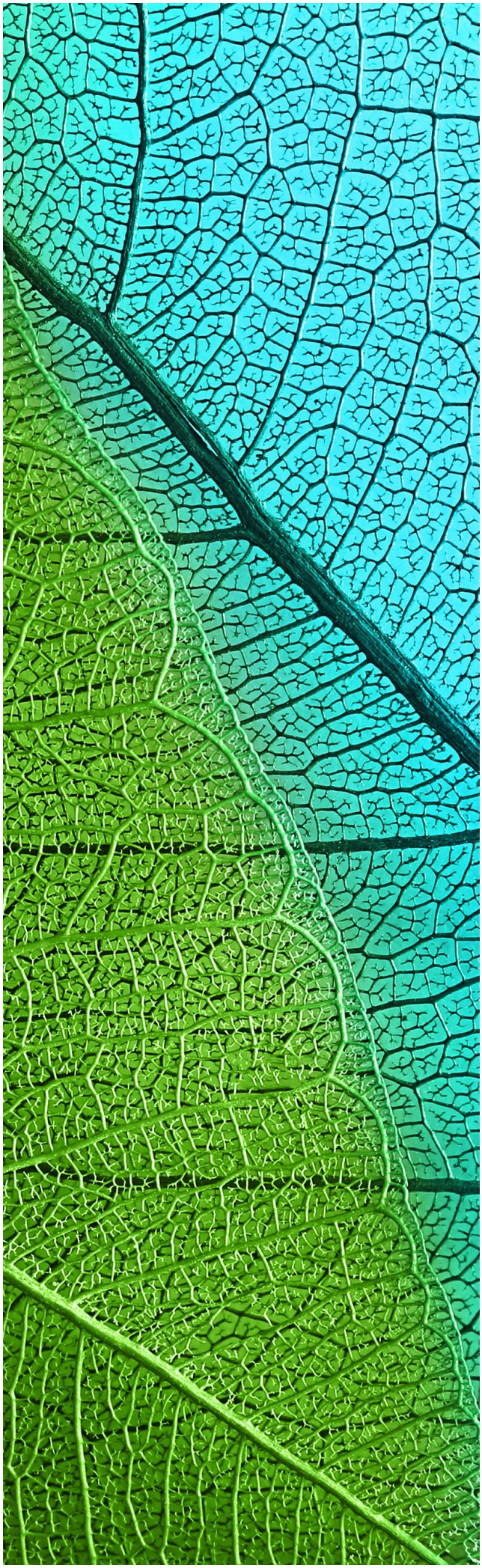

Crookwell 2 Wind Farm

Second Annual Report on the Implementation of the Bird and Bat Adaptive Management Plan

Prepared for
Crookwell Development Pty Ltd

July 2021
Report No. 8172 (41.0)

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1. Executive summary

Crookwell Development Pty Ltd engaged Nature Advisory to implement the approved Bir dan Bat Adaptive Management Plan (BBAMP) for the operating Crookwell II Wind Farm (C2WF) in the southern tablelands of New South Wales. Specifically, the scope of the plan included:

- Operational Bird and Bat Carcass (Fatality) Monitoring Program involving 16 out of the 28 turbines (>50%);
- Monitoring 'at risk' groups of birds; and
- Bird utilisation surveys.

This report constitutes the second annual report of BBAMP implementation at C2W2 covering the period January 2019- December 2020.

A total of 51 bird carcasses were recorded at C2WF during the monitoring period. These carcasses belonged to seventeen different bird species and a further four species that could not be identified. Eight Australian Magpie carcasses/feather remains were found at C2WF during the monitoring period, the highest number of any species, accounting for 16.28% of all bird mortality. The equal second most common species among bird carcasses found were Wedge-tailed Eagle and Brown Falcon, each with 10% of bird carcasses. Based on the detection of carcasses and feather spots, and measured detectability and scavenge rate; a total site loss was estimated of approximately 187 birds over the survey period, with a 95% confidence that fewer than 285 were lost. This equals approximately 3.3 birds per turbine per year.

A total of 29 bat carcasses of four species were recorded under the searched turbines at C2WF during the monitoring period. One additional bat carcass could not be identified and was recorded as an unknown species. White-striped Freetail Bat was disproportionally represented, making up over 60% of all carcass finds. Based on the detection of carcasses and measured detectability and scavenge rate; a total site loss was estimated of approximately 246 bats over the survey period, with 95% confidence that fewer than 477 were lost. This equals approximately 4.4 bats per turbine per year.

Two Black Falcon (*Falco subniger*) carcasses were recorded under turbines during the monitoring period: on 16th July 2019 and 29th August 2020. An additional carcass of this species was found on 26th February 2020 beside an access track 980 metres from a turbine. One Little Eagle (*Hieraaetus morphnoides*) carcass was found on 26th February 2020. Both species are listed as vulnerable in NSW under the *Biodiversity Conservation Act 2016* (BC Act).

These findings triggered targeted investigations involving extensive field surveys on and within ten kilometres of the wind farm from July 2020 to February 2021. These surveys found a very low and declining level of activity by both species within the survey area, and it was concluded that the risk of ongoing collision with turbines was low. This was confirmed after intensified monthly carcass searches under all 28 turbines during which no carcasses of either species were found after the August 2020 find. Reduced Black Falcon activity in the region from spring 2020 is almost certainly due to the breaking at this time of the 2018-20 drought that likely pushed many Black Falcons coastward from Australia's arid regions.

In response to the impact of the project on Black Falcon, mitigation measures were developed in consultation with NSW BCD and implemented. These included removal of perching opportunities

near turbines and increase in the height of grass under high-risk turbines. These measures substantially reduced raptor collisions at key turbines. These measures will continue in order to maintain a reduced risk of collision by raptors with these turbines. It is recommended that an additional raptor survey be undertaken to monitor raptor utilisation of C2WF by these species.

Bird utilisation of C2WF varies noticeably over the pre- and post-construction bird utiisation surveys. These differences were attributed to drought conditions affecting bird abundance and activity levels at different times during the monitoring program.

Bird and bat mortality was comparable with other wind farms in south-eastern Australia that Nature Advisory has monitored. Most species are not affected differently from wind farms elsewhere and the dominant species of bird and bat affected are also comparable, with magpies, eagles and other raptors, White-striped Freetail Bat and Gould's Wattled Bat making up a significant proportion of carcasses found. The impacts on the Black Falcon were unusual but are thought to be related to the recent drought.

Further carcass monitoring is not recommended for the reasons summarised below.

- Apart from Black Falcon, no repeated impacts were detected on any threatened bird or bat species during carcass monitoring;
- The activity of Black Falcon and Little Eagle in the region and on the wind farm since spring 2020 has reduced (see below), in the former case likely due to the breaking of the drought, and it has been concluded that continued Black Falcon collisions are unlikely; and
- Since the implementation of mitigation measures at key turbines with elevated raptor collision rates, raptor impacts have reduced with the result that these mitigation measures will continue.

To provide assurance that Black Falcon and Little Eagle activity on the wind farm is not continuing at unusual levels, a repeat of the raptor surveys is proposed at the sub-set of the regional raptor survey points that lie within the wind farm during the breeding season for these two species, from July to December 2021.

2. Introduction

C2WF is approximately 14 kilometres south-east of Crookwell and approximately 28 kilometres north-west of Goulburn in the Southern Tablelands of New South Wales. The site lies on a series of higher ridges that have been used for decades for sheep and cattle grazing. The majority of the area has been either completely or mostly cleared of its original native vegetation. As a consequence of the long grazing history, the vegetation present lacks an indigenous ground cover — introduced pasture grasses now dominate the ground coverDevelopment consent (DA 176-8-2004-i) was originally granted in June 2005 to Crookwell Development Pty Ltd for the Crookwell 2 Wind Farm (C2WF), comprising up to 46 wind turbines and associated infrastructure. This development consent was modified in 2009 (Mod-1), substituting larger turbines for those previously approved, relocating 20 of the 46 turbines and providing an alternate access road via Woodhouselee Road. Given subsequent further developments in wind turbine technology, approval was sought to update the Mod-1 development consent by further increasing turbine size and reducing turbine numbers from 46 to 32 and realigning some access tracks and cabling (Mod-2). Some 28, of the 32 turbines approved, were finally constructed.

As part of the approval process for Mod-2, the Office of Environment and Heritage (OEH) requested in a letter to Crookwell Development Pty Ltd dated 14 November 2016 that a Bird and Bat Adaptive Management Plan (BBAMP) be developed in accordance with Condition 84 of the Development Consent. Crookwell Development Pty Ltd first commissioned Brett Lane & Associates Pty Ltd (now Nature Advisory Pty Ltd) to develop the BBAMP (BL&A 2018a) following pre-construction Bird Utilisation Surveys (BUS), which were undertaken in February and November 2017 at the site.

Condition 84 states:

"***84.*** *Bird and Bat Adaptive Management Program must be prepared and undertaken, which takes account of bird/bat monitoring methods identified in the current editions of AusWEA Best Practice Guidelines for the Implementation of Wind Energy Projects in Australia and Assessing the Impacts of Wind farms on Birds - Protocols and Data Set Standards. The Program must be undertaken by a suitably qualified expert, approved by the Director General.*

The Program must incorporate ***Monitoring, and a Decision Matrix*** *that clearly sets out how the Proponent will respond to the outcomes of monitoring. It must:*

- ***(a)*** *Incorporate an ongoing role for the suitably qualified expert;*
- ***(b)*** *Set out monitoring requirements. The requirements must account for natural and human changes to the surrounding environment that might influence bird and/or bat behaviour such as changes in land use practices, and significant changes in water levels in nearby water bodies;*
- ***(c)*** *Incorporate a decision making framework that sets out specific actions and when it may be required to reduce identified impacts on bird and bats;*
- ***(d)*** *Set out available mitigation measures;*
- ***(e)*** *Incorporate reporting requirements on the outcomes of monitoring, on the application of the decision-making framework, the need for mitigation measures, progress with implementation of such measures, and their success. Reports must be prepared on an annual basis, from the commencement of operation, and must be*

prepared within 2 months of the end of the reporting period and be provided to the Director General. The Director General may vary the reporting requirement or period by notice in writing to the Applicant;

(f) *Identify any necessary mitigation measures and implementation strategy including, but not limited to, those referred in Condition 82.*

The Applicant is required to implement reasonable and feasible mitigation measures where the need for further action is identified through the Bird and Bat Adaptive Management Program."

Crookwell Development Pty Ltd engaged Nature Advisory to implement the approved BBAMP for C2WF. Specifically, the scope of the investigation included:

- Operational Bird and Bat Carcass (Fatality) Monitoring Program;
- Monitoring 'at risk' groups of birds; and
- Bird utilisation surveys.

This report constitutes the second annual report of BBAMP implementation at C2WF. It includes, but is not limited to:

- The survey methods (including list of observers, dates and times of observations);
- Estimates of bird and bat mortality rates (avifauna impacted per turbine per year);
- Maps of turbines, indicating which ones produced carcasses of species of concern;
- A discussion of any turbines where numerous carcasses have been found analysing potential factors influencing bird and bat strike, e.g., landscape position and habitat in close proximity.
- Seasonal and annual variation in the number and composition of bird and bat strikes, where detectable including consolidated tables of carcasses and species records from individual monthly reports;
- A review of the risk assessment based on the results of BBAMP investigations;
- Any other mortality recorded on site but not during designated carcass searches (i.e., incidental records by site personnel);
- Identification of any unacceptable impacts or impact triggers, and application of the decision-making framework and relevant adaptive management measures.
- A brief description of the management prescriptions implemented and identification of any modifications made to the original management practices.
- A summary of livestock carcass removal for the purposes of predator reduction;
- Details of any landowner feral animal control programs and their timing;
- A discussion of the results, including:
    - Whether indirect impacts on bird and bat use of the site are of significance at a local, regional, state or national level, or if species of concern have been affected.
    - Bird risk reduction measures.
    - Any further recommendations for reducing mortality, if necessary.

- Whether the level of mortality was unacceptable for affected listed ('at risk') species of birds or bats.
- Usage of the wind farm area by 'at risk' species and factors influencing this (ie. climatic, geographical and infrastructure).
- Analysis of the effectiveness of the decision-making framework.
- Recommendations for further monitoring.

This report is divided into the following sections:

Section 3 provides the methods and results of the carcass search program.

Section 4 provides the methods and results of the monitoring 'at risk' bird species.

Section 5 provides the methods and results of the bird utilisation survey.

Section 6 discusses the conclusions of the two years of monitoring at C2WF.

This investigation was undertaken by a team from Nature Advisory, comprising Beau Meney (Zoologist), Guille Mayor (Ecologist), Jackson Clerke (Zoologist), Michael Sebastian (Zoologist), Alan Brennan (Senior Ecologist and Project Manager) and Brett Lane (Principal Consultant).

3. Carcass search program

This section describes the methods and results of the carcass search program described in the approved BBAMP for C2WF. Data from the program have been analysed statistically to provide inputs to modelling that has provided estimated numbers of birds and bats impacted during the monitoring program.

This section includes methods and results of the carcass search program, and statistical analysis and estimates of total mortality for birds and bats respectively.

3.1. Methods

3.1.1. Carcass searches

From January 2019 to December 2020, monthly carcass searches were carried out at C2WF. To ensure a valid dataset for statistical analysis, the searches were done at 16 turbines (16/28, representing more than 50% of the turbines at the C2WF), split into the four operational areas of the wind farm (North east, North west, South East and South West – comprising the two chains of ridges). Turbines were selected randomly to ensure representativeness and are listed in Table 1. The same turbines were then searched for the whole two-year program.

In response to threatened raptor impact triggers (see Section 3.3), the July-December 2020 period of carcass searches included all 12 remaining turbines. These additional searches aimed to improve the chances of detecting impacts on threatened raptors so these search results were not used for mortality estimates.

Table 1: List of turbines searched

Turbines searched from January 2019 to June 2020 (for mortality estimates)			
1	7	13	24
3	8	15	25
4	10	18	26
6	12	21	27
Additional turbines searched July 2020 to December 2020			
2	11	17	22
5	14	19	23
9	16	20	28

Carcass searches were undertaken at each of the 16 turbines twice every month during a five-day period and involved two search zones, described below (see Figure 1). The turbines were searched to a radius of 120 metres once per month followed by a 60-metre radius "pulse" search within the same month.

- The inner zone (to 60 metres from the turbine tower base): nearly all microbats, and the majority of small to medium birds are expected to be found in this inner zone (based on Hull and Muir 2010) so search transects are spaced six metres apart were walked by the searcher due to the lower visibility of smaller carcasses at greater distances; and
- The outer zone (from 60 to 120 metres from the turbine tower base): where medium- and larger-bodies birds continue to fall, so search transects are spaced 12 metres apart due to their higher visibility at greater distances.

The search area for the additional turbines was from the base of the turbine out to a radius of 100 metres, searched via transects spaced 12 metres apart. No 'pulse' searches or inner zone searches were undertaken as bat species were not the focus of the trigger response, only medium- and large-sized raptors.

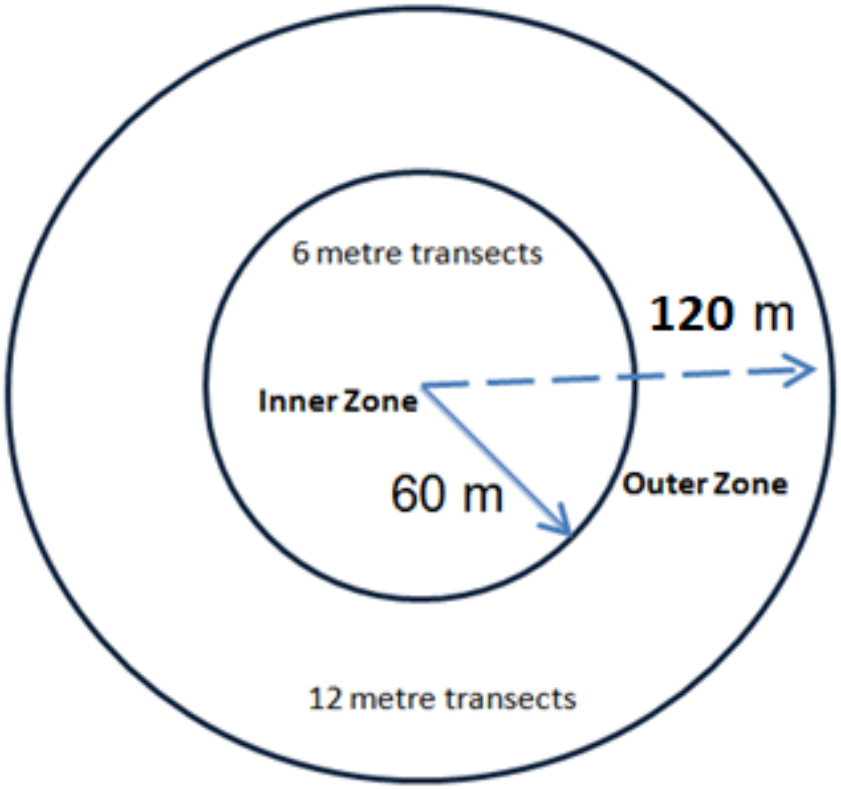

Figure 1: Diagram of inner and outer search zones at turbines

The search program involved 840 individual turbine searches, consisting of 384 initial searches, 384 pulse searches and 72 additional searches.

When a dead bird or bat was recorded under a turbine, a pro-forma (see the BBAMP) was filled out and numbered, and a photograph of the carcass *in* situ taken. When only feathers were found this was recorded as a feather spot. It is likely that feather spots represent a bird that has collided with a turbine and has later been scavenged.

On finding a dead bird, feather-spot or dead bat, the searcher:

- Removed it from the site to avoid re-counting; and
- Transferred carcasses to a freezer at the site office for storage so they could be identified and, if intact, used later in observer efficiency and scavenger trials (see below).

An incidental record is a carcass that was found under a turbine outside of the formal carcass search program (e.g., by wind farm personnel during routine inspections of infrastructure or during turbine searches under a turbine not selected for monthly searches).

The location of all turbines and the randomly selected turbines searched for the mortality estimates are shown in Figure 2.

3.1.2. Searcher efficiency trials

Searcher efficiency trials were undertaken in July 2019, February 2020, and December 2020. The purpose of the trials was to assess the efficiency of all Nature Advisory observers who took part in the monitoring program. Searchers consisted of; Beau Meney (zoologist), Guille Mayor (ecologist), and Michael Sebastian (zoologist).

This efficiency result is then used as a correction factor in statistical estimates of total mortality for the wind farm. It expresses how likely the searcher is, on average, to miss carcasses that are likely to be present under turbines, due to factors such as being obscured by dense vegetation.

The BBAMP (BL&A 2018a) states that four searcher efficiency trials will be conducted over the two-year monitoring period, two trials when grass height is short and two when grass height is long.

The initial trial was undertaken during July 2019 when the grass height was short. With grazing pressure compounded by very dry conditions across C2WF throughout the year, typical seasonal changes in grass density and height were not observed. A searcher efficiency trial was undertaken when grass was meant to be long in the first year but it was still short.

A further three such trials were conducted during the second year of operation, beginning in February 2020, with two during mid December 2020 when grass was actually tall. Spring efficiency trials were not carried out due to Covid-19 related interstate travel restrictions during that time, however due to the above average rainy summer and the cool temperatures the grass was tall during the December trials.

A total of twenty carcasses were used in each trial. This included ten bats and ten birds (Table 2). These 20 carcasses comprised those collected during previous searches, as well as road killed bird carcasses collected in preceding months and stored in a freezer at the wind farm office. Additional bird carcasses comprised Common Myna (*Acridotheres tristis*) species that were sourced from the control programs of Common Myna Action Groups.

Two to three carcasses were placed under seven pre-selected turbines. The positions of the placed carcasses were randomly generated (distance and bearing from tower) using the Microsoft Excel random number function. Medium to large birds were placed within the 120-metre inner and outer zones, and all bats and small birds within the 60-metre inner zone.

The observer searched all turbines within two hours of the carcasses being placed and recorded the number of carcasses found on the first search. The observer efficiency was calculated as the percentage of carcasses found of those placed.

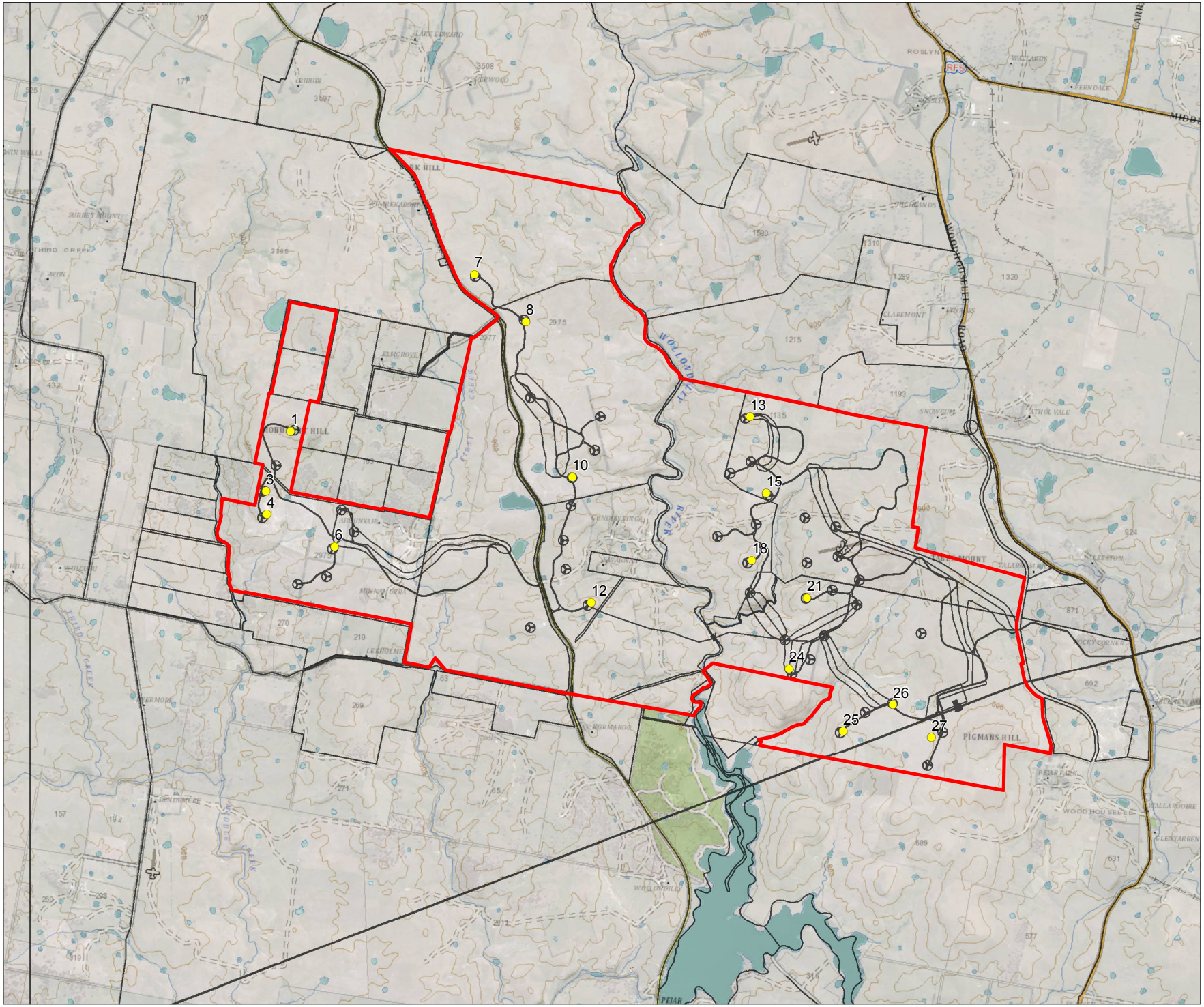

Figure 2: C2WF BAM Plan turbine searches

Project: Crookwell 2 Windfarm
Client: Crookwell Development Pty Ltd
Date: 4/04/2019

- Site Boundary - Crookwell 2
- Development layout
- Turbines searched

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Table 2: Species used in searcher efficiency trials at C2WF during the monitoring program.

