4 units for 4 nights; 16 survey nights. |
| **2023** | | |
| 1st quarter | 12-15 March 2023 | 4 units for 4 nights; 16 survey nights. |
| 2nd quarter | 26-29 June 2023 | 3 units for 4 nights; 12 survey nights. |
| 3rd quarter | 25-28 September 2023 | 4 units for 4 nights; 16 survey nights. |
| **Total** | | **108 survey nights** |

#### 4.1.1. Limitations

A 4th quarter survey was not undertaken for 2023 due to the commencement of BBAMP V2.0 in November 2024, which does not include Anabat survey. Anabat monitoring was discontinued due to surveys showing no correlation between activity levels and carcass finds for any species (BBAMP V2.0). There were problems with recordings obtained from AE-1 during all surveys in 2022 and 2023, possibly due to the exposed survey location with wind causing interference and cattle knocking over the unit. The very low recordings obtained from this survey location (19) may therefore be a reflection of survey interference rather than a lack of bats. The unit was tested and found to be working.

### 4.2. Survey results

Anabat call analysis has focussed on identification of threatened microbat species or common species known to be susceptible to turbine interactions (i.e. those that have been detected during mortality surveys). As call analysis can be time consuming and costly, all other calls that are from non-threatened species and/or those that have not been detected during mortality surveys are allocated to the grouping ‘other’. The total number of calls recorded each survey were analysed and allocated to the following species or grouping:

1. Large Bent-winged Bat *Miniopterus oceanensis oriane* (Vulnerable under NSW *Biodiversity Conservation Act 2017* (BC ACT))
2. Eastern False Pipistrelle *Falsistrellus tasmaniensis* (Vulnerable BC Act)
3. Yellow-bellied Sheathtail Bat *Saccolaimus flaviventris* (Vulnerable BC Act)
4. White-striped Freetail Bat *Austronomus australis*
5. Gould's Wattled Bat *Chalinolobus gouldii*
6. Other bats

For reference, a full analysis of all bat calls was completed in 2016 and showed that other bats known to occur at BRWF include those detailed below. These species still remain largely absent from mortality searches.

- Chocolate Wattled Bat *Chalinolobus morio*
- Southern Freetail Bat *Mormopterus planiceps*
- Inland Broad-nosed Bat *Scotorepens balstoni*
- Large Forest Bat *Vespadelus darlingtoni*
- Southern Forest Bat *Vespadelus regulus*
- Little Forest Bat *Vespadelus vulturnus*

Table 4-3 Results of Anabat analysis with selected species, all quarters combined (January 2022 – October 2023)(all sites)

| Species | AE1 Grassland control | AE2 Grassland Impact | AE3 Woodland impact | AE4 Woodland control | Total for spp. |
|---|---|---|---|---|---|
| **2022** | | | | | |
| White-striped Freetail Bat (*Austronomus australis*) | 4 | 0 | 55 | 3 | 62 |
| Gould's Wattled Bat (*Chalinolobus gouldii*) | 6 | 15 | 744 | 13 | 778 |
| Eastern False Pipistrelle (*Falsistrellus tasmaniensis*) | 1 | 1 | 10 | 3 | 15 |
| Large Bent-winged Bat (*Miniopterus orianae oceanensis*) | 0 | 2 | 329 | 15 | 346 |
| Other species | 15 | 56 | 1448 | 268 | 1787 |
| Total for sites | 26 | 74 | 2586 | 302 | 2988 |
| **2023** | | | | | |
| White-striped Freetail Bat (*Austronomus australis*) | 2 | 31 | 195 | 4 | 232 |
| Gould's Wattled Bat (*Chalinolobus gouldii*) | 2 | 45 | 522 | 12 | 581 |
| Eastern False Pipistrelle (*Falsistrellus tasmaniensis*) | 0 | 1 | 14 | 4 | 19 |
| Large Bent-winged Bat (*Miniopterus orianae oceanensis*) | 0 | 1 | 457 | 10 | 468 |
| Other species | 15 | 49 | 27 | 1263 | 1354 |
| Total for sites | 19 | 127 | 1215 | 1293 | 2654 |

### 4.2.1. Threatened species

Two threatened microbat species were recorded by Anabat at BRWF during the survey period January 2022 to October 2023 . These were;

- Large Bent-winged Bat
- Eastern False Pipistrelle

Large Bent-winged Bat has been recorded at BRWF since monitoring began in 2015. Eastern False Pipistrelle has been recorded in low numbers in 2015, 2018, 2019, 2020, 2021, 2022 and 2023. Neither of these species were detected in mortality carcass search surveys 2022 or 2023.

# 5. Incidental observations

## 5.1. Raptors

In 2022, there were 69 raptor observations; this is far greater than previous years' records which range from 23 to 59 per year. Raptor records in 2023 was within the usual range. Median annual raptor observations 2015-2023 is 40.8. Six raptor species were recorded during bird surveys or opportunistically on 89 occasions at BRWF during January 2022 – October 2023:

1. Australian Hobby *Falco longipennis*
2. Black-shouldered Kite *Elanus axillaris*
3. Brown Goshawk *Accipiter fasciatus*
4. Nankeen Kestrel *Falco cenchroides*
5. Swamp Harrier *Circus approximans*
6. Wedge-tailed Eagle *Aquila audax*

Of the raptor observations, only 26% were recorded during bird utilisation surveys; most observations were opportunistic. The most frequently recorded raptor that accounted for half of the records was Nankeen Kestrel with 27 observations in 2022 and 16 in 2023. Wedge-tailed Eagle was next most abundant with 20 recorded in 2022 and 12 in 2023. Table 5-1 summarises all raptor sightings from January 2022 to October 2023; details are given in Appendix B.

Table 5-1 Raptor species recorded at BRWF (January 2022 – October 2023)Table 5-2 Summary of number of raptors recorded in January 2022 - October 2023

| Common Name | Scientific Name | No. records 2022 | No. records 2023 |
|---|---|---|---|
| Australian Hobby | *Falco longipennis* | 4 | 2 |
| Black-shouldered Kite | *Elanus axillaris* | 15 | 3 |
| Brown Goshawk | *Accipiter fasciatus* | 2 | |
| Nankeen Kestrel | *Falco cenchroides* | 27 | 16 |
| Swamp Harrier | *Circus approximans* | 1 | |
| Wedge-tailed Eagle | *Aquila audax* | 20 | 12 |
| **Total** | | **69** | **33** |

## 5.2. Waterbirds

The BBMP V1.3 requires that the influence of the local wetlands on bird survey results is considered. There were 11 species of 'wetland' bird recorded during utilisation surveys between January 2022 till October 2023 (shown as utilisation survey type in Table 5-3 below). By far the majority (90%) of waterbird sightings at BRWF during January 2022 till October 2023 occurred opportunistically at the ephemeral wetlands surveyed (20,723 birds opportunistically compared to 140 birds during BUS). Most waterbird records come from opportunistic sightings at the wetlands.

The influence of waterbirds on BUS results is minor to moderate depending on the size of the flocks encountered. It is clear however, that the influence of waterbirds on mortality results is negligible. There has not been a waterbird carcass found at BRWF to date (2015 – 2023).

Table 5-3 Wetland species, survey type and count for all wetland species recorded at BRWF during the reporting period (January 2022 – October 2023)

| Common name | Species name | Survey | Count |
|---|---|---|---|
| Australasian Grebe | *Tachybaptus novaehollandiae* | Utilisation | 2 |
| | | Opportunistic | 334 |
| Australasian Shoveler | *Anas rhynchotis* | Utilisation | 2 |
| | | Opportunistic | 170 |
| Australasian Swamphen | *Porphyrio melanotus* | Opportunistic | 14 |
| Australian Shelduck | *Tadorna tadornoides* | Utilisation | 11 |
| | | Opportunistic | 58 |
| Australian Spotted Crake | *Porzana fluminea* | Opportunistic | 3 |
| Australian Wood Duck | *Chenonetta jubata* | Utilisation | 37 |
| | | Opportunistic | 279 |
| Black Swan | *Cygnus atratus* | Utilisation | 3 |
| | | Opportunistic | 250 |
| Black-winged Stilt | *Himantopus himantopus* | Opportunistic | 1 |
| Chestnut Teal | *Anas castanea* | Opportunistic | 10 |
| Duck spp | *Duck spp.* | Opportunistic | 381 |
| Eurasian Coot | *Fulica atra* | Utilisation | 29 |
| | | Opportunistic | 14113 |
| Great Cormorant | *Phalacrocorax carbo* | Opportunistic | 1 |
| Grebe spp | *Grebe spp.* | Opportunistic | 489 |
| Grey Teal | *Anas gracilis* | Utilisation | 4 |

| Common name | Species name | Survey | Count |
|---|---|---|---|
| | | Opportunistic | 1329 |
| Hardhead | *Aythya australis* | Opportunistic | 641 |
| Hoary-headed Grebe | *Poliocephalus poliocephalus* | Opportunistic | 746 |
| Little Pied Cormorant | *Microcarbo melanoleucos* | Utilisation | 7 |
| | | Opportunistic | 10 |
| Masked Lapwing | *Vanellus miles* | Utilisation | 4 |
| | | Opportunistic | 71 |
| Pacific Black Duck | *Anas superciliosa* | Utilisation | 34 |
| | | Opportunistic | 1624 |
| Pink-eared Duck | *Malacorhynchus membranaceus* | Opportunistic | 2 |
| Purple Swamp Hen | *Porphyrio porphyrio* | Opportunistic | 55 |
| Red-kneed Dotterel | *Erythrogonys cinctus* | Opportunistic | 1 |
| Unidentified Waterfowl | *Unidentified waterfowl* | Opportunistic | 40 |
| White-faced Egret | *Egretta novaehollandiae* | Utilisation | 7 |
| | | Opportunistic | 97 |
| White-necked Heron | *Ardea pacifica* | Opportunistic | 4 |
| **Total** | | | **20,863** |

# 6. Conclusion

This is the final report to be provided under BBMP V1.3 as the plan was updated in 2023. Results from November 2023, obtained using different methods from those herein, will be reported separately in 2026. This Biennial Report presents results for the period January 2022 – October 2023 and can be read in conjunction with the *Summary Results Report 2015-2023,* which discusses trends and recommendations.

After nine years of bird and bat monitoring at BRWF, the program is meeting its primary objective to detect collisions of bird and microbat species with turbines. Overall, survey effort is well above what is required for statistical analysis. The results reported herein are consistent with those of previous years: the species mix found during carcass searches were typical of those found in previous years. The threatened bird and bat species, raptors and most common bird species were also typical of those found in previous years. Results from Anabat data do not reflect bat mortalities, i.e. the most frequently recorded microbats by Anabat do not correlate with frequently found microbat carcasses. Of particular note, Large Bent-winged Bat continues to be recorded utilising the site but is not found during carcass searches.

There were a few anomalies in results:

- 2022 bird median annual mortality estimate (21) was outside the range of previous results (40-151). It was noted that detectability is likely to have affected the number of carcasses found and therefore the annual mortality estimate. This was discussed with the Operator throughout 2022; action to reduce vegetation cover was taken once landholder co-operation was gained. Although numbers were lower, the mix of species found was consistent with previous and subsequent years. For this reason, detectability is not considered a substantial limitation. Detectability trials will be run again in 2025 to reflect more recent conditions.
- Bird species richness was the lowest ever recorded in 2023 in the grassland control (19) and woodland (50) strata, likely to have been influenced by surveys concluding in October prior to the influx of seasonally migratory species during late spring and summer. In either case, changes in these strata do not reflect wind farm impacts as both are controls. The species richness in the grassland impact stratum was strong (within range) in both 2022 and 2023.
- In 2022 BUS and incidental raptor observations were much higher (69) than the previously recorded range (23-59). The mix of most commonly recorded species (Nankeen Kestrel and Wedge-tailed Eagle) was consistent with previous years.

A trend towards higher bird species richness than previous reporting years (since 2018) along with high raptor abundance is likely to be linked to the positive correlation found between bird species richness at Boco Rock WF and rainfall. Statistical analysis concludes that overall species richness and diversity has decreased over time (2015-2023) and there is no evidence that this is caused by BRWF as the change in observed in all stratum.

In conclusion, results from mortality, bird and Anabat monitoring were broadly consistent with expectations given results of previous years and continue to support the conclusions of *Summary Results Report 2015-2023*, including that Boco Rock WF does not pose a significant threat to local bird and bat populations.

# 7. References

DoE. (2015). *Referral guideline for 14 birds listed as migratory.* Canberra: Department of the Environment, Australian Government.

Symbolix. (2024b). *Boco Rock Wind Farm Bird Utilisation Survey - Year Nine Analysis.* prepared by Symbolix for NGH Environmental.

# Appendix A Results: Mortality Surveys

**January 2022 – October 2023 Detailed mortality results**

| Quarter | Month | Turbine ID: | Date | Common Name | Species: | No. | Threatened (Yes/No) | Easting | Northing | Notes: |
|---|---|---|---|---|---|---|---|---|---|---|
| 1st | Jan | 18 | 19/01/2021 | White-striped Freetail Bat | *Austronomus australis* | 1 | No | 685940 | 5945353 | < week old. No obvious physical damage. Male. |
| 1st | Feb | 54 | 13/02/2022 | White-striped Freetail Bat | Austronomus australis | 1 | No | 691205.43 | 5951082.15 | Body intact. 1 day old. Lower abdomen swollen with fluid. Male. |
| 1st | Feb | 59 | 13/02/2022 | White-striped Freetail Bat | Austronomus australis | 1 | No | 691519.92 | 5952724.54 | 1-2 days old. Damage to right forearm and both wing membranes. Male |
| 1st | Mar | 5 | 4/03/2022 | Common Starling | | 1 | No | 685306 | 5941971 | Fresh. Broken neck. Morning was very misty, may have flown into turbine tower. |
| 4th | Nov | 17 | 27/11/2022 | Eurasian Skylark | Alauda arvensis | 1 | No | 685932 | 5944944 | Appears to have been scavenged, only head, body and one leg remain. May not have been killed by the turbine. Could have been dropped by predator. Fresh - one day old |
| 1st | Jan | 62 | 15/01/2023 | Nankeen Kestrel | Falco cenchroides | 1 | No | 692120 | 5953698 | Feathers only, mainly primary wing weather. Some bones, picked |

| Quarter | Month | Turbine ID: | Date | Common Name | Species: | No. | Threatened (Yes/No) | Easting | Northing | Notes: |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | clean of flesh. |
| 2nd | Mar | 59 | 12/03/2023 | White-striped Freetail Bat | Austronomus australis | 1 | No | 691519.92 | 5952724.54 | Body intact. Wings still soft, eyes present. Blood pooled in lower abdomen. Jaw appears broken. |
| 3rd | Mar | 59 | 12/03/2023 | White-striped Freetail Bat | Austronomus australis | 1 | No | 691519.92 | 5952724.54 | Body intact. Wings still soft, eyes present. Blood pooled in lower abdomen. |
| 2nd | Jun | 50 | 26/06/2023 | Stubble Quail | Coturnix pectoralis | 1 | No | 690515 | 5953747 | No obvious sign of external injury |
| 3rd | Aug | 51 | 25/08/2023 | Australian Magpie | Cracticus tibicen | 1 | No | 690888 | 5953529 | No obvious sign of injury |
| 3rd | Aug | 5 | 28/08/2023 | Common Starling | Sturnus vulgaris | 1 | No | 685304 | 5941938 | No obvious sign of injury |
| 3rd | Sep | 1 | 28/09/2023 | Eurasian Skylark | Alauda arvensis | 1 | No | 685646 | 5940674 | No obvious sign of injury |
| 4th | Oct | 1 | 25/10/2023 | Raven sp. | Corvus sp. | 1 | No | 688216 | 5950005 | Old carcass, difficult to assess injuries. |

## November 2023 – April 2024 Detailed mortality results

| Quarter | Month | Turbine ID: | Date | Common Name | Species: | No. | Threatened (Yes/No) | Easting | Northing | Notes: |
|---|---|---|---|---|---|---|---|---|---|---|
| 4th | Dec | 39 | 20/12/2023 | Eurasian Skylark | Alauda arvensis | 1 | No | 688214 | 5950001 | Body intact. 1 day old. Lower abdomen swollen with fluid. Male. |

| Quarter | Month | Turbine ID: | Date | Common Name | Species: | No. | Threatened (Yes/No) | Easting | Northing | Notes: |
|---|---|---|---|---|---|---|---|---|---|---|
| 1st | Jan | 28 | 1/4/2024 | Common Starling | *Sturnus vulgaris* | 1 | No | 685470 | 5946863 | Intact carcass, not scavenged and no sign of obvious injury |
| 1st | Jan | 1 | 1/5/2024 | Australian Magpie | *Cracticus tibicen* | 1 | No | 685841 | 5943653 | Dry carcass and flattened from being on the ground for some time. Eyes missing. Difficult to determine injury as the carcass was quite stiff. |
| 1st | Mar | 64 | 3/25/2024 | White-striped Freetail Bat | *Austronomus australis* | 1 | No | 692299 | 5954181 | Left forearm broken. Lower abdomen swollen. |

# Appendix B Results: Bird Surveys

Threatened species listed in bold.

**January 2022 – October 2023 Bird survey results – utilisation and observation**

| Common Name | Scientific Name | Utilisation | Observation | Grand Total |
|---|---|---|---|---|
| Australasian Grebe | *Tachybaptus novaehollandiae* | 59 | 1 | 60 |
| Australasian Pipit | *Anthus novaeseelandiae* | 0 | 8 | 8 |
| Australasian Shoveler | *Anas rhynchotis* | 24 | 1 | 25 |
| Australasian Swamphen | *Porphyrio melanotus* | 5 | 0 | 5 |
| Australian Hobby | *Falco longipennis* | 4 | 1 | 5 |
| Australian Magpie | *Cracticus tibicen* | 0 | 135 | 135 |
| Australian Owlet-nightjar | *Aegotheles cristatus* | 0 | 1 | 1 |
| Australian Raven | *Corvus coronoides* | 0 | 7 | 7 |
| Australian Shelduck | *Tadorna tadornoides* | 8 | 5 | 13 |
| Australian Spotted Crake | *Porzana fluminea* | 1 | 0 | 1 |
| Australian Wood Duck | *Chenonetta jubata* | 17 | 3 | 20 |
| Black Swan | *Cygnus atratus* | 59 | 2 | 61 |
| Black-faced Cuckoo-shrike | *Coracina novaehollandiae* | 0 | 3 | 3 |
| Black-shouldered Kite | *Elanus axillaris* | 11 | 2 | 13 |
| Black-winged Stilt | *Himantopus himantopus* | 1 | 0 | 1 |
| Brown Falcon | *Falco berigora* | 1 | 4 | 5 |
| Brown Goshawk | *Accipiter fasciatus* | 1 | 1 | 2 |
| Brown Thornbill | *Acanthiza pusilla* | 0 | 6 | 6 |
| **Brown Treecreeper** | ***Climacteris picumnus*** | 0 | 2 | 2 |
| Brown-headed Honeyeater | *Melithreptus brevirostris* | 0 | 6 | 6 |
| Brush Bronzewing | *Phaps elegans* | 0 | 1 | 1 |
| Brush Cuckoo | *Cacomantis variolosus* | 0 | 1 | 1 |
| Buff-rumped Thornbill | *Acanthiza reguloides* | 0 | 4 | 4 |
| Chestnut Teal | *Anas castanea* | 2 | 0 | 2 |

| Common Name | Scientific Name | Utilisation | Observation | Grand Total |
|---|---|---|---|---|
| Common Starling | *Sturnus vulgaris* | 0 | 50 | 50 |
| Crimson Rosella | *Platycercus elegans* | 0 | 35 | 35 |
| **Diamond Firetail** | ***Stagonopleura guttata*** | 1 | 2 | 3 |
| Duck spp | *Duck spp* | 4 | 2 | 2 |
| **Dusky Woodswallow** | ***Artamus cyanopterus*** | 0 | 3 | 3 |
| Eastern Spinebill | *Acanthorhynchus tenuirostris* | 0 | 2 | 2 |
| Easter Yellow Robin | *Eopsaltria australis* | 0 | 1 | 1 |
| Eurasian Coot | *Fulica atra* | 76 | 2 | 78 |
| Eurasian Skylark | *Alauda arvensis* | 0 | 385 | 385 |
| European Goldfinch | *Carduelis carduelis* | 0 | 7 | 7 |
| Fan-tailed Cuckoo | *Cacomantis flabelliformis* | 0 | 5 | 5 |
| Fuscous Honeyeater | *Lichenostomus fuscus* | 0 | 3 | 3 |
| Galah | *Eolophus roseicapilla* | 0 | 39 | 39 |
| **Gang-gang Cockatoo** | ***Callocephalon fimbriatum*** | 0 | 2 | 2 |
| Golden Whistler | *Pachycephala pectoralis* | 0 | 1 | 1 |
| Great Cormorant | *Phalacrocorax carbo* | 1 | 0 | 1 |
| Grebe spp | *Grebe spp* | 4 | 0 | 4 |
| Grey Currawong | *Strepera versicolor* | 0 | 4 | 4 |
| Grey Fantail | *Rhipidura albiscapa* | 0 | 14 | 14 |
| Grey Shrike-thrush | *Colluricincla harmonica* | 0 | 31 | 31 |
| Grey Teal | *Anas gracilis* | 69 | 1 | 70 |
| Hardhead | *Aythya australis* | 20 | 0 | 20 |
| Hoary-headed Grebe | *Poliocephalus poliocephalus* | 47 | 0 | 47 |
| Hooded Robin | *Melanodryas cucullata* | 0 | 1 | 1 |
| Horsfields Bronze-cuckoo | *Chrysococcyx basalis* | 0 | 2 | 2 |
| House Sparrow | *Passer domesticus* | 0 | 2 | 2 |
| King Parrot | *Alisterus scapularis* | 0 | 1 | 1 |
| Laughing Kookaburra | *Dacelo novaeguineae* | 0 | 9 | 9 |

| Common Name | Scientific Name | Utilisation | Observation | Grand Total |
|---|---|---|---|---|
| Leaden Flycatcher | *Myiagra rubecula* | 0 | 1 | 1 |
| Little Pied Cormorant | *Microcarbo melanoleucos* | 3 | 1 | 4 |
| Little Raven | *Corvus mellori* | 0 | 112 | 112 |
| Magpie-Lark | *Grallina cyanoleuca* | 0 | 8 | 8 |
| Masked Lapwing | *Vanellus miles* | 21 | 3 | 24 |
| Nankeen Kestrel | *Falco cenchroides* | 26 | 10 | 36 |
| Noisy Miner | *Manorina melanocephala* | 0 | 1 | 1 |
| Pacific Black Duck | *Anas superciliosa* | 93 | 12 | 105 |
| Painted Button Quail | *Turnix varius* | 0 | 1 | 1 |
| Pallid Cuckoo | *Cacomantis pallidus* | 0 | 3 | 3 |
| Pied Currawong | *Strepera graculina* | 0 | 23 | 23 |
| Pink-eared Duck | *Malacorhynchus membranaceus* | 1 | 0 | 1 |
| Purple Swamp Hen | *Porphyrio porphyrio* | 7 | 0 | 7 |
| Red Wattlebird | *Anthochaera carunculata* | 0 | 56 | 56 |
| Red-browed Finch | *Neochmia temporalis* | 0 | 1 | 1 |
| Red-kneed Dotterel | *Erythrogonys cinctus* | 1 | 0 | 1 |
| Red-rumped Parrot | *Psephotus haematonotus* | 0 | 2 | 2 |
| Restless Flycatcher | *Myiagra inquieta* | 0 | 1 | 1 |
| Rose Robin | *Petroica rosea* | 0 | 1 | 1 |
| Rufous Whistler | *Pachycephala rufiventris* | 0 | 11 | 11 |
| Sacred Kingfisher | *Todiramphus sanctus* | 0 | 1 | 1 |
| **Scarlet Robin** | ***Petroica boodang*** | 0 | 11 | 11 |
| Shining Bronze-cuckoo | *Chrysococcyx lucidus* | 0 | 2 | 2 |
| Silvereye | *Zosterops lateralis* | 0 | 3 | 3 |
| Southern Whiteface | *Aphelocephala leucopsis* | 1 | 0 | 1 |
| **Speckled Warbler** | ***Chthonicola sagittata*** | 0 | 3 | 3 |
| Spotted Pardalote | *Pardalotus punctatus* | 0 | 6 | 6 |
| Striated Pardalote | *Pardalotus striatus* | 0 | 54 | 54 |

| Common Name | Scientific Name | Utilisation | Observation | Grand Total |
|---|---|---|---|---|
| Striated Thornbill | *Acanthiza lineata* | 0 | 5 | 5 |
| Stubble Quail | *Coturnix pectoralis* | 0 | 33 | 33 |
| Sulphur-crested Cockatoo | *Cacatua galerita* | 0 | 33 | 33 |
| Superb Fairywren | *Malurus cyaneus* | 0 | 10 | 10 |
| Superb Lyrebird | *Menura novae-hollandiae* | 0 | 3 | 3 |
| Swamp Harrier | *Circus approximans* | 1 | 0 | 1 |
| Tree Martin | *Petrochelidon nigricans* | 0 | 1 | 1 |
| Unidentified waterfowl | *Unidentified waterfowl* | 2 | 0 | 2 |
| Wedge-tailed Eagle | *Aquila audax* | 20 | 6 | 26 |
| Weebill | *Smicrornis brevirostris* | 0 | 1 | 1 |
| Welcome Swallow | *Hirundo neoxena* | 0 | 5 | 5 |
| White-browed Scrubwren | *Sericornis frontalis* | 0 | 3 | 3 |
| White-browed Treecreeper | *Climacteris affinis* | 0 | 3 | 3 |
| White-eared Honeyeater | *Lichenostomus leucotis* | 0 | 66 | 66 |
| White-faced Egret | *Egretta novaehollandiae* | 33 | 4 | 37 |
| White-naped Honeyeater | *Melithreptus lunatus* | 0 | 5 | 5 |
| White-throated Treecreeper | *Cormobates leucophaea* | 0 | 44 | 44 |
| White-winged Triller | *Lalage tricolor* | 0 | 1 | 1 |
| Willie Wagtail | *Rhipidura leucophrys* | 0 | 9 | 9 |
| Yellow-faced Honeyeater | *Lichenostomus chrysops* | 0 | 69 | 69 |
| Yellow-rumped Thornbill | *Acanthiza chrysorrhoa* | 0 | 4 | 4 |
| Yellow-tufted Honeyeater | *Lichenostomus melanops* | 0 | 2 | 2 |
| **Grand Total** | | **620** | **1430** | **2050** |

## Opportunistic Records (November 2023 - April 2024)

| Date | Month | Common Name | Native | Count | Observation | Site | Easting | Northing | Distance | Height | Raptor? | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21/11/2023 | Nov | Wedge-tailed Eagle | Yes | 2 | Observed | East of T42 | 688264 | 5949085 | 285 | 100 | Yes | Soaring |
| 21/11/2023 | Nov | Nankeen Kestrel | Yes | 1 | Observed | T42 | 687967 | 5949197 | 0 | 10 | Yes | Perched in tree |
| 22/11/2023 | Nov | Nankeen Kestrel | Yes | 1 | Observed | Front gate | 686583 | 5949370 | 0 | 10 | Yes | Hovering |
| 23/11/2023 | Nov | Nankeen Kestrel | Yes | 1 | Observed | Near T44 | 688546 | 5949500 | 100 | 12 | Yes | Hovering |
| 23/11/2023 | Nov | Nankeen Kestrel | Yes | 1 | Observed | T01 | 685569 | 5940719 | 40 | 10 | Yes | Hovering |
| 19/12/2023 | Dec | Nankeen Kestrel | Yes | 1 | Observed | Between T55 and T56 | 691384 | 5951373 | 100 | 20 | Yes | Hovering |
| 21/12/2023 | Dec | Nankeen Kestrel | Yes | 1 | Observed | T16 | 686006 | 5944783 | 80 | 15 | Yes | Hovering |
| 21/12/2023 | Dec | Wedge-tailed Eagle | Yes | 2 | Observed | T22 | 685863 | 5946516 | 280 | 60 | Yes | Soaring |

| Date | Month | Common Name | Native | Count | Observation | Site | Easting | Northing | Distance | Height | Raptor? | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21/12/2023 | Dec | Nankeen Kestrel | Yes | 1 | Observed | Gate to T25 | 687087 | 5947147 | | 10 | Yes | Hovering |
| 22/12/2023 | Dec | Nankeen Kestrel | Yes | 1 | Observed | T02 | 685089 | 5941353 | 40 | 15 | Yes | Hovering |
| 3/1/2024 | Jan | Nankeen Kestrel | Yes | 1 | Observed | Near front gate | 686584 | 5949461 | NA | 15 | Yes | Hovering |
| 3/1/2024 | Jan | White-throated Needletail | Yes | 20+ | Observed | Near T42 | 687904 | 5949250 | 150 | 200 | No | Flock of 20 + birds scattered over a large area and flying in an easterly direction |
| 3/1/2024 | Jan | Wedge-tailed Eagle | Yes | 1 | Observed | Near T42 | 688178 | 5949189 | 250 | 100 | Yes | Soaring |
| 4/1/2024 | Jan | Nankeen Kestrel | Yes | 1 | Observed | Roughly halfway between T30 and T26 | 686493 | 5947515 | NA | 15 | Yes | Hovering |
| 4/1/2024 | Jan | Nankeen Kestrel | Yes | 1 | Observed | Near T25 | 687281 | 5947062 | 100 | 20 | Yes | Hovering |

| Date | Month | Common Name | Native | Count | Observation | Site | Easting | Northing | Distance | Height | Raptor? | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5/1/2024 | Jan | Nankeen Kestrel | Yes | 1 | Observed | Near T04 | 685241 | 5941675 | 80 | 7 | Yes | In tree |
| 12/2/2024 | Feb | Nankeen Kestrel | Yes | 1 | Observed | Near T52 | 691084 | 5953939 | 40 | 15 | Yes | Hovering |
| 13/2/2024 | Feb | Nankeen Kestrel | Yes | 1 | Observed | Near T2A | 685547 | 5940992 | 120 | 15 | Yes | Hovering |
| 26/3/2024 | Mar | Wedge-tailed Eagle | Yes | 1 | Observed | Near T43 | 688549 | 5949093 | 200 | 100 | Yes | Riding thermal |
| 26/3/2024 | Mar | Nankeen Kestrel | Yes | 1 | Observed | T45 | 689096 | 5948911 | 60 | 10 | Yes | In tree |
| 28/3/2024 | Mar | Nankeen Kestrel | Yes | 1 | Observed | Gate to T5 | 685308 | 5941995 | 0 | 20 | Yes | Hovering |
| 27/4/2024 | Apr | Nankeen Kestrel | Yes | 1 | Observed | T52 | 691024 | 5953852 | 20 | 20 | Yes | Hovering |
| 27/4/2024 | Apr | Nankeen Kestrel | Yes | 1 | Observed | T42 | 687933 | 5949168 | 50 | 20 | Yes | Hovering |

| Date | Month | Common Name | Native | Count | Observation | Site | Easting | Northing | Distance | Height | Raptor? | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 28/4/2024 | Apr | Nankeen Kestrel | Yes | 1 | Observed | T32 | 686414 | 5948056 | 40 | 25 | Yes | Hovering |
| 28/4/2024 | Apr | Nankeen Kestrel | Yes | 1 | Observed | T16 | 685977 | 5944702 | 30 | 15 | Yes | Hovering |
| 28/4/2024 | Apr | Flame Robin | Yes | 1 | Observed | Between T02 and T02A | 685286 | 5941194 | 10 | 1 | No | Perched on rock wall |

### Wedge-tailed Eagle and Nankeen Kestrel survey results

| Common Name | Scientific Name | Stratum | Location | Month | Year | Observation type | Number |
|---|---|---|---|---|---|---|---|
| **Australian Hobby** | ***Falco longipennis*** | Control | 54r | Oct | 2022 | Seen | 1 |
| | | | T26 | Sep | 2022 | Seen | 2 |
| | | | Gate to T25 | Oct | 2022 | Seen | 1 |
| | | | Between Turbine 63 and T66 | Mar | 2023 | Seen | 1 |
| | | | Neat T26 | Jul | 2023 | Seen | 1 |
| **Black-shouldered Kite** | ***Elanus axillaris*** | Control | 30r | Sep | 2022 | Seen | 3 |
| | | Control | 55r | Aug | 2022 | Heard | 1 |

| Common Name | Scientific Name | Stratum | Location | Month | Year | Observation type | Number |
|---|---|---|---|---|---|---|---|
| | | | Near T09 | Jul | 2022 | Seen | 3 |
| | | | T25 | Jul | 2022 | Seen | 2 |
| | | | Between T18 and T19 | Sep | 2022 | Seen | 1 |
| | | | T03 | Sep | 2022 | Seen | 1 |
| | | | Near T09 | Oct | 2022 | Seen | 1 |
| | | | B/W T05 and T04 | Oct | 2022 | Seen | 1 |
| | | | B/W T04 and T03 | Oct | 2022 | Seen | 1 |
| | | | Between Turbine T2A and T02 | Nov | 2022 | Seen | 1 |
| | | | Gate between T2A and T2 | Apr | 2023 | Seen | 1 |
| | | | T54 | Aug | 2023 | Seen | 1 |
| | | | T28 | Aug | 2023 | Seen | 1 |
| **Brown Goshawk** | ***Accipiter fasciatus*** | Woodland | 103 | Sep | 2022 | Seen | 1 |
| | | | Road to T58 | Jul | 2022 | Seen | 1 |
| **Nankeen Kestrel** | ***Falco cenchroides*** | Woodland | 51r | Sep | 2022 | Seen | 1 |
| | | Control | 47r | Apr | 2022 | Seen | 1 |
| | | | Between T2 and T2A | Apr | 2022 | Seen | 1 |
| | | Grassland | 84 | Jul | 2023 | Seen | 1 |

| Common Name | Scientific Name | Stratum | Location | Month | Year | Observation type | Number |
|---|---|---|---|---|---|---|---|
| | | Grassland | 75 | Oct | 2022 | Seen | 1 |
| | | Grassland | 47 | Oct | 2023 | Seen | 1 |
| | | Control | 33r | Nov | 2022 | Seen | 1 |
| | | Grassland | 13r | Dec | 2022 | Seen | 1 |
| | | Grassland | 86 | Jan | 2022 | Seen | 1 |
| | | Control | 40r | Feb | 2022 | Seen | 1 |
| | | Control | 39r | Jan | 2023 | Seen | 1 |
| | | | Between T02A and T02 | Jan | 2022 | Seen | 1 |
| | | | Between T43 and T66 | Feb | 2022 | Seen | 1 |
| | | | Between T13 and T14 | Mar | 2022 | Seen | 1 |
| | | | Between T7 and T8 | Mar | 2022 | Seen | 1 |
| | | | Between T2 and T2A | Apr | 2022 | Seen | 1 |
| | | | Between T7 and T8 | May | 2022 | Seen | 1 |
| | | | Between T61and T60 | May | 2022 | Seen | 2 |
| | | | Near T46 | May | 2022 | Seen | 1 |
| | | | Opportunistic - Turbine 47 | Jun | 2022 | Seen | 1 |
| | | | Opportunistic - Turbine 46 | Jun | 2022 | Seen | 1 |

| Common Name | Scientific Name | Stratum | Location | Month | Year | Observation type | Number |
|---|---|---|---|---|---|---|---|
| | | | Turbine 44 | Jul | 2022 | Seen | 1 |
| | | | Near T09 | Jul | 2022 | Seen | 1 |
| | | | T25 | Jul | 2022 | Seen | 1 |
| | | | T26 | Sep | 2022 | Seen | 1 |
| | | | Near T05 | Oct | 2022 | Seen | 1 |
| | | | T02A | Oct | 2022 | Seen | 1 |
| | | | Between Turbine T63 and T66 | Dec | 2022 | Seen | 1 |
| | | | Near T25 | Dec | 2022 | Seen | 1 |
| | | | Turbine 26 | Feb | 2023 | Seen | 1 |
| | | | Turbine 55 | Feb | 2023 | Seen | 1 |
| | | | Turbine 36 | Mar | 2023 | Seen | 1 |
| | | | Road to T25 | Apr | 2023 | Seen | 1 |
| | | | Gate to T01 | Jun | 2023 | Seen | 1 |
| | | | B/W T25 and T26 | Jun | 2023 | Seen | 1 |
| | | | Gate to T01 | Jul | 2023 | Seen | 1 |
| | | | Between T06 and T07 | Sep | 2023 | Seen | 1 |
| | | | T66 | Sep | 2023 | Seen | 1 |
| | | | T46 | Sep | 2023 | Seen | 1 |

| Common Name | Scientific Name | Stratum | Location | Month | Year | Observation type | Number |
|---|---|---|---|---|---|---|---|
| | | | T25 | Sep | 2023 | Seen | 1 |
| | | | T09 | Oct | 2023 | Seen | 1 |
| | | | T21 | Oct | 2023 | Seen | 1 |
| **Swamp Harrier** | ***Circus approximans*** | Wetland | Lake on Avon Lake Road | Oct | 2022 | Seen | 1 |
| **Wedge-tailed Eagle** | ***Aquila audax*** | Control | 37r | May | 2022 | Seen | 1 |
| | | Woodland | 137 | Feb | 2022 | Seen | 1 |
| | | Woodland | 132 | Sep | 2023 | Seen | 1 |
| | | Grassland | 81 | Mar | 2022 | Seen | 1 |
| | | Grassland | 75 | Oct | 2022 | Seen | 1 |
| | | Control | 20r | Jun | 2022 | Seen | 2 |
| | | | Near T58 | Apr | 2022 | Seen | 1 |
| | | | Between T3 and T2 | Mar | 2022 | Seen | 1 |
| | | | Near site office | Mar | 2022 | Seen | 1 |
| | | | Near T58 | Apr | 2022 | Seen | 1 |
| | | | Opportunistic - Turbine 61 | Jun | 2022 | Seen | 1 |
| | | | Turbine 45 | Jul | 2022 | Seen | 1 |
| | | | 300m east of Turbine 32 | Aug | 2022 | Seen | 2 |

| Common Name | Scientific Name | Stratum | Location | Month | Year | Observation type | Number |
|---|---|---|---|---|---|---|---|
| | | | Near Turbine 63 | Sep | 2022 | Seen | 1 |
| | | | T26 | Sep | 2022 | Seen | 1 |
| | | | Near Turbine 58 | Oct | 2022 | Seen | 2 |
| | | | B/W T16 and T15 | Oct | 2022 | Seen | 1 |
| | | | Near T31 | Dec | 2022 | Seen | 1 |
| | | | Turbine 13 | Feb | 2023 | Seen | 1 |
| | | | Turbine 21 | Feb | 2023 | Seen | 2 |
| | | | Turbine 16 | Mar | 2023 | Seen | 2 |
| | | | 150 W of T49 | Jun | 2023 | Seen | 2 |
| | | | B/W T50 and T51 | Jun | 2023 | Seen | 1 |
| | | | T02 | Jun | 2023 | Seen | 1 |
| | | | Near T02 | Jul | 2023 | Seen | 1 |
| | | | Between T65 and T66 | Jul | 2023 | Seen | 1 |
| **Total** | | | | | | | **102** |

# Appendix C Accompanying reports

The following follow overleaf:

C.1 Mortality Estimate report, prepared by Symbolix

C.2 Bird Utilisation Survey analysis report, prepared by Symbolix

C.3 Summary Results Report 2015-2023, prepared by NGH Consulting

C.4 BRWF Results November 2023 – April 2024, prepared by NGH Consulting

## C.1 Mortality Estimate report

# Boco Rock Wind Farm Mortality Estimate - Year 9

Prepared for NGH Environmental, 27 June 2024, Ver. 1.0

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This report outlines an analysis of mortality at Boco Rock Wind Farm. Primarily, we are concerned with two time periods: the final ten months of the original survey method (01 Jan 2023 to 31 Oct 2023), and the the first six months of the updated survey method (01 Nov 2023 to 30 Apr 2024). We also briefly comment on the cumulative mortality from 01 Jan 2015 to 31 Oct 2023, which is the entirety of the monitoring period under the original survey method.

