Boco Rock Wind Farm Bird and Bat Monitoring

Annual Report 2021 Year 7

April 2022

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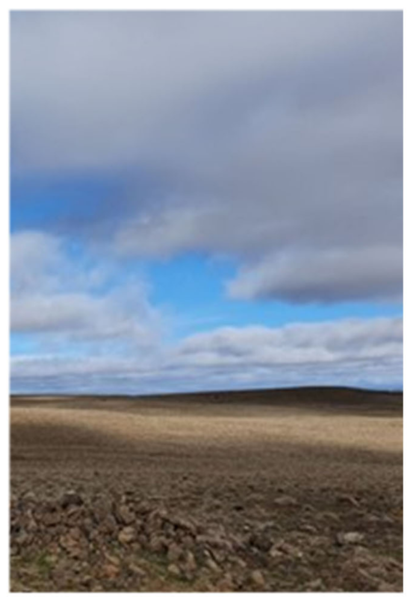

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Acronyms and abbreviations

ARI	Arthur Rylah Institute, Victoria
ASL	Above sea level
Av.	average
AWS	Automatic weather station
BBMP	Bird and Bat Management Plan
BC Act	*Biodiversity Conservation Act 2016* (NSW)
BRWF	Boco Rock Wind Farm
BOM	Australian Bureau of Meteorology
BRWF	Boco Rock Wind Farm
BUS	Bird Utilisation Survey
CWP Renewables	CWP Renewables Pty Ltd. are the operators of Boco Rock Wind Farm
Cwth	Commonwealth
DAWE	Department of Agriculture, Water and the Environment (Cwth) (formerly DoEE)
DECCW	(Former) Department of Environment, Climate Change and Water (NSW) (now DPIE)
DoEE	(Former) Department of the Environment and Energy (Cwth) (now DAWE)
DPIE	Department of Planning, Industry and Environment (NSW)
EES	Environment, Energy and Science (NSW), Division of DPIE (formerly OEH, and, prior, DECCW)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cwth)
FBB	Foliage, blossom and bark feeders
GPS	Global Positioning System
ha	hectares
IUCN	International Union for Conservation of Nature
km	kilometres
m	metres
NGH	NGH Consulting, formerly NGH Environmental
No.	number
NSW	New South Wales
OEH	(Former) Office of Environment and Heritage (NSW) (now EES)

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. The BRWF BBMP is designed to evaluate the operational impact of the wind farm on bird and bat species (NGH 2017). This report summarises the results of the seventh year of monitoring, undertaken in 2021. This report provides an analysis and evaluation of the current data including monitoring trends and higher risk species. The effectiveness of monitoring and management methods are reviewed and recommendations, including updates to the BBMP document itself, are made.

Survey effort and methods for the year 2021 follow those recommended in the BBMP v1.3, including monthly mortality surveys, monthly bird utilisation surveys and quarterly microbat surveys (Anabat). Methods of analysis include qualitative and statistical analysis, the latter of which has been undertaken by Symbolix Pty Ltd[1]. Results and analyses are discussed in terms of the objectives of the BBMP v1.3.

After seven complete years of operational monitoring at BRWF, the program is meeting its' primary objective to detect collisions of bird and microbat species with turbines, combined with rigorous statistical analysis to ascertain trends in data. Overall, survey effort is well above what is required for statistical analysis and refinement of future survey effort is warranted in line with updating the BBMP.

Results

Mortality surveys

Mortality surveys in 2021 resulted in 12 carcass/feather scatter finds: four birds and eight bats. Three species of bird were found: Australian Magpie (one), Eurasian Skylark (two) and Nankeen Kestrel (one). From the four bird carcasses found in 2021, the estimated total bird mortality at BRWF for 2021 is 40 individuals. With a 95% confidence level, it can be stated that fewer than 76 individuals were killed.

Two species of microbats were found: Gould's Wattled Bat (two) and White-striped Freetail Bat (six). From the eight bat carcasses found in 2021, the estimated total annual mortality of microbats (all species) was 55 (annual mean). With a 95% confidence level, it can be stated that fewer than 92 individuals were killed. As the majority of bat carcasses found were from a single species, White-striped Freetail Bat, a mortality estimate was derived for this species. Based on six White-striped Freetail Bat carcasses found in 2021, an estimated total annual mortality of 42 individuals was modelled to have been killed for the entire wind farm (annual mean). With a 95% confidence level, it can be stated that fewer than 73 individuals were killed.

Although the numbers vary from year to year, in general there has been a declining trend in the estimated annual mortality at Boco Rock Wind Farm, for both birds and bats. From the annual mean estimates of mortality across the wind farm, an estimate of microbat and bird deaths per turbine per year has been derived. The rate of microbat collision at BRWF in 2021 was estimated

[1] Symbolix assisted to develop the statistical design of the monitoring program and have analysed monitoring data collected since the commencement of the program in January 2015.

to be 0.82 bats/turbine. The rate of bird collision at BRWF in 2021 was approximately 0.6 birds/turbine. This is lower than most published mortality estimates for other Australian wind farms.

Bird utilisation surveys

For bird utilisation surveys, the total species richness was 59 and the total number of observations (abundance) was 665. Four threatened species were recorded in 2021: Dusky Woodswallow, Hooded Robin, Scarlet Robin and Speckled Warbler. All were recorded in the woodland stratum. Five raptors were recorded in 2021: Australian Hobby, Black-shouldered Kite, Brown Falcon, Nankeen Kestrel, Wedge-tailed Eagle. Over time at BRWF, the species assemblage has shifted over time at woodland sites as well as grassland impact and control sites.

Within the woodland stratum, species richness is fairly stable, species diversity changes with the season and the species assemblage has changed over time. Woodland species richness and relative abundance is different to grassland results as each stratum supports different species due to the contrasting habitat types. There is no evidence of an impact of the wind farm on woodland bird species abundance and richness, especially as the woodland stratum is greater than 500m from turbines.

Within the grassland stratum, both control and impact sites demonstrate a trend of decreasing diversity and abundance. Qualitative and quantitative analysis shows a gradual decline in species richness at all three strata – this is clearer at the grassland sites but is “slight” in magnitude across the board. The key to interpretation is to compare the impact stratum to the control. At BRWF, changes in the grassland impact stratum have been mirrored in the control stratum. On this basis, it seems wind farm operation is not driving the change but rather other processes, discussed in the report.

Microbat surveys

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). These are: Large Bent-winged Bat, Eastern False Pipistrelle, Yellow-bellied Sheathtail Bat, White-striped Freetail Bat, Gould's Wattled Bat. The remaining call files are attributed to ‘Other bats’. Large Bent-winged Bat and Eastern False Pipistrelle are NSW listed threatened species.

In 2021, 4,901 bat call files were analysed. Gould’s Wattled Bat was the most frequently detected species, present at all four sites and with a high number of passes at AE3 woodland impact site. Other species accounted for 56% of the microbat activity (2757 files). Detection of White-striped Freetail Bat is relatively low (21 in 2021) considering this is the most often found bat carcass during mortality surveys. Flight height is likely to be the cause of low detection rate, with White-striped Freetail Bats flying high and fast and may frequently be outside the range of the Anabat detector. The lack of correlation of microbat mortalities with Anabat call data is a reason to consider changes to Anabat survey effort.

Waterbird and wetland surveys

Nine wetlands / waterbodies are nearby or within BRWF and are monitored each monthly survey. From June 2021, wetlands began to fill following significant rainfall and all held water for the remainder of the year, along with abundant waterbirds. The majority (90%) of waterbird sightings at BRWF occur opportunistically at the ephemeral wetlands surveyed (1522 birds opportunistically compared to 171 birds during BUS). 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. This demonstrates that the layout of BRWF has posed neither a mortal threat nor a barrier to waterbirds, whether locally resident, nomadic or migratory.

Adaptive management

Table 7-3 of the endorsed BBMP v1.3 provides a sample of events that would automatically be considered moderate to high risk and require a management response. Three such events occurred during 2021: breeding birds close to turbines, multiple mortalities of any species, prolonged rain leading to improved conditions at wetlands near turbines. Management responses were taken for each of these events and are detailed in the report. No undesirable outcomes occurred in relation to these events in 2021.

A few other issues arose in the rollout of the 2021 BBMP. Poor ground visibility due to thick vegetation growth in the extended zone, and toward the end of year also in the high detectability zone, made survey conditions difficult and may have affected the number of smaller carcasses found. Symbolix have advised that modelled mortality estimates are still considered reliable despite reduced visibility. Further, the long term data shows reduced trends in mortality which align with reduced species richness across both impact and control sites, unlikely to be related to the BRWF. CWP Renewables have advised that the hardstand areas will be sprayed with herbicide as soon as weather permits and as at the time of this report these actions have commenced.

The BBMP (v1.3) at BRWF has completed its seventh year of operational monitoring (December 2021). After seven years of monitoring the data provides a good understanding of bird and bat activity and potential risks specific to BRWF. The cumulative data indicates the operation of the wind farm has not had any adverse effect on any bird or bat populations and as such the risks of the wind farm are shown to be low at a population level.

The following changes are recommended in order to refine and adapt the monitoring program and survey effort based on seven years of operational monitoring:

- Considering the use of dog-handler teams for mortality surveys rather than human searchers, increasing detectability and ultimately enabling a reduction in survey effort. Dogs are both more efficient with higher detectability achievable so may be of benefit to the program.
- Update searcher efficiency trials to ensure that detectability estimates are accurate and reflect current onsite conditions. This will need to be done if methods (i.e. dog teams) or personnel are changed. This will help quantify any impacts of vegetation growth on searcher efficiency and confirm mortality estimates are reflecting the state of the BRWF environment.
- Reducing the extent of surveys, supported by current monitoring data, implemented as an adaptive approach to ensuring ongoing efficiency in data collection and reporting that is tailored to BRWF.
- Preparing alternative modelling options that analyse future reduced survey effort supported by the long term monitoring data and statistical analysis.
- Removing BUS observations from monthly to relevant seasonal windows where activity is highest (October to March).
- Reducing frequency or eliminating Anabat surveys as they do not align with or accurately represent bat mortality or impacts to threatened species’ populations, which is their purpose.

- Updating the reporting frequency in line with updated monitoring activity and utilisation of results. Consider implementation of annual reporting with no quarterly reports.
- Delete the current ‘higher risk’ species table in the BBMP and replace with the updated risk assessment from the 2020 Annual Report as per Table 6-2.

The recommendations above would be addressed throughout 2022, concurrent to the current survey effort detailed in BBMP V3.1. Further modelling, supported by data analysis, would lead to an updated BBMP to reflect changes. An updated BBMP would streamline the monitoring program in an adaptive way and would ensure maximum detection, with more efficient survey effort. Changes to the BBMP should be submitted for approval where required by the project’s consent.

1. Introduction

1.1 Project 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 and consists of 67 GE 1.7-100 turbines mounted on 96 m towers with blades approximately 49 m long. The maximum height with the blade fully extended is 146 m. The rotor-swept area is from 47 to 146 m above the ground. 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 (BBMP v1.3, NGH 2017).

1.2 Objectives of the BBMP

The BBMP v1.3 was developed with input from the NSW Office of Environment & Heritage (OEH)[2]. Primary and secondary objectives of the BBMP v1.3 are (p.2, NGH 2017):

Primary objective

1. Detect collisions of bird and microbat species with turbines [at BRWF] during the operational phase of the project using the following methods:
    a. Mortality surveys (measuring direct impact) to monitor collision rates of birds and microbats.
    b. Supporting surveys (scavenger and detectability trials) to compare and validate results from mortality surveys. These surveys assist in interpreting the results of the mortality surveys and ensure the mortality survey intensity is sufficient to obtain meaningful information.

Secondary objective

1. Detect population changes in birds and microbats [at BRWF] using the following methods:
    a. Utilisation surveys (measuring indirect impact) to monitor bird activity and movements to ascertain trends in activity incline or decline.
    b. Passive Anabat surveys (measuring indirect impact) to monitor microbat species diversity and general activity levels, to comment on potential trends in activity increase or decline.

Note: activity levels are used as a surrogate for measuring population changes when addressing the secondary objective.

1.3 Objectives of the Annual Report

The reporting requirements of the BBMP v1.3 include quarterly technical reports and an annual report. Annual reports are to inform management and provide recommendations for subsequent years of the BBMP. In accordance with the BBMP v1.3, this annual report:

[2] OEH is now Biodiversity and Conservation Division (BCD), but references to the department will remain as OEH within this report given approval decisions were made under OEH (not BCD) before the commencement of the BBMP.

- Summarises the results of previous 12 months of monitoring data.
- Provides a synthesised summary of key results, their significance and the effectiveness of mitigation measures employed.
- Identifies trends and highlights any species at risk based on all monitoring data gathered to date (i.e. January 2015 to December 2021).
- Identifies any aspect of the monitoring program that requires updating, and provides a recommendation for revision.
- Identifies any aspect of the risk assessments that underpin the assumptions of the BBMP v1.3 that require updating and provides a recommendation for revision.

Additionally, this annual report provides further analysis and evaluation of issues that have arisen throughout the year where required.

1.4 Monitoring program design

In accordance with the BBMP v1.3, the surveys implemented throughout the seventh year of operation included:

- Mortality surveys (carcass searches) (undertaken monthly).
- Bird utilisation surveys (undertaken monthly).
- Passive Anabat surveys (undertaken in March, May, September and November).

Detectability and scavenger trials were undertaken in 2015 and were not required to be repeated in subsequent years, assuming conditions remain unchanged. All scheduled surveys were conducted and the survey effort was determined by the appointed expert (as required by the BBMP v1.3) to be consistent with the requirements of the BBMP v1.3.

Survey effort undertaken at BRWF from January to December 2021 for each survey type is contained within the relevant section, as well as tabulated in Appendix A.1.

1.5 Survey timing and conditions in 2021

The surveys implemented between January and December 2021 are listed in Table 1-1. The survey methods are summarised in the relevant section in this report. The procedures and full details for bird and bat monitoring requirements are given in the BBMP V1.3.

Table 1-1 Date and survey type for each month of 2021

Month	Date	Surveys undertaken
January	18-21	Mortality survey Bird utilisation survey
February	4-7	Mortality survey Bird utilisation survey
March	1-5	Mortality survey Bird utilisation survey Anabat survey
April	11-14	Mortality survey Bird utilisation survey
May	10-14	Mortality survey Bird utilisation survey

Month	Date	Surveys undertaken
		Anabat survey
June	1-4	Mortality survey Bird utilisation survey
July	12-15	Mortality survey Bird utilisation survey
August	18-21	Mortality survey Bird utilisation survey
September	13-16	Mortality survey Bird utilisation survey Anabat survey
October	7-10	Mortality survey Bird utilisation survey
November	10-14	Mortality survey Bird utilisation survey Anabat survey (data is incomplete)
December	7-10	Mortality survey Bird utilisation survey

1.5.1 Weather conditions

Field-collected and Bureau of Meteorology (BOM) temperature and wind data are provided in Appendix A.2.

After several dry years, this year (2021) and last year (2020) recorded above average annual rainfall. The yearly rainfall overall has been considerably above average for 2021. A total of 847.4 mm was recorded between January to December 2021, with the long-term yearly average recorded was 539.5 mm. Below average rainfall was observed in January, April and July; average rainfall in October and above average in February, March, May, June, August, September, November and December.

First quarter

Weather conditions during the three monthly survey events (spanning summer and autumn) included a very wet February and March with warm to mild temperatures consistent with summer and autumn seasons. Wind conditions during surveys were variable during the first quarter, with some very windy days in March particularly. Overall, conditions have been suitable for the survey types undertaken although very cold overnight conditions (e.g. -1.1°C) in March may have affected microbat survey results (microbats are less active in cold weather). Windy weather early in the morning on 2 March may have affected bird survey results. However, these effects are likely to have been small in magnitude overall.

Second quarter

The second quarter spans autumn and winter, with dry weather in April and some rainfall in May and June according to the Cooma Airport AWS weather station. No rain fell during the April survey event. Significant rain fell during the May survey event, with nearly 40mm on 12 May, and approximately 1mm on the 11 and 13 May. Rain is likely to have affected the visibility of birds during bird utilisation surveys. June survey days were both clear and rainy. Around 16mm of rainfall was received overnight and during the day on 3 June at Cooma airport (BOM 2021). Rain washed out two grassland impact surveys in June with only eight of ten conducted.

Temperatures during the April survey week were cold during the morning bird surveys to hot during the day (mortality surveys), with variable wind and cloud. The May survey period was cool with light winds on most days apart from the first day. The June survey week was cool, with mostly light winds.

Third quarter

The weather during the third quarter July, August and September survey events (winter to spring) presented a mix of clear and overcast conditions. Higher than average total rainfall was recorded for August and September 2021 at Cooma Airport, though rainfall was below average for July.

Fourth quarter

The weather during the fourth quarter October, November and December survey events presented a mix of clear, overcast and wet conditions. The 2021-22 La Niña event is likely the cause of the higher than average rainfall recorded for the fourth quarter. November and December rainfall was approximately double the average, though closer to average for October (Appendix A.2). The high rainfall of November and December led to poor survey conditions, including site inundation and flash flooding, preventing the completion of several surveys (see Section 3.1.3).

2. Mortality survey

The primary objective of the BRWF BBMP v1.3 is to detect collisions of birds and bats with turbines through mortality surveys to measure the direct impact of the operating wind farm. Interpretation of the 2021 results is supported by scavenger and detectability trials undertaken in 2015 and reported in the 2015 Annual Report, as well as the attached *Boco Rock Wind Farm Mortality Estimate – Year Seven* report in Appendix D.1

2.1 Methods and effort

2.1.1 Surveys

Mortality surveys are completed monthly within two different search areas:

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

Data from the carcass searches were analysed and reported on by Symbolix. Survey effort is summarised below and tabulated in Appendix A.1.

High detectability zone aka core zone (hardstand plus access road)

Searches are undertaken in the high detectability zone at all 67 turbines twice during each monthly survey, with an ideal search effort of 1608 searches over 12 months. The search area comprises the hardstand of the turbine (**~** 20 m x 20 m area) and access road to the turbine (~ 4 m by 120 m), resulting in an approximate search area per turbine of 880m^2. Searches are conducted along transects at 4 m spacing over the entire 880 m^2 search area (i.e. 2m either side of the walked line scanned for carcasses). Therefore, a total of five 20 m long transects plus one 120 m long transect along the road are surveyed per turbine. Searcher efficiency trials in 2014 and 2015 provided a detectability co-efficient for bats of 84% and birds 92%. This co-efficient was altered by vegetation growth in the latter part of 2022, and the effects and response is detailed in the *Limitations* section below.

The mortality surveys in the high detectability zone are pulsed; that is, this survey is repeated after a two-day interval at all turbines in the high detectability zone. This pulsed survey was designed to account for faster scavenger loss rates for smaller carcasses.

Extended zone

Mortality surveys are also undertaken in an 'extended zone' at 20 fixed turbines once per month (240 surveys over the year). The search area comprises an 80 x 80 m area resulting in an approximate search area per turbine of 6,400 m^2. Transect searches are conducted 12 m apart within the search area.[3]

The extended zone search area is additional to the high detectability zone search area, therefore the total search area for these turbines is 7,280 m^2 (i.e. 6,400 m^2 plus 880 m^2). The extended

[3] Note that methodology for extended zone survey has changed compared to that described in BBMP v1.3, as an adaptation to onsite conditions at NGH's discretion. The area surveyed has increased. The change in methodology has been taken into consideration by Symbolix for mortality estimate calculations.

search areas were marked with paint and GPS to ensure the same area was surveyed each month.

Wedge-tailed Eagle nest checks

Observations were undertaken during monthly surveys of a Wedge-tailed Eagle nest near turbines 58 and 65 from October to December 2021. The nest was checked during each survey event for the presence of chicks until the chicks fledged. Upon fledging, an additional extended zone mortality search was undertaken at Turbine 65 which is closest to the nest. This was undertaken to investigate perceived vulnerability to blade-strike of freshly fledged eagles. This pair have successfully fledged one or two chicks each year in 2016, 2017, 2018, 2019, 2020 and again in 2021.

Survey effort

The survey design allows for a minimum of 80% search effort to be accomplished to achieve statistical rigour. Overall survey coverage in 2021 was 100% (Table 2-1).

Table 2-1 Turbine survey coverage in 2021, by month; HD = High Detectability zone

Month	Turbine HD 1	Turbine HD 2	100%	% Coverage	Extended	100%	% Coverage
Jan	67	67	134	100	20	20	100
Feb	67	67	134	100	20	20	100
Mar	67	67	134	100	20	20	100
Apr	67	67	134	100	20	20	100
May	67	67	134	100	20	20	100
Jun	67	67	134	100	20	20	100
Jul	67	67	134	100	20	20	100
Aug	67	67	134	100	20	20	100
Sep	67	67	134	100	20	20	100
Oct	67	67	134	100	20	20	100
Nov	67	67	134	100	20	20	100
Dec	67	67	134	100	20	20	100
Total	**804**	**804**	**1608**	**100**	**240**	**240**	**100**

2.1.2 Limitations

Detectability in the extended zone

Vigorous vegetative growth in the latter part of 2020 and throughout 2021 means that extended zone areas were thick with grass and head-high annual weeds, which affected ground visibility. Field staff estimated that at some turbines, ground visibility in the extended zone was zero. This would have affected the total number of carcasses found.

However, as the original statistical design did not include an extended zone (which was added at the behest of OEH), the Monte-Carlo simulation used to derive mortality estimates models carcasses that could fall in the extended zone, regardless of where they are found. Symbolix have assured us that the accuracy of visibility estimates in the extended zone have little bearing on the modelling outcomes (A.Jackson *pers.comm* 2021).

Detectability in the high detectability zone

In the fourth quarter of 2021 vegetation (mainly grass) grew in the high detectability zone through the road base on around a quarter of turbine hardstands, which interrupts the field of view and makes searching for carcasses more arduous, more time-consuming and less efficient (Figure 2-1). In short, the detectability of carcasses has been reduced in the core zone. The months of concern (November, December 2021) correlate with the months when no carcasses were found at BRWF. The lack of carcasses found in September – December 2021 is unusual compared to previous years (refer Table 2-8). Extensive wet weather may have affected results.

In contrast to the extended zone (discussed above), visibility estimates in the high detectability zone can affect modelling outcomes. From searcher efficiency trials undertaken in 2014 and 2015, bat detectability has been calculated at 84% and bird detectability at 92% on the hardstand and road. It is estimated that overall detectability was reduced to 30% at some turbines in November - December in the high detectability zone.

Searcher efficiency trials have not yet been repeated. Discussions with Symbolix concluded that a high detectability co-efficient (which may not be achievable with the observed vegetation cover) could lead to an underestimate of mortality (A.Jackson, pers.comm. 4/3/22). However, Symbolix do not recommend re-running models to take into consideration reduced visibility for November to December, as survey effort for BRWF is already quite high compared to other wind farms. The high survey effort means that modelled mortality estimates obtained for 2021 are still considered robust and reliable (E. Stark, pers comm. 28/03/2022).

Further, climatic changes (drought followed by high rainfall, La nina) could be responsible for changes in mortality detection (E. Stark, pers comm. 28/03/2022). This is supported by BUS surveys showing a reduced species richness and diversity. Instead, Symbolix recommend re-running the detectability trial in line with updates proposed to the survey methodology in an anticipated BBMP v1.4. NGH agree and have made this recommendation to better reflect current onsite conditions. The amount of ground cover has changed significantly since initial detectability trials.

Figure 2-1 Vegetation growth in one of the turbine hard stand areas (the 'high detectability' zone), December 2021

2.1.3 Quantitative analysis

The mortality data for 2021 was analysed by Symbolix Pty Ltd. An estimate of overall mortality was derived by a Monte-Carlo simulation model (Hull and Muir 2010 in Symbolix 2022a). The model produces a set of thousands of 'simulations' or 'scenarios' wherein birds and bats collide with turbines according to the parameters of the model. Survey data (the number of bird or bat carcasses found in 2021 as well as the detectability and scavenger rates reported in the 2015 Annual Report) is then used to identify the simulations which reflect what was found on site (the 'matching' simulations). At this point, reduced visibility in the high detectability zone only would affect results if not accounted for. From these simulations, a range of mortalities is estimated representing a worst-case scenario (>95% confidence interval), a best-case scenario (0% confidence interval), a median (50% confidence) and an average (or 'mean'). The mean is the average number of deaths across all the matching simulations. The most reliable of the estimates are the median and average results as these represent the most likely real-life scenario (Elizabeth Stark, *pers. comm.*, 2017). The statistical methods and assumptions are described in detail in the *Mortality Estimate* report attached in Appendix D.1.

It should be noted that the assumptions of the model included:

- No upper limit on the number of birds and bats that could be on site.
- Birds and bats are present all year around.

Because natural environments have a carrying capacity or 'upper limit' on the number of individuals that can be sustained (Monte-Luna *et al.,* 2004), the Monte-Carlo simulation model is precautionary as it can overestimate mortality due to the above assumptions. Further, bats are not active all year at BRWF. This is evidenced by the significantly lower number of (or zero) passes detected by the Anabat surveys conducted in winter each year when compared to warmer seasons at the site since 2015. Therefore, the assumptions underpinning the mortality estimate will have resulted in an overestimate of mortality rates, particularly for microbats.

2.2 Results 2021

2.2.1 Overview

Mortality surveys in 2021 resulted in 12 carcass/feather scatter finds. The monthly distribution of carcass finds is shown in (Table 2-2). The highest number of carcasses was found in January (first quarter). No carcasses were found in six months out of 12. Locations of carcass finds are shown in Appendix B.2. No waterbirds or threatened species were found during mortality surveys in 2021.

Table 2-2 Monthly distribution of carcasses/feather scatters found at BRWF in 2021

Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Total
4	3	2	0	0	0	1	2	0	0	0	0	**12**

Of the five species identified from carcass finds in 2021, one was listed in the BBMP (v1.3) as a species that has potential for higher risk of collision with operating turbines (White-striped Freetail Bat). Analysis of mortality results is given in Section 2.1.3, including estimates of annual mortality. Table 2-3 shows the species identified from carcasses/feather scatters along with the number. There were four bird carcasses/feather scatters and eight bat carcasses found in 2021.

Table 2-3 Species and number of carcasses found during mortality surveys at BRWF in 2021

Common name	Species name	No. carcasses found	At risk species?
Birds			
Australian Magpie	*Cracticus tibicen*	1	No
Eurasian Skylark	*Alauda arvensis*	2	No
Nankeen Kestrel	*Falco cenchroides*	1	Yes
	Total birds	*4*	
Bats			
Gould's Wattled Bat	*Chalinolobus gouldii*	2	No
White-striped Freetail Bat	*Austronomus australis*	6	Yes
	Total bats	*8*	

*Identified from scattered feathers (only on one occasion for Australian Magpie – the remainder were carcasses).

The full mortality survey results for 2021 are given in Appendix B.1. The location of each carcass found is shown in the map in Appendix B.2. Table 2-4 summarises the carcass search results. It can be seen from Table 2-4 that the majority of carcasses were found in the high detectability (core) zone; only one of the finds was located in the extended zone in 2021.

A total of 139 carcasses have been detected over the seven years of monitoring; 126 of these were in the high detectability zone and only nine in the extended zone (four carcasses have been found in 'other'). The mortality modelling undertaken by Symbolix calculates a 'fall zone' for each species in both the extended and high detectability areas; the area that species of different sizes are expected to fall following collision. So, although finds are rare within the extended zone, the potential for birds and bats to land within the extended zone and go undetected is taken into account within the mortality estimate modelling and supported by six years of data collected during operation of the BRWF. This is described in more detail in the following sections.

Table 2-4. Summary of mortality surveys results by date from January to December 2021.

Turbine ID	Date	Survey quarter	Common Name	Threatened (Yes/No)	Found during monthly survey?	Survey zone
58	18/01/2021	1st	White-striped Freetail Bat	No	Yes	Core
18	19/01/2021	1st	White-striped Freetail Bat	No	Yes	Core
18	19/01/2021	1st	White-striped Freetail Bat	No	Yes	Core
55	20/01/2021	1st	White-striped Freetail Bat	No	Yes	Core
38	4/02/2021	1st	White-striped Freetail Bat	No	Yes	Core
27	5/02/2021	1st	Eurasian Skylark	No	Yes	Core
1	7/02/2021	1st	White-striped Freetail Bat	No	Yes	Core
5	2/03/2021	1st	Gould's Wattled Bat	No	Yes	Core
65	3/03/2021	1st	Gould's Wattled Bat	No	Yes	Core
59	12/07/2021	3rd	Nankeen Kestrel	No	Yes	Core
35	18/08/2021	3rd	Eurasian Skylark	No	Yes	Ext.
42	20/08/2021	3rd	Australian Magpie	No	Yes	Core

The seasonal timing of carcass finds is shown in Table 2-6. The highest number of carcasses (seven) were found in summer, mostly bats (six). All were found at the beginning of 2021 – January and February and none in December 2021 summer. No carcasses were found in spring 2021. In previous years (except 2015) the highest number of carcasses have been found in spring and/or summer. This is the first year there were zero carcasses found in spring.