Turbine	Carcass	Size class
July 2019 - Winter (short grass)		
27	Brown Falcon	Large
	White-striped Freetail Bat	Bat
	Grey Fantail	Small
26	Brown Falcon	Large
	White-striped Freetail Bat	Bat
	Common Myna	Medium
25	Eastern Barn Owl	Large
	White-striped Freetail Bat	Bat
	Grey Fantail	Small
6	Common Myna	Medium
	White-striped Freetail Bat	Bat
	Fairy Martin	Small
15	White-striped Freetail Bat	Bat
	White-striped Freetail Bat	Bat
	Nankeen Kestrel	Medium
24	Common Myna	Medium
	Common Myna	Medium
	White-striped Freetail Bat	Bat
12	Common Myna	Medium
	White-striped Freetail Bat	Bat
February 2020 (short grass)		
6	White-striped Freetail Bat	Bat
	Wedge-tailed Eagle	Large
	Common Starling	Medium
7	Fairy Martin	Small
	Common Myna	Medium
	Common Starling	Medium
8	Gould's Wattled Bat	Bat
	Common Myna	Medium
	Wedge-tailed Eagle	Large
10	Gould's Wattled Bat	Bat
	Common Myna	Medium
	Black Falcon	Large
12	Gould's Wattled Bat	Bat
	Common Myna	Medium
	Brown Falcon	Large
27	White-striped Freetail Bat	Bat
	Common Myna	Medium
	Common Myna	Medium
26	Large Forest Bat	Bat
	Wedge-tailed Eagle	Large
December 2020 (long grass)		
6	Black Falcon	Large

Turbine	Carcass	Size class
	Nankeen Kestrel	Medium
	Starling	Small
7	Australian Magpie	Medium
	White-striped Freetail Bat	Bat
	Black Falcon	Large
8	White-striped Freetail Bat	Bat
	Sulphur-Crested Cockatoo	Large
	Grey Fantail	Small
10	Black Falcon	Large
	White-striped Freetail Bat	Bat
	Microbat	Bat
12	Black Falcon	Large
	Microbat	Bat
	Microbat	Bat
27	Sulphur-Crested Cockatoo	Large
	Common Myna	Medium
	Microbat	Bat
26	Common Myna	Medium
	White-striped Freetail Bat	Bat
	December 2020 (long grass)	
6	Sulphur-crested Cockatoo	Large
	White-striped Freetail Bat	Bat
	Microbat	Bat
7	Black Falcon	Large
	Microbat	Bat
	Eastern Rosella	Medium
8	Magpie	Medium
	White-striped Freetail Bat	Bat
	Sulphur-crested Cockatoo	Large
10	Black Falcon	Large
	Microbat	Bat
	Microbat	Bat
12	White-striped Freetail Bat	Bat
	Chocolate Wattled Bat	Bat
	Black Falcon	Large
27	Magpie	Medium
	Black Falcon	Large
	Microbat	Bat
26	Sulphur-crested Cockatoo	Large
	Microbat	Bat

3.1.3. Scavenger trials

The effect of carcasses being removed by scavengers prior to being detected by the observer was quantified through scavenger trials. The effect is expressed as the average duration of carcasses

in the field before being removed by scavengers. This is also used as a correction factor in statistical estimates of mortality and determines how likely it is, on average, that a carcass is removed before an observer can detect it.

Trials were conducted concurrently with formal monthly searches beginning in May and June 2020 and in December 2020 to March 2021. A total of 50 carcasses were placed at turbines involved in the search program and distributed randomly as per the searcher efficiency trial. Remote-sensor cameras were set-up a short distance from the carcasses (< 5 metres) to document the elapsed time until scavenging took place and to identify the predator responsible.

3.2. Results

A total of 81 bird and bat carcasses were found at the at C2WF site during the 24 months of the monitoring period. This consisted of 48 birds and 28 bats found during formal carcass searches which made up approximately 93% of all mortality records. An additional three birds and two bats were found incidentally.

As is standard practice, it has been assumed that feather-spots discovered beneath turbines are the result of an initial turbine collision, with scavenging predators such as Red Fox or Ravens later consuming the carcass and leaving feather remains. Total numbers of carcasses per species is shown in Figure 3 and percentages of each species among all bird and bat finds is displayed in Figure 4.

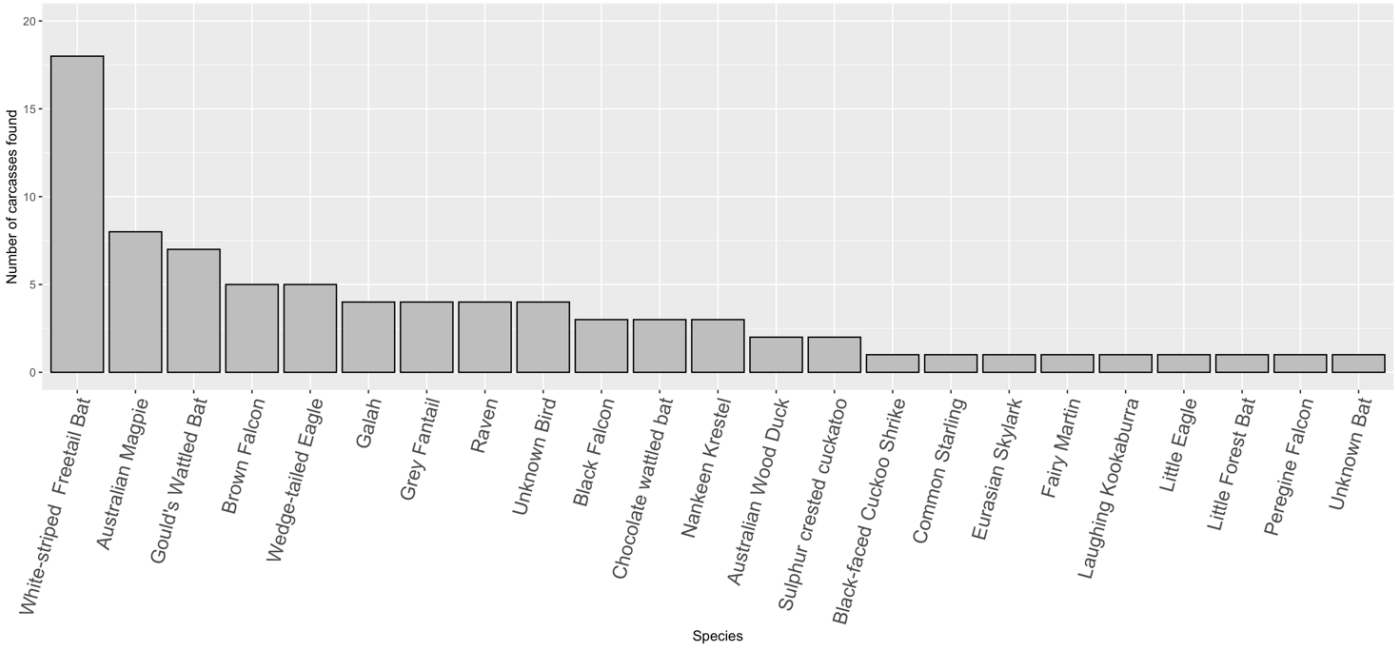

Figure 3: Number of bird and bat carcasses per species found during the monitoring period at CWF

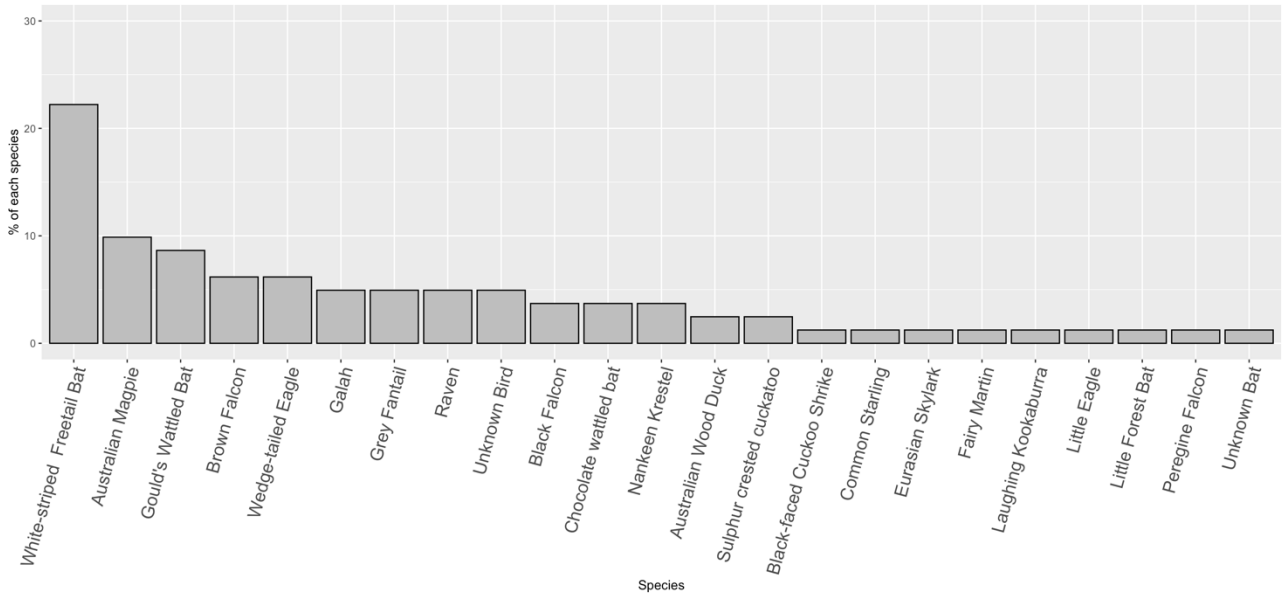

Figure 4: Percentages of each bird and bat species recorded at CWF during the monitoring period.

3.2.1. Bird mortality during the monitoring period

Some 51 bird carcasses were recorded at C2WF during the monitoring period (January 2019-December 2020). These carcasses belong to seventeen different bird species and a further four species that could not be identified due to their state of decomposition. (See Appendix 1 for detail carcass find records). Figure 5 shows the percentage of all carcasses contributed by each speceis found.

The number of carcasses and feather spots found by bird species is summarised in Table 3. Detailed information on each bird carcass, feather-spot and incidental record during 2019-2020 can be found in Appendix 1.

Of all carcasses detected, 48 carcasses/feather remains were found during formal monthly searches. The remaining three carcasses were found incidentally by the carcass monitoring team or wind farm personnel at turbines not part of the formal search. On average, about two sets of bird remains were recorded per month during the monitoring period.

Australian Magpie was the carcass most commonly found. A total of eight Australian Magpie carcases/feather remains were found at C2WF during the monitoring period, which accounted for just over 16 percent of all carcasses found. Australian Magpie is a very common species at the wind farm site based on the BUS surveys (see Section 5.2.6). It is a common, widespread bird in agricultural landscapes throughout southern eastern Australia.

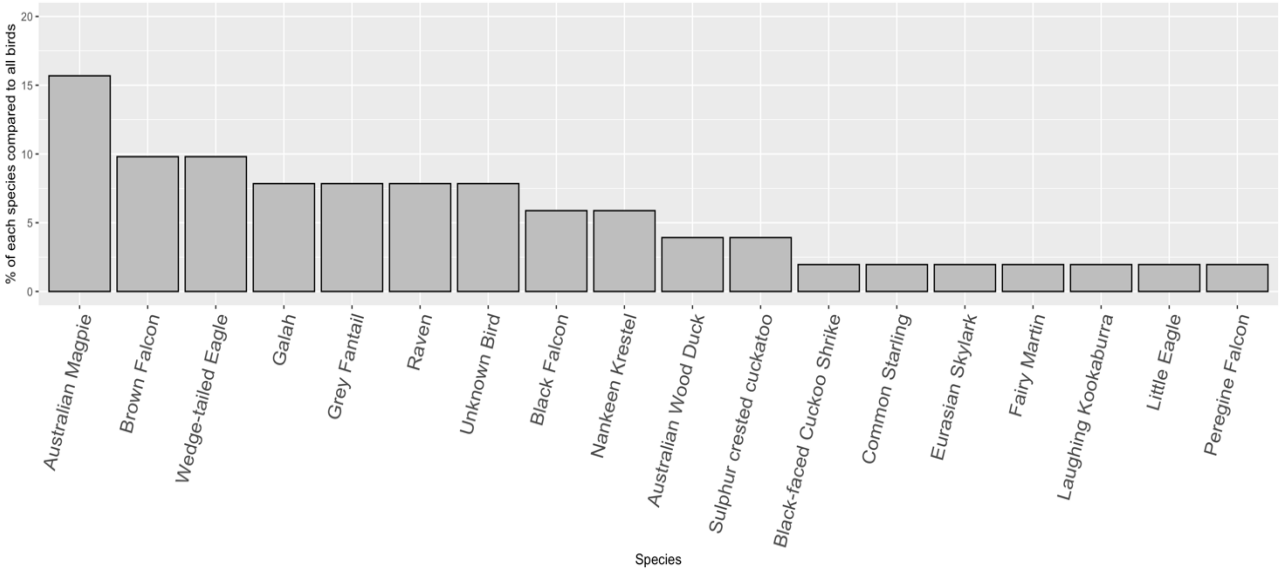

Figure 5: Percentage of carcasses recorded per each species of birds in relation to all bird species at C2WF

The equal second most found carcasses were the Wedge-tailed Eagle and Brown Falcon, with each representing around 10% of all bird carcasses found at C2WF during the monitoring period. Over 24 months of formal monitoring, a total of five Brown Falcon and four Wedge-tailed Eagle carcasses were found at C2WF. Equally, four carcasses were found during formal searches of Raven species, Galah and Grey Fantail, as well as unidentified remains.

Seven species were recorded once during carcass searches: Black-faced Cuckoo Shrike, Common Starling, Eurasian Skylark, Fairy Martin, Laughing Kookaburra, Little Eagle and Peregrine Falcon.

Table 3: Summary of bird carcass records at CWF over 2019-2020 carcass monitoring

Common Name	Scientific name	Formal	Feather Spots	Incidental	Total
Australian Magpie	*Gymnorhina tibicen*	8			8
Australian Wood Duck	*Chenonetta jubata*	2	1		3
Black Falcon	*Falco subniger*	2		1	3
Black-faced Cuckoo Shrike	*Coracina novaehollandiae*	1	1		2
Brown Falcon	*Falco berigora*	5			5
Common Starling	*Sturnus vulgaris*	1			1
Eurasian Skylark	*Alauda arvensis*	1			1
Fairy Martin	*Petrochelidon ariel*	1			1
Galah	*Eolophus roseicapilla*	4	1		5
Grey Fantail	*Rhipidura albiscapa*	4			4
Laughing Kookaburra	*Dacelo novaeguineae*	1			1
Little Eagle	*Hieraaetus morphnoides*	1			1
Nankeen Kestrel	*Falco cenchroides*	2	1	1	4
Peregrine Falcon	*Falco peregrinus*	1			1
Raven	*Corvus coronoides*	4	1		5
Sulphur crested cockatoo	*Cacatua galerita*	2			2

Common Name	Scientific name	Formal	Feather Spots	Incidental	Total
Unknown Bird sp.*	-	4	1		5
Wedge-tailed Eagle	*Aquila audax*	4		1	5
Total		48	6	3	57

*all efforts were made to identify carcass species; however, this was not always possible due to decomposition of or scavenged carcasses. See Appendix 1 for details of finds.

3.2.2. Bat mortality during monitoring period

A total of 29 bat carcasses of four species were found at C2WF during the monitoring period. One additional bat carcass could not be identified and was recorded as an unknown species (see Appendix 1). White-striped Freetail Bat made up over 60% of all bat carcasses and was the most commonly detected bat species. This was followed by Gould's Wattle Bat with seven carcasses that made up about 23% of all carcasses. A small number of remaining bat carcasses were the Chocolate Wattled Bat and Little Forest Bat.

Bat carcasses made up around 37% of all carcasses found during the monitoring period. Table 4 summarises the percentage of total collisions and species of carcasses found at C2WF during the monitoring period.

Table 4: Summary of detected bat mortality across the Crookwell 2 Wind Farm

Species	scientific name	Number of carcasses	Percentage of total bat carcasses	Percentage of all bird and bat carcasses
White-striped Freetail Bat	*Tadarida australis*	18	60	22.22
Gould's Wattle Bat	*Chalinolobus gouldii*	7	23.3	8.64
Little Forest Bat	*Vespadelus vulturnus*	1	3.3	1.23
Chocolate Wattled Bat	*Chalinolobus morio*	3	10	3.7
Unknown Bat Sp.	N/A	1	3.3	1.23
Subtotal		30	100	37

3.2.3. Mortality rates at individual turbines

Carcasses were not distributed evenly between searched turbines. The highest number of carcasses (14%) were found beneath Turbine 27 (Figure 6). Other turbines with a relatively high carcass number were turbines 10, 12 and 24 each with around 10% of carcasses. Overall, approximately 50% of carcasses were found under these four turbines.

The reasons for variations in carcass numbers among turbines is unclear and not immediately obvious. For example, turbines 26 and 25 are in very similar habitat to turbine 27 and all three are within a few hundred metres of one another, yet 26 recorded many fewer carcasses and 25 recorded none.

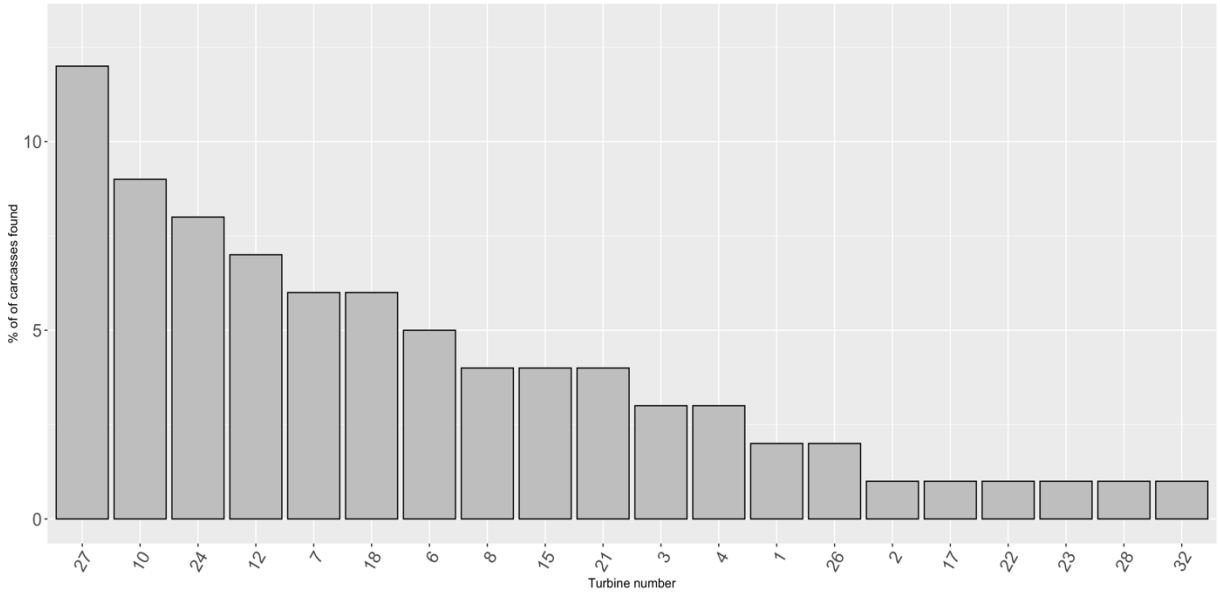

Figure 6: Percentages of carcasses found at each turbine during 2019-2020 carcass search at CWF

3.2.4. Searcher efficiency results

Carcass searches were carried out by three staff from Nature Advisory: Beau Meney (Zoologist), Michael Sebastian (Zoologist) and Guille Mayor (Ecologist). A total of four searcher efficiency trials were undertaken at C2WF during the monitoring period involving all three people. Beau undertook the searcher efficiency trial in July 2019 and February 2020, and Michael and Guille undertook the trials in December 2020. Given the trials required two people and there were Covid-19 related border restrictions during the winter months in 2020, trials with short grass were not possible in 2020.

Statistical analysis (Appendix 2) indicated that there was no significant differences in detection between bird and bat/bat proxies in terms of searcher efficiency, and no significant difference in detection rates between 2020 trials. There was some evidence of differences between searches, but this is accounted for via 'up-weighted' mortality estimates when data are aggregated. This conservative approach indicated that it was not essential to test each observer multiple times individually, and that aggregated results provide a suitable correction factor for overall mortality estimates.