The analysis is broken into the three related components below:

- Searcher efficiency / detectability – estimated from trials in summer 2014-15 and winter 2015.
- Scavenger loss rates – consisting of trials in August 2015.
- Mortality estimates - based on monthly surveys throughout 2023 and early 2024, and also all surveys conducted throughout 2015 - 2022

## 1 Available data

Survey data was collected and provided by NGH Environmental. A brief summary of the data is provided below, and the ultimate focus of this report is a discussion of the potential mortality.

Species archetype data was taken from Hull and Muir (2010).

### 1.1 Data cleaning

We used 2015-2022 data as previously provided and cleaned.

For the 2023 data, we cleaned and consolidated species name in the carcass finds data. Otherwise, data was used as-is.

## 2 Statistical methodology overview

Mortality through collision is an ongoing environmental management issue for wind facilities. Different sites present different risk levels; consequently different sites have different monitoring requirements. In order to estimate the mortality loss at a given site (in a way that is comparable with other facilities) we must account for differences in survey effort, searcher and scavenger efficiency. We used a Monte Carlo method to achieve this.

Best practice estimators project the number of found carcasses ($C$) up to the number of actual mortalities ($M$). They should account for:

- The probability a carcass will be detected by the searcher ($p$)
- The probability a carcass is not lost to scavenge or decay prior to the search ($r$)
- The probability a carcass falls within the searched area ($a$)
- The fraction of turbines searched ($f$)

Most mortality estimators, e.g. (Huso 2011), can be conceptualised as a ratio estimator

$$\hat{M} = \frac{C}{\hat{p} \cdot \hat{r} \cdot \hat{a} \cdot f} \tag{1}$$

with the terms in the denominator providing a "boost factor" to the number of carcasses found, $C$.

However, a limitation of analytical methods is estimating $r$ when the time between surveys is not constant. In Australia, it is common for the time between searches to vary due to seasonal changes in effort or the use of a pulsed design in which the turbine is searched monthly with a return visit a few days later. Additionally, ratio estimators cannot handle the cases when zero carcasses are found, as zero multiplied by any number still gives zero.

To address this, Symbolix have developed a Monte Carlo algorithm. We have used this method for mortality estimates at over forty wind farms in Australia to date.

Monte Carlo methods (Sawilowsky (2003), Ripley (1987)) simulate a large set of possible survey results, by simulating the actual survey protocol, and sampling from empirical distributions for scavenge loss and searcher efficiency. In this way, we directly sample the probability a carcass was lost before the survey, negating the need to calculate $r$ analytically each time.

We then estimate how many carcasses were truly generated, given the range of searcher and scavenger efficiencies, the survey frequency and coverage, and the true "found" details. After many simulations, we can estimate the likely range of mortalities that could have resulted in the recorded survey outcome (number of carcasses found).

This method has been benchmarked against analytical approaches (Huso (2011), Korner-Nievergelt et al. (2011))]. Its outputs are equivalent but it is able to robustly model more complex survey designs (e.g. pulsed surveys, rotating survey list).

Figure 1 provides an overview of the methodology. A detailed explanation can be found in Stark and Muir (2020).

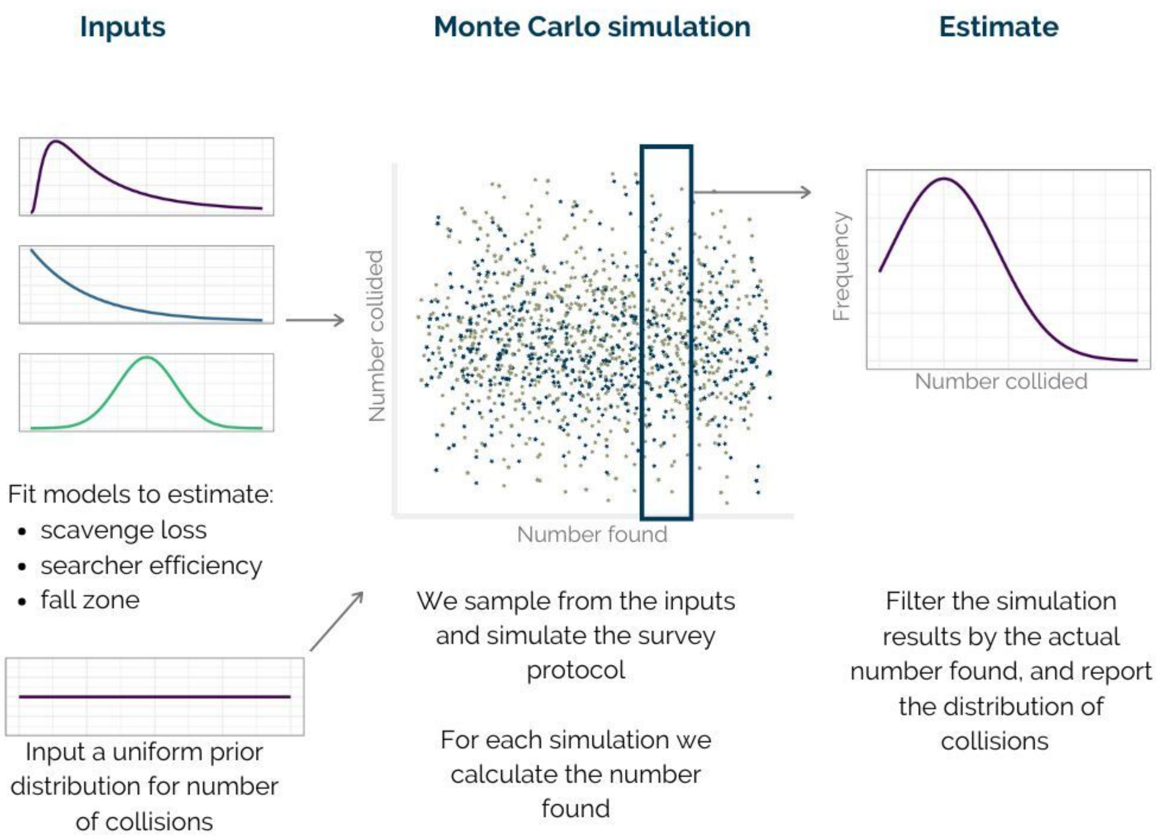


**Figure 1: Overview of how the mortality estimation works.**

The following sections outline how we estimate $p$, $r$ and $a$. $C$ is given by the field observation data, and $f$ is defined by the survey design.

# 3 Analysis and modelling

The survey program consisted of carcass searches, and adjunct scavenger and detection trials. We summarise the methods, field data and analysis results for each below.

## 3.1 Carcass search data

In 2023, from January to October inclusive, carcasses searches were undertaken at all turbines (67 total). The hardstand and road area was searched twice per month, using a "pulsed" method where the second search was taken two days after the first. Additionally, during the first monthly search, 21 turbines were searched out to an 80m radius. This included the inner hardstand/road area, but also an extended vegetated area.

From November 2023 to April 2024, the survey design changed. The turbines on the farm were partitioned into two strata, a higher risk stratum (19 turbines), and a lower risk stratum (48). Each stratum had eight turbines sampled. Turbines were searched out to a radius of 120m.

Carcass searches were undertaken by human searchers.

The carcass searches provide the $C$ and $f$ terms in Section 2.

### 3.1.1 Survey effort

The mortality estimate was based on a dated list of turbine surveys. The survey frequency is summarised in Table 1.

In the Monte Carlo algorithm, we explicitly simulate the survey design. The proportion of turbines sampled ($f$) is therefore accounted for in the simulation.

**Table 1: Number of surveys per month.**

| Date | Hardstand | Hardstand + 80m Radius Ext | Hardstand + 120m Radius Ext |
|---|---|---|---|
| 2023 Jan | 113 | 21 | |
| 2023 Feb | 113 | 21 | |
| 2023 Mar | 113 | 21 | |
| 2023 Apr | 113 | 21 | |
| 2023 May | 113 | 21 | |
| 2023 Jun | 113 | 21 | |
| 2023 Jul | 113 | 21 | |
| 2023 Aug | 113 | 21 | |
| 2023 Sep | 113 | 21 | |
| 2023 Oct | 113 | 21 | |
| 2023 Nov | | | 16 |
| 2023 Dec | | | 16 |
| 2024 Jan | | | 16 |
| 2024 Feb | | | 16 |
| 2024 Mar | | | 16 |
| 2024 Apr | | | 16 |

### 3.1.2 Carcass finds

The breakdown of found carcasses per species are summarised in Table 2.

**Table 2: Carcasses found during formal surveys, from the start of January 2023 to the end of April 2024.**

| Species | Bat | Bird | Feather Spot |
|---|---|---|---|
| Australian Magpie | | 2 | |
| Common Starling | | 2 | |
| Corvid sp. | | 1 | |
| Eurasian Skylark | | 2 | |
| Nankeen Kestrel | | | 1 |
| Stubble Quail | | 1 | |
| White-striped Freetail Bat | 2 | | |

One carcass was found incidentally. It is reported for completeness in Table 3.

**Table 3: Incidental carcass finds.**

| Species | Number found |
|---|---|
| White-striped Freetail Bat | 1 |

## 3.2 Searcher efficiency

The aim of searcher efficiency trials is the quantify the effectiveness of observers, at finding carcasses. They provide the $p$ term in Equation 2.

### 3.2.1 Field methods

Two searcher efficiency trials were held (summer 2014-15 and winter 2015). A range of small, medium and large avian carcass sizes were used. For bird detectability, all carcass sizes were used, while for bat detectability only small sized bird carcasses were used.

### 3.2.2 Results

No additional data has been collected since the original trials, and thus the analyses are unchanged. Tables 4 and 5 summarise the results.

**Table 4: Detection efficiencies for small sizes (used for bat modelling).**

| Variable | Hardstand + Road | Extended Area |
|---|---|---|
| Number found | 43 | 8 |
| Number placed | 51 | 38 |
| Mean detectability proportion | 0.84 | 0.21 |
| Detectability lower bound (95% confidence interval) | 0.71 | 0.1 |
| Detectability upper bound (95% confidence interval) | 0.93 | 0.37 |

**Table 5: Detection efficiencies for all sizes (used for bird modelling).**

| Variable | Hardstand + Road | Extended Area |
|---|---|---|
| Number found | 121 | 53 |
| Number placed | 131 | 111 |
| Mean detectability proportion | 0.92 | 0.48 |
| Detectability lower bound (95% confidence interval) | 0.86 | 0.38 |
| Detectability upper bound (95% confidence interval) | 0.96 | 0.57 |

**On the hardstand and road, bat detectability is 84%, with a 95% confidence interval of [71%, 93%]. Bird detectability is 92% with a 95% confidence interval of [86%, 96%].**

**The detection rate is lower on the extended region. Bat detectability is 21%, with a 95% confidence interval of [10%, 37%]. Bird detectability is 48% with a 95% confidence interval of [38%, 57%].**

## 3.3 Scavenger efficiency

In order to accurately estimate mortality, we must account for carcass loss to scavengers. Scavenger trials are performed to quantify the time until a carcass is completely lost as a result of scavenger activity, which is the $r$ term in Section 2.

### 3.3.1 Field methods

An analysis of scavenger efficiency was also conducted at Boco Rock from the 31st August 2015 for a 28 day period. A mix of bats and other carcasses of various sizes were used to measure the scavenger activity - as bats can be difficult to source in the numbers required. Additional species including chickens, rats, quails, mice and one eagle.

The survey plan was defined by placing the carcasses in several locations in the site and checking the carcasses for up to four weeks, initially every 12 hours for the first three days, then daily for four days, then every two days for a week, then twice a week until the last day of survey.

### 3.3.2 Statistical methods

Survival analysis (Kaplan and Meier (1958), Kalbfleisch and Prentice (2011)) was used to determine the distribution of time until complete loss from scavenge (or decay). Survival analysis was required to account for the fact that we do not necessarily know the exact time of scavenge loss, only an interval in which the scavenge event happened. For example, any carcass which is unscavenged at the end of the trial, has its scavenge event in the interval [$x$, $\infty$] (where $x$ is the length of the trial).

By performing survival analysis we can estimate the time until carcass loss after a given length of time, despite these unknowns.

### 3.3.3 Results

No additional data has been collected since the original trials, and thus the analyses remain unchanged.

**The mean time to total loss via scavenge is 7.8 days, with a 95% confidence window of [5.3, 11.3] days.**

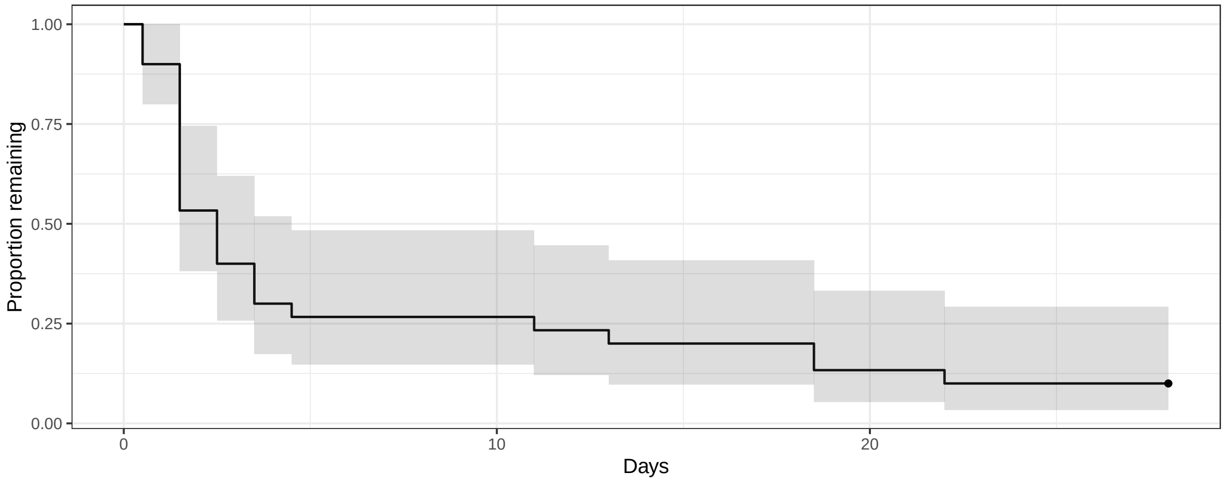


**Figure 2: Combined survival curves for birds and bats, with 95% confidence interval shaded.**

## 3.4 Coverage factor

The coverage factor estimates the probability that, given a carcass falls at a searched turbine, that the carcass falls within the searched area. This contributes to the $a$ term in Section 2.

### 3.4.1 Fall zone simulation - methods

We generated a carcass fall-zone distribution for bats and birds, given the turbine size at the wind farm.

The fall-zone distribution is the end result of the simulation method detailed in Hull and Muir (2010). The simulation method is a ballistics model describing bird and bat strikes by turbine blades.

### 3.4.2 Coverage factor calculation - methods

The percentage of the fall zone not covered by the survey area, provides a correction factor in the mortality estimate. Because carcasses that fall outside the searched area have a zero probability of being detected by a survey, the likelihood of landing in this region is essential to understanding the relationship between detections and actual losses.

### 3.4.3 Simulation inputs

Table 6 displays the dimensions and RPM of the turbines at Boco Rock Wind Farm while Table 7 shows the bird and bat physical parameters used. These are input into the fall zone simulation.

**Table 6: Turbine specifications for Boco Rock Wind Farm.**

| Rotor Diameter (m) | Tower Height (m) | RPM |
|---|---|---|
| 100 | 80 | 16.1 |

**Table 7: Bird and bat size parameters.**

| Species Type | Archetype | Mass (kg) | Min. area (sq m) | Max. area (sq m) |
|---|---|---|---|---|
| Bat | Gould's Wattled Bat | 0.014 | 0.028 | 0.014 |
| Bird | Raven | 0.680 | 0.045 | 0.100 |

### 3.4.4 Results

Figure 3 displays the simulation results, given the factors specified above. We display the cumulative density function (CDF) on the y axis versus the distance from turbine on the x axis for each species type. The CDF describes the expected proportion of carcass which fall less than or equal to a certain distance from the turbine. For example, we see that we expect about 89% of bat carcasses to fall within 50m of the turbine.

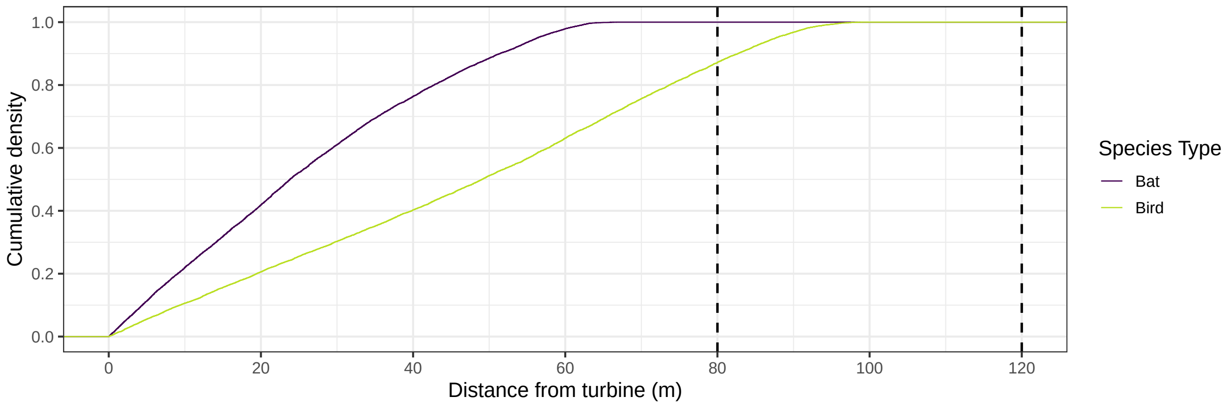


**Figure 3: Cumulative distribution function of the fall zone simulation output for birds and bats. Vertical lines indicate the survey radii of the pre-October 2023 (80m), and post October 2023 (120m) surveys..**

Once the fall zone distribution is calculated, we generate a "coverage factor". The coverage factor represents the expected proportion of carcasses which fall within the searched area, given the search protocol.

Because of the difference between searcher efficiency in the hardstand and extended zones, we have calculated the coverage factor separately.

Each turbine has a different hardstand/road area. **The average coverage factor in Hardstand and Road is 45% for bats, and 26% for birds.**

The extended zone is everything in the search radius, that is not in the hardstand. Consequently, every turbine has a different extended area (despite the overall survey protocol being the same at each turbine).

**The average coverage factor in Extended zone, up to and including October 2023, is 55% for bats, and 62% for birds.**

**The average coverage factor in Extended zone, from November 2023 onwards, is 55% for bats, and 74% for birds.**

# 4 Mortality estimate

With estimates for scavenge loss, searcher efficiency, and survey coverage, we then converted the number of bat and bird carcasses detected into estimates of overall mortality at Boco Rock Wind Farm.

The mortality estimation is done via a Monte Carlo algorithm. We used 15000 simulations, with the survey design simulated each time. Random numbers of virtual mortalities were simulated, along with the scavenge time and searcher efficiency (based on the measured confidence intervals). The proportion of virtual carcasses that were "found" was recorded for each simulation. Finally, those trials that had the same outcome as the reported survey detections were collated, and the initial conditions (i.e. how many true losses there were) reported on.

The model assumptions are listed below:

- There were 67 turbines on site available to strike bats and birds.
- Search frequency for each turbine was taken from the list of actual survey dates.
- Bats and birds are on-site at all times during this period.
- Bats and birds that are struck are immediately replaced (i.e. strikes one day do not affect the chance of strikes the next).
- We have used the standard practice of assuming that all carcasses and all feather spots (regardless of size or composition) are attributable to the wind turbines.
- Finds are random and independent, and not clustered with other finds.
- Until October 2023, we assume there was equal chance of any turbine being involved in a collision / mortality. Post October 2023, we assume that within strata (higher and lower risk), this assumption holds - but not between strata.
- We took scavenge loss and searcher efficiency rates as outlined above.
- We assumed an exponential scavenge shape.
- We assumed coverage factors as summarised above.

We ran a number of mortality estimates on bats and birds:

- Year 9: January 2023 to October 2023 (inclusive). This is the last of the survey under the old methods.
- Year 9: November 2023 to April 2024 (inclusive). This is the first six months of survey under the new methods.
- Cumulative years 1-9, January 2015 to October 2023. We have not run cumulative estimates past this point, due to the step change in survey design in November 2023.

## 4.1 Bats

In Year 9, Jan 23-Oct 23, a total of two bats were found. The resulting (median) estimate of total mortality is 15 individuals lost over the ten months.

In Nov 23-Apr 24, zero bats were found in both the higher and lower risk strata. The resulting (median) estimate of total mortality is 57 individuals lost over the six months.

Finally, we present the cumulative Y1-9 estimate (Jan 15 to Oct 23). Over this time period, a total of 74 bats were found. The resulting (median) estimate of total mortality is 465 individuals lost over the nine years.

These results are presented in Table 8 and Figure 4, to show the confidence on the mortality estimate.

**Table 8: Percentiles of the bat losses distributions.**

| Analysis Period | 0% | 50% (median) | 90% | 95% | 99% |
|---|---|---|---|---|---|
| Y9: Jan 23-Oct 23 | 2 | 15 | 31 | 35 | 51 |
| Y9: Nov 23-Apr 24 | 2 | 57 | 153 | 190 | 307 |
| Y1-9: Cumulative Jan 15-Oct 23 | 301 | 465 | 580 | 614 | 667 |

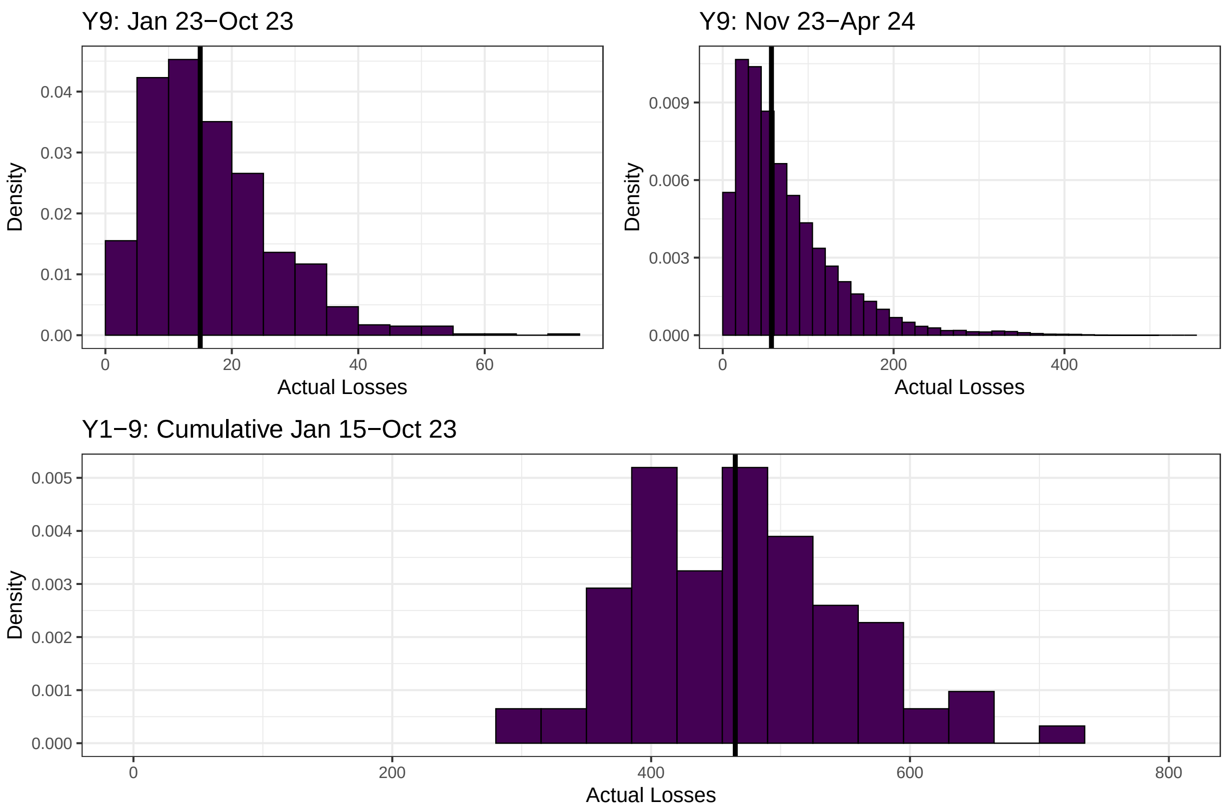


**Figure 4: Histograms of the total losses distributions (bats). The black solid lines show the median.**

## 4.2 Birds

In Year 9, Jan 23-Oct 23, a total of six birds were found. The resulting (median) estimate of total mortality is 40 individuals lost over the ten months.

In Nov 23-Apr 24, two birds were found in both the higher and lower risk strata. The resulting (median) estimate of total mortality is 122 individuals lost over the six months.

Finally, we present the cumulative Y1-9 estimate (Jan 15 to Oct 23). Over this time period, a total of 63 birds were found. The resulting (median) estimate of total mortality is 395 individuals lost over the nine years.

These results are presented in Table 9 and Figure 5, to show the confidence on the mortality estimate.

**Table 9: Percentiles of the bird losses distributions.**

| Analysis Period | 0% | 50% (median) | 90% | 95% | 99% |
|---|---|---|---|---|---|
| Y9: Jan 23-Oct 23 | 12 | 55 | 91 | 104 | 119 |
| Y9: Nov 23-Apr 24 | 7 | 122 | 223 | 267 | 379 |
| Y1-9: Cumulative Jan 15-Oct 23 | 358 | 564 | 723 | 767 | 911 |

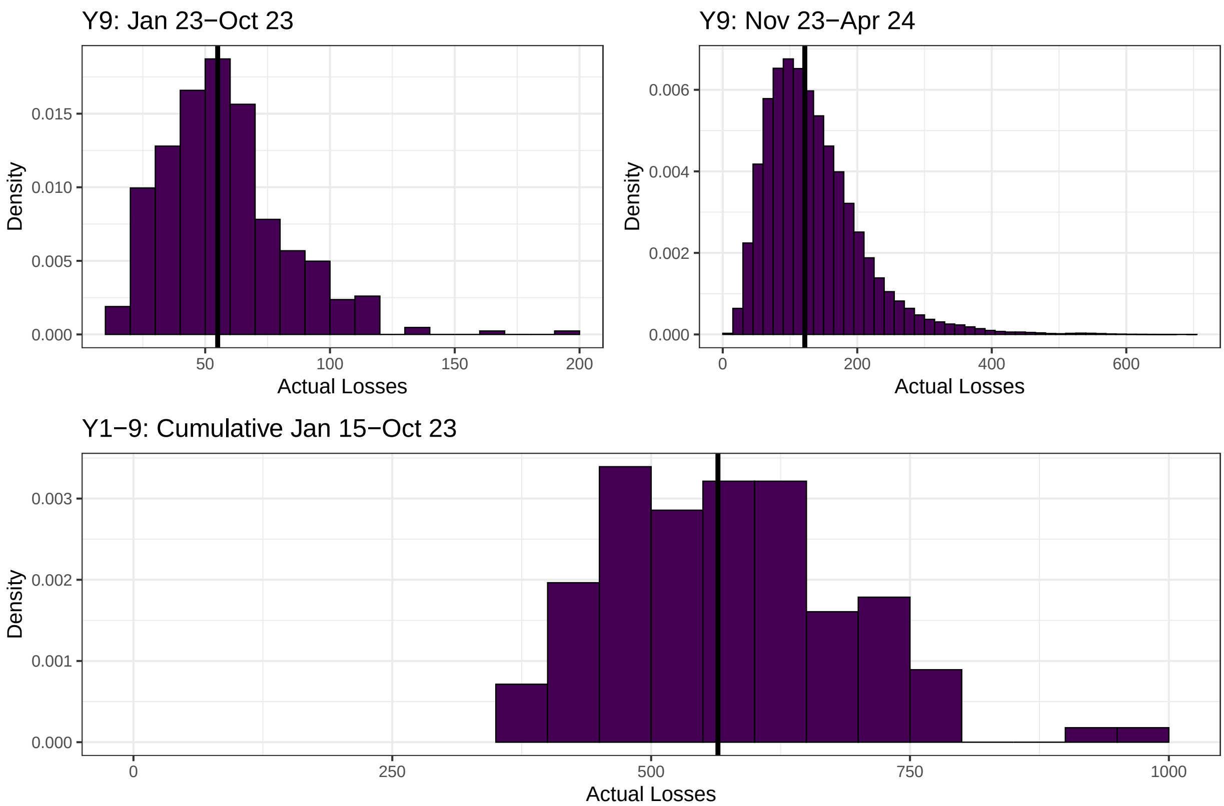


**Figure 5: Histograms of the total losses distributions (birds). The black solid lines show the median.**

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## C.2 Bird Utilisation Survey analysis report

# Boco Rock Wind Farm Bird Utilisation Survey - Year Nine Analysis

Prepared for NGH Environmental, 9 July 2024, Ver. 0.9 - For Review

This memo summarises our recent analysis of bird utilisation (point count) data collected at Boco Rock Wind Farm.

The aim of this analysis is to provide an overview of species and site characteristics. By comparing data collected through the nine years of operation, we aim to identify any changes in species presence or abundance that may be attributable to the presence of wind farm infrastructure. By using data from on-site as well as nearby reference sites, we are better able to understand if any patterns found are due to Boco Rock operations (as opposed to background changes in the area).

Data was collected by NGH Environmental[1], and cleaned and analysed by Symbolix.

Collection of general bird utilisation data at Boco Rock Wind Farm ceased in October 2023. Moving forward BRWF is conducting targeted surveys of bird species identified to medium to high risk.

## Survey summary

The data consists of bird "point counts". Surveys were conducted at specific locations for a set period of time. During this time, all birds and bird movements were noted.

The design was a stratified random point survey, where the stratifications are based on the relevant habitats on the farm. Data was collected in three distinct areas/habitat types (see map in Figure 1):

1. Grassland/Pasture: Defined as pasture within 500 metres of a turbine.
2. Control/Reference: There is a potential to place a wind turbine in the vicinity, but no wind turbines within 500 m. These sites are chosen to be similar habitat to the grassland sites, but with no turbines nearby.
3. Woodland: These sites are located in woodland area in the region. Note that there is no turbine infrastructure nearby; however, they are not considered controls. Instead this area was included because of regulator concerns that woodland species would be affected by the nearby wind facility.

[1] NGHBOCO_BUS_20240515.xlsx

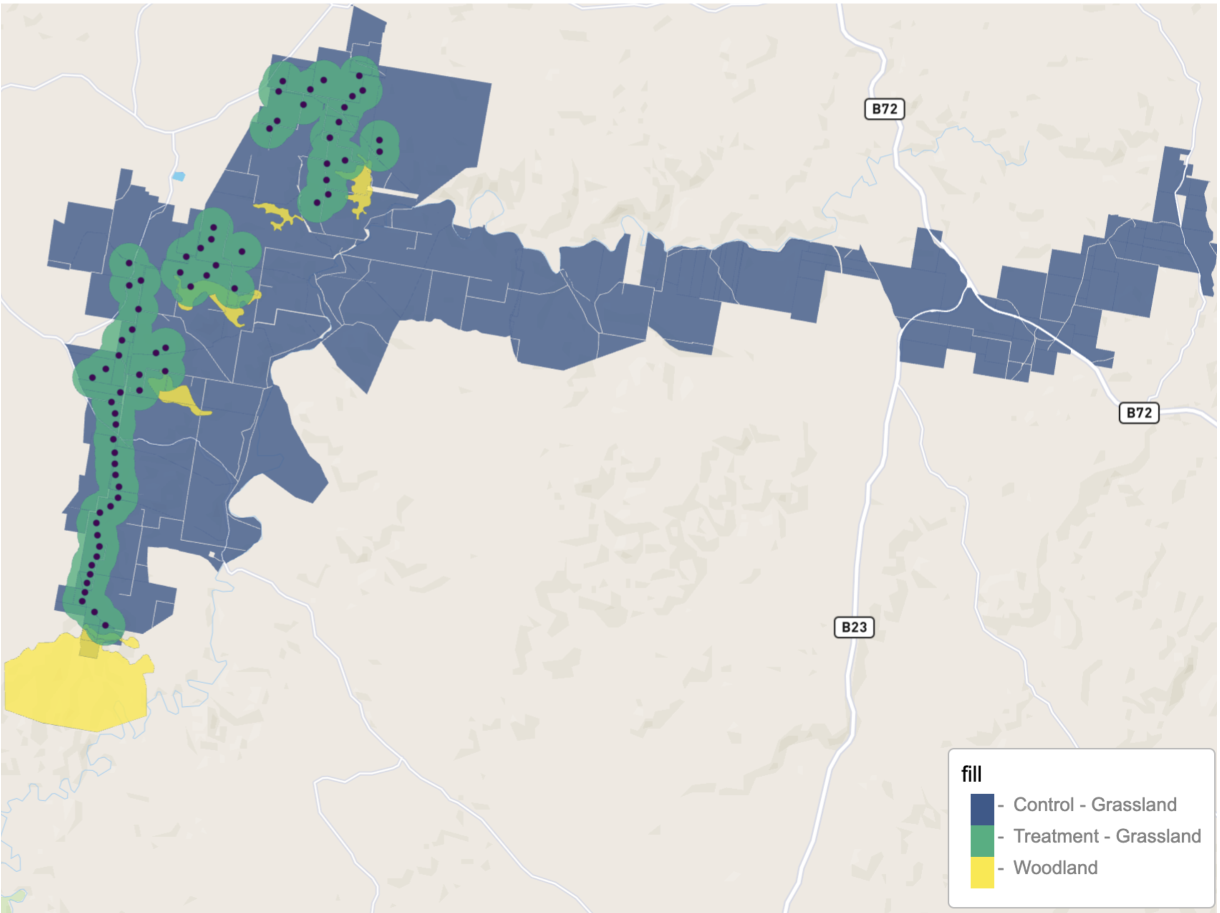


**Figure 1: Location of the three habitat types and survey points. The dots represent the turbine locations.**

The survey effort (number of site surveys) per month is summarised in Tables 1 and 2.