Table 2-5 Seasonal timing of carcasses found in 2021

Seasonal timing	Number of carcasses 2021		
	Birds	**Bats**	**Total**
Summer (Jan 2021, Feb 2021, Dec 2021)	1	6	7
Autumn (March, Apr, May)	0	2	2
Winter (Jun, Jul, Aug)	3	0	3
Spring (Sep, Oct, Nov)	0	0	0
Total	**4**	**8**	**12**

2.2.2 Birds

In 2021, there were four carcasses found from three species of bird as displayed in Table 2-4 (above) and listed below.

1. Australian Magpie (1)
2. Eurasian Skylark (2)
3. Nankeen Kestrel (1)

The highest number of bird carcasses was found in the third quarter (three). Only one carcass was detected in the first quarter and zero in the second and fourth. By season, the highest number of carcasses found in 2021 was in winter (three), with one in summer and none in spring and autumn. All results are given in Table 2-5.

Since 2015, 61 bird carcasses have been found (Table 2-6). Of these, 17 were introduced species (Eurasian Skylark and Common Starling) which account for 28% of total bird mortality finds.

Table 2-6 Distribution of bird carcasses between native and introduced species (2015-2021)

	2015	2016	2017	2018	2019	2020	*2021*	Total
Introduced	4	5	3	0	2	1	***2***	**17**
Native	7	2	7	10	2	11	***2***	**41**
Not identifiable					2	1		**3**
Total	**11**	**7**	**10**	**10**	**6**	**13**	***4***	**61**

Across all years of monitoring (2015-2021), the top three bird species found in mortality surveys are:

1. Eurasian Skylark (14 or 23% of the total bird finds).
2. Australian Magpie (9 or 15% total bird finds).
3. Nankeen Kestrel (7 or 11% total bird finds).

All three are common, secure species.

Across all years of monitoring (2015-2021), the top three bird guilds found during mortality surveys are detailed below (refer to Section 3.2.4 for more information on guilds):

- 'Introduced grassland ground' guild: 17 carcasses (Eurasian Skylark and Common Starling) accounting for 28%.
- 'Raptor' guild with 15 carcasses accounting for 25%.
- 'Generalist' ground guild with 13 accounting for 21%.

Five species have been found from the raptor guild (combining a number of behavioural sub-guilds e.g. aerial hover/pounce) since 2015 with Nankeen Kestrel most numerous (seven carcasses), followed by Wedge-tailed Eagle (four carcasses). Five species have also been found from the (native) generalist ground guild since 2015; Australian Magpie is by far the most common with nine from 13 carcasses or 69% of carcasses from this guild. The remaining four generalist ground guild carcasses are Ravens and one Sulphur-crested Cockatoo.

In summary the 2021 data does not present any surprising or unexpected results from the bird mortality carcasses found; rather the data is in keeping with resulprevious years.

Table 2-7 Carcass finds from bird guilds (2015-2021)

Bird guilds	Common Name	Number
Aerial hover/pounce	Brown Falcon	1
	Nankeen Kestrel	7
Aerial insectivore	Fairy Martin	1
	White-throated Needletail	2
Aerial pursuit	Peregrine Falcon	2
Aerial soar/quarter	Wedge-tailed Eagle	4
Ecotonal FBB	Rufous Fantail	2
Ecotonal predator	Brown Goshawk	1
Generalist ground	Australian Magpie	9
	Australian Raven	1
	Little Raven	1
	Raven sp.	1
	Sulphur-crested Cockatoo	1
Grassland ground	Australasian Pipit	1
	Stubble Quail	1
Introduced grassland ground	Common Starling	3
	Eurasian Skylark	14
Nocturnal	Southern Boobook	1
Unidentifiable	Unidentifiable	3
Woodland FBB*	Grey Fantail	3
	Shining Bronze-cuckoo	1
	Silvereye	1
Grand Total		**61**

*FBB: foliage, blossoms, and bark feeders

Mortality estimate (Symbolix 2021a)

From the four bird carcasses found in 2021, the estimated total bird mortality at BRWF for 2021 is 40 individuals. With a 95% confidence level, it can be stated that fewer than 76 individuals were killed.

2.2.3 Bats

In 2021, there were eight carcasses found from two species of bats as displayed in Table 2-4 (Section 2.2.1), and listed below:

1. Gould's Wattled Bat (2).
2. White-striped Freetail Bat (6).

All of the bat carcasses detected in 2021 were found in the first quarter. By season, six of the eight carcasses were found in summer (January /February only), with two carcasses found in autumn (March). It is usual for bat carcasses to be found at Boco Rock WF in the first and fourth quarters, as this represents the spring/summer periods of highest bat activity. The only exception to this trend were that this year (2021) no carcasses were found in Spring and in 2020 no bats were found for the year.

Across all years of monitoring (2015-2021), the most carcasses found have been from two bat species:

1. White-striped Freetail Bat (56 or 72% of the total bat finds).
2. Gould's Wattled Bat (15 or 19% 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 (72%). The mortality rate for this species is discussed further in Section 2.4.1.

In summary, the 2021 data is in keeping with previous years in terms of species type and number found during carcass searches, although zero carcass finds during the spring/summer fourth quarter is an unexpected result. This was discussed in Section 2.1.2.

Mortality estimate (Symbolix 2021a)

From the eight bat carcasses found in 2021, the estimated total annual mortality of microbats (all species) was 55 (annual mean). With a 95% confidence level, it can be stated that fewer than 92 individuals were killed.

The White-striped Freetail Bat is considered an at risk species because it is the most commonly detected microbat during carcass searches. A mortality estimate was undertaken for just this species. Based on six White-striped Freetail Bat carcasses found in 2021, an estimated total annual mortality of 42 individuals was modelled to have been killed for the entire wind farm (annual mean). With a 95% confidence level, it can be stated that fewer than 73 individuals were killed. Section 4.2 considers this species further in regard to activity levels recorded through Anabat survey.

2.3 Yearly comparisons

The total number of carcasses found during mortality surveys is shown for each year of monitoring (2015 to 2021) at BRWF in Table 2-8. The highest number of carcasses was found in the first year of monitoring in 2015 (35 carcasses). Although the numbers vary from year to year, in general there has been a declining trend in the estimated annual mortality at Boco Rock Wind Farm, for both birds (Figure 2-2) and bats (Figure 2-3).

Table 2-8 Total number of bird and bat carcasses found during each year of the BRWF BBMP, shown by quarter (with current reporting year in bold).

Quarter	2015	2016	2017	2018	2019	2020	2021
1st Quarter (Jan, Feb, Mar)	12	14	13	5	1	2	**9**
2nd Quarter (Apr, May, Jun)	6	4	3	2	2	5	**0**
3rd Quarter (Jul, Aug, Sep)	4	2	3	1	0	1	**3**
4th Quarter (Oct, Nov, Dec)	13	5	8	10	6	5	**0**
Total	*35*	*25*	*27*	*18*	*9*	*13*	***12***

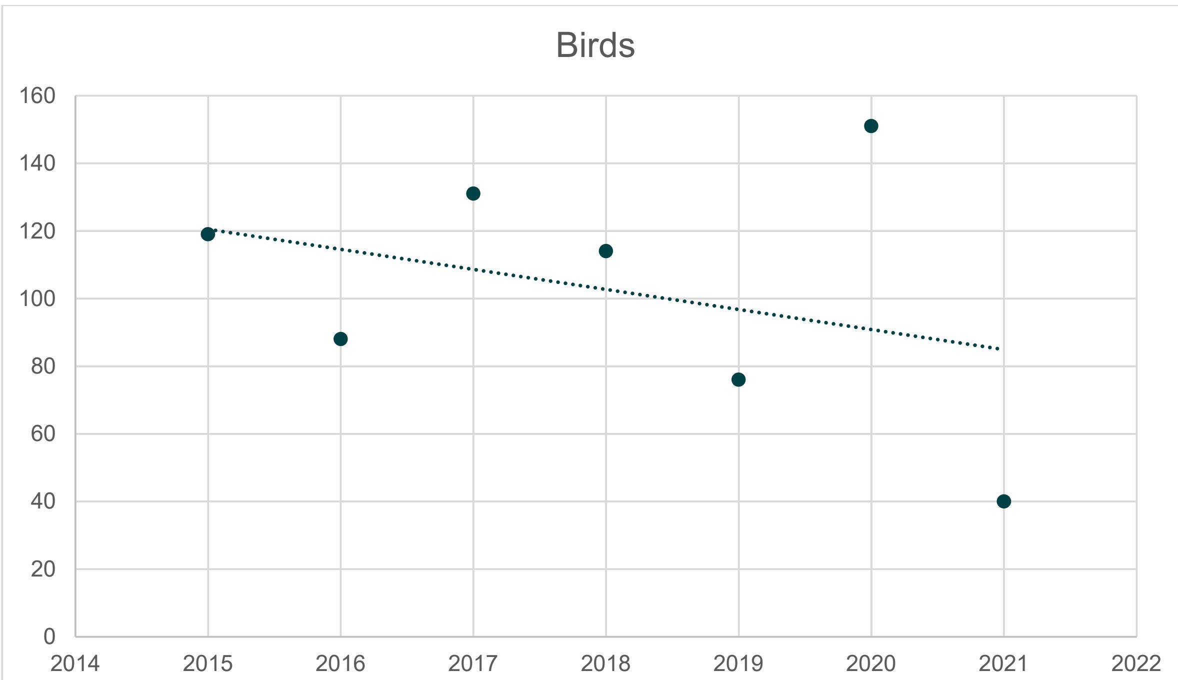

Figure 2-2 Estimated annual mortality for birds 2015 -2021, with trendline indicating a slight downward trend

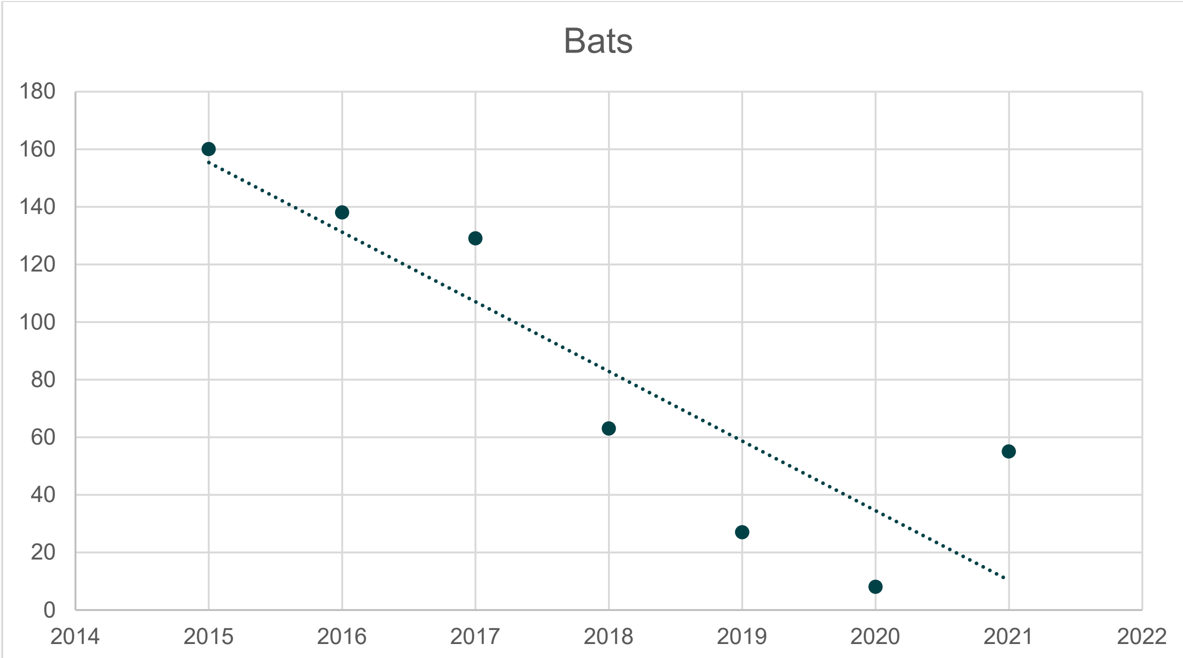

Figure 2-3 Estimated annual mortality for bats 2015-2021, with trendline indicating a clear downward trend

2.3.1 Estimated mortality per turbine per year

Wind farms around the world report bird and bat mortalities as number of birds or bats per turbine per year. From the annual mean estimates of mortality across the wind farm, an estimate of microbat and bird deaths per turbine per year at BRWF can be derived:

- With an estimated 55 microbat collisions across 67 turbines, the rate of microbat collision at BRWF in 2021 was estimated to be 0.82 bats/turbine (i.e. 27 divided by 67).
- With an estimated 40 bird mortalities across 67 turbines, the rate of bird collision at BRWF in 2021 was approximately 0.6 birds/turbine (see Appendix D.1).

These per turbine per year rates are discussed in context of other Australian wind farms in the following Section 2.4.

Table 2-9 compares estimated mortalities per turbine for birds and bats across the seven years of monitoring so far. As can be seen, the rate of bird mortality ranges from approximately 0.6 to 2.3 birds per turbine per year, with this year's (2021) result the lowest to date. For bats, mortality per turbine ranges from approximately 0.12 to 2.4 across the seven years of monitoring. As shown in Figure 2-2 and Figure 2-3, despite annual variations there is a declining trend of mortality at BRWF.

Table 2-9 The number of bird and bat mortalities per turbine per year at BRWF for 2015-2021 derived from Symbolix mortality estimates (all speceis annual mean).

Estimated number of mortalities per turbine per year								
Year	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Average**
Bats	2.39	2.06	1.93	0.94	0.40	0.12	0.82	1.24

Estimated number of mortalities per turbine per year							
Birds	1.72	1.31	1.96	1.70	1.13	2.3	0.6	1.53

2.4 Discussion

The pool of available data for comparison to mortality survey findings at other Australian wind farms has expanded in recent years, along with several summary reports, primarily from Victorian wind farms.

- Symbolix (2020) reports that between 7 and 10.8 bat mortalities occur per turbine per year in western Victoria, with little difference between small and large sized rotor swept areas.
- For birds, they report that between 3.4 and 4.1 bird mortalities occur per turbine per year for smaller turbines and between 5 and 6.7 birds per turbine per year for large turbines.

The average mortality rate at BRWF of 1.2 bats per turbine per year and 1.5 birds per turbine per year is well below calculations at other Australian wind farms.

2.4.1 White-striped Freetail Bats dominate carcass finds

At least 72% of bat carcasses found at BRWF belong to White-striped Freetail Bats. This species is the most commonly found bat species at Australian wind farms; one study found that as many White-striped Freetail Bats are struck at western Victorian wind farms as all birds combined (Symbolix, Post construction bird and bat monitoring at wind farms in Victoria, 2020). The Victorian Arthur Rylah Institute (ARI) conducted a risk assessment to determine if wind farm impacts could become a threatening process for White-striped Freetail Bat. They found that the Victorian populations "were not considered to be at risk such that they would become ... threatened under IUCN criteria from wind turbine collisions" (ARI, 2021). Previous risk assessments and evaluations for White-striped Freetail Bat at BRWF have concluded that the risk to the local population is low (e.g. the 5th Annual Report (NGH Environmental, 2019). We are comfortable that these past assessments remain valid, particularly in the context of the ARI assessment. However, the mortality rate of the White-striped Freetail Bat will continue to be a focus of the monitoring program.

3. Bird utilisation survey

3.1 Methods and effort

Bird utilisation surveys are completed monthly. Each month, ten locations are selected for survey (ideally 120 bird utilisation surveys during the 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.

3.1.1 Notes on BUS strata

Woodland was added as an adjunct stratum in response to OEH (now DPE) concerns for woodland bird species. Woodland habitat is limited within the wind farm and is predominantly located more than 500 m from all turbines and therefore outside of the impact zone as defined in the BBMP v1.3. Woodland survey sites were placed according to availability in the landscape. This design treats all woodland sites as impact sites despite most being more than 500m distant from the turbines. 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.

3.1.2 Effort in 2021

Table 3-1 shows the number of surveys per stratum at BRWF in 2021. A total of 106 bird utilisation surveys were undertaken with 37 sites in grassland control, 35 in grassland impact and 34 in woodland. In 2021, 82% survey coverage was achieved overall (106 from 130 survey sites), although just less than 80% coverage was achieved in the woodland stratum. Refer to Appendix A for bird utilisation survey locations.

Table 3-1 Number of surveys per stratification layer each month and in total for 2021

Month	Grassland Control	Grassland Impact	Woodland	Total
January	3	4	3	10
February	2	2	3	7
March	4	3	3	10

Month	Grassland Control	Grassland Impact	Woodland	Total
1st quarter totals	*9*	*9*	*9*	*27*
April	4	3	3	10
May	3	4	3	10
June	3	2	3	8
2nd quarter totals	*10*	*9*	*9*	*28*
July	3	4	3	10
August	4	3	3	10
September	3	3	4	10
3rd quarter totals	*10*	*10*	*10*	*30*
October	3	4	3	10
November	1	3	3	7
December	4	0	0	4
4th quarter totals	*8*	*7*	*6*	*21*
Total	*37*	*35*	*34*	*106*

3.1.3 Survey limitations

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 of some sites 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 (this year), 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 Results

Qualitative results collated and analysed in-house, alongside quantitative results undertaken externally are presented below. NGH Environmental provided all the 2021 BUS data to Symbolix for statistical analysis. The quantitative analysis of BUS results is undertaken by comparing data from on-site as well as control sites that have been collected through the seven years of operation to identify any changes in species presence or abundance. The longitudinal, reference-treatment (i.e. control-impact) structure of the survey allows to test for changes in on-site data that are not present in the control data (Symbolix 2021b). The methods of analysis involved:

- Box plots to consider species richness, Shannon diversity index and log visual count metrics
- Species-mix plots using ordination method after Bray and Curtis (1957) (in Symbolix 2021b), as well as a log transform (which also accounts for abundance) and a Wisconsin double standardisation.
- Trend modelling for Shannon diversity (gamma generalised linear model with zero-inflation) and species richness (negative binomial generalised linear model)
- Guild analyses.

For a detailed description of statistical methods, please refer to the Symbolix report in Appendix D.2.

3.2.1 Species richness and abundance

Species richness is the count of the number of species in an area. A combined total of 73 bird species were recorded in 2021 during both utilisation surveys and opportunistic observations at BRWF; 59 species were recorded in BUS only. Note: analysis by Symbolix uses only BUS data.

Table 3-2 Species richness each year of BUS monitoring (2015-2021), with current reporting period in italic, and total for monitoring project to date

Year	2015	2016	2017	2018	2019	2020	*2021*	Total
Species richness	89	75	73	69	65	66	*59*	117

Species abundance is the number of individuals per species. Note that aural observations are given a count of one individual. Abundance in 2021 was 665 (observations). This appears to continue a downward trend over the past six years of monitoring, with fewer bird observations every year of monitoring to date (Table 3-3).

Table 3-3 Number of observations during BUS for each year of monitoring at BRWF

	2015	2016	2017	2018	2019	2020	*2021*
Number of observations	1729	1283	1051	948	801	719	*665*

As the lead ecologist for each survey has been the same person, this is not likely to be an observer effect. For 2021, lower species abundance will have been influenced by reduced survey effort due to wet weather, particularly during February, November and December surveys. The reduced survey effort in 2021 coincides with the months that usually have the highest activity and species richness levels (spring/summer).

Symbolix analyse this further including species diversity which is a measure of species richness and relative abundance within an area (e.g. stratum) in Section 3.2.2. Note that previous statistical analysis reported in Annual Reports have correlated climatic conditions (i.e. declining rainfall) with this trend however this is not relevant in 2021 with well above average rainfall recorded over the year. Other influences are discussed in Section 3.3.

Habitat stratification layers

Table 3-4 show species richness and abundance recorded in each stratification layer during utilisation surveys between January and December 2021. The total species richness was 59 and the total number of observations (abundance) was 665. The highest abundance was in woodland sites (324), followed by grassland control sites (214). The lowest abundance was in grassland impact sites (127). This trend of descending abundance from woodland to grassland impact sites has been well established and discussed for BRWF.

Table 3-4. Species richness and abundance at grassland impact and control, and woodland utilisation survey sites from January to December 2021.

Bird species	Stratification Layer			
	Grassland control	Grassland impact	Woodland	Total
Richness	24	11	55	59
Abundance	214	127	324	665

Over time at BRWF, species richness (Table 3-5) and abundance (Table 3-6) has been decreasing across grassland control, grassland impact and woodland sites (N.B. survey site changes account for large change for control sites between 2015 and 2016; as detailed above).

Table 3-5 Species richness by each year of monitoring (2015-2021) for each stratum

	2015	2016	2017	2018	2019	2020	2021
Grassland control	63	36	30	35	28	26	24
Grassland impact	40	29	28	21	14	19	11
Woodland	66	58	58	53	53	52	55

Table 3-6 Species abundance by each year of monitoring (2015-2021) broken down by stratum

	2015	2016	2017	2018	2019	2020	_2021_
Grassland control	1059	1023	1022	928	687	698	_214_
Grassland impact	1014	696	572	471	423	365	_127_

	2015	2016	2017	2018	2019	2020	*2021*
Woodland	1311	1039	768	798	575	522	*324*

Rather than the species richness count of 11 for 2021 being a large decrease compared to 2020, it appears that this is a continuation of the general trend for grassland impact (although the species richness count in the grassland impact sites may have been influenced by zero December surveys for that stratum). Instead, the spike of 19 species in 2020 is more likely to be the anomaly.

The trendlines in Figure 3-1 (derived by NGH) show a similar angle of decline for grassland impact and grassland control sites. The woodland stratum is more stable than the grassland, although also decreasing. These results suggest that declining species richness appears to occur both within and outside the BRWF impact area, and is therefore unlikely to be caused by the wind farm operation.

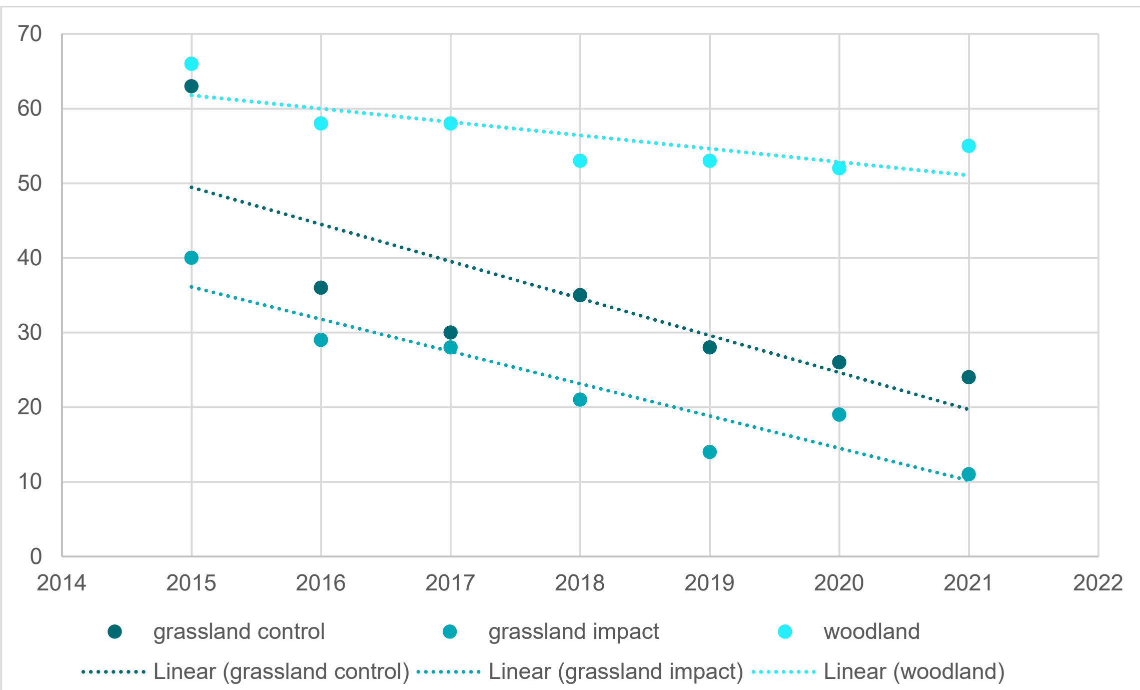

Figure 3-1 Scatterplot and trend lines for species richness at grassland control, grassland impact and woodland BUS sites over time (2015-2021)

Individual species and abundance

Table 3-7 provides a list of the most common individual species (30 or more observations) recorded during bird utilisation surveys in 2021. Observations of the introduced species Eurasian Skylark (183) continue to be substantially more frequent than that of any other bird species at grassland impact and control sites. They are rarely recorded at woodland sites. The most frequently recorded native species are common, ubiquitous grassland and woodland birds (Magpies, Ravens, Red Wattlebirds). Note, Eurasian Skylark and Australian Magpie are also the most common species found during mortality surveys (refer to Section 2.2.2).

A point of difference this year though, is the slightly higher proportion of woodland birds in the most common species list; this can probably be accounted for by the cancellation of multiple grassland bird surveys due to wet weather, as discussed in Section 3.1.3.

Table 3-7. Most common species recorded during bird utilisation surveys (>30 observations across all sites) in 2021.

Common Name	Observations			
	Grassland	Control	Woodland	Total
Eurasian Skylark*	67	116	0	183
Australian Magpie	18	28	28	74
Little Raven	13	23	5	41
Common Starling*	10	9	17	36
Striated Pardalote	0	0	31	34
Red Wattlebird	0	2	29	31

* Indicates exotic species.

3.2.2 Control-impact comparisons (Symbolix, 2021b)

The significance of changes in results from year-to-year which are documented in the preceding section, and whether these changes amount to trends, is analysed statistically in this and the following section. Multiple analysis types are used to search for any indications of significant change, which can then be followed up in the discussion to work out whether such changes could be caused by the operation of BRWF. Each analysis type may yield slightly different outcomes as the data is looked at in different ways. These are explained below.

Species richness

The overall bird species richness of woodland sites is higher than both the grassland and control sites (Figure 3-2) which is to be expected given the greater habitat complexity of woodlands. Woodland species richness has remained fairly constant over the last four years, accounting for seasonal variation. This variation is reflected in lower species richness in the second and third quarters of the year. There does appear to be a slight decreasing trend over the course of the seven years.

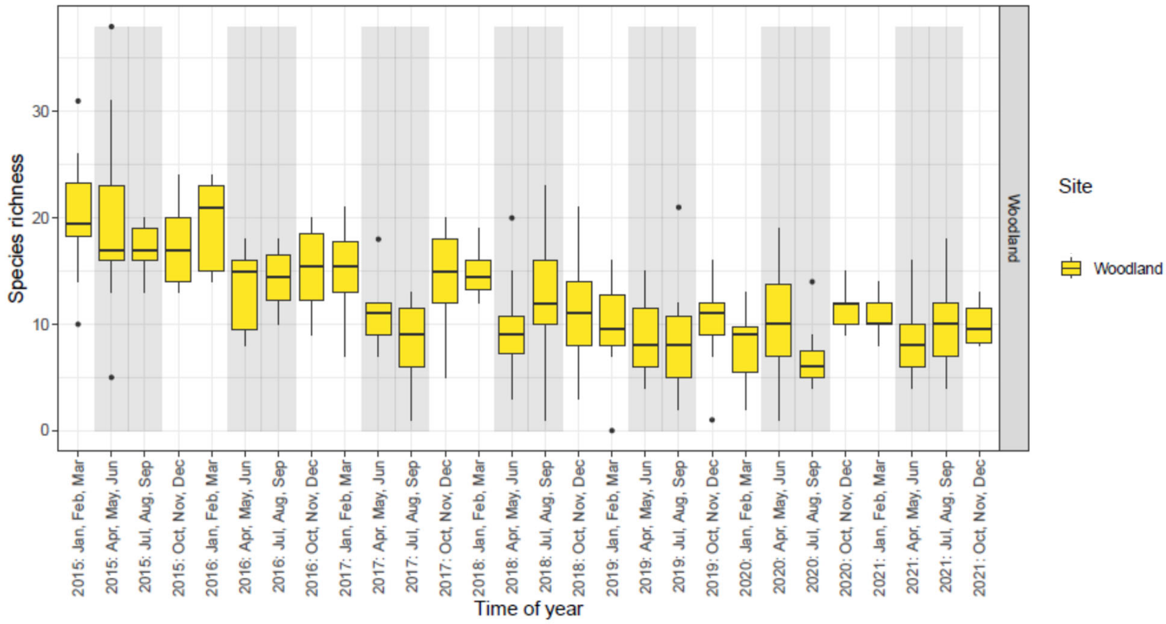

Figure 3-2 Distribution of species richness per survey, by site and time of year, Winter months highlighted in grey. Woodland sites only (Source: Symbolix 2022b)

Figure 3-3 shows species richness for grassland impact and control sites. The richness in grassland impact and control sites remains fairly stable, although there is a slight decrease even taking into consideration skews caused by missed surveys over the years.

