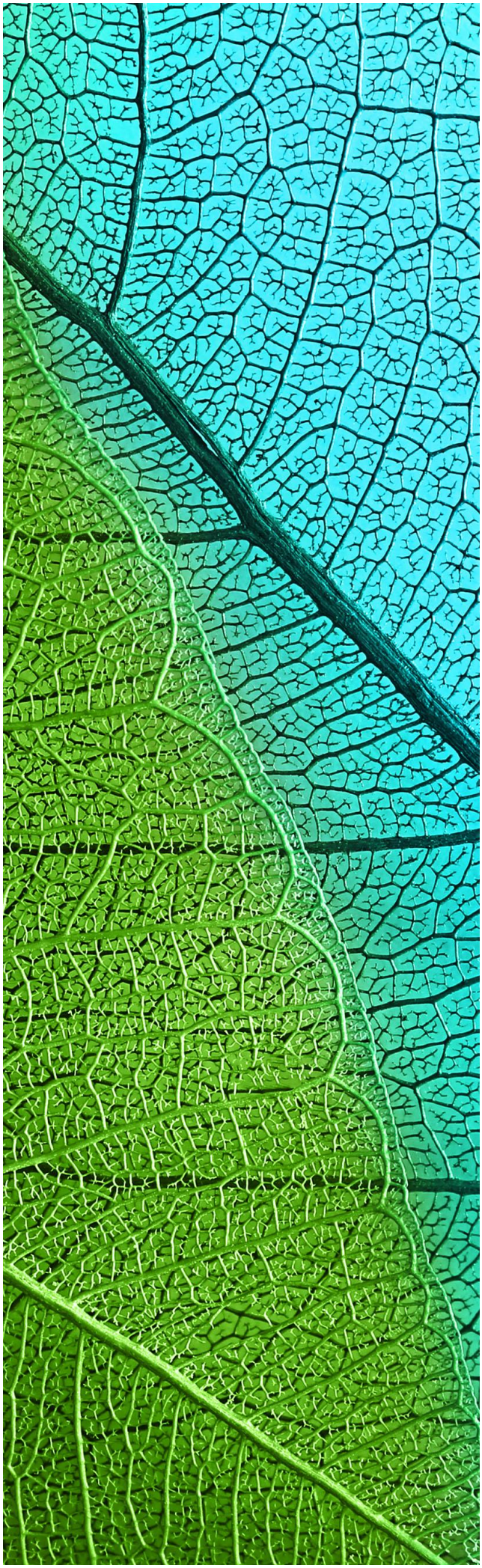

Sapphire Wind Farm

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

Prepared for SWF1 Operations Pty Ltd

June 2021
Report No. 16045 (26.1)

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1. Executive Summary

Sapphire Wind Farm (SWF) is located in the New England region of northern New South Wales. The site is 24 kilometres west of Glen Innes and three kilometres north of the Gwydir Highway (Figure 1). The site has been mostly cleared of its original native vegetation and used for grazing.

The wind farm currently comprises 75 turbines and associated infrastructure. The development consent was modified in 2016 to reduce the number of turbines from 159 to 75.

As per Condition C6 of the NSW approval for Sapphire Wind Farm a Bird and Bat Adaptive Management Plan (BBAMP) was developed and approved in 2017. Brett Lane & Associates Pty Ltd (BL&A), the predecessor to Nature Advisory Pty Ltd (Nature Advisory), was engaged to implement the BBAMP.

The first phase of the monitoring program comprised began in the partial-operational phase in July 2018 and in total comprised 24 months of fully operational surveys, including:

- Monthly monitoring of bird and bat collisions with turbines through carcass searches, including scavenger surveys (to determine carcass removal rates before detection), and observer efficiency trials (to determine how well observers detect carcasses);
- Monitoring 'at risk' groups of birds, including raptors and White-throated Needletail; and
- Assessing the effects of the wind farm on bird activity at the site, based on bird utilisation rates.

Between July 2018 and January 2021 (31 months), 930 turbine searches were undertaken (including 463, 100-metres radius searches and 464 60-meter radius). During these searches; 14 bird carcasses, 10 bat and 13 feather spots were found. A total of 9 birds, two feather spots and one bat were found incidentally. This consisted of 15 bird and five bat species identified.

Based on statistical analysis relation to bat mortality, based on the number of detected carcasses and the detectability and scavenging rate, there was a total site loss (all turbines combined) of around 166 bats over the 31 month search period, with the upper 95% confidence limit of fewer than 252 individuals. On an annual basis of 12 months this corresponds to a total site loss estimated loss of 64 bats with 95% confidence that fewer than 98 individuals were lost. Importantly, this is the lowest annual level of bat mortality at a wind farm monitored by Nature Advisory (unpub data).

Based on statistical analysis relation to bird mortality, based on the number of detected carcasses and the detectability and scavenging rate, there was a total site loss over 31 months of survey corresponded to an estimated loss of 457 birds with 95% confidence that fewer than 658 individuals were lost. On an annual basis of 12 months this corresponds to a total site loss estimated loss of 177 birds with 95% confidence that fewer than 255 individuals were lost.

Individual estimates were undertaken for Wedge-tailed Eagle and the estimate of total mortality over the 31 months was 13 individuals with 95% confidence that fewer than 27 individuals were lost. On an annual basis of 12 months this corresponds to a total site loss estimated loss of 5 WTEs with 95% confidence that fewer than 10 WTEs were lost.

The Australian Magpie was the most abundant of all bird and bat species mortalities found during formal searches, making up 18% of all mortality, followed by Wedge-tailed Eagle, which made up 13% of all mortality. Of the five bat species found 60% of these consisted of White-striped Freetail Bat.

Wedge-tailed Eagle was identified in the BBAMP as an 'at-risk' species. Its comparatively high mortality rate, is reflected in the raptor monitoring results, where Wedge-tailed Eagle was observed the most often from the three raptor species, and the BUS, where it was the only species observed flying at RSA height of all bird species observed. It is estimated that 13 individuals were lost during the monitoring period.

Other 'at-risk' species; White-throated Needletail, Regent Honeyeater or Swift Parrot were not observed during the monitoring program. The main habitat, Ironbark trees, are in very low numbers on the site and even when flowering would provide very limited habitat and foraging opportunities for the species. Therefore, risk from SWF operation is considered to be very low for these species.

No threatened or non-threatened management triggers occurred as a result of the monitoring program. It is unlikely that the results from the monitoring program or the mortality estimates suggest a significant impact on any of the species identified as mortalities. Each is a relatively common and widespread species to farmland landscapes in NSW and other parts of Australia, and each is considered secure and not in decline. It is unlikely that BWF would have a significant impact on any populations regionally, on a state level or overall.

It is recommended that the carrion removal plan be implemented as per the BBAMP Section 5.1., lambing be restricted, in consultation with land holders, within 200 metres of turbines, SWF staff continue to record any incidental carcasses found.

In line with Sapphire Wind Farm Condition C6, ongoing information collation should be included in reports submitted to the Director-General and OEH on an annual basis for the first five years of operation as outlined in Condition C6 of the Project Approval. This report represents the reporting on the first two years of operation.

2. Introduction

Sapphire Wind Farm (SWF) is located in the Kings Plain District, 24 kilometres west of Glen Innes and 28 kilometres east of Inverell in the northern tablelands of New South Wales (NSW) (Figure 1). A total of 75 turbines and associated infrastructure are sited within approximately 8,921ha of land. The land has been predominately cleared for grazing.

SWF proposed a 159-turbine wind farm in the northern Tablelands of NSW in 2007. The NSW Department of Planning and Infrastructure (DPI) and the Commonwealth Department of the Environment (DotE) approved the wind farm in June 2013 and December 2014 respectively. In January 2016, Sapphire Wind Farm Pty Ltd requested a modification to the approval to reduce the number of turbines from 159 to up to 109 turbines and increase the maximum tip height to 200 metres above the ground and rotor diameter to 126 metres. The DPE and the DotE approved the Modification request in June 2016. The project completed construction in late 2018 with a refined design which involved the construction of 75 turbines at locations approved in the Modification.

Condition C6 of the NSW approval required the preparation of a Bird and Bat Adaptive Management Program (BBAMP), these requirements have been outlined in the following section. Element (d) required the proponent to identify 'at risk' bird and bat groups, seasons and/or areas within the project site which may attract high levels of mortality. The BBAMP was prepared by Brett Lane & Associates Pty Ltd, predecessor of Nature Advisory Pty Ltd (BL&A 2017) and approved by the Director-General of DPI.

Sapphire Wind Farm Pty Ltd engaged Nature Advisory to implement the approved Bird and Bat Adaptive Management Program (BBAMP) for the SWF. Specifically, the scope of the work included:

- Operational bird and bat carcass (mortality) monitoring program;
- Monitoring 'at risk' groups of birds; and
- Bird utilisation surveys.

This report comprises the second annual report, covering all monitoring activities up to and including the second year of official operation of SWF. As per Section 4.7 of the BBAMP, the second annual report includes, but is not limited to:

- A brief description of the management prescriptions implemented and identification of any modifications made to the original management practices.
- The survey methods (including list of observers, dates and times of observations);
- Results of carcass searches and incidental carcass observations;
- Estimates of bird and bat mortality rates (avifauna impacted per turbine per year) based on statistical analysis;
- Seasonal and annual variation in the number and composition of bird and bat strikes, where detectable;
- 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 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 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 first year of monitoring at SWF.

This investigation was undertaken by a team from Nature Advisory, comprising Ahmad Barati (Zoologist), Candice Larkin (Zoologist), Jackson Clerke (Zoologist), Bernard O'Callaghan (Senior Ecologist and Project Manager) and Brett Lane.

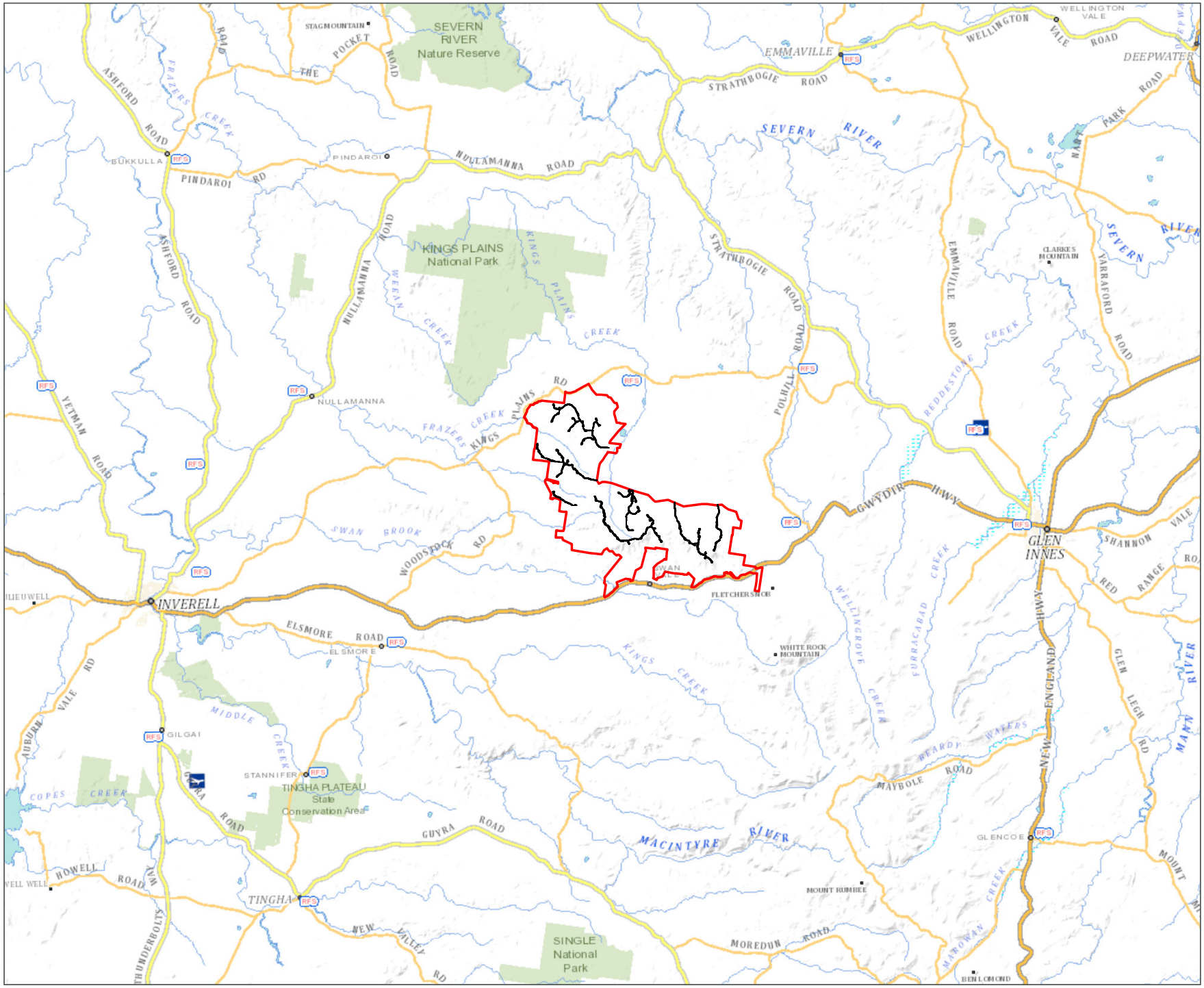

Figure 1: Locality map

Project: Sapphire Wind Farm BBAMP
Client: CWP Renewables Pty Ltd
Date: 23/03/2020

Study area
Turbines
Access tracks

N

Kilometers
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3. Carcass searches

3.1. Methods

3.1.1. Carcass searches

The mortality monitoring regime at SWF began in the partial-operational phase in July 2018. Monthly carcass searches were conducted for seven months while the wind farm was in partial operation where 33% of the operating turbines were searched. SWF became fully operational in February 2019 and the searches of the 33% of the operating turbines continued. The first full operation was from February 2019 to January 2020 and the second year included February 2020 to January 2021. This report covers all monitoring activities to date as part of the initial two-year mortality monitoring program at SWF under the BBAMP. The term 'monitoring period' used here refers to the period from July 2018 to January 2021 a total of 31 months.

Monthly carcass searches were undertaken under 18 turbines at SWF. Turbines were selected based on a randomised sampling design at the beginning of the implementation of the BBAMP (Table 1). This involved the selection of a random sub-set of turbines for monthly carcass searching. Random selection enables an assumption that the selected turbines together are representative of all turbines in the wind farm.

Table 1. List of turbines searched

Turbine numbers		
4	23	48
5	32	53
7	34	58
14	41	63
16	43	68
18	48	69

Carcass searches involved surveying all the sampled turbines once a month during a five to six-day search period out to a radius of 100 metres (Figure 2). Within a few days of the initial turbine searches, the turbines were then searched again in what is referred to as a 'pulse search'. This entails the inner zone of each turbine being searched a second time. The purpose of this is to provide additional data on frequency of mortalities occurring. It also provides additional opportunity to located any microbats which, given their small size, can be extremely difficult to locate.

A 100-metre-radius circular zone surrounding each designated turbine was searched each month, with two target search zones: the inner and outer zone, as follows:

- The inner zone: transects are spaced at four metres apart and carried out up to 60 metres from the turbine tower; nearly all microbats, and the majority of small to medium birds are expected to be found in this inner zone (based on the Hull and Muir model, 2010); and

- The outer zone: between 61 metres and 100 metres radius from the turbine tower base aims at detecting the medium and larger bodied birds; transects are spaced at twelve metres apart.

Ahmad Barati (zoologist) undertook carcass searches in 2018 and 2020 and Candice Larkin (zoologist) undertook the surveys in 2020 and 2021.

Mortalities were classed as either a bird carcass, a feather spot, a bat carcass or an incidental find. The last is any of the aforementioned classes found outside of the formal, monthly search (i.e., including at both target non-target turbines, finds by wind farm personnel). It is likely that feather spots represent a bird that has collided with a turbine and has later been scavenged. When a dead bird or bat was recorded under a turbine, pro-forma was filled out and numbered, and a photograph of the carcass in situ taken.

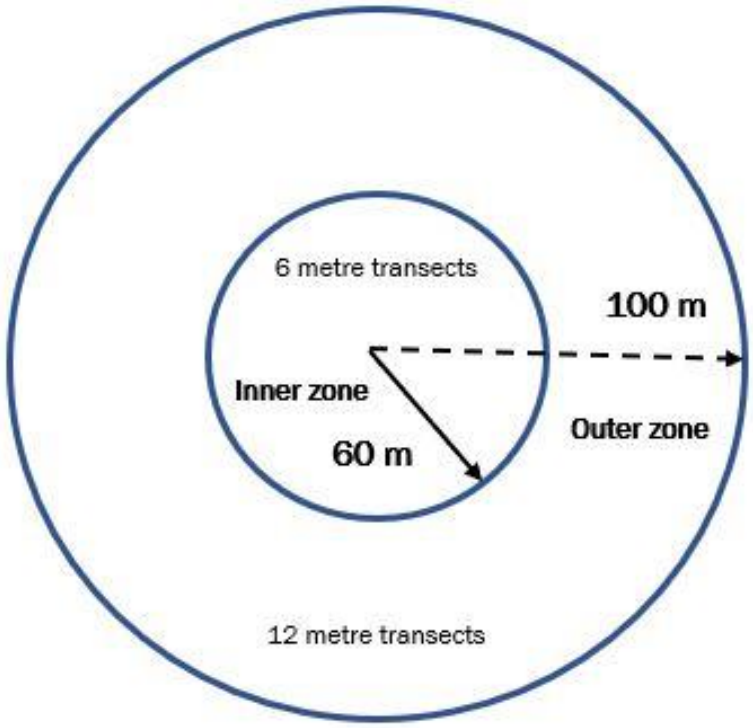

Figure 2. Diagram of inner and outer search zones at turbines

On finding a bird carcass, feather-spot or bat carcass, the finder:

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

The locations of all the turbines and the turbines searched are shown in Figure 3.