**Table 1: Number of distinct locations surveyed each month from 2015 to 2020. Note C, G, W corresponds to Control, Grassland, and Woodland respectively.**

| Year | Mon | C | G | W | Total | Year | Mon | C | G | W | Total | Year | Mon | C | G | W | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2015 | Jan | 3 | 3 | 4 | 10 | 2017 | Jan | 4 | 3 | 3 | 10 | 2019 | Jan | 3 | 3 | 4 | 10 |
| 2015 | Feb | 3 | 4 | 3 | 10 | 2017 | Feb | 3 | 4 | 3 | 10 | 2019 | Feb | 3 | 4 | 3 | 10 |
| 2015 | Mar | 4 | 3 | 3 | 10 | 2017 | Mar | 3 | 3 | 4 | 10 | 2019 | Mar | 4 | 3 | 3 | 10 |
| 2015 | Apr | 3 | 4 | 3 | 10 | 2017 | Apr | 4 | 3 | 3 | 10 | 2019 | Apr | 4 | 3 | 3 | 10 |
| 2015 | May | 3 | 3 | 4 | 10 | 2017 | May | 4 | 3 | 3 | 10 | 2019 | May | 3 | 4 | 3 | 10 |
| 2015 | Jun | 3 | 5 | 2 | 10 | 2017 | Jun | 3 | 4 | 3 | 10 | 2019 | Jun | 3 | 3 | 4 | 10 |
| 2015 | Jul | 3 | 5 | 2 | 10 | 2017 | Jul | 3 | 3 | 4 | 10 | 2019 | Jul | 4 | 3 | 3 | 10 |
| 2015 | Aug | 3 | 4 | 3 | 10 | 2017 | Aug | 3 | 4 | 3 | 10 | 2019 | Aug | 3 | 4 | 3 | 10 |
| 2015 | Sep | 3 | 5 | 2 | 10 | 2017 | Sep | 2 | 3 | 4 | 9 | 2019 | Sep | 3 | 3 | 4 | 10 |
| 2015 | Oct | 3 | 4 | 3 | 10 | 2017 | Oct | 3 | 4 | 3 | 10 | 2019 | Oct | 4 | 3 | 3 | 10 |
| 2015 | Nov | 3 | 4 | 3 | 10 | 2017 | Nov | 3 | 3 | 4 | 10 | 2019 | Nov | 3 | 4 | 2 | 9 |
| 2015 | Dec | 3 | 4 | 3 | 10 | 2017 | Dec | 5 | 3 | 2 | 10 | 2019 | Dec | 4 | 4 | 2 | 10 |
| 2016 | Jan | 4 | 3 | 3 | 10 | 2018 | Jan | 3 | 4 | 3 | 10 | 2020 | Jan | 4 | 3 | 3 | 10 |
| 2016 | Feb | 3 | 4 | 3 | 10 | 2018 | Feb | 3 | 4 | 3 | 10 | 2020 | Feb | 4 | 3 | 3 | 10 |
| 2016 | Mar | 3 | 4 | 3 | 10 | 2018 | Mar | 3 | 3 | 4 | 10 | 2020 | Mar | 3 | 3 | 4 | 10 |
| 2016 | Apr | 3 | 4 | 3 | 10 | 2018 | Apr | 4 | 3 | 3 | 10 | 2020 | Apr | 3 | 4 | 3 | 10 |
| 2016 | May | 4 | 6 | 0 | 10 | 2018 | May | 4 | 3 | 3 | 10 | 2020 | May | 3 | 4 | 3 | 10 |
| 2016 | Jun | 3 | 2 | 3 | 8 | 2018 | Jun | 3 | 3 | 4 | 10 | 2020 | Jun | 3 | 3 | 4 | 10 |
| 2016 | Jul | 3 | 5 | 2 | 10 | 2018 | Jul | 4 | 3 | 3 | 10 | 2020 | Jul | 4 | 3 | 0 | 7 |
| 2016 | Aug | 3 | 3 | 4 | 10 | 2018 | Aug | 4 | 3 | 3 | 10 | 2020 | Aug | 3 | 3 | 4 | 10 |
| 2016 | Sep | 3 | 3 | 4 | 10 | 2018 | Sep | 3 | 4 | 3 | 10 | 2020 | Sep | 3 | 4 | 3 | 10 |
| 2016 | Oct | 3 | 0 | 7 | 10 | 2018 | Oct | 3 | 3 | 4 | 10 | 2020 | Oct | 4 | 3 | 3 | 10 |
| 2016 | Nov | 6 | 0 | 4 | 10 | 2018 | Nov | 4 | 3 | 3 | 10 | 2020 | Nov | 4 | 3 | 3 | 10 |
| 2016 | Dec | 4 | 3 | 3 | 10 | 2018 | Dec | 5 | 3 | 2 | 10 | 2020 | Dec | 3 | 3 | 4 | 10 |

**Table 2: Number of distinct locations surveyed each month from 2020 to 2023. Note C, G, W corresponds to Control, Grassland, and Woodland respectively.**

| Year | Mon | C | G | W | Total |
|---|---|---|---|---|---|
| 2021 | Jan | 2 | 4 | 3 | 9 |
| 2021 | Feb | 2 | 2 | 3 | 7 |
| 2021 | Mar | 4 | 3 | 3 | 10 |
| 2021 | Apr | 4 | 1 | 3 | 8 |
| 2021 | May | 3 | 4 | 3 | 10 |
| 2021 | Jun | 3 | 2 | 3 | 8 |
| 2021 | Jul | 3 | 3 | 3 | 9 |
| 2021 | Aug | 4 | 3 | 3 | 10 |
| 2021 | Sep | 3 | 3 | 4 | 10 |
| 2021 | Oct | 3 | 4 | 3 | 10 |
| 2021 | Nov | 1 | 3 | 3 | 7 |
| 2021 | Dec | 4 | 0 | 0 | 4 |
| 2022 | Jan | 4 | 3 | 3 | 10 |
| 2022 | Feb | 4 | 3 | 3 | 10 |
| 2022 | Mar | 3 | 4 | 3 | 10 |
| 2022 | Apr | 3 | 1 | 3 | 7 |
| 2022 | May | 3 | 4 | 3 | 10 |
| 2022 | Jun | 3 | 3 | 3 | 9 |
| 2022 | Jul | 3 | 4 | 4 | 11 |
| 2022 | Aug | 3 | 4 | 3 | 10 |
| 2022 | Sep | 3 | 3 | 4 | 10 |
| 2022 | Oct | 4 | 4 | 2 | 10 |
| 2022 | Nov | 5 | 5 | 0 | 10 |
| 2022 | Dec | 3 | 3 | 4 | 10 |
| 2023 | Jan | 4 | 3 | 3 | 10 |
| 2023 | Feb | 4 | 3 | 3 | 10 |
| 2023 | Mar | 2 | 4 | 3 | 9 |
| 2023 | Apr | 3 | 3 | 4 | 10 |
| 2023 | May | 3 | 4 | 3 | 10 |
| 2023 | Jun | 3 | 3 | 4 | 10 |
| 2023 | Jul | 4 | 3 | 3 | 10 |
| 2023 | Aug | 3 | 4 | 3 | 10 |
| 2023 | Sep | 3 | 3 | 4 | 10 |
| 2023 | Oct | 3 | 4 | 3 | 10 |

# Methodology

Our objective was to provide information to assess the potential for indirect impacts to regional bird populations from the wind facility operations. This could manifest as changes in behaviour or avoidance of habitat over time.

The longitudinal, reference-treatment structure of the survey addresses this objective, by providing us the opportunity to test for changes in the on-site data that are not present in the reference data. To allow us to generate quantitative information, we considered a range of metrics and analysis approaches, rather than relying on a small number of statistical tests.

Mainly, we use graphical and descriptive approaches that focus on patterns in species mix. We use multivariate methods as well as single (univariate) metrics (species abundance, species richness and Shannon diversity) to provide the best chance of detecting important changes. However, we also use formal statistical tests (using linear models) to investigate changes in species richness and diversity over time.

## Box plots

Box plots provide a graphical representation of the distribution of survey values for each time of year and habitat type. Half of the values are contained within the “box”, with the whiskers (and dots) showing the spread of the other half. The line through the box shows the median.

## Species mix plots

Each survey point and site has a unique species mix that changes over time. We used this fact to describe differences between survey points over different sites and times. The difference in species mix between two points (or different seasons etc.), is expressed as a “similarity distance” - specifically the Bray-Curtis similarity (Bray and Curtis 1957). The distance is a statistical measure that accounts for the difference in species between surveys (i.e. two surveys with exactly the same species would have zero “distance” between them). This presence / absence measure gives weighting to rare / hard to observe species, and ensures results are not skewed towards trends in very common species.

We calculate the similarity distance between each survey pair and plot this as an ordination chart. The closer two surveys are to each other in an ordination plot, the more similar the species mix is between them.

By tracking changes in this similarity distance over time, we can get an indicator of changes between surveys, seasons and sites, and between turbine and reference points (Clarke 1993).

Differences in landscape or habitat would manifest by making subsequent observations at the same point “closer” than observations at other points or other sites. A change in species mix due to wind farm infrastructure could present as a change in the distance between impact and reference sites (this might be quite sudden or a gradual trend).

Note that it is the relative distance between points that is important, not the absolute distance between them. That is, points that are closer within a plot are more alike than those that are far apart, but we cannot compare distances between two species mix (or "ordination") plots.

# Results

## Species abundance

The following charts are a simple overview of each species seen, and its relative abundance. This includes data across all observation points and across all time periods. Note that Figure 2 and Figure 3 show the total counts across all surveys. Take care when comparing total numbers, as the number of surveys differed between habitats.

In 2015, *Alauda arvensis* (Eurasian Skylark) was the most common species for visual and auditory counts at the control locations, and in the top two at the on-site grassland locations (Figure 2, 3). Generally the common species were shared by the on-site and reference grassland sites, e.g. *Cacatua galerita* (Sulphur-crested Cockatoo) and *Sturnus vulgaris* (Common Starling). The species profile at the woodlands sites was (understandably) somewhat different, with *C. galerita* being dominant in the visual counts, and *Cormobates leucophaea* (White-throated Treecreeper) being dominant in the auditory counts.

In 2016, *A. arvensis* was in the top two most common species for visual and auditory counts, at both the control and grassland locations. *S. vulgaris* was the most common species for visual counts at control and grassland sites. In control and grassland, there were fewer *C. galerita* visual counts compared with 2015. For visual counts, levels of *Corvus mellori* (Little Raven) remained fairly constant from 2015 to 2016. For auditory counts, levels of *Cracticus tibicen* (Australian Magpie) remained fairly constant from 2015 to 2016.

In 2017, *A. arvensis* and *S. vulgaris* were still among the most common species seen at control and grassland sites, although lower numbers overall were seen compared to previous years. *C. mellori* was observed visually in high levels again at these locations, similar to previous years. There were some high counts of *Hirundo neoxena* (Welcome Swallow) and *Chenonetta jubata* (Australian Wood Duck). Auditory observations were very similar to 2016's auditory observations, over all site types.

In 2018, *A. arvensis* and *S. vulgaris* were still among the most common species seen, with many *C. mellori* also observed at the Control sites. There were more *L. chrysops* seen in the Grassland site compared to previous years. Auditory counts in 2018 remained similar to previous years.

In 2019, *A. arvensis* and *S. vulgaris* were among the most common species seen at control and grassland sites, as in previous years. *C. mellori* also had high visual counts at the control sites. Visual counts of *A. arvensis* and *C. mellori* were lower at control sites in 2019 than in the previous year, although *A. arvensis* auditory counts increased slightly.

In 2020, *S. vulgaris*, *C. mellori*, and *A. arvensis* were among the most common species seen in both Control and Grassland sites. *C. galerita* and *E. roseicapilla* were seen more in 2020 Grassland, compared with 2019. Regarding auditory counts, *A. arvensis* and *C. tibicen* were the most commonly heard in Control and Grassland, similar to last year.

In 2021, *S. vulgaris*, and *A. arvensis* were the two of the more common species in Control and

Grassland, with a high count of *C. jubata* also being seen in Control areas. *A. arvensis* was the most commonly heard species in both Control and Grassland, with *C. tibicen* also recording moderate auditory counts.

In 2022, *A. arvensis* and *C. mellori* were the most common species seen in the control and Grassland sites. *A. arvensis* was the most commonly heard species in both Control and Grassland, with *C. tibicen* also recording moderate auditory counts.

In 2023, *A. arvensis* was the most common species seen in the control and Grassland sites. *A. arvensis* was the most commonly heard species in both Control and Grassland, with *C. tibicen* also recording moderate auditory counts.

In the Woodland location, very few *C. galerita* were visually observed in 2016 compared to 2015. Visual counts of *Lichenostomus chrysops* (Yellow-faced Honeyeater) also decreased from 2015 to 2016. *Pardalotus striatus* (Striated Pardalote) auditory counts increased from 2015 to 2016. In 2017, the number of *S. vulgaris* visual counts decreased compared to 2016, and the number of visual counts of *C. galerita* and *Eolophus roselcapilla* (Galah) increased compared to 2016. 2018 Woodland visual and auditory counts remained quite similar to previous years, although there were a few more *P. elegans* observed in 2018 than 2017. Visual counts for *L. chrysops* and *S. vulgaris* were lower in 2019 in 2018. Auditory counts in 2019 remained similar to previous years. In 2020, the most commonly seen species were *S. vulgaris* and *E. roseicapilla*, while *C. tibicen* was the most commonly heard species. In 2021, the most common visually observed species were *S. vulgaris* and *P. elegans*, while the auditory observed species were *P. striatus*, *C. tibicen*, and *Anthochaera carunculata* (Red Wattlebird), In 2022, the most common visually observed species was *A. arvensis*, while the most common auditory observed species was *N. leucotis* (White-eared Honeyeater). In 2023, the most common visually observed species was *L. chrysops*, while the most common auditory observed species was *N. leucotis* again.

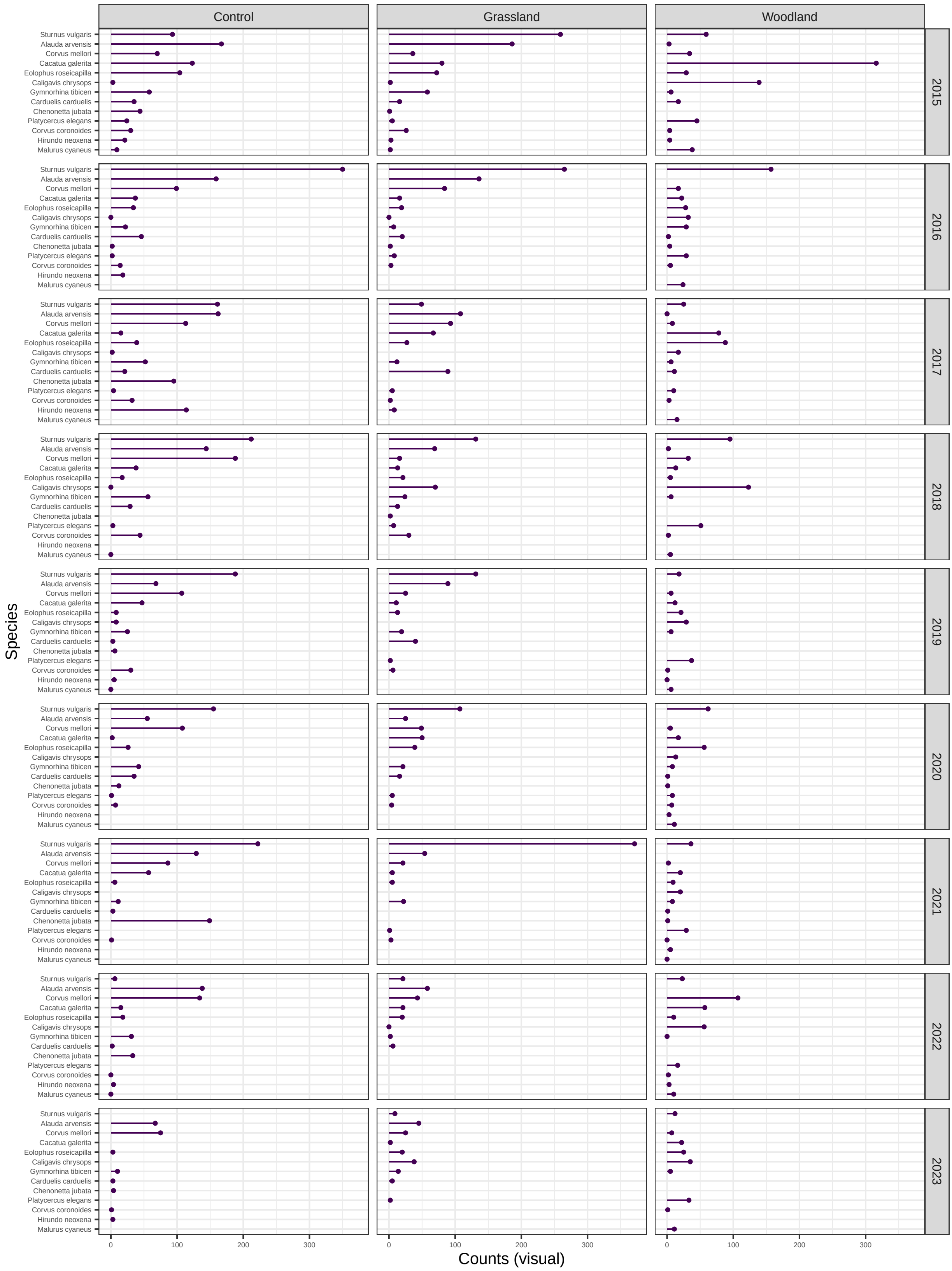


**Figure 2: Total visual counts by species for each habitat type. Only the top 10% of species are shown (for legibility).**

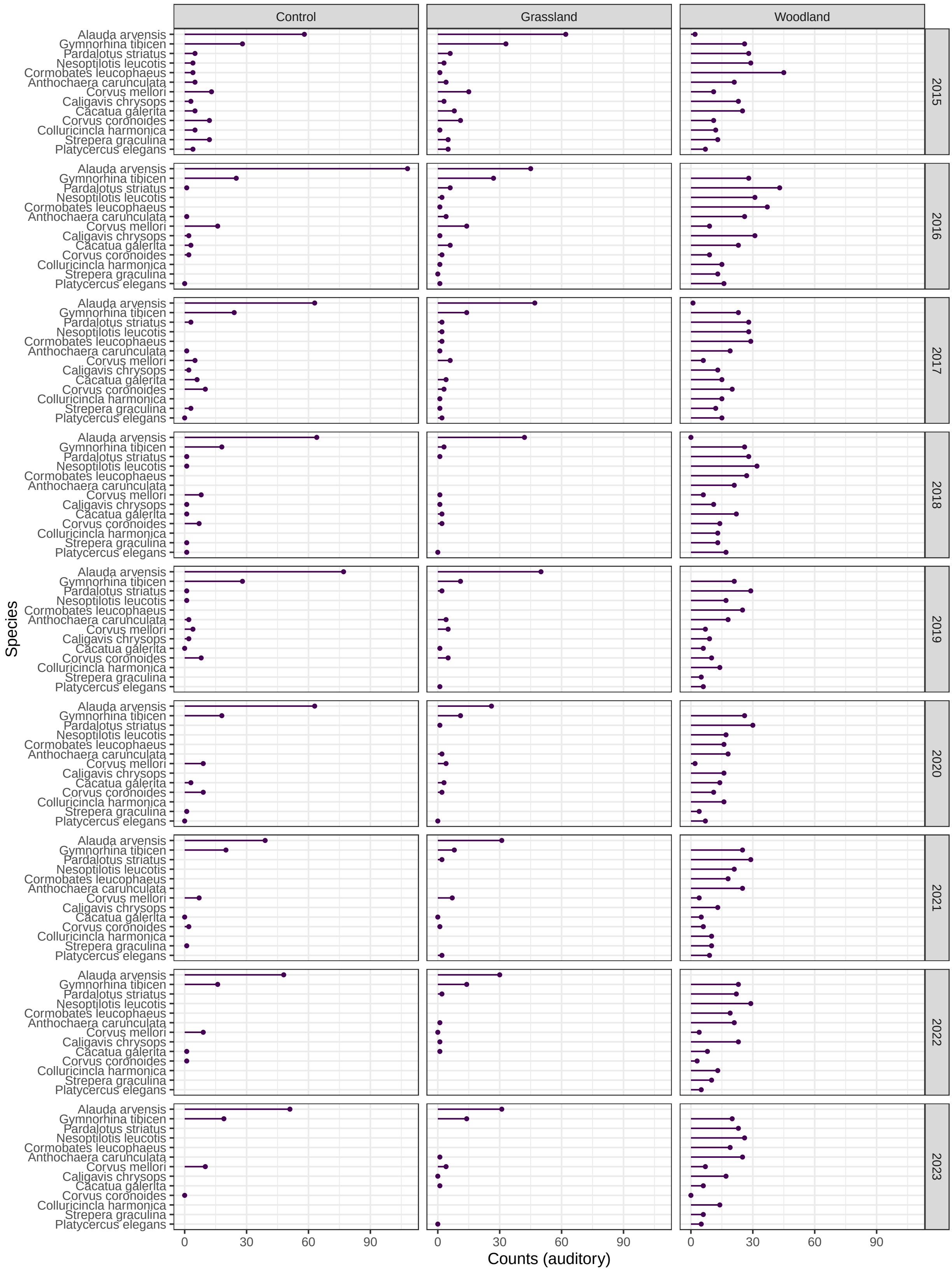


**Figure 3: Total auditory counts by species for each habitat type. Only the top 10% of species are shown (for legibility).**

## Reference-treatment comparisons

Figures 4 and 5 compare the species richness between habitat types throughout the year. These plots have the second and third quarters of the years to examine if there are any gross seasonal patterns; there don't appear to be any obvious patterns.

The overall richness of the woodland sites (Figure 5) is higher than both the grassland and control sites (Figure 4). The woodland richness has remained fairly constant over the last five years, accounting for seasonal variation. There does appear to be a slight decreasing trend over the course of the eight years. In particular, in the first three years, the richness looks to be decreasing, and it has remained at a stable lower level since then.

The richness in the control and grassland sites remains fairly stable since three years into the survey, although there is a hint of a decrease.

We also analysed the Shannon diversity (Shannon and Weaver (1949), Hill (1973)) per survey (Figure 6) and log visual count (Figure 7) metrics. The Shannon diversity plot showed similar patterns to the richness plot - seasonality variation in the woodland, fairly stable grassland sites (potentially a slight decreasing trend followed by a levelling off), and at the control sites, an apparent decrease followed by a levelling off in 2017 / 2018.

It is difficult to comment on the boxplot of any particular quarter, since there is so much variation.

The log visual count plot showed some seasonality, which didn't naturally follow a quarterly pattern. Control sites had higher log counts than other sites in earlier years on average, and there appeared to be a decreasing trend which stabilised in 2017 and 2018. However, it's harder to elucidate trends from count charts, as the variance is a lot greater. Certainly, the levels appear to be stable since 2016.

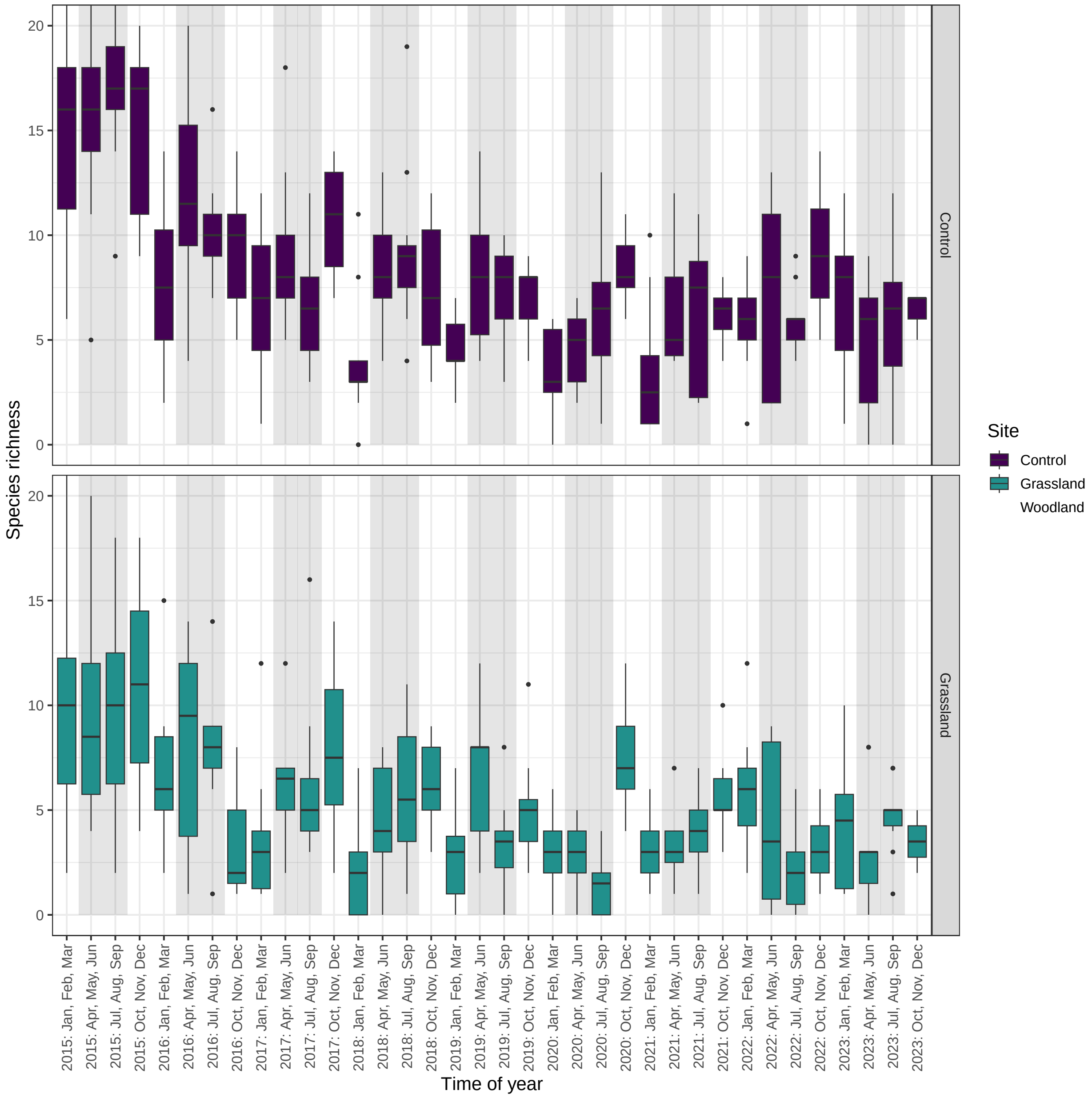


**Figure 4: Distribution of species richness per survey, by site and time of year. Winter months highlighted. Control and Grassland sites only.**

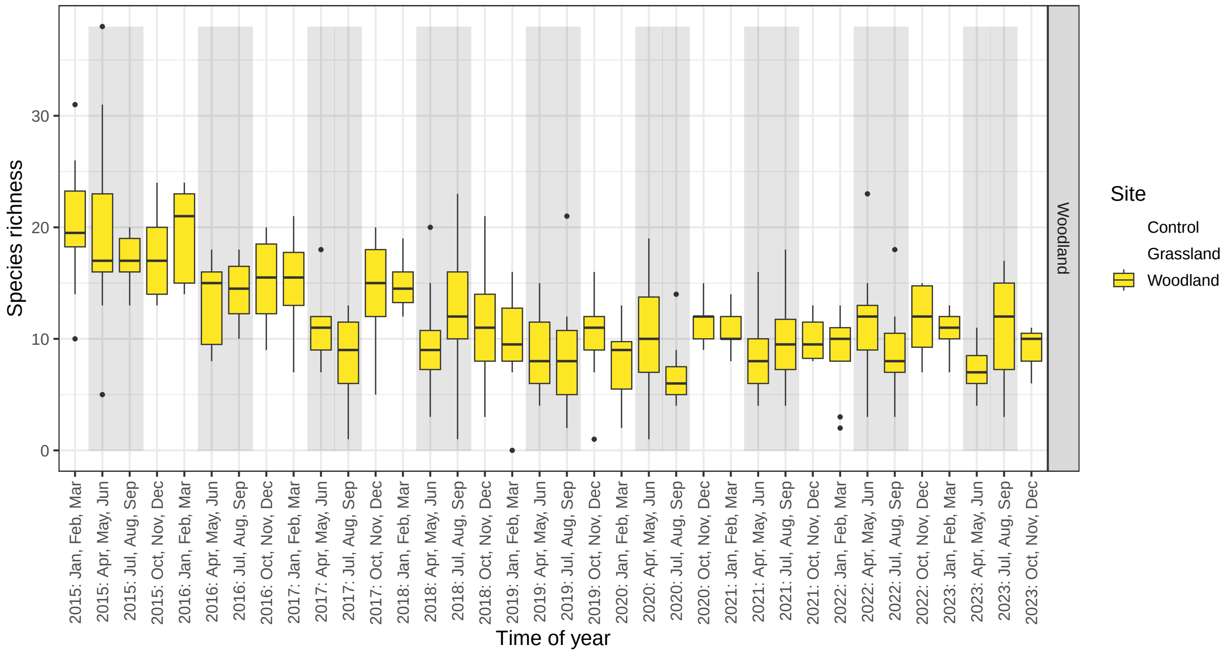


**Figure 5: Distribution of species richness per survey, by site and time of year. Winter months highlighted. Woodland sites only.**

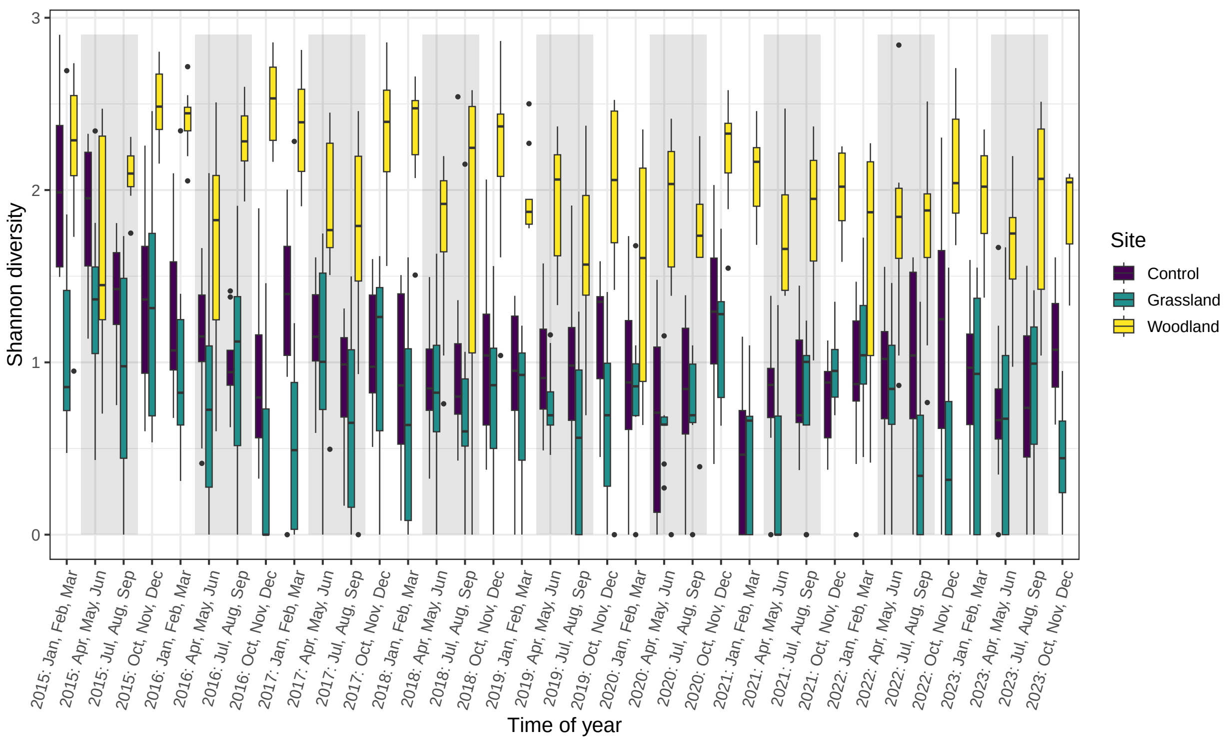


**Figure 6: Distribution of Shannon diversity per survey, by site and time of year.**

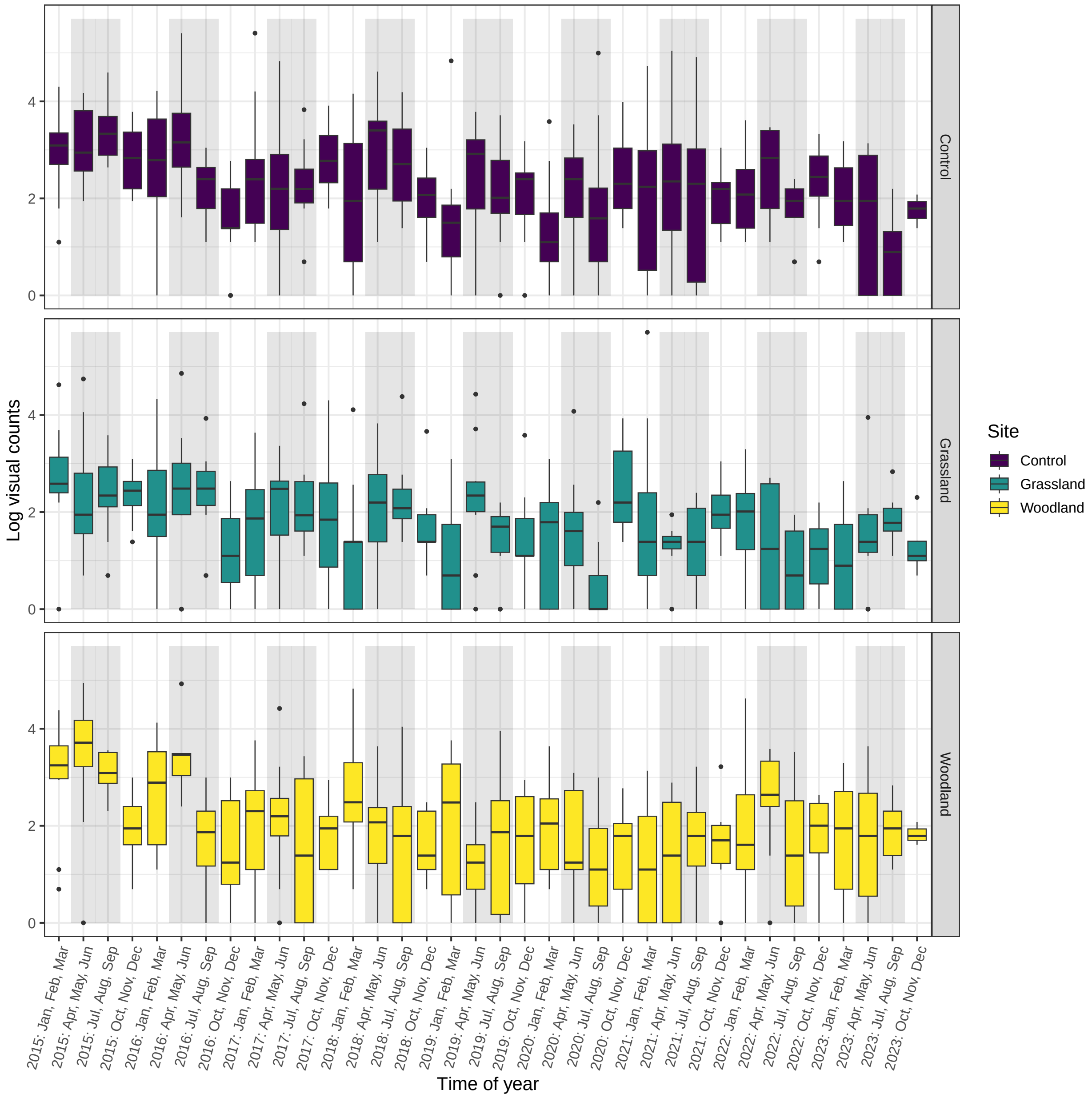


**Figure 7: Distribution of total log (visual) counts, by site and time of year**

## Species mix

In addition to the overall comparisons above we can directly contrast the species mix between surveys, sites and time periods. We do this by using an ordination method, which provides a graphical representation of the similarity of different surveys (Figure 8).