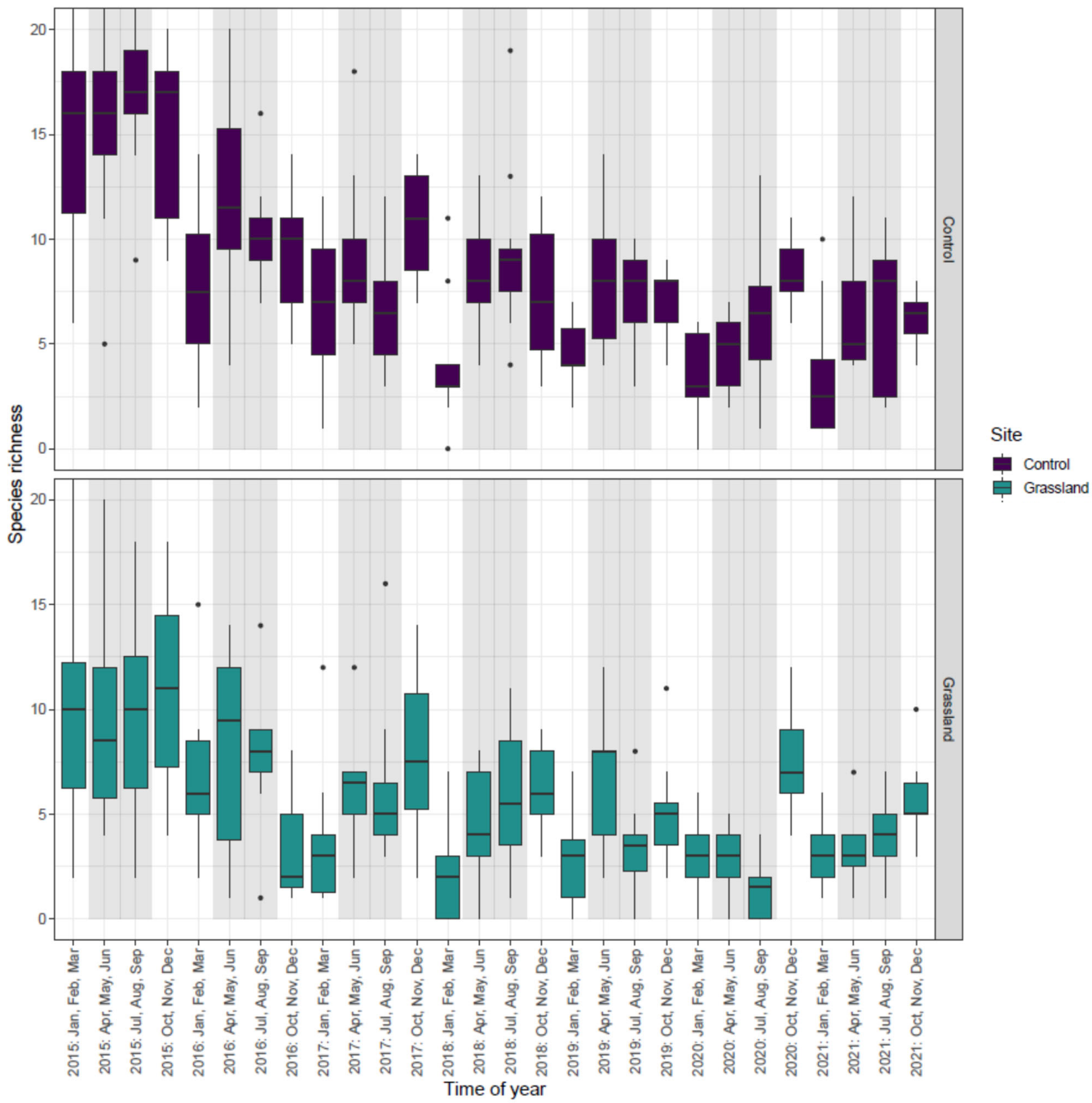

Figure 3-3 Distribution of species richness per survey, by site and time of year. Winter months highlighted grey. Grassland impact and control sites only.

Species abundance

Abundance of individual species (based on visual and auditory counts) varies from year to year although the mix of most abundant species is generally stable across years. There are a few exceptions, such as an increase in abundance in 2021 in observations of Australian Wood Duck *Chenonetta jubata*. This is likely caused by the increase in the rainfall the filling up of the waterbodies within the vicinity of the BRWF.

Species diversity

The Shannon diversity plot (Figure 3-4) showed similar patterns to the richness plot with seasonality effects in the woodland and fairly stable grassland control and impact sites. The first half of 2021 appears to show lower diversity than usual.

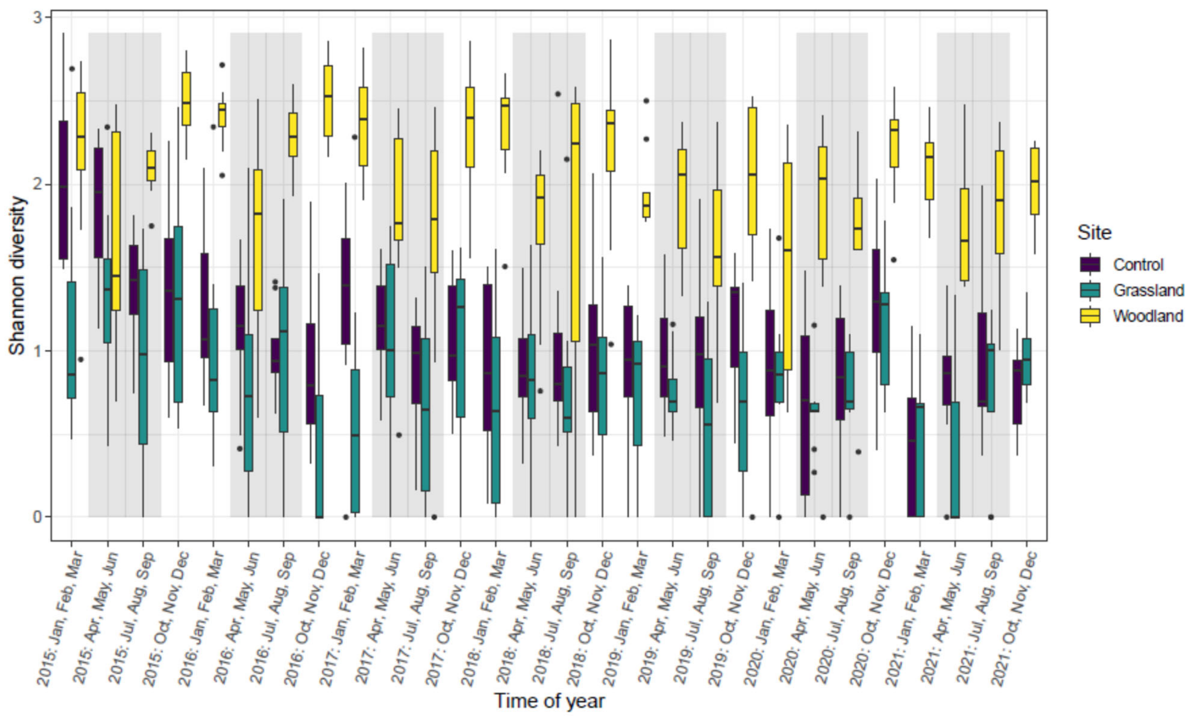

Figure 3-4 Distribution of Shannon diversity per survey, by site and time of year (Symbolix, 2022b)

Species assemblage

Technically, species assemblage refers to the bird community, while ‘species mix’ is used by statisticians to refer to the *surveyed* observations (which is a subset of the community). Trends in the mix inform us about trends in the underlying assemblage, and in this report, the terms are used interchangeably.

Figure 3-5 shows that the species assemblage at the woodland sites is distinct from the grassland sites, and that there is less variation in the woodland than in grassland. There is movement or change in the species mix over time at all sites.

At grassland control and impact sites, there does appear to be a shift in species assemblage over time. This shift is a little more prominent in the impact stratum, but as the shift is mirrored in the control stratum, there is no evidence of the shift being related to turbine impacts.

The ordination plots in Figure 3-5 below, show that there are general changes in the species assemblage over time, in all strata. The log transform and Wisconsin double standardisation tests presented the same patterns: a shift in the species mix over time, evident across all strata.

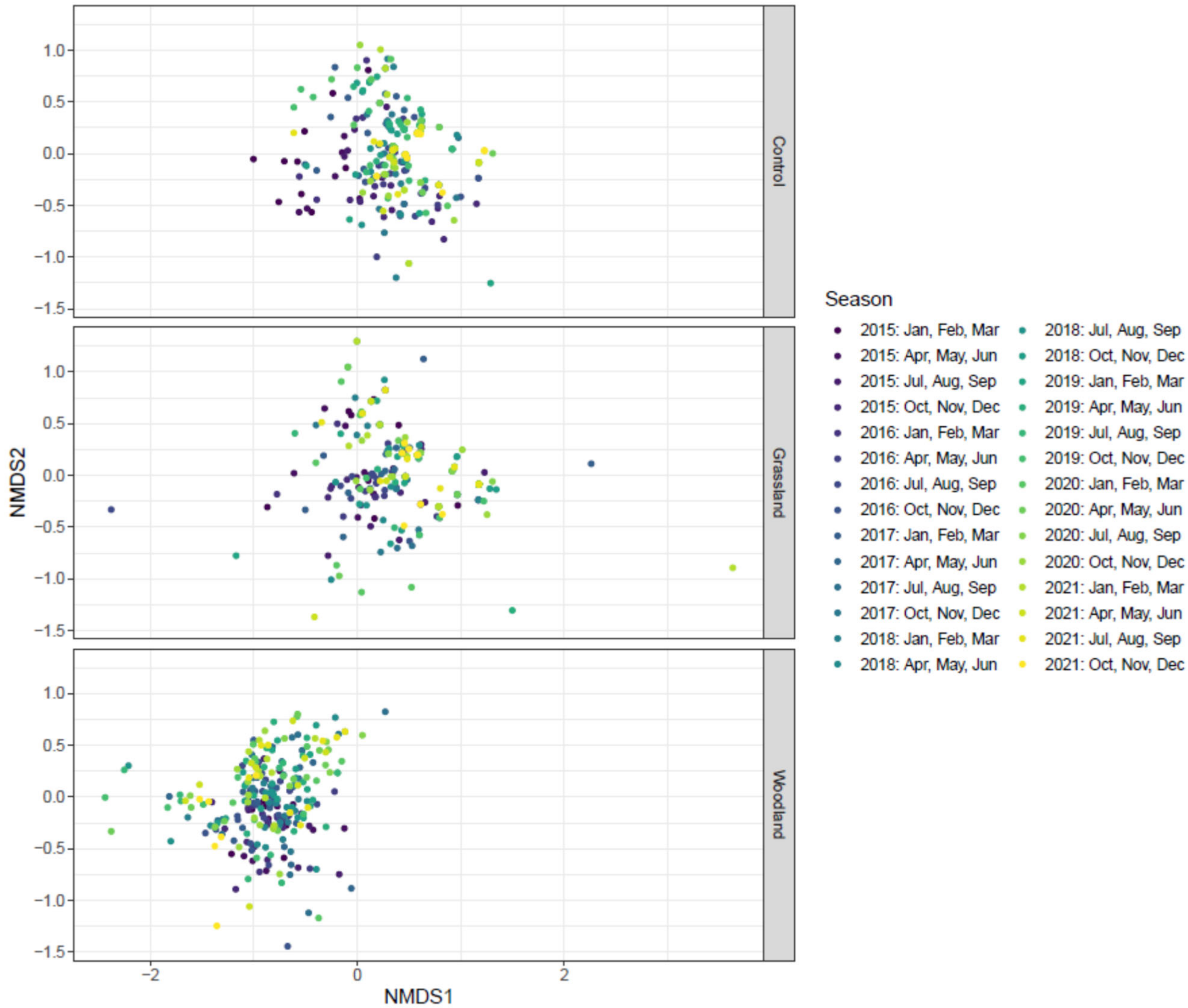

Figure 3-5 Species assemblage plot showing species mix per survey over time grouped by season and site, with distance based on presence/absence (Source: Symbolix 2022b). The closer the graphed dots, the more similar the species assemblage. Darker dots are earlier surveys with the colour lightening to yellow for the most recent surveys.

3.2.3 Trending modelling (Symbolix, 2021b)

Shannon diversity

Trend modelling of bird diversity as measured by the Shannon diversity index for BRWF showed the following:

- Shannon diversity appears to be decreasing over time.
- The positive association between (log) distance from turbine and Shannon diversity is still observable – the greater distance from a turbine, the greater Shannon diversity encountered.
- Baseline diversity is lower in the grassland impact sites but its' changes are reflected in the control area.

Richness

Bird species richness trend modelling provided much the same results as the Shannon index of bird diversity: species richness appears to be decreasing over time across all strata.

3.2.4 Guilds

Bird species have been grouped into the following 15 foraging guilds:

a) Wetland
b) Ecotonal predator
c) Ecotonal foliage, blossom and bark feeders ('ecotonal FBB')
d) Ecotonal ground feeder
e) Introduced ecotonal foliage, blossom and bark feeders ('introduced ecotonal FBB')
f) Native grassland ground feeders (insectivores, herbivores and granivores)
g) Introduced grassland ground feeders
h) Woodland ground feeders (including from fallen timber)
i) Woodland foliage, blossoms, and bark feeders ('woodland FBB')
j) Aerial insectivore
k) Aerial hover / pounce
l) Aerial pursuit
m) Aerial soaring / quartering
n) Generalist ground feeders
o) Nocturnal

The allocation of species to each guild is given in Appendix C.1. Table 3-8 shows the most abundant (greater than 100 observations) foraging guilds recorded in utilisation surveys at BRWF in 2021.

From a total of 781 bird observations in 2021, 222 (28%, or about one third of all observations) were attributed to the Introduced Grassland guild. This is a change from last year when the native Generalist Ground guild was most numerous for the first time. The abundance of the Introduced Grassland guild is otherwise consistent with previous years. In 2021, the Generalist Grassland guild (159 observations) accounted for 20% of the total count. Ecotonal FBB and Woodland FBB are the next most frequently observed guilds (16% and 14% respectively), which is consistent with previous years.

Table 3-8 Most abundant (>100 observations) foraging guilds recorded at BRWF during bird utilisation surveys in 2021.

Foraging guilds	Observations			
	Grassland impact	Grassland control	Woodland 'impact'	Total
Introduced grassland ground	77	127	18	222
Generalist ground	40	63	56	159
Ecotonal FBB	5	5	116	126
Woodland FBB	0	2	105	107

Analysis (Symbolix, 2022b)

Distance relationships

Symbolix looked at bird guilds at different distances from turbines but found no evidence of a statistically significant relationship between distance and proportion of different bird types. That is, the occurrence of birds from particular foraging behavioural guilds is not determined by distance from turbines. 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.

3.2.5 Threatened species and raptors

Threatened species

Four NSW (BC Act 2016) threatened species were recorded during bird surveys or opportunistically on nine occasions in 2021:

1. Dusky Woodswallow *Artamus cyanopterus*
2. Hooded Robin *Melanodryas cucullata*
3. Scarlet Robin *Petroica boodang*
4. Speckled Warbler *Chthonicola sagittate*

The most frequently recorded threatened species was the Scarlet Robin, recorded four times in 2021. All species were recorded during bird utilisation surveys. All observations were within woodland habitat, except for one observation of Hooded Robin at Control 1 in August 2021. Table 3-9 gives the locations of all threatened species sightings, with the locations shown on maps in Appendix C.4.

Fourteen NSW and Commonwealth threatened species have been detected at BRWF since monitoring began in January 2015. In addition to those species listed above, the following have been recorded in previous years: Brown Treecreeper *Climacteris picumnus*, Diamond Firetail *Stagonoleura guttata,* Flame Robin *Petroica phoenicea*, Freckled Duck *Stictonetta naevosa*, Gang-gang Cockatoo *Callocephalon fimbriatum*, Little Eagle *Hieraaetus morphnoides*, Spotted Harrier *Circus assimilis*, Varied Sittella *Daphoenositta chrysoptera,* White-bellied Sea Eagle *Haliaeetus leucogaster*, White-throated Needletail *Hirundapus caudacutus*.

No threatened bird species were detected during mortality surveys in 2021 (as discussed in Section 2.2).

Raptors

Five raptor species were recorded during bird surveys or opportunistically on 37 occasions at BRWF in 2021:

1. Australian Hobby *Falco longipennis*
2. Black-shouldered Kite *Elanus axillaris*
3. Brown Falcon *Falco berigora*
4. Nankeen Kestrel *Falco cenchroides*
5. Wedge-tailed Eagle *Aquila audax*

Only 22% of the raptor observations were recorded during bird utilisation surveys in 2021; most are opportunistic. In 2021, the most frequently recorded raptor was Nankeen Kestrel with 20 observations, followed closely by Wedge-tailed Eagle with 9 observations (this count does not include targeted WTE nest monitoring undertaken October to December). Table 3-9 provides information on all raptor sightings in 2021; these are also shown in Appendix C.4.

Twelve raptor species in total have been detected at BRWF since monitoring began in 2015. In addition to those five raptors listed above, the following have been recorded in previous years: Brown Goshawk *Accipiter fasciatus*, Collared Sparrowhawk *Accipiter cirrocephalus,* Little Eagle *Hieraaetus morphnoides*, Peregrine Falcon *Falco peregrinus*, Spotted Harrier *Circus assimilis*, Swamp Harrier *Circus approximans*, and White-bellied Sea Eagle *Haliaeetus leucogaster.* Five of these species have been found in mortality surveys: Nankeen Kestrel, Wedge-tailed Eagle, Peregrine Falcon, Brown Falcon and Brown Goshawk.

Combining BUS and opportunistic records, the 37 raptor observations in 2021 is greater than 2020 and 2019 observations (both 23); is similar to raptor observations in 2016 and 2017 (both 38) and is lower than observations in 2015 and 2018 (59 and 47 respectively). Median annual raptor observations 2015-2021 is 38. The number of observations in 2021 (37) is very close to the median.

Analysis (Symbolix, 2022b)

Symbolix grouped all raptor species into a single guild (raptors) to enable analysis due to the small dataset for the sub-guilds (including ecotonal predator, aerial pursuit, aerial soaring / quartering, etc). Even so, the dataset for raptors obtained during utilisation surveys only was insufficient to perform statistical tests. However, it was evident that there were fewer raptor observations (*during utilisation surveys only*) in 2019, 2020 and 2021 than in previous years (2015, 2016, 2017, 2018). Raptor mortalities have fairly been steady during this time (average of two each year, range between 1-4/year).

3.2.6 Summary

The woodland stratum does not have a reference site, as most woodland is located more than 500 m from a turbine. Within the stratum, species richness is fairly stable, species diversity changes with the season and the species assemblage has changed over time. As expected, based on habitat, woodland survey results are different to grassland in species richness and relative abundance. It is not possible to link changes in the woodland to windfarm operation as the sites are generally distant from the turbines, but there is no evidence of an impact of the wind farm on woodland bird species abundance and richness.

Grassland impact sites have consistently lower bird abundance and richness compared to the grassland control sites. This is likely to be related to habitat or landscape position (as described in Section 3.1.1) as decreases in diversity and abundance observed in grassland impact sites are also observed in grassland control sites. Thus, there is no evidence that the changes observed in birds have been caused by the wind farm.

These observations are discussed fully in the following Section 3.3.

Table 3-9. Threatened bird species and raptor species recorded at Boco Rock Wind Farm from January to December 2021.

Common Name	Stratum	Location	Co-ordinates (threatened species)	Month	Observation type	Number recorded
Threatened species						
Scarlet Robin	Woodland	132	685698 5939244	Feb	Heard	1
	Woodland	107	684638 5938677	Mar	Heard	1
	Woodland	122	685524 5939471	Jun	Heard	1
	Woodland	113	685472 5939788	Jul	Seen	2
Hooded Robin	Control	1	692273 5955861	Aug	Seen	1
	Woodland	26r	685969 5938280	Oct	Heard	1
Dusky Woodswallow	Woodland	137	685063 5940153	Jan	Flying at 4 m height	4
	Woodland	26r	685969 5938280	Oct	Seen	3
Speckled Warbler	Woodland	132	685698 5939244	Feb	Seen	1
Total						**15**
Raptors						
Wedge-tailed Eagle		Turbine 20		Jan	Flying at ~100 m height	1
		Turn-off to Turbine 58		Mar	Seen, 60 m height	1
		West of Turbine 6		Mar	Seen, 100 m height	2

Common Name	Stratum	Location	Co-ordinates (threatened species)	Month	Observation type	Number recorded
	Control	36r		Apr	Seen	1
		Turbine 55		Apr	Seen	1
		Turbine 62		Aug	Seen	1
	Woodland	119		Aug	Seen	1
	Woodland	25r		Nov	Seen	2
		Turbine 58		Nov	Seen	1
Black-shouldered Kite		Turbine 35		Sep	Seen	1
		B/W T02a and T02		Nov	Seen	1
Australian Hobby		Gate to Turbine 26		May	Seen	1
		Turbine 26		Aug	Seen	1
Brown Falcon		At front gate		Jan	Flying at ~15 m height	1
		Gate to Turbine 36		Mar	Seen, 10 m height	1
		Between T33 & T32		Sep	Seen	1
		Front gate at Avon Lake Rd		Dec	Seen	1
Nankeen Kestrel		Turbine 3		Jan	On ground	1
		Turbine 25		Jan	Flying at ~6 m	1

Common Name	Stratum	Location	Co-ordinates (threatened species)	Month	Observation type	Number recorded
					height	
		Between Turbine 34 and 37		Jan	Flying at ~7 m height	1
		Turbine 37		Jan	Flying at ~7 m height	1
		Between T2A and 2		Feb	Flying at ~ 10m	1
		Near Turbine 45		Feb	Flying at ~ 40m	2
		Turbine 14		Feb	On the ground	4
	Grassland	43		Mar	Seen, 5 m height	1
		Turbine 49		Mar	Seen, 5 m height	2
		Near Turbine 23		Mar	Seen, 15 m height	4
		Near Coopers Lake		Aug	Seen	1
	Woodland	170		Sep	Seen	2
		Turbine 58		Sep	Seen	1
		Turbine 3		Sep	Seen	2
	Grassland	51		Oct	Seen	1
	Grassland	83		Oct	Seen	1
		Turbine 09		Oct	Seen	1

Common Name	Stratum	Location	Co-ordinates (threatened species)	Month	Observation type	Number recorded
		Turbine 54		Nov	Seen	1
	Control	45r		Dec	Seen	1
		Turbine 25		Dec	Seen	1
Total						**37**

3.3 Discussion

3.3.1 Temporal changes in bird species assemblage

At BRWF, the species assemblage has shifted over time at woodland sites as well as grassland impact and control sites (as discussed in Section 3.2.2). This result is not unexpected given that recent research suggests bird assemblages generally are not stable entities, but rather they fluctuate in response to many factors (Maron, Lill, Watson, & Mac Nally, 2005). Such factors include Australia's highly variable climate, local, regional and continental scale resource variations, interspecific competition, fluctuations in predator abundance and habitat changes (Maron, Lill, Watson, & Mac Nally, 2005). Temporal variation in habitat availability, particularly in relation to water availability in a wetland landscape, strongly influences bird species assemblage more than it influences species richness (Lorenzon, et al., 2019). Stochastic processes (i.e. random events such as fire, flood) have also been found to be an important influence on bird assemblage over time (Baselga, Bonthoux, & Balent, 2015).

The key to interpreting the species assemblage change at BRWF is to compare the impact stratum to the control. At BRWF, changes in the grassland impact stratum have been mirrored in the control stratum. On this basis, it is determined that the wind farm operation is not driving the change but rather other processes such as those listed above.

3.3.2 Declining species richness

Qualitative and quantitative analysis shows a gradual decline in species richness at all three strata – this is more clear at the grassland sites but is 'slight' in magnitude across the board. The cause of declining species richness is perplexing as past analysis has shown there is a relationship between annual rainfall and species richness and diversity at BRWF, with below average rainfall years netting lower species richness and above average rainfall years netting higher species richness. This rainfall-diversity association is well supported in the literature e.g. (Keast & Marshall, 1951), with rainfall being a proxy for productivity.

Rainfall was well above average in 2021 (as detailed in Section 1.5); theoretically this should have lead to an increase in species richness, but instead richness (from BUS only) declined from 66 (2020) to 59. This is most striking in the grassland strata (impact and control combined) from 32 (2020) to 24 this year. Some explanation is provided by a reduction in survey effort but could also be related to climatic conditions (further discussion in Section 3.1.3).

However, Symbolix do not recommend re running models but updating the detectability trial in line with updates proposed to the survey methodology proposed in an anticipated updated BBMP. As current survey effort for BRWF is quite high and climatic changes (drought followed by high rainfall, La nina) could be responsible for changes in mortality detection (E. Stark, pers comm. 28/03/2022). This is supported by BUS surveys showing a reduced species richness and diversity at both the control and impact sites over the last two years (2020-2021).

Regarding grassland species richness, again the key to interpretation is to compare the impact stratum to the control. At BRWF, changes in the grassland impact stratum have been mirrored in the control stratum. On this basis, it seems wind farm operation is not driving the change but rather other processes, which may include:

a) Survey conditions were frequently less than ideal with windy and rainy conditions common throughout the year (refer to Appendix 9.A.2. This affects bird behaviour and visibility.

b) Studies suggest that recovery can be slow following periods of prolonged dry conditions (Ellis and Taylor 2014a, Ellis and Taylor 2014b, Recher and Davis 2014).

c) Ongoing deleterious bird population effects of the 2019/2020 'Black Summer' bushfires, particularly given the large tracts of fire-affected land to the north, east, south and west of the site (documented in the 2020 Annual Report).

d) The temporal scale of analysis (i.e. annual) may be too fine, leading to noise in the results given the natural variation and dynamic nature of bird communities and the long-term nature of processes such as colonisation and long-distance dispersal. White *et al*. (2010) suggest that regional influences trump local environmental variances in determining local species richness as a study becomes longitudinal. They explain that any site at any time would hold a certain suite of core species, along with a suite of 'occasional' species. The richness of occasional species is influenced at a regional (or continental) rather than local scale. (White, Morgan Ernest, Adler, Hurlbert, & Lyons, 2010).

   It may be that species richness was particularly high during the initial monitoring years (2015-2017); the regional conditions preceding years would need to be considered to understand this observation. Early species richness measurements included a smaller group of core species and a number of occasional species.

e) Interpretation of results needs to be in line with the statistical sampling design, which is year-to-year comparisons rather than before-after-control-impact design. Results of 2015 are not a baseline for comparison. The design allows large changes to be discernible and does not rely on the assumption that a single baseline measurement accurately captures 'before' conditions in dynamic systems.

f) It is possible that there is a greater spatial effect of habitat alienation caused by the turbines than anticipated and that some of the control sites are being affected by turbine operation. This is discussed in greater detail below.

g) Table 3-10 Annual rainfall at Nimmitabel (BOM, 2022) compared to species richness overall (figures given for utilisation only and utilisation plus opportunistic in bracket), at grassland sites only and wetland species only for all years of monitoring (2015-2020).

	Annual rainfall (mm)	Species richness overall	Grassland (C & I) sites only	Wetland species only
2015	749.3	89 (95)	71	17
2016	782.5	75 (89)	45	19
2017	695.3	73 (87)	41	20
2018	453.8	69 (72)	37	8
2019	352.9	65 (66)	30	3
2020	729.5	66 (68)	32	9
2021	1005.6	59 (73)	24	16

3.3.3 Shannon diversity increases with distance from turbines

Symbolix found that there is a positive association between (log) distance from turbine and Shannon diversity. 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 one at ten times the distance is expected to have 1.09 times the diversity. This may be due to the choice of exposed ridgetop locations for turbine infrastructure, which provide poorer habitat than sites on more heterogenous lower slopes. Or is may also be that turbine activity and infrastructure has caused a habitat alienation effect, also known as a displacement effect, which may lead to functional habitat loss.

One study found that the displacement effect of wind turbines on Black Kites *Milvus migrans* in the Strait of Gibraltar may have been as great as 674 m (Marques, et al., 2020). At BRWF, control sites are chosen to be 500 m or great from turbines. If other local species display similar displacement as Black Kites, it is possible that some control sites may in fact be influenced by turbine operation (i.e. be impact sites). There is little available research in this field as yet.

For BRWF, if low species richness persists throughout the current year (2022), particularly in the combined grassland strata with continuing rainfall (La nina), it may be worth analysing existing data further in the context of updating the BBMP to ensure accuracy for the current climatic conditions and in light of seven years of monitoring data. Analysis of the location of BUS data, for example by separating out closer and more distant control sites to search for a displacement effect could establish a more efficient future monitoring program where BUS surveys are significantly reduced.

4. Microbat surveys

4.1 Methods and effort

Passive overnight Anabat surveys were undertaken four times during 2021. 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 2021 is shown in table. Results were analysed by consultant bat expert Glenn Hoye of Flight by Night Bat Surveys.

Table 4-2 Microbat (Anabat) survey effort for 2021 at BRWF

Reporting quarter	Date	Effort
1st quarter	1-5 March 2021	4 units for 4 nights; 16 survey nights.
2nd quarter	10-14 May 2021	4 units for 4 nights; 16 survey nights.
3rd quarter	13-17 September 2021	4 units for 4 nights; 16 survey nights.
4th quarter	10-14 November 2021	4 units for 4 nights; 16 survey nights.[4]
Total		64 survey nights

[4] This Anabat data was not analysed due to the SD cards being lost in the post between subcontractors and NGH offices.

4.1.1 Survey limitations

Survey conditions have been inconsistent with 'suitable conditions' for microbat surveys ("hot, warm or mild and calm" p. 6 OEH 2018), including very cold overnight and heavy rain conditions in:

- March: -1.1°C minimum overnight
- May: overnight minimum temperatures ranged from 0 to 6.4 degrees Celsius
- September: overnight minimum temperatures ranged from -5.0 to 4.8 degrees Celsius, along with heavy overnight rain.