According to Section 6 of the BBAMP, an investigation may be warranted if any threatened or listed species is found as a casualty under a wind turbine; this is referred to as an 'impact trigger'. An immediate report must made if the following scenario occurs:

> *"A threatened bird/bat species (or recognisable parts thereof) listed 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 case of a non-threatened species carcass found, an impact trigger is defined as:

> *"A total of four or more bird or bat carcasses, or parts thereof, of the same species in two successive searches at the same turbine of a non-threatened species (excluding ravens, magpies, White Cockatoos, corellas, pipits and introduced species.*

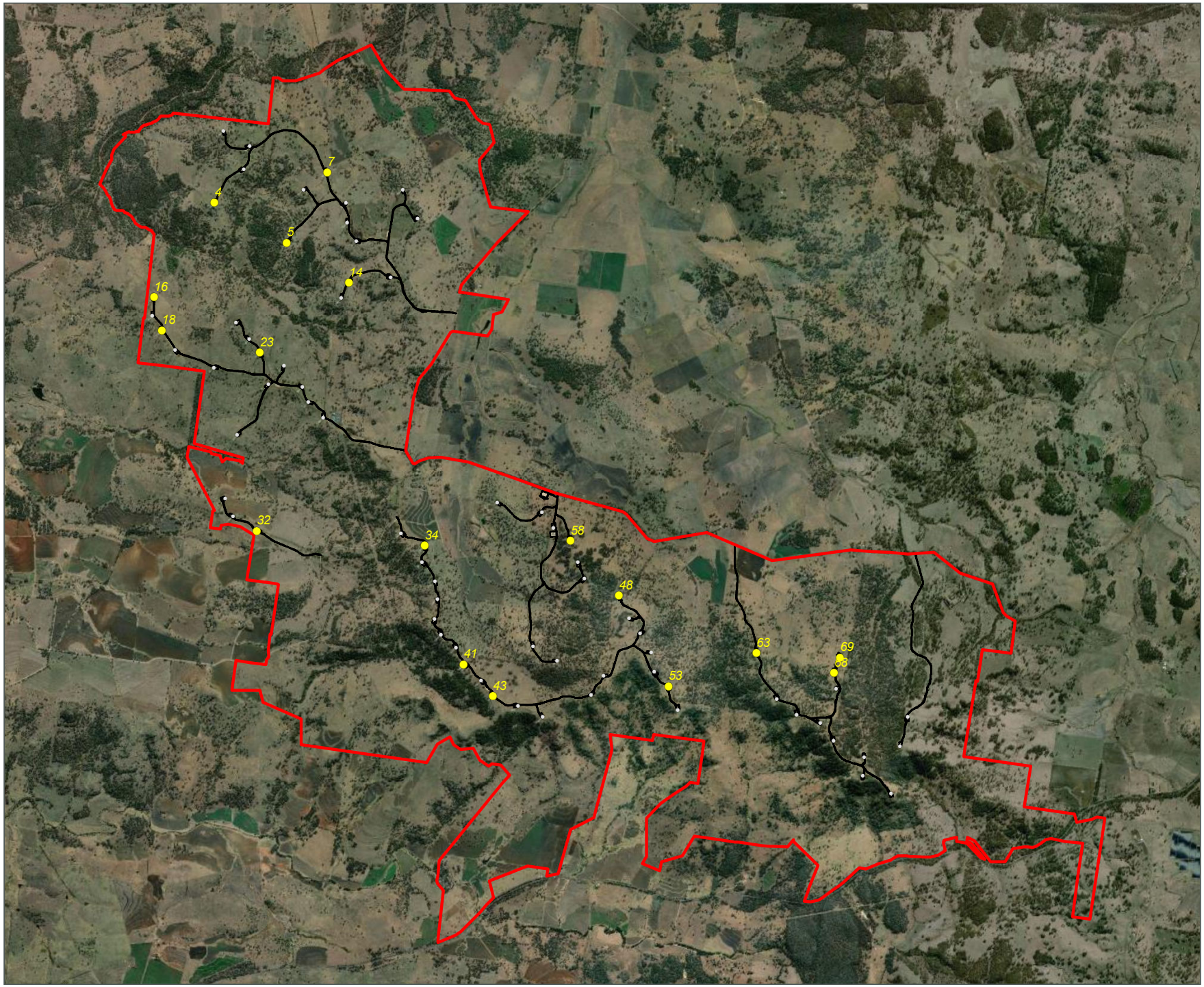

Figure 2: Sapphire Wind Farm turbine layout

Project: Sapphire Wind Farm BBAMP
Client: CWP Renewables Pty Ltd
Date: 23/03/2020

- Study area
- Target turbines
- Turbines
- Access tracks

N

Kilometers
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3.1.2. Searcher efficiency trials

The BBAMP states that searcher efficiency trials are to be undertaken twice over the two-year monitoring period in each of the two distinct seasons. The objective of having two trials is to account for the different vegetation conditions, with one being undertaken following summer rains when the grass is long (October-January) and the other in the drier winter months when the grass is short (July-August).

It is noted that NSW was severely affected by the drought and 2019 bushfires. The winter trial was undertaken on the 8th of August 2019, however, there was no significant change in vegetation condition over the summer period. The second trial was undertaken on the 21st of November 2020, prior to which the region had received a sharp increase in rain compared to the previous year. This resulted in increased vegetation growth, abundance and height and provided an opportunity for the grass to be considered as "long" for the purposes of the trial.

The purpose of these trials is to assess the efficiency of the zoologists implementing the carcass monitoring regime; Ahmad Barati, from February 2019 to July 2020 and Candice Larkin, from July 2020 to January 2021.

A total of twenty carcasses were used in each trial. This included five bats and fifteen birds in each (Table 2). Most carcasses had been collected during previous searches at SWF or other nearby winds farm, as well as road killed bird carcasses collected in preceding months and stored in a freezer at the wind farm office. Common Myna species were sourced from the control programs of Common Myna Action Group. All bats used in the trial were sourced from other wind farms in the region.

Observers from Nature Advisory, who were not involved with carcass searches, oversaw the efficiency trials and were responsible for placing the carcasses for the searcher and assessing the efficiency. Three to four carcasses were placed under six pre-selected turbines at the wind farm in each trial. The positions of the placed carcasses (distance and bearing from turbine) were randomly generated using the Microsoft Excel® random number function. All small carcasses (bats and mynas) and 25% of the medium–large bird carcasses were placed within the 100-metre outer zone. The remaining carcasses were distributed though the 60-metre inner zone.

The searchers 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.

The information collected in both trials has been used in the statistical data analysis outlined in Section 4.

Table 2. Species of carcass used in searcher efficiency trials at SWF

Turbine	Species	Size class
Winter (low vegetation)		
23	Common Myna	Small Bird
	Wedge-tailed Eagle	Large Bird
	Common Myna	Small Bird
	White-striped Freetail Bat	Bat
18	Wedge-tailed Eagle	Large Bird
	Common Myna	Small Bird
	White-striped Freetail Bat	Bat
	Sulphur-crested Cockatoo	Medium-Sized Bird
16	Wedge-tailed Eagle	Large Bird
	White-striped Freetail Bat	Bat
	Eastern Rosella	Medium-Sized Bird
	Pacific Baza	Medium-Sized Bird
14	Australian Wood Duck	Medium-Sized Bird
	White-striped Freetail Bat	Bat
	Tawny Frogmouth	Medium-Sized Bird
	Wedge-tailed Eagle	Large Bird
7	Common Myna	Small Bird
	Eastern Rosella	Small Bird
	Chocolate Wattled Bat	Bat
	Wedge-tailed Eagle	Large Bird
Summer (tall vegetation)		
58	Wedge-tailed Eagle	Large Bird
	Collared Sparrowhawk	Small Bird
	Common Myna	Small Bird
	White-striped Freetail Bat	Large Bird
59	Wedge-tailed Eagle	Large Bird
	Australian Magpie	Medium-Sized Bird
	Noisy Miner	Small Bird
	White-striped Freetail Bat	Bat
48	Wedge-tailed Eagle	Large Bird
	Crested Pigeon	Medium-Sized Bird
	Eastern Rosella	Small Bird
	Gould's Wattled Bat	Bat
43	Wedge-tailed Eagle	Large Bird
	Noisy Miner	Small Bird
	Noisy Miner	Small Bird
	White-striped Freetail Bat	Bat
69	Wedge-tailed Eagle	Large Bird
	Australian Magpie	Medium-Sized Bird
	Eastern Rosella	Small Bird
	White-striped Freetail Bat	Bat

3.1.3. Scavenger trials

The average duration of carcasses in the field prior to being removed by scavengers contributes to an essential correction factor required for the calculation of bird and bat mortality rates at wind farms. This correction factor contributes to statistical analysis and mortality estimates summarised in Section 4.

Scavenger trials were conducted during winter when the grass was short and again in summer, when the grass is longer, as required at SWF under the BBAMP. The first trial was undertaken in winter, when vegetation was low, concurrently with formal monthly searches beginning from 8th August to 17th September 2019. The second trial, undertaken in spring and summer, ran from 21st and 28th of November 2020, and from 3rd of February 2021. Additional data was also collected opportunistically in autumn 2020 from 21st and 23rd of April. Carcasses were placed at the same turbines selected for formal surveys and placed as zoologists undertook monthly surveys (Table 3).

Monitoring was carried out using remote-sensor camera traps. The first ten camera traps were deployed at a close distance (around 1 meter) to one carcass each. Once a carcass was scavenged, the camera was collected and deployed at another carcass until all 20 carcasses were monitored for at least 31 days. The cameras were retrieved after 31 days of monitoring and the photographs recorded on the SD card reviewed to determine on what day, if at all, the carcass was scavenged.

The use of the camera was time effective as it allowed for continuous monitoring of the carcass and an indication of the type of scavenger. The average duration in days that carcasses remained on the ground before being taken by a scavenger was then calculated for bats, small birds and medium to large birds. If the carcass was still present on site at day 30, as a precautionary approach it was recorded as being scavenged at day 30. The carcass was then removed and the experiment terminated.

Table 3. Species of carcasses used in scavenger trials at SWF

Placement Date	Turbine	Species placed	Carcass type
Winter 2019			
8/08/2019	23	Common Myna	Small Bird
8/08/2019	23	Wedge-tailed Eagle	Large Bird
8/08/2019	14	Australian Wood Duck	Medium-Sized Bird
9/08/2019	41	Rainbow Lorikeet	Small Bird
9/08/2019	18	Nankeen Kestrel	Medium-Sized Bird
9/08/2019	23	Wedge-tailed Eagle	Large Bird
9/08/2019	41	Common Myna	Small Bird
9/08/2019	14	Eastern Rosella	Medium-Sized Bird
11/08/2019	23	White-striped Freetail Bat	Bat
13/08/2019	59	Wedge-tailed Eagle	Large Bird
13/08/2019	58	White-striped Freetail Bat	Bat
15/08/2019	23	Wedge-tailed Eagle	Large Bird
15/08/2019	23	Magpie-Lark	Small Bird
16/08/2019	41	White-striped Freetail Bat	Bat
16/08/2019	58	Crimson Rosella	Medium-Sized Bird
16/08/2019	41	Sulphur-crested Cockatoo	Medium-Sized Bird
16/08/2019	41	White-striped Freetail Bat	Large Bird
16/08/2019	41	White-striped Freetail Bat	Bat
16/08/2019	16	Common Myna	Small Bird
17/08/2019	58	White-striped Freetail Bat	Bat
Autumn 2020			
21/04/2020	7	White-striped Freetail Bat	Bat
21/04/2020	7	Easter Rosella	Medium-Sized Bird

Placement Date	Turbine	Species placed	Carcass type
21/04/2020	16	White-striped Freetail Bat	Bat
23/04/2020	23	Australian Magpie	Medium-Sized Bird
23/04/2020	23	Australian Magpie	Medium-Sized Bird
23/04/2020	14	Australian Wood Duck	Medium-Sized Bird
23/04/2020	14	Wedge-tailed Eagle	Large Bird
23/04/2020	14	Nankeen Kestrel	Medium-Sized Bird
23/04/2020	5	Wedge-tailed Eagle	Large Bird
23/04/2020	5	White-striped Freetail Bat	Bat
Spring/summer 2020/21			
21/11/2020	58	White-striped Free-tailed Bat	bat
21/11/2020	58	Noisy Miner	small bird
21/11/2020	58	Collared Sparrowhawk	medium bird
21/11/2020	58	Wedge-tailed Eagle	large bird
21/11/2020	58	Eastern Rosella	small bird
21/11/2020	59	Noisy Miner	small bird
21/11/2020	59	White-striped Free-tailed Bat	bat
21/11/2020	59	Australian Magpie	medium bird
21/11/2020	48	Crested Pigeon	medium bird
21/11/2020	48	White-striped Free-tailed Bat	bat
21/11/2020	48	Little Red Flying Fox	bat
28/11/2020	34	Australian King-parrot	medium bird
28/11/2020	34	Australian Galah	medium bird
28/11/2020	63	White-striped Free-tailed Bat	bat
28/11/2020	63	Eastern Rosella	small bird
3/02/2021	9	Chocolate Wattled Bat	bat
3/02/2021	55	Galah	medium bird
3/02/2021	55	White-striped Free-tailed Bat	bat
3/02/2021	9	Eastern Rosella	small bird
3/02/2021	10	Australian Magpie	medium bird
3/02/2021	60	Dusky Woodswallow	small bird
3/02/2021	60	Red-rumped Parrot	small bird

3.2. Results

3.2.1. Carcass search results

A total of 49 bird and bat carcasses/remains were found under turbines during 31 months of the monitoring period at SWF. Of all birds and bats, during formal searches, 14 bird carcasses, 10 bat and 13 feather spots were found. A total of 9 birds, two feather spots and one bat 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 number of carcasses per species is shown in Figure 4 and percentages of each species among all bird and bat finds is summarised in Figure 5.

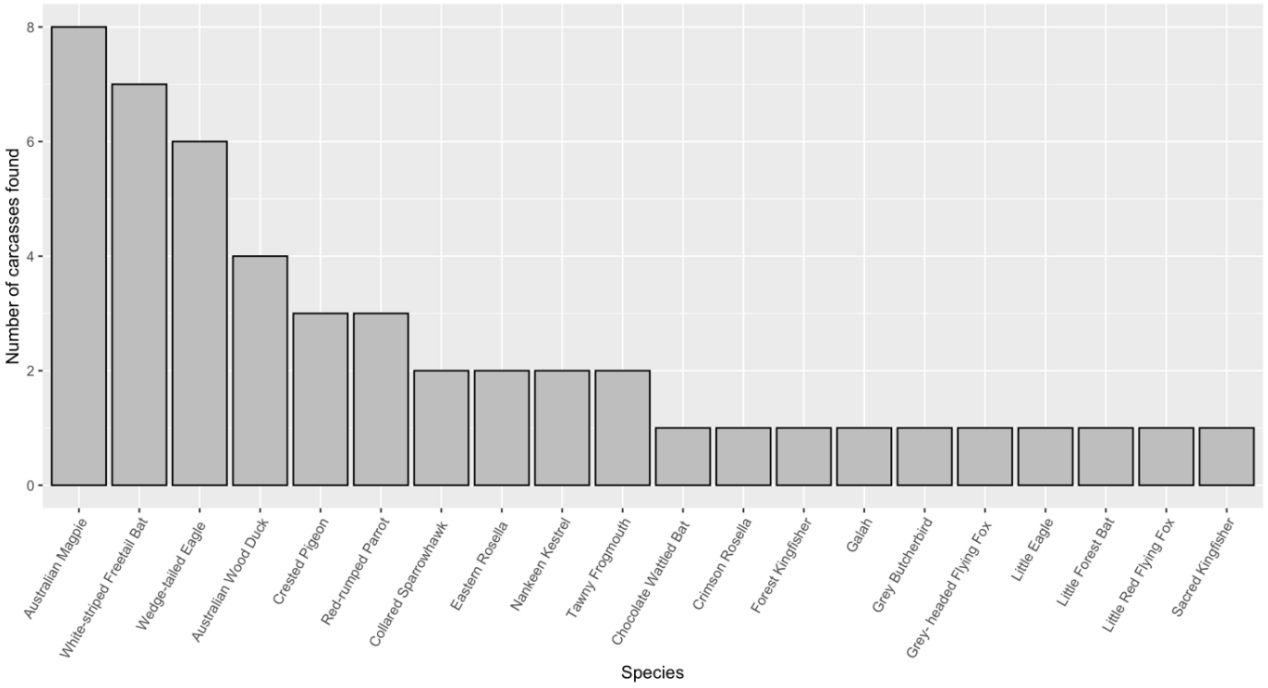

Figure 4: Number of bird and bat carcasses found during the monitoring period at SWF

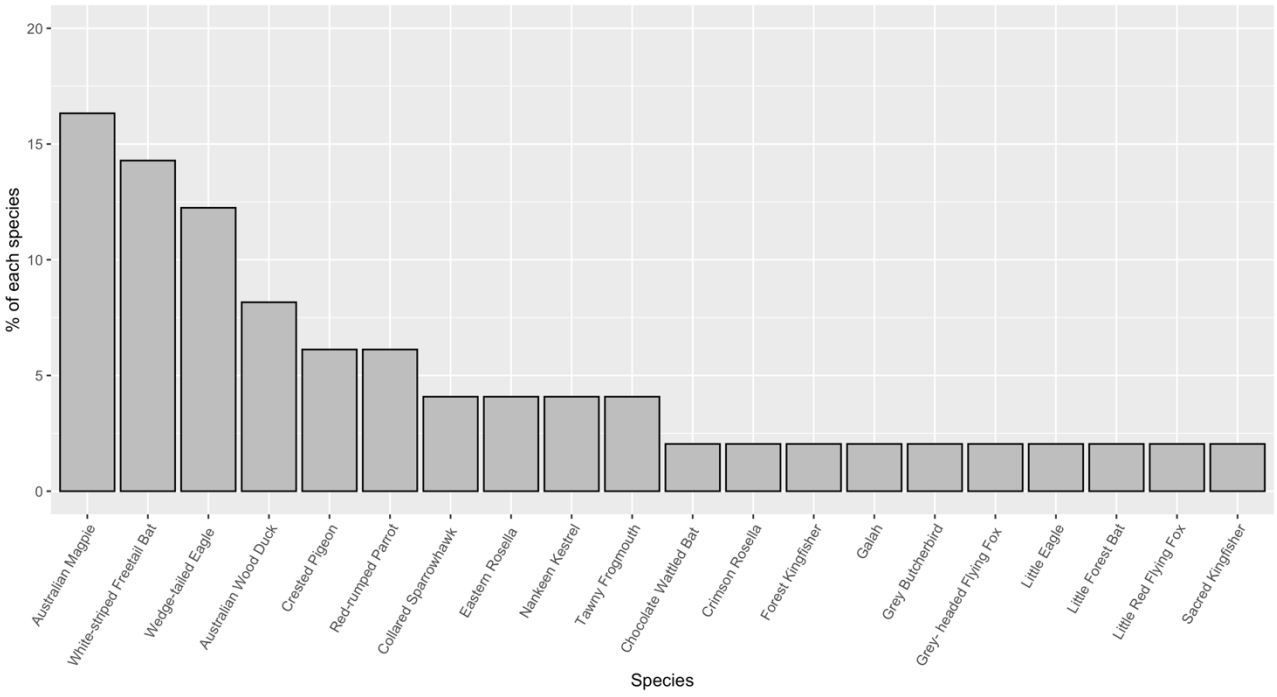

Figure 5: Percentages of each bird and bat species recorded at SWF during the monitoring period.