A summary of searcher efficiency results is shown in Table 5 below and detailed efficiency trial results are provided in Appendix 3.

Mean detectability was 66% with a 95% confidence interval of 53 to 78%. These results provide the correction factor included in the analysis summarised in Section 3.4.

Table 5: Searcher efficiency trial results

Carcass size class	Carcasses found	Carcasses placed	Average efficiency
July 2019 - Winter (short grass)			
Bats/small birds	6	8	75%
Medium to large bids	8	12	67%
February 2020 (short grass)			
Bats/small birds	4	7	57%
Medium to large bids	12	13	92%
December 2020 (long grass)			
Bats	3	10	30%
Medium to large bids	6	10	60%
December 2020 (long grass)			
Bats	7	10	70%
Medium to large bids	5	10	50%
Combined results (all seasons)			
Bats/small birds	20	35	57.1%
Medium to large bids	31	45	68.9%

3.2.5. Scavenger trials

The results of the scavenger trial are summarised in Table 6 and the detailed data presented in Appendix 4.

Table 6: Scavenger trial results

Season	Carcass type	Total carcasses	Ave days in field
Short grass	Bats	9	13.1
	Birds	10	15.6
	All	19	14.5
Long grass	Bats	13	3.1
	Birds	18	11
	All	31	8
Combined	Bats	20	6.9
	Birds	28	13
	All	48	10.3

Note that the statistical analysis uses the median number of days carcasses remain in the field (see section 3.4.2).

Red Fox and Ravens were identified as the dominant scavengers at C2WF.

These findings were used in the mortality estimates presented later.

3.3. Impact triggers

The C2WF BBAMP outlines additional management actions if a listed threatened species is impacted by the operation of the wind farm. As outlined in Section 3.2 above and Appendix 1, a few carcasses were found of species listed under the NSW BC Act. No species listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) were found.

Section 6.1.1 of the BBAMP states:

*"**Impact Trigger for Threatened Species:** A threatened bird/bat species (or recognisable parts thereof) listed as threatened under the Commonwealth EPBC Act or NSW Threatened Species Conservation Act 1995, is found dead or injured under or close to a wind turbine during any mortality search or incidentally by wind farm personnel."*

In the event of an impact trigger occurring the decision-making framework in section 6.1.2. is to be followed. This framework includes an investigation into the trigger's causes and significance, and exploration of potential mitigation measures. The responses to these impact triggers are summarised in Section 4 of this report.

Two Black Falcon (*Falco subniger*) carcasses were recorded under turbines during the monitoring period: on 16th July 2019 and 29th August 2020. An additional carcass of this species was found on 26th February 2020 beside an access track 980 metres from a turbine. One Little Eagle (*Hieraaetus morphnoides*) carcass was found on 26th February 2020. Both species are listed as vulnerable in NSW under the *Biodiversity Conservation Act 2016* (BC Act). The results of both further investigation and mitigation measures are presented in a separate report to BCD (Nature Advisory 2020).

The BBAMP also outlines a "non-threatened species impact trigger". However, this trigger did not occur during the monitoring period.

3.4. Mortality estimates

Data collected during the carcass search program has been provided to Symbolix Pty Ltd, a specialist data analyst organisation, to determine the estimated bird and bat mortality rates across the entire wind farm for the monitoring period. As indicated earlier, only carcass finds during the formal two-year, monthly 18-turbine search program have been used in the estimates. Other carcass finds have been include for information.

The detailed methodology, analysis and mortality estimates are provided by Symbolix Pty Ltd in Appendix 2. The results are summarised below.

3.4.1. Searcher efficiency

No significant difference was detected between the searcher efficiency trials (Section 3.2.6). Similarly, no difference in searcher efficiency was detected between birds and bats. As such efficiency was aggregated for mortality estimates. There was some evidence of differences between searchers however aggregating all searcher data up-weighted estimates ensuring these are more conservative, eliminating the need to use individual searcher data in modelling.

Mean searcher detectability proportion was 67%, with a 95% confidence interval of 56% to 77%.

3.4.2. Scavenger efficiency

The median time to scavenging for bats was 1.5 days (95% confidence interval of 0.5, 4.3 days). The median time to scavenging for birds was 8.9 days (95% confidence interval of 3.2, 24.8 days).

3.4.3. Bat mortality estimate

Based on the detection of carcasses and measured detectability and scavenge rate; it is expected there was a total site loss of approximately 246 bats over the survey period, with a 95% confidence that fewer than 477 were lost.

This equals approximately 4.4 bats per turbine per year.

3.4.4. Bird mortality estimate

Based on the detection of carcasses and feather spots, and measured detectability and scavenge rate; it is expected there was a total site loss of approximately 187 birds over the survey period, with a 95% confidence that fewer than 285 were lost.

This equals approximately 3.3 birds per turbine per year.

A separate estimate of the number of threatened birds was not possible as too few were found for a statistically robust estimate.

4. Monitoring 'at risk' groups

This section of the report documents the results of targeted monitoring of 'at risk' bird and bat species and groups. The results of the general pre- and post—construction bird utilisation surveys are presented later in Section 5.

4.1. Introduction

The key "at risk" groups were identified through the initial risk assessment in the BBAMP (BL&A 2018a) and included the following;

- Wedge-tailed Eagles (WTE),
- Other raptors,
- White-throated Needletail, and
- White-striped Freetail Bat.

The onsite occurrence of the above "at risk" species was monitored during the bird utilisation surveys, incidental sightings and carcass monitoring for the first two years of operation.

Any raptor and White-throated Needletail observations were recorded throughout the operational phase of the C2WF when an ecologist was on site for up to five days per month. Incidental observations of all raptors and needletails were recorded, and observed flight paths marked on a map.

Several impact triggers, as outlined in the BBAMP, occurred during the monitoring program at C2WF. A Black Falcon (listed as vulnerable in NSW under the BC Act) was found dead under a turbine in July 2019. This triggered an immediate response, which included point count raptor surveys from beginning of September up until mid-November 2019. Further Black Falcon carcass finds in 2020 (one of which was under a turbine) and a Little Eagle carcass find (also listed as vulnerable in NSW under the BC Act) in 2020 triggered further surveys from July 2020 until February 2021 as part of an investigation and mitigation response developed in consultation with BCD to minimise further impacts on these species. These investigations have been reported by Nature Advisory (2021a) and are summarised below. Investigations aimed to understand what ongoing risk the operation of C2WF posed to the species. Refer to the full report for detailed methods and results.

4.2. Methods

4.2.1. Incidental observations

All incidental raptor flights that were observed during the carcass monitoring program were recorded for the entire monitoring period. Information recorded included:

- Date location and duration of observation period;
- Time and duration of flight;
- No. and age of birds, where known;
- Flight height above ground (range);
- Flight behaviour;

- Flight behaviour observed included soaring, directional flight (flapping), circling, gliding and diving; and
- Other occasional behaviours included feeding, territorial displays, fighting and perching.

Flight paths were plotted as accurately as possible on large-scale aerial photographs of the site.

4.2.2. Point-count raptor surveys

Fixed point raptor surveys were undertaken at 40 survey points at C2WF and within a 10km buffer. Surveys were undertaken monthly from July 2020 to February 2021 by qualified ecologists skilled in Australian raptor species identification, consisting of Verity Fyfe (ecologist), Peter Lansley (zoologist) and Phillip Alan (zoologist).

The raptor surveys involved observations from vantage points during which the surrounding area was scanned with binoculars for 30 minutes. All raptor sightings were noted along with associated behaviour and flight heights. Dates, times, distances from observer and flight paths were recorded for all raptors seen.

4.3. Results

4.3.1. Incidental monitoring

A total of 10 species were observed incidentally during carcass monitoring surveys at C2WF. Most of these species were observed between one to three times; however, Nankeen Kestrel, Brown Falcon, Black Falcon and Wedge-tailed Eagle were seen more often, with Wedge-tailed Eagle being seen the most.

Black Falcon was first observed in June 2019. The number of Black Falcons is slightly skewed by seven observations made in a single month in February 2020, in which two zoologists were present on-site undertaking surveys. Many of these observations were made on the same day in different locations at different times of the day and it is highly likely they were of the same individual(s). Averaged over the 24-month monitoring period, this species was observed on or near the wind farm less than once a month.

Detailed data on incidental sightings is provided in Appendix 5 and summarised in Table 7 below. Figure 7 shows corresponding flight paths.

Table 7: Summarised incidental sighting data

Species	Total sightings	Average per month
Australian Hobby	1	0.05
Black Falcon	15	0.68
Black Kite	1	0.05
Brown Falcon	11	0.50
Little Eagle	1	0.05
Nankeen Kestrel	9	0.41
Peregrine Falcon	3	0.14
Wedge-tailed Eagle	22	1.00
Whistling Kite	1	0.05
White-bellied Sea Eagle	1	0.05

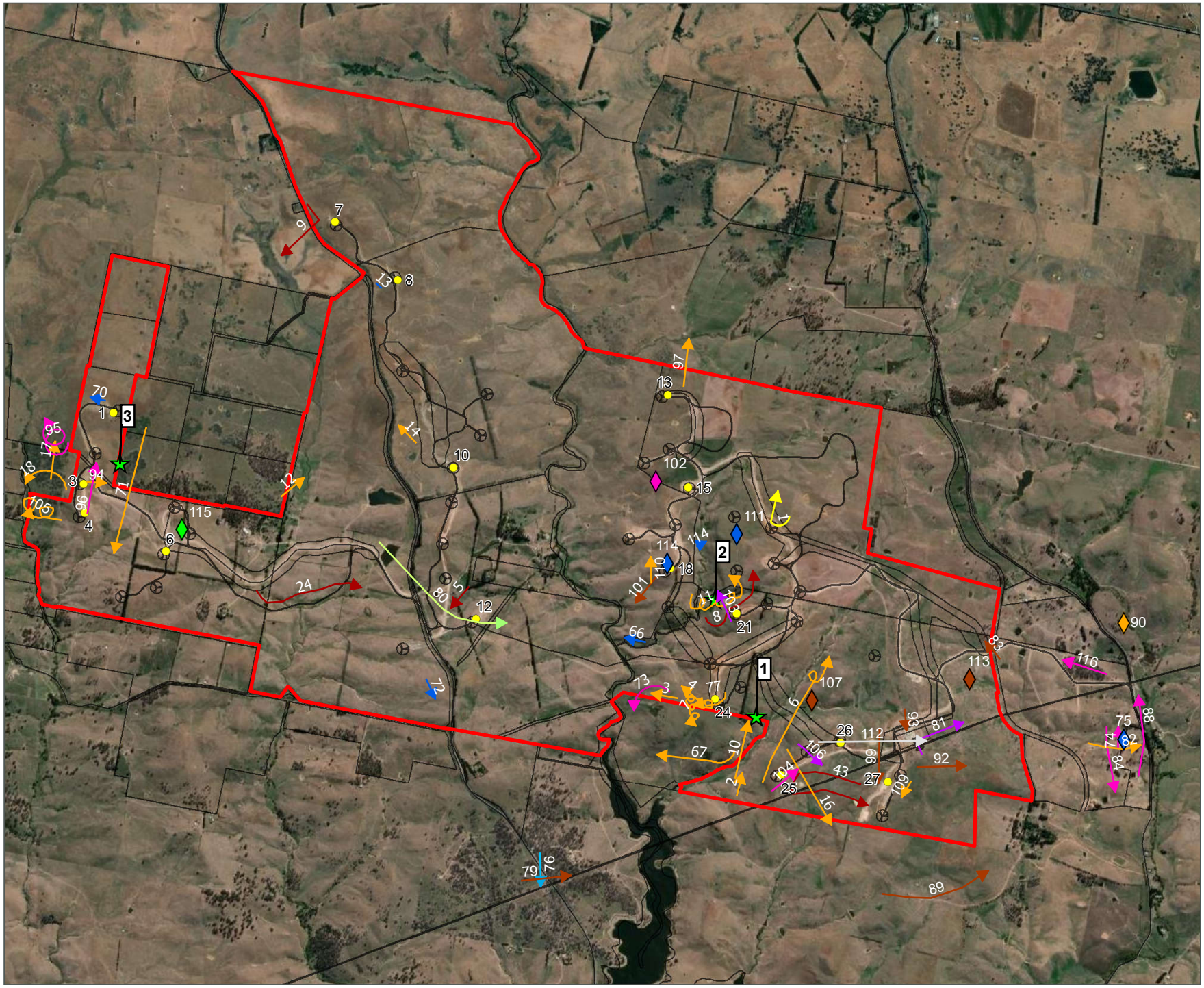

Figure 7 : Incidental Raptor flights recorded at C2WF

Project: Crookwell Wind Farm
Client: Crookwell Development Pty Ltd
Date: 18/05/2021

- Site Boundary
- Development layout
- Turbines searched
- Wedge-tailed Eagle nests

Incidental Raptor flights

- Black Falcon
- Black Kite
- Brown Falcon
- Nankeen Kestrel
- Peregrine Falcon
- Wedge-tailed Eagle
- Whistling Kite
- White-bellied Sea-eagle

Perched

- Australian Hobby
- Black Falcon
- Brown Falcon
- Nankeen Kestrel
- Wedge-tailed Eagle

N

Metres
0 600

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4.3.1. 'At risk' species mortality summary

Raptors

The total raptor mortalities are summarised in Table 8 below. A total of five species of raptor carcasses were found at C2WF. Brown Falcon and Wedge-tailed Eagle were the most impacted raptors, with five carcasses each. This was followed by Nankeen Kestrel with three and Black Falcon with two under turbines and one incidental carcass find 980 metres from a turbine. Raptors totalled 21% of carcasses found.

Table 8: Raptor carcasses found at C2WF during 24 months of monitoring.

Species	Total mortalities	Average per month	% of all mortality
Brown Falcon	5	0.21	6.2
Wedge-tailed Eagle	5	0.21	6.2
Black Falcon	3	0.13	3.7
Nankeen Kestrel	3	0.13	3.7
Little Eagle	1	0.04	1.2

Table 9 below indicates the number and turbine number where raptor carcasses were found. turbine 18 had the highest number, with four carcasses from three species. One Little Eagle mortality occurred at turbine 22 and two Black Falcon carcasses were found at turbines 10, 18 and 22. The third Black Falcon carcass was found 980 metres from turbine 22.

Table 9: Location of raptor carcasses at C2WF during 24 months of monitoring.

Turbines	3	4	10	15	18	21	22	23	24	27	Species Total
Nankeen Kestrel	1									2	3
Brown Falcon		1	1	1	2						5
Wedge-tailed Eagle		2						1	2		5
Black Falcon			1		1		1				3
Peregrine Falcon					1						1
Little Eagle						1					1
Turbine total	1	3	2	1	4	1	1	1	2	2	18

White-striped Freetail Bat

This species was identified as "at-risk" as it is commonly found dead under turbines at most wind farms. Studies (Symbolix 2020, Smales 2012) have identified this species is regularly over-represented in carcass search results at Victorian wind farms. Observations by Nature Advisory (unpublished data) at various wind farms in other parts of the species' range are consistent with these findings. This is related to the species foraging habits; the species flies many times the height of the tree canopy above the ground hunting for high flying insects. This means they regularly occur at turbine rotor swept area height.

carcasses of this species made up 22% of all carcasses found in the 24-month carcass search program, making it the most impacted species by turbine collision at C2WF. Table 10 identifies

turbines and carcass numbers for this species. Turbine 27 had the highest number of carcasses, with five found.

Table 10: Turbines where carcasses of the White-striped Freetail Bat were found.

Turbine	Mortalities
6	1
7	2
10	1
12	2
15	1
17	1
21	1
24	2
27	5
28	1
32	1

4.3.1. Raptor results from the bird utilisation surveys

Table 11 summarises the numbers of raptors observed during each bird utilisation surveys (BUS) undertaken at C2WF. Eleven species of raptor were observed during all BUS with Nankeen Kestrel and Brown Falcon by far the most common raptors observed. Wedge-tailed Eagle, while not observed as often, was observed in every BUS. Black Falcon was observed on four occasions.

There was a decrease in total raptor numbers between the pre- and post-construction BUS, however species diversity remained generally the same.

Table 11: Summary of raptor observations during BUS at C2WF

BUS survey	Pre-construction		Post-construction				Species totals
Raptor species	Mar-17	Nov-17	Feb-19	Feb-20	Nov-20	Dec-20	
Australian Hobby	1					1	2
Black Falcon				2	2		4
Brown Falcon	9	7	3	3	1		23
Brown Goshawk		1	3	1	1		6
Little Eagle							0
Nankeen Kestrel	9	9	1	3	2		24
Peregrine Falcon		2	1				3
Swamp Harrier				1			1
Wedge-tailed Eagle	2	3	1	1	2	1	10
Whistling Kite		1	7	1	2	2	13
White-bellied Sea Eagle				1			1
BUS Total	21	23	16	13	10	4	87

4.3.2. Point-count raptor surveys

The raptor survey involved experienced and qualified zoologists undertaking surveys for raptors for three weeks per month from July 2020 to February 2021 on and within 10 kilometres of the C2WF site. The detailed methods and results are available in the report Nature Advisory (2020) and are summarised below. The surveys aimed to understand the distribution and abundance of the two threatened raptor species that had collided with turbines in the preceding period at C2WF, namely Little Eagle and Black Falcon.

The investigation also involved searching all 28 Turbines each month from July to December 2020 for carcasses (i.e. a stepped-up search effort) to determine whether the targeted raptor species were continuing to collide with turbines. The carcass searching involved a qualified and experience zoologist walking transects out to 120 metres from the base of each turbine in accordance with the method described in the BBAMP. The search effort for this involved searching for seven consecutive days each month.

A total of 438 raptor observations of 10 species, including 370 flight paths were recorded during these raptor surveys (Table 12).

Table 12: Raptor survey results

Species	Number of raptors	Number of flight paths plotted
Nankeen Kestrel	152	134
Wedge-tailed Eagle	142	103
Brown Falcon	74	65
Whistling Kite	29	27
Brown Goshawk	13	13
Little Eagle	**8**	**8**
Swamp Harrier	7	7
Black Falcon	**6**	**6**
Peregrine Falcon	5	5
Australian Hobby	2	2
Grand Total	**438**	**370**

Single Black Falcons were seen on six occasions spread across the study area. These recordings were located in proximity to the south-west of the wind farm, along the west side of the wind farm and within the wind farm site. This species was last recorded during formal surveys on 12th October 2020 and incidentally in November 2020.

The Little Eagle was seen on eight occasions, all in an area close to the south edge of Pejar Dam to the south of the wind farm site. It is likely that only one or two individuals were involved, seen repeatedly. This species has not been recorded since 22nd September 2020.

The pattern of raptor collisions with turbines at the wind farm was reviewed using the carcass search data gathered since searches began in January 2019. The data shows that turbines 7, 8, 10 and 18 have resulted in 20 fatalities of the total 46 raptors affected since 2018. These four turbines (being 23% of those searched) are responsible for 44% of the birds affected.

The highest raptor collision numbers have occurred at turbine 18, where both planted and remnant native trees occur close to the turbine, suggesting that the availability of tree perches within 200 metres of turbines may increase raptor collision risk.

The following mitigation measures were implemented at C2WF during the investigation:

- Maintaining grass height at 20 centimetres or higher in the vicinity of the turbines impacting raptors to deter ground-feeding birds (e.g. European Starling) favoured as prey by Black Falcon. Grass height around the two turbines of greatest impact (Turbines 10 & 18) has been maintained at 20 centimetres or higher since at least early-mid October once growth reached this height.
- Planted (non-native) treed vegetation was removed from within approximately 200 metres or so of Turbines 10 & 18 to reduce perching opportunities for raptors. Tree removal occurred in late October 2020.

Allowing the grass length to grow above 20 centimetres discouraged Common Starling (a known food species for Black Falcon) from foraging under the turbines.

Planted cypress pine trees were removed from within 200 metres of turbines 10 and 18 in October 2020. Since this time no more raptor or other bird fatalities have occurred at these two turbines.

The targeted Black Falcon and Little Eagle surveys have been completed. No surveyed area was considered to have relatively concentrated, higher raptor activity (10 or more observations) and so more intensive surveys searching for nests did not occur.

Black Falcon has most likely now moved out of the area as it has not been sighted since November 2020. Little Eagle has also most likely now moved out of the area as this species has not been sighted since September 2020. This may be a response to the increase in rainfall across the continent more broadly. It is thought that very dry conditions inland played some part in Black Falcon moving into the Crookwell area as this species is considered nomadic and irruptive.

No carcasses of Black Falcon or Little Eagle were recorded during the searching of all 28 turbines present at C2WF for the duration of the more intensive investigation.

Due to the low use of the wind farm site and surrounding area by these two threatened raptor species the risk of collision with turbines is now considered to be lower than during the drought.

The implementation of the current mitigation measures — removal of perching opportunities and increase in the height of grass and maintenance of that height under high-risk turbines — will continue to maintain a reduced risk of collision by birds with these previously higher-impact turbines.

A full description of the work undertaken,and the mitigation measures implemented can be found in Nature Advisory (2020).

Given this conclusion, additional mitigation measures are not considered necessary.

4.4. Livestock removal and feral animal programs

C2WF staff have not implemented any carcass removal during the monitoring program. This was indicated as unnecessary and land holders had responsibility for removal of dead stock from their respective properties. During routine inspection of turbines over the monitoring period C2WF site management indicated that no dead stock requiring removal were observed.

C2WF was not aware of any feral animal control programs undertaken during the monitoring period. Staff also indicated that there was minimal rabbit presence at the site and as such, no control was required.

5. Bird Utilisation Survey

5.1. Introduction

Six Bird Utilisation Surveys (BUS) have been undertaken at C2WF to date. These consisted of two pre-construction surveys and four post-construction surveys. The pre-construction data provided a baseline for comparison with post-construction data to assess whether the construction and operation of the wind farm has affected bird utilisation of the site.

The survey schedule is summarised below.