The survey data in November was lost and therefore remains unanalysed. After collection of the Anabat units, the SD cards containing the data posted by the subcontracted ecologist were lost in transit to NGH, and bat call analysis could not be undertaken. Unfortunately, this means there is no bat call data for the fourth quarter 2021.

Although the lost SD cards creates limitations for data analysis, the Anabat results are not vital to the monitoring program. The mortality surveys are the most vital data for understanding impacts. One aim of collecting Anabat data is to allow further exploration into bat species presence if excessive mortalities were found. However, no bat (or bird) mortalities were found during the fourth monitoring quarter.

4.2 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*

4.2.1 Result summary

Despite less-than-ideal survey conditions, 4,901 call files were analysed. Table 4-3 presents total call analysis for each species. The highest level of activity was detected at AE3 woodland impact site, with more than 4600 call analysed from this site over the three surveys (March, May, September). Gould's Wattled Bat was the most frequently detected species, present at all four sites and with a high number of passes at AE3. Other species accounted for 56% of the microbat activity (2757 files).

Threatened species Eastern False Pipistrelle and Large Bent-winged Bat were detected at both woodland sites only.

Table 4-3 Results of Anabat analysis with selected species, all quarters combined 2021 (all sites)

Species	AE1 Grassland control	AE2 Grassland Impact	AE3 Woodland impact	AE4 Woodland control	Total for spp
Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)	0	0	12	3	15
Gould's Wattled Bat (*Chalinolobus gouldii*)	2	4	1957	75	2038
Large Bent-winged Bat (*Miniopterus orianae oceanensis*)	0	0	54	16	70
Other species	3	2	2636	116	2757
White-striped Freetail Bat (*Austronomus australis*)	0	1	14	6	21
Total for sites	**5**	**7**	**4673**	**216**	**4901**

4.2.2 Results by quarter

Gould's Wattled Bat was the most frequently recorded bat in March surveys (Table 4-4), with 2011 files allocated to this species including 1932 from the AE3 woodland impact site. The greatest activity level was measured in AE3 woodland impact, followed by AE4 woodland control.

Table 4-4 Anabat survey results, first quarter (March) 2021, with certain identification in brackets

Name	AE1 Grassland control	AE2 Grassland Impact	AE3 Woodland impact	AE4 Woodland control	Total
Eastern False Pipistrelle *Falsistrellus tasmaniensis*	0	0	12 (10)	3 (2)	15 (12)
Gould's Wattled Bat *Chalinolobus gouldii*	2 (2)	4 (3)	1932 (1827)	74 (26)	2011 (1853)
Large Bent-winged Bat *Miniopterus orianae oceanensis*	0	0	26 (16)	12 (3)	38 (19)

Name	AE1 Grassland control	AE2 Grassland Impact	AE3 Woodland impact	AE4 Woodland control	Total
White-striped Freetail Bat *Austronomus australis*	0	1	6 (5)	5 (3)	12 (8)
Other species	3	2	1458	95	1558
Total	5	6	3434 (3316)	189 (129)	3634 (3450)

In May 2021, all the microbat activity was detected in the two woodland survey sites; no activity was detected in the grassland sites. This may be related to the insulating effects of the woodland vegetation in the colder May conditions, allowing higher activity levels in those areas compared to open, frosty grassland. The majority (1165) of autumn calls were attributed to 'other species'; the next most frequently recorded (31) microbat was Large Bent-winged Bat, a NSW threatened species although less than 40% of these calls were classified as a 'certain' identification (shown in brackets).

Table 4-5 Anabat survey results, second quarter (May 2021)

Name	AE1 Grassland control	AE2 Grassland Impact	AE3 Woodland impact	AE4 Woodland control	Total
Eastern False Pipistrelle (*Falsistrellus tasmaniensis)*	0(0)	0(0)	0(0)	0(0)	0(0)
Gould's Wattled Bat (*Chalinolobus gouldii)*	0(0)	0(0)	23(21)	1(0)	24(21)
Large Bent-winged Bat (*Miniopterus orianae oceanensis)*	0(0)	0(0)	27(11)	4(1)	31(12)
White-striped Freetail Bat (A*ustronomus australis)*	0(0)	0(0)	1(1)	1(1)	2(2)
Other species	0(0)	0(0)	1147(894)	18(14)	1165(908)
Total	0(0)	0(0)	1198(927)	24(16)	1222(943)

The spring September surveys were also undertaken during cold weather (refer Section 4.1.1), and again microbat activity was recorded in woodland sites but not grassland sites. The level of activity coming out of the winter was much lower than the autumn May survey (total 44 call passes identified in September compared to 1222 in May). The majority of calls in early Spring were attributed to 'other species'. In September there was no certain identification of threatened species (shown in brackets).

Table 4-6 Anabat survey results, third quarter (September 2021)

Name	AE1 Grassland control	AE2 Grassland Impact	AE3 Woodland impact	AE4 Woodland control	Total

Name	AE1 Grassland control	AE2 Grassland Impact	AE3 Woodland impact	AE4 Woodland control	Total
Eastern False Pipistrelle *(Falsistrellus tasmaniensis)*	0(0)	0(0)	0(0)	0(0)	0(0)
Gould's Wattled Bat *(Chalinolobus gouldii)*	0(0)	0(0)	2(1)	0(0)	2(1)
Large Bent-winged Bat *(Miniopterus orianae oceanensis)*	0(0)	0(0)	1(0)	0(0)	1(0)
White-striped Freetail Bat *(Austronomus australis)*	0(0)	0(0)	7(0)	0(0)	7(0)
Other species	0(0)	0(0)	31(29)	3(3)	34(32)
Total	0(0)	0(0)	41(30)	3(3)	44(33)

4.2.3 Threatened microbat species

Two threatened microbat species were recorded at BRWF in 2021:

- 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 and 2021.

The loss of the November Anabat data will certainly have had an effect on number of call passes for all species, including threatened (refer to Section 4.1.1).

Neither of these species were detected in mortality carcass search surveys in 2021.

4.3 Yearly comparisons

The total volume of calls was greater in 2021 (4901) than the previous year. This may be related to a rainfall-species abundance correlation as for birds and other animals species. At an individual species level, results vary.

In 2021, Large Bent-winged Bat was detected at woodland survey sites only AE-3 (woodland impact) and AE-4 (woodland control) surveys sites with a total of 70 calls; the highest number of calls were detected in March (12 certain). In comparison, in 2020 Large Bent-winged Bat was recorded with greater frequency (310 calls) and across all four sites (including grassland), again with the highest number of files in March 219 certain).

In 2021 it was detected in the March survey only at AE-3 (woodland impact) and AE-4 (woodland control), with a total of 15 passes. This is a similar frequency to 2020 (17), although slightly different spatial use of BRWF; in 2020 Eastern False Pipistrelle was detected at AE-1 (grassland control), AE-2 (grassland impact) and AE-3 (woodland impact).

'Other species' were the most frequently recorded bat in both 2021 (2757 calls) as well as 2020 (2513 calls), followed by Gould's Wattled bat (2038 calls in 2021; 839 calls in 2020). Gould's Wattled Bat is the second most frequently found bat carcass during mortality surveys also.

Detection of White-striped Freetail Bat is relatively low for both years (21 in 2021 and 41 in 2020) considering this is most often found bat carcass during mortality surveys. Flight height is likely to be the cause of low detection rate, with White-striped Freetail Bats flying high and fast and may frequently be outside the range of the Anabat detector.

Despite detection issues for White-striped Freetail Bat, it was postulated in 2020 Annual Report that the number of carcasses found seems to follow the frequency of detection with fewer carcasses found when detection rates are lowest. This trend has not occurred in 2021, with a low of 21 White-striped Freetail Bat calls alongside an average result of six carcasses found, this could be a result of missing November Anabat call data. In addition, Anabat call data does not always correspond with microbat mortality, further analysis of the need for Anabat call data in line with BBMP updates could confirm the most efficient future survey effort.

5. Wetland Observations

5.1 Ephemeral wetland survey

5.1.1 Method and effort

In response to early concerns about the proximity of the wind farm to ephemeral wetlands, and the potential impact to waterbirds, the following nine wetlands / waterbodies were recorded nearby or within BRWF and monitored each monthly survey:

1. **Waterbody 1:** Boundary Lake, 600 m west of Turbine 49.
2. **Waterbody 2:** Small unnamed lake, 600 m north of Turbine 49.
3. **Waterbody 3:** Large ephemeral wetland, 150 m south-east of Turbine 30.
4. **Waterbody 4:** Large ephemeral expansive lake with emergent vegetation on Avon Lake Road, approximately 1.6 km from Turbine 41.
5. **Waterbody 5:** Coopers Lake, approximately 700 m north of Turbine 53.
6. **Waterbody 6:** Large ephemeral shallow wetland adjacent to Turbine 52.
7. **Waterbody 7:** Ephemeral wetland near on Brechnoch Road/Cow Bum Road.
8. **Waterbody 8:** Ephemeral wetland near main entry gate to BRWF.
9. **Waterbody 9:** Ephemeral wetland near Turbine 29/30.

The location of these waterbodies is shown on survey location maps in Appendix A.3. There are nine formal survey sites built into the monitoring program for wetlands (W1-W9), and opportunistic observations are made every survey month to monitor the species present and their general abundance, as well as noting changes in the water level at each. Twelve waterbody surveys were undertaken in 2021 at nine wetland sites totalling 108 surveys.

5.1.2 Results

As discussed in Section 1.5, rainfall totals for 2021 have been above average. However, it took several months before rainfall was reflected in the surface water conditions around BRWF (Table 5-1. Wetlands were dry January – May 2021. From June wetlands began to fill and all held water for the remainder of the year, along with abundant waterbirds.

Table 5-1 Rainfall statistics for Cooma airport, along with moisture status of the nine waterbodies / wetlands checked each month

Month	Long-term av. rainfall (mm)	2021 rainfall (mm)	Wetlands status
January	52.5	14.6	Dry
February	52.2	70.6	Dry
March	49.5	116	Dry
April	38.5	9.4	Dry
May	28.9	91	Dry
June	40.9	72.6	8 of 9 held some water
July	29.5	10.2	Between 1/3 to completely full
August	32.0	52.8	One empty, some shallow, some moderately

Month	Long-term av. rainfall (mm)	2021 rainfall (mm)	Wetlands status
			full
September	36.0	52.2	Full, or more than half full
October	44.9	45.6	Between 2/3 to completely full
November	69.6	183.8	Between 2/3 to completely full
December	54.5	111.8	All full, with the exception of one 3/5 full

Rainfall averages and monthly records for the Cooma airport weather station (BOM 2022a)

5.1.3 Influence of wetlands on survey results

The BBMP v1.3 requires that the influence of the local wetlands on bird survey results is considered. There were five species of 'wetland' bird recorded during utilisation surveys in 2021. These were recorded at just three sites: Control site 1, Control site 37r (both ephemeral drainage lines) and Woodland 26r (located along the MacLaughlin River). One of these records was a significant contribution to BUS results: 130 Australian Wood Ducks at Control site 1. However, by far the majority (90%) of waterbird sightings at BRWF occur opportunistically at the ephemeral wetlands surveyed (1522 birds opportunistically compared to 171 birds during BUS). Most waterbird records come from opportunistic sightings at the wetlands listed in Section 5.1.1 (Table 5-2).

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.

Table 5-2 Wetland species, survey type and count for all wetland bird species recorded at BRWF in 2021

Common name	Species name	Survey	Count
Australasian Grebe	*Tachybaptus novaehollandiae*	Utilisation	1
		Opportunistic	1
Australasian Shoveler	*Anas rhynchotis*	Opportunistic	54
Australian Reed Warbler	*Acrocephalus australis*	Utilisation	5
Australian Shelduck	*Tadorna tadornoides*	Opportunistic	45
Australian Wood Duck	*Chenonetta jubata*	Utilisation	150
		Opportunistic	771
Black Swan	*Cygnus atratus*	Opportunistic	15
Black-fronted Dotterel	*Elseyornis melanops*	Opportunistic	1
Black-winged Stilt	*Himantopus himantopus*	Opportunistic	38
Chestnut Teal	*Anas castanea*	Opportunistic	3

Common name	Species name	Survey	Count
Eurasian Coot	*Fulica atra*	Opportunistic	4
Grey Teal	*Anas gracilis*	Utilisation	9
		Opportunistic	469
Hoary-headed Grebe	*Poliocephalus poliocephalus*	Opportunistic	12
Masked Lapwing	*Vanellus miles*	Opportunistic	22
Pacific Black Duck	*Anas superciliosa*	Utilisation	6
		Opportunistic	67
Pink-eared Duck	*Malacorhynchus membranaceus*	Opportunistic	17
White-faced Heron	*Egretta novaehollandiae*	Opportunistic	3
Total			**1693**

5.1.4 Discussion

Waterbirds were identified as a higher risk group in the BBMP v1.3 and in the project approval conditions for BRWF and have been monitored informally since 2015 (i.e. outside of bird utilisation surveys, in an ‘opportunistic’ way). This is due to the proximity of the wind farm to ephemeral wetlands as well as to the general siting of the wind farm on the Monaro Plateau. Cooper Lake and Avon Lake are part of the Monaro Lakes complex, declared a Wetland of National Importance.

Over the seven years of monitoring, surveys have now sampled high rainfall periods in 2016 (discussed in the 2016 Annual Report), dry conditions in 2018/2019, post-bushfire and post-drought conditions in 2020 and high rainfall conditions again in 2021. The suite of environmental conditions have been sampled over a monthly basis. The assemblage of species recorded at the wetlands has changed in response to rainfall and surface water conditions. For example, Freckled Duck *Stictonetta naevosa* was briefly recorded at Avon Lake Road following high rainfall in June 2016, most likely on stop over between the coast and inland habitat areas (NGH 2017c).

These observations and others suggest that the larger ephemeral wetlands around BRWF do provide important habitat, stepping-stones and refuge in both times of boom and bust. However, throughout the seven years of monitoring and particularly during a time when extreme changes in climatic conditions have been experienced, there have been no waterbird carcasses found at BRWF. This demonstrates that the layout of BRWF has posed neither a mortal threat nor a barrier to waterbirds, whether locally resident, nomadic or migratory.

6. Review of adaptive management

6.1 Triggers for action

Table 7-3 of the endorsed BBMP v1.3 provides a sample of events that would automatically be considered moderate to high risk and require a management response (NGH 2017). Three such events occurred during 2021. Table 6-1 below provides a summary of events and management responses during 2021. Full details can be found in the relevant quarterly report.

Table 6-1 Trigger events that occurred in 2021 and the management response undertaken

Trigger event (from BBMP)	Incident	Management response	Conclusion	Outcome
Breeding birds close to turbines Detected breeding close to turbines where there is a high risk of adult or juvenile mortality.	Wedge-tailed Eagles nesting adjacent turbines 58 and 65	Nest monitored throughout breeding season (August to December 2021) to ascertain status of chicks (particularly for fledging). Additional extended zone mortality surveys were undertaken during post-fledging period (i.e. December 2021, January 2022).	Wedge-tailed Eagles have bred successfully near Turbines 58 and 65 for six consecutive years (2016, 2017, 2018, 2019, 2020, 2021) with 1-2 eaglets fledging each year. Results are documented in the Quarterly Reports.	This observation requires no further action except to observe the breeding WTE in 2022.
Multiple mortality of any species More than one carcass of any one native species detected.	January: 4 White-striped Freetail Bat carcasses February; 2 White-striped Freetail Bat carcasses. March: 2 Gould's Wattled Bat carcasses.	1. Review numbers. Two to four carcasses of a species at each event. Within previous ranges, not a large number. 2. Review past risk assessments. These numbers previously found to be non-significant. Assessments hold true for current events.	In each case, the numbers found (while multiple) are relatively low and are within the range found previously. Previous multiple finds have been subject to risk assessments for both these (non-threatened) species, with the conclusion that the numbers found at BRWF are unlikely to have a local population scale impact.	Watch and act approach. Continue usual monitoring program on the lookout for any for any abnormal results.
Prolonged rain which may lead to improved conditions in wetlands	Significantly higher than average rainfall was	The influx of waterbirds so far does not appear to have resulted in additional mortalities. It is not considered that the	Additional BUS or mortality surveys at sites close to wetlands may be advised, if multiple	Watch and act approach. No waterbird

Trigger event (from BBMP)	Incident	Management response	Conclusion	Outcome
adjacent to turbines and thereby increases in water bird numbers in close proximity to turbines	recorded in November and December	reduced visibility of mortality surveys has affected detection of waterbirds, due to their generally large body size.	waterbird mortalities detected. To date this has not occurred and thus is not warranted.	carcasses found. Continue usual monitoring program on the lookout for any for any abnormal results.

6.1.1 High risks identified

One high risk was identified during the reporting period:

- Breeding Wedge-tailed Eagles near turbines (Table 7-3 of the BBMP V1.3)

Monitoring of the Wedge-tailed Eagle nest near Turbine 58 re-commenced for the 2021 breeding season of this year. The nest was checked each month from August to December to ascertain the status of the chicks.

- In August, it was thought that one egg may have hatched, though presence of a hatchling could not be confirmed.
- In September, a single chick was observed and appears to be doing well. A kangaroo leg was observed in the nest, evidence that the parent eagles are providing food for the young.
- During the October surveys a single chick was observed and appeared to be doing well, having moulted its' white down.
- During the November surveys, the single chick was observed, appeared to be doing well, and approaching fledging.
- In December, the chick was not in the nest and appeared to have fledged.

High-risk species

The *BRWF 6th Annual Report 2020* (NGH 2021) provided an analysis of the 'high-risk' species identified at BRWF from 2015 to 2020 based data collected during mortality surveys (Symbolix, Collision Likelihood by Species at Boco Rock Wind Farm, 2020). The list of species is reproduced overleaf in Table 6-2.

Table 6-2 Total carcasses found and estimated total mortalities (median) over six years for each species found

Species	Type	Number found	Estimated mortalities (median)	% of total estimated mortalities	Relative collision likelihood
White-striped Freetail Bat	Bat	43	328	27.4	High
Eurasian Skylark	Bird	12	144	12.0	High
Gould's Wattled Bat	Bat	13	98	8.2	High
Australian Magpie	Bird	8	92	7.7	High
Nankeen Kestrel	Bird	5	62	5.2	High
Grey Fantail	Bird	3	41	3.4	Medium
Common Starling	Bird	3	41	3.4	Medium
Wedge-tailed Eagle	Bird	3	41	3.4	Medium
Unidentifiable	Bird	3	41	3.4	Medium
Rufous Fantail	Bird	2	33	2.8	Medium
White-throated Needletail	Bird	2	33	2.8	Medium
Eastern Bentwing Bat	Bat	3	25	2.1	Medium
Silvereye	Bird	1	19	1.6	Low
Fairy Martin	Bird	1	19	1.6	Low
Brown Goshawk	Bird	1	19	1.6	Low
Peregrine Falcon	Bird	1	19	1.6	Low
Shining Bronze-cuckoo	Bird	1	19	1.6	Low
Brown Falcon ??	Bird	1	19	1.6	Low
Little Raven	Bird	1	19	1.6	Low
Stubble Quail	Bird	1	19	1.6	Low
Australian Raven	Bird	1	19	1.6	Low
Southern Boobook	Bird	1	19	1.6	Low
Chalinolobus sp?	Bat	1	10	0.8	Low
Large Forest Bat	Bat	1	10	0.8	Low
Grey-headed Flying Fox	Bat	1	10	0.8	Low

The following high-risk species (as identified above) were impacted in 2021:

- White-striped Freetail Bat.
- Eurasian Skylark (exotic).
- Gould's Wattled Bat.
- Nankeen Kestrel.
- Australian Magpie.

These species are all listed in Table 6-2 confirming our confidence in the Table 6-2 analysis. This shows that the current monitoring has produced a reliable and consistent risk assessment and that the focus in updating the BBMP should be on the high-risk species in Table 6-2. No additional analysis based on 2021 is considered warranted.

6.1.2 Other issues

Poor ground visibility due to thick vegetation in survey areas

As discussed in Section 2.1.2 with regard to limitations to mortality surveys, ground visibility was hampered in the extended zones throughout the year and in the high detectability zone in November to December 2021.

This issue has been dealt with in the following way:

Extended zone

- NGH advised CWP Renewables Environmental team that vegetation management was desirable.
- CWP consulted with landholders in regards to vegetation management.

NGH understand that landholders have been reluctant to manage the vegetation in these areas. NGH preference would be renewed liaison with the landholders about possible control methods (grazing, whipper snipping), timing (just before planned survey) and responsibility (who will ensure it is undertaken) for managing vegetation in the extended zones around relevant turbines over the warmer months when growth is greatest and snakes are most active (spring, summer in particular). Table 6-3 shows the turbines at BRWF which have extended zones for mortality surveys.

Table 6-3 Turbines with extended zones which may require vegetation management for mortality surveys.

Extended zone turbines		
1	31	51
4	35	55
5	40	57
7	41	58
11	44	59
23	47	65
29	49	66

Core zone

- NGH advised CWP Renewables via monthly letters in November and December that vegetation management was strongly recommended through herbicide application, brush-cutting or mowing as appropriate.
- CWP Renewables have now organised for all the hardstand areas to be sprayed with herbicide.

7. Conclusion

After seven complete years of operational 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 and refinement of future survey effort is warranted in line with updating the BBMP.

The program is meeting its secondary objective to detect bird population changes through bird utilisation surveys. The following trends have been statistically identified for birds:

- Decreasing species richness and diversity over time – not related to wind farm operation as changes in the grassland impact stratum have been mirrored in the control stratum. Complex to determine the cause; but it may be related to slow recovery following drought, regional and/climatic conditions, or there may be statistical sampling/analysis reasons.
- The species assemblage has shifted over time at woodland sites as well as grassland impact and control sites; not unexpected given that bird assemblages fluctuate in response to many factors. At BRWF, changes in the grassland impact stratum have been mirrored in the control stratum. The wind farm operation is not likely to be driving the observed change.

For bats, Anabat surveys are not able to detect population change although the following can be stated with certainty:

- Activity levels recorded by Anabat over 2015-2021 indicate that threatened species are active at BRWF (including Large Bent-winged Bat) but have not been susceptible to regular blade-strike impacts (including barotrauma) (see section 4.3).

8. Recommendations

The BBMP (v1.3) at BRWF has completed its seventh year of operational monitoring (December 2021). After seven years of monitoring the data provides a good understanding of bird and bat activity and potential risks specific to BRWF. The cumulative data indicates the operation of the wind farm has not demonstrated any adverse effect on any bird or bat populations and as such the risks of the wind farm are shown to be low at a population level.

Based on the data obtained for the full seven years along with changes in the wind farm industry, and supporting the adaptive management requirements, recommendations to update the survey effort and monitoring program have been made.

The recommendations are to change the survey effort and design so it better reflects the latest methods, level of risk and seasonal activity of birds and bats at BRWF. This would involve updating the survey design including:

- Considering the use of dog-handler teams for mortality surveys rather than human searchers, increasing detectability and ultimately enabling a reduction in survey effort. Dogs are both more efficient with higher detectability achievable so may be of benefit to the program.
- Update searcher efficiency trials to ensure that detectability estimates are accurate and reflect current onsite conditions. This will need to be done if methods (i.e. dog teams) or personnel are changed. This will help quantify any impacts of vegetation growth on searcher efficiency and confirm mortality estimates are reflecting the state of the BRWF environment.
- Reducing the extent of surveys, supported by current monitoring data, implemented as an adaptive approach to ensuring ongoing efficiency in data collection and reporting that is tailored to BRWF.
- Preparing alternative modelling options that analyse future reduced survey effort supported by the long term monitoring data and statistical analysis.
- Removing BUS observations from monthly to relevant seasonal windows where activity is highest (October to March).
- Reducing frequency or eliminating Anabat surveys as they do not align with or accurately represent bat mortality or impacts to threatened species' populations, which is their purpose.
- Updating the reporting frequency in line with updated monitoring activity and utilisation of results. Consider implementation of annual reporting with no quarterly reports.
- Delete the current 'higher risk' species table in the BBMP and replace with the updated risk assessment from the 2020 Annual Report as per Table 6-2.

The recommendations above would be addressed throughout 2022, concurrent to the current survey effort detailed in BBMP V3.1. Further modelling, supported by data analysis, would lead to an updated BBMP to reflect changes. An updated BBMP would streamline the monitoring program in an adaptive way and would ensure maximum detection, with more efficient survey effort. Changes to the BBMP should be submitted for approval where required by the project's consent.

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Appendix A Survey effort and locations

A.1 Bird utilisation survey effort details 2021

Month	Date	Site	ID	Waypoint
January		Control	35r 28r 29r	678224 5958363 682896 5949707 683335 5948684
		Grassland	58 86 71 48	692045 5953613 692826 5952750 691454 5952077 690202 5954080
		Woodland	137 134 52r	685063 5940153 684662 5938927 685771 5939042
February		Control	174 48r	679606 5952804 680680 5951631
		Grassland	68 49	685855 5944868 685384 5942427
		Woodland	57r 138 132	684942 5940091 684733 5939154 685698 5939244
March		Control	34r 37r 49r 39r	678534 5959372 677551 5956341 681538 5951019 694711 5956643
		Grassland	60 43 72	686069 5944505 692466 5953443 691507 5952340
		Woodland	124 107 104	684871 5939827 684638 5938677 685545 5940244
April		Control	36r 172 50r 30r	677810 5957365 680262 5952031 683117 5949139 684414 5947898
		Grassland	96 84 76	686286 5945105 685737 5942428 685254 5940862
		Woodland	99 117 103	684407 5938637 685092 5939231 686209 5938966
May		Control	61	677650 5956747

Month	Date	Site	ID	Waypoint
			53r 175	683745 5948290 680991 5951307
		Grassland	89 93 77 44	685146 5947105 687083 5949438 688716 5949958 685616 5943956
		Woodland	51r 105 2r	684850 5939479 685603 5939302 685441 5940147
June		Control	62r 43r 58r	680079 5953079 681626 5953526 682228 5941688
		Grassland	91 94	686520 5949383 686860 5946968
		Woodland	122 171 128	685524 5939471 684741 5939283 685804 5940498
July		Control	55r 47r 22r	685218 5945518 685026 5944020 694022 5956693
		Grassland	82 81 53 75	690917 5950830 686281 5948849 686554 5947604 686476 5945718
		Woodland	119 113 106	684580 5939238 685472 5939788 692135 5951851
Aug		Control	54r	684994 5947202
			40r	693433 5956730
			1	692273 5955861
			42r	680605 5953231
		Grassland	46	685971 5943353
			47	686849 5946234
			56	690157 5952727
		Woodland	100	692260 5951978
			41r	687224 5946933
			133	687612 5948989
Sep		Control	19r	691137 5955413
			29r	683335 5948684

Month	Date	Site	ID	Waypoint	
			44r	682600	5953450
		Grassland	66	686355	5947841
			73	688403	5950793
			97	686691	5949751
		Woodland	8r	685374	5940063
			25r	684888	5938638
			170	687717	5949011
			173	685823	5939407
October		Control	24r	690597	5954785
			59r	683177	5942231
			63r	692344	5956199
		Grassland	51	686788	5947514
			62	685391	5946870
			63	688252	5949748
			83	686266	5950098
		Woodland	26r	685969	5938280
			114	685364	5939710
			135	687496	5946551
November		Control	46r	685171	5945045
		Grassland	56	690157	5952727
			69	691234	5952814
			90	686241	5949419
		Woodland	25r	684888	5938638
			101	684450	5939343
			110	692137	5951372
December		Control	32r	690844	5947265
			33r	689722	5946489
			45r	685290	5946075
			60r	683917	5943015

A.2 Survey weather conditions

Weather conditions during survey events throughout 2021 are given in the table below.

* Average temperatures refers to measurements taken during morning bird surveys, except on the first day of field trips where the temperature given is recorded during afternoon mortality surveys – these are indicated by numerals in parentheses. Wind conditions are given from both field measurements (as before, generally from morning surveys) and Bureau of Meteorology (BOM 2020a, Cooma airport; 9am) as ground measurements of wind speed are generally lower than at tree top height. Wind direction: N = north, E = east, S = south, W = west.