The results of the formal bird and bat carcass searches at SWF are summarised in Table 4. The table shows the number of carcasses and feather spots found during formal searches, and incidentally.

Table 4: Summary of carcass search results for bird and bats from July 2018 to January 2021 at SWF

Search type	Season	Month	Bird	Bat	Feather spot	Total mortalities
Formal searches	Partial-operational phase search results					
	Winter	Jul-18				0
		Aug-18			1	1
	Spring	Sep-18				0
		Oct-18				0
		Nov-18				0
	Summer	Dec-18		1		1
		Jan-19				0
	Official full wind farm operations period					
	Summer	Feb-19				0
	Autumn	Mar-19				0
		Apr-19				0
		May-19				0
	Winter	Jun-19	1			1
		Jul-19	1			1
		Aug-19				0
	Spring	Sep-19	2			2
		Oct-19		1		1
		Nov-19			1	1
	Summer	Dec-19				0
		Jan-20				0
		Feb-20	1			1
	Autumn	Mar-20		1		1
		Apr-20				0
		May-20		1		1
	Winter	Jun-20	1		2	3
		Jul-20	3		2	5
		Aug-20	2		1	3
	Spring	Sep-20		1	3	4
		Oct-20	2	1	1	4
		Nov-20		2	2	4
	Summer	Dec-20	1			1
		Jan-21		2		2
Formal searches total						37
Incidental search results						
Incidental Records	Partial-operational phase search results					
		Jul-18	1			
	Winter	Aug-18	2			2
	Spring	Sep-18			2	2
	Summer	Dec-18	1			1
		Jan-19	1			1
	Official full wind farm operations period					
	Summer	Feb-19	2			2
		Jan-20	1			1
	Autumn	Apr-20	1	1		2
Incidental finds total						12
Total finds for SWF BBAMP Project						49

Bird mortality during monitoring period

A total of 23 bird carcasses and 15 feather spots were recorded at SWF from July 2018 to January 2021. These finds belonged to fifteen different bird species (Figure 5). Of all carcasses found, 27 carcasses/feather remains were found during formal monthly searches. The remaining 11 finds carcasses were recorded after being found incidentally by carcass monitoring team or wind farm personnel. On average, 1.3 ± 0.34 bird remains were recorded per month during monitoring period.

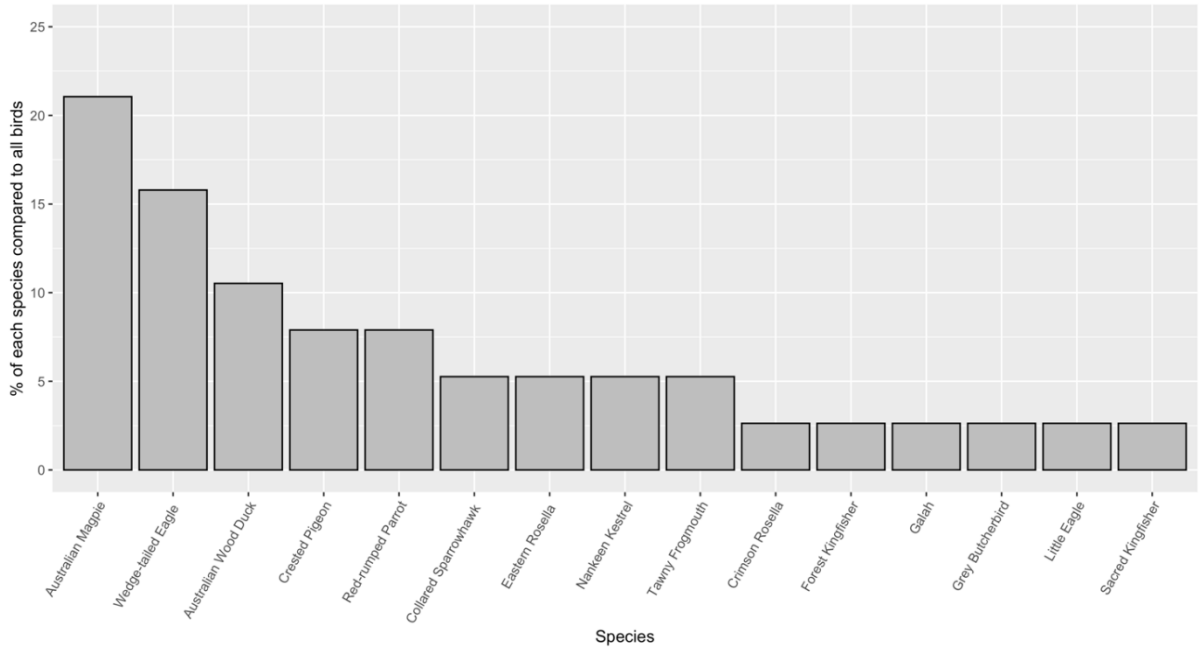

Figure 6: Percentage of carcasses recorded per each species of birds in relation to all bird species at SWF

Among all bird species recorded, the Australian Magpie (*Gymnorhina tibicen*) was the most common species. A total of eight Australian Magpie carcasses/feather remains were found at SWF during the monitoring period which accounts for 22% of all bird mortality and 18% of all bird and bat mortality during the monitoring period. The Australian Magpie is a very common species at the wind farm sites according to BUS surveys conducted inside the wind farm during operation phase of the wind farm. Thus, it is not surprising that this species in the most common bird species that is impacted by wind turbines. This species in usually among species with high mortality rate in most of other wind farms as well.

The second most common species among birds was Wedge-tailed Eagle (*Aquila audax*), which represented around 15% of bird species and 13% of total carcasses found at SWF during the monitoring period. During 31 months of monitoring period, a total of six Wedge-tailed Eagle mortalities were recorded at SWF, of which two were found during formal carcass search and four as incidental records. This species is an "at risk species" according to the BBAMP (Section 4).

Six species were recorded only once during carcass monitoring period; Crimson Rosella (*Platycercus elegans*), Forest Kingfisher (*Todiramphus macleayii*), Galah (*Eolophus roseicapilla*), Grey Butcherbird (*Cracticus torquatus*), Little Eagle (*Hieraeetus morphnoides*) and Sacred Kingfisher (*Todiramphus sanctus*).

During the monitoring period, no circumstances were witnessed during the survey period at SWF that would be identified as an impact trigger, according to the BAMP. Although there was a record of Little Eagle at the early stages of monitoring period, it was not directly related to turbine strike as described in the first annual report.

Detected bird mortality and the frequency of species occurrences is summarised in Table 5. Detailed information on each bird carcass, feather-spot and incidental record during the monitoring program to date can be found in Appendix 1: Bird and bat mortality data obtained during the pre-operational period and two years of monitoring at SWF (July 2018-January 2021).

Table 5: Summary of bird carcass records at SWF from July 2018 to January 2021

Common Name	Scientific Name	Formal	Incidental	Total	Feather Spots
Australian Magpie	*Gymnohina tibicen*	7	1	**8**	4
Australian Wood Duck	*Chenonetta jubata*	3	1	**4**	2
Crested Pigeon	*Ocyphaps lophotes*		3	**3**	1
Collared Sparrowhawk	*Accipiter cirrocephalus*	2		**2**	
Crimson Rosella	*Platycercus elegans*	1		**1**	1
Eastern Rosella	*Platycercus eximius*	1	1	**2**	1
Forest Kingfisher	*Todiramphus macleayii*	1		**1**	
Galah	*Eolophus roseicapilla*	1		**1**	1
Grey Butcherbird	*Cracticus torquatus*	1		**1**	
Nankeen Kestrel	*Falco cenchroides*	2		**2**	1
Red-rumped Parrot	*Psephotus haematonotus*	3		**3**	2
Sacred Kingfisher	*Todiramphus sanctus*	1		**1**	1
Tawny Frogmouth	*Podargus strigoides*	2		**2**	1
Wedge-tailed Eagle	*Aquila audax*	2	4	**6**	
Little Eagle	*Hieraaetus morphnoides*		1	**1**	
Total		**27**	**11**	**38**	**15**

Bat mortality during monitoring period

A total of 11 bat carcasses of five species were recorded at SWF during the monitoring period. Of all bat carcass recorded, the White-striped Freetail Bat (*Tadarida australis*) disproportionally represented over 60% of all carcass finds. The remaining four species had only one carcass per species in the total finds. Bat carcasses made up around 20% of all carcasses found during the pre-operation and first two years of full operation. Figure 6 outlines the percentage of total collisions and species of carcasses found at SWF during the monitoring period. Appendix 1 presents detailed bat mortality data.

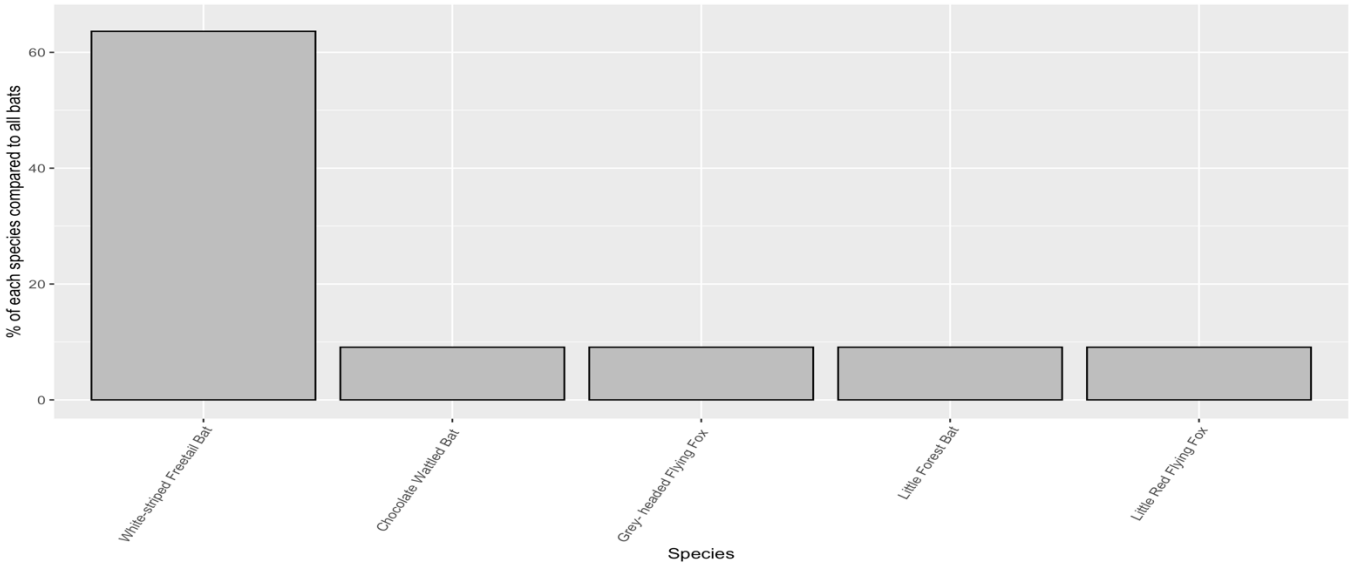

Figure 7: Percentages of each bat species compared to total bat carcasses found at SWF

Among all bat species recorded, the Grey-headed Flying Fox is listed as "Vulnerable' under both the NSW's *Biodiversity Conservation Act 2016* (BC Act) and the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999 (*EPBC Act). The carcass was found on the 1st December 2018 tangled on a fence line at a distance of over 100 meters from the turbine (Figure 8). Given the distance of this carcass and its condition when detected, it was determined it was extremely unlikely that mortality was caused by wind turbine, thus, it did not trigger a response under the BBAMP for a threatened species. Collision and entanglement with barbed wire, along with power lines and netting, are known to cause flying-fox mortalities and this is unfortunately not uncommon (OEH 2020). Similarly, a Little Red Flying fox was found alive on barbed wire at SWF on the 27th of December 2020, and was removed by Candice Larkin and taken to a wildlife carer. The risk the wind farm poses to this species remains low and is considered to have a negligible impact on the overall population.

The other species found at SWF were the Chocolate Wattled Bat, Little Red Flying Fox and Little Forest Bat. These species are common bat species in the region and have been documented at other wind farms near SWF.

Figure 8:Grey- headed Flying Fox mortality due to fence lines at SWF (left) and similar condition at other wind farms (right). Photos: A. Barati

Distance of carcasses from turbines

Carcasses were distributed from the base of turbines up to 100 meters with an average distance of 49.3 ± 7.1 (mean ± SE) from the turbines (Figure 9). A high proportion of carcasses (ca. 66%) were found at a distance of 0-60 meters from the turbines. Overall, there was a significant negative correlation between number of carcasses and the distance from the turbines ($t = -2.5$, $df = 18$, $p=0.01$, $R^2= -0.51$). The distribution pattern of carcasses varied between bird and bat carcases in term of their average distance from the turbines. On average, birds were found to be slightly closer to the turbine compared with bats (Figure 10). However, the difference was not statistically significant based on Analysis of Variance (ANOVA test, $F=0.004$, $df=1$, $p>0.05$).

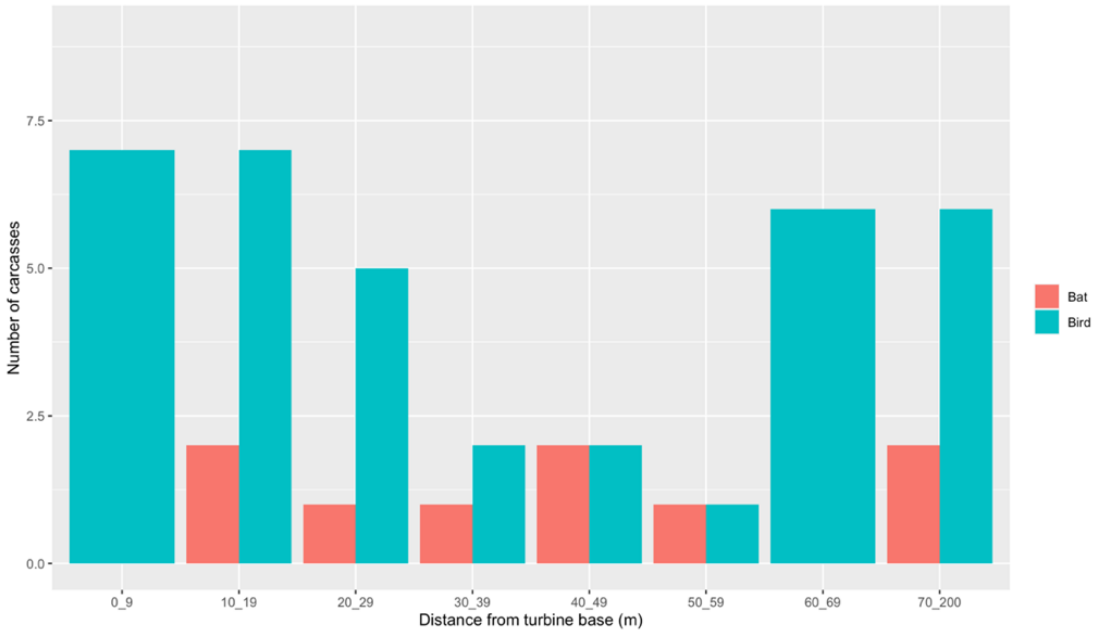

Figure 9: Distribution of carcasses found at distance categories from the turbine

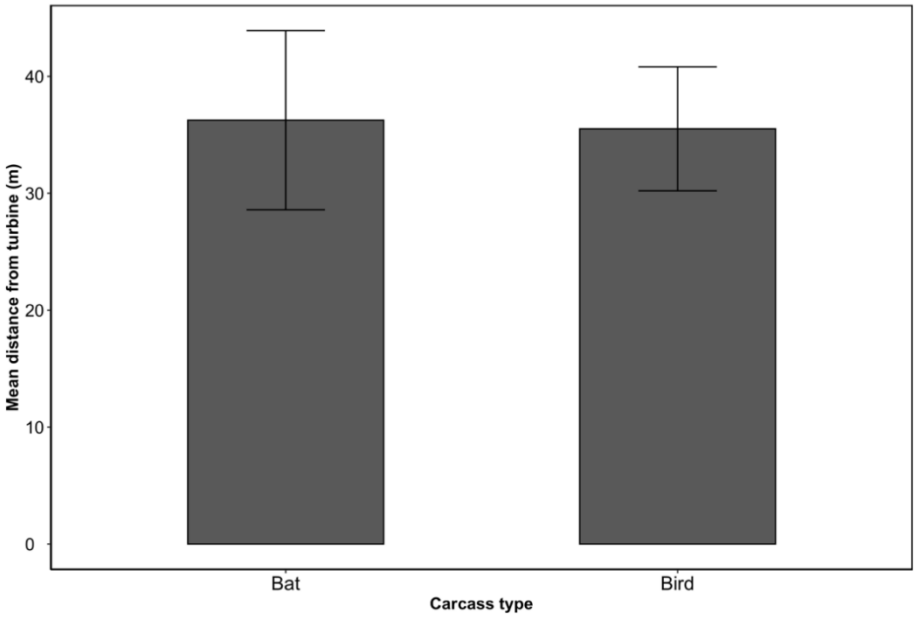

Figure 10: Mean distance of bird and bat carcasses from turbines at SWF during the period of carcass monitoring.

Monthly and seasonal variation of carcasses finds

The number of carcasses found across different months and seasons varied between from no detections per month, to five. The highest number of carcasses was recorded in July 2020 with a total of five birds and one bat recorded (Figure 11). Carcasses were distributed randomly in different seasons. No seasonal variation was apparent in the

mortality rate at the wind farm for birds (F=1.98, df=3,16, p>0.05) and bats (F=0.77, df=2,6, p>0.05). However, lack of significant seasonal variations in the bat mortality might be due to low numbers of bats recorded at this wind farm sites which is insufficient to demonstrate the seasonal changes (Figure 12).