In this plot the closer two survey points are, the more similar the species mix (presence / absence of species). Figure 8 shows an overall comparison of the three habitats. As with the richness charts above (Figures 4 and 5) we see that the species mix at the woodland sites (bottom panel on Figure 8) is distinct from the grassland sites. We can see there is a movement in the species mix over time. Earlier surveys are roughly clustered around the origin point, but there's a trend towards the right as time goes on.

We note that although there are three plots show in the figure, they all originate from the same ordination run - the three plots are only to provide clarity, and it is valid in this case to compare between plots.

At control and grassland sites, there does appear to be a shift in species mix over time, as we can see that the earlier (2015) surveys are clustered around the origin, but then later surveys (2017 and after) have a shift toward the right-hand side of the plot. There is no evidence from this plot of a turbine-related effect, as the shift is the same in both sites.

We also explored the species mix under two other conditions - using a log transform (which accounts for abundance as well), and also a Wisconsin double standardisation (which standardises by both species and site). Generally, the patterns were the same as the richness-only mix, and so we haven't presented those figures. Woodland was still distinct, and grassland / control had a lot of overlap in mix. The shift in mix over time was evident in both these plots.

We can see from the ordination plots that there are general changes in mix over time, in all strata. There is no evidence of of changes in the grassland stratum that aren't mirrored by changes in the control stratum.

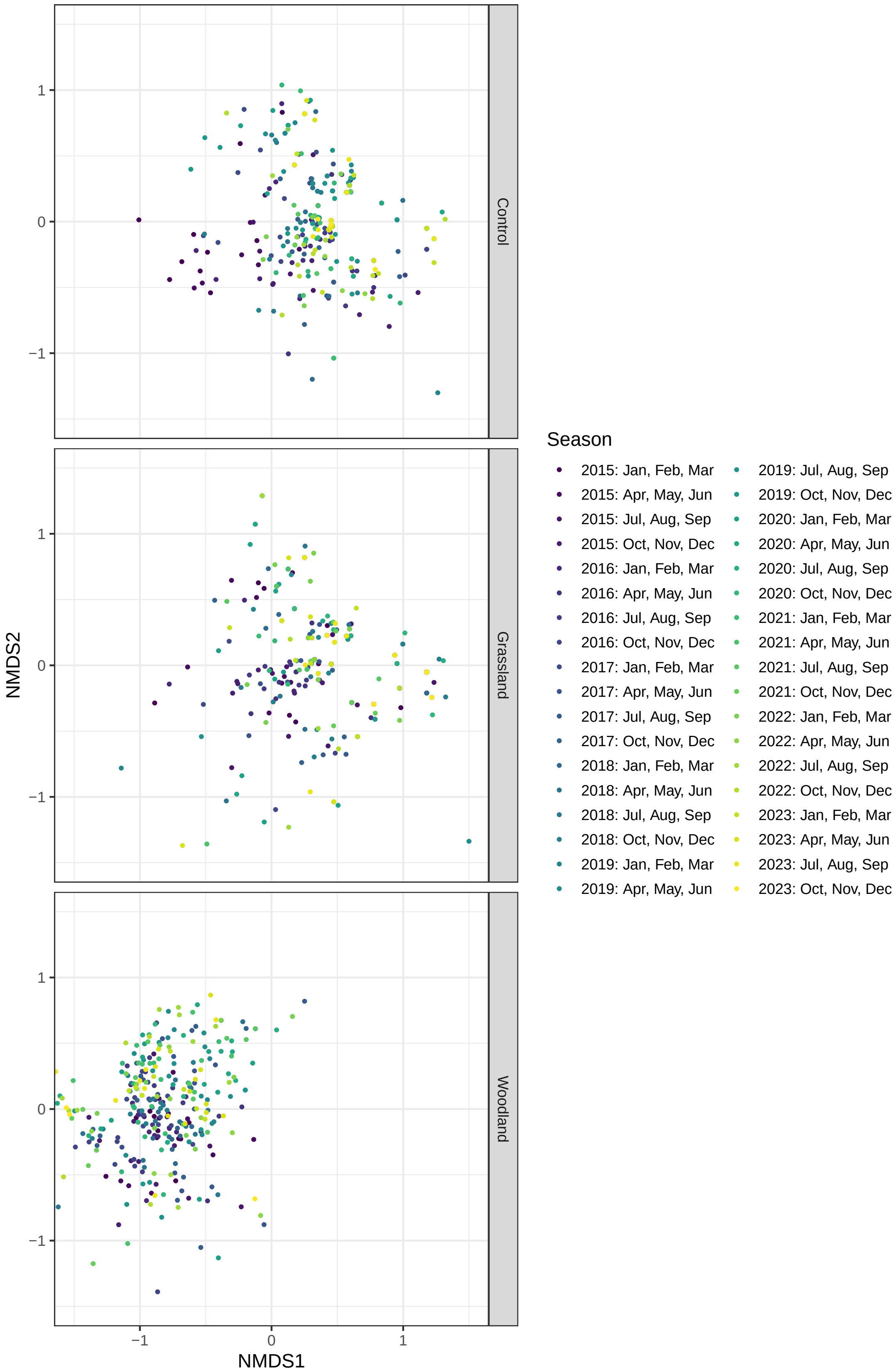


**Figure 8: 2D MDS grouped by season and site, with distance based upon presence / absence.**

# Trend modelling

## Shannon diversity

For the Shannon diversity model, we used a gamma generalised linear model with zero-inflation[2]. We modelled diversity against:

- time (months from the start of the survey period),
- monthly rainfall[3] (at the nearby Nimmitabel Wastewater Treatment Facility),
- log-distance (km) from the closest turbine, and
- and a zero-inflation factor (to account for the Shannon diversity equalling zero, if zero or one species are observed in a survey).

The model showed that increased rainfall is associated ($p = 0.001$) with increased Shannon diversity (on average, the diversity metric increases by a factor of 1.0012 per mm of rainfall). The ratio (in diversity) between the month with minimum rainfall (Jul 2018; 4.4 mm) and the month with maximum rainfall (Jan 2022; 187.2 mm), keeping all other things constant, is a factor of 1.25.

Shannon diversity also appears to be decreasing over time ($p < 0.001$). Each month, on average the Shannon diversity decreases by a factor of 0.996. For reference, the average Shannon diversity at the beginning of the surveys was 2.48 at control sites and 2.01 at grassland sites.

The zero-inflation factor accounted for the fact that the Shannon diversity had a value of zero, more than would be expected from a general gamma distribution (approximately 15% of the time, diversity equalled zero).

The interaction between site type and time (and indeed, the site type itself) was not significant ($p = 0.35$). While the baseline diversity is lower in the grassland area, its changes are reflected in the control area. Therefore, we do not have evidence of any changes in diversity due to wind farm activity.

## Richness

For species richness, we used a negative binomial generalised linear model, which properly handles the integer nature of the data. The richness model gave similar results to the Shannon diversity model.

# Concluding remarks

We also find that grassland sites have consistently lower diversity and counts compared to control sites. Results from some metrics, such as the richness and diversity, reflect the some variation in bird abundance, particularly evident in the woodland region. When we consider all

[2]Implemented in R using the `glmmTMB` package (Brooks et al. 2017).
[3]http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=139&p_display_type=dataFile&p_startYear=&p_c=&p_stn_num=070067

the univariate and multivariate visualisations, and the modelling, as combined evidence of the state of the species mix near the wind farm, we conclude that there has been a decrease in diversity and abundance in both the control and the grassland (impact) sites.

However, evidence does not point to the wind farm being the cause. There is a positive correlation between monthly rainfall and diversity/richness, and a positive correlation between distance from turbine and diversity/richness.

This data does indicate that the woodland species are somewhat different (in richness and relative abundance) from the grassland sites, but this is not unexpected. There is no evidence of an impact on woodland sites by the wind farm.

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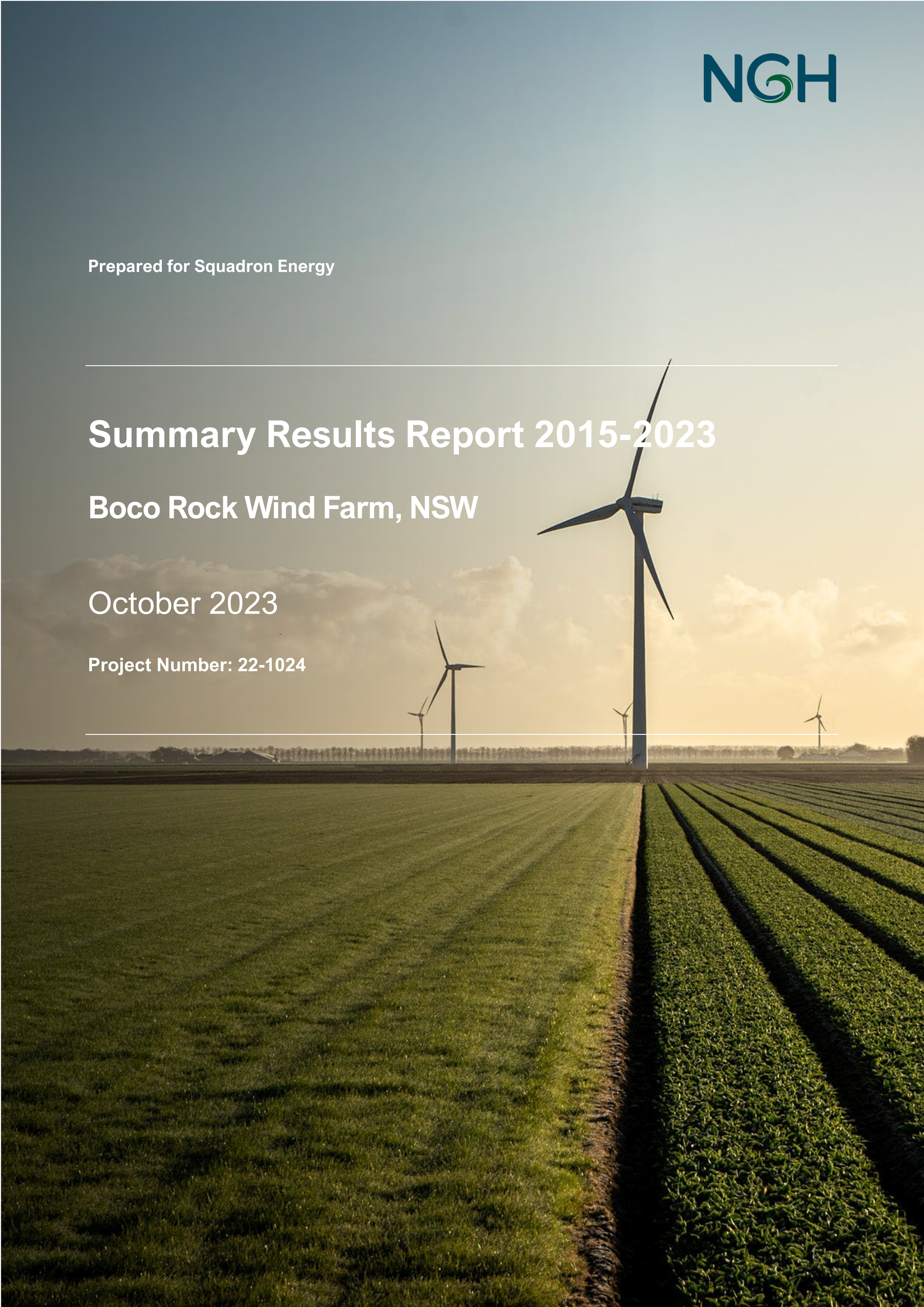
Shannon, C. E., and W. Weaver. 1949. *The Mathematical Theory of Information.* Urbana, Illinois: University of Illinois Press.

## C.3 Summary Results Report 2015-2023



Prepared for Squadron Energy

# Summary Results Report 2015-2023

## Boco Rock Wind Farm, NSW

October 2023

**Project Number: 22-1024**

# Document verification

| | |
|---|---|
| Project Title: | Boco Rock Wind Farm, NSW |
| Project Number: | 22-1024 |
| Project File Name: | 22-1024 BRWF Summary Report 2015-2023 final V1.docx |

| Revision | Date | Prepared by | Reviewed by | Approved by |
|---|---|---|---|---|
| Final | 18/10/2023 | Bianca Heinze | | Bianca Heinze |
| Draft | 17/10/2023 | Bianca Heinze | Jacqui Coughlan | Jacqui Coughlan |

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## Acronyms and abbreviations

| | |
|---|---|
| AWS | Automatic weather station |
| BBAMP | Bird and Bat Adaptive Management Plan |
| BC Act | *Biodiversity Conservation Act 2016* (NSW) |
| BCD | Biodiversity Conservation Division of DPE |
| BOM | Australian Bureau of Meteorology |
| BRWF | Boco Rock Wind Farm |
| BUS | Bird Utilisation Survey |
| CoA | Conditions of Approval |
| Cwth | Commonwealth |
| DAWE | Department of Agriculture, Water and the Environment (Cwth) (formerly DoEE) |
| DCCEEW | Department of Climate Change, Energy, the Environment and Water (formerly DAWE) |
| DPE | Department of Planning and Environment (NSW) |
| DPIE | (Former) Department of Planning, Industry and Environment (NSW) (now DPE) |
| EPBC Act | *Environment Protection and Biodiversity Conservation Act 1999* (Cwth) |
| GIS | Geographic information system |
| ha | hectares |
| ID | identification |
| km | kilometres |
| m | metres |
| NSW | New South Wales |
| OEH | Office of Environment and Heritage, now BCD |

| | |
|---|---|
| SOD | Shut down on demand |
| Sp/spp | Species/multiple species |
| V | Vulnerable |
| WTE | Wedge-tailed Eagle |
| WTNT | White-throated Needletail |

# 1. Introduction

## 1.1. Background

Operational bird and bat monitoring has been ongoing at Boco Rock Wind Farm (BRWF) near Nimmitabel, NSW since January 2015 under the BRWF Bird and Bat Adaptive Management Plan v1 (BBMP). Throughout 2023, consultation and planning has been undertaken to update the BBMP to reflect the findings of monitoring over the last eight-nine years. The updated Bird and Bat Adaptive Management Plan is known as BRWF BBAMP v2 (or 'BBAMP').

Updates to the BBAMP focus on turbine risk assessment, species risk assessment, triggers and thresholds for threatened and non-threatened species strikes. The BBAMP also provides a pathway to reduce survey effort and eventually cease monitoring at BRWF in line with results of monitoring which indicate that the wind farm is not having a population scale or significant impact upon any bird or bat species.

To accompany the BBAMP and summarise justifications for reducing monitoring, BCD have requested this summary results report.

## 1.2. Aim and structure

This report aims to provide a summary of results of all operational monitoring surveys undertaken at BRWF as documented in Annual Reports. While surveys for 2023 are incomplete at the time of writing (late September), results are included to August 2023. Reporting is organised by survey type with a focus on raw results and analysis by Symbolix (analysis undertaken to December 2022). Methods are not described in this report as they are described in detail in BBMP v1 and Annual Reports.

# 2. Carcass searches

## 2.1. Survey effort

In each month of 2015-2023, pulse searches have been conducted in the high detectability zone (along 120m of road and within hardstand) at all 67 turbines (i.e. each turbine surveyed twice) and extended zone (to 80m radius) searches undertaken at 20 randomly selected turbines.  Thus, annually there have been 1,608 high detectability zone searches and 240 extended zone searches with a few exceptions in the early years due to turbine maintenance. In total more 13,000 surveys have been undertaken in the high detectability zone and more than 2000 in the extended zone Table 2-1.

Table 2-1  Total survey effort (number of surveys) for carcass searches at BRWF, by year

| | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| High detectability | 1608 | 1557 | 1598 | 1607 | 1608 | 1608 | 1608 | 1608 | 1072 | **13874** |

| | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Extended zone | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 160 | **2080** |

## 2.2. Birds

Sixty-seven bird carcasses have been found during operational monitoring between January 2015 and August 2023 (Table 2-2). The total number of bird carcasses found annually has been variable, ranging from two (in 2022) to 13 (in 2020) with a mean of 7.44 and a median of 7. Nearly half (48.4%) of the 67 finds are represented by three species: Eurasian Skylark (15 carcasses; 22.4%); Australian Magpie (10 carcasses; 14.9%) and Nankeen Kestrel (8 carcasses; 11.9%). One threatened bird species has been found: White-throated Needletail. One carcass of this species was found in 2018 and another in 2020.

Table 2-2 Bird carcass finds at BRWF 2015-2022 (blank cells indicate species not found that year, asterisk indicates exotic species)

| Common Name | Species | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Australasian Pipit | *Anthus novaeseelandiae* | 1 | | | | | | | | | 1 |
| Australian Magpie | *Cracticus tibicen* | 1 | 1 | | 1 | | 5 | 1 | | 1 | 10 |
| Australian Raven | *Corvus coronoides* | | | | 1 | | | | | | 1 |
| Brown Falcon | *Falco berigora* | | | | 1 | | | | | | 1 |
| Brown Goshawk | *Accipiter fasciatus* | | | 1 | | | | | | | 1 |
| *Common Starling | *Sturnus vulgaris* | 1 | 1 | | | | 1 | | 1 | 1 | 5 |
| *Eurasian Skylark | *Alauda arvensis* | 3 | 4 | 3 | | 2 | | 2 | 1 | | 15 |
| Fairy Martin | *Petrochelidon ariel* | | | 1 | | | | | | | 1 |
| Grey Fantail | *Rhipidura albiscapa* | 2 | | | 1 | | | | | | 3 |
| Little Raven | *Corvus mellori* | | | | 1 | | | | | | 1 |
| Nankeen Kestrel | *Falco cenchroides* | 2 | | 1 | | 2 | 1 | 1 | | 1 | 8 |
| Peregrine Falcon | *Falco peregrinus* | | | 1 | 1 | | | | | | 2 |
| Raven | *Corvus sp.* | | | | | | 1 | | | | 1 |
| Rufous Fantail | *Rhipidura rufifrons* | | | 1 | 1 | | | | | | 2 |

| Common Name | Species | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Shining Bronze-cuckoo | *Chrysococcyx lucidus* | | | | 1 | | | | | | 1 |
| Silvereye | *Zosterops lateralis* | | | 1 | | | | | | | 1 |
| Southern Boobook | *Ninox boobook* | | | | | | 1 | | | | 1 |
| Stubble Quail | *Coturnix pectoralis* | | | | 1 | | | | | 1 | 2 |
| Sulphur-crested Cockatoo | *Cacatua galerita* | | | | | | 1 | | | | 1 |
| Unidentifiable | *Unidentifiable* | | | | | 2 | 1 | | | | 3 |
| Wedge-tailed Eagle | *Aquila audax* | 1 | 1 | 1 | | | 1 | | | | 4 |
| White-throated Needletail | *Hirundapus caudacutus* | | | | 1 | | 1 | | | | 2 |
| **Total** | | **11** | **7** | **10** | **10** | **6** | **13** | **4** | **2** | **4** | **67** |

## 2.3. Bats

Eighty-two bat carcasses have been found at BRWF in the period January 2015 to August 2023 (Table 2-3). The range is zero (2020) to 24 (2015) with an average of 10.25 and a median of 8 carcasses per year. White-striped Freetail Bat represents 73.2% of all bat carcass finds (60 carcasses found in the eight year period). Two threatened species have been found: four carcasses of Large Bent-winged Bat were found in 2015 and one Grey-headed Flying-fox in 2019.

Table 2-3 Bat carcass finds at BRWF 2015-2022

| Common Name | Species | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Wattled Bat | *Chalinolobus sp.* | 1 | | | | | | | | | 1 |
| Eastern Bentwing Bat | *Miniopterus oriane oceansis* | 4 | | | | | | | | | 4 |
| Gould's Wattled Bat | *Chalinolobus gouldii* | 1 | 6 | 5 | 1 | | | 2 | | | 15 |
| Grey-headed Flying-fox | *Pteropus poliocephalus* | | | | | 1 | | | | | 1 |
| Large Forest Bat | *Vespedalus darlingtoni* | | 1 | | | | | | | | 1 |

| Common Name | Species | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| White-striped Freetail Bat | *Austronomus australis* | 18 | 11 | 12 | 7 | 2 | | 6 | 2 | 2 | 60 |
| **Total** | | **24** | **18** | **17** | **8** | **3** | **0** | **8** | **2** | **2** | **82** |

## 2.4. Mortality estimates

An estimate of overall annual mortality separated for birds and bats was derived by a Monte-Carlo simulation model (Hull and Muir 2010 in Symbolix 2022a) by Symbolix for each year of monitoring. The results are presented in Table 2-4 and Figure 2-1.Trendlines indicate that mortalities of both birds and bats at BRWF are declining, despite some variation from year to year. This is supported by Symbolix's statistical analysis for BRWF which shows there is a clear declining trend (refer to Section 3.1 and Appendix B in BBAMP v2).

The estimated bird mortality in 2020 was significantly greater than 2019 and at the time was attributed to the positive correlation between bird activity and rainfall, with rainfall totals for 2020 being above average following several very dry years. Additionally, it was acknowledged that the 2019/2020 Black Summer bushfires may have influenced bird activity (which was higher in 2020) and therefore bird morality. Subsequent surveying has confirmed the 2020 bird mortality spike to be an anomalous result. Although the 2023 dataset is incomplete, survey to September 2023 has found five bird carcasses which is within the range of past results and that the general trend remains stable.

Table 2-4 Annual mortality estimates for birds and bats at BRWF Jan 2015 - Dec 2022

| Carcass type | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|
| Bat | 160 | 138 | 129 | 63 | 27 | 8 | 55 | 15 |
| Bird | 115 | 88 | 131 | 118 | 76 | 151 | 40 | 21 |

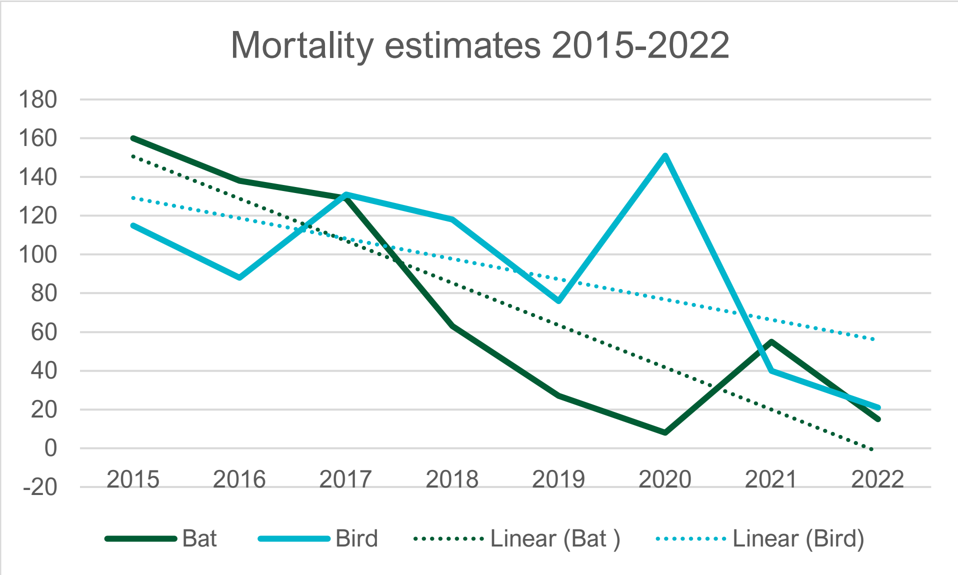


Figure 2-1 Mortality estimates at BRWF for birds and bats Jan 2015 - Dec 2022, including trendlines

# 3. Bird Utilisation Surveys

This section reports the results of Bird Utilisation Surveys (BUS) only and does not include incidental observations which are discussed in Section 5.

## 3.1. Survey effort

Between January 2015 and August 2023,1194 twenty minute BUS have been undertaken at BRWF (398 hours). This effort is distributed over the three strata: grassland control (415 surveys); grassland impact (351) and; woodland (428), as shown in Table 3-1. The grassland impact stratum has had the lowest proportion of total effort (<30%). Survey effort month to month has been influenced by external factors such as flood and rain.

Table 3-1 Number of BUS surveys by strata and year

| Strata | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | Total | % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Control | 37 | 42 | 40 | 42 | 44 | 40 | 37 | 41 | 92 | 415 | 34.7% |
| Grassland | 50 | 37 | 40 | 34 | 40 | 32 | 32 | 38 | 48 | 351 | 29.3% |
| Woodland | 36 | 39 | 39 | 38 | 39 | 37 | 33 | 35 | 132 | 428 | 35.8% |
| **Grand Total** | **123** | **118** | **119** | **114** | **123** | **109** | **102** | **114** | **272** | **1194** | **100%** |

## 3.2. Species richness

Species richness is the count of the number of species in an area. Between January 2015 and August 2023, BUS has yielded a count of 122 bird species for BRWF. Total species richness has varied from year to year (range: 65 to 89), with an average species richness across 2015-2022 of 72.1. Bird survey results by year are listed in Appendix A. Broken across the strata, annual results are shown in Table 3-2. Note that species richness for 2023 is for January – August only. Averages therefore are calculated for 2015-2022 inclusive.

Table 3-2 Species richness for each year (of BBMPv1) shown per stratum and as a total (note: total is not a sum of columns/rows as species may be recorded in multiple strata/years.)

| Strata | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | Total | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Grassland – control | 63 | 37 | 31 | 35 | 28 | 26 | 24 | 42 | 17 | 83 | 35.8 |
| Grassland – impact | 40 | 29 | 28 | 21 | 14 | 19 | 11 | 23 | 18 | 54 | 23.1 |
| Woodland | 66 | 58 | 58 | 53 | 53 | 52 | 55 | 65 | 27 | 101 | 57.5 |
| **Total** | **89** | **76** | **74** | **69** | **65** | **66** | **59** | **79** | **44** | **122** | **72.1** |

Table 3-2 shows that the woodland stratum has consistently higher species richness than grassland, which is to be expected given greater habitat complexity. Statistical analysis confirms this (refer to Appendix B). All sites exhibit an apparent sharp decline in species richness in the first year or two of monitoring, which has stabilised subsequently. For grassland sites, this was caused at least in part by the reclassification or elimination of some randomly sampled BUS sites due to poor representation of habitat strata (e.g. some 2015 grassland sites were immediately adjacent to woodland causing a skew is BUS results for those sites). As shown in Figure 3-1, there is a declining (linear) trend for species richness at all strata, although this is less pronounced at woodland sites.

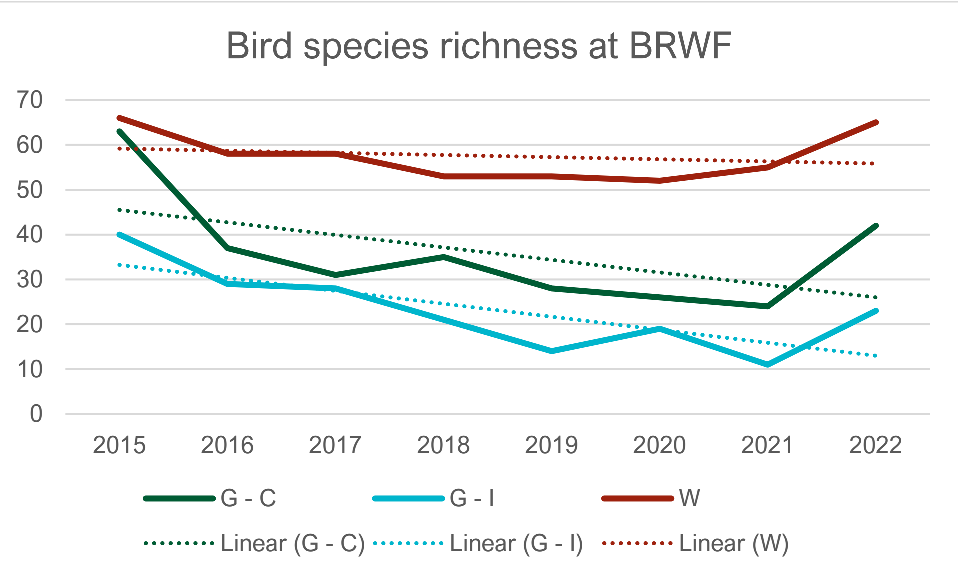


Figure 3-1 Bird species richness at BRWF and linear trendlines. G-C = grassland control, G-I = grassland impact, W = woodland

During the years 2017 and 2019, statistical analysis found a correlation between declining species richness and below average rainfall at Nimmitabel. This was documented in Annual Reports for those years. Annual rainfall stabilised from 2020 but species richness did not in grassland strata. This was hypothesised to be caused by a slow ecological bounce-back following drought years. Species richness for 2022 appears to show that delayed bounce back.

## 3.3. Species abundance

Species abundance is the number of individuals per species. Note that aural observations are given a count of one individual. Between January 2015 and August 2023, more than 8000 observations have been made of 17,879 birds at BRWF (note that this does not consider likely repeat observations of individuals over time). This includes 3652 observations in woodland, 2745 in grassland control and 1863 in grassland impact sites Table 3-3.

Table 3-3 Number of observations during BUS for each strata and year

| Strata | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Grassland – control | 571 | 410 | 343 | 321 | 276 | 237 | 214 | 282 | 2745 |
| Grassland – impact | 501 | 268 | 240 | 174 | 183 | 139 | 127 | 182 | 1863 |
| Woodland | 657 | 605 | 468 | 453 | 342 | 343 | 324 | 328 | 3652 |
| **Total** | **1729** | **1283** | **1051** | **948** | **801** | **719** | **665** | **792** | **8260** |

Observations in 2015 skews interpretation of trends due to BUS site changes between 2015-2016. Therefore, the graph has been made for 2016-2022 only. Again, there has been a declining trend of bird observations (Figure 3-2). Most pronounced has been a decline in the number of woodland observations and most stable are grassland impact observations. Of note, the declining trend has occurred across all strata including control.

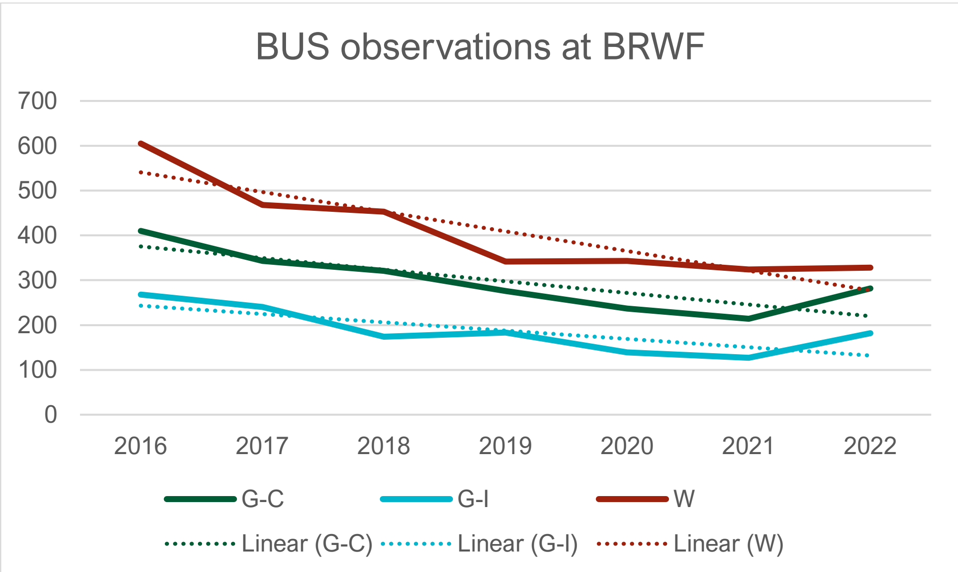


Figure 3-2 Number of BUS observations for each stratum and year at BRWF (G-C = grassland control, G-I = grassland impact, W = woodland).

The most common (abundant) species at BRWF at grassland sites (control and woodland) have been remarkably consistent across the years. Eurasian Skylark *(Alauda arvensis)* and Common Starling *(Sturnus vulgaris)* were the top two most common species in 2015, 2016, 2017, 2018 and 2019. These two exotic species remained dominant subsequently but were also joined by native species Little Raven *(Corvus mellori),* Sulphur-crested Cockatoo *(Cacatua galerita)* and Australian Magpie *(Cracticus tibicen)* in subsequent years.

There has been variation in the most common (abundant) species at woodland sites with Sulphur-crested Cockatoo, Yellow-faced Honeyeater *(Lichenostomus chrysops)*, Striated Pardalote *(Pardalotus striatus)*, Galah *(Eolophus roseicapilla)*, White-throated Treecreeper *(Cormobates leucophaea)*, Red Wattlebird *(Anthochaera carunculate)*, Australian Magpie, White-eared Honeyeater *(Nesoptilotis leucotis)* in the top places at different points between 2015-2022.

## 3.4. Control-impact comparisons

Year on year comparisons have been documented in Annual Reports, with the exception of 2022 for which an Annual Report was not produced. The statistical analysis report for 2022 is attached in Appendix B. In summary, analysis has been taken each year to look for any statistically significant changes. There are downward trends for richness and abundance (as discussed above) and these are present across all strata, therefore there is no significant difference between control and impact sites. Shannon diversity per survey indicates seasonal variation in the woodland, fairly stable grassland impact sites and an apparent decline in grassland control sites (2015-2016) followed by a levelling off from 2017/2018 (this has been previously accounted for by changes to survey sites). Variation in the grassland impact sites have generally been mirrored in the control sites (Figure 3-3).

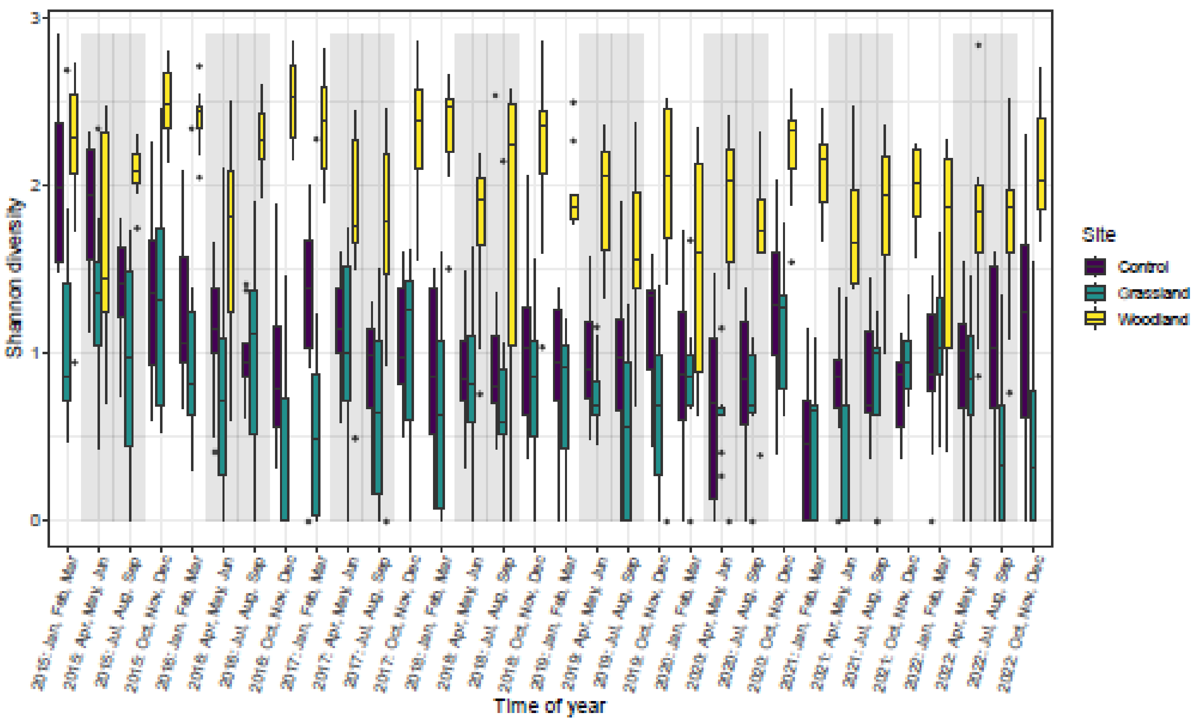


Figure 3-3 Box plot of Shannon diversity per survey (Jan 2015 - Dec 2022) for each strata demonstrating high variation over time, with grassland control generally mirroring grassland impact results.