Pre-construction BUS:

- Late Summer: 10th-16th February 2017 (BL&A 2017)
- Spring bird utilisation survey: 19th – 24th November 2017 (BL&A 2018b)

Post-construction BUS:

- Late Summer: 18th – 22nd February 2019 (BL&A 2019)
- Late summer utilisation survey: 23rd – 28th February 2020 (Nature Advisory 2021b);
- Late spring utilisation survey: 23rd – 26th November 2020 (Nature Advisory 2021c);
- Summer utilisation survey: 7th – 9th December 2020 (Nature Advisory unpublished data);

BUS were undertaken consistent with the requirements for a "Level One" bird risk assessment in accordance with 'Wind Farms and Birds - Interim Standards for Risk Assessment' issued by the Australian Wind Energy Association (AusWEA 2005). This approach has been endorsed in the Association's latest Best Practice Guidelines (Clean Energy Council 2018).

The bird utilisation surveys were undertaken by a team from Nature Advisory comprising; Khalid Al Dabbagh (Zoologist), Guille Mayor (Ecologist), Justin Sullivan (Ecologist) and Greg Hosking (Zoologist).

5.2. Methods

All surveys followed the same methods outlined below allowing for suitable comparisons.

5.2.1. Fixed-site bird count method

The fixed-point bird count method used to collect bird utilisation data involved an observer stationed at a survey site for 15 minutes. The adequacy of using 15 minutes as an interval to record the presence of birds during bird utilisation surveys was investigated in an earlier study at another wind farm site (Nature Advisory unpublished data). This showed that 82 to 100 percent (average 88 percent) of species seen in one hour of surveying were seen in the initial 15 minutes of observation. Based on this result, the period of 15 minutes used in the formal bird utilisation surveys was considered adequate to generate representative data on the bird species in the area during replicate surveys.

During this period, all birds observed within 200 metres were recorded. The species, the number of birds and the height of the bird when first observed were documented. For species of concern (threatened species, waterbirds and raptors), the minimum and maximum heights were recorded.

Flight heights were measured at 10 m intervals between 0 and 40 metres and at 20 metre intervals above 40 metres and up to 160 metres. This allowed for more precise description of bird flight heights and use of the data in the event RSA height changed as wind farm planning proceeded.

During all surveys, observations were recorded in pre-defined field observation forms. Raw data were then entered into spreadsheet files and tables and graphs were extracted. Graphs were generated in Microsoft Excel and R (R Core Team 2018).

5.2.2. Locations of survey points

Seven fixed survey points were established at five impact points and two reference points. Impact points were located near and among turbine locations. Reference points were located on edges of the wind farm boundaries in areas of similar habitat and at least 500 metres away from the proposed turbines. The pre-construction surveys consisted of eight survey points, which was reduced to seven post-construction due to private land access restrictions and a change in layout of the wind farm site. This does not impact comparison significantly.

The survey sites were distributed as evenly as possible (subject to access constraints) across the proposed wind farm site to maximise coverage in areas where wind turbines would be located (Figure 8). Impact sites were positioned on elevated ground where possible, allowing a clear view in all directions.

The reference points were established on public land for ease of access and were in areas covered by some remnant native vegetation and/or natural wetlands to provide a clear picture of birds at different habitats within the wind farm site.

5.2.3. Timing of the surveys

The timing of the BUS aim to cover a suitable period for surveying birds. During Spring and early summer surveys, most Spring breeders are singing and displaying, being easier to detect. Furthermore, most summer migrants are already in the region. During late summer; populations are probably at their maximum abundance following spring-summer breeding and most of the summer visitors to the wind farm area are still present.

During the surveys, eight counts were made at each survey point. Counts were made twice at four different times of the day to allow for time-of-day differences in bird movements and activity. This schedule ensured that all sites were visited at all times of day so that no time-of-day biases affected the pooled count data.

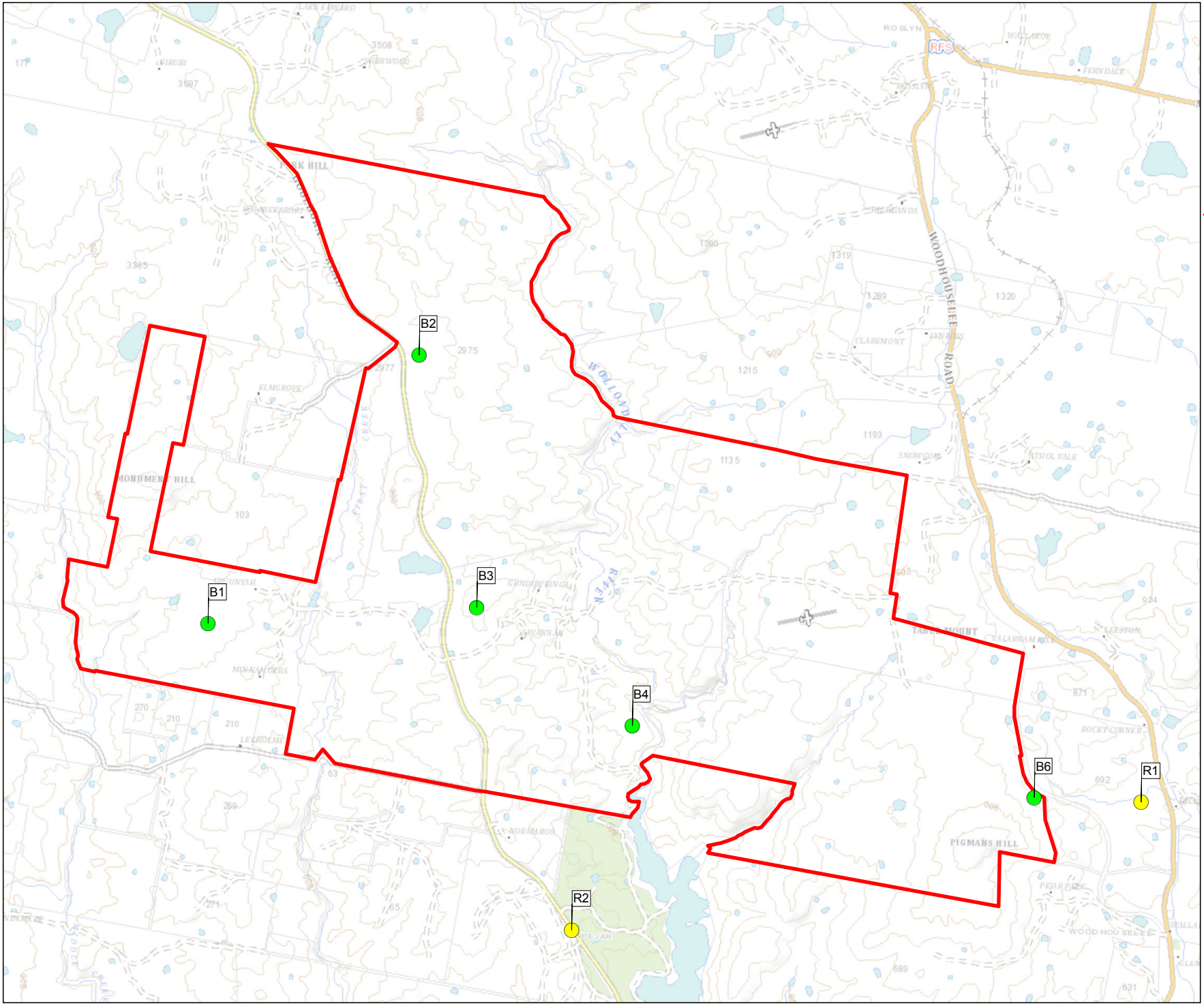

Figure 8: Crookwell 2 BUS points

Project: Crookwell 2 and 3 Windfarm
Client: Crookwell Development Pty Ltd
Date: 29/03/2019

- Site Boundary - Crookwell 2
- BUS locations (Impact Sites)
- BUS locations (Reference Sites)

N

Metres
0 500 1,000

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5.2.4. Incidental observations

In addition to the observations during formalised, fixed-point counts, incidental observations of birds of concern (threatened species, raptors, and waterbirds) were made whilst travelling throughout the proposed wind farm site. Notes were also made of birds observed in remnant woodlands and any early morning and evening roosting movements on the site. Emphasis was placed on observing birds that were moving through the site at RSA height.

5.2.5. Limitations

The utilisation rates and species relative abundances recorded during the current surveys are representative of the site for the time period covered as they take into consideration time-of-day changes in bird activity and species occurrence. They are therefore considered to provide an sound basis on which to assess the bird impacts of the C2WF.

5.2.6. BUS comparison

First, the suitability of the survey method was checked using a cumulative species number graph (see results below). Chi-square distribution tests were used to investigate the distribution of individuals in height categories. To investigate the variations of species diversity and abundance between impact and reference sites and between pre- and post-construction surveys conducted, analysis of variance (ANOVA) was performed, with species diversity and abundance as dependent factor and sites type (impact/reference) as predicting parameter. Abundance data were log-transferred to meet normal distribution in ANOVA tests. All statistical analyses were undertaken in R environment (R Core Team 2018).

5.3. BUS comparisons

5.3.1. Species frequency and abundance

A total of 100 species were recorded at C2WF during the six BUS. Ninety-one species were recorded at impact points and 71 at the reference points (Figure 9 and Figure 10). Species recorded during these surveys were predominantly farmland and bushland species with some records of raptors and waterbirds.

At impact points, the species with the highest frequency of observation were Australian Magpie, Common Starling, Galah, Magpie-lark and Raven species. At reference points, the species with highest frequency of observation were Australian Magpie, Noisy Miner, Common Starling, Crimson Rosella and Galah. These common species also dominated the count (relative abundance of birds) although with slight changes in the ranking of the common species (Figure 11 and Figure 12). Thus, a very similar pattern was observed between impact points and reference points with the Noisy Miner being the most frequent species recorded during surveys.

Species richness (e.g., mean number of species per site) varied slightly between the pre-construction and post-construction BUS. During pre-construction surveys, a total of 83 species were recorded compared with 73 species for post-construction surveys.

The abundance of most common species remained almost similar between pre and post construction surveys with Common Starling and Australian Magpie as the two most abundant species for both survey periods. The five most common species with respect to their abundance (e.g., number of individuals recorded) during pre- and post-consecution surveys are presented in Table 13 below. (Figure 13 and Figure 14). These five species comprised 44.5% of all individual birds recorded in the pre-construction survey and approximately 61% in post-construction surveys.

Table 13: Pre- and post-construction most common species

Pre-construction (% of total individuals birds)	Post-construction (% of total individuals birds)
Common Starling (18.66%)	Common Starling (30%)
Australian Magpie (8.96%)	Australian Magpie (14%)
Crimson Rosella (6.41%)	Galah (6.4%)
Galah (6.36%)	Sulphur-crested Cockatoo (5.56%)
Yellow-rumped Thornbill (6.15%)	Raven Sp. (5.0%)

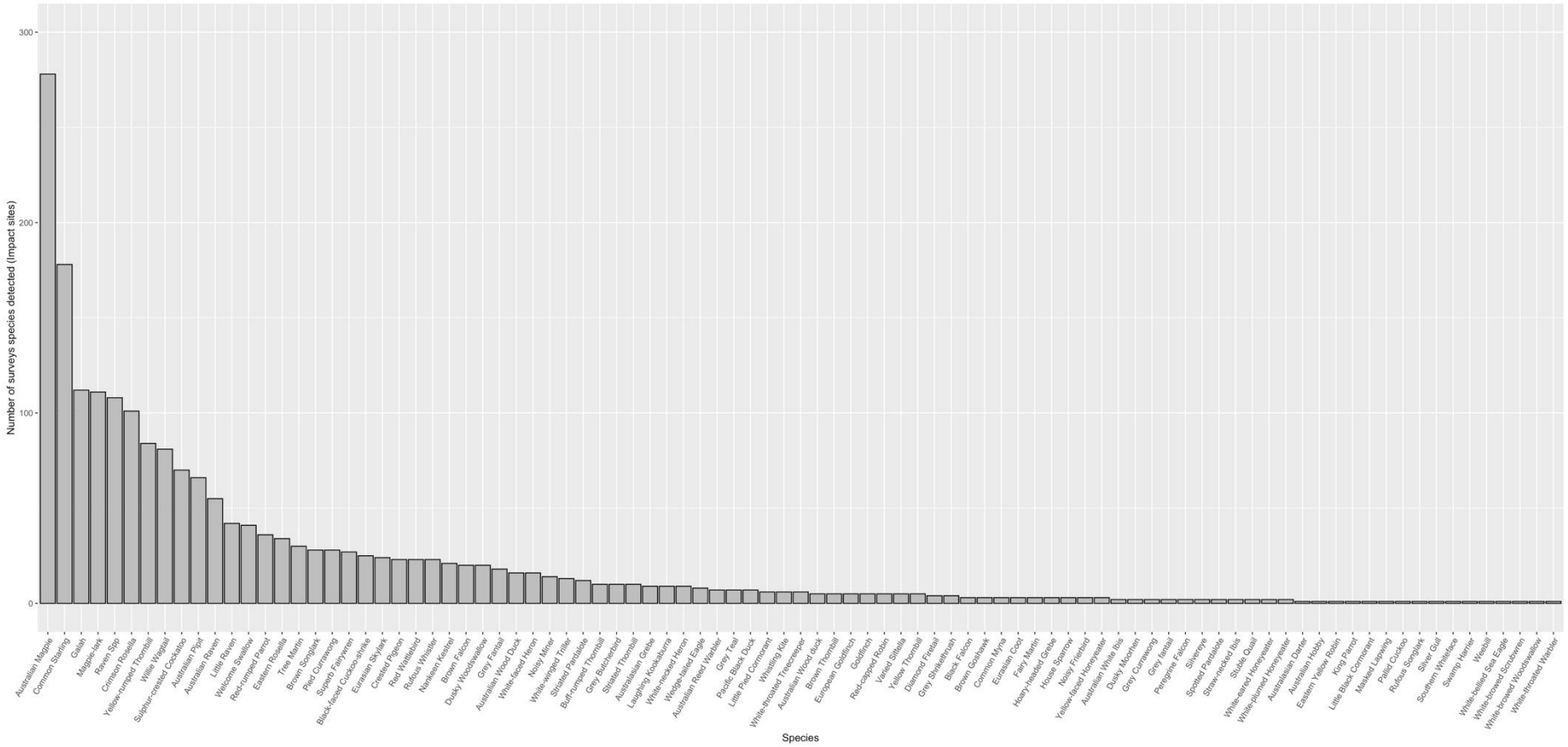

Figure 9: Frequency of species detection in impact points at Crookwell 2 Wind Farm. Values represent the number of surveys that a given species was observed.

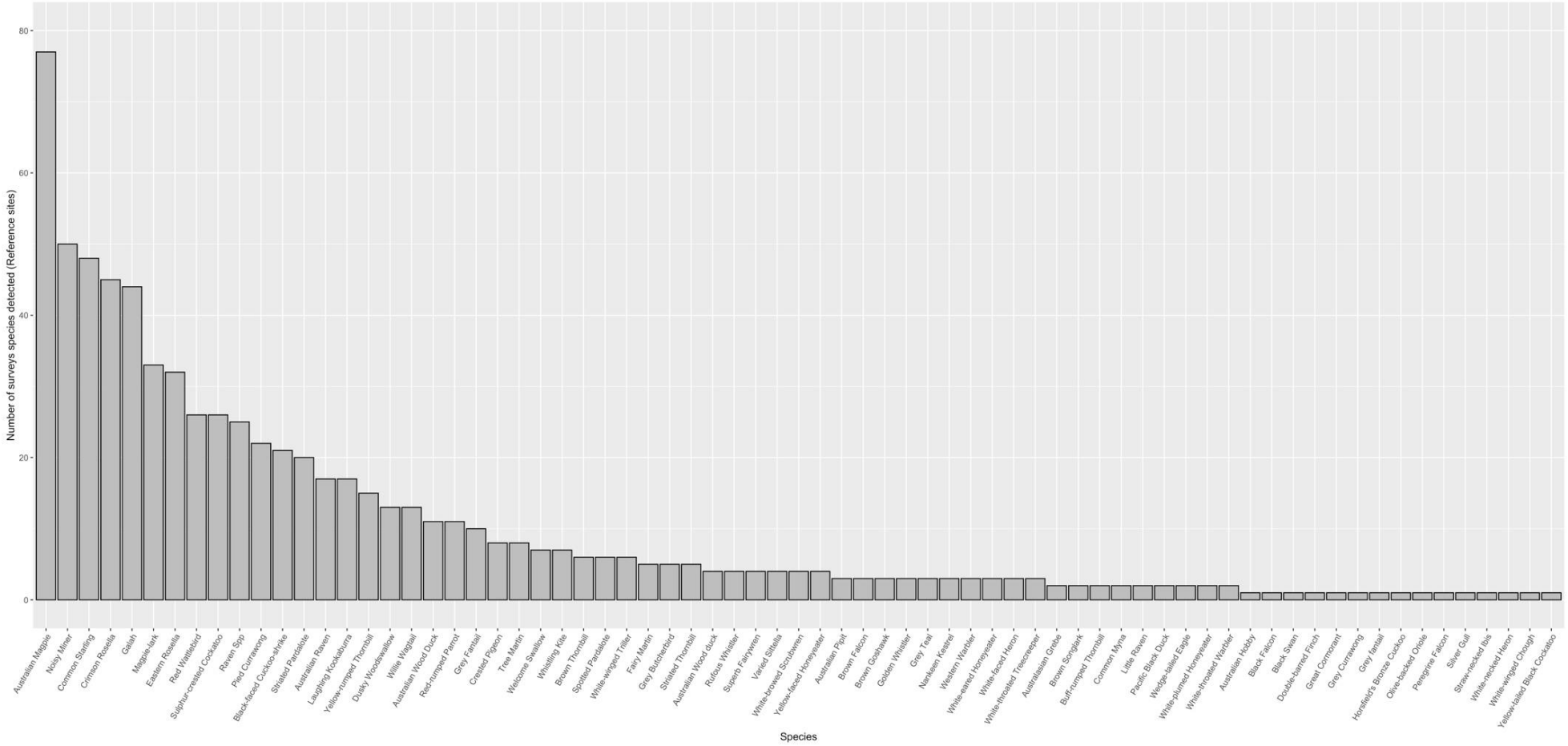

Figure 10: Frequency of species observed at reference points at Crookwell 2 Wind Farm. Values represent the number of surveys that a given species was detected.

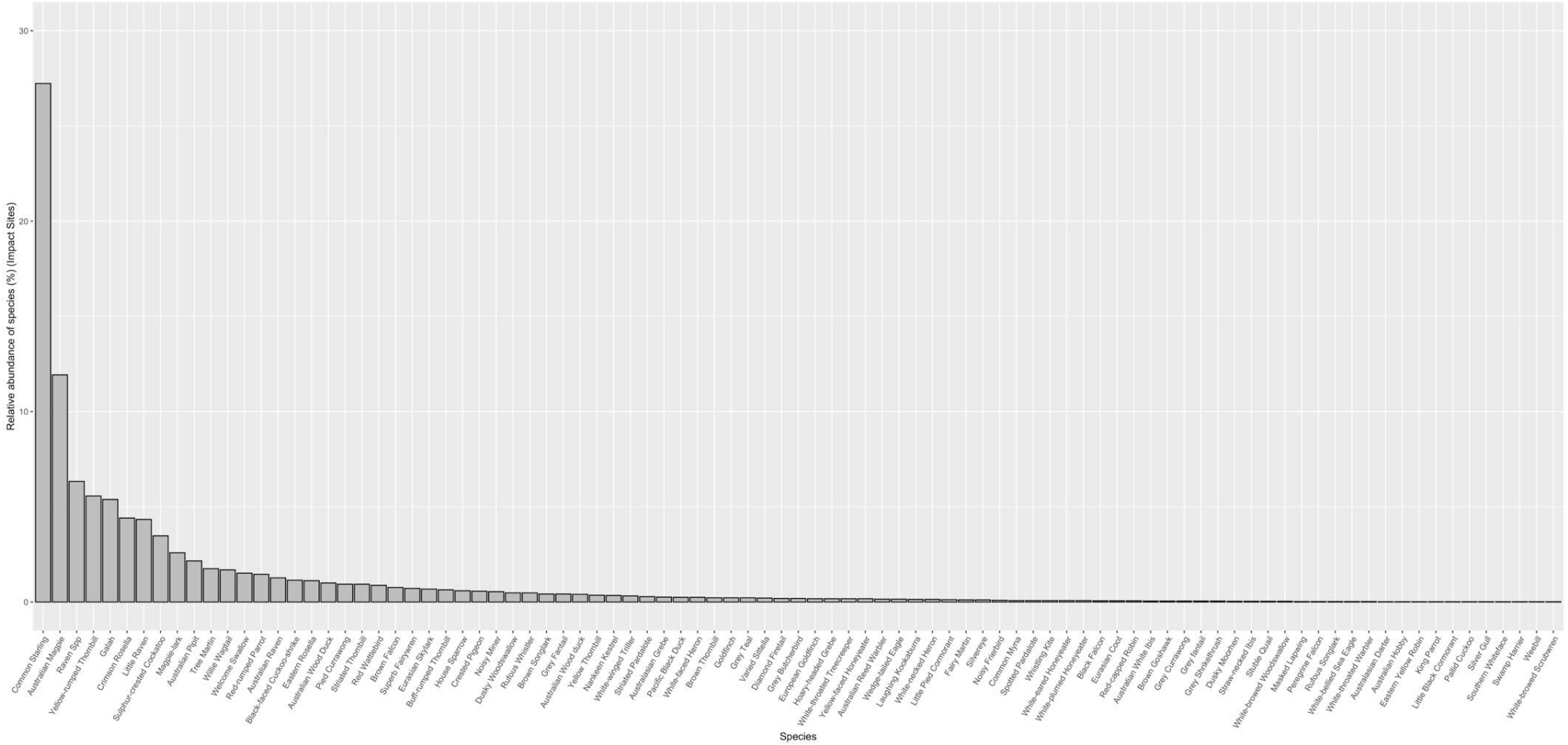

Figure 11:Relative abundance of species observed in impact points at Crookwell 2 Wind Farm. Values represent percentages of individual from a given species.