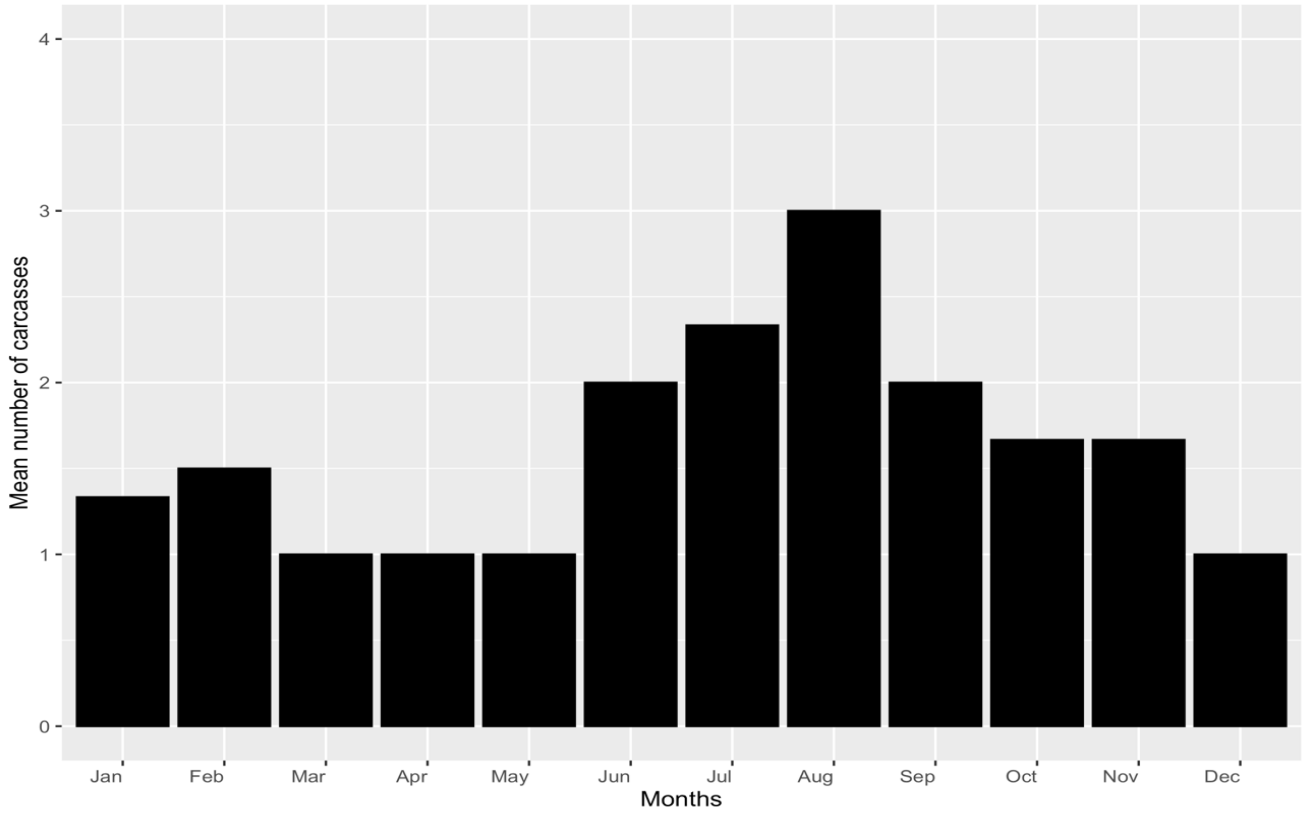

Figure 11: Mean number of carcasses recorded per each month at SWF during the period of carcass monitoring

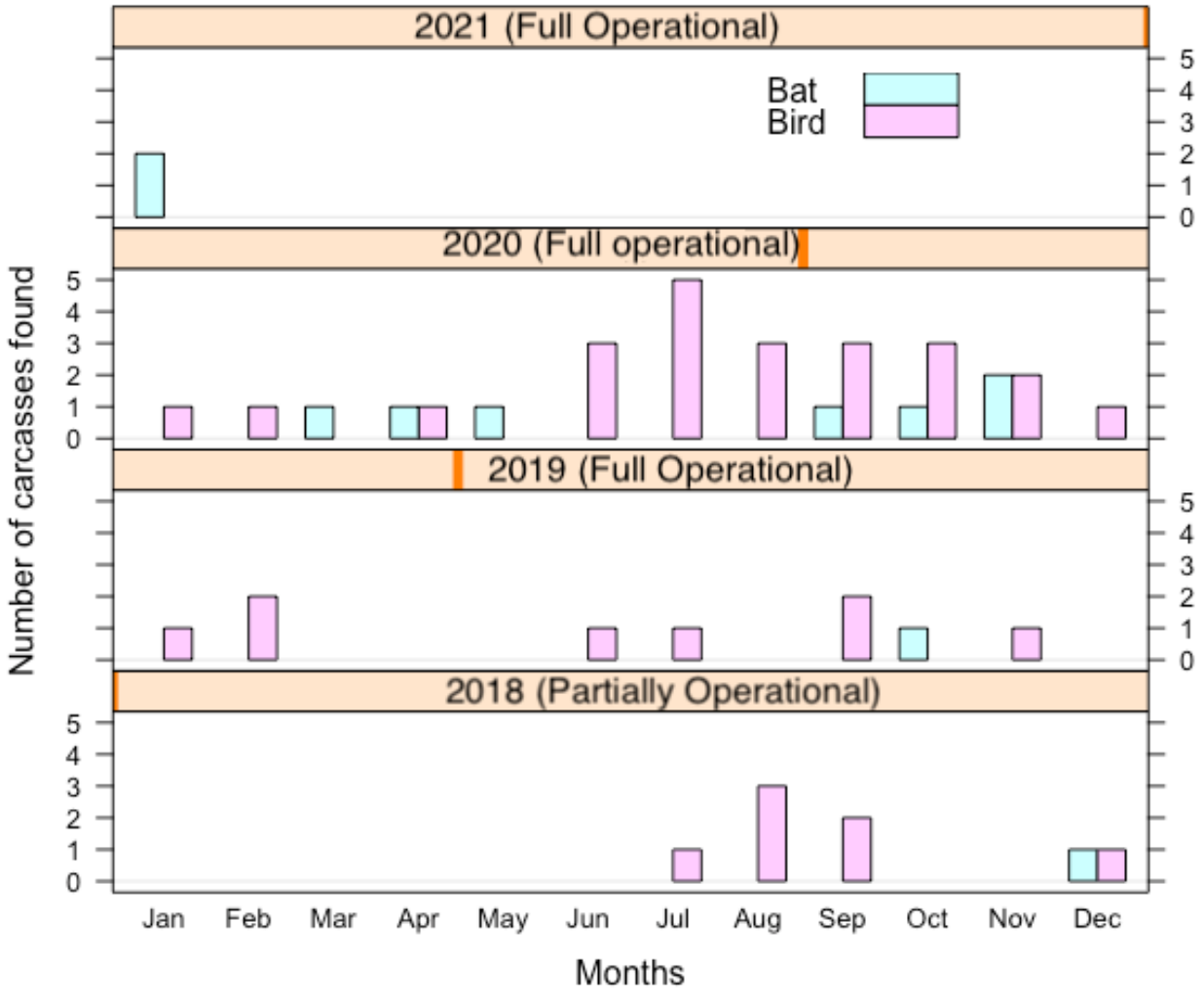

Figure 12: Number of birds and bat carcasses found during monitoring period from July 2018 to January 2021

3.2.2. Searcher efficiency results

Table 6 below outlines the results of both trials, by both zoologists undertaking the searches at SWF.

Efficiency during the winter trial was 100% with no carcasses missed by the searcher. During the summer trial one carcass from 18 was missed, resulting in efficacy of approximately 94.5% overall. Although 20 carcasses were laid out, two were apparently scavenged before the zoologist was able to find them during the trial search (i.e., they did not locate them during the trial and the observer could not locate it immediately after the trial was completed, meaning it had been scavenged prior to the zoologist commencing the search). These have been excluded from statistical analysis (Section 4). Only one small bird was missed during the efficiency trial in summer.

Table 6. Searcher efficiency trial results

Turbine	Species	Size class	Detected
Winter (low vegetation) - Searcher: Ahmad Barati			
23	Common Mynah	Small Bird	✓
	Wedge-tailed Eagle	Large Bird	✓
	Common Mynah	Small Bird	✓
	White-striped Freetail Bat	Bat	✓
18	Wedge-tailed Eagle	Large Bird	✓
	Common Mynah	Small Bird	✓
	White-striped Freetail Bat	Bat	✓
	Sulphur-crested Cockatoo	Medium-Sized Bird	✓
16	Wedge-tailed Eagle	Large Bird	✓
	White-striped Freetail Bat	Bat	✓
	Eastern Rosella	Medium-Sized Bird	✓
	Pacific Baza	Medium-Sized Bird	✓
14	Australian Wood Duck	Medium-Sized Bird	✓
	White-striped Freetail Bat	Bat	✓
	Tawny Frogmouth	Medium-Sized Bird	✓
	Wedge-tailed Eagle	Large Bird	✓
7	Common Myna	Small Bird	✓
	Eastern Rosella	Small Bird	✓
	Chocolate Wattled Bat	Bat	✓
	Wedge-tailed Eagle	Large Bird	✓
Summer (tall vegetation) - Searcher: Candice Larkin			
58	Wedge-tailed Eagle	Large Bird	✓
	Collared Sparrowhawk	Medium Bird	✓
	Common Myna*	Small Bird	× *
	White-striped Freetail Bat*	Bat	×*
59	Wedge-tailed Eagle	Large Bird	✓
	Australian Magpie	Medium Bird	✓
	Noisy Miner	Small Bird	×
	White-striped Freetail Bat	Bat	✓
48	Wedge-tailed Eagle	Large Bird	✓
	Crested Pigeon	Medium Bird	✓
	Eastern Rosella	Medium Bird	✓
	Gould's Wattled Bat	Bat	✓
43	Wedge-tailed Eagle	Large Bird	✓
	Noisy Miner	Small Bird	✓
	Noisy Miner	Small Bird	✓
	White-striped Freetail Bat	Bat	✓
69	Wedge-tailed Eagle	Large Bird	✓
	Australian Magpie	Medium Bird	✓
	Eastern Rosella	Small Bird	✓
	White-striped Freetail Bat	Bat	✓

Notes: ✓ = Found; X = missed.

***** Two carcasses scavenged prior to the trial turbine search commencing

3.2.3. Scavenger trial results

The results of the scavenger trial are presented in Table 7 and the detailed data are presented in Appendix 2.

During the periods where the grass was short (generally winter); bats were taken on average after 3.3 days, small birds 2.3, medium birds, 5.9 and large birds 30. During the

long grass periods (generally spring/summer) bats were taken on average after 13.2 days, small birds 8.5, medium birds, 6.7 and large birds were again 30, though there were only two large carcasses available during this period.

Bat and small birds lower average days in the field during short grass periods is likely related to their small size making them available to a wider range of scavengers such as; Ravens and Magpies. In contrast; the higher days on average during long grass for these classes may be related to the fact such scavengers as the aforementioned rely entirely on visual foraging habits. Longer grass would make scavenging more challenging during these times.

Medium carcasses remained more or less the same on average in the field between the periods and this may be related to this class being targeted by larger scavengers such as the Red Fox which relies primarily on scent to find food rather than visuals. Short or long grass would make little difference to such foraging habits.

The large carcasses consisted mainly of Wedge-tailed Eagle and were not scavenged, with none being taking before the trial was terminated after 30 days. This appears to be a common occurrence, as trials conducted by Nature Advisory at other wind farms in NSW using only Wedge-tailed Eagle carcasses showing that are typically not scavenged and remain in the field until they completely decompose (Nature Advisory unpublished data).

Figure 13 shows an example of motion camera results obtained during the scavenger trials.

Table 7. Results of the scavenger trials at SWF

Time period	Carcass type	Number of carcasses	Average days in the field
Short grass	Bat	8	3.3
	Small Bird	5	2.3
	Medium birds	10	5.9
	Large birds	7	30.0
	Total	30	10.0
Long grass	Bat	6	13.2
	Small Bird	5	8.5
	Medium birds	9	6.7
	Large birds	2	30.0
	Total	22	11.1
Overall totals	Bat	14	7.1
	Small Bird	10	5.6
	Medium birds	19	6.2
	Large birds	9	30.0
	Overall total	52	10.5

Figure 13. Examples of scavengers at SWF detected by camera traps, Common Brushtail Possum right and Red Fox left.

4. Statistical analysis

All data collected during the carcass search program has been provided to Symbolix Pty Ltd, a specialist data analyst organisation, in order to determine bird and bat mortality rates. All monthly searches, including during the commissioning phase, have been utilised to estimate mortality. Only formal finds have been included, that is finds by the searcher during formal monthly random carcass searches.

Detailed methods of analysis and mortality estimates are provided by Symbolix Pty Ltd in Appendix 3.

4.1. Results

Detailed results are summarised below. The estimations are given as overall (the entire monitoring period) and as 12-month periods beginning from the first monitoring month after the preconstruction survey.

4.1.1. Searcher Efficiency

No significant difference was detected between the two searcher efficiency trials undertaken (Section 3.2.2). Similarly, not difference is searcher efficiency was detected between birds and bats. As such efficiency was aggregated for mortality estimates.

Overall; efficiency was 92% mean detectability proportion with a 95% confidence interval of 80% to 98%.

4.1.2. Scavenger trials

There was no significant difference detected between scavenging rates for the different periods. Additionally, there was no significant difference detected between birds and bat scavenging rates. Thus, the results were aggregated.

The trials included seven Wedge-tailed Eagle carcasses, none of which were scavenged within the 30 days of the trails. As such, Wedge-tailed Eagle data has been excluded from the general bird and bat aggregate data and analysed separately due to their unique scavenging profile.

Under the assumptions outlined in Appendix 3, the mean time to total loss for bats, small birds, and medium birds is 12.3 days (95% confidence interval of 5.4, 27.9 days).

For large birds (Wedge-tailed Eagle), the mean time to total loss is 513 days (95% confidence window of 269, 977 days).

4.1.3. Bats

Based on the number of detected carcasses and the detectability and scavenging rate, it is estimated there was a total site loss (all turbines combined) of around 166 bats over the entire search period, the upper 95% confidence limit on this estimate is fewer than 252 individuals. On an annual basis of 12 months this corresponds to a total site loss estimated loss of 64 bats with 95% confidence that fewer than 98 individuals were lost.

During the first year of searches a total of one bat was found during formal surveys. The resulting estimate of total mortality is estimated at (mean) 33 bats over the survey period with 95% confidence that fewer than 81 individuals were lost.

By comparison, in the second year of searches, a total of three bats were found during formal surveys. The resulting estimate of total mortality is 53 bats with 95% confidence that fewer than 103 individuals were lost.

There was not a significant difference in the mortality numbers for bats between the two years.

4.1.4. Birds

Based on the detected carcasses and feather spots and detectability and scavenging rate, a total site loss over 31 months of survey corresponded to an estimated loss of 457 birds with 95% confidence that fewer than 658 individuals were lost. On an annual basis of 12 months this corresponds to a total site loss estimated loss of 177 birds with 95% confidence that fewer than 255 individuals were lost.

Individual estimates were undertaken for Wedge-tailed Eagle and the estimate of total mortality over the 31 months was 13 individuals with 95% confidence that fewer than 27 individuals were lost. On an annual basis of 12 months this corresponds to a total site loss estimated loss of 5 WTEs with 95% confidence that fewer than 10 WTEs were lost.

During the first year of searches, a total of three birds were found during formal surveys. The resulting estimate of total mortality was 80 birds over the survey period, with 95% confidence that fewer than 161 individuals were lost.

By comparison, in the second year of searches, a total of ten birds were found during formal searches. The resulting estimate of total mortality was 162 birds over the search period, with 95% confidence that fewer than 264 individuals were lost.

It was detected that mortality numbers were significantly higher for the second year than in the first, excluding Wedge-tailed Eagles.

For Wedge-tailed Eagle exclusively; the first-year mortality rate was zero individuals found and the resulting estimates are five over the survey period (95% confidence of less than 14). During the second year; two Wedge-tailed Eagles were detected resulting in an estimate of 12 mortalities over the second year of monitoring (95% confidence less than 14). Year one was significantly lower than the second.

4.2. Limitations

In evaluating the potential impact of the wind farm, 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, an upper limit was not applied on the number of bats and birds that could be onsite, and it has been assumed that bats and birds were present all year round. The ecological feasibility of this assumption must be accounted for when using these results to evaluate overall ecological impact.

Individual species' ecology, including movement patterns, flight habits, habitat usage, social habits and territories must be considered when using these estimations to evaluate impacts. This is explored further in Section 5. .

5. Monitoring 'at-risk' species

As part of the BBAMP, monitoring of 'at-risk' species groups coinciding with monthly carcass searches is required at SWF. These surveys determine if the operating turbines will have an effect on the behaviour of any of these species.

Monitoring of "at risk" groups provide useful information within an adaptive management framework for addressing the bird and bat impacts of the wind farm.

5.1. Species of concern

The key "at risk" groups were identified through the risk assessment (BBAMP 2017). These included:

- Wedge-tailed Eagle,
- Other raptors,
- White-throated Needletail,
- Regent Honeyeater, and
- Swift Parrot.

5.1.1. Wedge-tailed Eagle and other raptors

A total of three species over a total of 15 observations were recorded during the monitoring period. These consisted of; Wedge-tailed Eagle (9), Whistling Kite (2) and Nankeen Kestrel (4). This would indicate the overall level of habitat use by raptors at SWF is low.

Overall, due to the low topography at SWF, the area can be predominately identified as low-quality habitat for Wedge-tailed Eagle. The observation rate within the wind farm was low.

The Nankeen Kestrel was observed on three occasions at SWF. This species prefers open habitats within woodland or grasslands and occurs commonly in farmland landscapes.

Whistling Kite was observed on several occasions at SWF, but more frequently outside the wind farm scavenging on remains of livestock or wildlife. Despite this, no mortality of Whistling Kite was recorded at SWF.

The low numbers of raptors observed corresponds with the mortality results with only one of the species observed, Wedge-tailed Eagle, being identified as a mortality. Flight behaviours observed of this species frequently being recorded at 150-200 metres above the ground indicates risk behaviour that would bring them into the rotor swept area of turbines, causing collisions.

Table 8. Raptor observations at SWF

Date	Time	Species	Number of Individuals	Behaviour	Nearest Turbine
30/07/2018	13:00	Wedge-tailed Eagle	1	flying, soaring, south of turbine 32, 500 m	32
17/09/2018	11:30	Wedge-tailed Eagle	2	flying southwards near 18	18
30/11/2018	12:10	Wedge-tailed Eagle	2	perched, flying 500m north turbine 18	18
5/02/2019	9:30	Whistling Kite	1	perched, flying 700m from 41 between 41 and 43	41
22/05/2019	9:00	Nankeen Kestrel	1	flying east side of 14 about 500 m	14
22/05/2019	13:00	Nankeen Kestrel	1	perched on trees near 14	14
31/05/2019	14:10	Nankeen Kestrel	1	perched then flying near 16	16
8/08/2019	15:40	Wedge-tailed Eagle	1	flying turbine 4 to 16.	4
9/09/2019	9:30	Wedge-tailed Eagle	2	flying around turbine 58 to west	58
11/12/2019	10:00	Whistling Kite	1	flying around turbine 7 towards 5	7
5/11/2019	9:30	Wedge-tailed Eagle	1	flying between 41 and 43	41
15/01/2020	10:20	Wedge-tailed Eagle	1	flying at 500m from turbine 5	5
20/03/2020	13:00	Wedge-tailed Eagle	1	flying at ~200 m of height visible form turbine 14	14
23/03/2020	9:30	Wedge-tailed Eagle	1	flying between turbine 5 and 16 at ~150 m height	16
17/04/2020	10:20	Nankeen Kestrel	1	flying at around ~ 200 m height probably outside wind farm boundaries	68

5.1.2. White-throated Needletail, Regent Honeyeater and Swift Parrot

There were no observations of White-throated Needletail, Regent Honeyeater or Swift Parrot during either the pre-commissioning or operational phase at SWF.