Species assemblage analysis is presented in Figure 3-4 below; each dot represents species and colours represent surveys with darker colours indicating earlier surveys (first quarter 2015) through to yellow indicating later surveys (fourth quarter 2022). Figure 3-4 shows that the assemblage at woodland sites is distinct from grassland sites and that there is movement or change in the assemblage over time at all sites (although less so at woodland sites). The species assemblage plots are similar for grassland impact and control although with more variation at grassland impact sites. Overall assemblage changes in the impact stratum are mirrored in the control stratum.

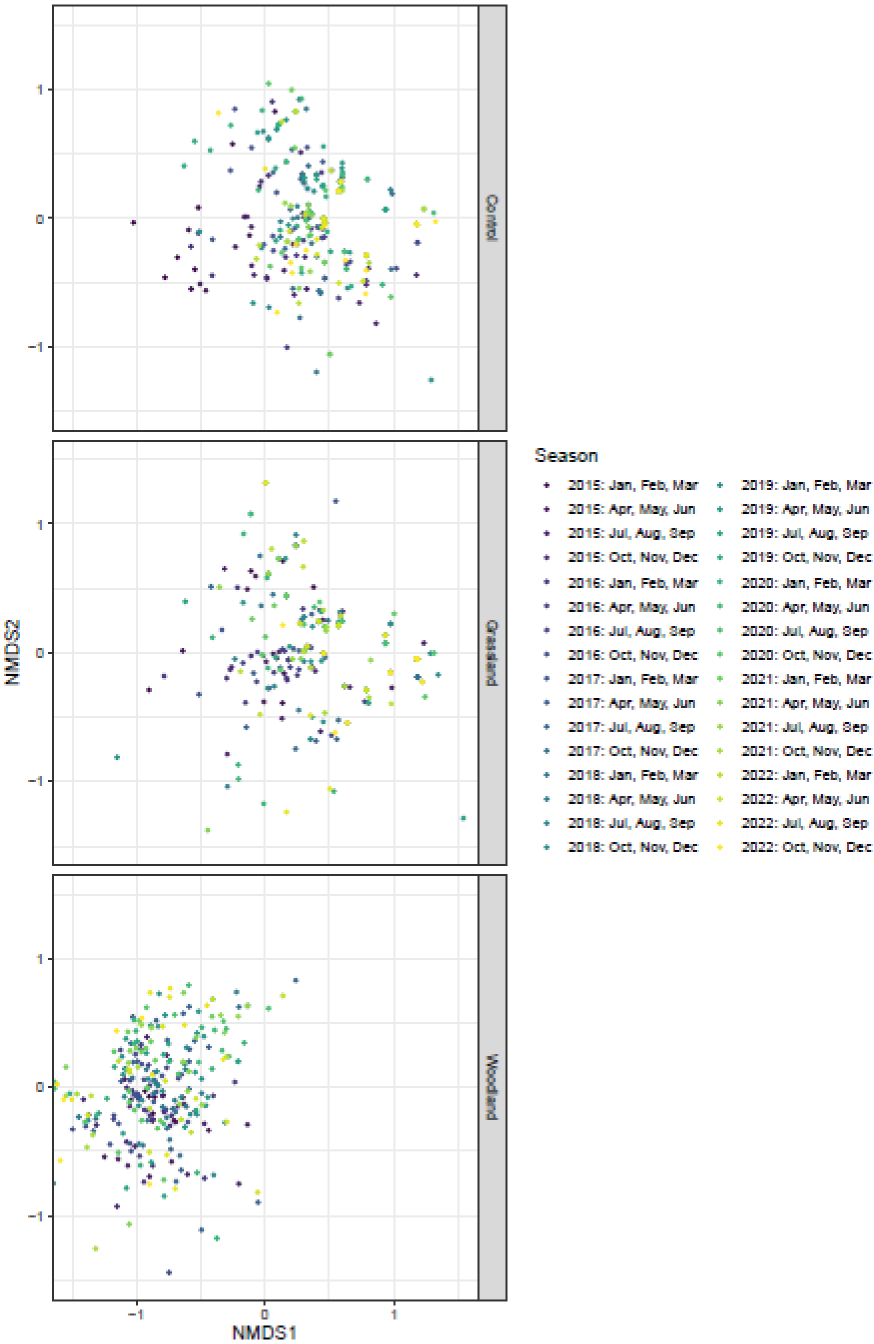


Figure 3-4 MDS (species assemblage analysis) grouped by season and stratum, with distance based upon presence/absence

## 3.5. Distance relationship

Analysis has found no statistically significant relationship between distance from a turbine and proportion of birds from different guilds. For example, Eurasian Skylark from the Introduced Grassland Ground guild are just as likely to be encountered at a grassland survey site within five metres of a turbine as they are more than 500 m from a turbine. There is a positive association between Shannon diversity and distance from a turbine. For example, keeping other variables fixed, a site at twice the distance from a turbine is expected to have 1.03 times the diversity, and a site at ten times the distance is expected to have 1.11 times the diversity. However, given that turbines are located on the cleared, wind exposed ridgelines with little cover or habitat diversity it is not surprising that bird diversity is lowest near turbines and increases as habitat diversity increases away from the turbines and towards woodlands. Figure 3-5 shows a typical area of BRWF with woodland areas 250m or more from turbines and only scattered shrubs and trees approaching turbines.

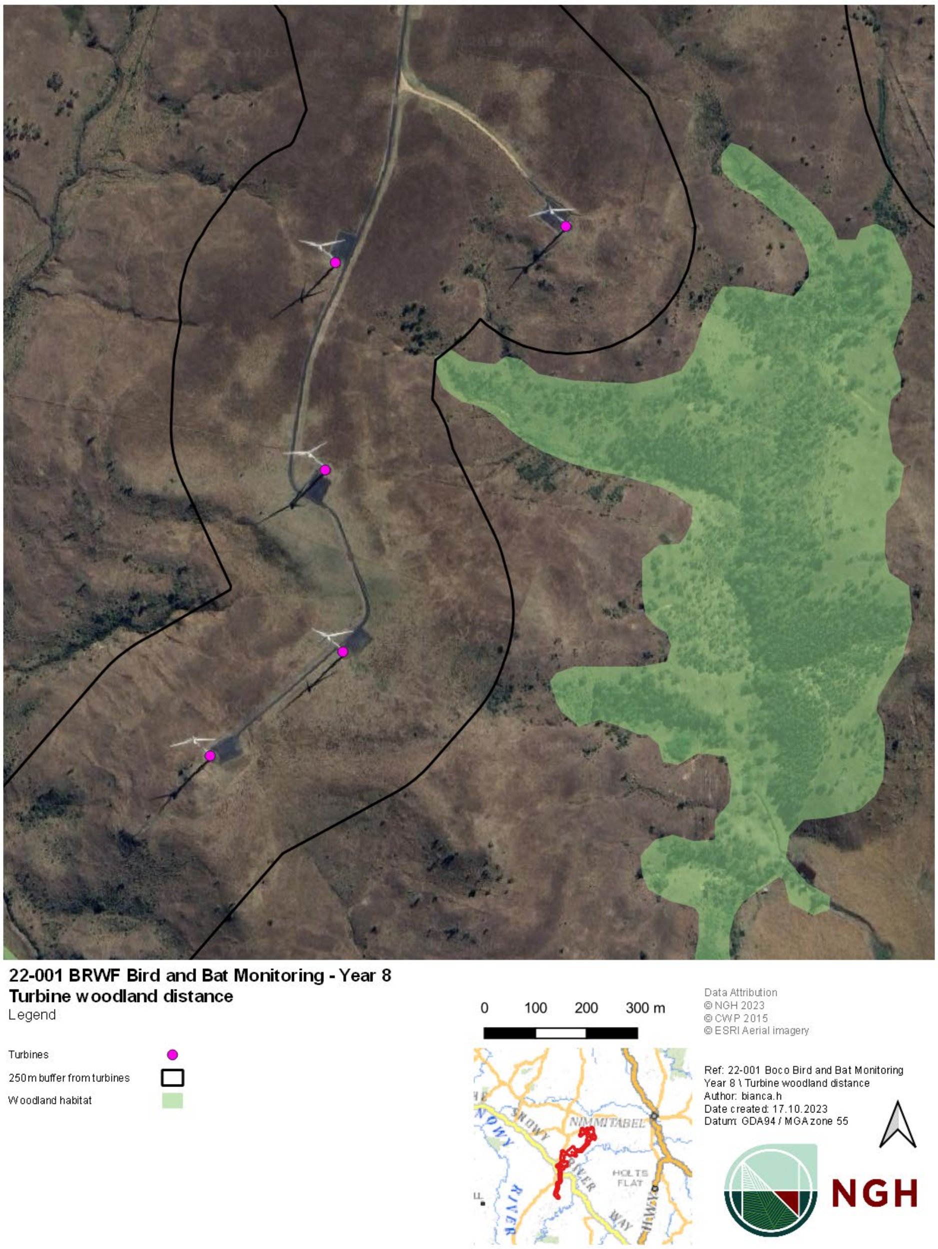


Figure 3-5 Turbines located on cleared ridges, with woodland areas generally 250m or more from turbines

## 3.6. Threatened species

Eleven BC Act threatened species have been recorded at BRWF from January 2015 to August 2023. Excluding 2023 (incomplete dataset), the number of individuals observed of all threatened species combined per year has ranged from 14 to 67 as shown in Table 3-4. (Note: each sighting of a bird counts as an individual recorded, therefore this is an overestimate of abundance). Scarlet Robin has been recorded most consistently, being observed every year of survey. White-bellied Sea-eagle has not been observed during BUS since 2015 when a single individual was observed.

Table 3-4 Number of individuals per year for each threatened species recorded at BRWF

| Species Name | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Brown Treecreeper *Climacteris picumnus* | 1 | 1 | | | 1 | | | 1 | 2 | 6 |
| Diamond Firetail *Stagonopleura guttata* | | 2 | | 3 | 1 | | | 3 | | 9 |
| Dusky Woodswallow *Artamus cyanopterus* | 7 | 19 | | 10 | 8 | 4 | 7 | 3 | | 58 |
| Flame Robin *Petroica phoenicea* | 1 | 8 | 1 | | 2 | | | | | 12 |
| Gang-gang Cockatoo *Callocephalon fimbriatum* | 19 | | | | | 1 | | 2 | | 22 |
| Hooded Robin *Melanodryas cucullata* | 2 | | | | 1 | | 2 | 1 | | 6 |
| Scarlet Robin *Petroica boodang* | 19 | 21 | 17 | 14 | 6 | 8 | 5 | 8 | 5 | 103 |
| Speckled Warbler *Chthonicola sagittata* | | 6 | 5 | 1 | 2 | 1 | 1 | 3 | | 19 |
| Spotted Harrier *Circus assimilis* | 2 | | | 1 | | | | | | 3 |
| Varied Sittella *Daphoenositta chrysoptera* | | 10 | 2 | | | | | | | 12 |
| White-bellied Sea Eagle *Haliaeetus leucogaster* | 1 | | | | | | | | | 1 |
| **Total** | **52** | **67** | **25** | **29** | **21** | **14** | **15** | **21** | **7** | **251** |

The majority of threatened species observations have been at woodland sites; Table 3-5 shows that 89% of threatened species observations have occurred at woodland BUS sites.

Table 3-5 Threatened species observations per strata and as a percentage of total

| Strata | Observations | Percentage of total |
|---|---|---|
| Grassland control | 12 | 7.3% |
| Grassland impact | 6 | 3.7% |
| Woodland | 146 | 89% |
| **Grand Total** | **164** | **100%** |

## 3.7. Conclusion

The purpose of BUS is to ascertain whether BRWF is having a discernible impact upon local bird populations. The downward trends in species richness and abundance along with assemblage changes have occurred across all strata not just the impacted grassland. That is, changes in the grassland impact stratum are mirrored in the grassland control and woodland strata. This strongly suggests that BRWF is not having an impact upon local bird populations and that the patterns observed are due mostly to local and regional environmental conditions. This conclusion has been drawn for several years, supported by statistical analysis and has been documented in regular Annual Reports.

# 4. Microbat surveys

Anabat files have been analysed by Greg Richards and Glenn Hoye. Anabat files are scanned to count call passes of focus species:

1. Large Bent-winged Bat *Miniopterus oceanensis oriane* (Vulnerable under NSW *Biodiversity Conservation Act 2017* (BC ACT))
2. Eastern False Pipistrelle *Falsistrellus tasmaniensis* (Vulnerable BC Act)
3. White-striped Freetail Bat *Austronomus australis*
4. Gould's Wattled Bat *Chalinolobus gouldii*

These are focus species because they have been found regularly during carcass searches and/or are a threatened species. For reference, a full analysis of all bat calls was completed in 2016 and showed that the following additional bats species occur at BRWF:

- Chocolate Wattled Bat *Chalinolobus morio*
- Southern Freetail Bat *Mormopterus planiceps*
- Inland Broad-nosed Bat *Scotorepens balstoni*
- Large Forest Bat *Vespadelus darlingtoni*
- Southern Forest Bat *Vespadelus regulus*
- Little Forest Bat *Vespadelus vulturnus*

These species still remain largely absent from mortality searches.

## 4.1. Survey effort

For the duration of the monitoring program to date, Anabat surveys have been undertaken once per quarter (four times per year) to monitor microbat activity. Additional targeted (e.g. nacelle height) Anabat surveys were undertaken in 2015/2016 following mortality of Large Bent-winged Bat, however this data has been stored, analysed and reported on separately from the quarterly monitoring under BBMP v1[1]. Quarterly Anabat survey sites are shown in Table 4-1.

Table 4-1 Anabat survey sites at BRWF

| Anabat site | Stratification | Description | Nearest turbine |
|---|---|---|---|
| AE-1 | Grassland control | Open grassland near Avon Lake Road > 500 m from turbines | 34, 35 |
| AE-2 | Grassland impact | Open grassland between turbines 49 & 50 (< than 500 m distance from turbines) | 49, 50 |
| AE-3 | Woodland impact | Two rows of trees meeting < 500 m from turbine. No woodland patches occur within 500 m of turbines so this is the densest vegetation. | 25 |
| AE-4 | Woodland control | Woodland > 500 m from turbines | 35, 37 |

Approximately 560 Anabat survey nights have been undertaken at BRWF based on 16 survey nights per quarter each year (Table 4-2). Although four Anabat units have been placed for four nights each quarter, some units have malfunctioned from time to time, resulting in less than 100% survey efficacy. These instances were discussed in Annual Reports.

Table 4-2 Anabat survey effort at Boco Rock January 2015 - August 2023

| Effort | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Quarter 1 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | **144** |
| Quarter 2 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | **144** |
| Quarter 3 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | **144** |
| Quarter 4 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | | **128** |
| **Total** | **64** | **64** | **64** | **64** | **64** | **64** | **64** | **64** | **48** | **560** |

[1] Large Bent-winged Bat targeted monitoring was reported in NGH Environmental (2017) *Risk Analysis: Eastern Bentwing-bat, Boco Rock Wind Farm.* Reported prepared for CWP Renewables. This report was provided to OEH in 2017.

## 4.2. Survey results

Over January 2015 – December 2022, 8721 calls have been positively attributed to focus species (Table 4-3). Many thousands more have been attributed to the 'other species' group consisting of those species listed earlier which are not individually counted.

Table 4-3 Total positive call identifications by focus species and year (counts for Gould's Wattled Bat commenced in 2016)

| Species | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Eastern False Pipistrelle | 2 | 0 | 0 | 5 | 1 | 17 | 15 | 15 | 55 |
| Gould's Wattled Bat | | 34 | 1082 | 1101 | 856 | 839 | 2038 | 778 | 6728 |
| Large Bent-winged Bat | 15 | 3 | 16 | 152 | 285 | 310 | 70 | 346 | 1197 |
| White-striped Freetail Bat | 209 | 90 | 155 | 110 | 53 | 41 | 21 | 62 | 741 |
| **Total** | **226** | **127** | **1253** | **1368** | **1195** | **1207** | **2144** | **1201** | **8721** |

Results have fluctuated widely from year to year (range 127-1368) and overall there appears to be an increasing trend in microbat activity (Figure 4-1). As for birds, this 'trend' in annual activity levels is likely to be related to environmental conditions such as rainfall rather than the operation of BRWF.

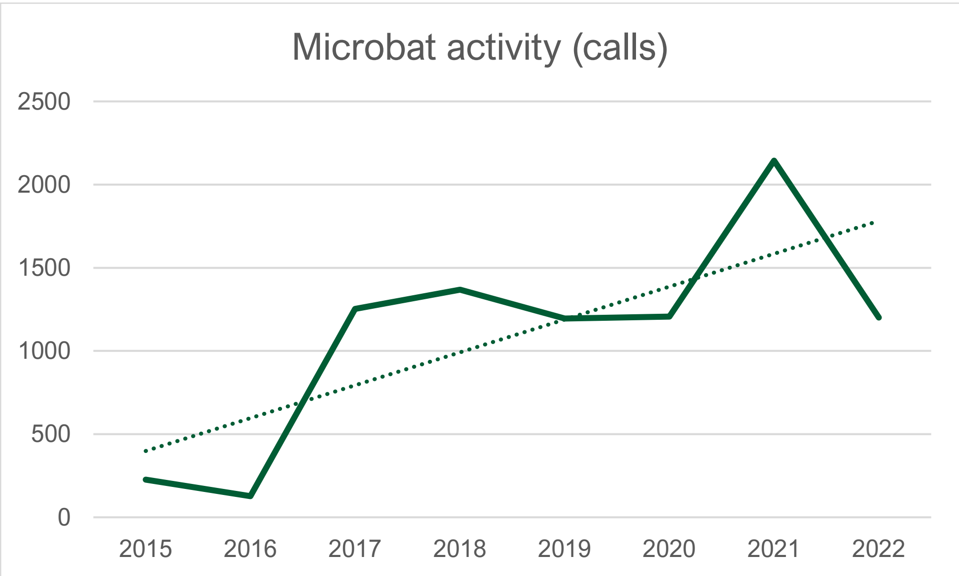


Figure 4-1 Microbat activity by year with trendline

Microbat activity at BRWF also shows a strong seasonality, with most results obtained over the warmer months. Results can be sorted according to site, which (as shown in Table 4-1) is stratified into woodland and grassland impact and control. Surprisingly, the woodland impact site which consists only of two rows of trees meeting in a paddock has the highest activity level overall compared to other sites as shown in Table 4-4. The next highest activity level is recorded at grassland impact site which is an area of open grassland. The areas with the lowest activity levels are the control sites located more than 500m from a turbine.

Table 4-4 Positive call identifications by site and species

| Species | AE-1 Grassland control | AE-2 Grassland impact | AE-3 Woodland impact | AE-4 Woodland control |
|---|---|---|---|---|
| Eastern False Pipistrelle | 7 | 4 | 38 | 6 |
| Gould's Wattled Bat | 219 | 975 | 5168 | 366 |
| Large Bent-winged Bat | 34 | 126 | 941 | 96 |
| White-striped Freetail Bat | 210 | 246 | 185 | 100 |
| **Total** | **470** | **1351** | **6332** | **568** |

From this summary, we can surmise that BRWF is not having a negative effect on local microbat activity and that other differences between the sites (e.g. habitat and orographic) are likely to be more relevant to understanding microbat local activity.

## 4.3. Threatened species

Large Bent-winged Bat and Eastern False Pipistrelle have been present at BRWF at varying activity levels during 2015-2022. Given a threatened bat carcass has not been detected at BRWF since 2015, it seems unlikely that changes in activity levels are related to turbines or mortality. In fact, rainfall is more likely to be a factor in detection of Eastern False Pipistrelle given preference for wetter habitats, however this has not been analysed.

# 5. Incidental observations

Incidental bird observations at BRWF occur opportunistically during other surveys and while travelling around the site. Incidental observations are also recorded when checking the nine waterbodies/wetlands which are within and around the BRWF site. Fifty-one species have been recorded in this way.

## 5.1. Raptors

Eleven raptor species have been recorded opportunistically (Table 5-1) at BRWF (compared to 10 species recorded during BUS) with nearly double the number of incidental raptor observations compared to those made during BUS as shown in Table 5-2. Little Eagle and Swamp Harrier have not been recorded during BUS while Collared Sparrowhawk *(Accipiter cirrocephalus)* has only been recorded (on two occasions) during BUS. It was anticipated that raptor results would be low in BUS because raptors are not so active at the time of day that BUS are usually undertaken (mornings); for this reason they were excluded from BUS analysis and specifically recorded during incidental observations throughout the day.

Table 5-1 Raptor species recorded opportunistically at BRWF

| Common name | Species | No. observations |
|---|---|---|
| Australian Hobby | *Falco longipennis* | 10 |
| Black-shouldered Kite | *Elanus axillaris* | 12 |
| Brown Falcon | *Falco berigora* | 11 |
| Brown Goshawk | *Accipiter fasciatus* | 1 |
| Little Eagle | *Hieraaetus morphnoides* | 1 |
| Nankeen Kestrel | *Falco cenchroides* | 85 |
| Peregrine Falcon | *Falco peregrinus* | 7 |
| Spotted Harrier | *Circus assimilis* | 2 |
| Swamp Harrier | *Circus approximans* | 2 |
| Wedge-tailed Eagle | *Aquila audax* | 78 |
| White-bellied Sea Eagle | *Haliaeetus leucogaster* | 1 |
| **Total** | | **210** |

Table 5-2 Number of raptor observations per year by survey type

| Survey type | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| BUS | 23 | 15 | 20 | 19 | 6 | 4 | 8 | 16 | 1 | 112 |
| Incidental | 33 | 19 | 16 | 26 | 16 | 17 | 29 | 43 | 9 | 210 |

The purpose of recording incidental raptor observations at BRWF was to note whether BRWF was having an impact on raptor populations which might not be discernible through BUS alone (due to insufficient number of observations). Figure 5-1 shows that raptor observations have fluctuated widely from year to year during 2015 and 2022 but overall the number of observations has been steady.

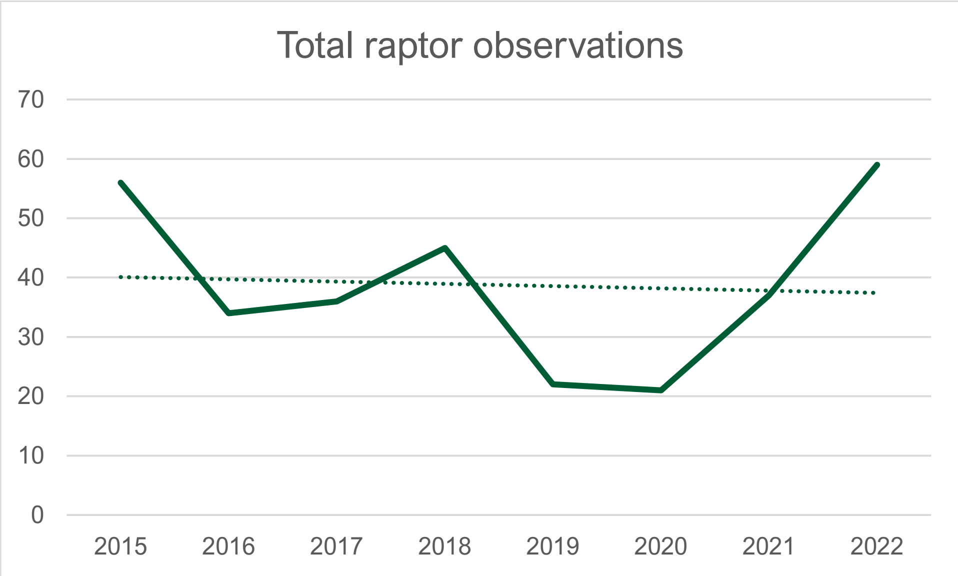


Figure 5-1 Total raptor observations (BUS and opportunistic) by year at BRWF showing trendline

Nankeen Kestrel is one of the most frequently recorded carcasses at BRWF during mortality surveys. Figure 5-2 presents a plot of number of annual Nankeen Kestrel observations and annual number of Nankeen Kestrel carcasses found and does not suggest a relationship that needs analysis. There is no evidence that BRWF is having a negative impact upon local raptor populations.

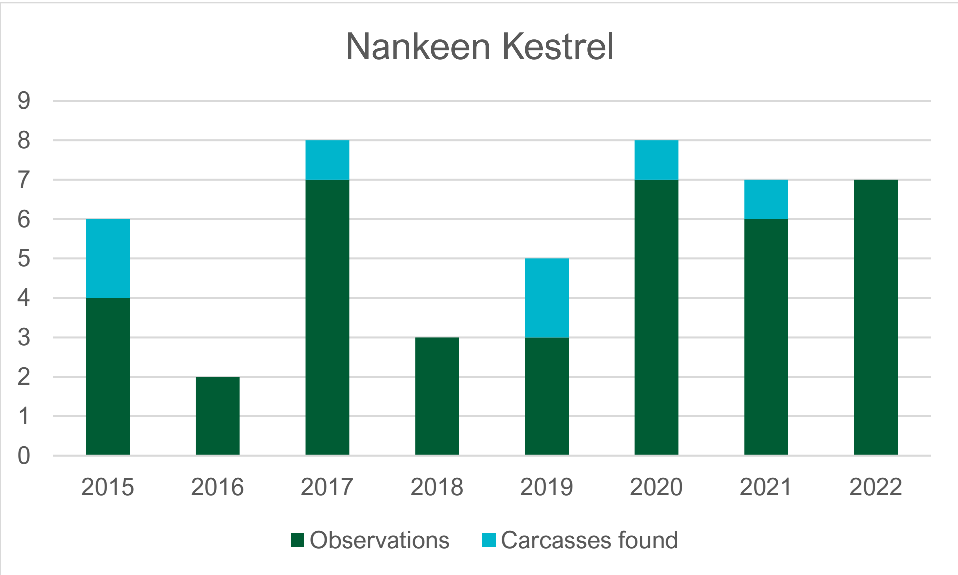


Figure 5-2 Number of Nankeen Kestrel observations and carcasses found annually

## 5.2. Waterbirds

Thirty-four species of waterbird (including two sets of ‘unidentified waterfowl’ have been recorded incidentally over January 2015 – August 2023 as shown in Table 5-3. This compares to 20 species recorded during BUS.

Table 5-3 Waterbird species recorded incidentally at BRWF and number of observations

| **Common name** | Species | No. observations |
|---|---|---|
| Australasian Grebe | *Tachybaptus novaehollandiae* | 2 |
| Australasian Shoveler | *Anas rhynchotis* | 2 |
| Australian Darter | *Anhinga novaehollandiae* | 1 |
| Australian Reed Warbler | *Acrocephalus australis* | 4 |
| Australian Shelduck | *Tadorna tadornoides* | 15 |
| Australian Wood Duck | *Chenonetta jubata* | 29 |
| Banded Lapwing | *Vanellus tricolor* | 2 |
| Black Swan | *Cygnus atratus* | 4 |
| Chestnut Teal | *Anas castanea* | 2 |
| Eurasian Coot | *Fulica atra* | 9 |
| Grey Teal | *Anas gracilis* | 8 |
| Hardhead | *Aythya australis* | 1 |
| Little Pied Cormorant | *Microcarbo melanoleucos* | 1 |
| Masked Lapwing | *Vanellus miles* | 6 |
| Pacific Black Duck | *Anas superciliosa* | 26 |
| Pink-eared Duck | *Malacorhynchus membranaceus* | 1 |
| Whiskered Tern | *Chlidonias hybrida* | 2 |
| White-faced Egret | *Egretta novaehollandiae* | 2 |
| White-faced Heron | *Egretta novaehollandiae* | 10 |
| White-necked Heron | *Ardea pacifica* | 1 |
| **Total** | | **128** |

Waterbirds were most frequently recorded at the lake on Avon Lake Road (216 observations), followed by Boundary Lake (150 observations), the ephemeral wetlands 150m south-east of Turbine 30 (137) and Coopers Lake (126) as shown in Table 5-4.

Table 5-4 Number of waterbird observations sorted by location

| **Incidental observation site** | Number of observations |
|---|---|
| Wetland 600m north of Turbine 49 | 83 |
| Lake on Avon Lake Rd | 216 |
| Between T35 and T37 | 1 |

| Incidental observation site | Number of observations |
|---|---|
| Boundary Lake | 150 |
| Coopers Lake | 126 |
| Dam near T30 | 42 |
| Ephemeral lake by main gate | 83 |
| Ephemeral pool along Brechnoch Rd | 86 |
| Ephemeral pool along Cow Bum Rd | 8 |
| Ephemeral wetland 150 m SE Turbine 30 | 137 |
| Sited near T33 | 1 |
| T52 acre-sized wetland | 3 |
| Waterbody 600m north of T49 | 41 |
| **Total** | **977** |

The number of waterbird observations at local wetlands around BRWF appears to be correlated with annual rainfall at Nimmitabel as shown in Figure 5-3. This has not been statistically tested but demonstrates the likely driver of waterbird number fluctuations given no carcass detection at BRWF.

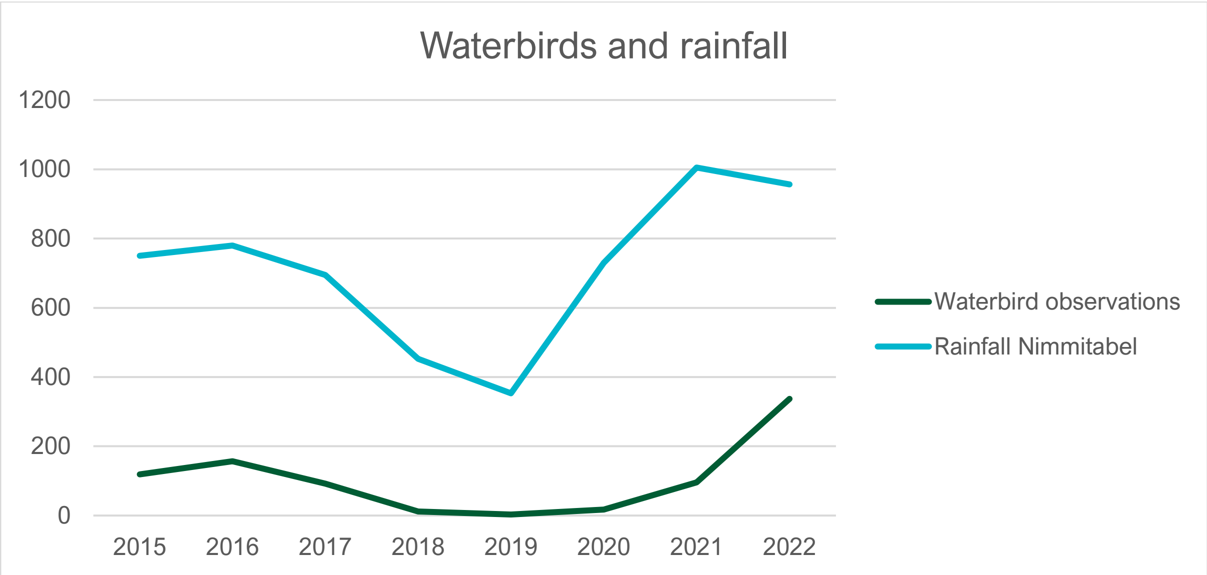


Figure 5-3 Number of waterbird observations and annual rainfall at Nimmitabel (mm)

The purpose of recording waterbirds at nearby wetlands was to see if there was a correlation between waterbird activity and waterbird mortality at BRWF. Over more than eight years of monitoring, there have been no waterbird carcasses found at BRWF despite a high level of activity at nearby wetlands. Therefore, it can be stated that BRWF is not impacting local waterbird populations or their ability to move between areas of suitable habitat.

# 6. Conclusion

This report summarises the results of more than eight years of operational bird and bat monitoring at BRWF. Results are presented from January 2015 to August 2023, or, where an incomplete dataset would skew results, to December 2022. Three survey types have been undertaken: carcass searches, Bird Utilisation Surveys and microbat (Anabat). Additionally, incidental observations have focussed on raptors and waterbirds.

Over 13,874 high detectability zone and 2080 extended zone carcass searches, 67 bird and 82 bat carcasses have been found. Eurasian Skylark, Australian Magpie and Nankeen Kestrel were the most common bird species found, together representing around 50% of total bird finds. White-striped Freetail Bat is the most common bat species found representing 73.2% of all bat carcass finds.

Annual mortality estimates for birds and bats have been calculated by Symbolix for each complete year of survey (i.e. 2015-2022). Overall there is a declining trend in carcasses found and mortality estimates for both birds and bats.

The number of BUS surveys undertaken to date is 1194 over 398 hours. Survey effort has been distributed across three strata: grassland control (more than 500m from a turbine), grassland impact (less than 500m from a turbine) and woodland (all patches are more than 500m from a turbine). Total species richness, abundance and diversity has varied from year to year as measured by direct numbers and by statistical analysis, but there has been a clear declining trend across all three indicators. The declining trend in these parameters observed in the grassland impact site has been mirrored in the grassland control site indicating that factors other BRWF are influencing local bird dynamics. Changes in species assemblage in the grassland impact site are also present in the grassland control site, again indicating that BRWF is not the driver of change.

The majority (89%) of the threatened species recorded at BRWF are woodland species and have been recorded at the woodland sites. Woodland species richness and abundance has been more stable than grassland. This is unlikely to be related to the BRWF but does demonstrate that the wind farm is not affecting woodland patches locally.

Approximately 560 Anabat survey nights have been undertaken at BRWF with 8721 calls positively attributed to focus species. Anabat results show strong seasonality and activity appears to be increasing over time however, these results are more likely to be related to environmental conditions such as rainfall rather than operation of BRWF. This has not been analysed statistically. Nonetheless, results indicate that BRWF is not having a negative impact on microbat activity including that of threatened species.

Incidental observations have focussed on raptors and waterbirds at local wetlands. Raptor observations have been stable throughout the monitoring period and there is no evidence that BRWF is having an effect on the local raptor population, even for Nankeen Kestrel which is one of the most frequently found carcasses. Likewise, waterbird observations vary from year to year along with annual rainfall and waterbird carcasses have not been found at BRWF. Therefore it is highly unlikely that BRWF is having any impact upon local waterbird populations or their ability to move in response to rainfall changes.

Thus, overall all data collected over the past eight to nine years strongly suggests that BRWF is not having an impact upon local bird and bat populations. On this basis, we propose to scale back the monitoring program.