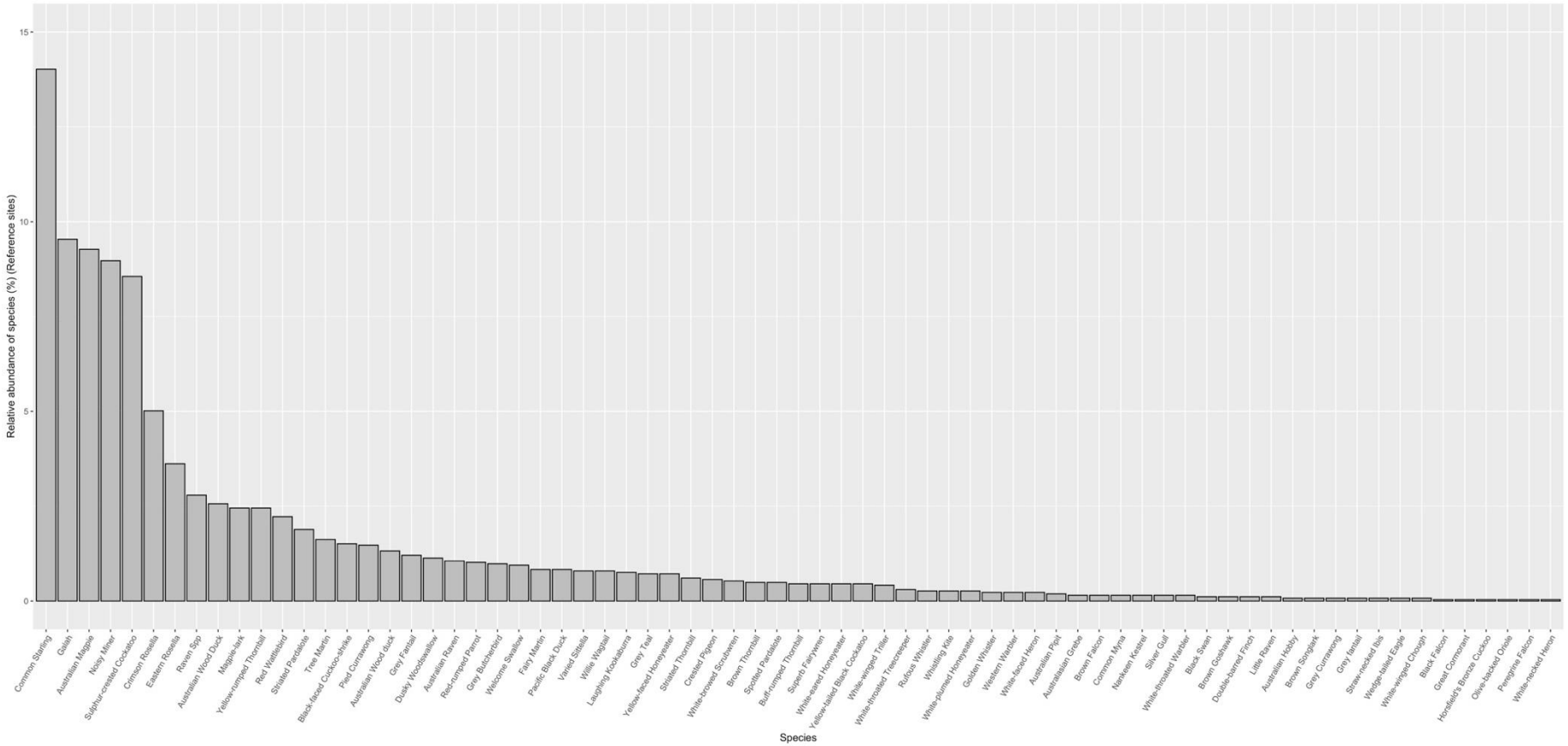

Figure 12: Relative abundance of species observed in reference points at Crookwell 2 Wind Farm. Values represent percentages of individual for a given species.

5.3.2. Variation in species richness and abundance among all survey points

When results were combined for all BUS, the diversity of bird species (species/survey) varied between the ten observation points, likely depending on the habitat surrounding each of the points. Generally, points within or close to patches of remnant woodlands had more species than those within open treeless habitats. Points with more mature native trees, that are located close to or within a remnant woodland, attracted more species than those in open grazing paddocks. Points in more wooded habitats included points BUS07, which showed the highest number of species compared with points in generally cleared habitats, such as BUS02 (Figure 13). The species richness per survey point varied from 4.8 ± 0.36 (mean ± se) at BUS02 to 13.37 ± 1.02 at BUS07. Mean number of species detected per site was 6.9 ± 0.24 at impact points and 7.72 ± 0.42 at reference points. An ANOVA test indicated that this difference was not statistically significant (ANOVA, F=2.77, df=1&380, p=0.09).

Like the number of species, mean abundance of birds (number of birds/survey) varied between points but more so (Figure 14). Mean number of birds recorded per survey varied from 16.72 ± 2.76 individuals/survey at BUS03 up to 49.75 ±9.23 individuals/survey at BUS07, with an average value of 28.19 ± 4.5 individuals/survey across all points. In addition, the mean abundance of birds recorded per survey at impact points was 28.18 ± 1.9 individuals/survey, very similar to reference points (28.22 ± 2.3), a difference found not to be statistically significant (ANOVA, F=0.01, df=1&380, p=0.99). Again, points within or close to patches of remnant woodlands and dams had higher abundance than those within cleared habitats.

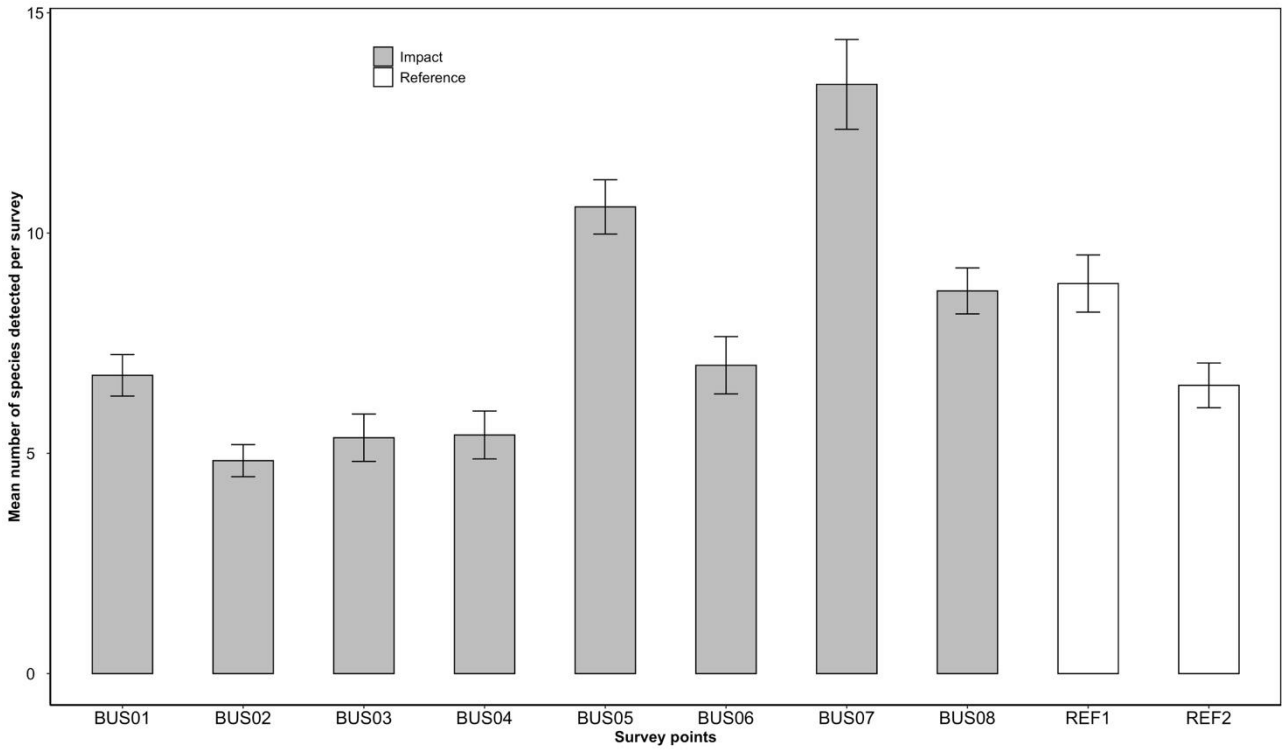

Figure 13: Mean richness (number of species per survey) of birds among impact and references survey points at Crookwell Wind Farm.

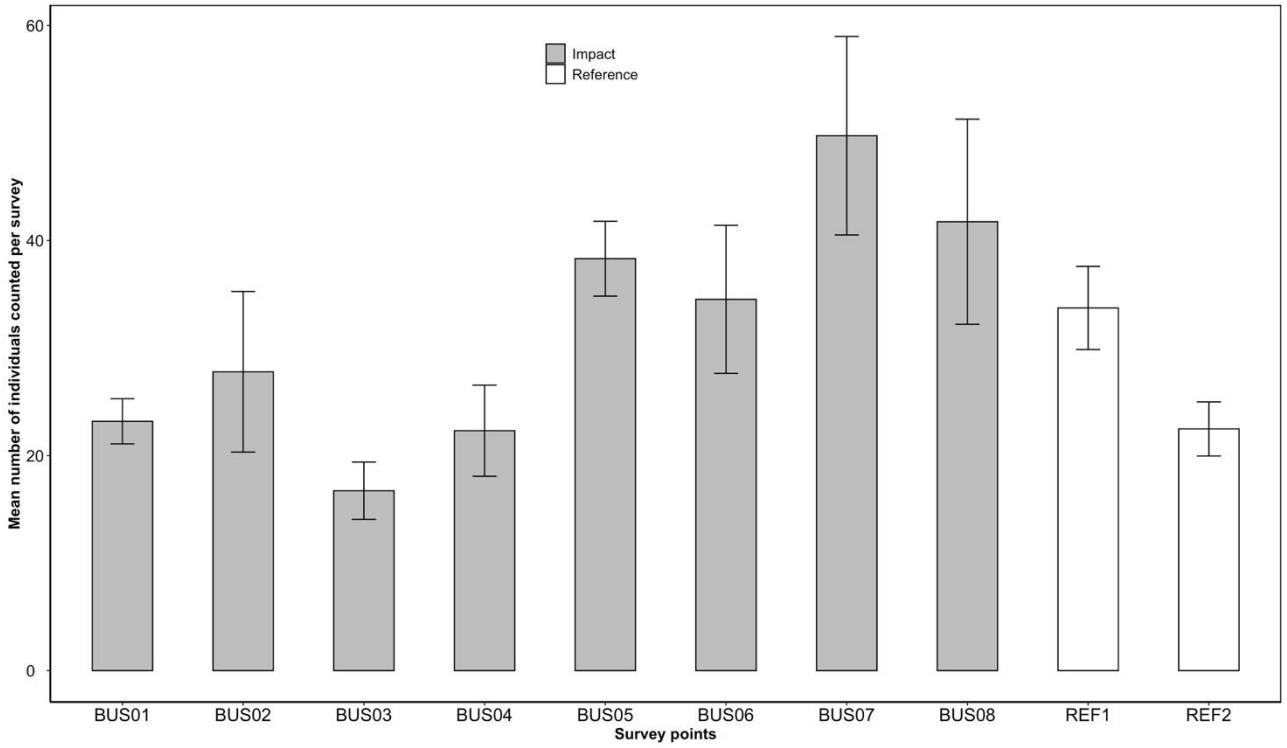

Figure 14: Mean abundance (number of birds recorded per survey) at impact and survey points at Crookwell Wind Farm

5.3.3. Variation in species diversity and abundance pre- and post-construction

During pre-construction BUS surveys, the mean number of species recorded per survey was 9.63 (Figure 15) which did not vary significantly between impact and reference sites (ANOVA, F=2.67, df=1&158, p=0.10), although there was a noticeable tendency for the impact point surveys to record fewer species that the reference point surveys. During post-construction BUS surveys, the mean number of species recorded per site was 5.29 with impacts points having a statistically significantly lower abundance compared with reference points (ANOVA, F=7.04, df=1&220, p=0.008;Figure 15).

When the corresponding two pre- and post- construction BUS results were compared, a lower mean number of species per survey was observed in post-construction surveys compared with pre-construction phase. Similarly, on average a lower abundance of birds was recorded during post-construction surveys compared with pre-construction surveys conducted in 2017 (Table 14, Figure 16).

These variations in the diversity and abundance of birds could be associated with environmental conditions in the survey periods. BUS in 2017 were conducted during a normal rainfall period and thus more favourable conditions for birds. By contrast, most BUS conducted in the post-construction period (2019-2020) were undertaken during severe drought conditions (BOM 2021, see Section 3.2.5). Drought conditions in the post-construction period clearly affected BUS results equally at impact and reference points. In view of the strong effect of the drought on both impact and reference point survey results, and considering the consistent differences between these point both before and after the wind farm commenced operations, it is concluded that the wind farm did not effect the number of species using the impact area.

Table 14: Summary statistics for ANOVA test examining impacts of survey period and site type on the diversity and abundance of birds at Crookwell wind farm site.

Predicting factor	*df*	F- value	P-value[3]
Bird abundance			
Survey period[1]	1	73.23	**> .0001**
Site type[2]	1	3.31	0.0696
Residuals	379		
Bird diversity			
Survey type	1	137.01	**> .0001**
Site type	1	10.19	**0.0015**
Residuals	379		

[1]Surveys period is categorised as pre- and post-construction BUS

[2] Site type represents impact and reference points

[3] Statistically significant values are shown as bold

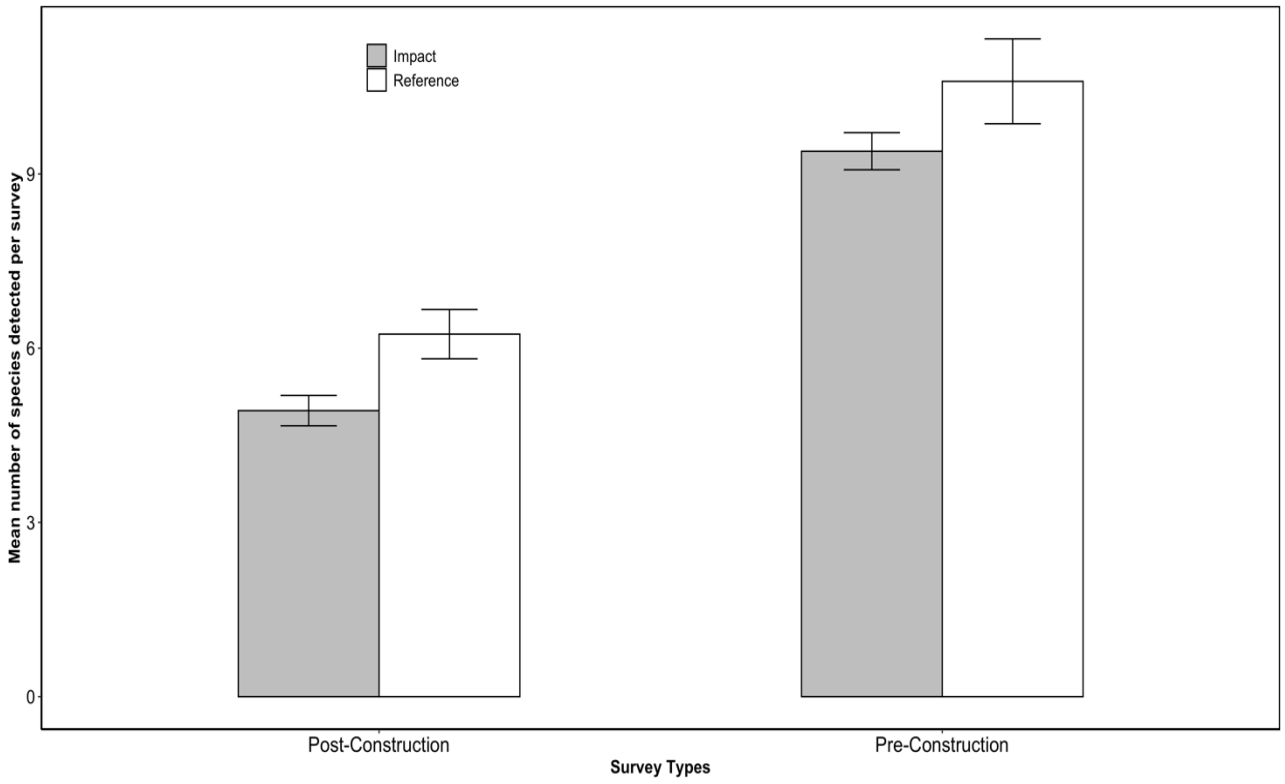

Figure 15: Mean number of species per survey at impact and survey points during pre and post-construction BUS at C2WF.

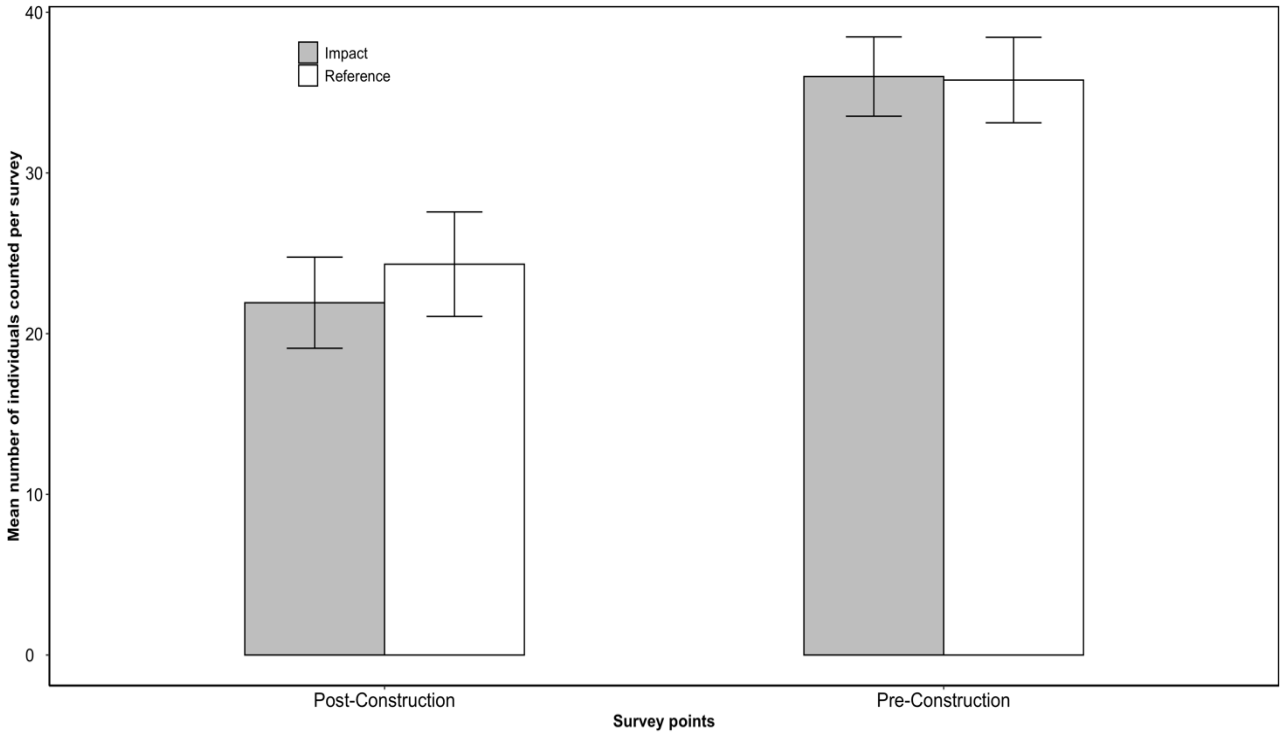

Figure 16: Mean abundance (number of birds recorded per survey) at impact and survey points during pre and post-construction BUS at Crookwell Wind Farm.

5.3.4. Flight height variation during pre-construction and post-construction periods

Bird observation heights were classified as below RSA (< 35 metres), at RSA (35–160 metres), and above RSA (> 160 metres) heights. For all BUS combined, of the total 10769 bird observations recorded; 94.4% of birds were seen flying below RSA height which was statistically a significant proportion (χ^2 = 18126, df=2, p < 0.0001).

The same patterns were observed for pre and post construction surveys with majority of birds observed below RSA height during both survey periods (Pre-construction: χ^2 = 8726, df=2, p < 0.0001; Post-construction: χ^2 = 9477, df=2, p < 0.0001). The proportion of birds that were recorded flying below RSA heights was 91.4% for pre-construction surveys and increased to 98.1% in the post-construction surveys (Table 15, Figure 17**Figure 17**).

Table 15: Summary of number of birds recorded at the three flight heights at Crookwell Wind Farm

Flight Height	Pre-construction		Post-construction	
	Number of birds	Percentage of all birds	Number of birds	Percentage of all birds
A (below RSA)	5245	91.16%	4922	98.12%
B (at RSA)	507	8.81%	88	1.75%
C (above RSA)	1	0.01	6	0.11%

Flight Height	Pre-construction		Post-construction	
	Number of birds	Percentage of all birds	Number of birds	Percentage of all birds
Total birds recorded	5753		5016	

Although the overall patterns in terms of the percentage of birds that were recorded at different height was similar between the two surveys (Figure 17), the percentage of birds flying at the RSA height decreased by approximately seven percentage points, or an overall 80 percent decline during post construction surveys compared with pre-construction surveys (Figure 18). This indicates turbine avoidance on the part of many birds by flying below operating turbines.