There are a very limited number of ironbark trees, which can provide habitats for the Regent Honeyeater and Swift Parrot when flowering. Year 2019 was extremely dry throughout the northern tablelands and no flowering ironbark trees were observed. Therefore, suitable habitats for the Regent Honeyeater and Swift Parrot at SWF are extremely limited. In addition, no individuals of either species were recorded during BUS at SWF (Section 6).

The nearest known existing habitat for the Regent Honeyeater was at Travelling Stock Reserves (TSR) near Bundarra, about 50 kilometres southwest of SWF. During an informal survey, a pair of Regent Honeyeater were sighted in this area on 10th of October 2019 (A. Barati, personal observations). Birds remained in the area for about two weeks, but based on other reports, failed to breed in this habitat.

5.2. Mitigation measures to reduce risk

Section 5.1 of the BBAMP outlines mitigation measures to be implemented to reduce risk to 'at-risk' species identified in Section 3.5 of the BBAMP. This included a carrion removal program aimed at reducing predator occurrence on site, namely Wedge-tailed Eagles. This is outlined below:

- A designated suitable person will be appointed (such as a wind farm employee or landowner) to perform the function of Carrion Removal Coordinator who will undertake the activities described below.
    - Monthly inspections of the wind farm site to search for any stock, introduced or native mammal and bird carcasses (to be recorded as incidental finds) that may attract raptors (e.g., kangaroos, pigs, goats, foxes, rabbits, dead stock). This search will be undertaken via vehicle and visual checks in addition to using binoculars to look for large carcasses within 200 metres of each turbine.
    - Additional, opportunistic observations by operators during normal inspections and work routines and by landowners as they travel around their properties provides further opportunity to identify and report carcasses of stock or feral animals so that timely collection can be undertaken to remove them. This can be addressed by operator and landowner protocols.
    - Any carcasses and/or remains found that are within 200 metres of turbines, will be collected and disposed of as soon as possible, in a manner that will avoid attracting raptors close to turbines.
    - Consult with landowner or site or asset manager in relation to the appropriate disposal of collected carrion, to be located at least 200 metres away from the closest turbine.
    - Wind energy facility maintenance staff and landowners will be required to notify the Carrion Removal Coordinator immediately following identification of carrion on site in between monthly searches.
    - Carcass occurrence and removal will be recorded in a "management log book" maintained by SWF asset manager.

The Nature Advisory zoologist on site (Ahmad Barati pers. comms.) indicated that no carrion was observed under the turbines during the first year and that this was likely related to severe drought experienced in the region prior to 2020. Stock was observed primarily around water sources and animals were fed artificially through grain etc., away from turbines. During late 2019 and early 2020 the region received higher rainfall which resulted in higher grass.

Pest animal baiting is done in August by land holders annually.

6. Bird Utilisation Surveys

This section outlines bird utilisation surveys (BUS) undertaken at SWF to date. Two BUS surveys were undertaken during the monitoring program; one in Summer 2019/20 and another in Spring 2021.

The Summer 2019/20 BUS is detailed in the First Annual Report for Sapphire Wind Farm (Nature Advisory 2020) and summarised below. Refer to that report for detailed methodology and results.

The following section details methodology and results of the Spring 2021 BUS and compares results between the two surveys. The preconstruction surveys (ELA 2011) were undertaken by a different consultancy under a different methodology and unfortunately could not be used for before and after construction comparison.

6.1. Pre construction BUS survey (2009)

The data were collected from five survey periods between 27th October 2008 and the 15th May 2009. The results are outlined in the ecological assessment report by ELA (2011).

Bird surveys were undertaken by ELA (2011) and included the following.

- A total of 48 diurnal bird surveys were undertaken throughout the wind farm site, using the two hectare – 20 minute approach adopted from the Birdlife Australia methodology
- Incidental observations were also made while traversing around the site
- Call playback for nocturnal birds over 11 nights; and
- Spotlighting for 16 person hours.

6.1.1. Results

A total of 83 bird species were recorded during surveys, two of which were introduced. These species are listed in Appendix E of ELA (2011). The study area supports potential foraging habitats throughout all seasons and breeding as well as roosting habitat for a wide variety of bird species. Hollow bearing trees, suitable for breeding and roosting by birds and bats also occurred in a variety of areas. Habitat for wetland bird species was limited primarily to farm dams. Key findings include:

- No owl species were recorded;
- Raptor species recorded included:
    - *Falco cenchroides* (Nankeen Kestrel);
    - *Aquila audax* (Wedge-tailed Eagle);
    - *Elanus axillaris* (Black-shouldered Kite);
    - *Accipiter fasciatus* (Brown Goshawk); and
    - *Haliastur sphenurus* (Whistling Kite);
- Seven threatened species were recorded in the study area:
    - *Climacteris picumnus victoriae* (Brown Treecreeper);

- *Stagonopleura guttata* (Diamond Firetail);
- *Melanodryas cucullata cucullata* (Hooded Robin);
- *Glossopsitta pusilla* (Little Lorikeet);
- *Petroica boodang* (Scarlet Robin);
- Pyrrholaemus saggitatus (Speckled Warbler); and
- Neophema pulchella (Turquoise Parrot).

- Twelve listed migratory species were identified as potentially occurring from an EPBC Act protected matters search within the study area. Of these, potential habitat occurred for seven species. None were recorded during surveys.

The bird utilisation surveys were considered a suitable level of effort to provide the basis of a program to monitor the impacts of the wind farm on birds.

6.2. Summer 2019/2020 BUS summary

The findings of the Summer 2019/2020 BUS are below:

- The areas inside and surrounding Sapphire Wind Farm are largely made of cleared plateaus supporting a low diversity and abundance of common, predominantly farmland birds. Notably, the area supports a low diversity of raptors due to the lack of suitable habitats.
- The bird utilisation surveys recorded a total of 50 species of birds; 42 at the impact and 41 at the reference points.
- The species with the highest frequency of observation was Noisy Miner followed by Australian Magpie and Eastern Rosella. The five main species observed during BUS, comprised 41% of all individual birds recorded at the impact survey points and about 35% at the reference survey points.
- The relative abundance of birds varied between the six observation points, depending on the habitat surrounding each of the points. Points within or close to patches of remnant woodlands returned higher relative abundance than those within open treeless habitats. Survey sites with more mature native trees, that are located close to or within a remnant woodland attracted more birds than highly cleared grazing paddocks. Despite these variations, the diversity of species at impact and reference points did not significantly differ based on statistical tests, suggesting a more uniform habitat across most parts of the wind farm and surrounding areas.
- The majority of birds were recorded flying below RSA heights (99.65% at impact & 100% at reference points).
- Overall, a low proportion of birds (0.25%) were observed at RSA height. The Wedge-tailed Eagle was the only species recorded at RSA height.
- Waterbirds were found to be largely confined to farm dams and were mainly very common waterbird species including Australian Wood Duck and Straw-necked Ibis.
- The Speckled Warbler was the only threatened species (BC Act) recorded utilising the wind farm site. This species was recorded at reference point 2, away from the turbines.

6.3. BUS Survey summer 2021

The bird utilisation survey (BUS) was undertaken consistent with 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).

6.3.1. Methods

A fixed-point count method was used in the survey. The fixed-point bird count method involved an observer stationed at a survey point for 15 minutes. The adequacy of using 15 minutes as a period to record the presence of birds during bird utilisation surveys was investigated in an earlier study at another wind farm site (Brett Lane & Associates Pty Ltd, unpublished data). The study showed that 82 to 100 percent (average 88 percent) of species actually 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 the survey.

During this period, all bird species and numbers of individual 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 height is presented as below, at or above rotor swept area (hereafter RSA) height:

- **A =** Below RSA (< 73 metres above ground)
- **B =** At RSA (74 – 200 metres above ground)
- **C =** Above RSA (> 200 metres above ground)

During the surveys, eight counts (replicates) were made at each of the four-impact and two reference points. Table 9 indicates when each point was counted on each survey day. This schedule ensured that all points were visited equally at different times of day to allow for time-of-day differences in bird movements and activity.

Table 9: Times when points were counted for each fixed-point bird count survey day

Time	Day 1	Day 2	Day 3
7:30		RF2	BUS1
8:00		BUS3	RF1
8:00		BUS4	RF2
8:30		BUS2	
9:00		RF1	BUS3
9:30	BUS2	BUS1	BUS4
10:00	BUS1	RF1	BUS1
10:30		BUS2	RF1
10:30		RF2	BUS2
11:00		BUS4	RF2
11:00		BUS3	BUS3

Time	Day 1	Day 2	Day 3
11:30		BUS4	
12:00		BUS2	
12:30	RF2	RF1	BUS1
13:00	BUS4	BUS1	
13:30	BUS3	BUS2	BUS3
13:30		RF2	
14:00		BUS4	
14:30	BUS2	BUS3	BUS4
15:00		BUS4	BUS3
15:30		RF2	RF2
15:30		BUS1	RF1
16:00		RF1	BUS1
16:30			BUS2

Note: See Figure 1 for survey point locations. The prefix 'Ref' refers to reference points.

6.3.2. Locations of survey points

Six fixed survey points were established; four impact points and two reference points. Impact points were located near operational turbines and reference points were located at least 500 metres away from impact points in areas of similar habitat (Figure 14).

The survey points were distributed as evenly as possible (subject to access constraints) across the wind farm to sample the various habitat types and maximise coverage in areas where wind turbines are located. Impact points were positioned as far as possible on elevated ground, allowing a clear view in all directions. Table 10 below provides a description of the habitats associated with each impact and reference point.

Table 10: Habitat associated with each survey point

Survey point	Habitat
BUS01	Located in inside the wind farm, close to turbine number 59. A remnant of native vegetation but also close to a large fragmented area with scattered trees. Clean understory cover.
BUS02	Inside the farm close to turbine number 58. Large open area but some scattered eucalypt trees some. Clean understory cover. Cattle and sheep grazing area.
BUS03	Located on the top of ridge, close to turbine 10. Fragmented on one side but some scattered eucalypts present at other slope. Area dominated by reverse keystone species such as Noisy Miners. Clear understory cover.
BUS04	Near turbine 5. Close to a remnant patch of eucalypt trees, but open area and highly modified on one side. Clean understory vegetation. Close to small dam.
Ref1	Inside the windfarm, about 700 metres from turbine 58. Small patch of native woodland mainly eucalypt trees.
Ref2	Located outside windfarm boundaries, at about 500 south west of the main office, close to the road. This area contains a remnant of native eucalypt trees with some grassy understory. Relatively suitable habitat for woodland birds.

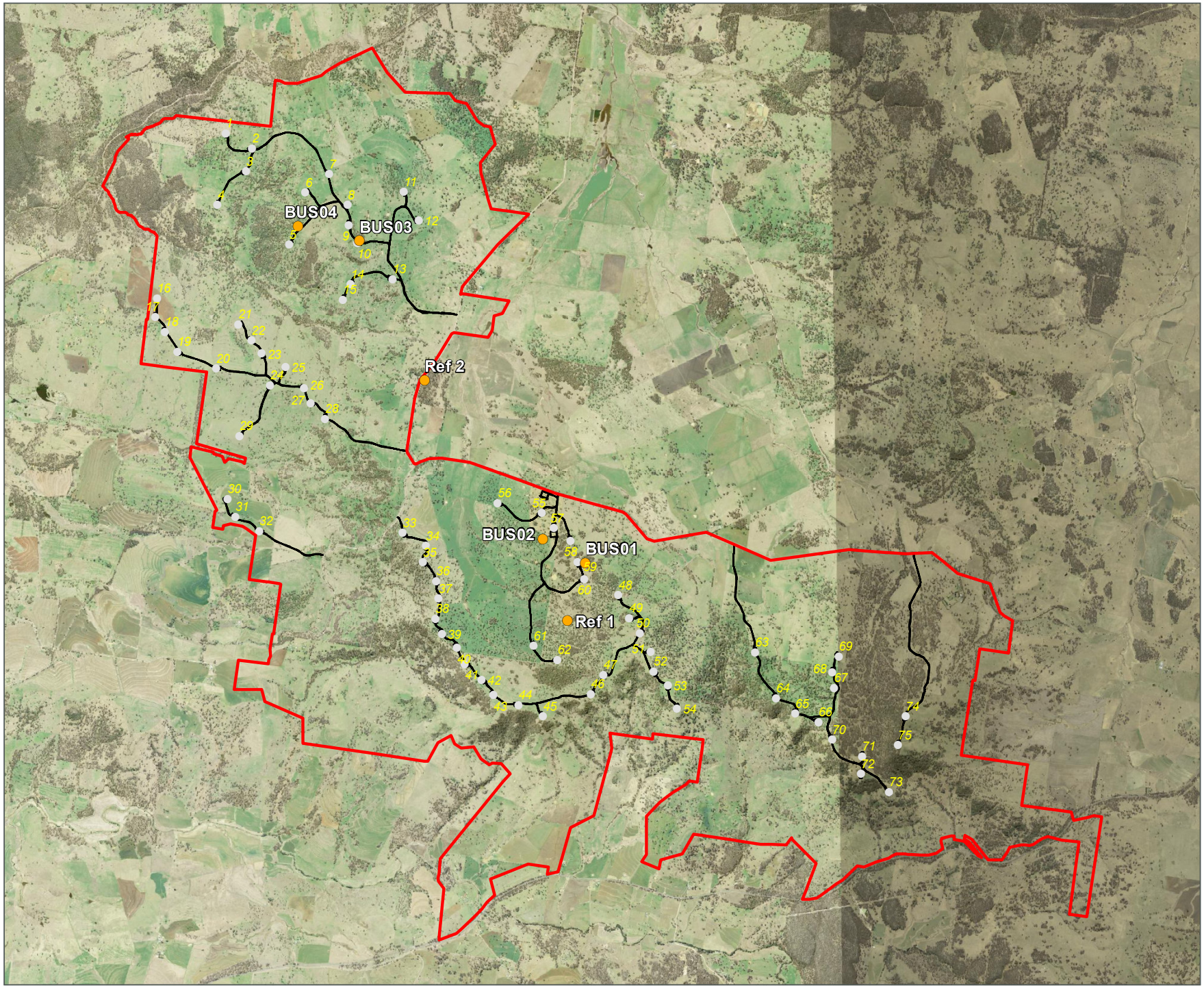

Figure 14Location of BUS points at Sapphire Wind Farm

Project: Sapphire Wind Farm BBAMP
Client: CWP Renewables Pty Ltd
Date: 03/04/2020

- Study area
- Turbines
- Access tracks
- BUS and reference points

N

Kilometers
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6.3.3. Incidental observations

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

6.3.4. Limitations

The current bird utilisation survey was undertaken during summer of 2021. The utilisation rates and species abundances recorded during the current survey are considered to be representative of the site. They are also considered to provide a reasonable basis on which to assess the bird risks associated with the Sapphire Wind Farm.

6.3.5. Data preparation and statistical analysis

Observations were recorded in the pre-defined filed observation forms. Raw data were then entered into spreadsheet file and tables and graphs were extracted. Graphs were generated in Microsoft Excel and R (R Core Team 2018). 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 different BUS, analysis of variance (ANOVA) was performed, with species diversity and abundance as dependent factor and sites type (impact/reference) as predicting parameter. All statistical analyses were undertaken in R environment (R Core Team 2018).

6.3.6. Results

6.3.7. Survey Suitability

The cumulative number of species observed from the consecutive fixed-point bird counts conducted at the observation points during the spring survey period has been plotted in Figure 15.

The cumulative species–count sequence curve below shows a clear asymptote, suggesting that the number of new species added to the diversity levelled off after around 40 counts, and only few species were added afterwards. The result strongly suggested that the surveys provided a representative picture of the diversity of bird species flying over the wind farm site during the survey period.

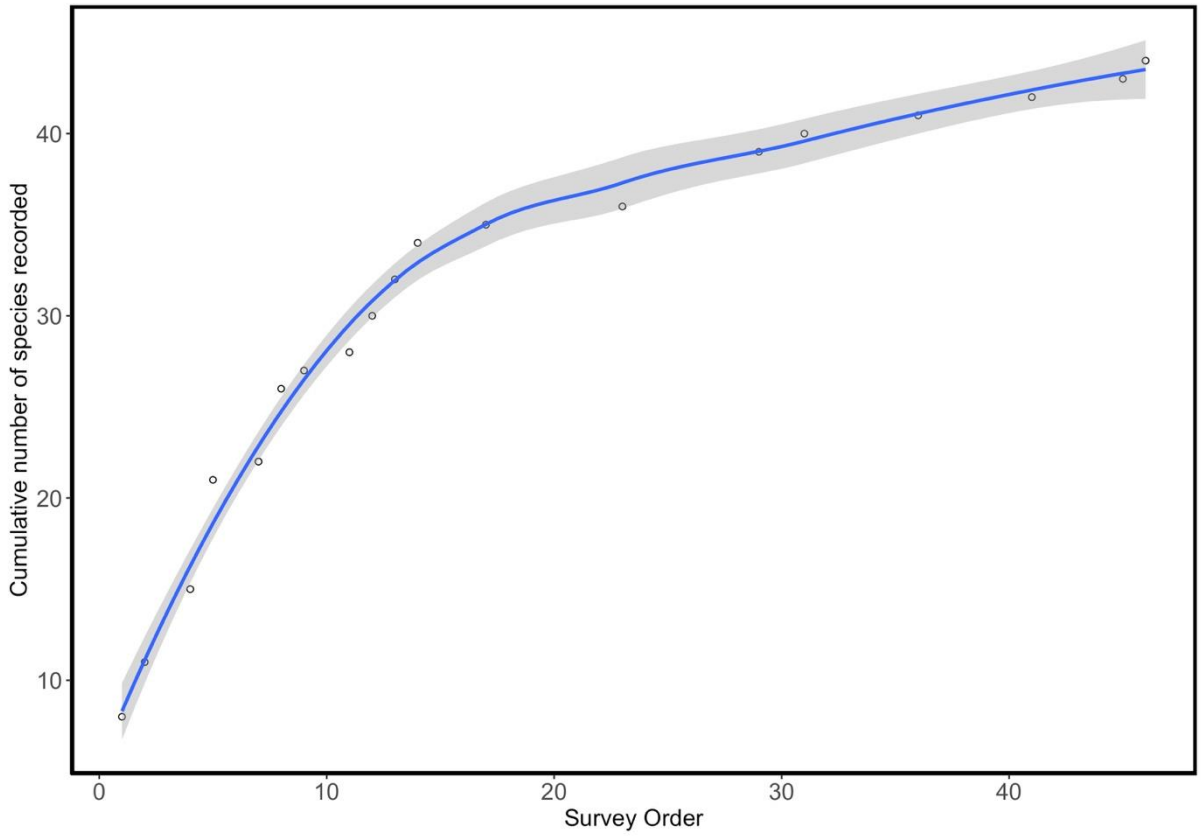

Figure 15: The cumulative number of species of birds recorded during consecutive counts at the BUS points at SWF

6.3.8. Species frequency and abundance

Overall, 44 bird species were recorded during the survey as summarised in Figure 16. Of all species recorded, 40 were recorded at the impact survey points and 32 at the reference sites (Table 11, Figure 16 & Figure 17). Species recorded during these surveys were predominantly farmland and bushland species with limited records of raptors and waterbirds. The raw data is presented in Appendix 4.