Date	Average temp during survey (°C)	Average Wind*	Conditions
18/01/21	28.6	14.9 km/hr	Warm, sunny, light wind
19/01/21	11.3	3 km/hr	Cool, clear, light breeze
20/01/21	11.1	0.7 km/hr	Cool, clear to patchy cloud, light breeze
21/01/21	14	2.4 km/hr	Mild, clear, light breeze
04/02/21*	26.1	22 km/hr	Warm, low heavy cloud, strong wind
05/02/21	21.4	1.5 km/hr northerly	Mild, partly cloudy, light breeze
06/02/21*	20.1	14.2 km/hr	Heavy rain in morning. Mild, overcast, windy in afternoon.
07/02/21	10.1	Nil	Cool, clear, calm
01/03/21*	27.6	15.6 km/hr	Warm, partly cloudy, windy
02/03/21	7.6	21.4 km/hr SE	Cold, mostly clear, windy
03/03/21	5.9	4.4 km/hr SW	Cold, partly cloudy, light wind
04/03/21	7.3	2.2 km/hr N	Cold, clear, calm
11/04/21*	(9)	(14.2 km/hr)	Cold, partly cloudy, windy
12/04/21	5	22.8 km/hr SW	Cold, cloudy, very windy
13/04/21	4.1	2.1 km/hr NE	Cold, clear, light breeze
14/04/21	14.7	4.9 km/hr W	Mild, partly cloudy, light wind
10/5/21	(11.4)	9.8	Cold, cloudy, windy
11/5/21	9.1	Nil	Cool, cloudy, calm
12/5/21	7.9	7.9	Cool, clear, light breeze
13/5/21	7.1	2.5	Cool, overcast, drizzling rain, light wind
01/6/21	(12.8)	(11)	(Cold, overcast, light wind)

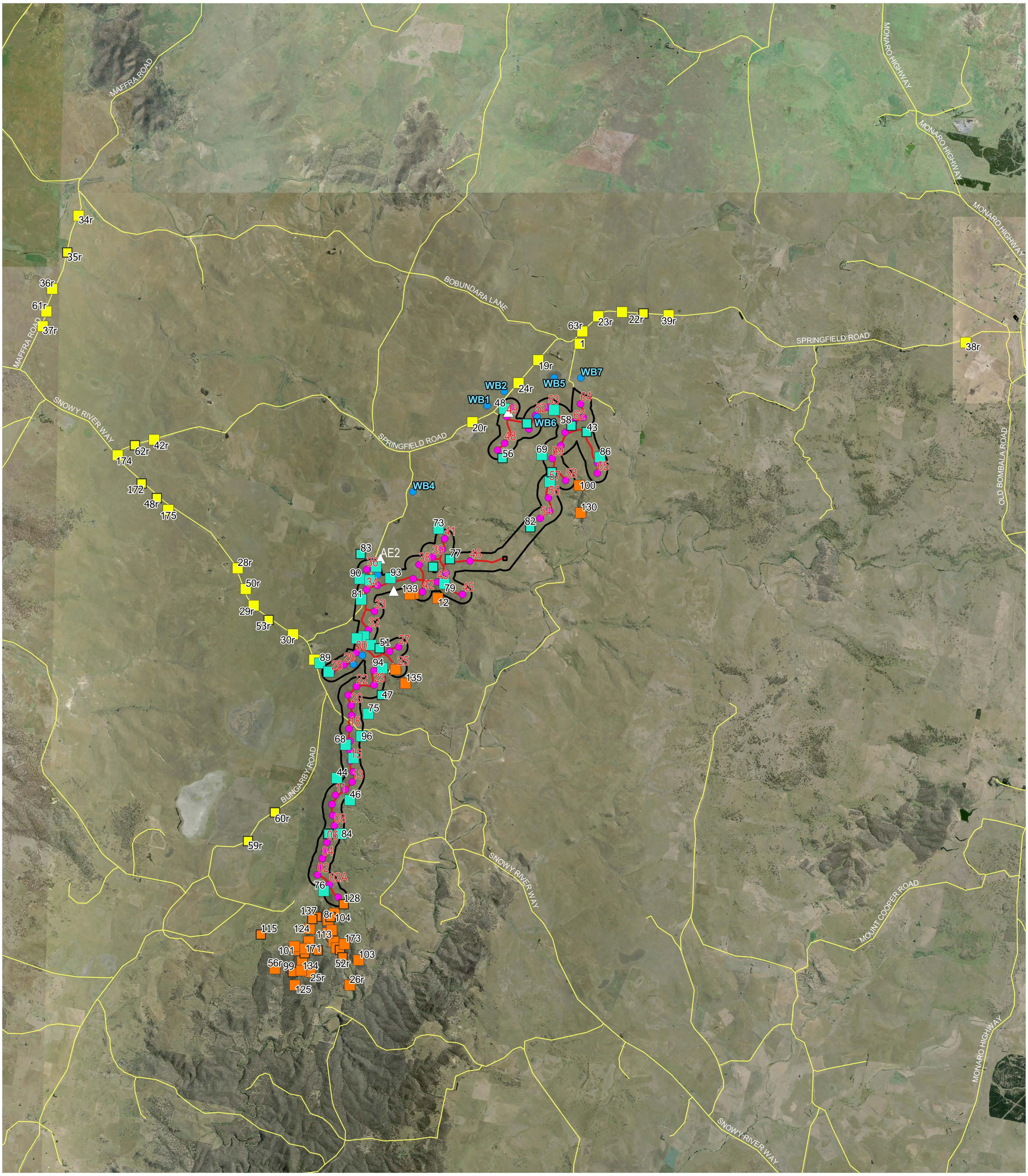
Date	Average temp during survey (°C)	Average Wind*	Conditions
02/6/21	5.9	1	Cold, mostly clear, light breeze/calm
03/6/21	(10.7)	(10)	Cold, rainy , overcast, light wind
04/6/21	5.5	4.2	Cold, patchy cloud, light breeze
12/07/21	11.1	12.8	Cool, cloudy, light wind
13/07/21	3.2	1.5 northly	Cold, clear, light breeze
14/07/21	5.9	15.5 northerly	Cold, overcast, windy
15/07/21	6.3	14 north-westerly	Cold, cloudy, breezy to very windy
18/8/2021	19.4	2	Cold, clear, light wind
19/8/2021	1.8	3.1 NE	Cold, partly cloudy, light breeze
20/08/2021	6.3	8.0 NE	Cold, clear, light wind
21/08/2021	8.5	8.6 N/NW	Cold, clear, light wind
13/09/2021[5]	9.8	13.0	Cold, cloudy, windy
14/09/2021	3.0	10.6	Cold, overcast, light drizzle, light wind
15/09/2021	2.7	0.0	Cold, clear, calm
16/09/2021	7.3	0.0	Cold, cloudy, calm
07/10/2021[6]	15.3	26.4	Cool, clear, windy
08/10/2021	10.4	0.3	Cold, clear, calm/light breeze
09/10/2021	11.6	1.2	Cold, clear, calm/light breeze
10/10/2021	8.2	2.0	Cold, overcast, calm/light breeze
10/11/2021[7]	(18.6)	(3.4)	Mild, cloudy, light breeze, rain looming
11/11/2021	8.1	4.7	Cold, mostly partly cloudy with some clear periods, light wind

[5] Temperature and wind data from this day represents a single data point only, not an average.
[6] Temperature and wind data from this day represents a single data point only, not an average.
[7] Temperature and wind data from this day represents a single data point only, not an average.

Date	Average temp during survey (°C)	Average Wind*	Conditions
12/11/2021	7.1	8.5	Cold, overcast, light wind, recent rain
13/11/2021[1]	(8.2)	(12.9)	Cold, overcast, windy, raining
07/12/2021[8]	(19.8)	(11.8)	Mild, partly cloudy, light wind, rain looming
08/12/2021	8.0	3.8	Cold, overcast, light breeze
09/12/2021	(8.7)	(2.8)	Cold, overcast, light breeze, raining
10/12/2021[1]	(9.7)	(10.3)	Cold, overcast, windy, raining

[8] Temperature and wind data from this day represents a single data point only, not an average.

A.3 Map: Survey locations

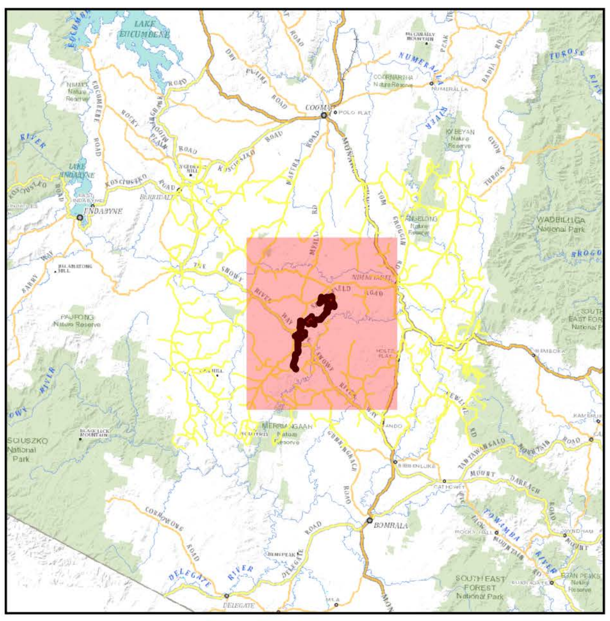


BRWF SURVEY POINTS

- Project Boundary
- Turbines
- Road Network
- Access tracks
- Water body survey locations
- Anabat locations

Bird Utilisation Surveys

- Control
- Grassland
- Woodland



0 1 2 3 4 km

Data Attribution
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© NSW LPI 2021
Ref: 19-937 Boco Wind Farm Year 6 120620 \ 2020 Annual BUS
Author: Vitaly.K
Date created: 26.03.2021
Datum: GDA94 / MGA zone 55

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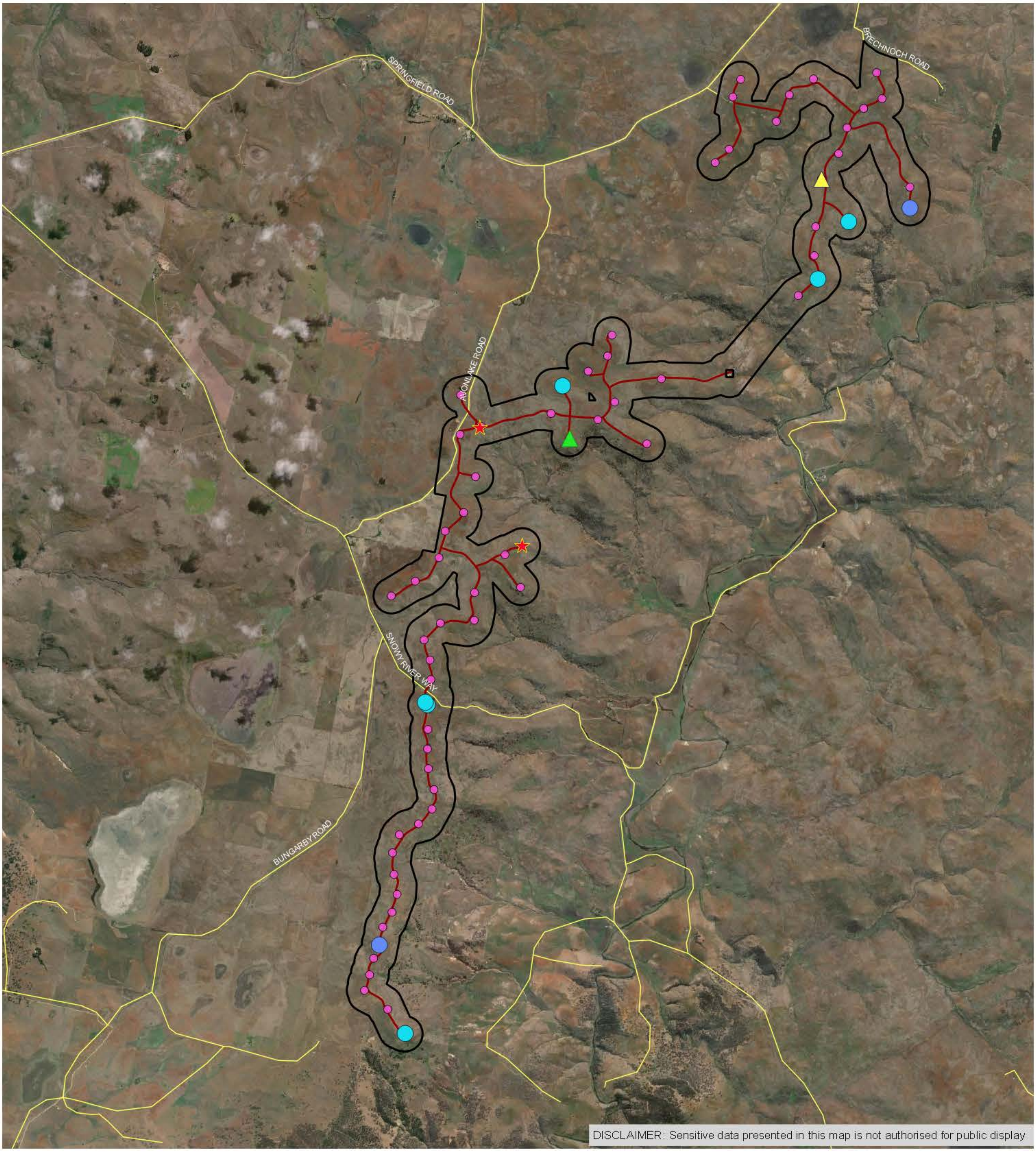
Appendix B Results: Mortality Surveys

B.1 Detailed mortality results table 2021

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.
		18	19/01/2021	White-striped Freetail Bat	*Austronomus australis*	1	No	685968	5945319	> week old. Old, dry, stiff carcass. Male. Too old to assess for damage
		55	20/01/2021	White-striped Freetail Bat	*Austronomus australis*	1	No	691465	5951306	Male. Lower abdomen exposed. Maggots present. No wing damage. Several days old.
		58	18/01/2021	White-striped Freetail Bat	*Austronomus australis*	1	No	691898	5952114	Less than one week old. No obvious wing damage. Lower abdomen exposed and full of maggots. Sex indeterminate.
	Feb	1	7/02/2021	White-striped Freetail Bat	*Austronomus australis*	1	No	685657	5940695	Couple days old. Full of maggots. No obvious physical damage.
		27	5/02/2021	Eurasian Skylark	*Alauda arvensis*	1	No	687304	5947550	Freshly dead. Blood in beak. Left shoulder broken. Back exposed.
		38	4/02/2021	White-striped Freetail Bat	*Austronomus australis*	1	No	687872	5949805	Died overnight/morning. Male. No obvious physical damage
	Mar	5	2/03/2021	Gould's Wattled Bat	*Chalinolobus gouldii*	1	No	685294	5941940	About a week old. Right humerus broken with bone exposed.
3rd	Jul	59	12/07/2021	Nankeen Kestrel	*Falco cenchroides*	1	No	691516	5952712	Carcass not found. No indication of time since death.
		65	3/03/2021	Gould's Wattled Bat	*Chalinolobus gouldii*	1	No	692760	5952307	Died overnight. No obvious physical damage
	Aug	35	18/08/2021	Eurasian Skylark	*Alauda arvensis*	1	No	686708	5949209	1-2 days old. Eyes gone. No obvious sign of damage.
		42	20/08/2021	Australian Magpie	*Cracticus tibicen*	1	No	687972	5949063	About a day old. No eyes. Top of back exposed. Male

B.2 Map: carcass find locations

Map for carcass finds is shown overleaf



2021 Mortality Survey Results

Project Boundary
Road Network
Access Tracks
Turbine

2021 Mortality
Australian Magpie
Eurasian Skylark
Gould's Wattled Bat
Nankeen Kestrel
White-striped Freetail Bat

0 1 2 km

Data Attribution
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Ref: 21-039 Boco Rock Year 7 Monitoring 190521 \ 21-039 BOCO2021 Mortality Report 20220310
Author: Ian.C
Date created: 10.03.2022
Datum: GDA94 / MGA zone 55

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Appendix C Results: Bird lists

C.1 Cumulative bird foraging guilds and associated species for all monitoring years

Guilds based on foraging substrate, foraging style and where relevant, movement patterns.

Foraging behaviour guilds	Common Name
Aerial hover / pounce	Black-shouldered Kite
	Brown Falcon
	Nankeen Kestrel
Aerial insectivore	Dusky Woodswallow
	Fairy Martin
	Tree Martin
	Welcome Swallow
	White-throated Needletail
Aerial pursuit	Peregrine Falcon
Aerial soar / pounce	Nankeen Kestrel
Aerial soar / quarter	Little Eagle
	Spotted Harrier
	Swamp Harrier
	Wedge-tailed Eagle
	White-bellied Sea Eagle
Ecotonal FBB	Crimson Rosella
	Eastern Rosella
	Pallid Cuckoo
	Pied Currawong
	Red-rumped Parrot
	Rufous Fantail
	Rufous Whistler
	Southern Whiteface
	Striated Pardalote

Foraging behaviour guilds	Common Name
	Superb Fairywren
	White-eared Honeyeater
	Yellow-Faced Honeyeater
	Yellow-tailed Black Cockatoo
Ecotonal ground	Flame Robin
	Willie Wagtail
	Yellow-rumped Thornbill
Ecotonal predator	Australian Hobby
	Brown Goshawk
	Collared Sparrowhawk
Generalist ground	Australian Magpie
	Australian Raven
	Common Bronzewing
	Crested Pigeon
	Galah
	Little Raven
	Magpie Lark
	Raven sp.
	Sulphur-crested Cockatoo
Grassland ground	Australasian Pipit
	Brown Quail
	Brown Songlark
a	Diamond Firetail
	Rufous Songlark
	Singing Bushlark
	Stubble Quail
	Sulphur-crested Cockatoo
Introduced ecotonal FBB	Common Blackbird
Introduced grassland ground	Common Starling

Foraging behaviour guilds	Common Name
	Eurasian Skylark
	European Goldfinch
	House Sparrow
Nocturnal	Australian Owlet-nightjar
Wetland	Australasian Grebe
	Australasian Shoveler
	Australian Darter
	Australian Reed Warbler
	Australian Shelduck
	Australian Spotted Crake
	Australian Wood Duck
	Banded Lapwing
	Black Swan
	Black-fronted Dotterel
	Black-winged Stilt
	Chestnut Teal
	Eurasian Coot
	Freckled Duck
	Grey Teal
	Hardhead
	Hoary-headed Grebe
	Intermediate Egret
	Masked Lapwing
	Pacific Black Duck
	Pink-eared Duck
	Purple Swamphen
	Red-kneed Dotterel
	Straw-necked Ibis
	Unidentified ducks

Foraging behaviour guilds	Common Name
	Unidentified waterfowl
	Whiskered Tern
	White-faced Heron
	White-necked Heron
Woodland FBB	Black-faced Cuckoo-shrike
	Brown Thornbill
	Brown Treecreeper
	Brown-headed Honeyeater
	Brush Cuckoo
	Crescent Honeyeater
	Eastern Spinebill
	Eastern Yellow Robin
	Fan-tailed Cuckoo
	Fuscous Honeyeater
	Gang-gang Cockatoo
	Golden Whistler
	Grey Butcherbird
	Grey Currawong
	Grey Fantail
	Grey Shrike-thrush
	Horsfields Bronze-cuckoo
	Jacky Winter
	King Parrot
	Laughing Kookaburra
	Noisy Miner
	Olive-backed Oriole
	Red Wattlebird
	Restless Flycatcher
	Sacred Kingfisher

Foraging behaviour guilds	Common Name
	Shining Bronze-cuckoo
	Silvereye
	Speckled Warbler
	Spotted Pardalote
	Striated Thornbill
	Varied Sittella
	Variegated Fairy-wren
	Weebill
	White-browed Scrubwren
	White-naped Honeyeater
	White-plumed Honeyeater
	White-throated Honeyeater
	White-throated Treecreeper
	White-winged Triller
Woodland ground	Buff-rumped Thornbill
	Hooded Robin
	Leaden Flycatcher
	Red-browed Finch
	Scarlet Robin
	Spotted Quail-thrush
	Superb Lyrebird
	White-winged Chough

C.2 Bird species list 2021

Threatened species listed in bold. *Asterisk indicates exotic species.

2021 Utilisation survey results – grassland, woodland, control combined

Row Labels	Common Name	Heard	Seen	Grand Total
Acanthiza chrysorrhoa	Yellow-rumped Thornbill		3	3
Acanthiza lineata	Striated Thornbill		1	1
Acanthiza pusilla	Brown Thornbill		8	8
Acanthiza reguloides	Buff-rumped Thornbill	1	2	3
Acanthorhynchus tenuirostris	Eastern Spinebill	3	3	6
Acrocephalus australis	Australian Reed Warbler		5	5
Alauda arvensis	Eurasian Skylark	70	183	253
Anas gracilis	Grey Teal		9	9
Anas superciliosa	Pacific Black Duck		6	6
Anthochaera carunculata	Red Wattlebird	25	13	38
Anthus novaeseelandiae	Australasian Pipit		6	6
Aquila audax	Wedge-tailed Eagle		4	4
Artamus cyanopterus	Dusky Woodswallow		7	7
Cacatua galerita	Sulphur-crested Cockatoo	5	82	87
Cacomantis flabelliformis	Fan-tailed Cuckoo	3		3
Cacomantis pallidus	Pallid Cuckoo	3		3
Carduelis carduelis	European Goldfinch		4	4
Chenonetta jubata	Australian Wood Duck		150	150
Chthonicola sagittata	Speckled Warbler		1	1
Cinclosoma punctatum	Spotted Quail-thrush		1	1
Colluricincla harmonica	Grey Shrike-thrush	10	1	11
Coracina novaehollandiae	Black-faced Cuckoo-shrike	2	3	5
Corcorax melanorhamphos	White-winged Chough	1		1
Cormobates leucophaea	White-throated Treecreeper	18		18
Corvus coronoides	Australian Raven	9	4	13
Corvus mellori	Little Raven	18	109	127

Row Labels	Common Name	Heard	Seen	Grand Total
Coturnix pectoralis	Stubble Quail	7	2	9
Cracticus tibicen	Australian Magpie	53	41	94
Dacelo novaeguineae	Laughing Kookaburra	5		5
Eolophus roseicapilla	Galah	2	20	22
Eopsaltria australis	Eastern Yellow Robin	1		1
Falco cenchroides	Nankeen Kestrel		6	6
Grallina cyanoleuca	Magpie Lark	1	2	3
Hirundo neoxena	Welcome Swallow		5	5
Lichenostomus chrysops	Yellow-Faced Honeyeater	13	20	33
Lichenostomus fuscus	Fuscous Honeyeater	1		1
Lichenostomus leucotis	White-eared Honeyeater	21	5	26
Malurus cyaneus	Superb Fairywren	2		2
Manorina melanocephala	Noisy Miner	1	2	3
Melanodryas cucullata	Hooded Robin	1	1	2
Melithreptus brevirostris	Brown-headed Honeyeater	2	1	3
Melithreptus lunatus	White-naped Honeyeater	2		2
Pachycephala rufiventris	Rufous Whistler	5		5
Pardalotus punctatus	Spotted Pardalote	8		8
Pardalotus striatus	Striated Pardalote	31	5	36
Passer domesticus	House Sparrow		16	16
Petroica boodang	Scarlet Robin	3	2	5
Phaps chalcoptera	Common Bronzewing	1		1
Platycercus elegans	Crimson Rosella	11	30	41
Platycercus eximius	Eastern Rosella		2	2
Psephotus haematonotus	Red-rumped Parrot	1		1
Rhipidura albiscapa	Grey Fantail	2	2	4
Rhipidura leucophrys	Willie Wagtail	1	1	2
Sericornis frontalis	White-browed Scrubwren		4	4

Row Labels	Common Name	Heard	Seen	Grand Total
Strepera graculina	Pied Currawong	11	8	19
Strepera versicolor	Grey Currawong	3		3
Sturnus vulgaris	Common Starling	8	629	637
Tachybaptus novaehollandiae	Australasian Grebe		1	1
Zosterops lateralis	Silvereye		1	1
Grand Total		365	1411	1776

2021 Utilisation survey results – control sites only

Scientific name	Common Name	Heard	Seen	Total
Acanthiza chrysorrhoa	Yellow-rumped Thornbill		3	3
Alauda arvensis	Eurasian Skylark	39	129	168
Anas gracilis	Grey Teal		1	1
Anas superciliosa	Pacific Black Duck		2	2
Anthochaera carunculata	Red Wattlebird	1	1	2
Anthus novaeseelandiae	Australasian Pipit		6	6
Aquila audax	Wedge-tailed Eagle		1	1
Cacatua galerita	Sulphur-crested Cockatoo		57	57
Carduelis carduelis	European Goldfinch		3	3
Chenonetta jubata	Australian Wood Duck		149	149
Corvus coronoides	Australian Raven	2	1	3
Corvus mellori	Little Raven	7	86	93
Coturnix pectoralis	Stubble Quail	2	1	3
Cracticus tibicen	Australian Magpie	21	11	32
Eolophus roseicapilla	Galah		8	8
Falco cenchroides	Nankeen Kestrel		1	1
Grallina cyanoleuca	Magpie Lark		2	2
Lichenostomus leucotis	White-eared Honeyeater	1		1

Scientific name	Common Name	Heard	Seen	Total
Melanodryas cucullata	Hooded Robin		1	1
Pardalotus striatus	Striated Pardalote	1		1
Passer domesticus	House Sparrow		16	16
Platycercus elegans	Crimson Rosella		2	2
Strepera graculina	Pied Currawong	2		2
Sturnus vulgaris	Common Starling	2	225	227
Grand Total		**78**	**706**	**784**

2021 Utilisation survey results – grassland impact sites only

Scientific name	Common Name	Heard	Seen	Total
Alauda arvensis	Eurasian Skylark	31	54	85
Cacatua galerita	Sulphur-crested Cockatoo		5	5
Corvus coronoides	Australian Raven	1	3	4
Corvus mellori	Little Raven	7	21	28
Coturnix pectoralis	Stubble Quail	1	1	2
Cracticus tibicen	Australian Magpie	8	22	30
Eolophus roseicapilla	Galah		5	5
Falco cenchroides	Nankeen Kestrel		3	3
Pardalotus striatus	Striated Pardalote	2		2
Platycercus elegans	Crimson Rosella	2	1	3
Sturnus vulgaris	Common Starling	2	371	373
Grand Total		**54**	**486**	**540**

2021 Utilisation survey results – woodland sites only

Scientific name	Common Name	Heard	Seen	Total
Acanthiza lineata	Striated Thornbill		1	1
Acanthiza pusilla	Brown Thornbill		8	8

Scientific name	Common Name	Heard	Seen	Total
Acanthiza reguloides	Buff-rumped Thornbill	1	2	3
Acanthorhynchus tenuirostris	Eastern Spinebill	3	3	6
Acrocephalus australis	Australian Reed Warbler		5	5
Anas gracilis	Grey Teal		8	8
Anas superciliosa	Pacific Black Duck		4	4
Anthochaera carunculata	Red Wattlebird	24	12	36
Aquila audax	Wedge-tailed Eagle		3	3
Artamus cyanopterus	Dusky Woodswallow		7	7
Cacatua galerita	Sulphur-crested Cockatoo	5	20	25
Cacomantis flabelliformis	Fan-tailed Cuckoo	3		3
Cacomantis pallidus	Pallid Cuckoo	3		3
Carduelis carduelis	European Goldfinch		1	1
Chenonetta jubata	Australian Wood Duck		1	1
Chthonicola sagittata	Speckled Warbler		1	1
Cinclosoma punctatum	Spotted Quail-thrush		1	1
Colluricincla harmonica	Grey Shrike-thrush	10	1	11
Coracina novaehollandiae	Black-faced Cuckoo-shrike	2	3	5
Corcorax melanorhamphos	White-winged Chough	1		1
Cormobates leucophaea	White-throated Treecreeper	18		18
Corvus coronoides	Australian Raven	6		6
Corvus mellori	Little Raven	4	2	6
Coturnix pectoralis	Stubble Quail	4		4
Cracticus tibicen	Australian Magpie	24	8	32
Dacelo novaeguineae	Laughing Kookaburra	5		5
Eolophus roseicapilla	Galah	2	7	9
Eopsaltria australis	Eastern Yellow Robin	1		1
Falco cenchroides	Nankeen Kestrel		2	2

Scientific name	Common Name	Heard	Seen	Total
Grallina cyanoleuca	Magpie Lark	1		1
Hirundo neoxena	Welcome Swallow		5	5
Lichenostomus chrysops	Yellow-Faced Honeyeater	13	20	33
Lichenostomus fuscus	Fuscous Honeyeater	1		1
Lichenostomus leucotis	White-eared Honeyeater	20	5	25
Malurus cyaneus	Superb Fairywren	2		2
Manorina melanocephala	Noisy Miner	1	2	3
Melanodryas cucullata	Hooded Robin	1		1
Melithreptus brevirostris	Brown-headed Honeyeater	2	1	3
Melithreptus lunatus	White-naped Honeyeater	2		2
Pachycephala rufiventris	Rufous Whistler	5		5
Pardalotus punctatus	Spotted Pardalote	8		8
Pardalotus striatus	Striated Pardalote	28	5	33
Petroica boodang	Scarlet Robin	3	2	5
Phaps chalcoptera	Common Bronzewing	1		1
Platycercus elegans	Crimson Rosella	9	27	36
Platycercus eximius	Eastern Rosella		2	2
Psephotus haematonotus	Red-rumped Parrot	1		1
Rhipidura albiscapa	Grey Fantail	2	2	4
Rhipidura leucophrys	Willie Wagtail	1	1	2
Sericornis frontalis	White-browed Scrubwren		4	4
Strepera graculina	Pied Currawong	9	8	17
Strepera versicolor	Grey Currawong	3		3
Sturnus vulgaris	Common Starling	4	33	37
Tachybaptus novaehollandiae	Australasian Grebe		1	1
Zosterops lateralis	Silvereye		1	1
Grand Total		**233**	**219**	**452**

2021 Opportunistic sightings

Scientific name	Common Name	Seen	Total
Anas castanea	Chestnut Teal	3	3
Anas gracilis	Grey Teal	469	469
Anas rhynchotis	Australasian Shoveler	54	54
Anas superciliosa	Pacific Black Duck	67	67
Aquila audax	Wedge-tailed Eagle	7	7
Chenonetta jubata	Australian Wood Duck	771	771
Cygnus atratus	Black Swan	15	15
Egretta novaehollandiae	White-faced Heron	3	3
Elanus axillaris	Black-shouldered Kite	2	2
Elseyornis melanops	Black-fronted Dotterel	1	1
Falco berigora	Brown Falcon	4	4
Falco cenchroides	Nankeen Kestrel	24	24
Falco longipennis	Australian Hobby	2	2
Fulica atra	Eurasian Coot	4	4
Himantopus himantopus	Black-winged Stilt	38	38
Malacorhynchus membranaceus	Pink-eared Duck	17	17
Poliocephalus poliocephalus	Hoary-headed Grebe	12	12
Tachybaptus novaehollandiae	Australasian Grebe	1	1
Tadorna tadornoides	Australian Shelduck	45	45
Vanellus miles	Masked Lapwing	22	22
Grand Total		**1561**	**1561**

2021 Wetland survey sightings

Scientific name	Common Name	Seen	Grand Total

Scientific name	Common Name	Seen	Grand Total
Acrocephalus australis	Australian Reed Warbler	5	5
Anas castanea	Chestnut Teal	3	3
Anas gracilis	Grey Teal	478	478
Anas rhynchotis	Australasian Shoveler	54	54
Anas superciliosa	Pacific Black Duck	73	73
Chenonetta jubata	Australian Wood Duck	921	921
Cygnus atratus	Black Swan	15	15
Egretta novaehollandiae	White-faced Heron	3	3
Elseyornis melanops	Black-fronted Dotterel	1	1
Fulica atra	Eurasian Coot	4	4
Himantopus himantopus	Black-winged Stilt	38	38
Malacorhynchus membranaceus	Pink-eared Duck	17	17
Poliocephalus poliocephalus	Hoary-headed Grebe	12	12
Tachybaptus novaehollandiae	Australasian Grebe	2	2
Tadorna tadornoides	Australian Shelduck	45	45
Vanellus miles	Masked Lapwing	22	22
Grand Total		**1693**	**1693**

C.3 Bird species list for BRWF – all surveys to date (2015 to 2021)

131 bird species have been identified during the BRWF BBMP surveys to date (including instances where birds have been identified only to genus level, as in the list below). This tallies 18,602 birds seen or heard over the six years of monitoring 2015-2021 (noting that individual birds may be seen more than once but will be recorded multiple times).