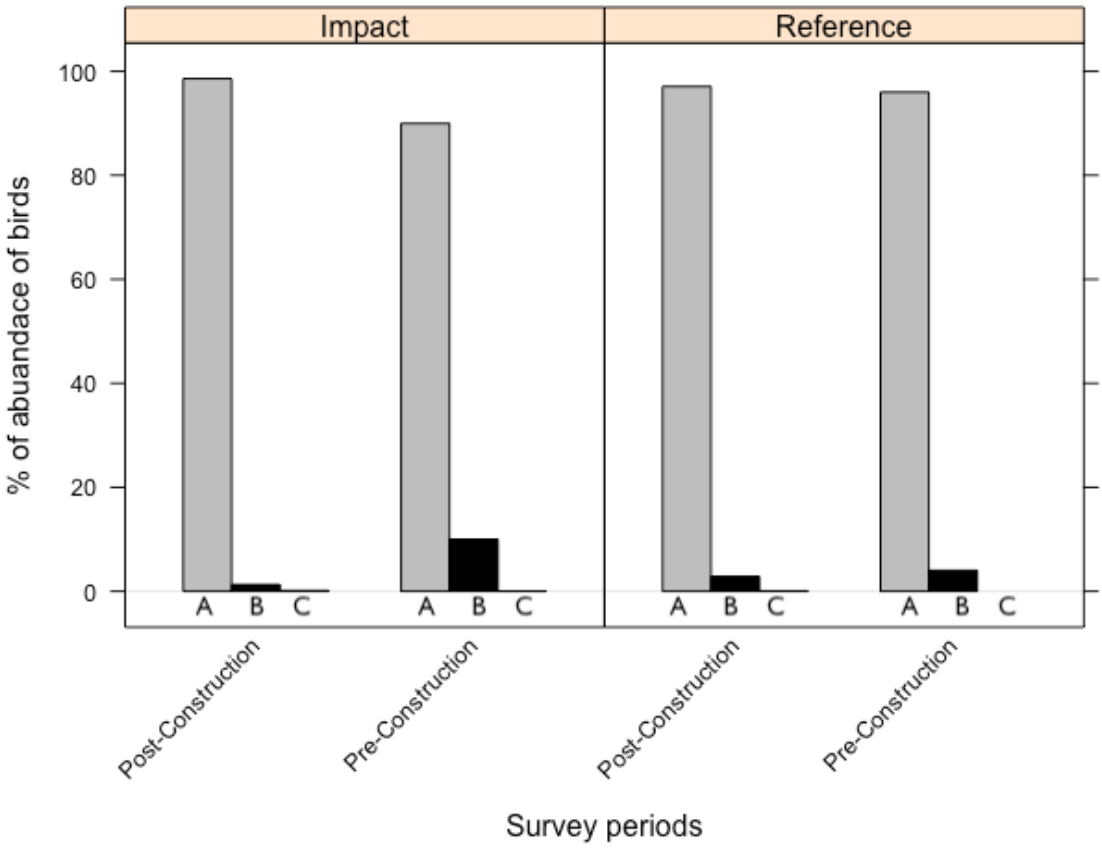

Figure 17: Percentages of birds recorded at different height classes (A, B and C) during pre and post-construction BUS conducted at Crookwell Wind Farm.

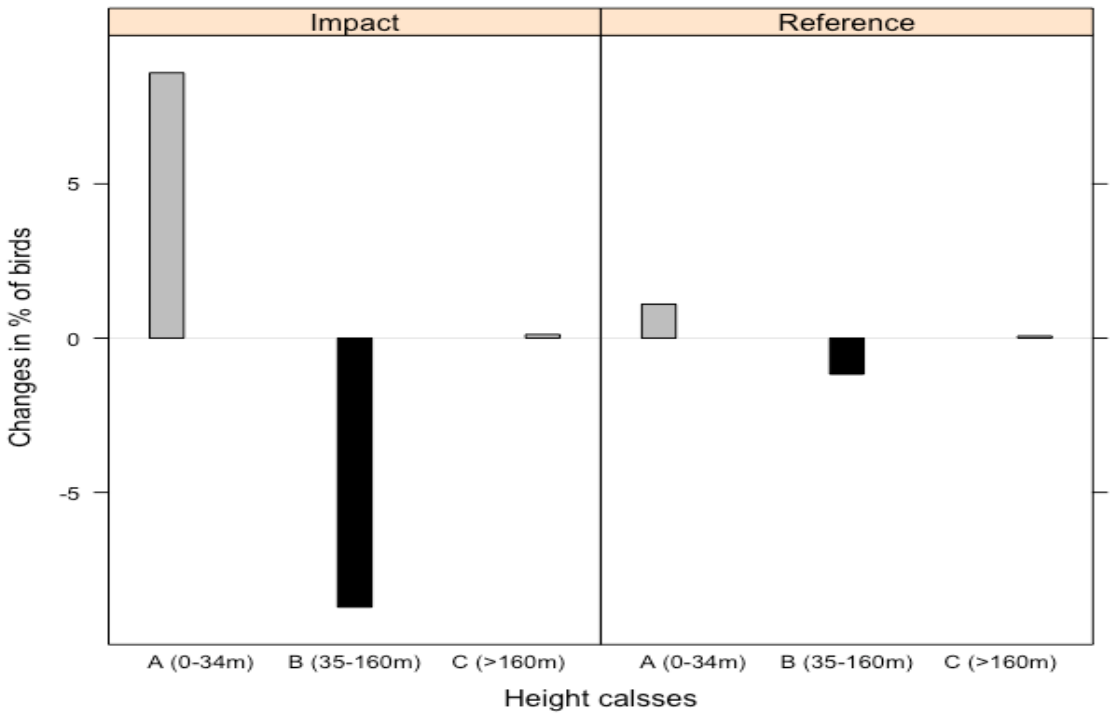

Figure 18: Changes in the percentages of birds utilising different height classes (A, B and C) during pre-and post-construction BUS conducted at Crookwell Wind Farm.

5.3.5. Changes in the diversity and abundance of birds flying at RSA height

Mean diversity of birds recorded flying at the RSA height was 2.01± 0.13 (mean ± se) during pre-construction surveys and 1.3 ± 0.12 during post-construction BUS (**Figure 19**). The reduction in the diversity birds at RSA height during operational phase of the wind farm was statistically significant. Similarly, the abundance of birds flying at RSA height declined during post-construction surveys compared to pre-operational phase BUS. These variations were only significant at the impact sites suggesting that birds were responding differently to the operation of the wind farm at the impact and reference sites (**Table 16**, Figure 19).

Table 16: Summary statistics for ANOVA test examining impacts of survey period and site type on the diversity and abundance of birds fling at RSA height at Crookwell wind farm site

Predicting factor	*df*	F- value	P-value[3]
Bird abundance			
Survey period[1]	1	2.59	**0.04**
Site type[2]	1	0.10	0.99
Residuals	109		
Bird diversity			
Survey type	1	9.43	**< 0.01**

Predicting factor	*df*	F- value	P-value[3]
Site type	1	0.63	0.80
Residuals	109		

[1]Surveys period is categorised as pre- and post-construction BUS

[2] Site type represents impact and reference points

[3] Statistically significant values are shown as bold

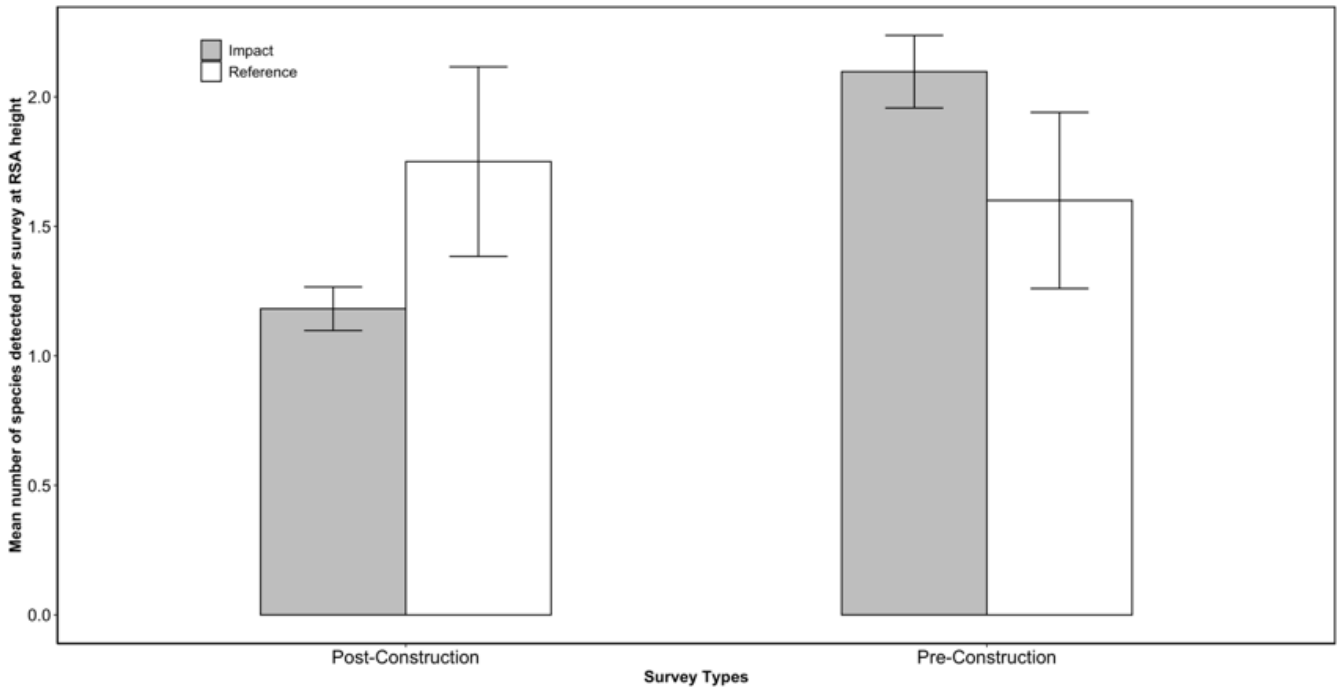

Figure 19: Changes in the mean species recorded per survey at RSA height at impact and reference sites during pre and post-construction BUS conducted at Crookwell Wind Farm.

5.4. Conclusions

The conclusions from comparison of pre-construction (N=2) and post-construction (N=4) BUS at Crookwell 2 Wind Farm are presented below:

- Overall, a total of 100 species were recorded during six BUS conducted at C2WF from 2017 to 2020. Of all species recorded, 91 species were recorded at the impact survey points and 71 at the reference survey points.
- Species recorded during these surveys were predominantly farmland and bushland species with some records of raptors and waterbirds.
- At the impact points, the species with the highest frequency of observation were Australian Magpie, Common Starling, Galah, Magpie-lark and Raven species. At the reference sites, the species with highest frequency of observation were Australian Magpie, Noisy Miner, Common Starling, Crimson Rosella and Galah. These five species comprised 44.5% of all individual birds recorded in the pre-construction surveys and approximately 61% in post-construction surveys.

- Combined for all BUS, the diversity of bird species (species/survey) varied between the survey points and depended on the habitat surrounding each of the points. The number of species per survey varied from 4.8 ± 0.36 (mean ± se) at BUS02 to 13.37 ± 1.02 at BUS07. Mean number of species detected per point was 6.9 ± 0.24 at impact points and 7.72 ± 0.42 at reference points.
- During pre-construction surveys, the mean number of species recorded per survey was 9.63 which did not vary significantly between impact and reference points. During post-construction BUS surveys, the mean number of species recorded per site was 5.29 and statistically significantly lower at impact points compared with reference points.
- On average, a lower mean number of species per survey was observed in post-construction compared with pre-construction surveys. Similarly, on average a lower abundance of birds was recorded during post-construction compared with pre-construction surveys. The decline in the number and abundance of bird species was most likely due to severe drought conditions during post-construction surveys.
- In all surveys, the majority of birds were recorded flying below RSA heights. The proportion of birds observed flying at RSA height decline from around 8% in pre-construction surveys to as low as 1.7% in the post-construction BUS. Similarly, the mean diversity of species observed at RSA height declined significantly from 2.01± 0.13 (mean ± se) during pre-construction surveys and 1.3 ± 0.12 during post-construction BUS. The decline was observed only at impact survey points.
- Overall, a low proportion of birds (preconstruction surveys: 8.81% and postconstruction surveys 1.75%) were observed at RSA height, representing an 80 percent reduction on the numbers of birds flying at RSA height. The decline in the proportion of birds flying at RSA height was significant, suggesting that bird might be adapting to avoid RSA height.

6. Discussion

The largest numbers of carcasses found during the C2WF formal carcass search program (i.e. not including incidentally found carcasses) were of the Australian Magpie (eight carcasses, 16.6% of the total), followed by Brown Falcon (five, 10.4%), and Wedge-tailed Eagle, Raven species, Galah, Grey Fantail and unidentified remains (four, 8.3%).

It is unlikely that Australian Magpie would be impacted at a local, regional, state or national level as it one of Australia's most abundant and widespread bird species, adaptable and successful in almost any environment, including urban environments.

Wedge-tailed Eagle and Brown Falcon were identified as 'at-risk' in the BBAMP, making them species of concern; Wedge-tailed Eagle specifically, and Brown Falcon indirectly as 'other raptors'. Brown Falcon is another very common species found throughout Australia, Tasmania and most of New Guinea (Marchant and Higgins 1993; Birdlife International 2021). Higher population densities occur in the south-east of the country (Marchant and Higgins 1993, Birdlife Australia 2020). This species was the most frequently observed raptor across all BUS surveys. The population is stable or possibly declining slightly although local declines have been reported in some agricultural areas due to poisoning and lack of breeding sites (Marchant and Higgins 1993; Ferguson-Lees and Christie 2001). It is estimated that the total Australian breeding population is 225,000 pairs, the there are no recent population estimates (Marchant and Higgins 1993). Birdlife International 2021 lists this species as least concern and does not believe the decline to be sufficiently rapid to approach the thresholds for Vulnerable. It is highly unlikely that C2WF is affecting the population beyond a local level, and it is further unlikely that the impact locally would be significant.

The Wedge-tailed Eagle was the third most found carcass during formal carcass searches and the second most frequently observed raptor species during BUS. Its foraging behaviour likely explains this. The species often flies and soars n thermals to many hundreds of metres above the ground while searching for food, which increases their risk of collision. The level of mortality at C2WF is not considered unacceptable as Birdlife International (2021) consider the species population as increasing. Mitigation opportunities which can further reduce mortality risk for the 'at-risk' species are outlined in Section 7.

The most frequently found bat carcasses were White-striped Freetail Bat. Several studies (Symbolix 2020, Smales 2012) have identified this species is commonly over-represented as mortalities across Victorian wind farms. This species is one of the most widespread and common of Australia's microbat species, found in almost all habitats, and it is unlikely that C2WF is having a significant impact on regional or national populations. It is likely though, given estimated bat numbers of 246 bats over two years, and White-striped Freetail Bat making up 60% of this, that there may be a local population impact on this species.

Overall mortality estimates for bird (3.3 per turbine per year) and bats (4.4 per turbine per year) were comparable with other wind farms at which Nature Advisory has undertaken monitoring in south-eastern Australia, including in the southern tableland's region.

Little Eagle (one carcass) and Black Falcon (min. two and possibly three carcasses), both listed as Vulnerable under the BC Act triggered management actions under the BBAMP decision-making framework. The investigations (described in Section 4.4) concluded that due to the low use of the wind farm site and its surrounding area by the two threatened raptor species, the risk of ongoing collision with turbines was low. The implementation of the current mitigation measures to reduce risk, specifically for these two species — removal of perching opportunities nearby turbines and increase in the height of grass

under high-risk turbines to reduce activity by falcon prey species — will continue to maintain a reduced risk of collision by these birds with these turbines.

There were some differences in bird utilisation of the site between pre and post construction periods. This may be related to changing climatic conditions on the site rather than the establishment and operation of C2WF. The regions where C2WF is located experienced drought conditions between 2017 and 2020, when surveys finished. The average rainfall around Woodhouselee (located adjacent the wind farm) is 765mm annually. It fell to 611mm in 2018 and to 423mm in 2019. There was not sufficient data from this location in 2020, however at nearby Gundowringa, 953mm fell in 2020 (BOM 2021).

The BUS results indicated that the abundance of birds at RSA height declined 80 percent, a statistically significant decline. This indicated that birds were avoiding turbines by flying below them.

7. Recommendations

This section provides recommendations on future monitoring and mitigation measures.

7.1. Carrion removal

During the monitoring program C2WF has left the management of carrion removal up to local land holders to undertake as part of their usual activity. As there were no carcass removals recorded and no log book maintained, it is not possible to evaluate whether removal should be increased or decreased. As Wedge-tailed Eagle is one of the most impacted bird species on the site, it is important that the carrion removal program be undertaken diligently and a log book maintained. The program is outlined in Section 5.1 of the BBAMP.

Carcass occurrence and removal, and the times and dates of each monthly search should be recorded in a "management log book" maintained by the C2WF asset manager. This log book is to be provided to OEH as part of an annual report, in accordance with the approved BBAMP.

7.2. Restrict lambing and feeding near turbines

Lambing should be restricted in paddocks at least 200 metres away from turbines, in consultation with land holders, to reduce the risk that raptors (Wedge-tailed Eagles in particular) are attracted close to the turbines.

Feeding stock close to turbines should be discontinued as it may contribute to unnecessary bird impacts. Stock should not be fed grain within a 200-metre radius of wind turbines as this may attract parrots and cockatoos that can then collide with turbines.

As C2WF cannot impose such restrictions on private land holders (given their long-standing pre-existing lease agreement), undertaking these mitigation measures must be done in consultation and cooperation with them.

C2WF should contact relevant land holders to discuss restricting the above activities and report the results of consultations to OEH.

7.3. Carcass search program

It is considered that two years of carcass searches, combined with the BUS surveys have provided an understanding of the impact the wind farm on birds and bats on the site.

Few threatened species were recorded after mitigation measures were implemented and the drought broke so further carcass searches are not recommended.

7.4. Raptor survey

Given that mitigation measures are in place for raptor species, and for Black Falcon in particular, it is recommended that monthly raptor surveys at the 2020-21 survey points *within* the C2WF be undertaken from July to December, a period that includes the breeding seasons of both Little Eagle and Black Falcon.

7.5. Incidental monitoring

Incidental reporting of carcasses by C2WF staff must continue in accordance with the approved BBAMP. C2WF should continue to photograph and store in a freezer any carcasses found by staff under turbines until identified by a qualified and experienced ecologist as per the BBAMP. This will continue to provide some indication of on-going impacts to birds and bats at the wind farm and, should impacts on threatened species be detected, the impact trigger requirements must be implemented.

7.6. Reporting

The above activities should continue to be reported to the regulator in an annual report.

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Appendix 1: Detailed carcass records during the C2WF monitoring period (January 2019 - December 2020)

Common name	Scientific name	Threatened Status	Report (R)/ Feather spot (FS)/ Incidental (INC)	Turbine number	Distance from turbine (m)	Bearing from turbine (°)	Notes
Brown Falcon	*Falco berigora*		INC18.10.1	7	35	S	Freshly killed and intact. No obvious trauma, clean specimen.
Nankeen Kestrel	*Falco cenchroides*		INC18.12.1	25	102	?	Well decomposed, but largely intact.
Eurasian Skylark*	*Alauda arvensis*		FS19.1.1	7	40	S	Feather spot. Only a wing and one foot remained.
Galah	*Eolophus roseicapilla*		FS19.1.2	10	20	N	Feather spot. Only a wing remained.
Wedge-tailed Eagle	*Aquila audax*		R19.1.3	4	35	S	Long dead. Simply the skeleton and feathers remain.
Wedge-tailed Eagle	*Aquila audax*		R19.1.6	24	115	SW	Old carcass. No head present, only feathers and Bones remain. Talon bones were completely eaten away and disconnected.
White-striped Freetail Bat	*Austronomis australis*		R19.1.4	15	90	E	Intact. Dry and eaten inside.
Gould's Wattled Bat	*Chalinolobus gouldii*		R19.1.5	24	10	E	Intact. Dry and eaten inside.
White-striped Freetail Bat	*Austronomis australis*		R19.1.8	12	7	N	Squashed by bulldozer, but fresh. Note: Live White-striped Freetail Bat found at the base of the turbine just metres away.
White-striped Freetail Bat	*Austronomis australis*		R19.1.9	12	20	N	Intact.
Gould's Wattled Bat	*Chalinolobus gouldii*		R19.1.6	24	20	E/SE	Intact. Dry and eaten inside.
White-striped Freetail Bat	*Austronomis australis*		R19.2.1	7	3	NW	Intact. Visible wounds. Reasonably fresh, slight decay.
Fairy Martin	*Petrochelidon ariel*		R19.2.2	8	53	N	Intact, decaying due to insects. Somewhat recent, but >3 days.
Galah	*Eolophus roseicapilla*		FS19.2.3	10	47	NW	Feather spot.
Raven sp.	*Corvid sp.*		FS19.2.4	1	91	SE	Feather spot. Black feathers.
Nankeen Kestrel	*Falco cenchroides*		INC19.3.7	3	20	N/A	Intact.

Common name	Scientific name	Threatened Status	Report (R)/ Feather spot (FS)/ Incidental (INC)	Turbine number	Distance from turbine (m)	Bearing from turbine (°)	Notes
White-striped Freetail Bat	*Austronomis australis*		INC19.3.8	27	8	N/A	Intact.
Unknown bat sp.	*N/A*		R19.3.1	10	34	E	Well decomposed. Only the skeletal frame of wings remain.
White-striped Freetail Bat	*Austronomis australis*		R19.3.2	12	32	E	Intact. Fresh. No obvious signs of injury.
Raven sp.	*Corvid sp.*		R19.3.4	6	93	N	Well decomposed, head missing with just bones and feathers remaining.
White-striped Freetail Bat	*Austronomis australis*		R19.3.3	6	27	N	Intact. Fresh.
White-striped Freetail Bat	*Austronomis australis*		R19.3.5	24	13	NE	Intact.
White-striped Freetail Bat	*Austronomis australis*		R19.3.6	21	61	S	Intact, but decomposed.
Grey Fantail	*Rhipidura albiscapa*		R19.4.1	8	39	S	Intact. No obvious signs of injury.
Brown Falcon	*Falco berigora*		R19.4.2	4	65	SE	In two pieces. Heavy impact and well decomposed.
Common Starling	*Sturnus vulgaris*		FS19.4.3	7	30	E	30+ feathers found.
Grey Fantail	*Rhipidura albiscapa*		R19.4.4	7	56	SW	Intact. No obvious signs of injury.
Grey Fantail	*Rhipidura albiscapa*		R19.4.5	8	57	W	Intact. Severe head injury (open cavity).
Gould's Wattled Bat	*Chalinolobus gouldii*		R19.5.1	27	70	E	Intact. Exposed to the elements for some time.
Brown Falcon	*Falco berigora*		FS19.5.2	12	94	SE	Feather-spot. Tuft of feathers, brown and white in colour.
Brown Falcon	*Falco berigora*		FS19.6.1	15	42	W	Feather-spot. Red Fox scat found next to feathers suggesting the likely scavenger culprit.
Black Falcon	*Falco subniger*	Vulnerable (NSW)	R19.7.3	18	0		Head missing, but otherwise intact. Appears to be directly due to blade impact, with subsequent collision with turbine column likely.
Raven sp.	*Corvid sp.*		FS19.7.1	1	85	S	Feather-spot, black feathers. Likely Raven sp.
Wedge-tailed Eagle	*Aquila audax*		R19.7.2	24	58	SE	Somewhat old carcass, with insides largely scavenged.