# Appendix A Raw bird survey results by year

| Common name | Species name | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Australasian Grebe** | *Tachybaptus novaehollandiae* | 2 | 16 | | | | | 2 | 41 | 14 |
| **Australasian Pipit** | *Anthus novaeseelandiae* | 32 | 12 | 6 | 11 | 8 | 6 | 6 | 3 | 4 |
| **Australasian Shoveler** | *Anas rhynchotis* | 13 | 12 | 5 | | | | 7 | 14 | 6 |
| **Australasian Swamphen** | *Porphyrio melanotus* | | | 3 | | | | | 5 | |
| **Australian Darter** | *Anhinga novaehollandiae* | | | | 1 | | | | | |
| **Australian Hobby** | *Falco longipennis* | | 1 | 3 | 2 | 2 | | 2 | 3 | 1 |
| **Australian Magpie** | *Cracticus tibicen* | 150 | 102 | 90 | 93 | 88 | 81 | 74 | 69 | 29 |
| **Australian Owlet-nightjar** | *Aegotheles cristatus* | 2 | | | | | | | 1 | |
| **Australian Raven** | *Corvus coronoides* | 68 | 24 | 48 | 50 | 40 | 32 | 13 | 5 | |
| **Australian Reed Warbler** | *Acrocephalus australis* | 2 | 1 | | 1 | | 1 | 1 | | |
| **Australian Shelduck** | *Tadorna tadornoides* | 1 | 2 | 2 | 1 | | 6 | 8 | 9 | 1 |
| **Australian Spotted Crake** | *Porzana fluminea* | | | 1 | | | | | | 1 |
| **Australian Wood Duck** | *Chenonetta jubata* | 20 | 7 | 7 | 1 | 1 | 2 | 12 | 10 | 7 |
| **Banded Lapwing** | *Vanellus tricolor* | | 1 | 4 | 1 | | 1 | | | |
| **Black Swan** | *Cygnus atratus* | 8 | 12 | 6 | | | 1 | 9 | 37 | 14 |
| **Black-faced Cuckoo-shrike** | *Coracina novaehollandiae* | 1 | 7 | 1 | 2 | 1 | 1 | 3 | 2 | |
| **Black-fronted Dotterel** | *Elseyornis melanops* | | | | | | | 1 | | |
| **Black-shouldered Kite** | *Elanus axillaris* | | 2 | | | | | 2 | 10 | 1 |
| **Black-winged Stilt** | *Himantopus himantopus* | 4 | 1 | | | | | 7 | | |
| **Brown Falcon** | *Falco berigora* | 6 | 4 | 3 | 5 | 3 | 2 | 4 | 2 | 3 |
| **Brown Goshawk** | *Accipiter fasciatus* | 1 | | | | | | | 2 | |
| **Brown Quail** | *Coturnix ypsilophora* | | 1 | | | | | | | |
| **Brown Songlark** | *Cincloramphus cruralis* | 2 | | 1 | | | | | | |
| **Brown Thornbill** | *Acanthiza pusilla* | 5 | 10 | 10 | 9 | 7 | 5 | 2 | 4 | |
| **Brown Treecreeper** | *Climacteris picumnus* | 1 | 1 | | | 1 | | | 1 | 1 |
| **Brown-headed Honeyeater** | *Melithreptus brevirostris* | 2 | 7 | 5 | 5 | 6 | 1 | 3 | 4 | 2 |
| **Brush Bronzewing** | *Phaps elegans* | | | | | | | | 1 | |

| Common name | Species name | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Brush Cuckoo** | *Cacomantis variolosus* | 3 | | 1 | | | 1 | | 1 | |
| **Buff-rumped Thornbill** | *Acanthiza reguloides* | 6 | 4 | 3 | 6 | 1 | 1 | 2 | 4 | |
| **Chestnut Teal** | *Anas castanea* | | 3 | 5 | | | | 2 | 1 | |
| **Collared Sparrowhawk** | *Accipiter cirrocephalus* | | 1 | 1 | | | | | | |
| **Common Blackbird** | *Turdus merula* | | | | 2 | | | | | |
| **Common Bronzewing** | *Phaps chalcoptera* | | | | | 2 | 2 | 1 | | |
| **Common Starling** | *Sturnus vulgaris* | 90 | 53 | 47 | 46 | 48 | 43 | 36 | 27 | 10 |
| **Crescent Honeyeater** | *Phylidonyris pyrrhopterus* | 1 | | | | | | | | |
| **Crested Pigeon** | *Ocyphaps lophotes* | 1 | 3 | 3 | 2 | 1 | 1 | | | |
| **Crimson Rosella** | *Platycercus elegans* | 46 | 33 | 26 | 39 | 20 | 15 | 23 | 13 | 11 |
| **Diamond Firetail** | *Stagonopleura guttata* | | 2 | 1 | 3 | 1 | 1 | | 2 | |
| **Dusky Woodswallow** | *Artamus cyanopterus* | 2 | 4 | 2 | 4 | 2 | 2 | 2 | 2 | |
| **Eastern Rosella** | *Platycercus eximius* | 12 | 4 | | | 3 | | 1 | | |
| **Eastern Spinebill** | *Acanthorhynchus tenuirostris* | 8 | 1 | 2 | 1 | 1 | | 5 | 1 | |
| **Eastern Yellow Robin** | *Eopsaltria australis* | 3 | 3 | 1 | 2 | 2 | | 1 | | |
| **Eurasian Coot** | *Fulica atra* | 2 | 1 | 1 | 1 | | 2 | 2 | 39 | 15 |
| **Eurasian Skylark** | *Alauda arvensis* | 338 | 325 | 263 | 234 | 218 | 147 | 183 | 218 | 66 |
| **European Goldfinch** | *Carduelis carduelis* | 29 | 17 | 23 | 8 | 9 | 6 | 2 | 4 | 1 |
| **Fairy Martin** | *Petrochelidon ariel* | | 1 | 1 | | | | | | |
| **Fan-tailed Cuckoo** | *Cacomantis flabelliformis* | 7 | 3 | 2 | | 2 | 3 | 3 | 3 | |
| **Flame Robin** | *Petroica phoenicea* | 7 | 8 | 2 | 2 | 3 | | | | |
| **Freckled Duck** | *Stictonetta naevosa* | | 1 | | | | | | | |
| **Fuscous Honeyeater** | *Lichenostomus fuscus* | | | | | 1 | | 1 | 1 | 1 |
| **Galah** | *Eolophus roseicapilla* | 65 | 29 | 35 | 20 | 22 | 40 | 13 | 23 | 5 |
| **Gang-gang Cockatoo** | *Callocephalon fimbriatum* | 6 | | | | | 1 | | 1 | |
| **Golden Whistler** | *Pachycephala pectoralis* | | | 1 | 1 | | | | 1 | |
| **Great Cormorant** | *Phalacrocorax carbo* | | | | | | | | | 1 |
| **Grey Butcherbird** | *Cracticus torquatus* | 7 | 11 | 5 | 5 | 3 | 5 | | | |
| **Grey Currawong** | *Strepera versicolor* | 7 | 5 | 5 | 5 | 6 | 4 | 3 | 1 | 2 |
| **Grey Fantail** | *Rhipidura albiscapa* | 19 | 16 | 9 | 5 | 5 | 7 | 4 | 7 | 3 |

| Common name | Species name | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Grey Shrike-thrush** | *Colluricincla harmonica* | 22 | 16 | 19 | 14 | 15 | 19 | 11 | 15 | 5 |
| **Grey Teal** | *Anas gracilis* | 19 | 18 | 9 | | | 1 | 19 | 42 | 13 |
| **Hardhead** | *Aythya australis* | 4 | | | | | | | 7 | 4 |
| **Hoary-headed Grebe** | *Poliocephalus poliocephalus* | 11 | 13 | 1 | | | | 1 | 32 | 6 |
| **Hooded Robin** | *Melanodryas cucullata* | 2 | | | | 1 | | 2 | 1 | |
| **Horsfields Bronze-cuckoo** | *Chrysococcyx basalis* | 3 | | 2 | 4 | | | | | |
| **House Sparrow** | *Passer domesticus* | | | | 1 | 2 | | 1 | 1 | 1 |
| **Intermediate Egret** | *Ardea intermedia* | | | 1 | | | | | | |
| **Jacky Winter** | *Microeca fascinans* | | | | 1 | 1 | | | | |
| **King Parrot** | *Alisterus scapularis* | 1 | | | | | | | 1 | |
| **Laughing Kookaburra** | *Dacelo novaeguineae* | 26 | 21 | 11 | 14 | 1 | 4 | 5 | 4 | 3 |
| **Leaden Flycatcher** | *Myiagra rubecula* | | 1 | 4 | | | | | 1 | |
| **Little Eagle** | *Hieraaetus morphnoides* | | 1 | | | | | | | |
| **Little Pied Cormorant** | *Microcarbo melanoleucos* | | | | | | | | 1 | 3 |
| **Little Raven** | *Corvus mellori* | 95 | 86 | 55 | 44 | 35 | 38 | 41 | 61 | 25 |
| **Magpie Lark** | *Grallina cyanoleuca* | 13 | 3 | 8 | 5 | 5 | 8 | 2 | | |
| **Magpie-Lark** | *Grallina cyanoleuca* | | | | | | | | 3 | 4 |
| **Masked Lapwing** | *Vanellus miles* | 5 | 24 | 15 | | | | 10 | 13 | 8 |
| **Nankeen Kestrel** | *Falco cenchroides* | 25 | 14 | 16 | 17 | 8 | 8 | 20 | 26 | 5 |
| **Noisy Miner** | *Manorina melanocephala* | 3 | | | 2 | | 2 | 2 | 1 | |
| **Olive-backed Oriole** | *Oriolus sagittatus* | | 1 | | 1 | | | | | |
| **Pacific Black Duck** | *Anas superciliosa* | 11 | 23 | 9 | 6 | 1 | 2 | 9 | 62 | 21 |
| **Pallid Cuckoo** | *Cacomantis pallidus* | 4 | 2 | 3 | 3 | 3 | 1 | 3 | 1 | |
| **Peregrine Falcon** | *Falco peregrinus* | 4 | 2 | | 2 | | | | | |
| **Pied Currawong** | *Strepera graculina* | 38 | 15 | 21 | 15 | 7 | 8 | 14 | 12 | 5 |
| **Pink-eared Duck** | *Malacorhynchus membranaceus* | 2 | | | | | | 4 | 1 | |
| **Purple Swamp Hen** | *Porphyrio porphyrio* | | | | | | | | 3 | 3 |
| **Raven sp.** | *Corvus sp.* | 6 | 1 | | 1 | | 3 | | | |
| **Red Wattlebird** | *Anthochaera carunculata* | 49 | 38 | 25 | 27 | 29 | 22 | 31 | 25 | 19 |
| **Red-browed Finch** | *Neochmia temporalis* | | 1 | | | 1 | | | 1 | |

| Common name | Species name | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Red-kneed Dotterel** | *Erythrogonys cinctus* | | | 1 | | | | | | |
| **Red-rumped Parrot** | *Psephotus haematonotus* | 1 | | 3 | 1 | 2 | 3 | 1 | 2 | |
| **Restless Flycatcher** | *Myiagra inquieta* | 3 | | 3 | 1 | 1 | | | | 1 |
| **Rufous Fantail** | *Rhipidura rufifrons* | | | | 1 | | | | | |
| **Rufous Songlark** | *Megalurus mathewsi* | 3 | | | | | | | | |
| **Rufous Whistler** | *Pachycephala rufiventris* | 24 | 18 | 8 | 3 | 6 | 6 | 5 | 6 | |
| **Sacred Kingfisher** | *Todiramphus sanctus* | 3 | 1 | 2 | 3 | 1 | | | 1 | |
| **Scarlet Robin** | *Petroica boodang* | 17 | 19 | 16 | 12 | 5 | 8 | 4 | 7 | 3 |
| **Shining Bronze-cuckoo** | *Chrysococcyx lucidus* | 3 | 5 | 1 | | 1 | | | 1 | |
| **Silvereye** | *Zosterops lateralis* | 10 | 8 | 1 | 6 | 4 | 2 | 1 | 2 | 1 |
| **Singing Bushlark** | *Mirafra cantillans* | 3 | | | | | | | | |
| **Southern Whiteface** | *Aphelocephala leucopsis* | 1 | | | | 1 | 1 | | 1 | |
| **Speckled Warbler** | *Chthonicola sagittata* | | 4 | 3 | 1 | 2 | 1 | 1 | 2 | |
| **Spotted Harrier** | *Circus assimilis* | 2 | | | 3 | | | | | |
| **Spotted Pardalote** | *Pardalotus punctatus* | 9 | 17 | 13 | 11 | 4 | 6 | 8 | 5 | |
| **Spotted Quail-thrush** | *Cinclosoma punctatum* | | 2 | 1 | | | 3 | 1 | | |
| **Straw-necked Ibis** | *Threskiornis spinicollis* | | 2 | 5 | | | | | | |
| **Striated Pardalote** | *Pardalotus striatus* | 50 | 65 | 35 | 36 | 36 | 29 | 34 | 27 | 9 |
| **Striated Thornbill** | *Acanthiza lineata* | 1 | 6 | 6 | 4 | 5 | 5 | 1 | 2 | |
| **Stubble Quail** | *Coturnix pectoralis* | 13 | 6 | 4 | 2 | 4 | 6 | 9 | 25 | 6 |
| **Sulphur Crested Cockatoo** | *Cacatua galerita* | | | | | | | | 5 | |
| **Sulphur-crested Cockatoo** | *Cacatua galerita* | 112 | 52 | 50 | 41 | 22 | 28 | 16 | 17 | 8 |
| **Superb Fairywren** | *Malurus cyaneus* | 26 | 15 | 10 | 6 | 4 | 4 | 2 | 5 | |
| **Superb Lyrebird** | *Menura novae-hollandiae* | 2 | | 3 | | 1 | 1 | | 2 | |
| **Swamp Harrier** | *Circus approximans* | 1 | | | | | | | 1 | |
| **Tree Martin** | *Petrochelidon nigricans* | 9 | 2 | 2 | | | 1 | | | |
| **Unidentified ducks** | *Anas spp.* | | 6 | 3 | | | | | | |
| **Unidentified Waterfowl** | *Unidentified waterfowl* | 3 | 2 | 1 | | | | | 2 | |
| **Varied Sittella** | *Daphoenositta chrysoptera* | | 4 | 2 | | | | | | |
| **Variegated Fairy-wren** | *Malurus lamberti* | 1 | | | | | | | | |
| **Wedge-tailed Eagle** | *Aquila audax* | 18 | 13 | 15 | 20 | 11 | 13 | 9 | 17 | 3 |

| Common name | Species name | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Weebill** | *Smicrornis brevirostris* | | | 1 | | | | | 1 | |
| **Welcome Swallow** | *Hirundo neoxena* | 11 | 6 | 3 | | 3 | 1 | 3 | 4 | 1 |
| **Whiskered Tern** | *Chlidonias hybrida* | 3 | | | | | | | | |
| **White-bellied Sea Eagle** | *Haliaeetus leucogaster* | 2 | | | | | | | | |
| **White-browed Scrubwren** | *Sericornis frontalis* | 3 | 2 | 1 | 1 | | 2 | 2 | 1 | |
| **White-browed Treecreeper** | *Climacteris affinis* | | | | | | | | 2 | |
| **White-eared Honeyeater** | *Lichenostomus leucotis* | 46 | 38 | 35 | 34 | 24 | 24 | 25 | 35 | 11 |
| **White-faced Heron** | *Egretta novaehollandiae* | 8 | 21 | 13 | 1 | | 1 | 2 | 19 | 13 |
| **White-naped Honeyeater** | *Melithreptus lunatus* | 6 | 1 | 4 | 3 | 4 | 3 | 2 | 4 | 1 |
| **White-necked Heron** | *Ardea pacifica* | 4 | | 2 | | | | | | |
| **White-plumed Honeyeater** | *Lichenostomus penicillatus* | 2 | | | | | | | | |
| **White-throated Honeyeater** | *Melithreptus albogularis* | | 1 | | | | | | | |
| **White-throated Needletail** | *Hirundapus caudacutus* | | 1 | | | | | | | |
| **White-throated Treecreeper** | *Cormobates leucophaea* | 59 | 49 | 36 | 30 | 27 | 16 | 18 | 21 | 10 |
| **White-winged Chough** | *Corcorax melanorhamphos* | | | | | | 1 | 1 | | |
| **White-winged Triller** | *Lalage tricolor* | 1 | | | | | | | | |
| **Willie Wagtail** | *Rhipidura leucophrys* | 19 | 8 | 9 | 6 | 11 | 7 | 2 | 6 | 1 |
| **Yellow-faced Honeyeater** | *Lichenostomus chrysops* | 55 | 44 | 23 | 28 | 21 | 23 | 18 | 39 | 14 |
| **Yellow-rumped Thornbill** | *Acanthiza chrysorrhoa* | 4 | 4 | 3 | 2 | 3 | 1 | 1 | 3 | |
| **Yellow-tailed Black Cockatoo** | *Calyptorhynchus funereus* | | | | 1 | | 5 | | | |
| **Yellow-tufted Honeyeater** | *Lichenostomus melanops* | | | | | | | | 2 | |

# Appendix B BUS statistical report 2022

The BUS statistical report by Symbolix follows overleaf.

# Boco Rock Wind Farm Bird Utilisation Survey - Year Eight Analysis

Prepared for NGH Environmental, 27 July 2023, Ver. 0.9 - For Review

This memo summarises our recent analysis of bird utilisation (point count) data collected at Boco Rock Wind Farm.

The aim of this analysis is to provide an overview of species and site characteristics. By comparing data collected through the eight years of operation, we aim to identify any changes in species presence or abundance that may be attributable to the presence of wind farm infrastructure. By using data from on-site as well as nearby reference sites, we are better able to understand if any patterns found are due to Boco Rock operations (as opposed to background changes in the area).

Data was collected by NGH Environmental[1], and cleaned and analysed by Symbolix.

## Survey summary

The data consists of bird "point counts". Surveys were conducted at specific locations for a set period of time. During this time, all birds and bird movements were noted.

The design was a stratified random point survey, where the stratifications are based on the relevant habitats on the farm. Data was collected in three distinct areas/habitat types (see map in Figure 1):

1. Grassland/Pasture: Defined as pasture within 500 metres of a turbine.
2. Control/Reference: There is a potential to place a wind turbine in the vicinity, but no wind turbines within 500 m. These sites are chosen to be similar habitat to the grassland sites, but with no turbines nearby.
3. Woodland: These sites are located in woodland area in the region. Note that there is no turbine infrastructure nearby; however, they are not considered controls. Instead this area was included because of regulator concerns that woodland species would be affected by the nearby wind facility.

[1] 230046 Observation data 2022 update.xlsx, 230046 Survey Data 2022 update .xlsx, 21-039_NGHBOCO_BirdUtilisationData_2021.xlsx

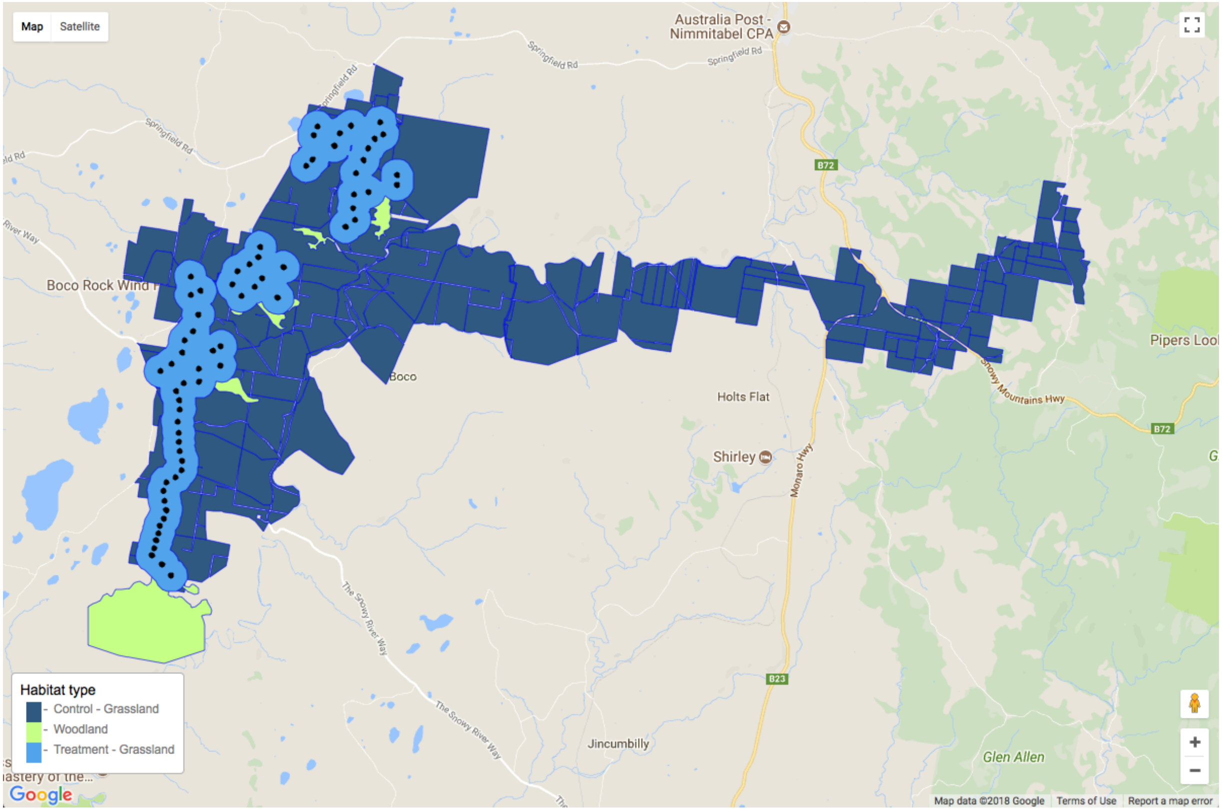


**Figure 1: Location of the three habitat types and survey points. The dots represent the turbine locations.**

The survey effort (number of site surveys) per month is summarised in Table 1.

**Table 1: Number of distinct locations surveyed each month. Note C, G, W corresponds to Control, Grassland, and Woodland respectively.**

| Year | Mon | C | G | W | Total | Year | Mon | C | G | W | Total | Year | Mon | C | G | W | Total | Year | Mon | C | G | W | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2015 | Jan | 3 | 3 | 4 | 10 | 2017 | Jan | 4 | 3 | 3 | 10 | 2019 | Jan | 3 | 3 | 4 | 10 | 2021 | Jan | 2 | 4 | 3 | 9 |
| 2015 | Feb | 3 | 4 | 3 | 10 | 2017 | Feb | 3 | 4 | 3 | 10 | 2019 | Feb | 3 | 4 | 3 | 10 | 2021 | Feb | 2 | 2 | 3 | 7 |
| 2015 | Mar | 4 | 3 | 3 | 10 | 2017 | Mar | 3 | 3 | 4 | 10 | 2019 | Mar | 4 | 3 | 3 | 10 | 2021 | Mar | 4 | 3 | 3 | 10 |
| 2015 | Apr | 3 | 4 | 3 | 10 | 2017 | Apr | 4 | 3 | 3 | 10 | 2019 | Apr | 4 | 3 | 3 | 10 | 2021 | Apr | 4 | 1 | 3 | 8 |
| 2015 | May | 3 | 3 | 4 | 10 | 2017 | May | 4 | 3 | 3 | 10 | 2019 | May | 3 | 4 | 3 | 10 | 2021 | May | 3 | 4 | 3 | 10 |
| 2015 | Jun | 3 | 5 | 2 | 10 | 2017 | Jun | 3 | 4 | 3 | 10 | 2019 | Jun | 3 | 3 | 4 | 10 | 2021 | Jun | 3 | 2 | 3 | 8 |
| 2015 | Jul | 3 | 5 | 2 | 10 | 2017 | Jul | 3 | 3 | 4 | 10 | 2019 | Jul | 4 | 3 | 3 | 10 | 2021 | Jul | 3 | 3 | 3 | 9 |
| 2015 | Aug | 3 | 4 | 3 | 10 | 2017 | Aug | 3 | 4 | 3 | 10 | 2019 | Aug | 3 | 4 | 3 | 10 | 2021 | Aug | 4 | 3 | 3 | 10 |
| 2015 | Sep | 3 | 5 | 2 | 10 | 2017 | Sep | 2 | 3 | 4 | 9 | 2019 | Sep | 3 | 3 | 4 | 10 | 2021 | Sep | 3 | 3 | 4 | 10 |
| 2015 | Oct | 3 | 4 | 3 | 10 | 2017 | Oct | 3 | 4 | 3 | 10 | 2019 | Oct | 4 | 3 | 3 | 10 | 2021 | Oct | 3 | 4 | 3 | 10 |
| 2015 | Nov | 3 | 4 | 3 | 10 | 2017 | Nov | 3 | 3 | 4 | 10 | 2019 | Nov | 3 | 4 | 2 | 9 | 2021 | Nov | 1 | 3 | 3 | 7 |
| 2015 | Dec | 3 | 4 | 3 | 10 | 2017 | Dec | 5 | 3 | 2 | 10 | 2019 | Dec | 4 | 4 | 2 | 10 | 2021 | Dec | 4 | 0 | 0 | 4 |
| 2016 | Jan | 4 | 3 | 3 | 10 | 2018 | Jan | 3 | 4 | 3 | 10 | 2020 | Jan | 4 | 3 | 3 | 10 | 2022 | Jan | 4 | 3 | 3 | 10 |
| 2016 | Feb | 3 | 4 | 3 | 10 | 2018 | Feb | 3 | 4 | 3 | 10 | 2020 | Feb | 4 | 3 | 3 | 10 | 2022 | Feb | 4 | 3 | 3 | 10 |
| 2016 | Mar | 3 | 4 | 3 | 10 | 2018 | Mar | 3 | 3 | 4 | 10 | 2020 | Mar | 3 | 3 | 4 | 10 | 2022 | Mar | 3 | 4 | 3 | 10 |
| 2016 | Apr | 3 | 4 | 3 | 10 | 2018 | Apr | 4 | 3 | 3 | 10 | 2020 | Apr | 3 | 4 | 3 | 10 | 2022 | Apr | 3 | 1 | 3 | 7 |
| 2016 | May | 4 | 6 | 0 | 10 | 2018 | May | 4 | 3 | 3 | 10 | 2020 | May | 3 | 4 | 3 | 10 | 2022 | May | 3 | 4 | 3 | 10 |
| 2016 | Jun | 3 | 2 | 3 | 8 | 2018 | Jun | 3 | 3 | 4 | 10 | 2020 | Jun | 3 | 3 | 4 | 10 | 2022 | Jun | 3 | 3 | 3 | 9 |
| 2016 | Jul | 3 | 5 | 2 | 10 | 2018 | Jul | 4 | 3 | 3 | 10 | 2020 | Jul | 4 | 3 | 0 | 7 | 2022 | Jul | 3 | 4 | 4 | 11 |
| 2016 | Aug | 3 | 3 | 4 | 10 | 2018 | Aug | 4 | 3 | 3 | 10 | 2020 | Aug | 3 | 3 | 4 | 10 | 2022 | Aug | 3 | 4 | 3 | 10 |
| 2016 | Sep | 3 | 3 | 4 | 10 | 2018 | Sep | 3 | 4 | 3 | 10 | 2020 | Sep | 3 | 4 | 3 | 10 | 2022 | Sep | 3 | 3 | 4 | 10 |
| 2016 | Oct | 3 | 0 | 7 | 10 | 2018 | Oct | 3 | 3 | 4 | 10 | 2020 | Oct | 4 | 3 | 3 | 10 | 2022 | Oct | 4 | 4 | 2 | 10 |
| 2016 | Nov | 6 | 0 | 4 | 10 | 2018 | Nov | 4 | 3 | 3 | 10 | 2020 | Nov | 4 | 3 | 3 | 10 | 2022 | Nov | 5 | 5 | 0 | 10 |
| 2016 | Dec | 4 | 3 | 3 | 10 | 2018 | Dec | 5 | 3 | 2 | 10 | 2020 | Dec | 3 | 3 | 4 | 10 | 2022 | Dec | 3 | 3 | 4 | 10 |

# Methodology

Our objective was to provide information to assess the potential for indirect impacts to regional bird populations from the wind facility operations. This could manifest as changes in behaviour or avoidance of habitat over time.

The longitudinal, reference-treatment structure of the survey addresses this objective, by providing us the opportunity to test for changes in the on-site data that are not present in the reference data. To allow us to generate quantitative information, we considered a range of metrics and analysis approaches, rather than relying on a small number of statistical tests.

Mainly, we use graphical and descriptive approaches that focus on patterns in species mix. We use multivariate methods as well as single (univariate) metrics (species abundance, species richness and Shannon diversity) to provide the best chance of detecting important changes. However, we also use formal statistical tests (using linear models) to investigate changes in species richness and diversity over time.

## Box plots

Box plots provide a graphical representation of the distribution of survey values for each time of year and habitat type. Half of the values are contained within the "box", with the whiskers (and dots) showing the spread of the other half. The line through the box shows the median.

## Species mix plots

Each survey point and site has a unique species mix that changes over time. We used this fact to describe differences between survey points over different sites and times. The difference in species mix between two points (or different seasons etc.), is expressed as a "similarity distance" - specifically the Bray-Curtis similarity (Bray and Curtis 1957). The distance is a statistical measure that accounts for the difference in species between surveys (i.e. two surveys with exactly the same species would have zero "distance" between them). This presence / absence measure gives weighting to rare / hard to observe species, and ensures results are not skewed towards trends in very common species.

We calculate the similarity distance between each survey pair and plot this as an ordination chart. The closer two surveys are to each other in an ordination plot, the more similar the species mix is between them.

By tracking changes in this similarity distance over time, we can get an indicator of changes between surveys, seasons and sites, and between turbine and reference points (Clarke 1993).

Differences in landscape or habitat would manifest by making subsequent observations at the same point "closer" than observations at other points or other sites. A change in species mix due to wind farm infrastructure could present as a change in the distance between impact and reference sites (this might be quite sudden or a gradual trend).

Note that it is the relative distance between points that is important, not the absolute distance between them. That is, points that are closer within a plot are more alike than those that are far apart, but we cannot compare distances between two species mix (or “ordination”) plots.

# Results

## Species abundance

The following charts are a simple overview of each species seen, and its relative abundance. This includes data across all observation points and across all time periods. Note that Figure 2 and Figure 3 show the total counts across all surveys. Take care when comparing total numbers, as the number of surveys differed between habitats.

In 2015, *Alauda arvensis* (Eurasian Skylark) was the most common species for visual and auditory counts at the control locations, and in the top two at the on-site grassland locations (Figure 2, 3). Generally the common species were shared by the on-site and reference grassland sites, e.g. *Cacatua galerita* (Sulphur-crested Cockatoo) and *Sturnus vulgaris* (Common Starling). The species profile at the woodlands sites was (understandably) somewhat different, with *C. galerita* being dominant in the visual counts, and *Cormobates leucophaea* (White-throated Treecreeper) being dominant in the auditory counts.

In 2016, *A. arvensis* was in the top two most common species for visual and auditory counts, at both the control and grassland locations. *S. vulgaris* was the most common species for visual counts at control and grassland sites. In control and grassland, there were fewer *C. galerita* visual counts compared with 2015. For visual counts, levels of *Corvus mellori* (Little Raven) remained fairly constant from 2015 to 2016. For auditory counts, levels of *Cracticus tibicen* (Australian Magpie) remained fairly constant from 2015 to 2016.

In 2017, *A. arvensis* and *S. vulgaris* were still among the most common species seen at control and grassland sites, although lower numbers overall were seen compared to previous years. *C. mellori* was observed visually in high levels again at these locations, similar to previous years. There were some high counts of *Hirundo neoxena* (Welcome Swallow) and *Chenonetta jubata* (Australian Wood Duck). Auditory observations were very similar to 2016's auditory observations, over all site types.

In 2018, *A. arvensis* and *S. vulgaris* were still among the most common species seen, with many *C. mellori* also observed at the Control sites. There were more *L. chrysops* seen in the Grassland site compared to previous years. Auditory counts in 2018 remained similar to previous years.

In 2019, *A. arvensis* and *S. vulgaris* were among the most common species seen at control and grassland sites, as in previous years. *C. mellori* also had high visual counts at the control sites. Visual counts of *A. arvensis* and *C. mellori* were lower at control sites in 2019 than in the previous year, although *A. arvensis* auditory counts increased slightly.

In 2020, *S. vulgaris*, *C. mellori*, and *A. arvensis* were among the most common species seen in both Control and Grassland sites. *C. galerita* and *E. roseicapilla* were seen more in 2020 Grassland, compared with 2019. Regarding auditory counts, *A. arvensis* and *C. tibicen* were the most commonly heard in Control and Grassland, similar to last year.

In 2021, *S. vulgaris*, and *A. arvensis* were the two of the more common species in Control and

Grassland, with a high count of *C. jubata* also being seen in Control areas. *A. arvensis* was the most commonly heard species in both Control and Grassland, with *C. tibicen* also recording moderate auditory counts.

In 2022, *A. arvensis* and *C. mellori* were the most common species seen in the control and Grassland sites. *A. arvensis* was the most commonly heard species in both Control and Grassland, with *C. tibicen* also recording moderate auditory counts.

In the Woodland location, very few *C. galerita* were visually observed in 2016 compared to 2015. Visual counts of *Lichenostomus chrysops* (Yellow-faced Honeyeater) also decreased from 2015 to 2016. *Pardalotus striatus* (Striated Pardalote) auditory counts increased from 2015 to 2016. In 2017, the number of *S. vulgaris* visual counts decreased compared to 2016, and the number of visual counts of *C. galerita* and *Eolophus roselcapilla* (Galah) increased compared to 2016. 2018 Woodland visual and auditory counts remained quite similar to previous years, although there were a few more *P. elegans* observed in 2018 than 2017. Visual counts for *L. chrysops* and *S. vulgaris* were lower in 2019 in 2018. Auditory counts in 2019 remained similar to previous years. In 2020, the most commonly seen species were *S. vulgaris* and *E. roseicapilla*, while *C. tibicen* was the most commonly heard species. In 2021, the most common visually observed species were *S. vulgaris* and *P. elegans*, while the auditory observed species were *P. striatus*, *C. tibicen*, and *Anthochaera carunculata* (Red Wattlebird), In 2022, the most common visually observed species was *A. arvensis*, while the most common auditory observed species was *N. leucotis* (White-eared Honeyeater).


**Figure 2: Total visual counts by species for each habitat type. Only the top 10% of species are shown (for legibility).**

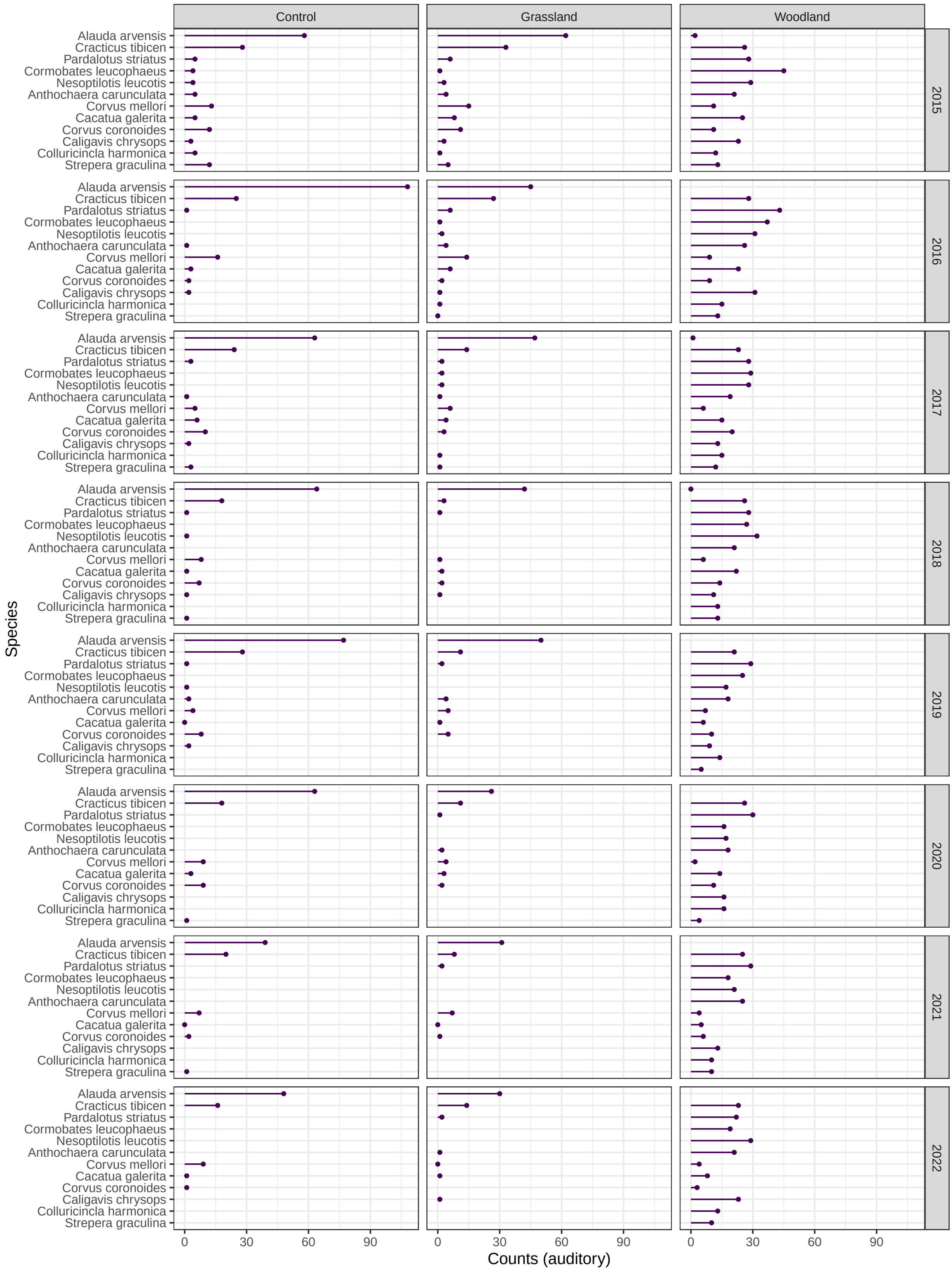


**Figure 3: Total auditory counts by species for each habitat type. Only the top 10% of species are shown (for legibility).**

## Reference-treatment comparisons

Figures 4 and 5 compare the species richness between habitat types throughout the year. These plots have the second and third quarters of the years to examine if there are any gross seasonal patterns; there don't appear to be any obvious patterns.

The overall richness of the woodland sites (Figure 5) is higher than both the grassland and control sites (Figure 4). The woodland richness has remained fairly constant over the last five years, accounting for seasonal variation. There does appear to be a slight decreasing trend over the course of the eight years. In particular, in the first three years, the richness looks to be decreasing, and it has remained at a stable lower level since then.

The richness in the control and grassland sites remains fairly stable since three years into the survey, although there is a hint of a decrease.