At the impact points, the Species with the highest frequency of observation were Noisy Miner (occurring in 31 out of 32 surveys) followed by Eastern Rosella (28 out of 32) and Australian Magpie (26 out of 32). At the reference sites, the species with highest observation were Noisy Miner (occurring in 16 out of 16 surveys), Easter Rosella (16 out of 16) and Sulphur-Crested Cockatoo (12 out of 16). Common species dominated the count although with slight change in the sequence of the common species. Thus, nearly similar pattern was observed between impact points and reference sites with the Noisy Miner being the most frequent species recorded during surveys.

Species richness (e.g., mean number of species per site) varied between the six observation points, but rather insignificantly (see below for details). The number of species recorded at each of the observation points was influenced mainly by availability of habitat diversity, and was usually higher on points surrounded by remnant vegetations, that include large trees, than those

points in open, treeless habitats. Table 11 presents the distribution of bird numbers (relative abundance) and their height distribution among the impact and reference observation points. Figure 18 and Figure 19 present this graphically.

The five most common species with respect to their abundance (e.g., number of individuals recorded) at the impact and reference survey points are presented in the table below. These five species comprised 64% of all individual birds recorded at the impact survey points and about 69% at the reference survey points. The common resident species were the leading species and dominated over the summer season.

Table 11: Highest species abundance of impact and reference points

Impact survey points (% of total individuals birds recorded)	Reference survey points (%of total individuals birds recorded)
Noisy Miner (21.07%)	Noisy Miner (26.37%)
Sulphur-crested Cockatoo (13.34%)	Eastern Rosella (18.14%)
Eastern rosella (13.09%)	Sulphur-crested Cockatoo (14.76%)
Red-rumped Parrot (9.7%)	Australian Magpie (6.11%)
Australian Magpie (7.3%)	Galah (5.27%)

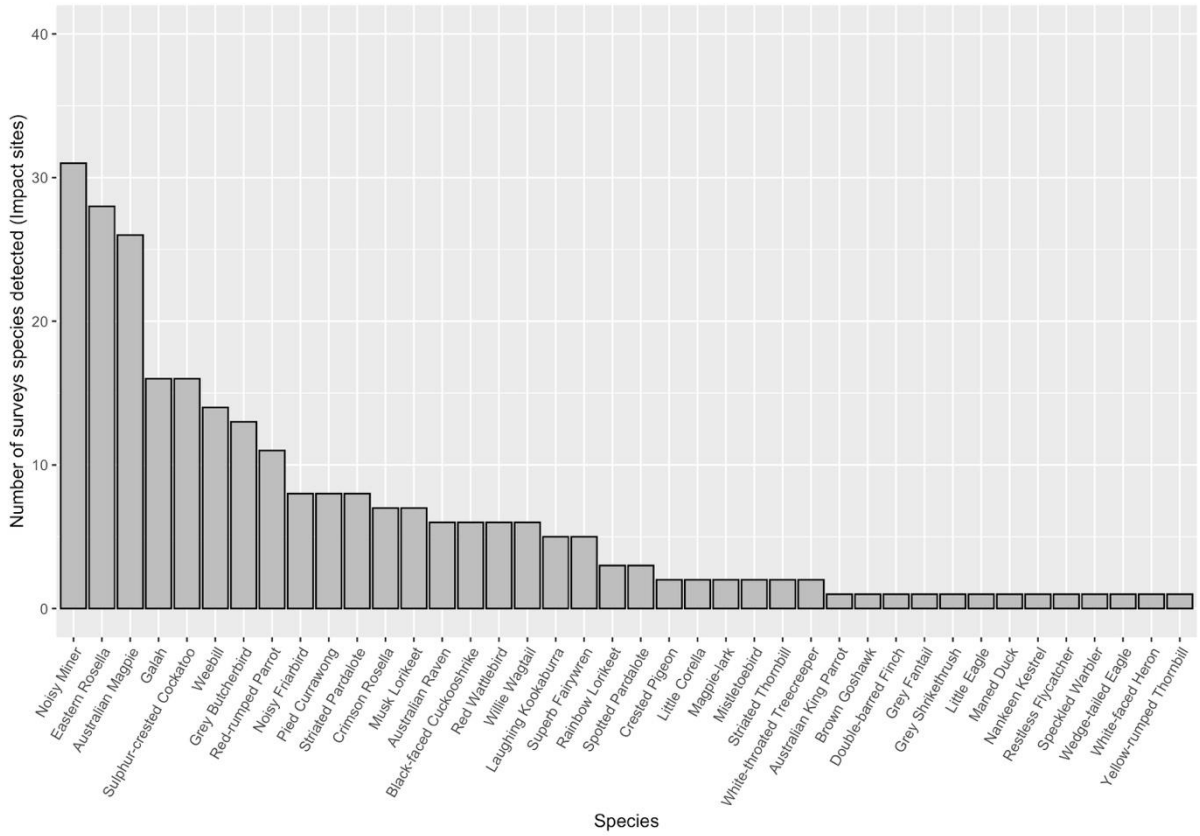

Figure 16: Frequency of species detection in impact sites at SWF. Values represent the number of surveys that a given species was observed

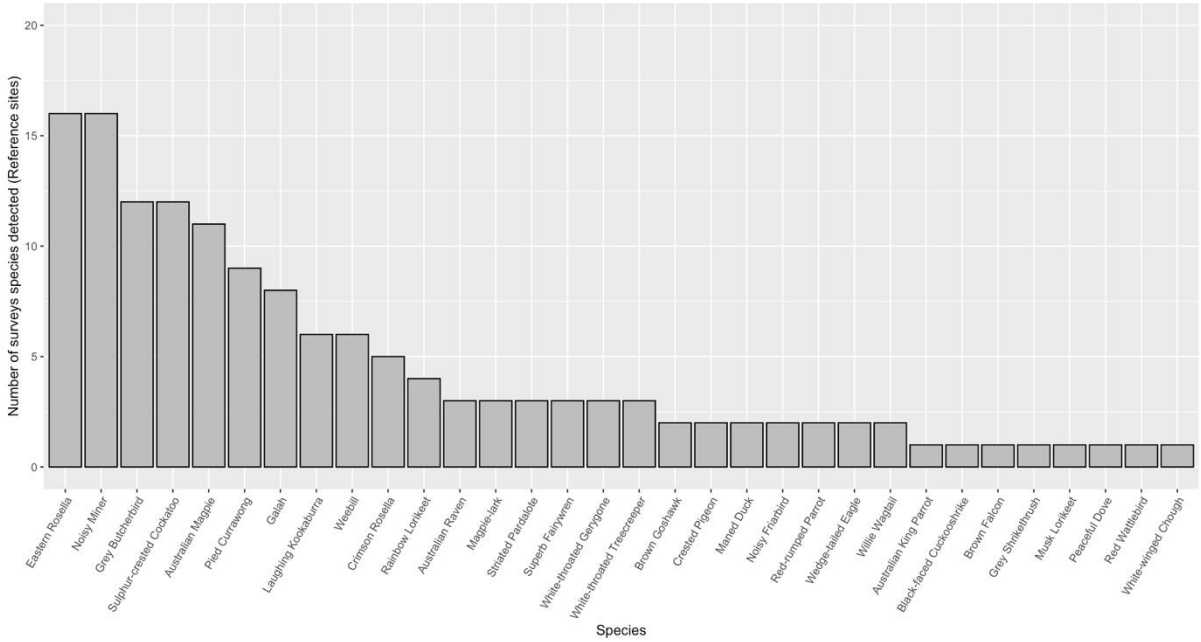

Figure 17: Frequency of species observed at reference sites. Values represent number of surveys that a given species was detected.

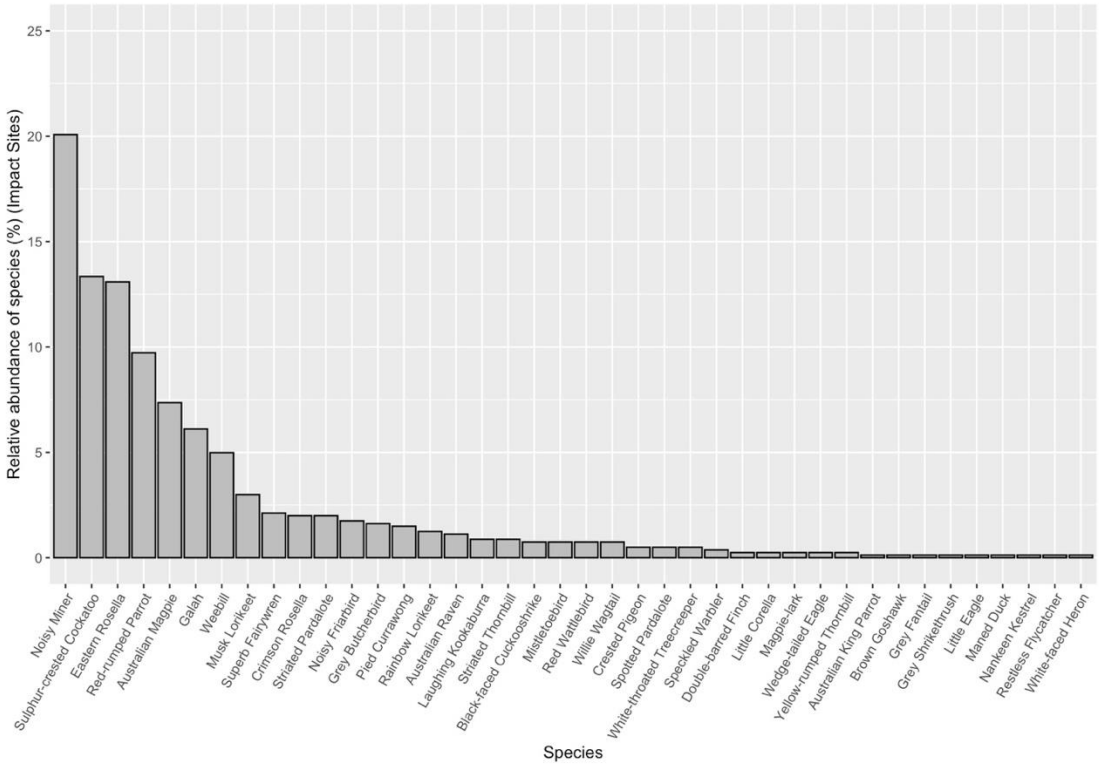

Figure 18: Relative abundance of species observed in impact sites at SWF. Values represent percentages of individual from a given species.

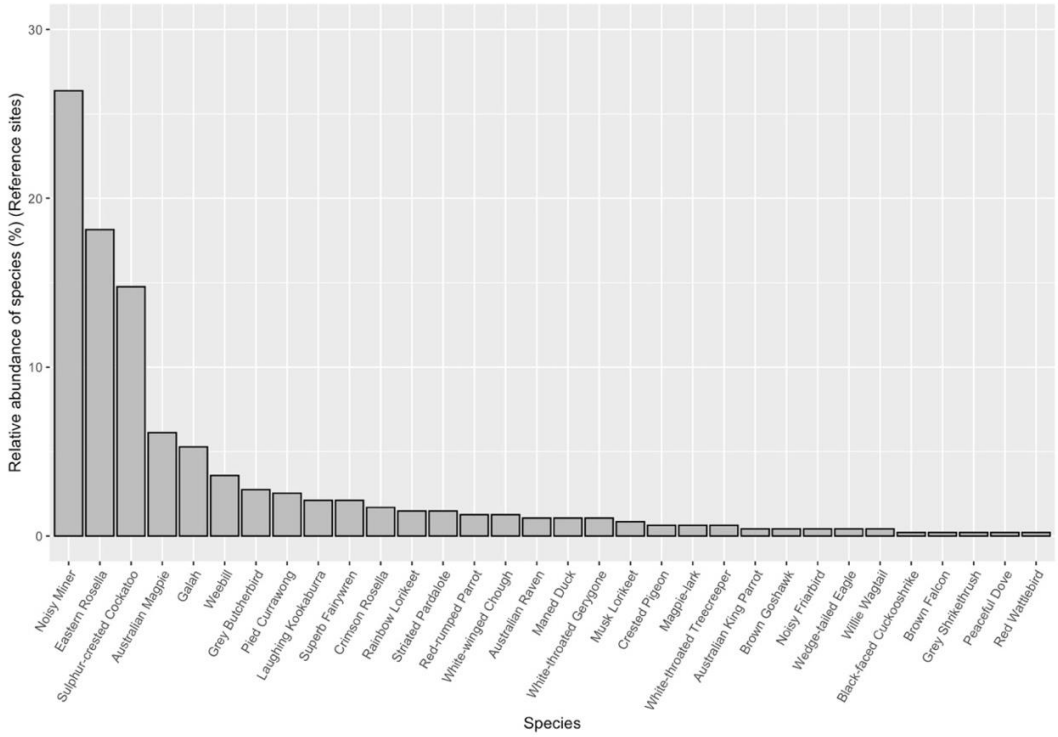

Figure 19: Relative abundance of species observed in reference sites at SWF. Values represent percentages of individual from a given species

6.3.9. Variabilities of species richness and abundance among survey points

The diversity of bird species (species/survey) varied between the six observation points and depended on the habitat surrounding each of the points. Table 12 summarises results for abundance and height distributions for each point. Points within or close to patches of remnant woodlands returned higher richness than those within open treeless habitats. Those 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. These types of location included points BUS01 which showed the highest diversity of birds compared to highly cleared areas such as BUS03 and BUS04 (Figure 20). The species richness per survey varied from 11.75± 1.6 (mean ± se) at BUS02 to 5.8 ± 0.83 at BUS04. Mean number of species detected per site was 7.06 ± 0.63 at impact points and 9.06 ± 0.86 at reference points. ANOVA test suggested that this difference is not significant (ANOVA, F=0.84, df=1&46, p=0.36).

Similar to the species diversity patterns, mean abundance of birds (number of birds/survey) varied between sites. The variations of abundance among site were higher compared to variations of species richness (Figure 21). Mean number of birds recorded per survey varied from 35.5 ± 5.2 individuals/survey at BUS02 to as low as 14.5 ±1.9 individuals/survey at BUS03, with an average value of 27.5 ± 3.5 individuals/survey across all sites (Figure 8). In addition, the mean abundance of birds recorded per survey at impact points was 25.06 ± 2.6 individuals/survey whereas the mean abundance at reference points was slightly higher (29.62 ± 3.8). The difference between mean abundance of bird was found to be statistically insignificant between impact and reference points (ANOVA, F=0.95, df=1&46, p=0.33). Generally, similar to species richness, points within or close to patches of remnant woodlands returned higher abundance than those within open treeless habitats.

Table 12: Summary of the relative abundance (numbers) and height distribution of bird at the impact and reference points during spring survey at SWF

Observation points/ Impact	A	B	C	Total	% Importance	% at RSA
BUS1	279	0	0	279	22	0
BUS2	284	0	0	284	22	0
BUS3	114	2	0	116	9	1.7
				123	10	
Impact Total	**800**	**2**	**0**	**802**	**63**	**0.27**
Ref 2	244	1	0		19	0.44
Ref 1	228	1	0		18	
Reference total	**472**	**2**	**0**	**474**	**37**	**0.44**
Grand Total	**1272**	**4**	**0**	**1276**	**100**	**0.31**

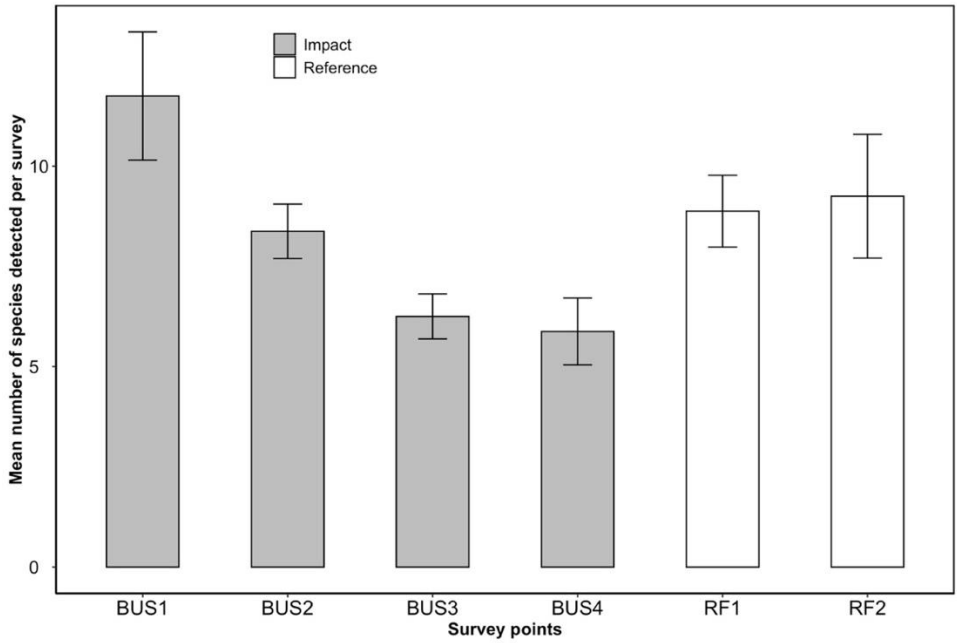

Figure 20: Mean richness (number of species per survey) of birds among impact and references survey points

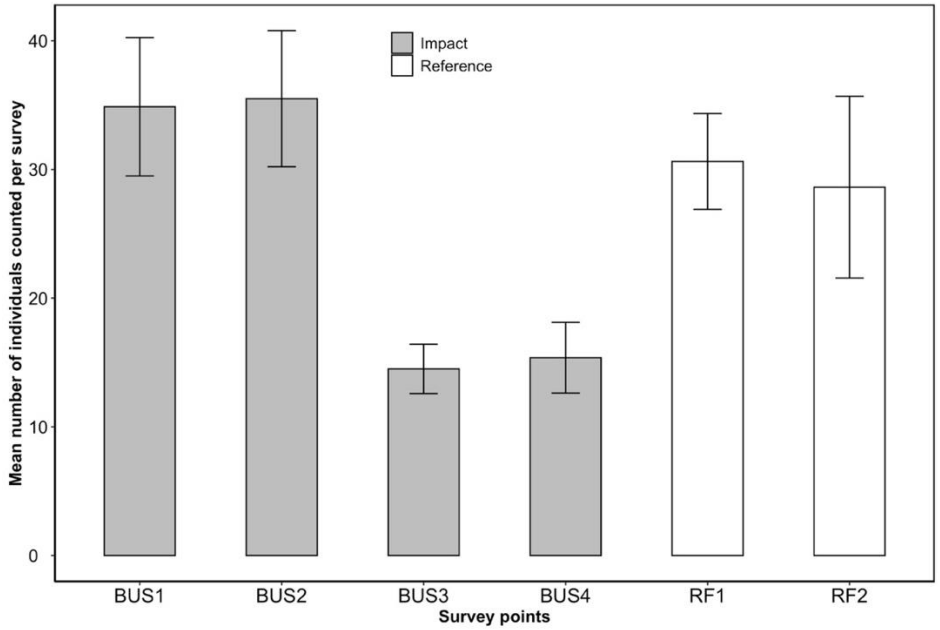

Figure 21: Mean abundance (number of birds recorded per survey) at impact and survey points

6.3.10. Flight Heights

Bird observation heights were classified as below RSA (< 73 metres), at RSA (74–200 metres), and above RSA (> 200 metres) heights. Table 13 presents a summary of observations in each height class and detailed results of the species numbers recorded in each the are presented in Appendix 4.