Common name	Scientific name	Threatened Status	Report (R)/ Feather spot (FS)/ Incidental (INC)	Turbine number	Distance from turbine (m)	Bearing from turbine (°)	Notes
Australian Wood Duck	*Chenonetta jubata*		FS19.8.1	10	39	W	Feather-spot, chest feathers of Australian Wood Duck.
Australian Magpie	*Cracticus tibicen*		R19.9.1	18	2	S	Fresh. Used in scavenger trials.
Australian Magpie	*Cracticus tibicen*		R19.9.2	27	60	W	Just a wing found. Disposed of.
Gould's Wattled Bat	*Chalinolobus gouldii*		R19.9.3	15	71	SW	Fresh. Carcasses used in scavenger trials
Chocolate Wattled Bat	*Chalinolobus morio*		R19.10.1	6	27	E	Fresh, blood around mouth FA 3.3cm
Chocolate Wattled Bat	*Chalinolobus morio*		R19.10.2	3	0	S	No signs of injury
Australian Magpie	*Cracticus tibicen*		R19.10.3	12	80	S	Wing only
White-striped Freetail Bat	*Austronomis australis*		R19.10.4	27	41	NW	Blood around head
White-striped Freetail Bat	*Austronomis australis*		R19.10.5	27	36	NW	Wing bone exposed
Laughing Kookaburra	*Dacelo novaeguineae*		R19.10.6	6	41	NW	No signs of injury
White-striped Freetail Bat	*Austronomis australis*		R19.10.7	27	30	W	No signs of injury
Nankeen Kestrel	*Falco cenchroides*		FS19.11.2	27	114	N	Feather spot.
Wedge-tailed Eagle	*Aquila audax*		R19.11.1	4	86	NW	Intact carcass. Juvenile.
Australian Magpie	*Cracticus tibicen*		FS19.11.3	27	55	NW	Feather spot.
Nankeen Kestrel	*Falco cenchroides*		FS19.12.1	18	62	N	Feather spot.
Little Forest Bat	*Vespadelus vulturnus*		R20.1.1	3	17	W	Old and decayed.
Brown Falcon	*Falco berigora*		FS20.1.2	18	27	N	Feather spot.
Black-faced Cuckoo Shrike	*Coracina novaehollandiae*		FS20.2.4	7	90	W	Feather-spot
Black Falcon	*Falco subniger*	Vulnerable (NSW)	R20.2.1	nearest to T22	900	E	Old carcass, with only the wings and upper body remaining. Location of the carcass suggests it was scavenged and carried by a fox.
Little Eagle	*Hieraaetus morphnoides*	Vulnerable (NSW)	R20.2.2	21	80	S	Reasonably fresh. Upper body appears to have suffered trauma. Adult bird.
Gould's Wattled Bat	*Chalinolobus gouldii*		INC20.2.3	24	32	SE	Fresh and intact. Killed within the previous 24 hours.

Common name	Scientific name	Threatened Status	Report (R)/ Feather spot (FS)/ Incidental (INC)	Turbine number	Distance from turbine (m)	Bearing from turbine (°)	Notes
Chocolate Wattled Bat	*Chalinolobus morio*		R20.3.1	12	30	W	Intact. One maggot and small ants on specimen initially. A few days old. FA 33.4mm, ear 9mm.
Australian Magpie	*Cracticus tibicen*		R20.3.2	21	55	E	Intact. Female or immature bird.
Gould's Wattled Bat	*Chalinolobus gouldii*		R20.3.3	15	36	W	Blood emanating from abdomen (torso). Perhaps 1-3 days old.
White-striped Freetail Bat	*Austronomis australis*		R20.3.4	12	6	E	Fresh and intact. Killed within the previous 24 hours.
Australian Magpie	*Cracticus tibicen*		R.20.4.1	6	72	20 NE	Split in two. Recent
Raven sp.	*Corvid sp.*		FS.20.4.1	12	88	260 SW	Outer wing
Grey Fantail	*Rhipidura albiscapa*		R.20.4.2	8	63	90 E	Intact. Broken tibia
Brown Falcon	*Falco berigora*		FS.20.4.2	18	36	10 NE	Outer wing
Peregrine Falcon	*Falco peregrinus*		R.20.5.2	18	15	190 SE	Juvenile. Abdomen partially scavenged
White-striped Free-tailed Bat	*Tadarida australis*		R.20.4.1	27	30	280 NW	Intact. Broken wrist bone
White-striped Free-tailed Bat	*Tadarida australis*		R.20.4.2	7	47	100 SE	Intact. Abdomen open.
Australian Wood Duck	*Chenonetta jubata*		FS.20.5.1	26	52	350 NW	Several body feathers
Forest bat sp.	*Vespadelus sp.*		R.20.5.1	27	32	80 NE	Intact. Broken wrist bone
Australian Magpie	*Cracticus tibicen*		FS.20.7.1	10	50	350 NW	Scavenged, only chest feathers left.
Wedge-tailed Eagle	*Aquila audax*		R20.9.1	T23	60	SE	Decomposing
Unidentified bird	*N/A*		FS20.8.1	24	108	300 W	Clump of brown, downy feathers
Unidentified bird	*N/A*		FS20.8.2	2	50	80 E	Body and flight grey feathers
Black Falcon	*Falco subniger*	Vulnerable (NSW)	R20.8.1	10	48	120 E	Broken wing and neck, bare patch on chest
Unidentified bird	*N/A*		FS20.8.3	21	21	280 SE	Downy feathers and some tissue attached. Scavenged.
Sulphur-crested Cockatoo	*Cacatua galerita*		R20.10.1	T26	33	45 NE	Blood at beak
Sulphur-crested Cockatoo	*Cacatua galerita*		R20.10.2	T18	108	145 SE	One wing

Common name	Scientific name	Threatened Status	Report (R)/ Feather spot (FS)/ Incidental (INC)	Turbine number	Distance from turbine (m)	Bearing from turbine (°)	Notes
White-striped Free-tailed Bat.	*Tadarida australis*		R20.11.1	T28	62	180 S	Wound on back
White-striped Free-tailed Bat.	*Tadarida australis*		R20.11.2	T17	50	95 SE	Intact
White-striped Free-tailed Bat.	*Tadarida australis*		R20.11.3	T24	3	135 SE	Intact
Galah	*Eolophus roseicapilla*		FS20.12.1	T27	84	135 SE	Feather spot
Galah	*Eolophus roseicapilla*		FS20.12.2	T27	86	148 SE	Feather spot. Could be the same bird.
Australian Magpie	*Cracticus tibicen*		R20.12.1	T10	14	325 NW	Intact
White-striped Free-tailed Bat.	*Tadarida australis*		R20.12.2	T10	30	120 SE	Intact

Appendix 2: Crookwell 2 Wind Farm mortality estimate

symbolix

Crookwell 2 Wind Farm Mortality Estimate - Years 1 and 2

Prepared for Nature Advisory, 7 May 2021, Ver. 1.0

This report outlines an analysis of the mortality data collected at the Crookwell 2 Wind Farm from 2019-01-16 to 2020-12-17. The analysis is broken into the three related components below:

- Searcher efficiency / detectability – estimated from trials in July 2019, February 2020, and December 2020
- Scavenger loss rates – consisting of trials in August 2019, September 2019, October 2019, May 2020, June 2020, December 2020, and March 2021
- Mortality estimates - based on monthly surveys at 28 turbines, from 2019-01-16 to 2020-12-17

The data was collected and provided by Nature Advisory 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 Nature Advisory[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 the range of searcher and scavenger efficiencies, and the survey frequency and coverage, and

[1] Crookwell WF_Symbolix mortality data 210506.xlsx

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

Three searcher efficiency trials were held (July 2019, February 2020, and December 2020). The detectability trials used bird (44 replicates), bat (31 replicates), and bat proxy (4 replicates) carcasses. A range of bird sizes were used, ranging from small (Common Starling), to medium (Australian magpie), to large (Wedge-tailed Eagle).

We found no evidence that searcher efficiency differed between birds and bats/bat proxies via AICc selection. Similarly, we found no evidence that searcher efficiency differed between the three surveys.

There was some evidence (ΔAICc $= -1.7$) which supported differentiating between specific observers. However, the net result of NOT including observer is that the observer with the poorest detection efficiency is up-weighted in the mortality estimate, giving a higher estimated mortality. This is a more conservative estimate of turbine-related fatality. Therefore, bird and bat detection efficiencies are aggregated in the following mortality estimate, and specific observer is not included in the modelling.

Table 1 summarises the result.

Detectability is 67%, with a 95% confidence interval of [56%, 77%].

Table 1: Detection efficiencies for birds and bats.

Variable	Value
Number found	53
Number placed	79
Mean detectability proportion	0.67
Detectability lower bound (95% confidence interval)	0.56
Detectability upper bound (95% confidence interval)	0.77

Scavenger efficiency

Scavenger efficiency trials were conducted during August 2019, September 2019, October 2019, May 2020, June 2020, December 2020, and March 2021. Trials ran over 30 days, and used

both bats (24 replicates), and birds of various sizes (26 replicates).

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. By performing survival analysis we can estimate the average survival percentage after a given length of time, despite these unknowns.

AICc selection suggested that the most parsimonious model was one that differentiated between birds and bats. We thus have treated them separately in the mortality estimate.

Figure 1 shows survival curves fitted to bats and birds. The survival curves (solid lines) show the estimated proportion of the sets remaining at any given time. The shaded portions are the 95% confidence intervals on the estimates. For example, we see that for bats we expect around 7% to 41% of carcasses to remain after ten days with the expectation being around 17%. For birds, we expect around 30% to 70% of carcasses to remain after ten days with the expectation being around 46%.

Under these assumptions, the median time to total loss via scavenge for bats is 1.5 days, with a 95% confidence window of [0.5, 4.3] days. For birds, the median time to total loss via scavenge is 8.9 days, with a 95% confidence window of [3.2, 24.8] days.

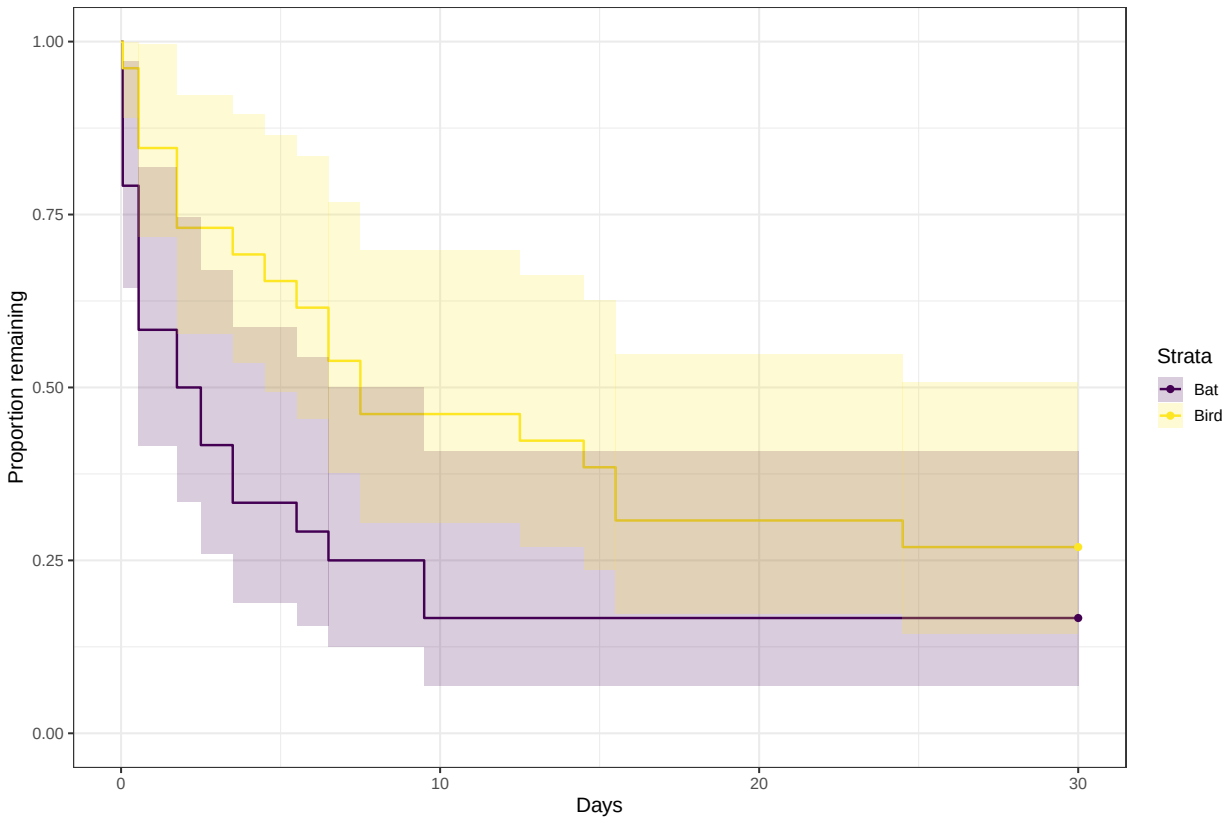

Figure 1: Survival curves for birds and bats, with 95% confidence interval shaded.

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 2. For standard surveys the search radius was 100 metres and for pulse surveys the search radius was 60 metres.

Table 2: Number of surveys per month.

Date	Pulse	Standard
2019 Jan	16	16
2019 Feb	17	16
2019 Mar	15	16
2019 Apr	16	16
2019 May	16	16
2019 Jun	16	16
2019 Jul	16	16
2019 Aug	8	11
2019 Sep	8	8
2019 Oct	32	29
2019 Nov	16	16
2019 Dec	16	16
2020 Jan	14	16
2020 Feb	14	16
2020 Mar	4	16
2020 Apr	32	16
2020 May	16	16
2020 Jun	12	16
2020 Jul	20	16
2020 Aug	16	28
2020 Sep	16	28
2020 Oct	0	28
2020 Nov	32	28
2020 Dec	16	28

Mortality estimate - years one and two combined

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 at Crookwell 2 Wind Farm from 2018-12-16 to 2020-12-17 (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 28 turbines on site.
- Search frequency for each turbine was taken from a list of actual survey dates (see Table 2 for a summary).
- Mortalities were allowed to occur up to a month before the initial survey (2019-01-16) and until the final surveyed date (2020-12-17).
- 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 log-normal scavenge shape ("olfactory" scavengers).
- We took scavenge loss and search efficiency rates as outlined above.
- All 28 turbines were surveyed and were searched out to a 100 metre radius for standard surveys and 60 metres for pulse surveys. We estimated the "coverage factor" for the survey – i.e. the total fall zone surveyed for birds and bats (using estimates from Hull and Muir (2010)). We assumed that the coverage factor was 73% for birds and 94% for bats.

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 3.

Table 3: Carcasses found during formal surveys over two years.

Species	Bat	Bird	Feather spot
White-striped Freetail Bat	17	0	0
Gould's Wattled Bat	6	0	0
Chocolate Wattled Bat	3	0	0
Little Forest Bat	1	0	0
Unknown Bat Skeleton	1	0	0
Australian Magpie	0	7	1
Brown Falcon	0	4	0
Grey Fantail	0	4	0
Wedge-tailed Eagle	0	4	0
Raven	0	3	1
Black Falcon	0	2	0
Sulphur Crested Cuckatoo	0	2	0
Australian Wood Duck	0	1	1
Nankeen Kestrel	0	1	1
Common Starling	0	1	0
Eurasian Skylark	0	1	0
Fairy Martin	0	1	0
Galah wing	0	1	0
Laughing Kookaburra	0	1	0
Little Eagle	0	1	0
Peregine Falcon	0	1	0
Unknown Bird	0	0	5
Galah	0	0	3
Black-faced Cuckoo Shrike	0	0	1

We also note a number of carcasses were found opportunistically. We don't include these in our formal estimate of mortality, but we do report them in Table 4 for completeness.

Table 4: Informal carcass finds.

Species	Count
Nankeen Kestrel	1
White-striped Freetail Bat	1
Wedge-tailed Eagle	1
Black Falcon	1
Gould's Wattled Bat	1

Bat mortality estimate – results

During the two years of surveys a total of 28 bats were found during formal surveys (Table 3). The resulting estimate of total mortality, accounting for searcher efficiency, scavenge rate, search area and timing of surveys is an expectation (mean) of 246 and a median of 220 bats lost on site over the two years.

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 246 bats over the survey period, and are 95% confident that fewer than 477 individuals were lost.

Table 5: Percentiles of estimated total bat losses over the two years of survey period.

0%	50% (median)	90%	95%	99%	99.9%
103	220	398	477	604	644

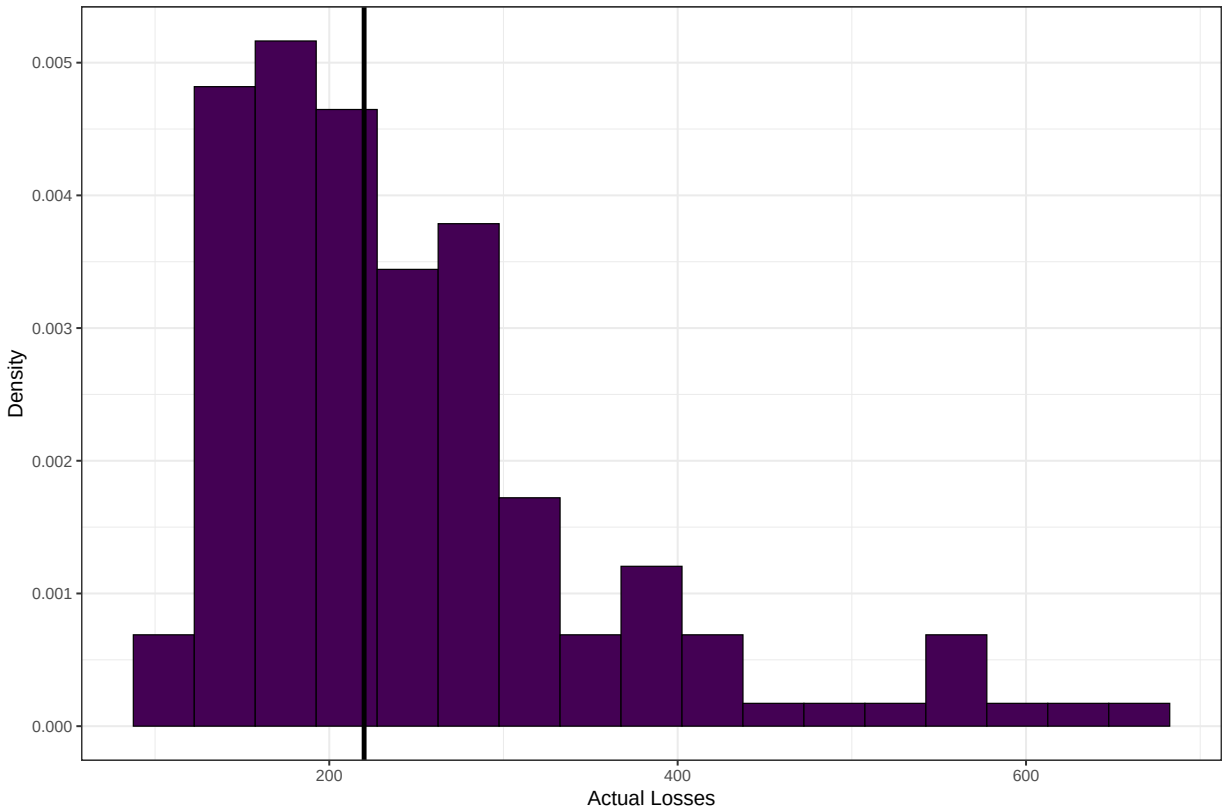

Figure 2: Histogram of the total losses distribution (bats), given 28 were detected on-site. The black solid line shows the median.

Bird mortality estimate - results

During the two years of surveys a total of 48 birds were found during formal surveys (Table 3). The resulting estimate of total mortality, accounting for searcher efficiency, scavenge rate, search area and timing of surveys is an expectation (mean) of 187 and a median of 178 birds lost on site over the twenty-four months.

Table 6 and Figure 3 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 187 birds over the survey period, and are 95% confident that fewer than 285 individuals were lost.

Table 6: Percentiles of estimated total bird losses over the two years of survey period.

0%	50% (median)	90%	95%	99%	99.9%
106	178	244	285	347	381

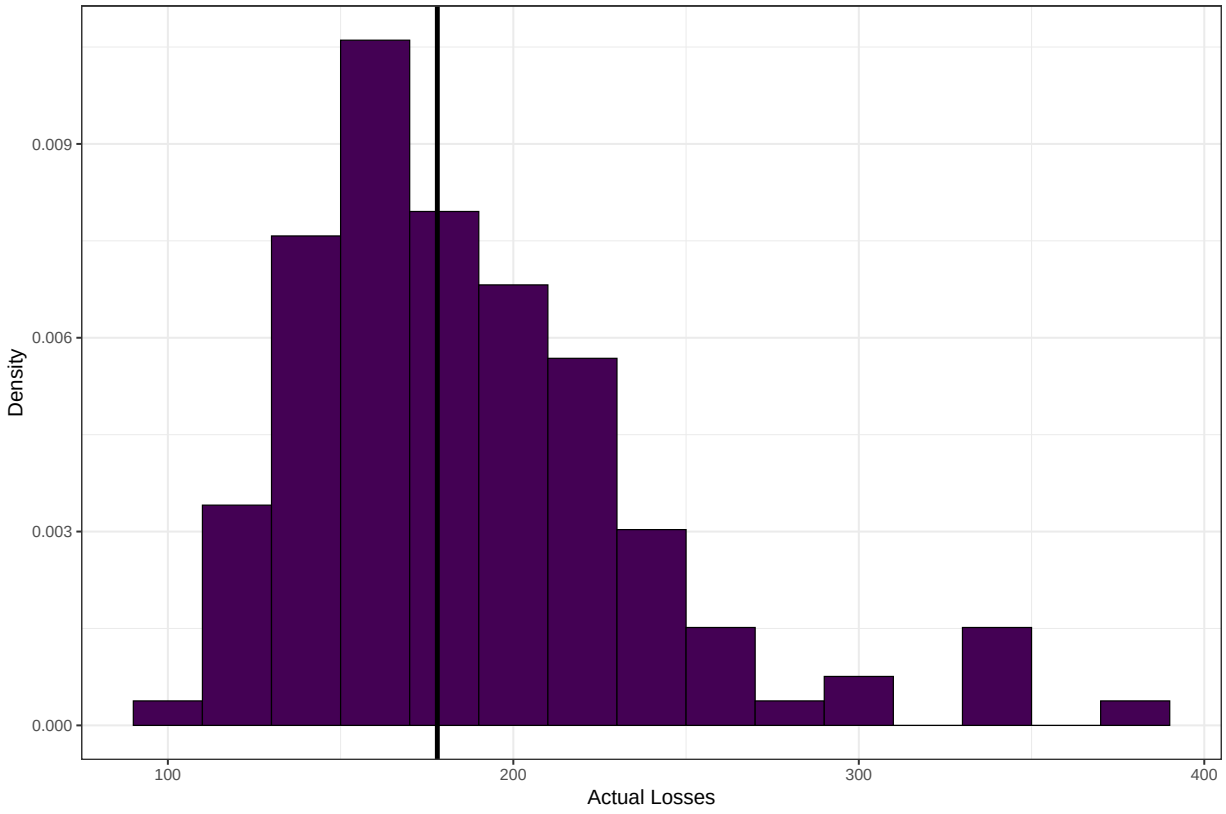

Figure 3: Histogram of the total losses distribution (birds), given 48 were detected on-site. The black solid line shows the median.