We also analysed the Shannon diversity (Shannon and Weaver (1949), Hill (1973)) per survey (Figure 6) and log visual count (Figure 7) metrics. The Shannon diversity plot showed similar patterns to the richness plot - seasonality variation in the woodland, fairly stable grassland sites (potentially a slight decreasing trend followed by a levelling off), and at the control sites, an apparent decrease followed by a levelling off in 2017 / 2018.

It is difficult to comment on the boxplot of any particular quarter, since there is so much variation.

The log visual count plot showed some seasonality, which didn't naturally follow a quarterly pattern. Control sites had higher log counts than other sites in earlier years on average, and there appeared to be a decreasing trend which stabilised in 2017 and 2018. However, it's harder to elucidate trends from count charts, as the variance is a lot greater. Certainly, the levels appear to be stable since 2016.

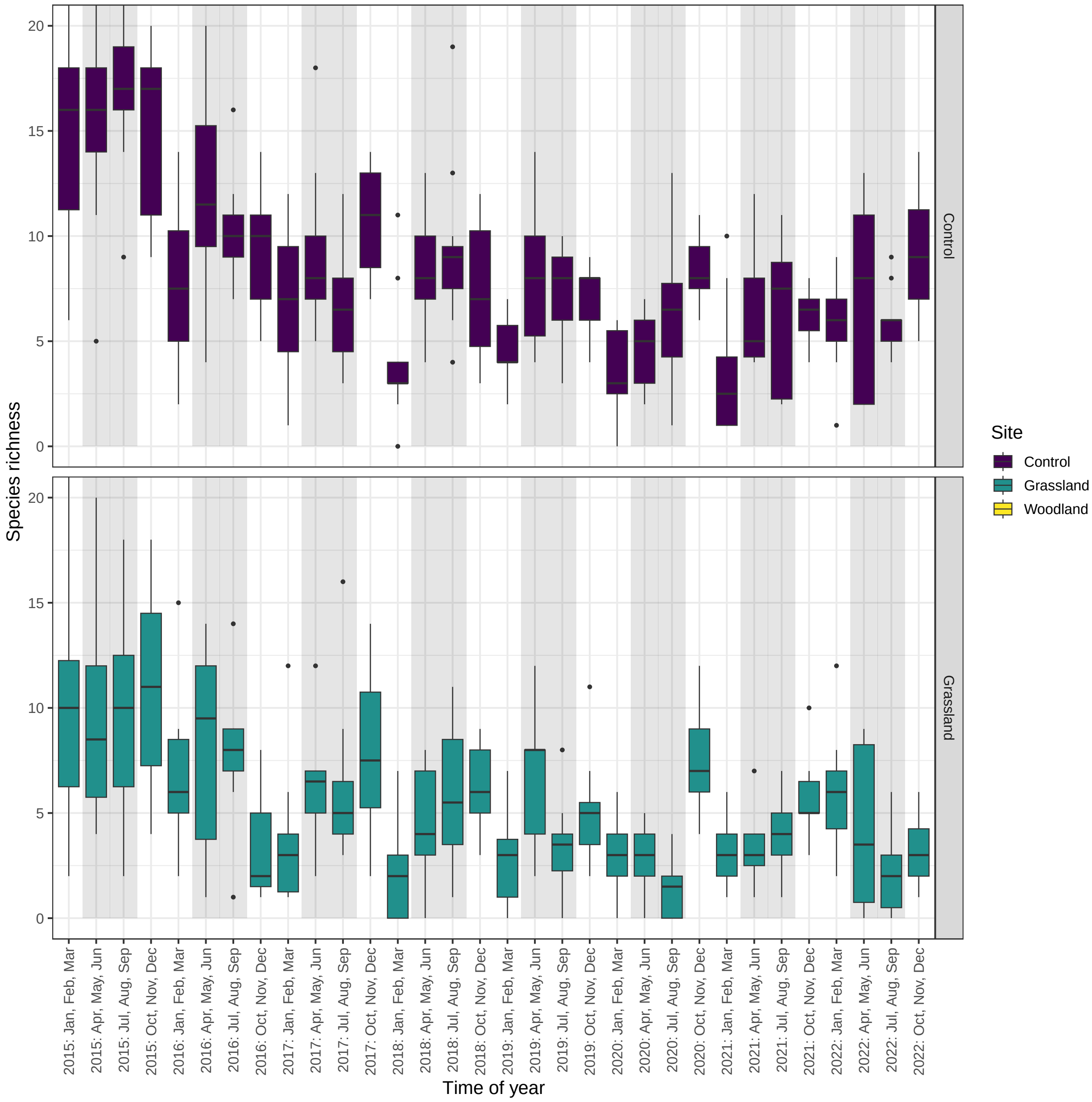


**Figure 4: Distribution of species richness per survey, by site and time of year. Winter months highlighted. Control and Grassland sites only.**

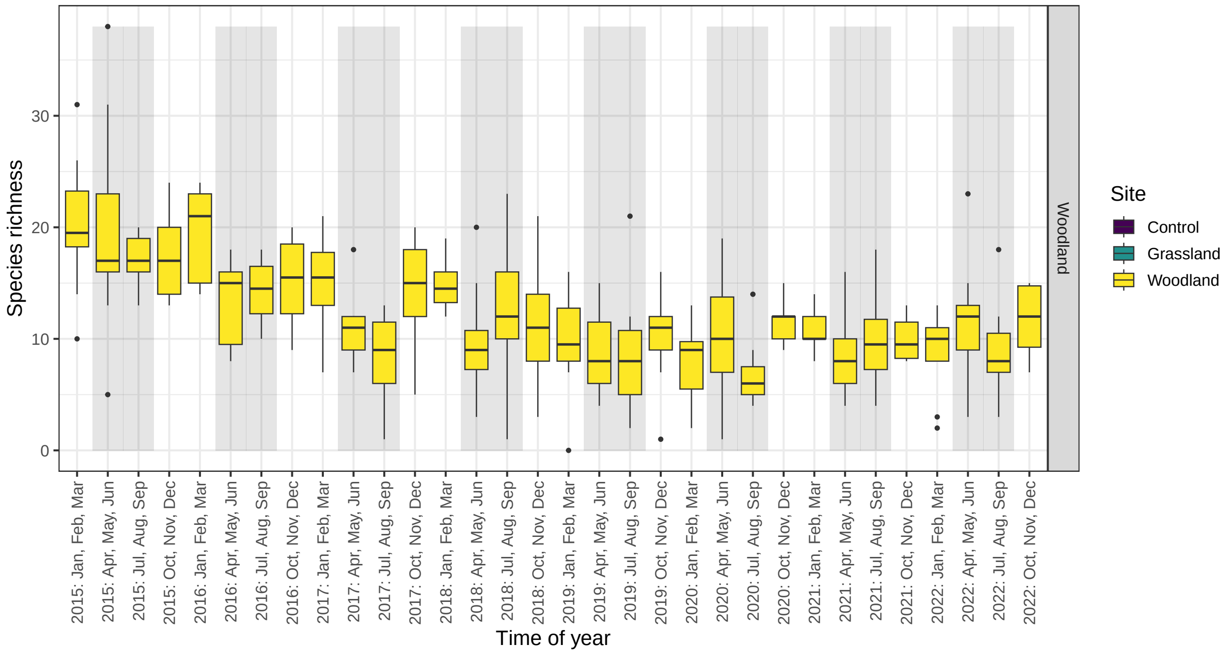


**Figure 5: Distribution of species richness per survey, by site and time of year. Winter months highlighted. Woodland sites only.**

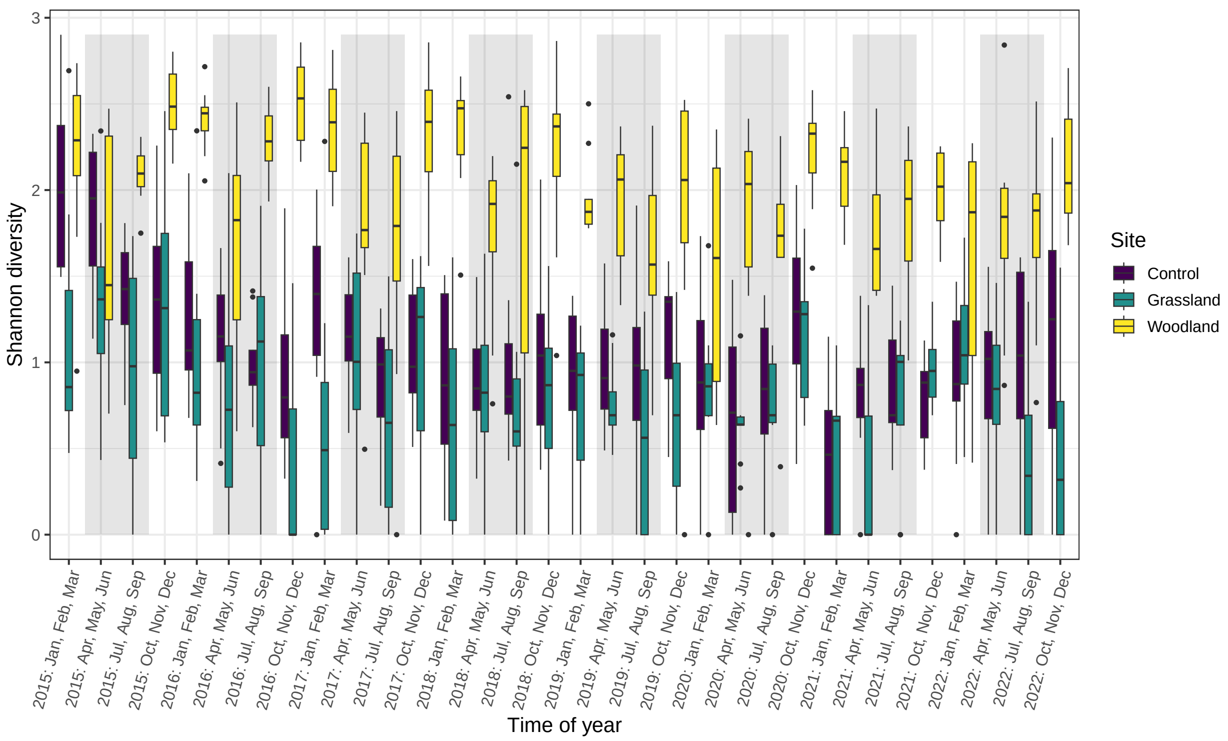


**Figure 6: Distribution of Shannon diversity per survey, by site and time of year.**

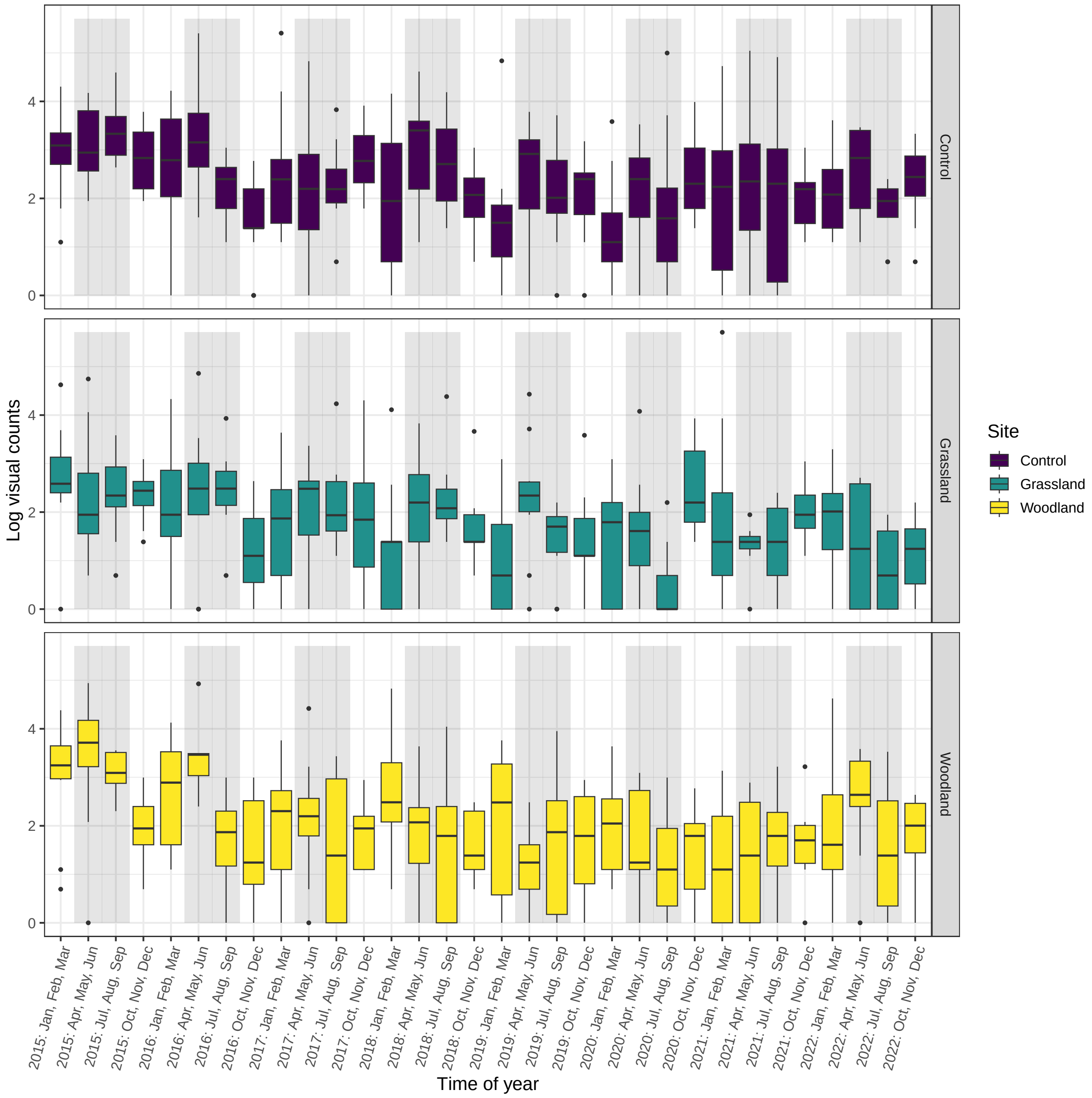


**Figure 7: Distribution of total log (visual) counts, by site and time of year**

## Species mix

In addition to the overall comparisons above we can directly contrast the species mix between surveys, sites and time periods. We do this by using an ordination method, which provides a graphical representation of the similarity of different surveys (Figure 8).

In this plot the closer two survey points are, the more similar the species mix (presence / absence of species). Figure 8 shows an overall comparison of the three habitats. As with the richness charts above (Figures 4 and 5) we see that the species mix at the woodland sites (bottom panel on Figure 8) is distinct from the grassland sites. We can see there is a movement in the species mix over time. Earlier surveys are roughly clustered around the origin point, but there's a trend towards the right as time goes on.

We note that although there are three plots show in the figure, they all originate from the same ordination run - the three plots are only to provide clarity, and it is valid in this case to compare between plots.

At control and grassland sites, there does appear to be a shift in species mix over time, as we can see that the earlier (2015) surveys are clustered around the origin, but then later surveys (2017 and after) have a shift toward the right-hand side of the plot. There is no evidence from this plot of a turbine-related effect, as the shift is the same in both sites.

We also explored the species mix under two other conditions - using a log transform (which accounts for abundance as well), and also a Wisconsin double standardisation (which standardises by both species and site). Generally, the patterns were the same as the richness-only mix, and so we haven't presented those figures. Woodland was still distinct, and grassland / control had a lot of overlap in mix. The shift in mix over time was evident in both these plots.

We can see from the ordination plots that there are general changes in mix over time, in all strata. There is no evidence of of changes in the grassland stratum that aren't mirrored by changes in the control stratum.

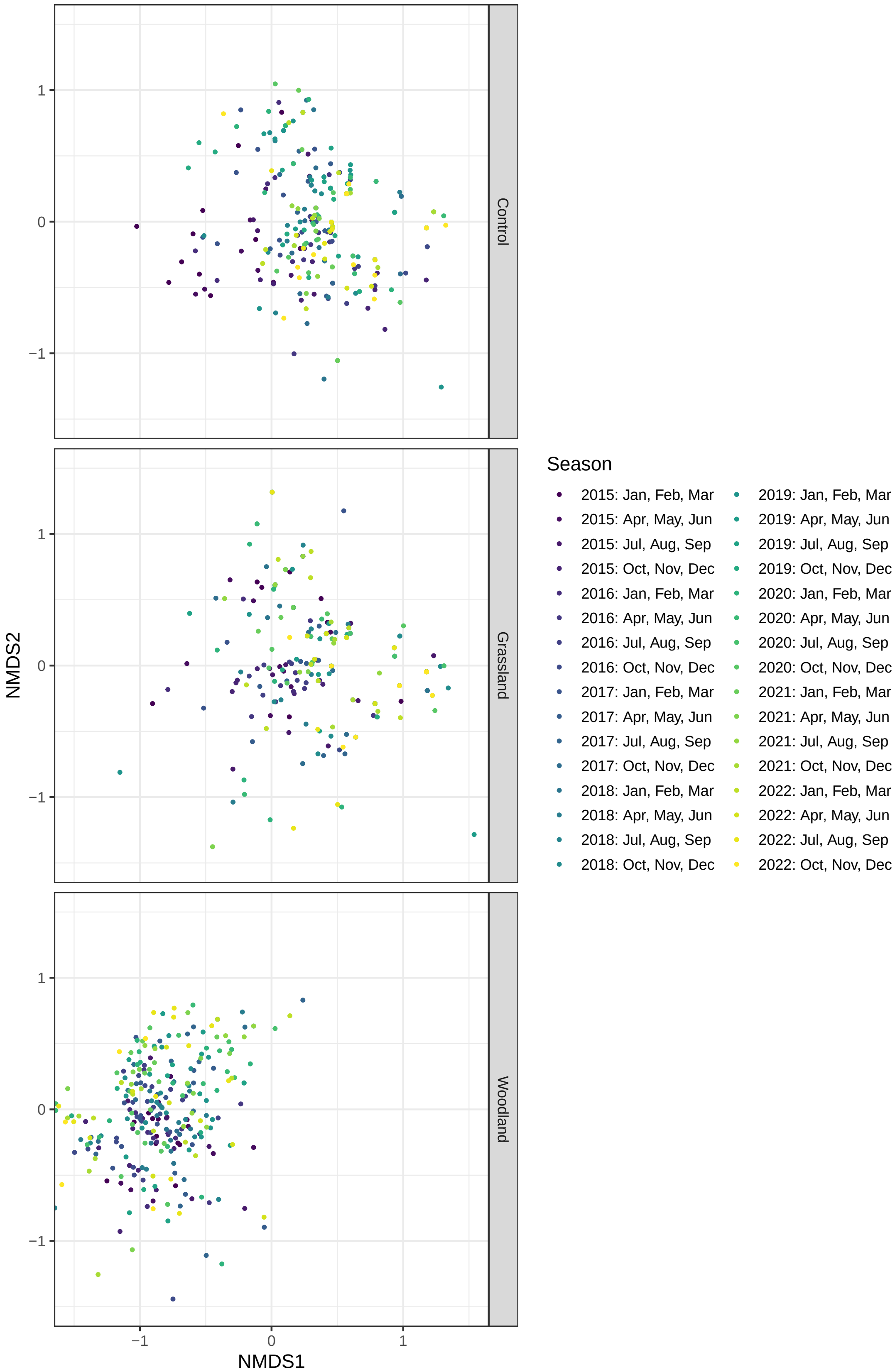


**Figure 8: 2D MDS grouped by season and site, with distance based upon presence / absence.**

# Trend modelling

## Shannon diversity

For the Shannon diversity model, we used a gamma generalised linear model with zero-inflation[2]. We modelled diversity against:

- time (months from the start of the survey period),
- monthly rainfall[3] (at the nearby Nimmitabel Wastewater Treatment Facility),
- log-distance (km) from the closest turbine, and
- and a zero-inflation factor (to account for the Shannon diversity equalling zero, if zero or one species are observed in a survey).

The model showed that increased rainfall is associated ($p < 0.001$) with increased Shannon diversity (on average, the diversity metric increases by a factor of 1.0014 per mm of rainfall). The ratio (in diversity) between the month with minimum rainfall (Jul 2018; 4.4 mm) and the month with maximum rainfall (Jan 2022; 187.2 mm), keeping all other things constant, is a factor of 1.3.

Shannon diversity also appears to be decreasing over time ($p < 0.001$). Each month, on average the Shannon diversity decreases by a factor of 0.996. For reference, the average Shannon diversity at the beginning of the surveys was 2.48 at control sites and 2.01 at grassland sites.

Interestingly, we found a positive association between (log) distance from turbine and Shannon diversity ($p = 0.056$). For example, keeping other variables fixed, a site at double the distance to a turbine is expected to have 1.03 times the diversity, and a site at ten times the distance is expected to have 1.11 times the diversity. However, we do not have enough information to assess whether this is due to turbine activity, or other factors such as choice of turbine location, and turbine support infrastructure (e.g. birdlife avoiding the hardstand and road).

The zero-inflation factor accounted for the fact that the Shannon diversity had a value of zero, more than would be expected from a general gamma distribution (approximately 14% of the time, diversity equalled zero).

The interaction between site type and time (and indeed, the site type itself) was not significant ($p = 0.79$). While the baseline diversity is lower in the grassland area, its changes are reflected in the control area. Therefore, we do not have evidence of any changes in diversity due to wind farm activity.

[2] Implemented in R using the `glmmTMB` package (Brooks et al. 2017).

[3] http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=139&p_display_type=dataFile&p_startYear=&p_c=&p_stn_num=070067

### Richness

For species richness, we used a negative binomial generalised linear model, which properly handles the integer nature of the data. The richness model gave similar results to the Shannon diversity model.

## Concluding remarks

We also find that grassland sites have consistently lower diversity and counts compared to control sites. Results from some metrics, such as the richness and diversity, reflect the some variation in bird abundance, particularly evident in the woodland region. When we consider all the univariate and multivariate visualisations, and the modelling, as combined evidence of the state of the species mix near the wind farm, we conclude that there has been a decrease in diversity and abundance in both the control and the grassland (impact) sites.

However, evidence does not point to the wind farm being the cause. There is a positive correlation between monthly rainfall and diversity/richness, and a positive correlation between distance from turbine and diversity/richness.

This data does indicate that the woodland species are somewhat different (in richness and relative abundance) from the grassland sites, but this is not unexpected. There is no evidence of an impact on woodland sites by the wind farm.

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## C.4 BRWF Results November 2023 – April 2024

Prepared for Squadron Energy

# Bird and Bat Adaptive Management Plan – Results November 2023 to April 2024

## Boco Rock Wind Farm

Southern Tablelands, NSW

August 2024

Project Number: 230699

nghconsulting.com.au

# Document verification

| | |
|---|---|
| Project Title: | Boco Rock Wind Farm |
| Project Number: | 230699 |
| Project File Name: | 230699 BRWF Results Nov 2023-April 2024 Final V1 |

| Revision | Date | Prepared by | Approved by |
|---|---|---|---|
| Final V1.0 | 12/08/2024 | Stella O'Dwyer | Bianca Heinze |
| Draft V1.0 | 6/08/2024 | Stella O'Dwyer | Bianca Heinze |
| | [Enter a date] | [Click to enter name] | [Click to enter name] |
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# Table of Contents

## Figures



## Table

# Acronyms and Abbreviations

| | |
|---|---|
| AWS | Automatic weather station |
| BBAMP | Bird and Bat Adaptive Management Plan |
| BC Act | *Biodiversity Conservation Act 2016* (NSW) |
| BCS | *Biodiversity, Conservation and Science Group (BCS) of the NSW Department of Climate Change, Energy, the Environment and Water* |
| BOM | Australian Bureau of Meteorology |
| BRWF | Boco Rock Wind Farm |
| CE | Critically endangered |
| Cth | Commonwealth |
| E | Endangered |
| EEC | Endangered ecological community – as defined under relevant law applying to the proposal |
| EPBC Act | *Environment Protection and Biodiversity Conservation Act 1999* (Cwth) |
| GIS | Geographic information system |
| ha | hectares |
| km | kilometres |
| LGA | Local government area |
| m | metres |
| TEC | Threatened ecological community |
| V | Vulnerable |

# 1. Introduction

## 1.1. Objectives of the interim monitoring results report

This *Monitoring Results November 2023 - April 2024* report fulfills reporting requirements under BBAMP V2.0 (NGH 2023), section 8.1 for the interim period November 2023 to April 2024 to:

- Summarise the monitoring outcomes, including a list of any threatened species finds with BCS notification dates.
- Provides statistical analysis of mortality data including calculating mortality estimates.
- Analyses of any anomalies in monitoring outcomes, data collection or statistical analysis.
- Discusses triggers, applications of decision-making frameworks, progress and efficacies of any mitigation measures enacted and 'lessons learned' (adaptive management).
- Provides qualitative analysis of whether thresholds have been achieved for reducing carcass search effort.

# 2. Carcass searches

## 2.1. Survey method & effort

Carcass searches during November 2023 – April 2024 were conducted in accordance with the BBAMP V2.0. The monitoring plan at BRWF involves monthly non-pulsed searches of 18 out of 67 turbines from October[1] to April, representing 27% of the wind farm, as negotiated with BCS. The timing is to capture periods of highest seasonal risk to species of concern at BRWF (particularly migratory birds and bats). Refer to Section 5.2 of the BBAMP V2.0 for in-depth carcass search methodologies.

Carcass searches were undertaken monthly from November 2023 to April 2024 inclusive, for a total of six survey events for this reporting period. A total of 96 searches were conducted. Mortality searches were undertaken out to 120m$^2$ radius at each turbine, with a total search area of 1,920m$^2$ per survey event.

### 2.1.1. Limitations

Turbines are categorised into high risk and low risk stratum at the behest of BCS. To prevent selection bias, nine turbines from each stratum were randomly selected using QGIS's 'random selection tool' with a total sample of 18 turbines. Proportional bias resulting from uneven risk distribution between strata was addressed during statistical analysis to ensure balanced representation from both risk categories.

Rough ground and uneven vegetation distribution within the 120m radius search area makes for difficult search conditions. The majority (but not all) of the searched area is in a low detectability zone. BBAMP v1.3 accounted for this with 'high detectability' (hardstand and track) and 'extended'

[1] This first BBAMP v2 season began in November once the plan was approved; subsequent monitoring will commence October each year.

(other) zones. While statistical analysis indirectly takes into account the proportion of the searched area in each detectability zone, overall detectability is low (refer to Appendix C).

Seasonal variability is also accounted for in detectability co-efficients. However, vegetation density within each searched area also varies, including in the previously defined as 'extended zones' (see Figure 2-1 and Figure 2-2). During the course of the November 2023 – April 2024 reporting period it was found that detectability co-efficients likely did not sufficiently capture the variety of detectability across the 120m radius searched area. To overcome this, it is proposed to undertake new detectability trials at the start of the next season (October 2024).


Figure 2-1 Typical long-grassed area, with lower detectability

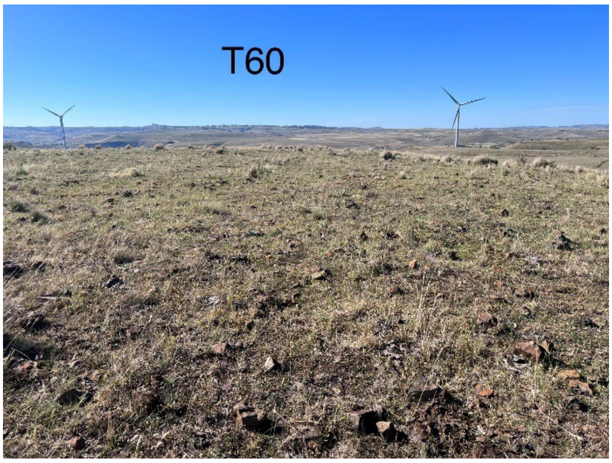



Figure 2-2  Typical open areas with high detectability

The first mortality surveys under BBAMP v2.0 (with increased search radius) in November were undertaken over four very long days exceeding 12 hours. The field staff identified that fatigue was affecting focus for carcass searches. Surveys were extended to five days to reduce daily fatigue, and this was reported as effective in increasing concentration by field staff.

Carcass finds (refer section below) were low in number, even considering the reduced survey period. It is not yet clear whether this reflects detectability (e.g. ground conditions discussed above), surveyor fatigue (also discussed) or a genuine reduction in carcass occurrence. Continued surveys will assist in determining cause.

## 2.2. Survey results

Mortality surveys during November 2023 – April 2024 resulted in four carcass/feather scatter finds. The monthly distribution of carcass finds is shown in below (see

Table 2-1). The highest number of carcasses was found in January 2024 (first quarter). No carcasses were found in three out of the six months from November 2023 till April 2024. Locations of carcass finds are shown in Appendix D. No waterbirds or threatened species were found during mortality surveys November 2023 – April 2024.

Table 2-1 Monthly distribution of carcasses/feather scatters found at BRWF (November 2023 – April 2024).

| Survey period | Number of carcasses found |
|---|---|
| November 2023 | 0 |
| December 2023 | 1 |
| January 2024 | 2 |
| February 2024 | 0 |
| March 2024 | 1 |
| April 2024 | 0 |

Table 2-2 below shows the species identified from carcasses/feather scatters along with the number. Of the four species identified from mortality searches during November 2023 – April 2024, one was listed in the BBAMP (V2.0) as high risk species: White-striped Freetail Bat – this species has higher risk of collision with operating turbines.

Table 2-2 Summary of mortality survey results by date from BRWF (November 2023 – April 2024)

| Tubine ID | Date | Survey Quarter | Common name | Species name | No. carcasses found | At risk species? | Found during monthly surveys? |
|---|---|---|---|---|---|---|---|
| **Birds** | | | | | | | |
| 39 | 12/20/2023 | 4th | Australian Magpie | *Cracticus tibicen* | 1 | No | Yes |
| 28 | 1/4/2024 | 1st | Common Starling | *Sturnus vulgaris* | 1 | No | Yes |
| 1 | 1/5/2024 | 1st | Eurasian Skylark | *Alauda arvensis* | 1 | No | Yes |
| | | | | ***Total birds*** | **3** | | |
| **Bats** | | | | | | | |
| 64 | 25/3/2024 | 1st | White-striped Freetail Bat | *Austronomus australis* | 1 | Yes | No |
| | | | | ***Total bats*** | **1** | | |

The full mortality survey results for November 2023 to April 2024 are given in Appendix A. The location of each carcass found is shown in the map in Appendix D1.2. Table 2-2 summarises the carcass search results.

### 2.2.1. Birds

Across all years of monitoring (2015-April 2024), the top three bird species found in mortality surveys are:

1. Eurasian Skylark (16 or 22% of the total bird finds)
2. Australian Magpie (11 or 15% total bird finds)
3. Nankeen Kestrel (8 or 11% total bird finds)

All three are common, secure species. The findings for November 2023 – April 2024 are broadly consistent with past results. Six raptor species have been found since 2015 with Nankeen Kestrel most numerous. Again, results from November 2023 – April 2024 are consistent with past results.

In summary the data from November 2023 – April 2024 does not present any surprising or unexpected results from the bird mortality carcasses found; the data is in keeping with results of previous years.

### 2.2.2. Bats

During November 2023 to April 2024, one bat carcass was found from a singular species: White-striped Freetail Bat. The White-striped Freetail Bat was found at turbine 64 in March (autumn) (see Table 2-2). Even taking into consideration the reduced survey period (6 months compared to 12), this is a low result. The range is zero (2020) to 24 (2015) with an average of 9 and a median of 8 bat carcasses per year.

Across all years of monitoring (2015-April 2024), most carcasses found have been from two bat species:

1. White-striped Freetail Bat (61 or 73% of the total bat finds)
2. Gould’s Wattled Bat (15 or 18% total bat finds)

Both are common, secure species. However, the greatest percentage of finds is attributed only to a single species, the White-striped Freetail Bat (73%). The mortality rate for this species is discussed further in Section 2.2.5. The results from November 2023 to April 2024 are in keeping with previous years in terms of species type and proportion found during carcass searches.

### 2.2.3. Comparison with previous years

shows the number of carcasses found for each year of survey between November and April, to allow comparison with the current reporting period. The range of bird carcasses found during November to April mortality surveys is one to six. Finds during the current reporting period are in the middle of the range (three). The number of bat carcasses found in the same time period ranges from zero to 13. Finds during the current reporting period are at the lower end of the range (one).

Table 2-3 Results of mortality surveys between November and April for 2016-2024 (2015 results cannot be included as do not match month range)

| Type | Nov 2016-Apr 2017 | Nov 2017-Apr 2018 | Nov 2018-Apr 2019 | Nov 2019-Apr 2020 | Nov 2020-Apr 2021 | Nov 2021-Apr 2022 | Nov 2022-Apr 2023 | Nov 2023-Apr 2024 |
|---|---|---|---|---|---|---|---|---|
| Birds | 5 | 6 | 5 | 3 | 6 | 1 | 2 | 3 |
| Bats | 13 | 5 | 7 | 0 | 8 | 2 | 2 | 1 |

### 2.2.4. Threatened species

No threatened species were detected during the carcass searches conducted from November 2023 to April 2024.

### 2.2.5. Mortality estimates

Mortality estimates were derived for November 2023 – April 2024. Cumulative estimates have not been undertaken with the new data due to the step change in survey design. As for previous years, mortality estimates were derived by the Monte-Carlo simulation model (Hull and Muir 2010 in Symbolix 2024).

The median mortality estimate for bats is 32 individuals lost over 6 months, with a range of two to 137. The median mortality estimate for birds is 73 individuals over 6 months, with a range of four to 205. Annual mortality estimates were not calculated due to limitations, discussed below. There are therefore limitations to comparison of 2023-2024 mortality estimates with previous years as a simple doubling of the 6-month figure is inaccurate.

However, for the purpose of context, previous annual median mortality estimates have been in the range of eight to 160 bats per annum and 40 to 131 birds (Table 2-4). The 6-month mortality estimate for the 2023-2024 BBAMP v2 reporting period appears to be roughly within or close to this range using a crude doubling calculation (i.e. 73 birds x 2 = 146). Although this seems to be an increase compared to recent years, the rate is not unreasonably high given the context of previous years' results (e.g. sudden spike in bird median estimated annual mortality in 2020).

Table 2-4 Annual medium mortality estimates for previous years at BRWF

| Carcass type | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|
| Bat | 160 | 138 | 129 | 63 | 27 | 8 | 55 | 27 |
| Bird | 115 | 88 | 131 | 118 | 76 | 151 | 40 | 40 |

### 2.2.6. Limitations to statistical analysis

Year to year variation and differences in mortality results are expected (as demonstrated by past results). The apparent rise in mortality estimates for birds and bats for November 2023 to April 2024 compared to recent years may be due to an increase in bird and bat mortality at BRWF. It is however, certainly influenced by a reduction in estimate certainty caused by changed survey methods. Note that carcasses were not detected at a greater frequency during the survey season despite an increased search radius.

The chance that the survey method detects a carcass can be *approximated* as (proportion of turbines searched) x (coverage factor) x (detection probability). In this case, the latter two terms interact with each other via a weighted averaged, because the chance of finding something in the vegetated zone is much smaller than that in the hardstand.

Under BBAMP V1.3, the *relative* chance of finding a bat, accounting for the survey design, searcher efficiency, and coverage, but ignoring scavenger[2] is approximately (1) * (.84*.45 + .21*.55) = 0.5. For birds, it is slightly higher: (1) * (.92*.26 + .48*.62) = 0.54.

Under BBAMP V2.0, the *relative* chance of finding a bat, accounting for the same factors, is approximately (16/67) * (.84*.45 + .21*.55) = 0.1. For birds, again it is slightly higher: (16/67) * (.92*.26 + .48*.74) = 0.15.

The difference is primarily driven by the reduced sampling fraction. So, all other things remaining constant, we expect to find 4-5 times fewer carcasses per survey under BBAMP V2.0 compared to BBMP V1.3 (in a given time period). Whether or not this manifests, depends on that assumption of constancy. It should be noted that BBAMP V2.0 focuses on times of high site usage, so it may actually have a higher underlying mortality rate than at other times of the year[3].

In summary, survey methods under BBAMP V1.3 searched all available high detectability areas (i.e. 100% coverage of high detectability areas for all 67 turbines) compared to BBAMP V2.0 searches of 17 hardstands (25% coverage of high detectability areas), leading to lower probability of carcass detection. Although the search radius has increased for each turbine, and overall there is more area being searched across the wind farm, the effort has been displaced from high detectability to low detectability areas. So every carcass that is found must now represent a higher number of carcasses that might not have been found, leading to higher mortality estimates.

# 3. Bird surveys

## 3.1. Survey method & effort

Bird surveys under BBAMP v2.0 consist of targeted surveys for:

- White-throated Needletail
- Wedge-tailed Eagle
- Nankeen Kestrel

Refer to Section 5.3 of the BBAMP V2.0 for detailed methodologies.