Species name	Common Name	Heard	Seen	Total
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	6	43	49
Acanthiza lineata	Striated Thornbill	10	58	68
Acanthiza pusilla	Brown Thornbill	18	103	121
Acanthiza reguloides	Buff-rumped Thornbill	3	82	85
Acanthorhynchus tenuirostris	Eastern Spinebill	11	8	19
Accipiter cirrocephalus	Collared Sparrowhawk	0	2	2
Accipiter fasciatus	Brown Goshawk	0	1	1
Acrocephalus australis	Australian Reed Warbler	0	18	18
Aegotheles cristatus	Australian Owlet-nightjar	2		2
Alauda arvensis	Eurasian Skylark	778	1556	2334
Alisterus scapularis	King Parrot	0	1	1
Anas castanea	Chestnut Teal	0	43	43
Anas gracilis	Grey Teal	1	1404	1405
Anas rhynchotis	Australasian Shoveler	0	244	244
Anas spp.	Unidentified ducks	0	880	880
Anas superciliosa	Pacific Black Duck	0	629	629
Anhinga novaehollandiae	Australian Darter	0	1	1
Anthochaera carunculata	Red Wattlebird	172	176	348
Anthus novaeseelandiae	Australasian Pipit	20	75	95
Aphelocephala leucopsis	Southern Whiteface	0	3	3
Aquila audax	Wedge-tailed Eagle	0	135	135
Ardea intermedia	Intermediate Egret	0	1	1
Ardea pacifica	White-necked Heron	0	7	7

Species name	Common Name	Heard	Seen	Total
Artamus cyanopterus	Dusky Woodswallow	1	62	63
Aythya australis	Hardhead	0	39	39
Cacatua galerita	Sulphur-crested Cockatoo	152	1039	1191
Cacomantis flabelliformis	Fan-tailed Cuckoo	19	1	20
Cacomantis pallidus	Pallid Cuckoo	18	1	19
Cacomantis variolosus	Brush Cuckoo	5		5
Callocephalon fimbriatum	Gang-gang Cockatoo	4	16	20
Calyptorhynchus funereus	Yellow-tailed Black Cockatoo	1	68	69
Carduelis carduelis	European Goldfinch	9	398	407
Chenonetta jubata	Australian Wood Duck	5	1461	1466
Chlidonias hybrida	Whiskered Tern	0	67	67
Chrysococcyx basalis	Horsfields Bronze-cuckoo	8	1	9
Chrysococcyx lucidus	Shining Bronze-cuckoo	8	3	11
Chthonicola sagittata	Speckled Warbler	3	13	16
Cincloramphus cruralis	Brown Songlark	1	2	3
Cinclosoma punctatum	Spotted Quail-thrush	3	4	7
Circus approximans	Swamp Harrier	0	1	1
Circus assimilis	Spotted Harrier	0	5	5
Climacteris picumnus	Brown Treecreeper	2	1	3
Colluricincla harmonica	Grey Shrike-thrush	103	13	116
Coracina novaehollandiae	Black-faced Cuckoo-shrike	8	16	24
Corcorax melanorhamphos	White-winged Chough	2		2
Cormobates leucophaea	White-throated Treecreeper	205	34	239
Corvus coronoides	Australian Raven	157	254	411
Corvus mellori	Little Raven	159	1199	1358
Corvus sp.	Raven sp.	0	12	12
Coturnix pectoralis	Stubble Quail	42	2	44

Species name	Common Name	Heard	Seen	Total
Coturnix ypsilophora	Brown Quail	1		1
Cracticus tibicen	Australian Magpie	443	498	941
Cracticus torquatus	Grey Butcherbird	33	4	37
Cygnus atratus	Black Swan	0	98	98
Dacelo novaeguineae	Laughing Kookaburra	65	26	91
Daphoenositta chrysoptera	Varied Sittella	0	16	16
Egretta novaehollandiae	White-faced Heron	0	146	146
Elanus axillaris	Black-shouldered Kite	0	4	4
Elseyornis melanops	Black-fronted Dotterel	0	1	1
Eolophus roseicapilla	Galah	44	666	710
Eopsaltria australis	Eastern Yellow Robin	11	1	12
Erythrogonys cinctus	Red-kneed Dotterel	0	8	8
Falco berigora	Brown Falcon	1	33	34
Falco cenchroides	Nankeen Kestrel	0	144	144
Falco longipennis	Australian Hobby	0	12	12
Falco peregrinus	Peregrine Falcon	0	10	10
Fulica atra	Eurasian Coot	0	37	37
Grallina cyanoleuca	Magpie Lark	33	20	53
Haliaeetus leucogaster	White-bellied Sea Eagle	0	2	2
Hieraaetus morphnoides	Little Eagle	0	1	1
Himantopus himantopus	Black-winged Stilt	0	102	102
Hirundapus caudacutus	White-throated Needletail	0	50	50
Hirundo neoxena	Welcome Swallow	1	181	182
Lalage tricolor	White-winged Triller	1		1
Lichenostomus chrysops	Yellow-Faced Honeyeater	131	458	589
Lichenostomus fuscus	Fuscous Honeyeater	1	6	7
Lichenostomus leucotis	White-eared Honeyeater	188	50	238

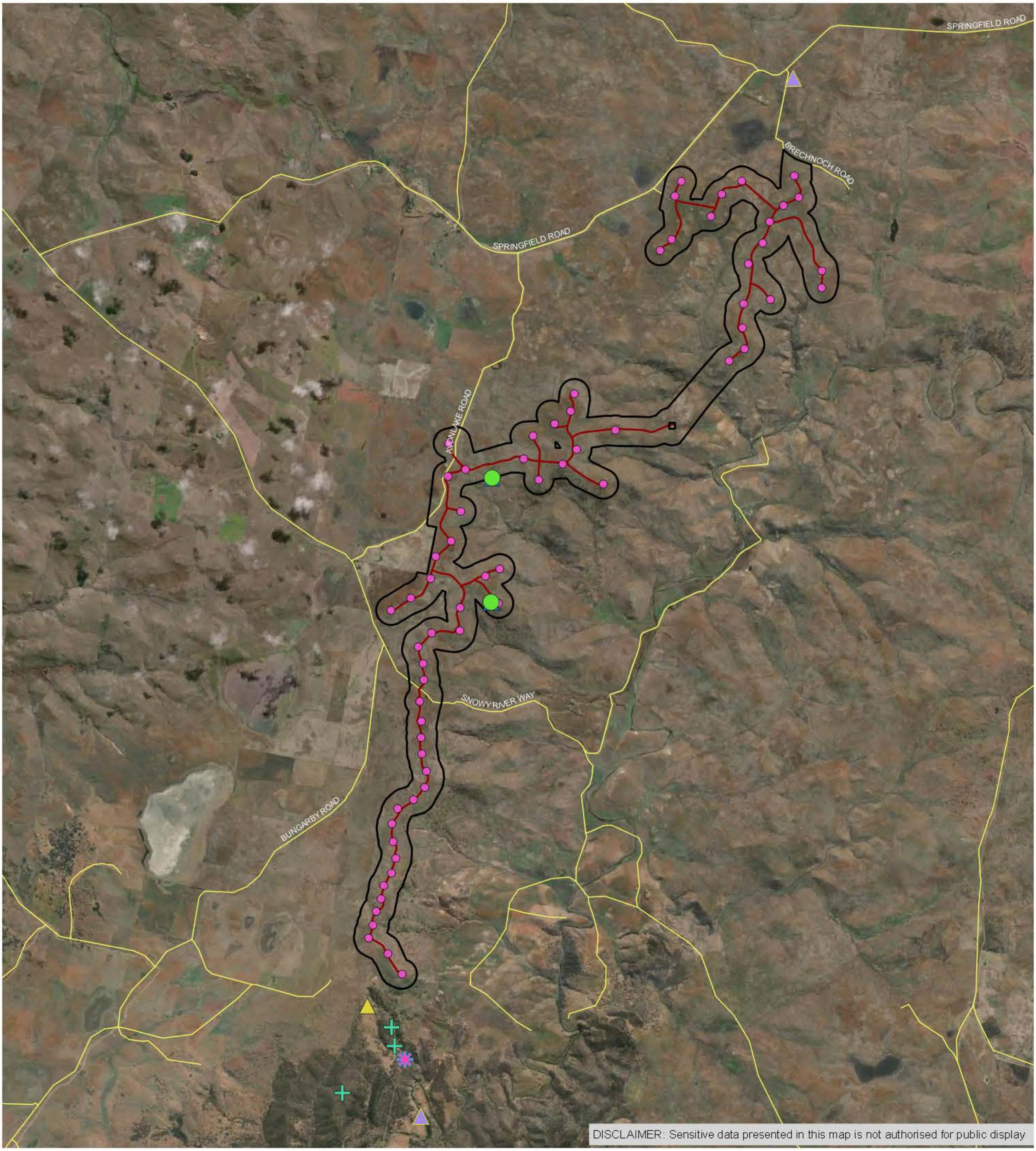
Species name	Common Name	Heard	Seen	Total
Lichenostomus penicillatus	White-plumed Honeyeater	0	7	7
Malacorhynchus membranaceus	Pink-eared Duck	0	27	27
Malurus cyaneus	Superb Fairywren	30	110	140
Malurus lamberti	Variegated Fairy-wren	0	4	4
Manorina melanocephala	Noisy Miner	6	4	10
Megalurus mathewsi	Rufous Songlark	3		3
Melanodryas cucullata	Hooded Robin	2	3	5
Melithreptus albogularis	White-throated Honeyeater	1		1
Melithreptus brevirostris	Brown-headed Honeyeater	23	22	45
Melithreptus lunatus	White-naped Honeyeater	12	64	76
Menura novae-hollandiae	Superb Lyrebird	7		7
Microeca fascinans	Jacky Winter	0	4	4
Mirafra cantillans	Singing Bushlark	1	2	3
Myiagra inquieta	Restless Flycatcher	6	3	9
Myiagra rubecula	Leaden Flycatcher	5		5
Neochmia temporalis	Red-browed Finch	0	22	22
Ocyphaps lophotes	Crested Pigeon	4	16	20
Oriolus sagittatus	Olive-backed Oriole	0	2	2
Pachycephala pectoralis	Golden Whistler	0	2	2
Pachycephala rufiventris	Rufous Whistler	63	9	72
Pardalotus punctatus	Spotted Pardalote	63	12	75
Pardalotus striatus	Striated Pardalote	246	102	348
Passer domesticus	House Sparrow	0	38	38
Petrochelidon ariel	Fairy Martin	0	8	8
Petrochelidon nigricans	Tree Martin	0	93	93
Petroica boodang	Scarlet Robin	55	35	90
Petroica phoenicea	Flame Robin	2	29	31

Species name	Common Name	Heard	Seen	Total
Phaps chalcoptera	Common Bronzewing	2	4	6
Phylidonyris pyrrhopterus	Crescent Honeyeater	0	1	1
Platycercus elegans	Crimson Rosella	93	276	369
Platycercus eximius	Eastern Rosella	2	43	45
Poliocephalus poliocephalus	Hoary-headed Grebe	0	236	236
Porphyrio porphyrio	Purple Swamphen	0	4	4
Porzana fluminea	Australian Spotted Crake	0	3	3
Psephotus haematonotus	Red-rumped Parrot	5	23	28
Rhipidura albiscapa	Grey Fantail	40	41	81
Rhipidura leucophrys	Willie Wagtail	36	31	67
Rhipidura rufifrons	Rufous Fantail	0	1	1
Sericornis frontalis	White-browed Scrubwren	2	16	18
Smicrornis brevirostris	Weebill	0	5	5
Stagonopleura guttata	Diamond Firetail	1	13	14
Stictonetta naevosa	Freckled Duck	0	1	1
Strepera graculina	Pied Currawong	93	56	149
Strepera versicolor	Grey Currawong	29	8	37
Sturnus vulgaris	Common Starling	68	3146	3214
Tachybaptus novaehollandiae	Australasian Grebe	0	35	35
Tadorna tadornoides	Australian Shelduck	0	98	98
Threskiornis spinicollis	Straw-necked Ibis	0	52	52
Todiramphus sanctus	Sacred Kingfisher	9	2	11
Turdus merula	Common Blackbird	2		2
Unidentified waterfowl	Unidentified waterfowl	0	337	337
Vanellus miles	Masked Lapwing	1	199	200
Vanellus tricolor	Banded Lapwing	0	29	29
Zosterops lateralis	Silvereye	16	90	106

Species name	Common Name	Heard	Seen	Total
Grand Total		3817	**18124**	**21941**

C.4 Map: Threatened species and raptors

Maps showing locations of threatened species and raptors recorded in 2021 are given overleaf.



Threatened Species Results

- 141128_BOC_S1_ProjectBoundary
- Stage 1_As Constructed_WTG_Bird and Bat
- BOC_RoadNetwork
- Stage 1_As Constructed_Roads_Bird and Bat

2022 Threatened Species

- Dusky Woodswallow
- Eastern False Pipistrelle
- Hooded Robin
- Large Bentwing Bat
- Scarlet Robin
- Speckled Warbler

0 1 2 3 4 km

Data Attribution
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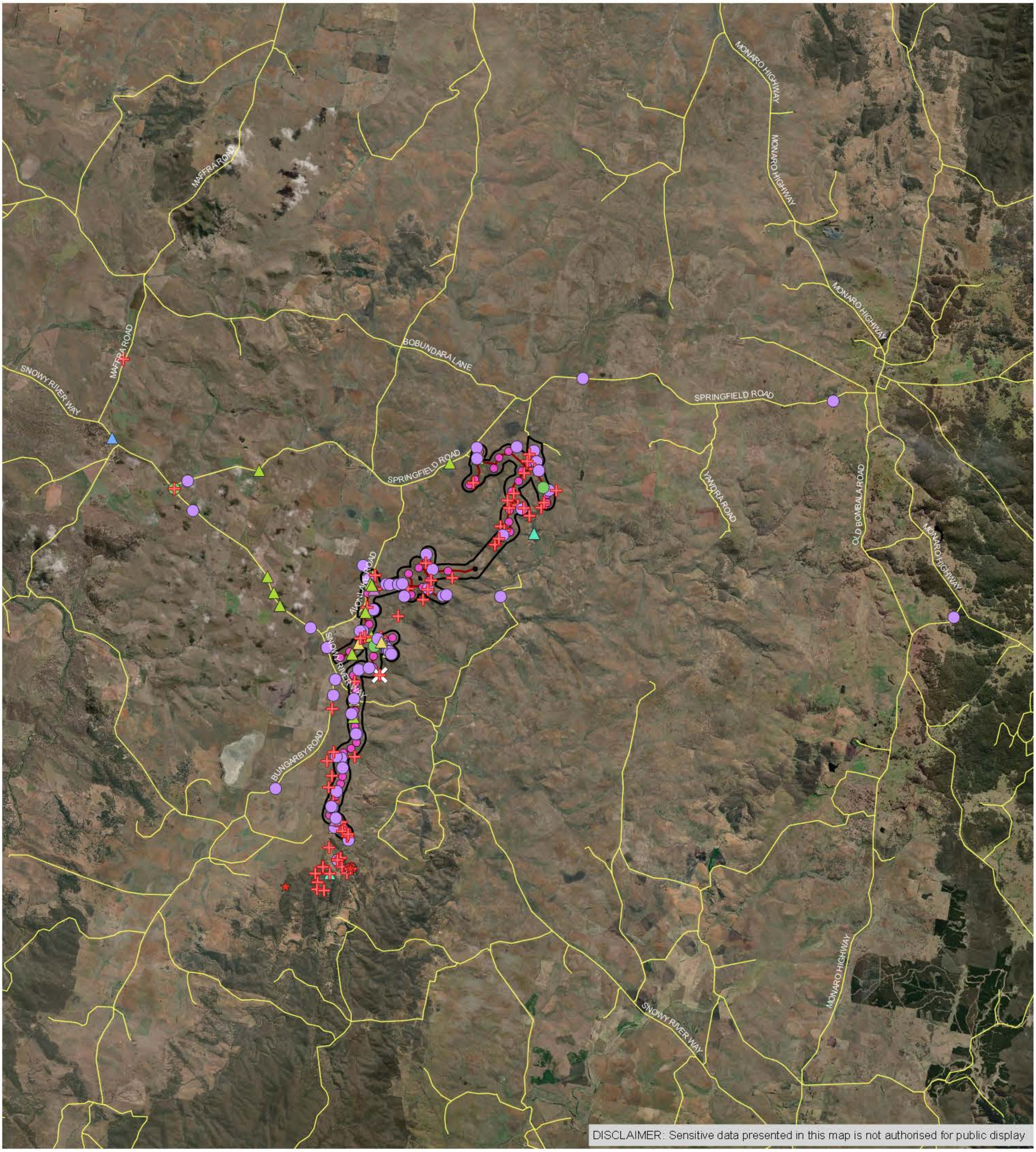
Ref: 21-039 Boco Rock Year 7 Monitoring 190521 \
21-039BOCOYear7_ThreatenedSpeciesAnnualReport_2022
Author: Ian.C
Date created: 09.03.2022
Datum: GDA94 / MGA zone 55

NGH



Raptor Survey Results

- Project Boundary
- Turbines
- Road Network
- Access Tracks

2015-2021 Annual Report GIS Raptors copy

- Australian Hobby
- Black-shouldered Kite
- Brown Falcon
- Brown Goshawk
- Collared Sparrowhawk
- Little Eagle
- Nankeen Kestrel
- Peregrine Falcon
- Spotted Harrier
- Swamp Harrier
- White-bellied Sea Eagle
- Active WTE Nest

0 1 2 3 4 5 km

Data Attribution
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Ref: 21-039 Boco Rock Year 7 Monitoring 190521 \ 21-039 BOCO2015-2021 Raptor Survey Results Report 20220308
Author: Ian.C
Date created: 15.03.2022
Datum: GDA94 / MGA zone 55

Appendix D Analysis: Specialist Reports

D.1 Mortality monitoring, Symbolix Pty Ltd

Boco Rock Wind Farm Mortality Estimate – Year Seven. Report prepared for NGH Environmental by Symbolix Pty Ltd., February 2022

Boco Rock Wind Farm Mortality Estimate - Year Seven

Prepared for NGH Environmental, 9 February 2022, Ver. 1.0

This report outlines an analysis of the seventh year mortality data collected at Boco Rock Wind Farm from 2021-01-18 to 2021-12-10. 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 2021, and also all surveys conducted throughout 2015 - 2021

The data was collected and provided by NGH Environmental (NGH). and is analysed "as-is." A brief summary of the data is provided below, and the ultimate focus of this report is a discussion of the potential mortality.

Available data

The data analysed was collected, verified and provided to us from NGH[1].

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 simulation to achieve this.

The analysis used survey data to estimate the average time to scavenge loss and searcher efficiency (and related confidence intervals). The algorithm then simulated different numbers of virtual mortalities. We could then estimate how many carcasses were truly in the field, given

[1] Carcasses found: `2020 Mortality to Symbolix.xlsx`, `Symbolix_Mortality_Estimate_Template.xlsx`. Scavenger and detectability trials: `scavenger_detectability results.xlsx`. Survey data: `Symbolix Mortality survey details 2020_v2.xlsx`, `Symbolix_Mortality_Estimate_Template.xlsx`.

the range of searcher and scavenger efficiencies, and 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.

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).

Searcher efficiency

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.

Using binomial regression, we found the cleared areas provide significantly higher detectability than the extended area ($p < 0.001$ for small sizes, and also $p < 0.001$ for all sizes).

Tables 1 and 2 summarise the results.

Table 1: Detection efficiencies for small sizes.

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 2: Detection efficiencies for all sizes.

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%].

Scavenger efficiency

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 (six) and other carcasses of various sizes (24) 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.

Survival analysis (Kaplan and Meier 1958) was used to determine the average time until complete loss from scavenge. Survival analysis was required to account for the fact that we do not know the exact time of scavenge loss, only an interval in which the scavenge event happened. In three cases we have "right-censored" intervals, as an eagle and two chickens were still found on the ground the final day of the survey. By performing survival analysis we can estimate the average survival percentage after a given length of time, despite these unknowns.

Running the detectability trial at the start of the scavenger trial means that the carcasses were checked within the first day of placing them. To account for this we have assumed that if the carcass was lost in the first day (after the detectability trial), it survived for between 15 minutes and one day.

It was found that the ground type (Hardstand or Extended) did not significantly affect survival time ($p = 0.811$), and neither did the carcass type ($p = 0.152$). Therefore, we combined all data to give us a more precise estimate of overall time to scavenge. Figure 1 displays the combined survival curve.

Under these assumptions, the mean time to total loss via scavenge is 7.8 days, with a 95% confidence window of [5.3, 11.3] days.

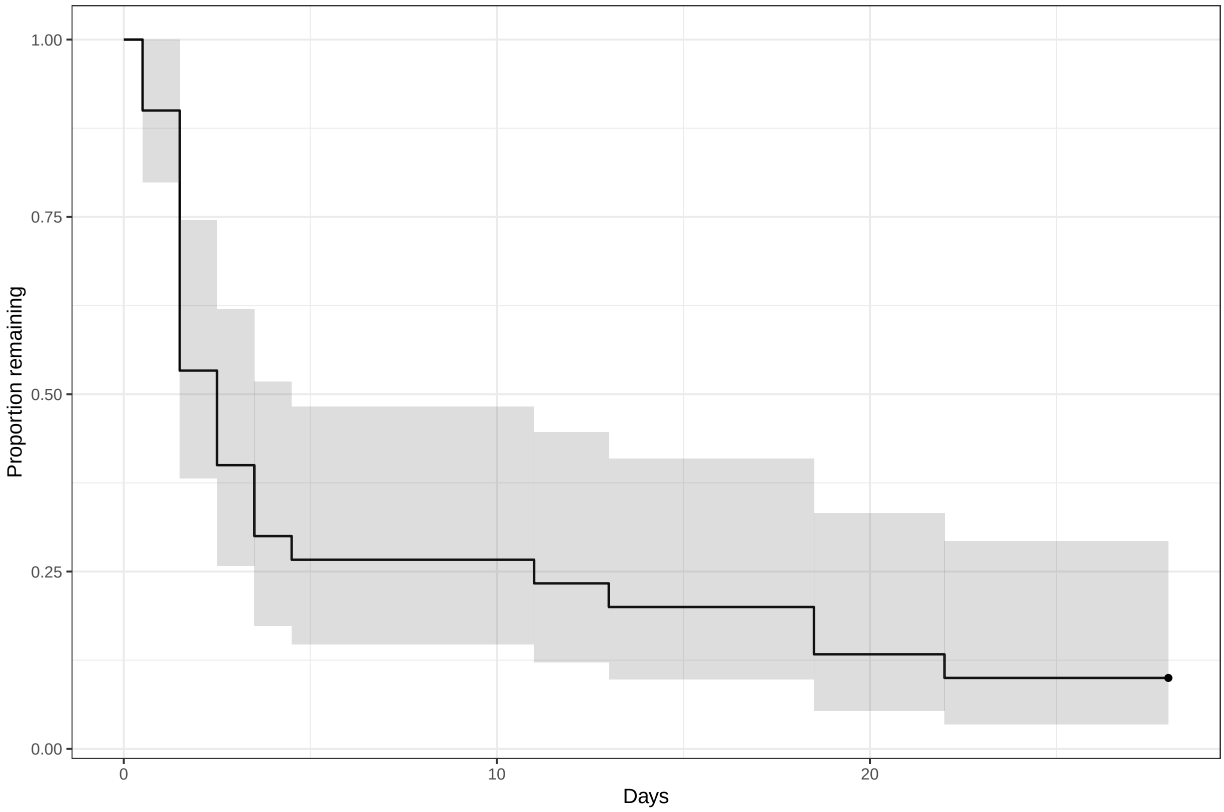

Figure 1: Combined survival curves for birds and bats, with 95% confidence interval shaded.

Other scavenger patterns

There are three general types of scavenger behaviour:

- “perfect”
- “olfactory”; and
- “visual”

These names are classifiers only, and not necessarily accurate descriptions of the actual processes employed by the scavenger. A “perfect” scavenger will find the carcass with constant efficiency, irrespective of the amount of time it has lain on the ground. “Visual” scavengers are more efficient in the earlier period post-mortem, and are less likely to find a carcass the longer it has lain there. “Olfactory” scavengers are the opposite of “visual” scavengers. They require the carcass to lie for some period, before their efficiency of detection increases.

Due to the small number of trials, we have focused on the mean loss rate, and not the shape. This means that we have assumed all scavengers to be “perfect,” which is the middle of the two other types.

Mortality projection inputs

Carcass search data

The mortality estimate was based on a dated list of turbine surveys. The survey frequency is summarised in Table 3.

The searched areas consisted in two zones.

The high detectability search area is:

- each turbine's hardstand area
- an approximately 4x120m road.

Searches were conducted at 4 m transects within the search area. The hardstand / road zone around the turbines was searched twice per survey month for each turbine (Table 3).

The low detectability (extended) search area is:

- **pre June 2019**[2]: an approximately 80x80m section sharing a border with the hardstand. The center of the extended section edge is aligned with the center of the hardstand edge.
- **post June 2019**: a circular area with radius 80m, centered on the turbine, excluding the hardstand and access road

Searches were conducted at 12 m transects within the extended search area in the "pre" setting, and at 10 m in the "post" setting. The extended area was searched once per survey month for 21 turbines.

Custom shape files were generated for each turbine's search area.

Table 3: Number of surveys per month in 2021.

Month	Hardstand / Road Surveys	Extended Zone Surveys
Jan	134	21
Feb	134	21
Mar	134	21
Apr	134	21
May	134	21
Jun	134	21
Jul	134	21
Aug	134	21
Sep	134	21
Oct	134	21
Nov	134	21
Dec	134	21

[2]This only applies to the combined Years 1-7 estimate, not to the Year 7 estimate.

Mortality estimate - year seven

Mortality estimation – methodology

With estimates for scavenge loss and searcher efficiency we then converted the number of bat and bird carcasses detected into an estimate of overall mortality Boco Rock from 2021-01-01 to 2021-12-31 (we allow for collisions to occur up to a month prior to the first survey).

The mortality estimation is done via Monte-Carlo simulation. We used 25000 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 complete set of model assumptions are listed below.

- There were 67 turbines on site.
- Search frequency for each turbine was taken from a list of actual survey dates (see Table 3 for a summary).
- Mortalities were allowed to occur from 2021-01-01 until 2021-12-31.
- Birds are on-site at all times during this period.
- Bats are on-site at all times during this period.
- Finds are random and independent, and not clustered with other finds.
- There was equal chance of any turbine individually being involved in a collision / mortality.
- We assumed an exponential scavenge shape ("perfect" scavengers).
- We took scavenge loss and search efficiency rates as outlined above.
- The survey design involved searching every turbine roughly twice per month on the hardstand/access road. It also involved searching approximately 20 turbines in the extended zone once per month. We estimated the "coverage factor" for the survey procedure - i.e. the total fall zone surveyed for birds and bats (using estimates from Hull and Muir (2010)). For the hardstand/road we estimate that around 45% of the bat and 26% of the bird fall zone was searched per turbine (on average). For the extended zone, around 55% of the bat and 62% bird zone was searched on average[3].