Comparison of year one and year two results

Bat results

During the first year of surveys (2018-12-16 to 2020-01-15) a total of 18 bats were found during formal surveys. The resulting estimate of total mortality is an expectation (mean) of around 179 bats over the survey period, and we are 95% confident that fewer than 320 individuals were lost.

In comparison, in the second year of surveys (2020-01-16 to 2020-12-17) a total of 10 bats were found during formal surveys. The resulting estimate of total mortality an expectation of 78 bats over the survey period, and we are 95% confident that fewer than 142 individuals were lost.

Statistical testing (using the Kolmogorov-Smirnov test) was used to determine if there was a significant difference between the modelled distribution of mortalities in year one and year two.

When considering all bat mortalities, we find the distribution of the first year to be shifted right compared to the distribution of year two mortalities (the test statistic $D = 0.69$ is greater than

the critical value D* = 0.35 at the 0.05 significance level).

Assuming all model assumptions hold, this would imply that the true total number of bat losses in year one was significantly higher than the number of losses in year two.

Bird results

During the first year of surveys a total of 28 birds were found during formal surveys. The resulting estimate of total mortality is an expectation of around 131 birds over the survey period, and we are 95% confident that fewer than 185 individuals were lost.

In comparison, in the second year of surveys a total of 20 birds were found during formal surveys. The resulting estimate of total mortality an expectation of 74 birds over the survey period, and we are 95% confident that fewer than 114 individuals were lost.

Using the Kolmogorov-Smirnov test, we find the distribution of bird mortalities of the first year to be shifted right, compared to the distribution of year two mortalities (the test statistic $D = 0.77$ is greater than the critical value $D^* = 0.35$ at the 0.05 significance level).

Assuming all model assumptions hold, this would imply that the true total number of bird losses in year one was significantly higher than the number of losses in year two.

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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Appendix 3: Searcher efficiency trial results (2019-2020)

Turbine	Carcass	Size class	Detected
July 2019 - Winter (short grass)			
27	Brown Falcon	Large	✓
	White-striped Freetail Bat	Bat	✓
	Grey Fantail	Small	X
26	Brown Falcon	Large	X
	White-striped Freetail Bat	Bat	X
	Common Myna	Medium	✓
25	Eastern Barn Owl	Large	✓
	White-striped Freetail Bat	Bat	X
	Grey Fantail	Small	✓
6	Common Myna	Medium	✓
	White-striped Freetail Bat	Bat	✓
	Fairy Martin	Small	✓
15	White-striped Freetail Bat	Bat	✓
	White-striped Freetail Bat	Bat	X
	Nankeen Kestrel	Medium	✓
24	Common Myna	Medium	✓
	Common Myna	Medium	X
	White-striped Freetail Bat	Bat	✓
12	Common Myna	Medium	✓
	White-striped Freetail Bat	Bat	✓
February 2020 (short grass)			
6	White-striped Freetail Bat	Bat	✓
	Wedge-tailed Eagle	Large	✓
	Common Starling	Medium	✓
7	Fairy Martin	Small	✓
	Common Myna	Medium	✓
	Common Starling	Medium	x
8	Gould's Wattled Bat	Bat	x
	Common Myna	Medium	✓
	Wedge-tailed Eagle	Large	✓
10	Gould's Wattled Bat	Bat	✓
	Common Myna	Medium	✓
	Black Falcon	Large	✓
12	Gould's Wattled Bat	Bat	✓
	Common Myna	Medium	✓
	Brown Falcon	Large	✓
27	White-striped Freetail Bat	Bat	x
	Common Myna	Medium	✓
	Common Myna	Medium	✓
26	Large Forest Bat	Bat	x
	Wedge-tailed Eagle	Large	✓
December 2020 (long grass)			
6	Black Falcon	Large	✓

Turbine	Carcass	Size class	Detected
	Nankeen Kestrel	Medium	✓
	Starling	Small	✓
7	Australian Magpie	Medium	X
	White-striped Freetail Bat	Bat	X
	Black Falcon	Large	X
8	White-striped Freetail Bat	Bat	✓
	Sulphur-Crested Cockatoo	Large	X
	Grey Fantail	Small	✓
10	Black Falcon	Large	✓
	White-striped Freetail Bat	Bat	✓
	Microbat	Bat	✓
12	Black Falcon	Large	✓
	Microbat	Bat	X
	Microbat	Bat	X
27	Sulphur-Crested Cockatoo	Large	X
	Common Myna	Medium	X
	Microbat	Bat	X
26	Common Myna	Medium	X
	White-striped Freetail Bat	Bat	X
	December 2020 (long grass)		
6	Sulphur-crested Cockatoo	Large	X
	White-striped Freetail Bat	Bat	✓
	Microbat	Bat	✓
7	Black Falcon	Large	✓
	Microbat	Bat	✓
	Eastern Rosella	Medium	X
8	Magpie	Medium	X
	White-striped Freetail Bat	Bat	X
	Sulphur-crested Cockatoo	Large	✓
10	Black Falcon	Large	✓
	Microbat	Bat	✓
	Microbat	Bat	✓
12	White-striped Freetail Bat	Bat	✓
	Chocolate Wattled Bat	Bat	X
	Black Falcon	Large	X
27	Magpie	Medium	X
	Black Falcon	Large	✓
	Microbat	Bat	✓
26	Sulphur-crested Cockatoo	Large	✓
	Microbat	Bat	X

Appendix 4: Scavenger trial data obtained during monitoring at C2WF

Species	Carcass size	Placement Date	Scavenged date	Scavenged time	Days in the field	Turbine	Scavenger*
Brown Falcon	Large	14/08/2019	27/08/2019	2:55:00 AM	13	27	Red Fox
Nankeen Kestrel	Medium	14/08/2019	21/08/2019	3:16:00 AM	7	6	Red Fox
White-striped Freetail Bat	Bat	14/08/2019	17/08/2019	5:25:00 PM	3	8	Australian Raven
White-striped Freetail Bat	Bat	14/08/2019	14/08/2019	11:38:00 AM	0	24	Australian Raven
Australian Magpie	Large	5/09/2019	13/09/2019	9:13:00 AM	8	27	Australian Raven
Gould's Wattled Bat	Bat	5/09/2019	5/09/2019	2:34:00 AM	1	24	Australian Raven
Grey Fantail	Small	5/09/2019	30/09/2019	12:31:00 PM	25	13	Red Fox
White-striped Freetail Bat	Bat	5/09/2019	9/09/2019	9:09:00 AM	4	25	Australian Raven
Gould's Wattled Bat	Bat	5/09/2019	15/09/2019	3:48:00 AM	10	18	unknown
Brown Falcon	Large	5/09/2019	21/09/2019	8:37:00 PM	16	25	Red Fox
Common Myna	Medium	6/09/2019	12/09/2019	5:40:00 AM	6	6	Red Fox
Common Myna	Medium	7/09/2019	11/09/2019	3:41:00 PM	4	8	Australian Raven
Common Myna	Medium	30/09/2019	16/10/2019	7:18:00 PM	16	8	Red Fox
Common Starling	Medium	1/10/2019	1/10/2019	9:01:00 PM	1	21	Red Fox
Common Starling	Medium	1/10/2019	2/10/2019	11:54:00 PM	2	13	Red Fox
Common Starling	Medium	1/10/2019	2/10/2019	9:09:00 PM	2	25	Red Fox
White-striped Freetail Bat	Bat	1/10/2019	7/10/2019	4:13:00 AM	6	25	Unknown
Common Starling	Medium	2/10/2019	9/10/2019	4:13:00 AM	7	6	Red Fox
Common Starling	Medium	2/10/2019	17/10/2019	2:22:00 AM	15	27	Red Fox
White-striped Freetail Bat	Bat	22/10/2019	25/10/2019	12:58:00 AM	3	8	Red Fox
White-striped Freetail Bat	Bat	22/10/2019	23/10/2019	N/A	1	6	N/A
White-striped Freetail Bat	Bat	23/10/2019	25/10/2019	12:31:00 AM	2	27	Red Fox
Laughing Kookaburra	Large	24/10/2019	25/10/2019	N/A	1	6	N/A
White-striped Freetail Bat	Bat	24/10/2019	24/10/2019	9:49:00 PM	0	25	Red Fox
Peregrine Falcon	Large	26/05/2020	n/a	n/a	30	21	Red Fox
White-striped Free-tailed Bat	Bat	28/05/2020	28/05/2020	7:54:00 AM	0	8	Little Raven
White-striped Free-tailed Bat	Bat	29/05/2020	31/05/2020	7:54:00 AM	2	8	Little Raven

Species	Carcass size	Placement Date	Scavenged date	Scavenged time	Days in the field	Turbine	Scavenger*
Peregrine Falcon	Large	22/06/2020	n/a	n/a	30	21	Red Fox
White-striped Free-tailed Bat	Bat	24/06/2020	3/07/2020	11:50:00 AM	8	6	Australian Magpie
Australian Magpie	Large	25/06/2020	27/06/2020	12:42:00 AM	2	13	Red Fox
Common Myna	Medium	25/06/2020	13/07/2020	12:00:00 PM	19	26	Australian Raven
Brown Falcon	Large	14/12/2020	N/A	N/A	30	21	N/A
Nankeen Kestrel	Medium	14/12/2020	15/12/2020	6:15:00 AM	2	8	Red Fox
Black Falcon	Large	14/12/2020	N/A	N/A	30	8	N/A
Bat sp.	Bat	15/12/2020	18/12/2020	12:44:00 AM	4	21	Unkown
White-striped Freetail Bat	Bat	15/12/2020	15/12/2020	12:52:00 PM	1	6	Unknown
Welcome Swallow	small	15/12/2020	22/12/2020	12:11:00 PM	8	13	Unknown
Bat sp.	Bat	15/12/2020	N/A	N/A	30	26	N/A
Bat sp.	Bat	15/12/2020	N/A	N/A	30	6	N/A
Nankeen Kestrel	Medium	15/12/2020	N/A	N/A	30	7	N/A
Black Falcon	Large	29/03/2021	n/a	N/A	11	7	N/A
Nankeen Kestrel	Medium	29/03/2021	3/04/2021	8:48:00 PM	5	8	Red Fox
Little Red Flying Fox	Medium	29/03/2021	29/03/2021	5:21:00 AM	0	12	Red Fox
Little Red Flying Fox	Medium	29/03/2021	8/03/2021	10:00:00 AM	10	13	Red Fox
Southern Freetail Bat	Bat	29/03/2021	n/a	N/A		21	N/A
Gould's Wattled Bat	Bat	29/03/2021	30/03/2021	8:37:00 AM	1	18	Australian Raven
Gould's Wattled Bat	Bat	29/03/2021	6/04/2021	9:01:00 AM	7	16	Australian Raven
Gould's Wattled Bat	Bat	29/03/2021	31/03/2021	9:57:00 AM	2	20	Australian Raven
Magpie	Medium	29/03/2021	n/a	N/A	30	9	N/A
Bat sp.	Bat	29/03/2021	N/A	N/A	30	9	N/A

*where scavenger is listed as 'unknown' this indicates that the scavenging event was missed (i.e., no photo of the scavenger taking the carcass was obtained). In this case the next photo that the carcass is no longer present is assumed to the be the general day it was taken.

Appendix 5: Incidental raptor observations at C2WF during monitoring period

Map Ref	Species	Date	Start time	Finish time	No of birds	Flight height	Flight direction	Flight behaviour	Notes
1	Little Eagle	15/03/2019	13:49	13:50	1	80		Flapping	One adult, mobbed by several magpies. Nearly hit by blades as a result. As close as 10 metres from strike area.
2	Wedge-tailed Eagle	11/06/2019	15:06	15:08	2	100	North-east	Gliding, soaring	
3	Wedge-tailed Eagle	13/06/2019	10:35	10:36	1	100	East	Soaring	
4	Wedge-tailed Eagle	13/06/2019	10:35	10:37	1	150	North	Gliding	
5	Black Falcon	13/06/2019	15:05	15:06	1	30		Flapping	One individual seen flying to the north of turbine 12 and heading south-west. Individual seen again along Crookwell Road when leaving site.
6	Wedge-tailed Eagle	16/07/2019							
7	Wedge-tailed Eagle	17/07/2019							
8	Black Falcon	17/07/2019	9:39	9:41	2	90		Flapping	Pair seen flying northward at RSA height, in close proximity turbines 23 and 21.
9	Black Falcon	18/07/2019	16:17	16:17	1	70	West	Flapping	One individual sighted being harassed magpies and flying west over Crookwell Road.
10	Wedge-tailed Eagle								
11	Wedge-tailed Eagle								
12	Wedge-tailed Eagle	13/08/2019	11:14	11:15	1	200	North	Gliding	Flew north approximately 1km.
13	Nankeen Kestrel	13/08/2019	12:35	12:38	1	15	West	Hovering	Flew west approximately 185m.
14	Wedge-tailed Eagle	13/08/2019	12:45	12:47	1	400	West	Gliding, soaring	
15	Black Falcon	13/08/2019	14:28	14:28	1	5		Foraging	Hunting.
16	Wedge-tailed Eagle	14/08/2019	15:05	15:07	1	90	South-east	Gliding	Flying between T25 and T28.
17	Wedge-tailed Eagle	15/08/2019	11:27	11:30	2	70		Courtship display, gliding	West of T2, flying above RSA height, 400-500m high.
18	Wedge-tailed Eagle	15/08/2019	11:33	11:35	1	250		Soaring	
24	Black Falcon	6/09/2019	12:30		1	20	East	Flapping	1 Black Falcon moving east along WF track harassed by starlings.

Map Ref	Species	Date	Start time	Finish time	No of birds	Flight height	Flight direction	Flight behaviour	Notes
43	Black Falcon	2/10/2019			1			Hovering	Hovering against wind and diving for birds on the ground, 50m west of turbine 28.
66	Nankeen Kestrel	13/11/2019	11:20	11:20	1	15	West	Hovering, flapping	1 x Nankeen Kestrel observed at 15m above ground, flying over riparian planting area, west of T23. Hovered over-head and flew west.
67	Wedge-tailed Eagle	13/11/2019	11:45	11:47	3	150	West	Soaring	3 x Wedge-tailed Eagle observed soaring at 100-150m above ground, west of T25. Flying above gully.
70	Nankeen Kestrel	14/11/2019	8:27	8:27	1	100	North-west	Flapping	1 x Brown Falcon observed at 100m above ground, flying north west of T1.
71	Wedge-tailed Eagle	14/11/2019	8:28	8:33	2	180		Soaring	2 x Wedge-tailed Eagle observed at 180m above ground, soaring 200 west of T1-T4 (soaring along gully).
72	Nankeen Kestrel	14/11/2019	9:40	9:40	1	20		Foraging	1 x Nankeen Kestrel observed south of main wind farm access road on Crookwell Road.
73	Brown Falcon	14/11/2019	11:19	11:19	1	120		Flapping	1 x Brown Falcon observed at 120m high being swooped by approx. 15 Australia Magpies, 500m west of T24.
74	Brown Falcon	23/02/2020	13:29	13:32	1	20	N	Flapping	Flying over R1
75	Nankeen Kestrel	23/02/2020	15:49	15:52	1	25	S	Hovering	Over R1
76	Whistling Kite	23/02/2020	16:06	16:09	1	300	S	Gliding	Over R2
77	Wedge-tailed Eagle	24/02/2020	9:55	10:00	3	100	West	Soaring	Over T24. Pair being harassed by juvenile, very vocal, low flights between turbines but eventually catching a thermal and getting over RSA.
78	Kestrel	24/02/2020	12:45	12:50	1	20	East	Flapping	
79	Black Falcon	24/02/2020	14:00	14:02	1	50	East	Flapping	Detected seconds after noisy miners and magpies in the area alarmed collectively. Flying over R2
80	White-bellied Sea Eagle	24/02/2020	14:52	14:56	1	200	North-east	Soaring	Flying over Dam across the road from T12 and flying over T12 and continuing E
81	Peregrine Falcon	25/02/2020	7:25	7:27	1	50	East	Flapping	Flying between the towers at the site office power station and then heading East.
82	Wedge-tailed Eagle	25/02/2020	16:23	16:24	1	40	East	Soaring	Over R1
83	Black Falcon	26/02/2020	12:00	12:06	1	20	North-west	Flapping	Seen from site office gate. Most BF observations have taken place in this area.
84	Brown Falcon	26/02/2020	14:20	14:22	1	100	South	Soaring	Over R1

Map Ref	Species	Date	Start time	Finish time	No of birds	Flight height	Flight direction	Flight behaviour	Notes
87	Nankeen Kestrel	26/02/2020	16:45	16:56	1	20		Hovering	
88	Brown Falcon	27/02/2020	10:30	10:32	1	20	N	Flapping	Over R1
89	Black Falcon	27/02/2020	15:30	15:33	1	100	North-east	Soaring	Over track between R1 and B5
90	Wedge-tailed Eagle	27/02/2020	15:30	15:33	2	100		Soaring	Over farm north of R1, off site
91	Brown Falcon	27/02/2020	15:37	15:38	1	100	East	Flapping	
92	Black Falcon	27/02/2020	16:40	16:44	2	10	East	Displaying	Two individuals chasing each other and doing acrobatics over the hill behind the site office, photos taken. A third large dark falcon chases them away but could not ID that third individual.
93	Black Falcon	27/02/2020	17:00	17:02	1	20	S	Foraging	One individual trying to hunt starlings in front of the site office
94	Wedge-tailed Eagle	27/02/2020	17:30	17:36	2	20	East	Soaring	Two individuals try to roost in a dead tree 20m NE of T3 but they keep flying due to my presence
95	Brown Falcon	24/02/2020	1:35	1:36	2	50	N	Circling	Two individuals circling near turbine 2 above pasture and woodland habitat.
96	Brown Falcon	25/02/2020	2:42	2:43	1	1	N	Direct flight	One individual seen on the ground beneath Turbine 4, where it then flew in the direction of turbine 2.
97	Wedge-tailed Eagle	26/02/2020	9:50	9;52	2	150	N	Soaring	Two individuals seen soaring above the valley near turbine 13
98	Nankeen Kestrel	27/02/2020	9:40	9:40	1	5	NE	Direct flight	One individual flushed from the roadside.
99	Black Falcon	28/02/2020	6:11	6:12	1	20	S	Direct flight	Flew past the site office and landed on a log on top of the hill near Turbine 27.
100	Black Falcon	27/02/2020	5:32	5:42	1	35	W	Direct flight	One individual seen flying along gully, evading a magpie, and then perching on top of a dead tree.
101	Black Falcon	22/04/2020	10:20	15:28	1	30	NW	Direct flight	One individual flying SW of T18
102	Brown Falcon	22/04/2020	13:20	13:22	1	0	W	Perched	One individual perched on a fence between T14 and T15
103	Peregrine Falcon	21/04/2020	14:00	14:20	1	50	NW	Foraging	One individual chasing starlings by T21, flying very close to turbines. May be same individual found dead in May in T18.

Map Ref	Species	Date	Start time	Finish time	No of birds	Flight height	Flight direction	Flight behaviour	Notes
104	Brown Falcon	23/04/2020	9:00	9:03	1	30	NE	Direct flight	Flying past T25
105	Wedge-tailed Eagle	28/05/2020	10:00	10:05	1	150	S	Soaring	One individual soaring and circling W of T4
106	Peregrine Falcon	26/05/2020	15:25	15:28	1	50	SE	Direct flight	One individual flying between T25 and T26
107	Black Falcon	20/07/2020			1			Foraging	foraging between T21, T25, T26 and T28.
108	Brown Falcon	25/08/2020			2		W	Perched	Along the road to the substation from the Woodhouselee Rd entrance, beyond the third gate. Pair flying westwards across open pasture. Flapping flight, landed and perched on electrical tower.
109	Wedge-tailed Eagle	30/08/2020			1			Soaring	Soaring near T27. Small, soaring individual mobbed by birds. Landed in open pasture to avoid mobbing, then flew away.
110	Wedge-tailed Eagle	22/09/2020			1			Direct	Gliding near T18. Definitely a WTE, but on the small end of the size range. Glided past T18, within about 150-200m of it.
111	Nankeen Kestrel	26/09/2020			1			Hovering	Hovering near the first gate from T19 between T19 and T15.Hovering, looking for prey. Used high winds of the day to hover.
112	Black Kite	27/09/2020			1			Direct	Glided across wind farm from horse paddock to near substation. Was mobbed by magpies through T26
113	Black Falcon	27/09/2020			1			Soaring	Soaring and being mobbed by magpies near the substation, was within 150m of the entrance road at the substation
114	Nankeen Kestrel	30/10/20			1			Hovering	Hovering and diving over a valley to capture prey 200-400m NE of T18

Map Ref	Species	Date	Start time	Finish time	No of birds	Flight height	Flight direction	Flight behaviour	Notes
115	Australian Hobby	12/12/2020			1			Direct	Flying across paddocks and perching on fence posts between T5/6 and T1-4.
116	Brown Falcon	12/11/2020			1			Direct	Flying above copse of trees along entrance road to wind farm from Woodhouselee Rd.