### 3.1.1. White-throated Needletail

White-throated Needletail surveys were incorporated into BBAMP V2.0 following detection during mortality survey. The species was rarely recorded during nine years of bird utilisation surveys,

[2] (as we have assumed this to remain constant between design iterations)
[3] This is a limitation to simply doubling search results to estimate annual carcass finds.

most likely due to methodology being unsuitable for that species. Targeted White-throated Needletail surveys were undertaken between November 2023 and April 2024 and entail two methods. These include:

1. Evening roost survey – identify potential roosting habitat within BRWF and a one-kilometre buffer zone, and monthly evening point count surveys of birds coming into roost in habitat identified at BRWF.
2. Sky scanning – regular scanning for flocks of White-throated Needletail opportunistically throughout time on site.

Refer to Section 5.3.1 of the BBAMP V2.0 for additional survey methodology details. Potential roost habitat was identified by GIS using canopy and woody vegetation layers clipped to ridgelines. These patches were then ground-truthed and assessed for potential as White-throated Needletail roosts based on habitat description 'tall trees along ridge tops" (DoE, 2015). Survey effort is shown in Table 3-1 below.

Table 3-1 White-throated Needletail survey effort November 2023 to April 2024

| Date | Method | Effort |
|---|---|---|
| November 2023 | Watching potential roost location 60 mins before dusk and 30 minutes after | 2 surveyors x 1.5 hrs = 3 hrs |
| December 2023 | | 2 surveyors x 1.5 hrs = 3 hrs |
| January 2024 | | 2 surveyors x 1.5 hrs = 3 hrs |
| February 2024 | | 2 surveyors x 1.5 hrs = 3 hrs |
| March 2024 | | 2 surveyors x 1.5 hrs = 3 hrs |
| April 2024 | | 2 surveyors x 1.5 hrs = 3 hrs |
| **Total season effort** | | **18 hours** |

### 3.1.2. Wedge-tailed Eagle and Nankeen Kestrel

Since 2015, Wedge-tailed Eagle nests near turbines 58 and 65 have been surveyed in October to December (BBAMP V1.3 2017). The Wedge-tailed Eagle pair have successfully fledged one or two chicks each year in 2016, 2017, 2018, 2019, 2020 and again in 2021. The updated BBAMP proposes to continue Wedge-tailed Eagle monitoring at this site and to include the following (BBAMP V2.0 2023):

1. Nesting survey – During November 2023 to April 2024, patches of woodland and trees were inspected for signs of stick nests. Nests are mapped as either active or inactive at the time of survey. Active nests are checked for fledging from October to December

2. Site use – regular scanning for raptor species opportunistically throughout time on site at BRWF, including species, number and flight direction.

Refer to Section 5.3.2 of the BBAMP V2.0 (2023) for additional survey methodology details.

### 3.1.3. Limitations

Actual potential White-throated Needle-tail roost habitat is scant at BRWF, with most ridgelines bare of overstorey vegetation. Where upper slopes feature woodland edges or lines of trees, these were taken to constitute roost habitat at BRWF and were targeted for evening roost surveys. Windy weather during four roost surveys may have affected bird detectability, but this is considered unlikely to have influenced results.

One storm front passed during a survey event in the October 2023 – April 2024 period, providing the only genuine opportunity to scan for White-throated Needletails. Scans were still conducted regularly while on site at other times.

While raptors were regularly recorded during bird utilisation surveys under BBAMP V1.3, raptors were more frequently sighted opportunistically. Thus, focusing on opportunistic observation of raptors, without timed surveys, is not considered a limitation.

## 3.2. Survey results

### 3.2.1. White-throated Needletail

#### Roost habitat desktop analysis

To identify and delineate ridgelines within the landscape, a Topographic Position Index (TPI) analysis was carried out. The TPI is a robust method for spatially distinguishing topographic features such as hilltop, valley bottom, exposed ridge, flat plain and upper or lower slope. Our analysis was achieved using the Landform Classification tool within the Topography Toolbox for ArcGIS (Jenness 2006; Dilts 2015) run in ESRI ArcGIS Desktop 10.8.3 using a 2m DEM (GeoScience Australia 2024). As the method is scale-dependent, the model was run iteratively to test and select a range of parameter settings to attain the optimal settings for identifying the relevant topographic features within the vicinity of BRWF. The final output raster was smoothed and boundary-cleaned using ESRI Spatial Analyst before being converted to a vector polygon feature layer which delineated local topographic features, including ridgelines.

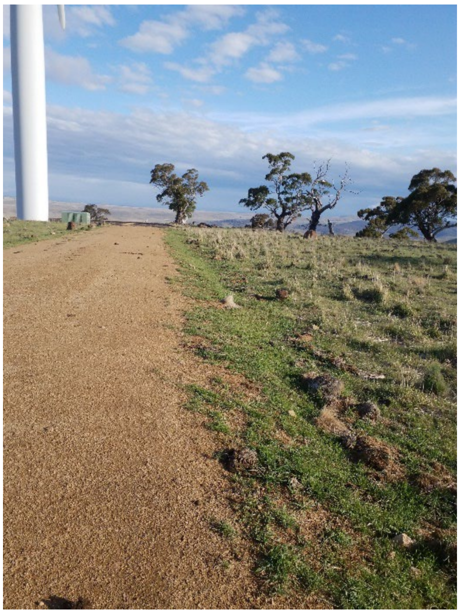
The mapped ridgeline areas were subsequently clipped to the NVR woody vegetation map attributes “Tree Cover” and “Tree Cover Matrix”, which identified areas with theoretically appropriate landscape position and vegetation. NGH ecologists then examined the output to verify woody habitat on ridgelines and upper slopes. The final dataset includes areas identified as potential roost habitat for the White-throated Needle-tail at BRWF.

#### Roost Habitat

The White-throated Needletail has been “found to roost in tree hollows in tall trees on ridge-tops” (DoE, 2015). Areas of potential roost habitat were field validated and/or checked on GIS. Results of habitat assessment (HA) at potential woodland roosting sites (as shown in figures in Appendix D) are given in Table 3-2. In summary, three sites were selected as potential White-throated Needletail roost locations and targeted for further survey near Turbines 42, 45 and 25.

Table 3-2 Habitat assessment of potential roost habitat for White-throated Needletail

| HA ID | Comments | Potential roost site? | Photo |
|---|---|---|---|
| 1 | Field: Scattered trees with very small patch woodland. Approximate tree height 10-12 m. Trees not tall, hollows potentially present, small patch, location not entirely ridge-top. Between turbine 35 and 37. | No |  |
| 2 | Field: Woodland habitat on upper slopes extending toward ridge and around turbine 42. Approximate tree height 12-15 m. Trees taller, hollows potentially present, small patch, trees close to ridge-top. | **Yes** |  |

| HA ID | Comments | Potential roost site? | Photo |
|---|---|---|---|
| 3 | Field: Woodland trees along slopes extending to edge of ridge, mainly mature trees with hollows present. Approximate tree height 10- 15 m. Turbine 45. | **Yes** |  |
| 4 | Field: Woodland on slope and in gully with finger of open woodland *Eucalyptus viminalis* extending along upper slope near ridge. Mature trees with small, medium and large hollows. Approximate tree height 10-15 m. Moderate potential as roost – very open. Turbine 25. | **Yes** |  |

| HA ID | Comments | Potential roost site? | Photo |
|---|---|---|---|
| 5 | Field: Scattered trees at easter ridge tip, separated from woodland described above by ~100m. Not suitable roost as due to canopy separation and distance from woodland. Approximate tree height 10- 15 m. Turbine 25. | No |  |
| 6 | Desktop: Scattered trees, not suitable roost. Near turbine 54. | No | Refer to maps in Appendix D |
| 7 | Desktop: Scattered trees, not suitable roost. | No | Refer to maps in Appendix D |
| 8 | Desktop: Scattered trees, not suitable roost. Near turbine 3. | No | Refer to maps in Appendix D |
| 9 | Desktop: Scattered trees, not suitable roost. Near turbine 1. | No | Refer to maps in Appendix D |

## Evening roost survey

Evening roost surveys were undertaken at two of the potential roost sites: HA 4 (near turbine 25) and HA 3 (near Turbine 45). There were no White-throated Needletail detected during the evening roost survey from November 2023 to April 2024. Below are the results for the White-throated Needletail roost surveys (Table 3-3).

Table 3-3 White-throated Needletail Evening Roost Survey Results

| Date | Turbine | HA ID | Habitat | Time | Observations | Weather |
|---|---|---|---|---|---|---|
| 22/11/23 | T25 | 4 | Grove of *E. viminalis* | 1830-2000 | No White-throated Needletails | Mild, partly cloudy, windy |
| 22/12/23 | T45 | 3 | Open woodland | 1830-2000 | No White-throated Needletails | Cool, overcast, light wind |
| 5/1/24 | T25 | 4 | Grove of *E. viminalis* | 1830-2000 | No White-throated Needletails | Mild, overcast, windy. |
| 15/2/24 | T45 | 3 | Open woodland | 1830-2000 | No White-throated Needletails | Mild, overcast, windy |
| 28/3/24 | T25 | 4 | Grove of *E. viminalis* | 1830-2000 | No White-throated Needletails | Warm, clear, windy |
| 27/4/24 | T45 | 3 | Open woodland | 1730-1900 | No White-throated Needletails | Cold, overcast, light wind |

### Sky scanning

More than twenty records of White-throated Needletails were seen opportunistically in January 2024, flying ahead of a weather event (refer to Table 3-4 below).

Table 3-4 Opportunistic White-throated Needletail records at BRWF (November 2023-April 2024)

| Date | Common Name | Count | Location | Easting | Northing | Notes |
|---|---|---|---|---|---|---|
| 3/1/2024 | White-throated Needletail | 20+ | Near T42 | 687904 | 5949250 | Flock of 20 + birds scattered over a large area and flying in an easterly direction |

## 3.2.2. Wedge-tailed Eagle and Nankeen Kestrel

### Nesting survey

A known Wedge-tailed Eagle nest is located between Turbines 58 and 65; this has not been active during the current reporting period. One additional raptor nest was found during surveys between November 2023 and April 2024; an old Nankeen Kestrel nest (inactive) (Table 3-5).

Table 3-5 Nesting surveys for Wedge-Tailed Eagle and Nankeen Kestrel at BRWF (November 2023-April 2024)

| Date | Location (nearest turbine) | Habitat | Time | Observations |
|---|---|---|---|---|
| 22/11/23 | 42,43,45 | Open woodland | 1200-1400 | Old Nankeen Kestrel nest |
| 23/12/23 | 35, 37 | Open woodland | 900-1100 | No raptor nests found |
| 23/12/23 | East of 61, 65, 66 | Isolated snow gums in grassland (including stags) | 1130-1400 | No raptor nests found |
| 23/12/23 | Between 58 and 65 | Woodland | 1400-1430 | Known Wedge-tailed Eagle nest inactive |
| 6/1/24 | Between 57 and 56 | Isolated snow gums in grassland (including stags) | 900-1000 | No raptor nests found |
| 6/1/24 | 25 | Grove of *E. viminalis* | 1030-1200 | No raptor nests found |
| 6/1/24 | 6, 5 | Isolated snow gums in grassland (including stags) | 1230-1400 | No raptor nests found |
| 16/2/24 | 4, 3, 2A | Isolated snow gums in grassland (including stags) | 900-1130 | No raptor nests found |
| 16/2/24 | 42,43,45 | Open woodland | 1200-1400 | No raptor nests found |
| 29/3/24 | East of 61, 65, 66 | Isolated snow gums in grassland (including stags) | 900-1130 | No raptor nests found |
| 29/3/24 | Between 57 and 56 | Isolated snow gums in grassland (including stags) | 1200-1300 | No raptor nests found |
| 30/4/24 | 6, 5, 4, 3, 2A | Isolated snow gums in grassland (including stags) | 900-1300 | No raptor nests found |

## Site use survey

During surveys undertaken from November 2023 to April 2024, the following species were observed opportunistically during site use surveys (refer to Table 3-6):

- Nankeen Kestrel (20)
- Wedge-tailed Eagle (6)

Table 3-6 Wedge-Tailed Eagle and Nankeen Kestrel records during site use survey (November 2023 – April 2024)

| Date | Common Name | Count | Location | Easting | Northing |
|---|---|---|---|---|---|
| 21/11/2023 | Wedge-tailed Eagle | 2 | East of T42 | 688264 | 5949085 |
| 21/11/2023 | Nankeen Kestrel | 1 | T42 | 687967 | 5949197 |
| 22/11/2023 | Nankeen Kestrel | 1 | Front gate | 686583 | 5949370 |
| 23/11/2023 | Nankeen Kestrel | 1 | Near T44 | 688546 | 5949500 |
| 23/11/2023 | Nankeen Kestrel | 1 | T01 | 685569 | 5940719 |
| 19/12/2023 | Nankeen Kestrel | 1 | Between T55 and T56 | 691384 | 5951373 |
| 21/12/2023 | Nankeen Kestrel | 1 | T16 | 686006 | 5944783 |
| 21/12/2023 | Wedge-tailed Eagle | 2 | T22 | 685863 | 5946516 |
| 21/12/2023 | Nankeen Kestrel | 1 | Gate to T25 | 687087 | 5947147 |
| 22/12/2023 | Nankeen Kestrel | 1 | T02 | 685089 | 5941353 |
| 3/1/2024 | Nankeen Kestrel | 1 | Near front gate | 686584 | 5949461 |
| 3/1/2024 | Wedge-tailed Eagle | 1 | Near T42 | 688178 | 5949189 |
| 4/1/2024 | Nankeen Kestrel | 1 | Between T30 and T26 | 686493 | 5947515 |
| 4/1/2024 | Nankeen Kestrel | 1 | Near T25 | 687281 | 5947062 |
| 5/1/2024 | Nankeen Kestrel | 1 | Near T04 | 685241 | 5941675 |
| 12/2/2024 | Nankeen Kestrel | 1 | Near T52 | 691084 | 5953939 |
| 13/2/2024 | Nankeen Kestrel | 1 | Near T2A | 685547 | 5940992 |
| 26/3/2024 | Wedge-tailed Eagle | 1 | Near T43 | 688549 | 5949093 |
| 26/3/2024 | Nankeen Kestrel | 1 | T45 | 689096 | 5948911 |

| Date | Common Name | Count | Location | Easting | Northing |
|---|---|---|---|---|---|
| 28/3/2024 | Nankeen Kestrel | 1 | Gate to T5 | 685308 | 5941995 |
| 27/4/2024 | Nankeen Kestrel | 1 | T52 | 691024 | 5953852 |
| 27/4/2024 | Nankeen Kestrel | 1 | T42 | 687933 | 5949168 |
| 28/4/2024 | Nankeen Kestrel | 1 | T32 | 686414 | 5948056 |
| 28/4/2024 | Nankeen Kestrel | 1 | T16 | 685977 | 5944702 |

# 4. Incidental observations

One threatened species was observed opportunistically during the November 2023 to April 2024 surveys:

- Flame Robin *Petroica phoenicea* – Vulnerable BC Act

Flame Robins were last recorded at BRWF in May 2019 (one individual). Historically (January 2015 - October 2023), 11 sightings have been recorded at BRWF. The majority of records occurred during the 2016 bird utilisation surveys (eight sightings).

# 5. Impact triggers and response management

## 5.1. Impact triggers

As detailed in Section 6 of the BBAMP V2.0 (2023),

CoA 3.3 c) requires a:

> *'decision making framework that sets out specific actions and when they may be required to be implemented to reduce any impacts on bird and bat populations that have been identified as a result of the monitoring.'*

Section 6 of the BBAMP sets out mortality events that would require Agency notification and/or consultation along with impact triggers and response management. Section 6.1 impact triggers relate to mortality surveys with findings of threatened species generally, and Large Bent-wing Bat, Grey-headed Flying-fox and White-throated Needletail specifically. Section 6.2 impact triggers relate to non-threatened species. From these sections, three initial trigger types are shown in Table 5-1 along with their activation status during the November 2023 to April 2024 reporting period.

No impact triggers were activated.

Table 5-1 Status of impact triggers during November 2023 to April 2024 season

| Impact trigger title | Description and location in BBAMP | Status |
|---|---|---|
| A carcass of a threatened species | One or more carcasses.<br>S6.1.1 – Table 6.1 | Not activated |
| A carcass of a non-threatened raptor | Three or more of the same species in three consecutive months<br>S6.2.1 – Table 6.4 | Not activated |
| Other non-threatened species | 10 or more carcasses in two consecutive months at the same turbine<br>S6.2.1 – Table 6.4 | Not activated |

## 5.2. Mitigation and adaptive management

Mitigation measures are to be implemented in response to triggers to reduce impacts on bird and microbats. No impact triggers were activated in the reporting period and no mitigation measures were required.

### 5.2.1. Reducing carcass search effort

BBAMP V2.0, commencing in November 2023, aims to reduce survey effort while maintaining effective monitoring of bird and bat mortality. Despite the intention to decrease effort, the total search area increased from 63.9 ha under BBAMP V1.3 to 81 ha under BBAMP V2.0, which was expected to result in higher carcass finds (and therefore mortality estimates). As discussed, *fewer* carcass finds have led to higher mortality estimates.

Under BBAMP V2.0 if, after the first year of monitoring, results indicate a low risk to local avifauna (as outlined in the *Summary Report*), the survey effort will be reviewed and potentially reduced. Clear conclusions cannot be drawn by comparison of mortality estimates for the November 2023 – April 2024 reporting period with previous years. Further survey is required to determine whether the new monitoring methods (notably the increased search radius) provide a substantially different view regarding the risk posed to local avifauna compared to results of 2015-2023. The next biennial report (reporting November 2024 – April 2026) will review the survey effort.

# 6. Conclusion

This *Monitoring Results November 2023 - April 2024* report fulfills reporting requirements under BBAMP V2.0 (NGH 2023) for the interim period November 2023 to April 2024. Monthly mortality surveys were undertaken at 18 of 67 turbines out to 120m$^2$ radius from the turbine, with a total of

96 searches over six months. Four carcasses of common species were found comprising three birds and one bat. No waterbirds, raptors or threatened species were found during mortality surveys. Search results are consistent with previous years.

The median mortality estimates are 32 bats and 73 birds lost over the 6 month period. This is likely to be within the higher end of the range annual mortality estimates derived in previous years. There are several limitation to comparing mortality estimates for previous years with the November 2023 – April 2024 estimates. Firstly, the time period for the estimation is different (six months for the current period compared to 12). Secondly, the survey season for this estimate is intentionally biased toward the periods of higher site activity and mortality, whereas the annual estimates are for the whole year. Thirdly, and most substantially, the relative chance of finding a bird or bat carcass is lower under the BBAMP v2.0 methods. This leads to higher uncertainty and therefore a higher mortality estimate per carcass found.

Targeted bird surveys were undertaken for White-throated Needletail, Wedge-tailed Eagle and Nankeen Kestrel in the form of habitat surveys and opportunistic sky scanning. Three areas with potential White-throated Needletail roost habitat were identified and two were surveyed monthly between November 2023 and April 2024. Eleven raptor stick nest surveys were undertaken to map nests across BRWF; no active nests were found.

Sky scanning identified one flock of around 20 White-throated Needletail in January 2024 associated with a frontal system. Raptors were recorded every month of survey for a total of 20 Nankeen Kestrel observations and six Wedge-tailed Eagles. Flame Robin, a NSW vulnerable species, was observed opportunistically, having not been recorded at BRWF since 2019.

Impact triggers, which pertain to mortality survey results, were not activated during the reporting period therefore mitigation measures and adaptive management was not required. Further survey is required to determine whether the new monitoring methods provide substantially different results regarding the risk posed to local avifauna compared to results of 2015-2023.

# 7. References

DoE. (2015). *Referral guideline for 14 birds listed as migratory.* Canberra: Department of the Environment, Australian Government.

Jenness, J. (2006, September 15). *Topographic Position Index (tpi_jen.avx) extension for ArcView 3.x, v. 1.2.* Retrieved from Jenness Enterprises: http://www.jennessent.com/arcview/tpi.htm

# Appendix A Results: Mortality Surveys

**November 2023 – April 2024 Detailed mortality results**

| Quarter | Month | Turbine ID: | Date | Common Name | Species: | No. | Threatened (Yes/No) | Easting | Northing | Notes: |
|---|---|---|---|---|---|---|---|---|---|---|
| 4th | Dec | 39 | 20/12/2023 | Eurasian Skylark | Alauda arvensis | 1 | No | 688214 | 5950001 | Body intact. 1 day old. Lower abdomen swollen with fluid. Male. |
| 1st | Jan | 28 | 1/4/2024 | Common Starling | *Sturnus vulgaris* | 1 | No | 685470 | 5946863 | Intact carcass, not scavenged and no sign of obvious injury |
| 1st | Jan | 1 | 1/5/2024 | Australian Magpie | *Cracticus tibicen* | 1 | No | 685841 | 5943653 | Dry carcass and flattened from being on the ground for some time. Eyes missing. Difficult to determine injury as the carcass was quite stiff. |
| 1st | Mar | 64 | 3/25/2024 | White-striped Freetail Bat | *Austronomus australis* | 1 | No | 692299 | 5954181 | Left forearm broken. Lower abdomen swollen. |

# Appendix B Results: Bird Surveys

**Opportunistic Records (November 2023 - April 2024)**

| Date | Month | Common Name | Native | Count | Observation | Site | Easting | Northing | Distance | Height | Raptor? | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21/11/2023 | Nov | Wedge-tailed Eagle | Yes | 2 | Observed | East of T42 | 688264 | 5949085 | 285 | 100 | Yes | Soaring |
| 21/11/2023 | Nov | Nankeen Kestrel | Yes | 1 | Observed | T42 | 687967 | 5949197 | 0 | 10 | Yes | Perched in tree |
| 22/11/2023 | Nov | Nankeen Kestrel | Yes | 1 | Observed | Front gate | 686583 | 5949370 | 0 | 10 | Yes | Hovering |
| 23/11/2023 | Nov | Nankeen Kestrel | Yes | 1 | Observed | Near T44 | 688546 | 5949500 | 100 | 12 | Yes | Hovering |
| 23/11/2023 | Nov | Nankeen Kestrel | Yes | 1 | Observed | T01 | 685569 | 5940719 | 40 | 10 | Yes | Hovering |
| 19/12/2023 | Dec | Nankeen Kestrel | Yes | 1 | Observed | Between T55 and T56 | 691384 | 5951373 | 100 | 20 | Yes | Hovering |
| 21/12/2023 | Dec | Nankeen Kestrel | Yes | 1 | Observed | T16 | 686006 | 5944783 | 80 | 15 | Yes | Hovering |

| Date | Month | Common Name | Native | Count | Observation | Site | Easting | Northing | Distance | Height | Raptor? | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21/12/2023 | Dec | Wedge-tailed Eagle | Yes | 2 | Observed | T22 | 685863 | 5946516 | 280 | 60 | Yes | Soaring |
| 21/12/2023 | Dec | Nankeen Kestrel | Yes | 1 | Observed | Gate to T25 | 687087 | 5947147 | | 10 | Yes | Hovering |
| 22/12/2023 | Dec | Nankeen Kestrel | Yes | 1 | Observed | T02 | 685089 | 5941353 | 40 | 15 | Yes | Hovering |
| 3/1/2024 | Jan | Nankeen Kestrel | Yes | 1 | Observed | Near front gate | 686584 | 5949461 | NA | 15 | Yes | Hovering |
| 3/1/2024 | Jan | White-throated Needletail | Yes | 20+ | Observed | Near T42 | 687904 | 5949250 | 150 | 200 | No | Flock of 20 + birds scattered over a large area and flying in an easterly direction |
| 3/1/2024 | Jan | Wedge-tailed Eagle | Yes | 1 | Observed | Near T42 | 688178 | 5949189 | 250 | 100 | Yes | Soaring |
| 4/1/2024 | Jan | Nankeen Kestrel | Yes | 1 | Observed | Roughly halfway between T30 and T26 | 686493 | 5947515 | NA | 15 | Yes | Hovering |

| Date | Month | Common Name | Native | Count | Observation | Site | Easting | Northing | Distance | Height | Raptor? | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4/1/2024 | Jan | Nankeen Kestrel | Yes | 1 | Observed | Near T25 | 687281 | 5947062 | 100 | 20 | Yes | Hovering |
| 5/1/2024 | Jan | Nankeen Kestrel | Yes | 1 | Observed | Near T04 | 685241 | 5941675 | 80 | 7 | Yes | In tree |
| 12/2/2024 | Feb | Nankeen Kestrel | Yes | 1 | Observed | Near T52 | 691084 | 5953939 | 40 | 15 | Yes | Hovering |
| 13/2/2024 | Feb | Nankeen Kestrel | Yes | 1 | Observed | Near T2A | 685547 | 5940992 | 120 | 15 | Yes | Hovering |
| 26/3/2024 | Mar | Wedge-tailed Eagle | Yes | 1 | Observed | Near T43 | 688549 | 5949093 | 200 | 100 | Yes | Riding thermal |
| 26/3/2024 | Mar | Nankeen Kestrel | Yes | 1 | Observed | T45 | 689096 | 5948911 | 60 | 10 | Yes | In tree |
| 28/3/2024 | Mar | Nankeen Kestrel | Yes | 1 | Observed | Gate to T5 | 685308 | 5941995 | 0 | 20 | Yes | Hovering |
| 27/4/2024 | Apr | Nankeen Kestrel | Yes | 1 | Observed | T52 | 691024 | 5953852 | 20 | 20 | Yes | Hovering |

| Date | Month | Common Name | Native | Count | Observation | Site | Easting | Northing | Distance | Height | Raptor? | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27/4/2024 | Apr | Nankeen Kestrel | Yes | 1 | Observed | T42 | 687933 | 5949168 | 50 | 20 | Yes | Hovering |
| 28/4/2024 | Apr | Nankeen Kestrel | Yes | 1 | Observed | T32 | 686414 | 5948056 | 40 | 25 | Yes | Hovering |
| 28/4/2024 | Apr | Nankeen Kestrel | Yes | 1 | Observed | T16 | 685977 | 5944702 | 30 | 15 | Yes | Hovering |
| **28/4/2024** | **Apr** | **Flame Robin** | **Yes** | **1** | **Observed** | **Between T02 and T02A** | **685286** | **5941194** | **10** | **1** | **No** | **Perched on rockwall** |

# Appendix C Symbolix mortality estimate report

An excerpt follows from the Symbolix mortality estimate report pertaining to the period November 2023 – April 2024.

# 4 Mortality estimate

With estimates for scavenge loss, searcher efficiency, and survey coverage, we then converted the number of bat and bird carcasses detected into estimates of overall mortality at Boco Rock Wind Farm.

The mortality estimation is done via a Monte Carlo algorithm. We used 15000 simulations, with the survey design simulated each time. Random numbers of virtual mortalities were simulated, along with the scavenge time and searcher efficiency (based on the measured confidence intervals). The proportion of virtual carcasses that were "found" was recorded for each simulation. Finally, those trials that had the same outcome as the reported survey detections were collated, and the initial conditions (i.e. how many true losses there were) reported on.

The model assumptions are listed below:

- There were 67 turbines on site available to strike bats and birds.
- Search frequency for each turbine was taken from the list of actual survey dates.
- Bats and birds are on-site at all times during this period.
- Bats and birds that are struck are immediately replaced (i.e. strikes one day do not affect the chance of strikes the next).
- We have used the standard practice of assuming that all carcasses and all feather spots (regardless of size or composition) are attributable to the wind turbines.
- Finds are random and independent, and not clustered with other finds.
- Until October 2023, we assume there was equal chance of any turbine being involved in a collision / mortality. Post October 2023, we assume that within strata (higher and lower risk), this assumption holds - but not between strata.
- We took scavenge loss and searcher efficiency rates as outlined above.
- We assumed an exponential scavenge shape.
- We assumed coverage factors as summarised above.

We ran a number of mortality estimates on bats and birds:

- Year 9: January 2023 to October 2023 (inclusive). This is the last of the survey under the old methods.
- Year 9: November 2023 to April 2024 (inclusive). This is the first six months of survey under the new methods.
- Cumulative years 1-9, January 2015 to October 2023. We have not run cumulative estimates past this point, due to the step change in survey design in November 2023.

## 4.1 Bats

In Year 9, Jan 23-Oct 23, a total of two bats were found. The resulting (median) estimate of total mortality is 15 individuals lost over the ten months.

In Nov 23-Apr 24, zero bats were found in both the higher and lower risk strata. The resulting (median) estimate of total mortality is 57 individuals lost over the six months.

Finally, we present the cumulative Y1-9 estimate (Jan 15 to Oct 23). Over this time period, a total of 74 bats were found. The resulting (median) estimate of total mortality is 465 individuals lost over the nine years.

These results are presented in Table 8 and Figure 4, to show the confidence on the mortality estimate.

**Table 8: Percentiles of the bat losses distributions.**

| Analysis Period | 0% | 50% (median) | 90% | 95% | 99% |
|---|---|---|---|---|---|
| Y9: Jan 23-Oct 23 | 2 | 15 | 31 | 35 | 51 |
| Y9: Nov 23-Apr 24 | 2 | 57 | 153 | 190 | 307 |
| Y1-9: Cumulative Jan 15-Oct 23 | 301 | 465 | 580 | 614 | 667 |

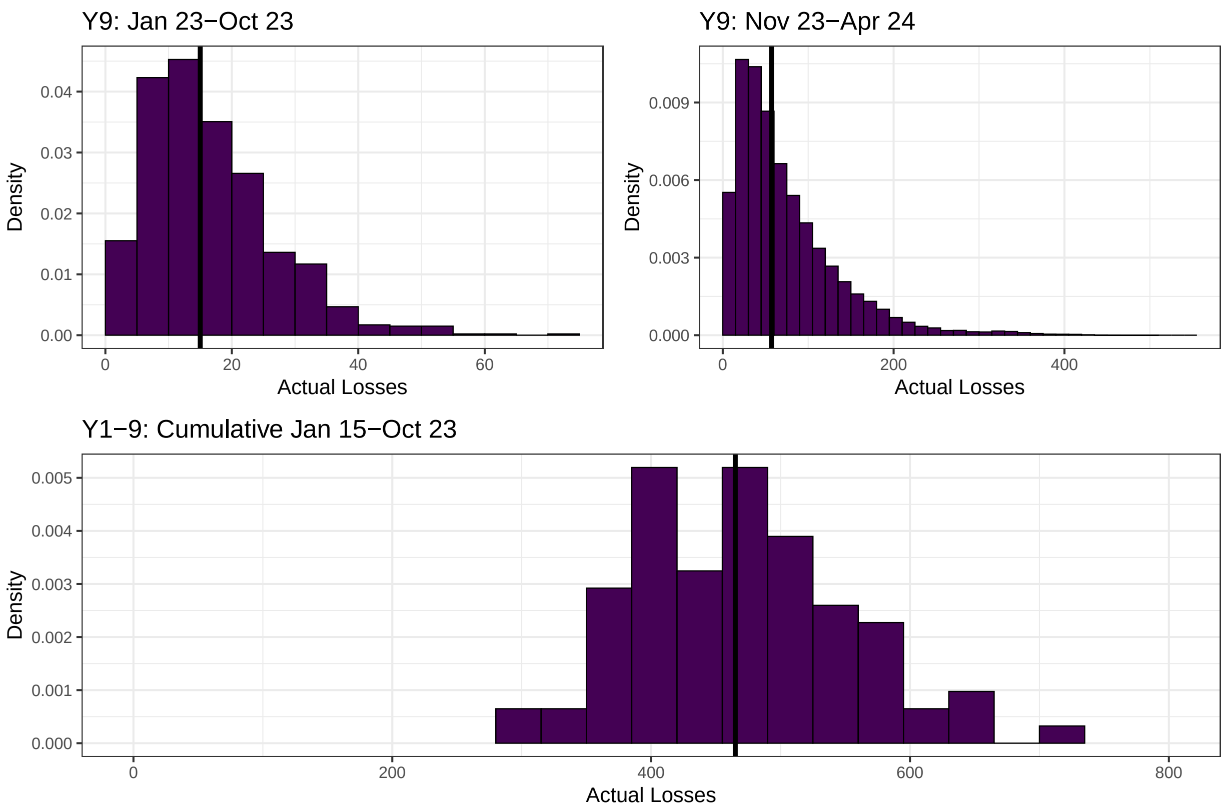



**Figure 4: Histograms of the total losses distributions (bats). The black solid lines show the median.**

## 4.2 Birds

In Year 9, Jan 23-Oct 23, a total of six birds were found. The resulting (median) estimate of total mortality is 40 individuals lost over the ten months.

In Nov 23-Apr 24, two birds were found in both the higher and lower risk strata. The resulting (median) estimate of total mortality is 122 individuals lost over the six months.

Finally, we present the cumulative Y1-9 estimate (Jan 15 to Oct 23). Over this time period, a total of 63 birds were found. The resulting (median) estimate of total mortality is 395 individuals lost over the nine years.

These results are presented in Table 9 and Figure 5, to show the confidence on the mortality estimate.

**Table 9: Percentiles of the bird losses distributions.**

| Analysis Period | 0% | 50% (median) | 90% | 95% | 99% |
|---|---|---|---|---|---|
| Y9: Jan 23-Oct 23 | 12 | 55 | 91 | 104 | 119 |
| Y9: Nov 23-Apr 24 | 7 | 122 | 223 | 267 | 379 |
| Y1-9: Cumulative Jan 15-Oct 23 | 358 | 564 | 723 | 767 | 911 |

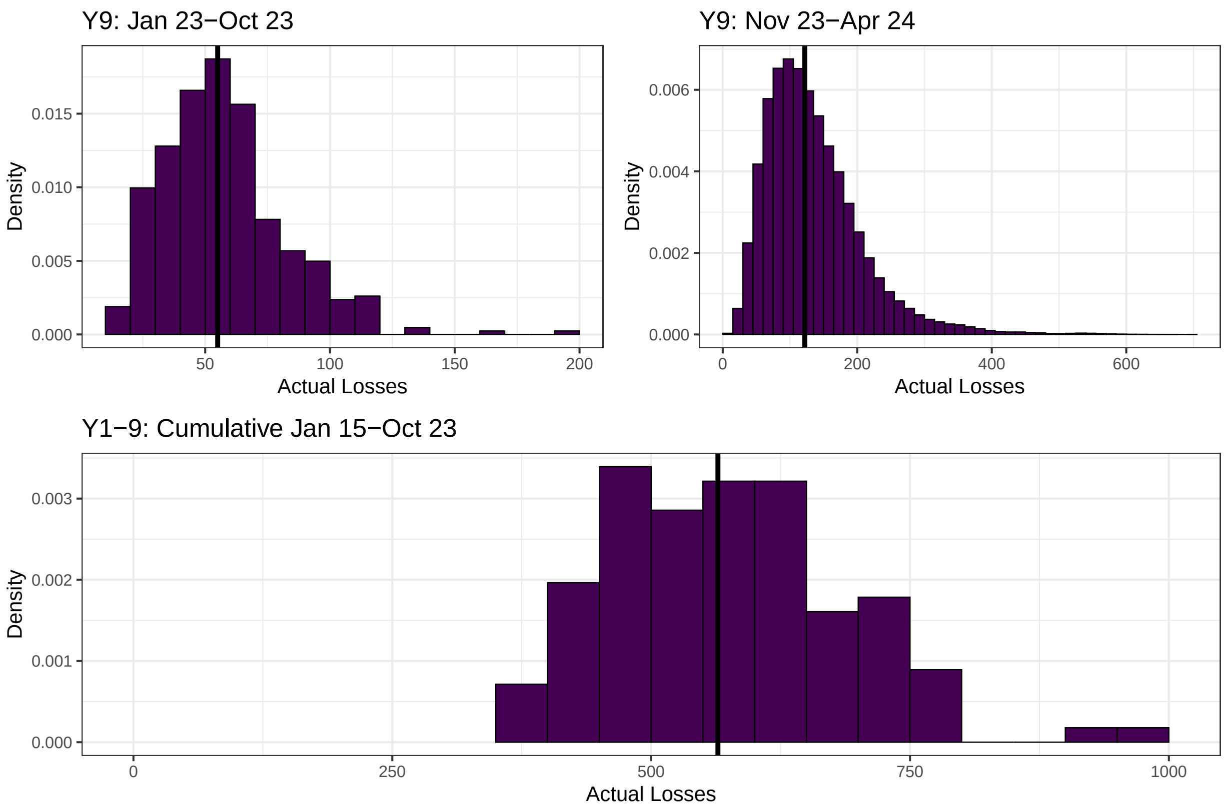



**Figure 5: Histograms of the total losses distributions (birds). The black solid lines show the median.**