Mortality projection results

After running the simulation we investigated the distribution of mortalities that could have resulted in the actual numbers found during the surveys. The breakdown of found carcasses per species are summarised in Table 4.

[3] Note that these values are indicative - the actual coverage factor calculation involves a complex weighted average which accounts for the different parts of fall zone searched at each survey at each turbine.

Table 4: Carcasses found during formal surveys in the seventh year of surveying.

Year	Species	Bat	Bird
2021	Gould's Wattle Bat	2	
2021	White-striped Freetail Bat	6	
2021	Australaian Magpie		1
2021	Eurasian Skylark		2
2021	Nankeen Kestrel		1

No carcasses were found incidentally in 2021.

Bat mortality estimate – results

During the seventh year of surveys a total of eight bats were found during formal surveys (Table 4). The resulting estimate of total mortality, accounting for searcher efficiency, scavenge rate, search area and timing of surveys is an expectation (mean) of 55 and a median of 52 bats lost on site over the 12 months.

Table 5 and Figure 2 display the percentiles of the distribution, to show the confidence interval in this average.

Based on the detected carcasses and measured detectability and scavenge rate, we expect that there was a total site loss of around 55 bats over the survey period, and are 95% confident that fewer than 92 individuals were lost.

If we just consider White-striped Freetail bats, the six carcasses found imply an estimated (mean) loss of 42 over the survey period. The 95% confidence value is 73.

Table 5: Percentiles of estimated total bat losses over the seventh year of surveying.

0%	50% (median)	90%	95%	99%	99.9%
14	52	83	92	113	121

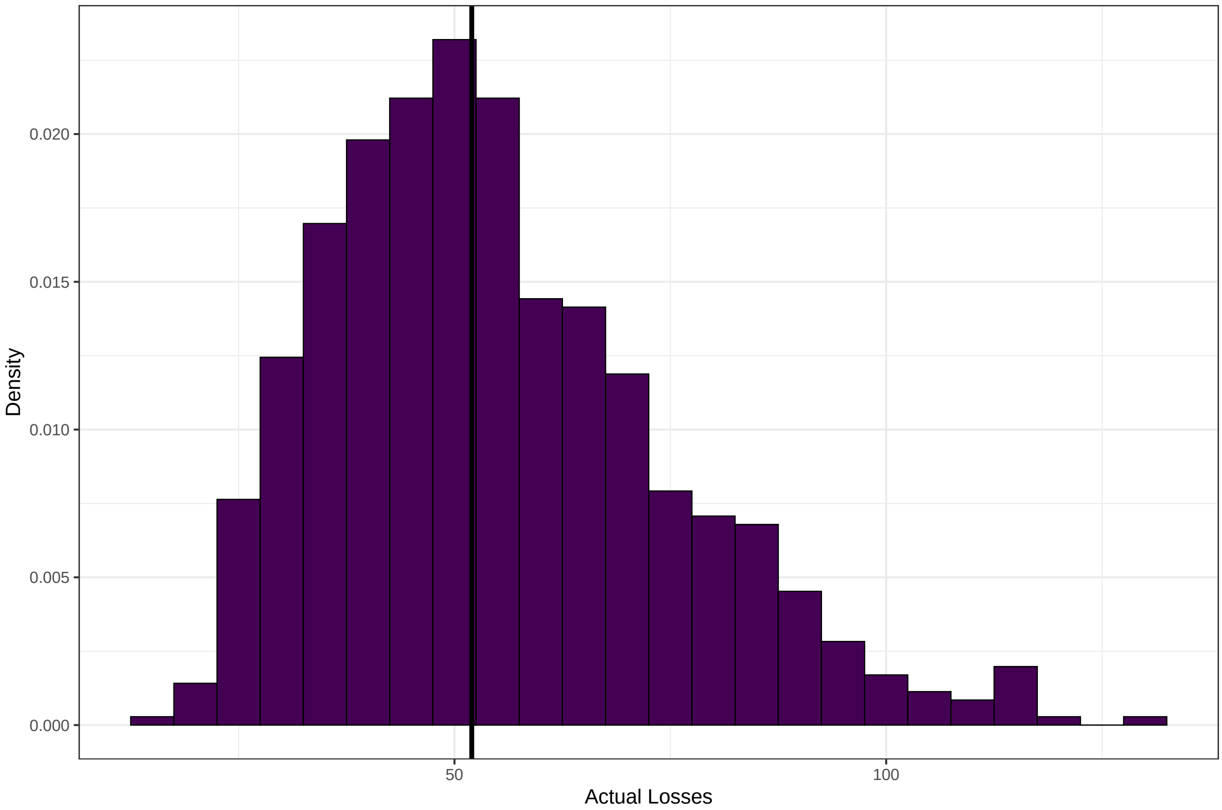

Figure 2: Histogram of the total losses distribution (bats), given 8 were detected on-site. The black solid line shows the median.

Bird mortality estimate - results

During the seventh year of surveys a total of 4 birds were found during formal surveys (Table 4). The resulting estimate of total mortality, accounting for searcher efficiency, scavenge rate, search area and timing of surveys is an expectation (mean) of 40 and a median of 36 birds lost on site over the 12 months.

Table 6 and Figure 3 display the percentiles of the distribution, to show the confidence interval in this average.

Based on the detected carcasses and feather spots and measured detectability and scavenge rate, we expect that there was a total site loss of around 40 birds over the survey period, and are 95% confident that fewer than 76 individuals were lost.

Table 6: Percentiles of estimated total bird losses over the seventh year of surveying.

0%	50% (median)	90%	95%	99%	99.9%
8	36	66	76	102	133

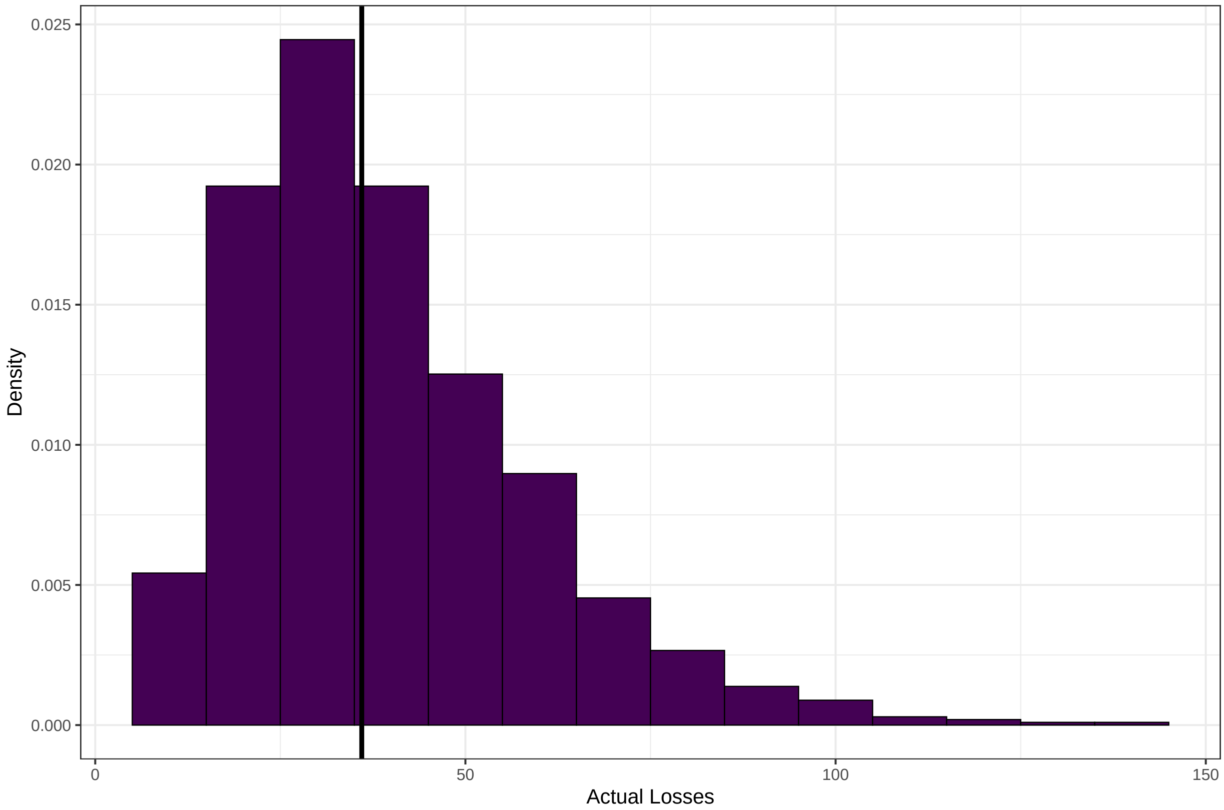

Figure 3: Histogram of the total losses distribution (birds), given 4 were detected on-site. The black solid line shows the median.

Mortality estimate - years one to seven combined

Mortality estimation - methodology

The methodology for the combined estimate is the same as above.

The coverage factors have been updated:

- For the extended zone, around 14% of the bat and 17% bird zone was searched on average (pre June 2019). Post June 2019, see the Year Seven estimates.

Mortality projection results

The breakdown of found carcasses per species from 2015-2020 are summarised in Table 7.

Table 7: Carcasses found during formal surveys in seven years of surveying.

Species	Bat	Bird
Chalinolobus sp?	1	
Eastern Bentwing Bat	3	
Gould's Wattle Bat	2	
Gould's Wattled Bat	13	
Grey-headed Flying Fox	1	
Large Forest Bat	1	
White-striped Freetail Bat	49	
Australaian Magpie		1
Australian Magpie		8
Australian Raven		1
Brown Falcon ??		1
Brown Goshawk		1
Common Starling		3
Eurasian Skylark		14
Fairy Martin		1
Grey Fantail		3
Little Raven		1
Nankeen Kestrel		6
Peregrine Falcon		1
Rufous Fantail		2
Shining Bronze-cuckoo		1
Silvereye		1
Southern Boobook		1
Stubble Quail		1
Unidentifiable		3
Wedge-tailed Eagle		3
White-throated Needletail		2

Bat mortality estimate – results

During seven years of surveys (2015-01-05 to 2021-12-10) a total of 70 bats were found during formal surveys (Table 7). The resulting estimate of total mortality, accounting for searcher efficiency, scavenge rate, search area and timing of surveys is an expectation (mean) of 425 and a median of 421 bats lost on site over the seven-year period.

Table 8 and Figure 4 display the percentiles of the distribution, to show the confidence interval in this average.

Based on the detected carcasses and measured detectability and scavenge rate, we expect that there was a total site loss of around 425 bats over the survey period, and are 95% confident that fewer than 560 individuals were lost.

If we just consider White-striped Freetail bats, the 49 carcasses found imply an estimated (mean) loss of 308 over the survey period. The 95% confidence value is 436.

Table 8: Percentiles of estimated total bat losses over seven years of surveying.

0%	50% (median)	90%	95%	99%	99.9%
241	421	530	560	634	688

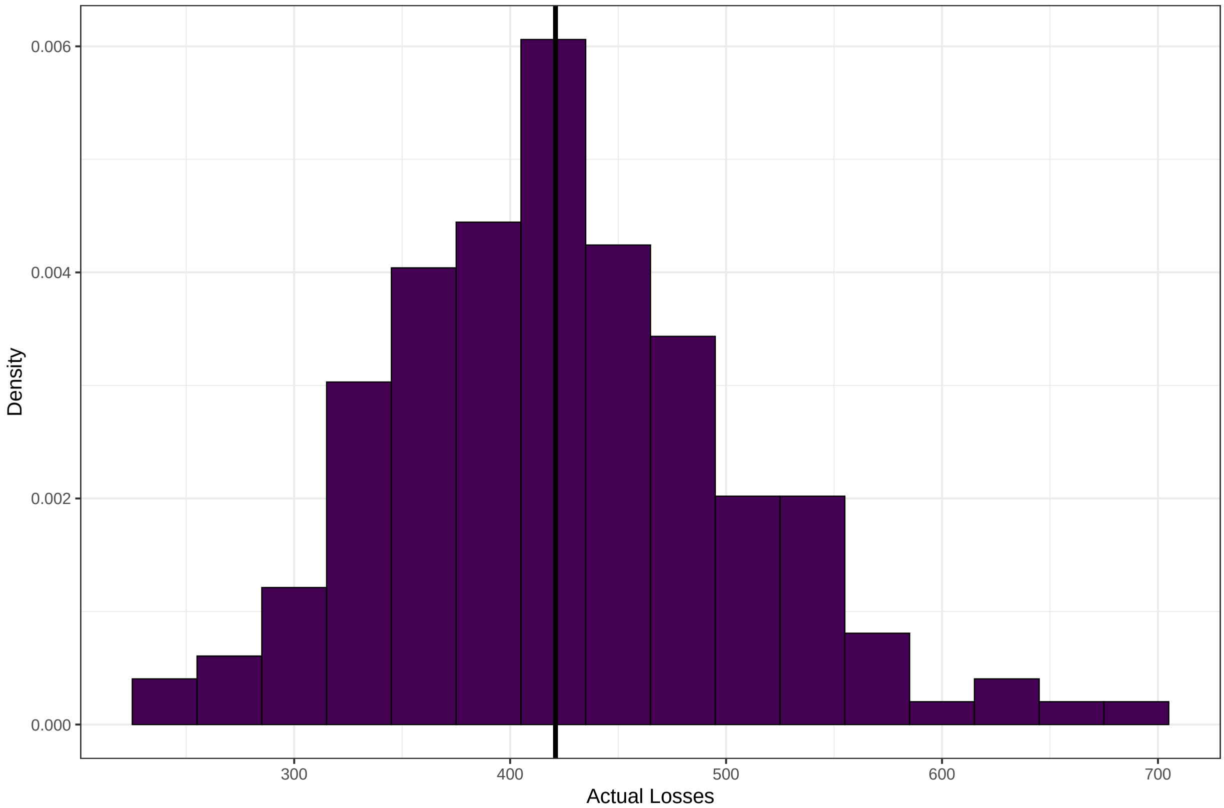

Figure 4: Histogram of the total losses distribution (bats) over seven years, given 70 were detected on-site. The black solid line shows the median.

Bird mortality estimate - results

During seven years of surveys of surveys a total of 55 birds were found during formal surveys (Table 7). The resulting estimate of total mortality, accounting for searcher efficiency, scavenge rate, search area and timing of surveys is an expectation (mean) of 465 and a median of 448 birds lost on site over the seven-year period.

Table 9 and Figure 5 display the percentiles of the distribution, to show the confidence interval in this average.

In determining the estimate, 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.

Based on the detected carcasses and feather spots and measured detectability and scavenge rate, we expect that there was a total site loss of around 465 birds over the survey period, and are 95% confident that fewer than 662 individuals were lost.

Table 9: Percentiles of estimated total bird losses over seven years of surveying.

0%	50% (median)	90%	95%	99%	99.9%
296	448	591	662	764	770

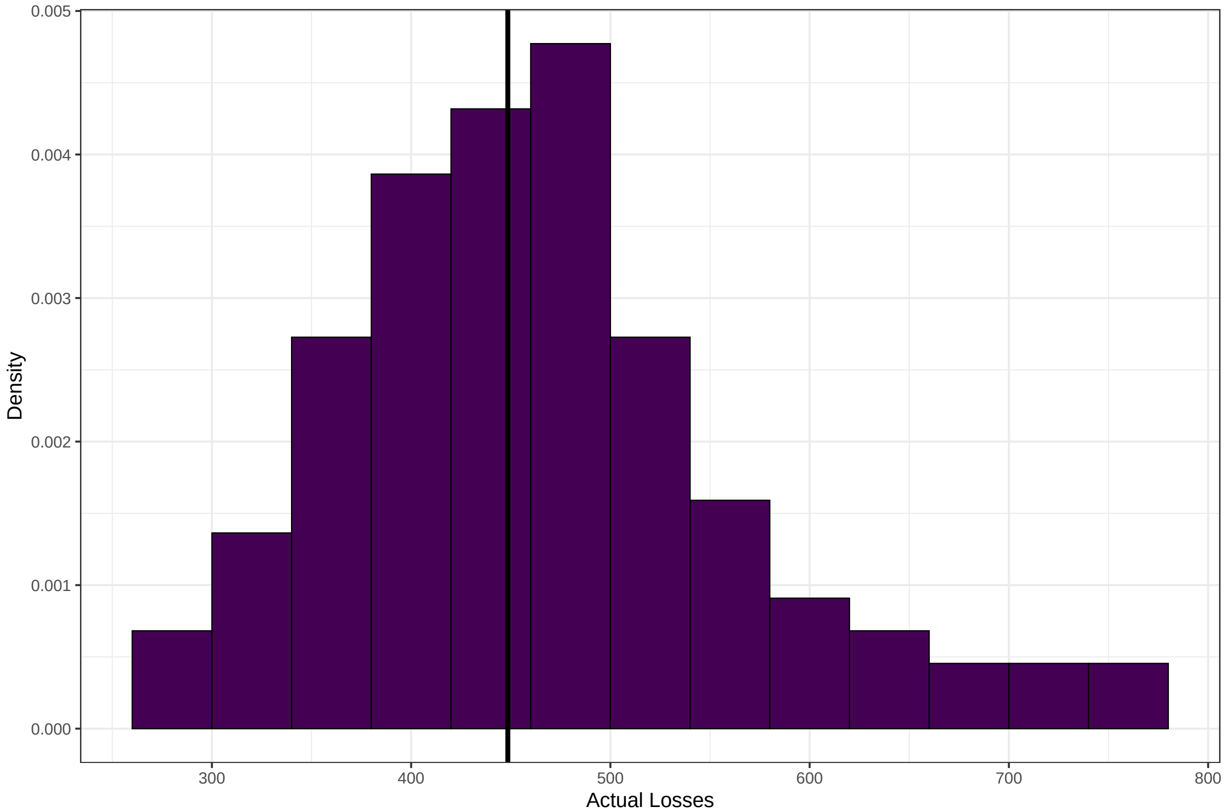

Figure 5: Histogram of the total losses distribution (birds) over seven years, given 55 were detected on-site. The black solid line shows the median.

Concluding remarks

In evaluating the potential impact, it is important to remember that all mortality estimators have an inherent assumption that there is an unlimited supply of carcasses to be found. In particular, we did not apply an upper limit on the number of bats that could be onsite, and we assumed that bats were present all year round. The ecological feasibility of this assumption should be accounted for if using these results to comment on overall ecological impact.

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D.2 Bird utilisation surveys, Symbolix Ptd Ltd

Boco Rock Wind Farm Bird Utilisation Survey Analysis - Year Seven. Report prepared for NGH Environmental by Symbolix Pty Ltd, March 2022

Boco Rock Wind Farm Bird Utilisation Survey - Year Seven Analysis

Prepared for NGH Environmental, 25 February 2022, 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 seven 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.

[1] 21-039_NGHBOCO_BirdUtilisationData_2021.xlsx

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 all 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.

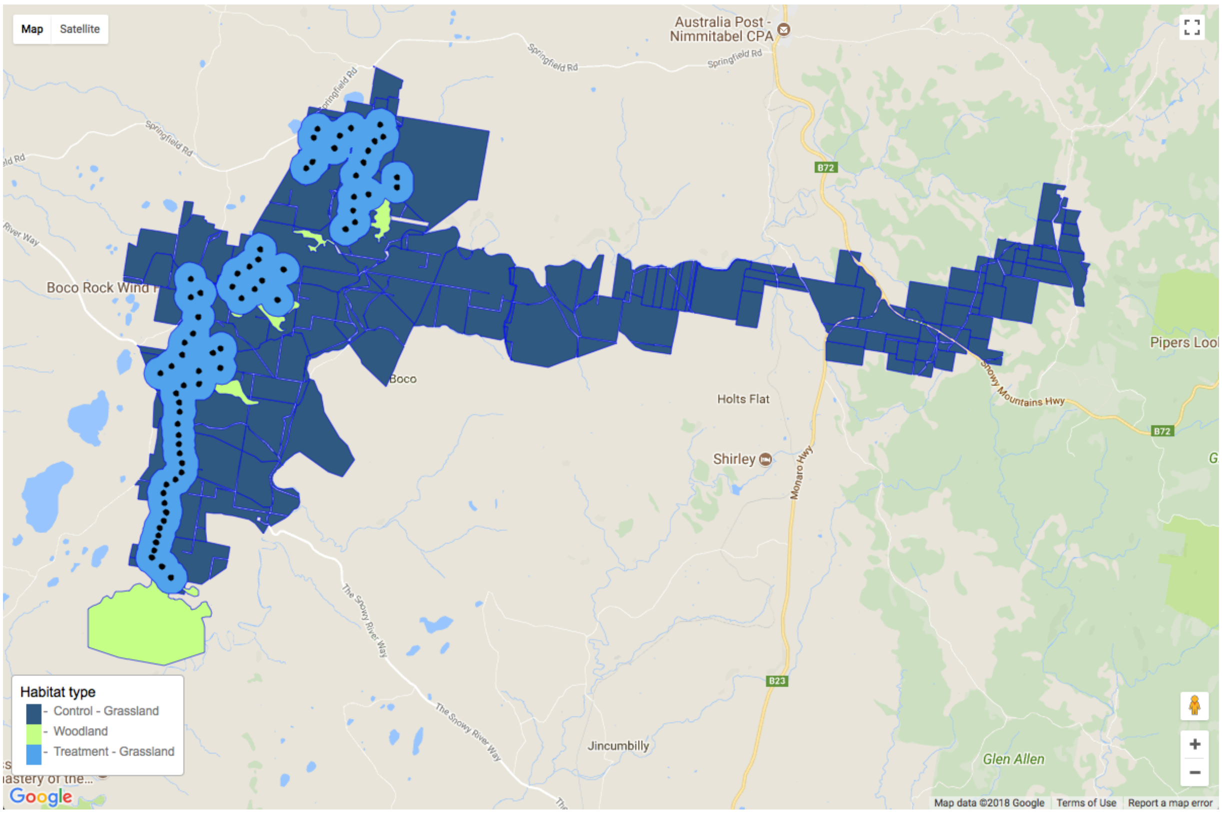

Figure 1: Relative location of the three habitat types and survey locations. The dots represent the turbine locations.

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	4	3	3	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						
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						

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. While the patterns in species abundance are useful, 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 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),

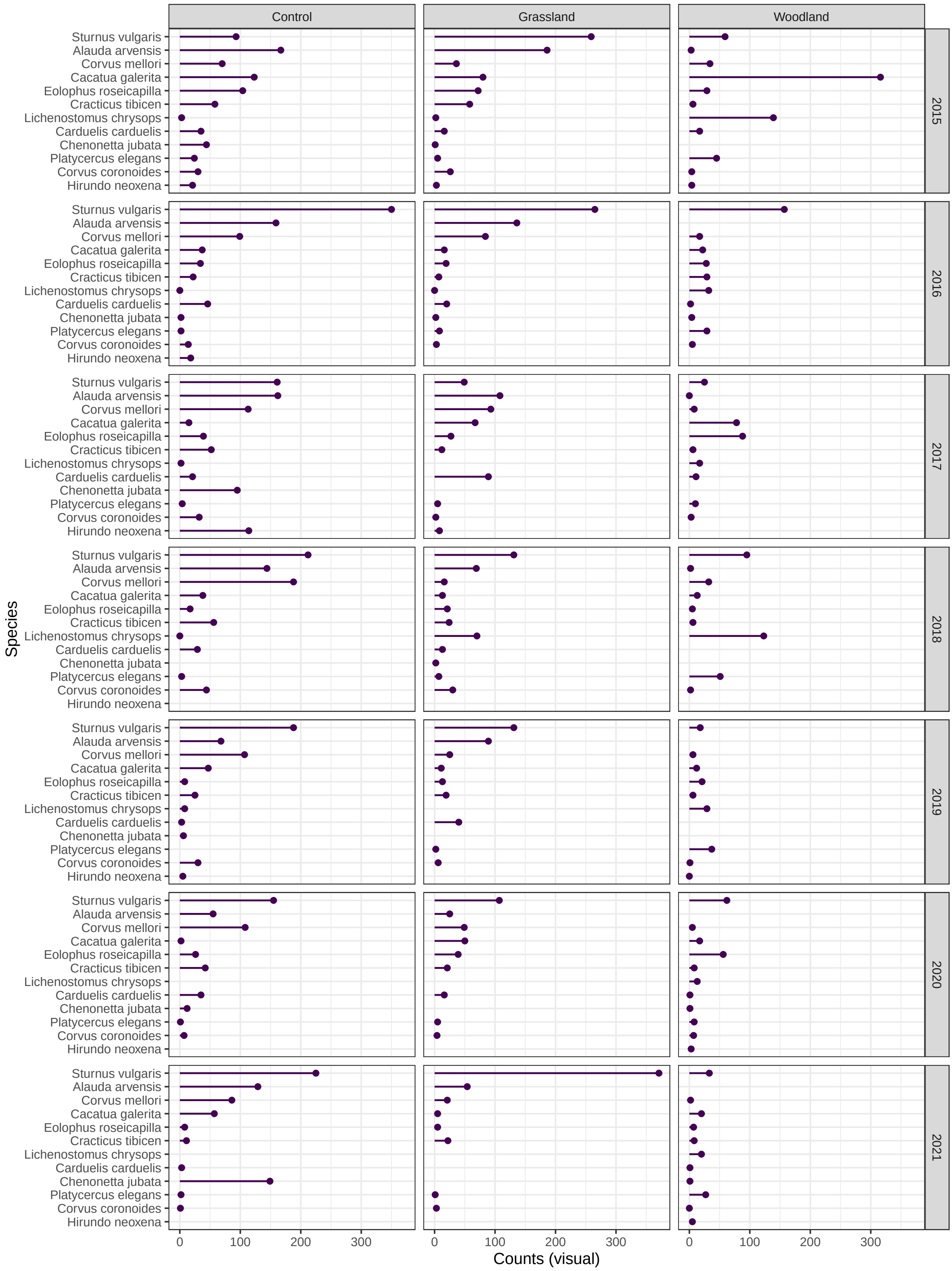

Figure 2: Total visual counts by species for each habitat type. Only the top 10% of species are shown (for legibility).

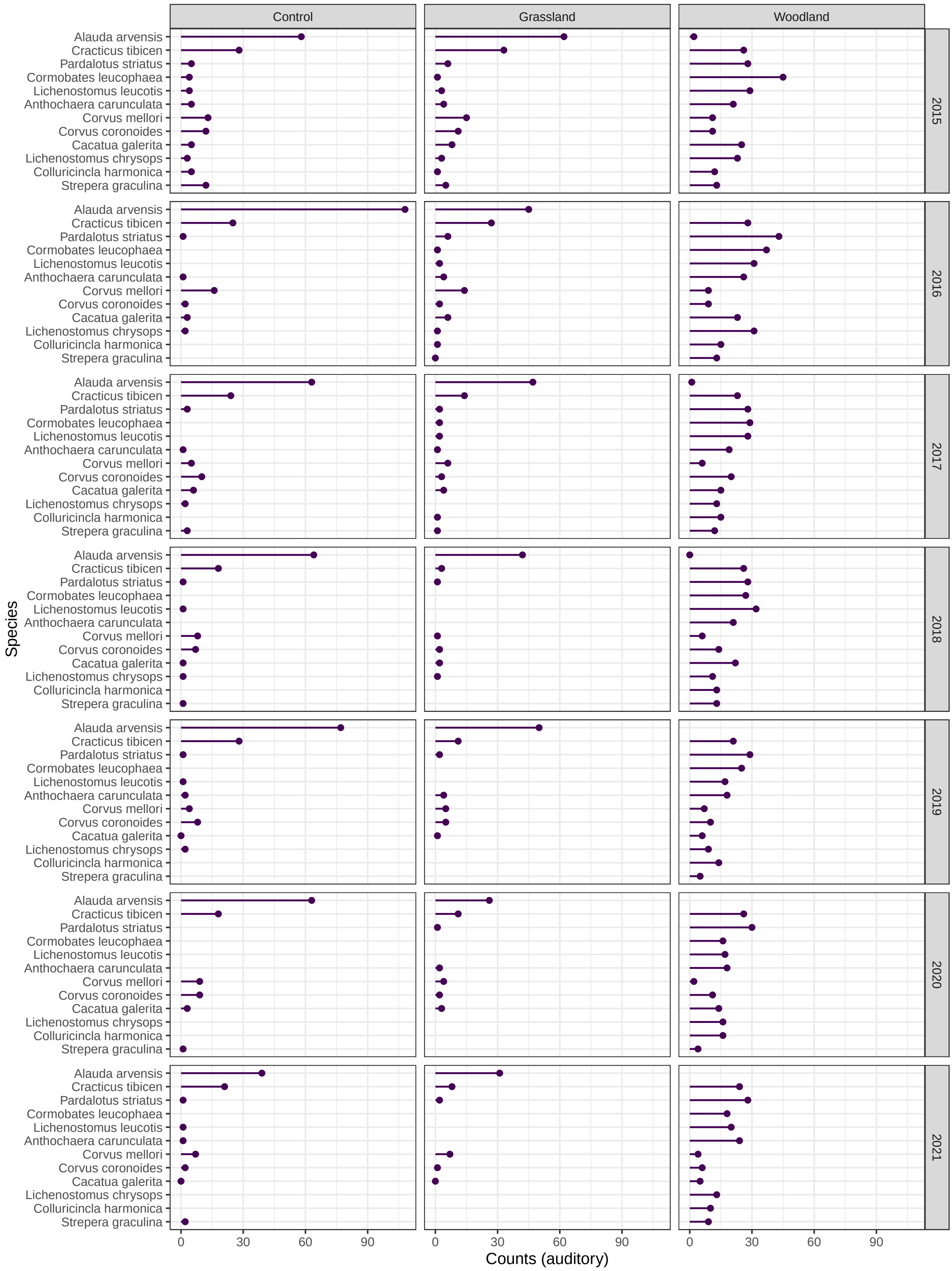

Figure 3: Total auditory counts by species for each habitat type. Only the top 10 "% of species are shown (for legibility).