Birds were not distributed equally in different height groups (A, B and C) Figure 22. A significant proportion of birds were observed at the height of below RSA ($\chi^2 = 1260$, df=2, $p < 0.0001$). The same patterns were observed for impact and reference points separately (Impact sites: $\chi^2 = 794$, df=1, $p < 0.0001$; Reference sites: $\chi^2 = 466.2$, df=1, $p < 0.0001$) with the majority of birds occurring at the height of below RSA. The majority of birds were recorded flying below RSA heights at impact (99.7%, Figure 9) and reference points (99.5%).

Table 13: Summary of number of birds recorded at the three flight heights at SWF

Flight Height	Impact survey points		Reference survey points	
	Number of birds	Percentage of all birds	Number of birds	Percentage of all birds
A (below RSA)	800	99.7%	472	99.5%
B (at RSA)	2	0.3%	2	0.5%
C (above RSA)	0	0	0	0
Total birds recorded	**802**	**63%**	**474**	**37%**

The diversity of species of birds seen flying at RSA heights was very low compared to the total birds recorded at impact points and only one species out of 44 species (2%) was observed at RSA height.

Birds flying at the RSA heights consisted only of Wedge-tailed Eagle, which was recorded at both impact and reference sites. The relative abundance of birds flying at RSA heights at each of the survey points was randomly distributed. Wedge-tailed Eagle that were flying at RSA height were observed at Reference Sites 1 and 2 and BUS03 (2 individuals, Figure 23).

Height distribution shows that almost majority of birds flew below RSA height, which were either on the ground or in trees (from 1 to 20 metres height), therefore reducing collision risks between these bird species operational wind turbines. Over 85% of individual birds were observed at the height below 20 meters which, along with the height of turbine towers suggest a low risk of collision for most of the bird species.

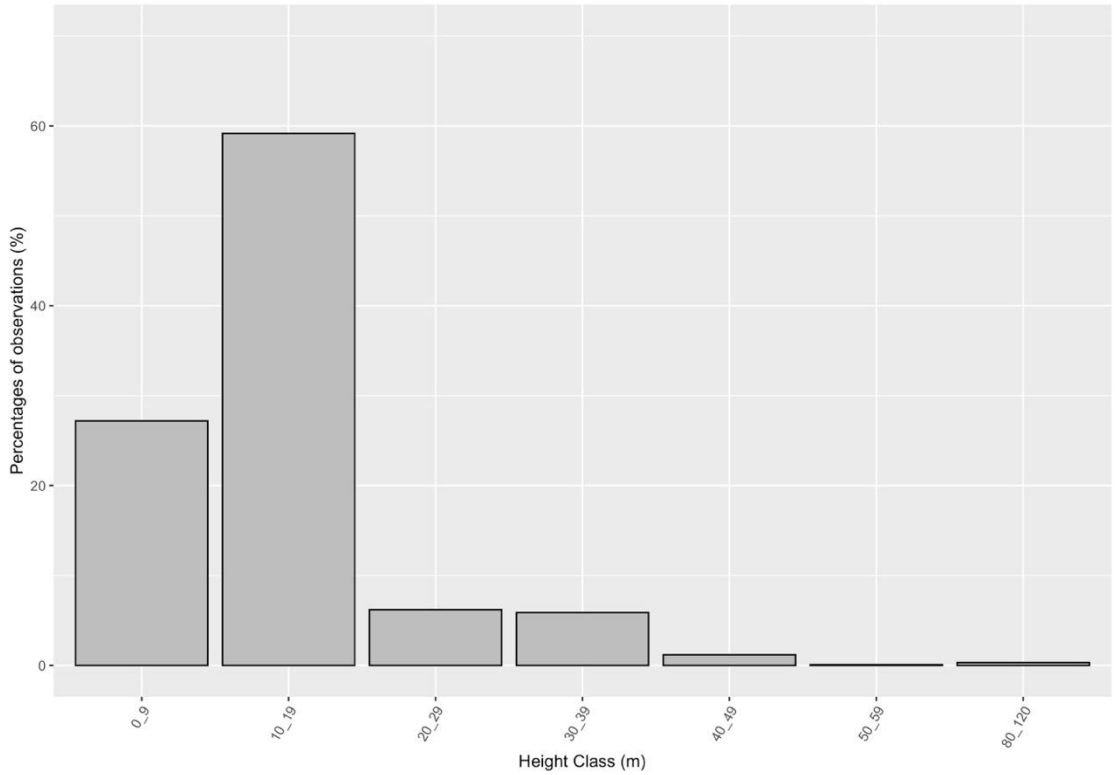

Figure 22: The distribution of bird heights as recorded during BUS at SWF

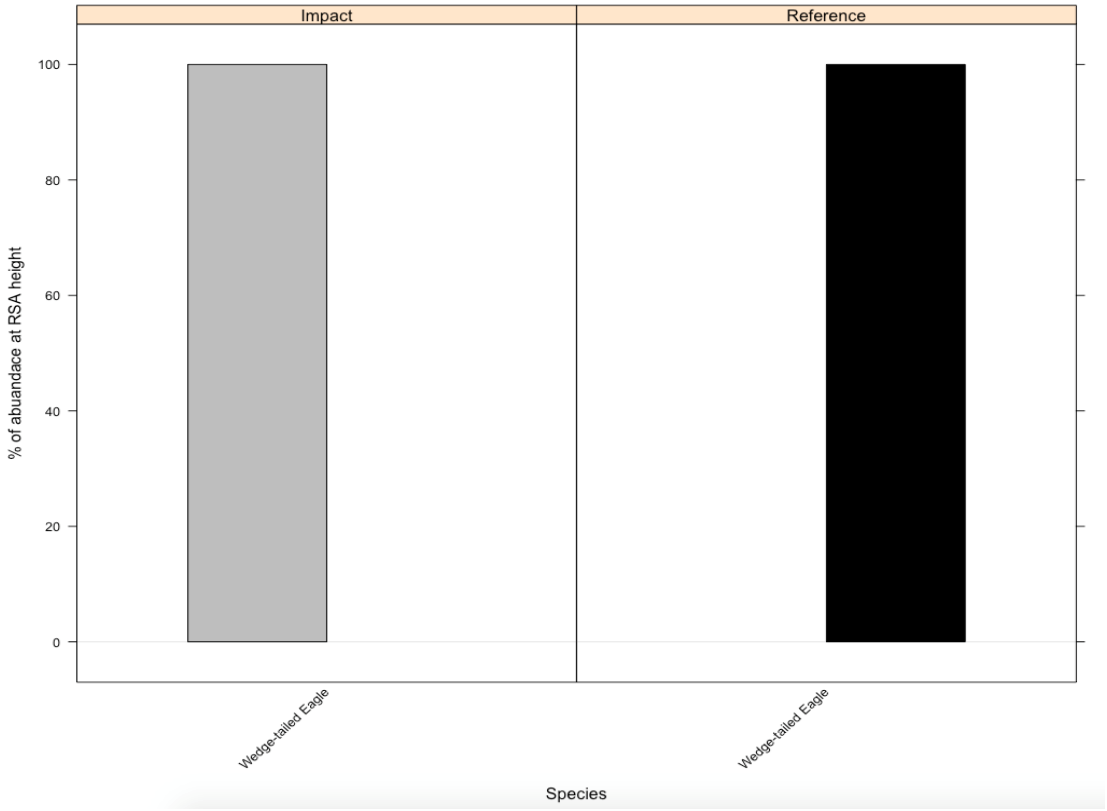

Figure 23: Relative abundance of species observed at RAS height at impact and reference point

6.3.11. Threatened Species

The majority of birds found to utilise the wind farm site were common birds. Two listed species recorded during the bird utilisation surveys; Little Eagle and Speckled Warbler.

The Speckled Warbler *Pyrrholaemus sagittatus* is considered as vulnerable (NSW *Biodiversity Conservation Act 2016*) and occurs throughout most of NSW but is sparsely scattered, with most breeding in the western slopes of the Great Dividing. It is primarily a bird of eucalypt woodlands with an open or sparse understorey and ground cover of grasses. This species was recorded at both 2019 and 2021 BUS. In 2019 BUS, there was one individual of this species recorded during spring surveys in similar areas described above as its preferred habitat. In 2021 BUS, three individuals were recorded. Impacts on this vulnerable species is considered low as the flight height of this species is below RSA risk zone and also given that this species was recorded only once at reference points which was over one kilometre away from the nearest turbine at SWF.

The Little Eagle *Hieraaetus morphnoides* is widespread in mainland Australia. The Little Eagle forages in or over a range of habitats from grassland to forest, mainly woodland or open woodland, and in southern Australia preys on a range of vertebrates though mostly mammals; successful broods are usually of one fledgling (e.g., Marchant & Higgins 1993; Debus 2017). This species is listed as Vulnerable in NSW. During BUS at Sapphire Wind Farm, Little Eagle was recorded once but was flying under RSA height.

6.3.12. Raptors

Five raptor species were recorded during the spring survey, comprising a total of 10 observations (Table 14). The majority of raptors were seen flying below RSA heights (60%), and 40% were recorded flying ta RSA heights. However, the overall importance calculated as a percentage of all birds recorded during BUS was rather low and constituted as low as 0.31%.

The most important raptors seen flying at RSA heights was Wedge-tailed Eagle which made up 100% of observations at RSA height. This species is a known common raptor in most open habitats and recorded as common in many similarly placed wind farms.

Overall, the frequency of observation of Wedge-tailed Eagle was low in this wind farm compared to nearby wind farms. Particularly due to the habitat types of the areas around Sapphire Wind Farm, it is usually rare to observe Wedge-tailed Eagles. Importantly, no active Wedge-tailed Eagle was found at SWF both during BUS. Raptors are usually the most vulnerable species to collision with operating turbines because of their soaring habits while foraging, however, the collision rate of raptors at SWF is considerably low compared to many other wind farms. Most of the areas at SWF are open woodlands with usually a flat landscape thus not an ideal habitat for raptors such as Wedge-tailed Eagles. The low occurrence of Wedge-tailed Eagle is reflected both in BUS and raptor observations at SWF.

6.3.13. Waterbirds

Only one waterbird species was recorded in this survey which was a White-faced Heron. This species was recorded only once and was observed below RSA height (Table 14). White-faced Heron is a very common farmland waterbird that usually found along the edges of farm dams and forage in open paddocks next to the dams during day and night.

Table 14: Raptor and Waterbird species recorded at the impact survey points during spring survey at Sapphire Wind Farm

Species	Total number of birds	Total flying at RSA heights	% flying at RSA heights	% RSA of total RSA birds	% RSA bird of all BUS birds
Raptors					
Brown Falcon	1	0	0	0	0
Brown Goshawk	3	0	0	0	0
Little Eagle	1	0	0	0	0
Nankeen Kestrel	1	0	0	0	0
Wedge-tailed Eagle	4	4	100	100	0.31
Total raptors	10	4	40	100	0.31
Waterbirds					
White-faced Heron	1	0	0	0	0
Total Waterbirds	1	0	0	0	0
Grand Total	**11**	**4**	**40**	**100**	**0.31**

6.4. Comparison between 2019 and 2021 post-construction BUS results

As per Sapphire Wind Farm BBAMP, two BUS surveys were conducted at project site. A total of 44 bird species of birds were recorded during 2021 survey, of which 40 species were recorded at the impact survey points and 32 at the reference sites. In 2019 surveys, higher quantities of bird species were recorded with a total of 50 species of birds; 42 at the impact and 41 species occurring only at the reference points. The different between the species richness between two survey was not statistically significant. However, there was a significant difference between the two surveys in term of mean number of birds recorded per survey. Overall, mean number of birds recorded per survey was 16.54 ± 0.98 in 2019 BUS and 26.58 ± 2.19 in 2021 BUS. Statistical analysis suggested that the mean number of birds (species abundance) was significantly higher in 2021 BUS (Figure 24).

However, it is noted that there was a considerable ecological shift in the period around the summer of 2020. The drought and the bushfires of 2019-20 are likely to have changed the pattern of movement in bird species. These changes were not able to be quantified through these surveys.

With respect to threatened species, during both BUS in 2019 and 2021, Speckled Warbler was recorded as a listed species. In 2021 BUS, in addition to Speckled Warbler, Little Eagle was also recorded during surveys.

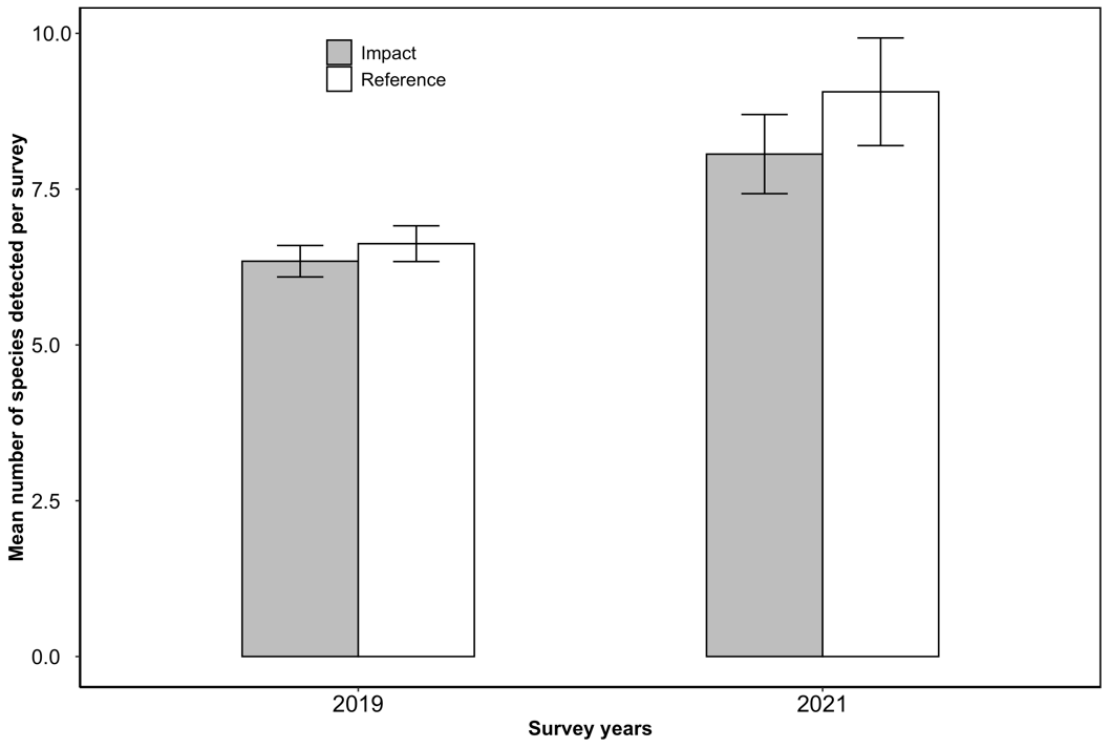

Figure 24: Mean abundance (number of birds recorded per survey) at impact and survey points during 2019 and 2021 BUS at Sapphire Wind Farm

6.5. Conclusions

The conclusions from the current spring BUS of the Sapphire Wind Farm are presented below:

- The areas inside and surrounding Sapphire Wind Farm are largely made of cleared plateaus supporting a low diversity and abundance of common, predominantly farmland birds. Notably, the area supports a low diversity of raptors and waterbirds due to the lack of suitable habitat.
- A total of 44 bird species were recorded during this survey of which, 40 species were recorded at the impact survey points and 32 at the reference sites.
- The species with the highest frequency of observation was Noisy Miner in both 2019 and 2021 surveys occurring in about 70% of surveys followed by other common species such as Australian Magpie and Easter Rosella. These five species comprised 64% of all individual birds recorded at the impact survey points and about 69% at the reference survey points. The common resident species were the leading species and dominated over the summer season.
- The relative abundance (birds/ha/hour) varied between the six observation points, depending on the habitat surrounding each of the points. Points within or close to patches of remnant woodlands returned higher relative abundance than those within open treeless habitats. Survey sites with more mature native trees, that are located close to or within a

remnant woodland attracted more birds than highly cleared grazing paddocks. Despite these variations, the richness of species at impact and reference points did not significantly differ based on statistical tests, suggesting a uniform habitat across most parts of the wind farm and surrounding areas.

- In this survey, the majority of birds were recorded flying below RSA heights (99.7% at impact and 99.5% at reference points). Similar results were observed in 2019 surveys with over 89% of birds recorded flying below RSA height at impact sites and 96% at reference points.
- Overall, a low proportion of birds (0.31%) were observed at RSA height. All birds recorded flying at RSA heights were Wedge-tailed Eagles. During 2019 surveys, other species such as Australian Raven and Nankeen Kestrel were also recorded flying at RSA height.
- The diversity of waterbirds was low with only one species recorded during the surveys and with only one individual.
- Two listed species were recorded at Sapphire Wind Farm including Little Eagle and the Speckled Warbler. The Speckled Warbler was also recorded in 2019 BUS suggesting that they might have a viable population within the site. Little Eagle was the other listed species recorded during this BUS. Little Eagle was not recorded in 2019 surveys but in one case an indicial collision of Little Eagle with the power lines was recorded at the early stages of the wind farm operation.