Reference-treatment comparisons

Figures 4 and 5 compare the species richness between habitat types throughout the year.

The overall richness of the woodland sites is higher than both the grassland and control sites. The woodland richness has remained fairly constant over the last four years, accounting for seasonal variation. This variation is reflected in lower richness in the second and third quarters of the year (shaded). There does appear to be a slight decreasing trend over the course of the six years.

The richness in the grassland sites remains fairly stable over the last four years, although there is a hint of a decrease. Note that the 2016 fourth quarter richness for grassland only contains December observations, whereas the 2015 and 2017 fourth quarter richness box plots contain observations from October, November, and December. As the richness in December is generally lower than in October and November, the apparently low richness in 2016 fourth quarter grassland is due to a skew caused by lack of October / November data.

Species richness in the control sites appears to have been decreasing over the first two years of surveying (which is consistent with the Grassland and Woodland sites), but appears to have stabilised since 2017.

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 effects 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. The first half of 2021 appears to show lower diversity than usual.

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.

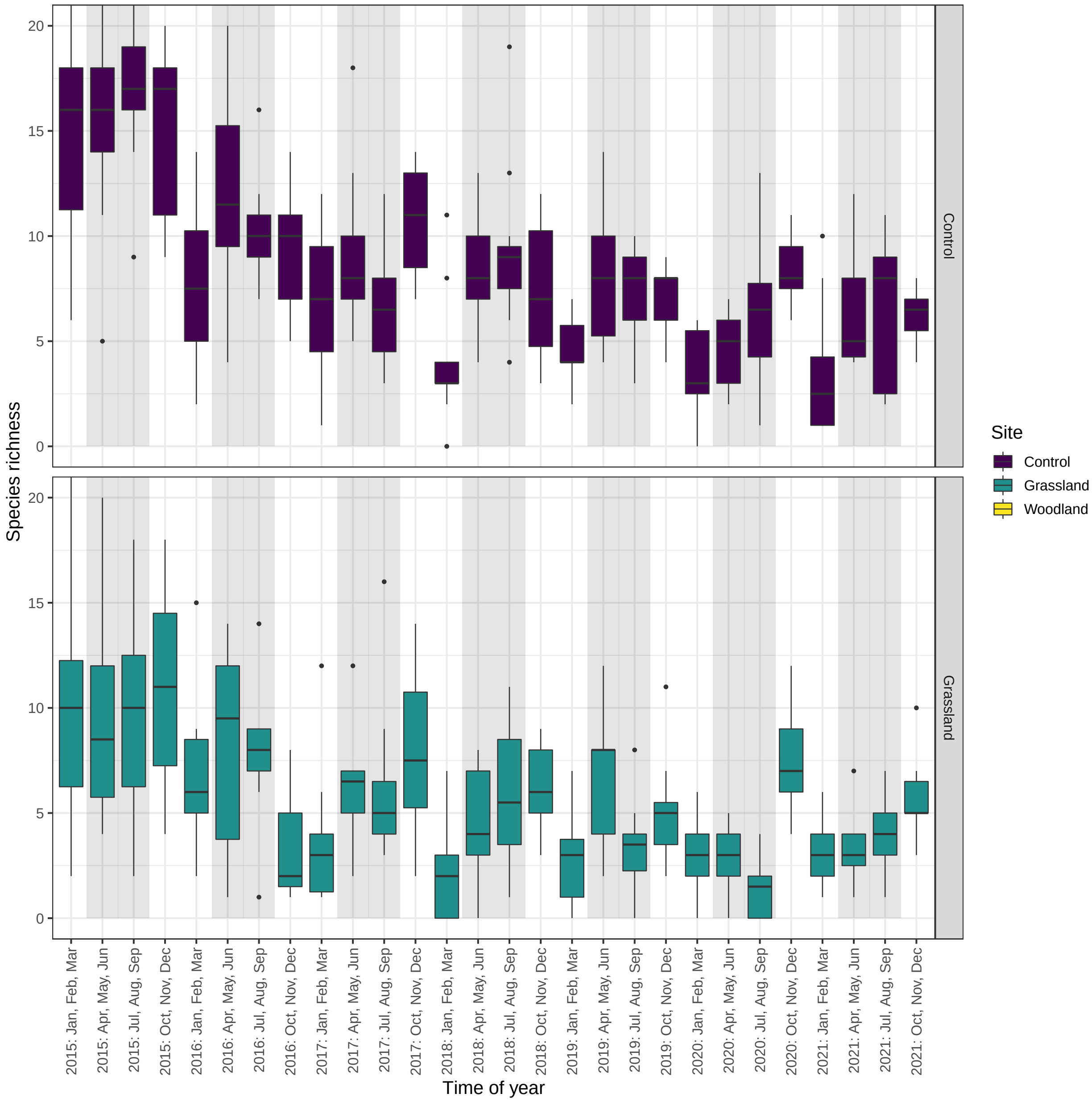

Figure 4: Distribution of species richness per survey, by site and time of year. Winter months highlighted. Control and Grassland sites only.

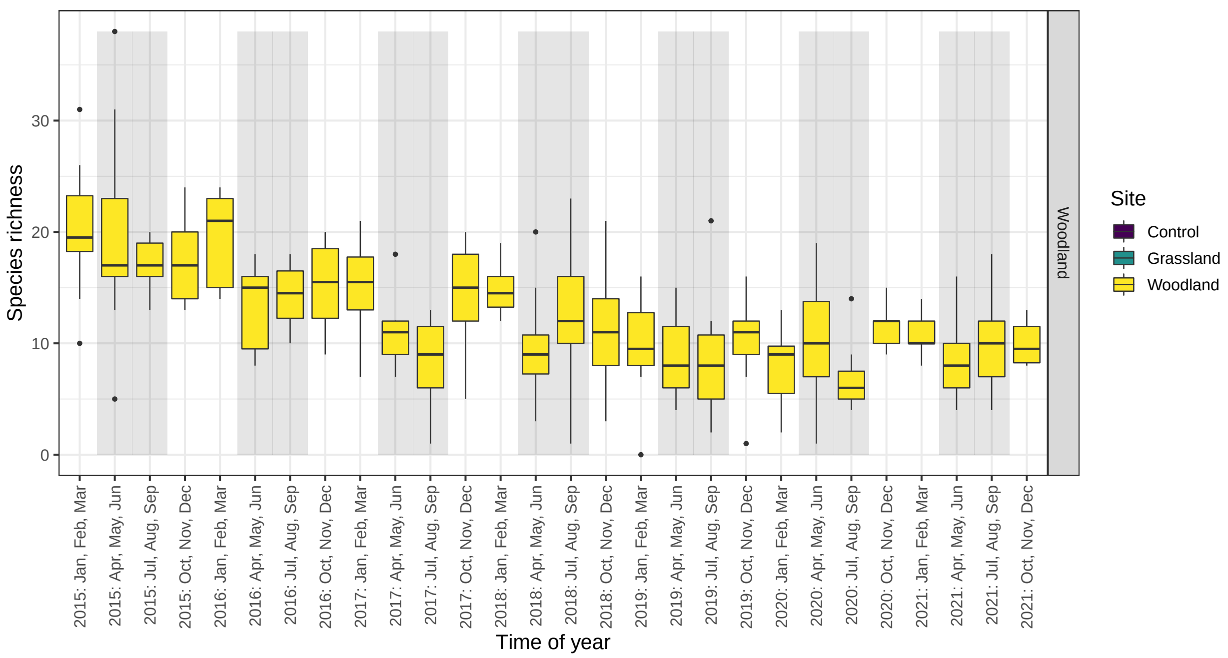

Figure 5: Distribution of species richness per survey, by site and time of year. Winter months highlighted. Woodland sites only.

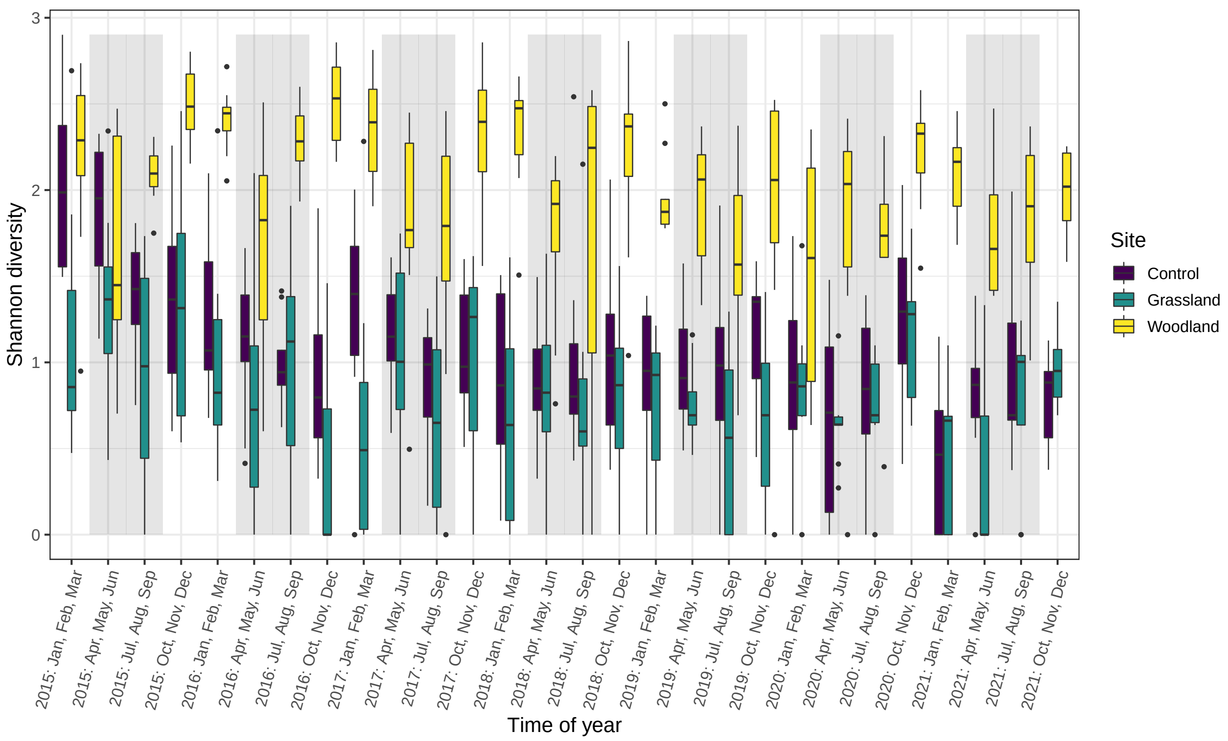

Figure 6: Distribution of Shannon diversity per survey, by site and time of year.

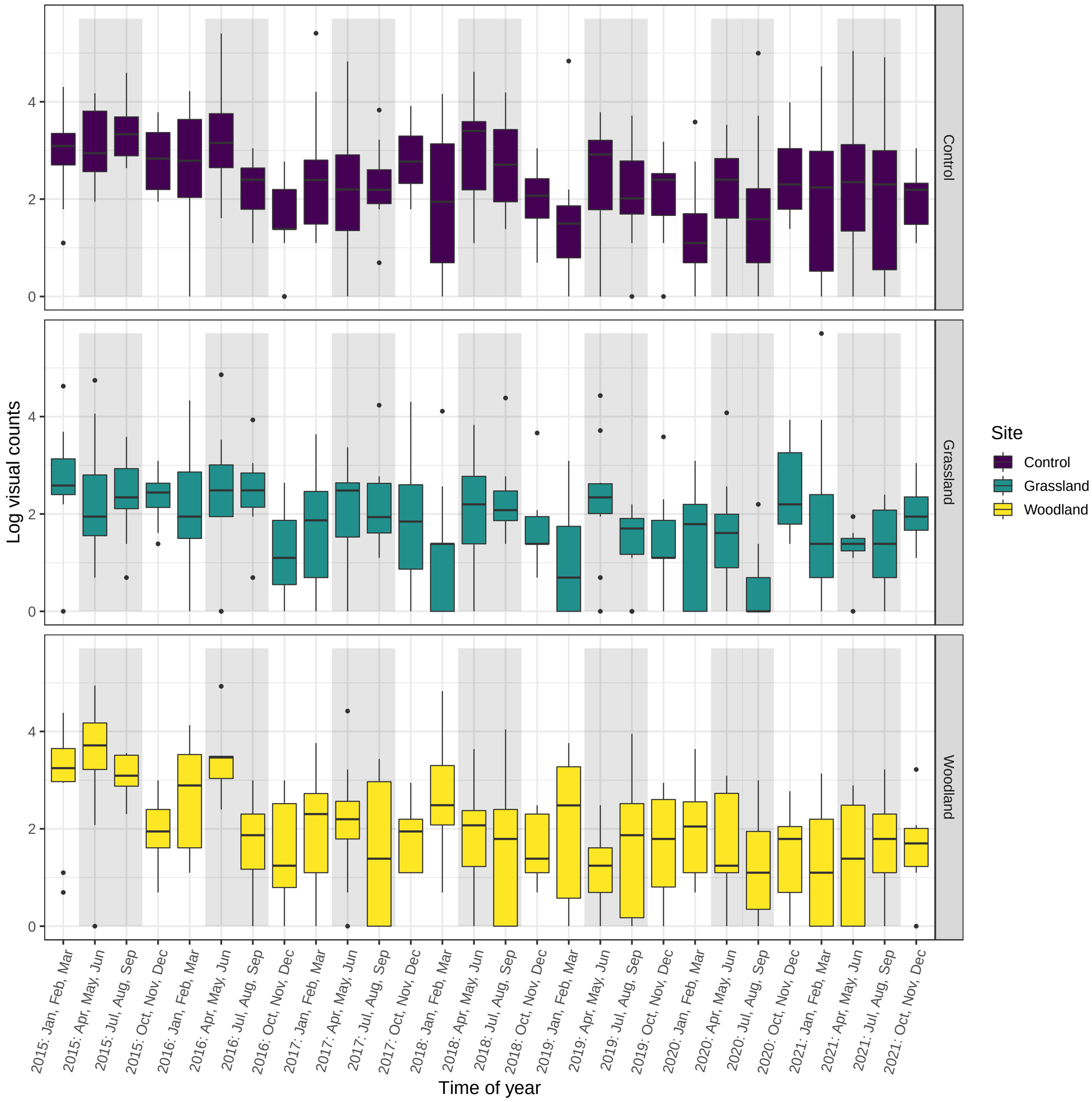

Figure 7: Distribution of total log (visual) counts, by site and time of year

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 that there is a movement in the species mix over time. Earlier surveys are roughly clustered around the (0, -0.5) point, but there's a trend towards the right upper corner (1, 0) 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 the control sites, the early surveys have a different mix, but after the third quarter of 2015, the mix has changed. This makes sense, because we know that around this time, certain control sites were dropped from the survey and new sites were added.

Grassland sites show a lot of overlap with control sites, implying they have a similar species mix. Like the control sites, the first two quarters of 2015 look like they have a different species mix to the rest of the surveys.

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. This is a little more prominent in the grassland stratum. There is no evidence from this plot of a turbine-related effect.

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.

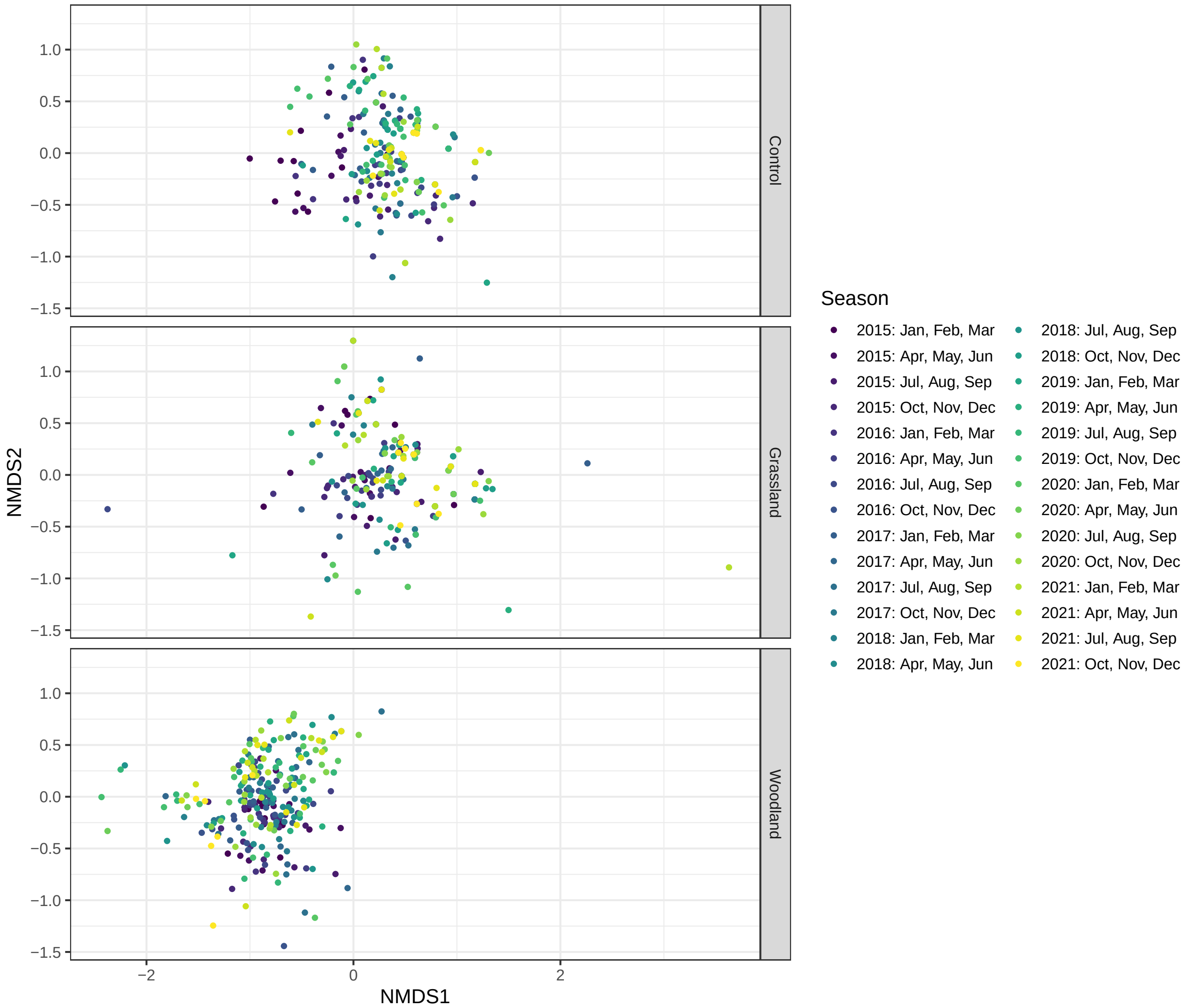

Figure 8: 2D MDS grouped by season and site, with distance based upon presence / absence.

Trend modelling

Shannon diversity

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

- time (at month level),
- monthly rainfall[3] (at the nearby Nimmitabel Wastewater Treatment Facility),
- log-distance from the closest turbine, and
- and a zero-inflation factor (the Shannon diversity equals zero if zero or one species are seen).

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 1.0015 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 (Nov 2017; 175.7 mm), keeping all other things constant, is a factor of 1.29.

Shannon diversity also appears to be decreasing over time ($p < 0.001$). Each month, on average the Shannon diversity decreases by a factor of 0.995. 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 ($p = 0.004$). 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 one at ten times the distance is expected to have 1.09 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 13% of the time, diversity equalled zero).

The interaction between site type and time (and indeed, the site type itself) was not significant ($p = 0.46$). While the baseline diversity is lower in the grassland area, its changes are reflected in the control area. Therefore, at present we do not have sufficient 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, so we only briefly summarise the results. The final richness model had the same set of predictor variables as the diversity model (time, rainfall, and log-distance). Coefficients had the same directionality - i.e. richness appears to be decreasing over time, and so forth.

Guild analyses

Once we consider groups of species (or priority species alone) there is often a paucity of data and little scope to generate robust statistical tests for change. It is still informative to consider descriptive patterns in subgroups.

In this section we consider raptors and skylarks.

Raptors

Figure 9 shows the average number of raptor[4] observations per survey, split by quarter and site type. We did not perform statistical tests because of the very low counts of raptors seen, and because the values are discrete (at low counts, it is difficult to distinguish change – are three birds statistically “less” then four birds?). This means that many formal statistical tests are unreliable and calculated metrics tend to have low statistical confidence.

2019 has shown a drop across the board in raptors observed, with no raptors recorded in the first three quarters of the year. In the last quarter of the year, there were a few raptor sightings (*Aquila audax* and *Falco berigora* in the Woodland and Control sites respectively). This may be due to the extreme weather and drought conditions in 2019.

This appears to have continued in 2020/21 - there are a lot less raptor sightings than in previous years.

[4] Raptors being: Australian Hobby, Black-shouldered Kite, Brown Falcon, Brown Goshawk, Collared Sparrowhawk, Nankeen Kestrel, Peregrine Falcon, Spotted Harrier, Wedge-tailed Eagle, White-bellied Sea Eagle

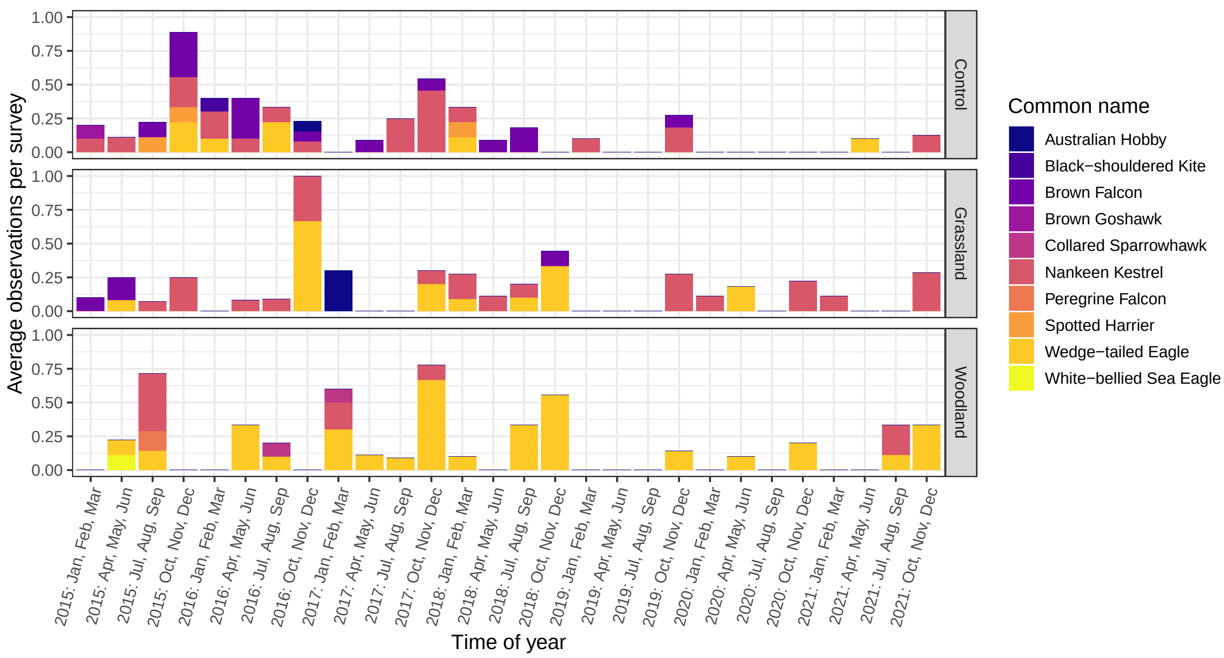

Figure 9: Average raptor observations per survey, by species and time of year.

Skylarks

The scientific literature has a found a variety of results regarding the interaction of skylarks and wind turbines.

Devereux, Denny, and Whittingham (2008) found skylarks were not affected by wind turbines. However, Mascarenhas et al. (2017) found that skylarks were attracted to the turbines due to insects. Additionally, Perrow (2017) quotes Morinha et al. (2014), who explained increased skylark deaths due to their flight patterns.

In this section we investigate this relative patterns of skylarks versus other grassland ground species (introduced and native). We look for trends over time, and relationships to the distance from turbine.

Figure 10 shows the average number of *A. arvensis* (Eurasian Skylark) counts per survey over time. The woodland habitat is excluded from the analysis as we are concentrating on grassland species.

We have grouped the charts into Grassland (less than 500 m from turbines) and Control (500 m to 20 km from turbines) as this provides a simple split to compare the trend adjacent to turbines with the trend at a distance.

There does no clear increasing trend in skylark numbers adjacent to turbines (i.e. within the Grassland strata). We can see obvious seasonality effects (a dip in observations in the first quarter) and generally higher levels in the other three quarters). It's also important to note the lack of grassland surveys in late 2016, which contributes to the fourth quarter dip in observations.

The baseline counts of the native grassland species are too low to undertake formal statistical testing. The two large peaks at 2016 second quarter (Control), and 2021 first quarter (Grassland) show the highly variable nature of the count data. Certainly, in 2019 they are very low (no native grassland species seen in the last three quarters of 2019 in Grassland) but it's not out of the range of reason, compared to previous seasons' counts.

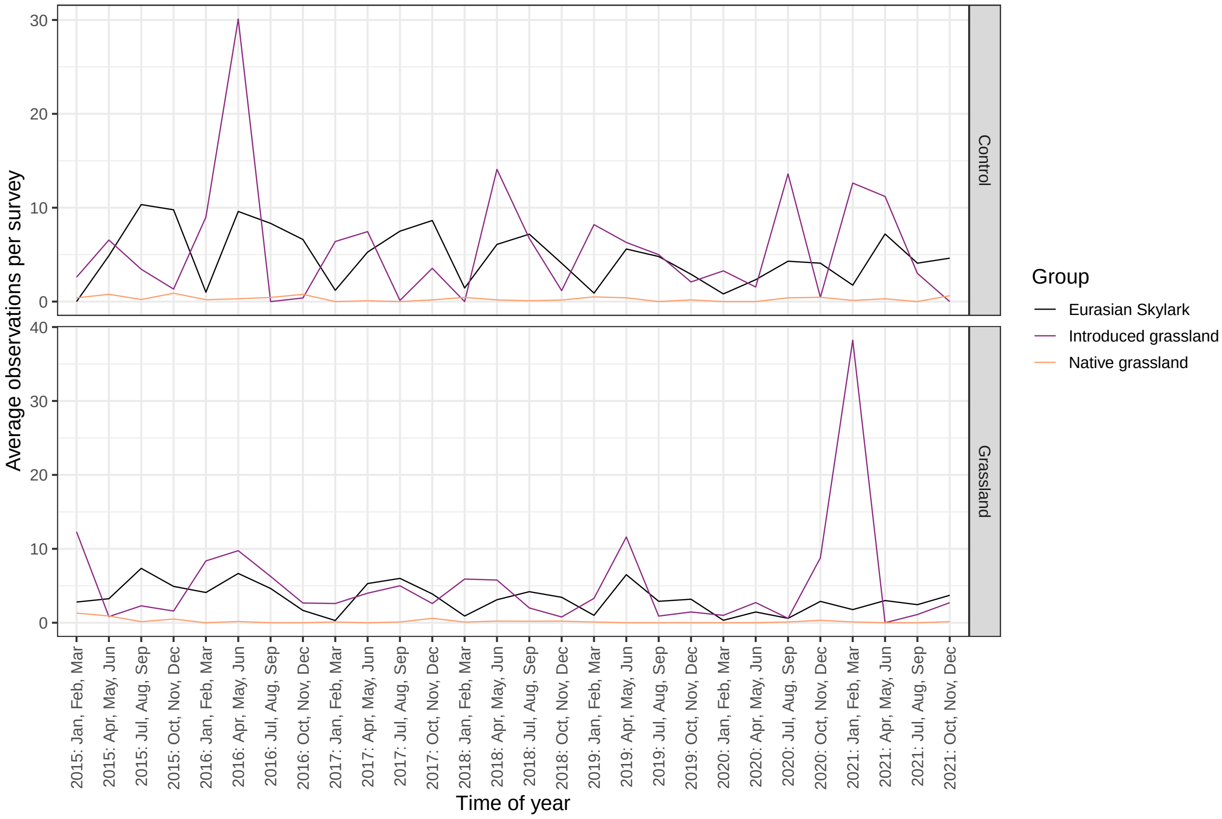

Figure 10: Average number of skylark observations per season versus other species groups.

We attempted to fit models looking at proportions of birds groups at different distances, but could find no evidence of a significant relationship between distance and proportion of different bird type.

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, and in the Skylark guild. When we consider all the data and modelling tests 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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