7. Discussion

The post-construction bird and bat carcass searches for the 31 months of the operation of SWF were undertaken in accordance with the approved BBAMP (BL&A 2017).

Between July 2018 and January 2021 all selected turbines were searched at least 24 times. In total 930 turbine searches were undertaken (including 463, 100-metres radius searches and 464 60-meter radius). During these searches; 14 bird carcasses, 10 bats and 13 feather spots were found. A total of 9 birds, two feather spots and one bat were found incidentally. This consisted of 15 bird and five bat species identified. It is estimated there was a total site loss (all turbines combined) of around 166 bats and 457 birds (including confidence intervals) over the survey period. For birds this equals roughly 0.2 birds per turbine per month and 0.01 bats per turbine per month over 31 months.

The Australian Magpie was the most abundant of all bird and bat species mortalities found during formal searches, making up 18% of all mortality combined, followed by Wedge-tailed Eagle, which made up 13% of all mortality. These results are not unusual for wind farms in NSW (Nature Advisory unpublished data) as both are common and widespread farmland species. Australian Magpie was the third most abundant bird observed in the BUS, after Noisy Miner and Eastern Rosella however, Noisy Miner recorded no mortalities and Eastern Rosella only two. This is likely related to Australian Magpie's preference for open habitats common in farmlands and typical positions for turbines in landscapes, whereas the others prefer woodlands. While not observed in the BUS, it is not uncommon for Magpies to fly quite high when traversing the landscape, as is evident in mortality results.

Of the five bat species found 60% of these consisted of White-striped Freetail Bat. A number of studies (Symbolix 2020, Moloney et. al 2019, Smales 2012) have identified this species is commonly over-represented as mortalities across 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 with which it prefers to fly many times the height of the tree canopy for high flying insects. This unfortunately brings them into RSA of turbines.

It is unlikely that the results from the monitoring program or the mortality estimates suggest a significant impact on any of the species identified as mortalities. Each is a relatively common and widespread species to farmland landscapes in NSW and other parts of Australia, and each is considered secure and not in decline. It is unlikely that BWF would have a significant impact on any populations regionally, on a state level or overall. That said, Wedge-tailed Eagle was identified as an 'at-risk' species in the BBAMP and is considered further below.

The relatively high Wedge-tailed Eagle mortalities, compared with other species, is reflected in the raptor monitoring results, where Wedge-tailed Eagle was observed the most often from the three raptor species, and the BUS, where it was the only species observed flying at RSA height of all bird species observed. Wedge-tailed Eagle foraging habits are likely to main reason why this species was a frequent mortality. The species tend to soar from close to the ground, to many

hundreds of metres above it while searching for foraging opportunities, which unfortunately will bring them into RSA height and increase risk of collision compared with other species. It is estimated that 13 individuals were lost during the monitoring period. Statistical analysis showed the number of Wedge-tailed Eagles lost in the second year was significantly higher than the first. This may be related to the easing of drought conditions during the second year of monitoring providing more foraging opportunities in the area. While this level of mortality is not considered significant for the species, there are mitigation opportunities which can further reduce mortality risk for the 'at-risk' species. These are outlined in Section 8.

The estimated mortality and mortality monitoring results are relatively low compared with other wind farms that Nature Advisory monitors (Nature Advisory unpublish data) in northern NSW. This is likely related to the lower RSA height of turbine blades at SWF. A lower blade tip of >70 metres RSA appears to reduce the numbers of species which are likely to enter RSA, particularly that of micro-bat species (Section 3.2.1). This is generally supported by BUS surveys, where only Wedge-tailed Eagle was observed using RSA airspace, and mortality results which held low species diversity of mortalities and numbers of which were made up primarily of Australian Magpie and Wedge-tailed Eagle.

Additional reasons for low mortality may include; habitat types, with cleared and fragmented areas throughout the wind farm providing poor habitat for many species and foraging opportunities. The 2019 bushfire and drought resulting in comparatively low movement and activities of species around the wind farm, the consequences of which may have extended into the second year of monitoring.

Poor and limited habitat is likely the main reason for a lack of other 'at-risk' species observations during BUS or incidentally. White-throated Needletail, Regent Honeyeater or Swift Parrot were not observed during the monitoring program. The main habitat; Ironbark trees, are in very low numbers on the site and even when flowering would provide very limited habitat and foraging opportunities for the species. Therefore, risk from SWF operation is considered to be very low for these species and additional monitoring is not recommended.

Statistical analysis suggested that the mean number of birds (species abundance) was significantly higher in 2021 BUS. This variations in the abundance of birds could be associated with ecological conditions of the survey periods. BUS 2019 was primally conducted during the severe drought period with minimum rainfall. No flowing tree was observed in 2019 surveys. In contrast; BUS 2021 was undertaken during conditions after considerable rainfall and thus more favourable habitat conditions. The rainfall has ecological consequences such as higher food resources and flowering status of trees. For example, a higher diversity of parrots has been recorded in BUS 2021 compared to 2019.

This trend is also evident in the mortality results which showed that bird loses in the second year of monitoring were significantly higher than the first.

No threatened or non-threatened management triggers occurred as a result of the monitoring program. It should be noted, one Little Eagle was found at SWF injured beneath a powerline. This

species is listed as 'Vulnerable' in New South Wales under the BC Act. It was found 900 metres from the nearest turbine on 26th July 2018 by wind farm staff and was transferred to the local vet. A short investigation concluded that it was highly unlikely that the casualty was caused by a wind turbine. Therefore, the mortality was not attributed to collision with turbines and not recorded as an incidental or casualty record, or to have triggered an impact trigger.

Additionally, one Grey-headed Flying–Fox, listed as Vulnerable under the EPBC Act, was found caught in barbed-wire fencing. This find did not trigger an investigation under the BBAMP due to the determination of the incident as not having been caused by a wind turbine. Grey-headed Flying-Fox have also been found flying into barbed–wire fencing at nearby wind farms. It is suggested that ongoing observations of this phenomenon be recorded to determine the scale of impacts barbed-wire fencing is having on the Grey-headed Flying–Fox.

These two mortality cases demonstrate the effectiveness of the decision-making framework of the BBAMP when undertaking investigations into the impacts of the wind farm on threatened species.

8. Recommendations

This section provides recommendations on future monitoring and mitigation measures.

Carcass search program

It is considered that two years of mortality search data as described in the Sapphire Wind Farm BBAMP and outlined in the report above have provided a useful baseline set of data to gain an understanding of the impact the wind farm is having on bird and bat species. This carcass search program has provided useful estimates of bird and bat mortality and the species impacted by the wind farm.

The information gained in the first two years is considered as satisfactory. Extending the regular carcass searches beyond this two-year period is not recommended.

Incidental monitoring

It is recommended that incidental reporting of carcasses by SWF staff be continued. Carcasses and featherspots should continue to recorded on a datasheet, photograph and stored in the freezer on the wind farm site in line with the BBAMP. This data can be provided to Nature Advisory remotely to identify. This will continue to provide some indication of on-going impacts to birds and bats at the wind farm. Particularly for Wedge-tailed Eagle which is easily identifiable and visible from a distance. Data on incidental monitoring should be tabulated annually.

In line with Condition C6 this information should be included in reports submitted to the Director-General and OEH on an annual basis for the first five years of operation as outlined in Condition C6 of the Project Approval.

Species of concern.

This report identified:

- No impact triggers on listed species;
- Some mortality of Wedge tailed Eagles.

The BBAMP identified specific measures to reduce mortality of the WTEs which should continue as part of the implementation of the BBAMP. Specifically, these measures include:

- Carrion removal -
  The BBAMP requires ongoing carrion management as part on the operational implementation of the BBAMP. Thus, it is important that the carrion removal program be undertaken continued in line with Section 5.1 of the BBAMP. The reporting on carrion removal can be incorporated into the annual reports for the first five years of operation as outlined in Condition C6 of the Project Approval.
- Limit lambing near turbines - Where possible, lambing should not be encouraged in paddocks close to turbines in consultation with land holders. Where possible, lambing

should occur at least 200 metres from turbines to reduce the risk that raptors 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.

Ongoing reporting

In line with Condition C6 the information detailed above should be included in reports submitted to the Director-General and OEH on an annual basis for the first five years of operation as outlined in Condition C6 of the Project Approval. This report meets the requirement for the first two years of operation.

The annual report will provide an opportunity to monitor impacts on 'at-risk' species, particularly Wedge-tailed Eagle, and adaptive management in reviewing carrion removal or potential additional survey requirements.

9. References

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Appendix 1: Bird and bat mortality data obtained during the pre-operational period and two years of monitoring at SWF (July 2018-January 2021)

Report ID	Turbine number	Species ID	Type of Carcass	Distance from Turbine	Formal* or Incidental	Date of find
2018.7.01	NA	Little Eagle	Bird	NA	Incidental	26/07/2018
2018.8.01	57	Crested Pigeon	Bird	1	Incidental	6/08/2018
2018.8.01	57	Crested Pigeon	Bird	1	Incidental	9/08/2018
2018.8.01	16	Australian Magpie	Feather Spot	50	Feather Spot	27/08/2018
2018.9.01	57	Crested Pigeon	Feather Spot	5	Incidental	13/09/2018
2018.9.01	57	Australian Magpie	Feather Spot	5	Incidental	13/09/2018
2018.12.01	66	Wedge-tailed Eagle	Bird	100	Incidental	12/12/2018
2018.12.01	18	Grey- headed Flying Fox	Bat	100	Carcass	27/12/2018
2019.01.01	56	Wedge-tailed Eagle	Bird	25	Incidental	24/01/2018
2019.02.01	70	Wedge-tailed Eagle	Bird	65	Incidental	4/02/2019
2019.02.01	57	Eastern Rosella	Bird	10	Incidental	21/02/2019
2019.06.01	48	Australian Wood Duck	Bird	20	Carcass	7/06/2019
2019.07.01	18	Tawny Frogmouth	Bird	30	Carcass	11/07/2019
2019.09.01	68	Collared Sparrowhawk	Bird	25	Carcass	4/09/2019
2019.09.01	48	Australian Magpie	Bird	30	Carcass	9/09/2019
2019.10.01	32	Chocolate Wattled Bat	Bat	20	Carcass	4/10/2019
2019.11.01	63	Tawny Frogmouth	Feather Spot	25	Feather Spot	4/11/2019
2020.01.01	33	Australian Wood Duck	Bird	1	Incidental	13/01/2020
2020.02.01	69	Australian Magpie	Bird	5	Carcass	7/02/2020
2020.03.01	23	White-striped Freetail Bat	Bat	10	Carcass	31/03/2020
2020.04.01	58	White-striped Freetail Bat	Bat	5	Incidental	6/04/2020
2020.04.01	22	Wedge-tailed Eagle	Bird	50	Incidental	21/04/2020
2020.05.01	23	White-striped Freetail Bat	Bat	35	Carcass	15/05/2020
2020.06.01	16	Australian Magpie	Feather Spot	10	Feather Spot	11/06/2020
2020.06.01	14	Collared Sparrowhawk	Bird	60	Carcass	11/06/2020

Report ID	Turbine number	Species ID	Type of Carcass	Distance from Turbine	Formal* or Incidental	Date of find
2020.06.01	58	Australian Magpie	Feather Spot	10	Feather Spot	16/06/2020
2020.07.01	63	Crimson Rosella	Feather Spot	10	Feather Spot	25/07/2020
2020.07.01	53	Wedge-tailed Eagle	Bird	105	Carcass	25/07/2020
2020.07.01	16	Australian Wood Duck	Feather Spot	10	Feather Spot	26/07/2020
2020.07.01	59	Wedge-tailed Eagle	Bird	65	Carcass	28/07/2020
2020.07.01	58	Forest Kingfisher	Bird	5	Carcass	28/07/2020
2020.08.01	34	Australian Magpie	Bird	90	Carcass	26/08/2020
2020.08.01	58	Nankeen Kestrel	Bird	65	Carcass	19/08/2020
2020.08.01	59	Sacred Kingfisher	Feather Spot	40	Feather Spot	31/08/2020
2020.09.01	7	Australian Wood Duck	Feather Spot	25	Feather Spot	16/09/2020
2020.09.01	16	Red-rumped Parrot	Feather Spot	80	Feather Spot	16/09/2020
2020.09.01	32	White-striped Freetail Bat	Bat	45	Carcass	23/09/2020
2020.09.01	4	Nankeen Kestrel	Feather Spot	40	Feather Spot	27/09/2020
2020.10.01	69	White-striped Freetail Bat	Bat	35	Carcass	25/10/2020
2020.10.01	69	Grey Butcherbird	Bird	40	Carcass	25/10/2020
2020.10.01	68	Australian Magpie	Bird	15	Carcass	25/10/2020
2020.10.01	41	Galah	Feather Spot	10	Feather Spot	26/10/2020
2020.11.01	58	Red-rumped Parrot	Feather Spot	60	Feather Spot	21/11/2020
2020.11.01	59	Eastern Rosella	Feather Spot	85	Feather Spot	21/11/2020
2020.11.01	48	Little Red Flying Fox	Bat	70	Carcass	21/11/2020
2020.11.01	48	Little Forest Bat	Bat	45	Carcass	28/11/2020
2020.12.01	69	Red-rumped Parrot	Bird	60	Carcass	24/12/2020
2021.01.01	63	White-striped Freetail Bat	Bat	55	Carcass	26/01/2021
2021.01.01	58	White-striped Freetail Bat	Bat	10	Carcass	26/01/2021

***Formal: includes feather spot and carcass (bird and bat)**

Appendix 2: Scavenger trail data obtained during monitoring at SWF

Season	Species	Carcass size	Placement Date	Scavenged date	Days in the field	Turbine
Short grass	Common Myna	Small Bird	8/08/2019	9/08/2019	1	23
	Wedge-tailed Eagle	Large Bird	8/08/2019	NA	30	23
	Australian Wood Duck	Medium-Sized Bird	8/08/2019	19/08/2019	11	14
	Rainbow Lorikeet	Small Bird	9/08/2019	16/08/2019	7	41
	Nankeen Kestrel	Medium-Sized Bird	9/08/2019	16/08/2019	7	18
	Wedge-tailed Eagle	Large Bird	9/08/2019	NA	30	23
	Common Myna	Small Bird	9/08/2019	9/08/2019	1	41
	Eastern Rosella	Small Bird	9/08/2019	11/08/2019	2	14
	White-striped Freetail Bat	Bat	11/08/2019	13/08/2019	2	23
	Wedge-tailed Eagle	Large Bird	13/08/2019	NA	30	58
	White-striped Freetail Bat	Bat	13/08/2019	17/08/2019	4	58
	Wedge-tailed Eagle	Large Bird	15/08/2019	NA	30	23
	Magpie-lark	Small Bird	15/08/2019	17/08/2019	2	23
	White-striped Freetail Bat	Bat	16/08/2019	25/08/2019	9	41
	Crimson Rosella	Small Bird	16/08/2019	16/08/2019	1	58
	Sulphur-crested Cockatoo	Medium-Sized Bird	16/08/2019	17/08/2019	1	41
	White-striped Freetail Bat	Large Bird	16/08/2019	NA	30	41
	White-striped Freetail Bat	Bat	16/08/2019	16/08/2019	1	41
	Common Myna	Small Bird	16/08/2019	18/08/2019	2	16
	White-striped Freetail Bat	Bat	17/08/2019	20/08/2019	3	58
	White-striped Freetail Bat	Bat	21/04/2020	23/04/2020	2	7
	Eastern Rosella	Medium-Sized Bird	21/04/2020	25/04/2020	4	7
	White-striped Freetail Bat	Bat	21/04/2020	22/04/2020	1	16
	Australian Magpie	Medium-Sized Bird	23/04/2020	27/04/2020	4	23

Season	Species	Carcass size	Placement Date	Scavenged date	Days in the field	Turbine
	Australian Magpie	Medium-Sized Bird	23/04/2020	28/04/2020	5	23
	Australian Wood Duck	Medium-Sized Bird	23/04/2020	2/05/2020	9	14
	Wedge-tailed Eagle	Large Bird	23/04/2020	23/05/2020	30	14
	Nankeen Kestrel	Medium-Sized Bird	23/04/2020	29/04/2020	6	14
	Wedge-tailed Eagle	Large Bird	23/04/2020	23/05/2020	30	5
	White-striped Freetail Bat	Bat	23/04/2020	27/04/2020	4	5
Long grass	White-striped Free-tailed Bat	Bat	21/11/2020	21/11/2020	0	58
	Noisy Miner	Small Bird	21/11/2020	21/11/2020	0	58
	Collared Sparrowhawk	Small Bird	21/11/2020	21/11/2020	0	58
	Wedge-tailed Eagle	Large Bird	21/11/2020	not scavenged	30	58
	Eastern Rosella	Small Bird	21/11/2020	21/11/2020	0	58
	Noisy Miner	Small Bird	21/11/2020	not scavenged	30	59
	White-striped Free-tailed Bat	Bat	21/11/2020	Failed	Failed	59
	Australian Magpie	Medium-Sized Bird	21/11/2020	25/11/2020	4	59
	Crested Pigeon	Medium-Sized Bird	21/11/2020	23/11/2020	2	48
	White-striped Free-tailed Bat	Bat	21/11/2020	not scavenged	30	48
	Little Red Flying Fox*	Large Bat	21/11/2020	not scavenged	30	48
	Australian King-parrot	Medium-Sized Bird	28/11/2020	30/11/2020	2	34
	Australian Galah	Medium-Sized Bird	28/11/2020	29/11/2020	2	34
	White-striped Free-tailed Bat	Bat	28/11/2020	2/12/2020	4	63
	Eastern Rosella	Small Bird	28/11/2020	5/12/2020	7	63
	Chocolate Wattled Bat	Bat	3/02/2021	not scavenged	30	9
	Australian Galah	Medium-Sized Bird	3/02/2021	not scavenged	30	55
	White-striped Free-tailed Bat	Bat	3/02/2021	5/12/2020	2	55
	Eastern Rosella	Small Bird	3/02/2021	3/12/2020	0	9

Season	Species	Carcass size	Placement Date	Scavenged date	Days in the field	Turbine
	Australian Magpie	Medium-Sized Bird	3/02/2021	3/12/2020	0	10
	Dusky Woodswallow	Small Bird	3/02/2021	4/12/2020	1	60
	Red-rumped Parrot	Small Bird	3/02/2021	not scavenged	30	60

Appendix 3: Sapphire Wind Farm mortality estimate

symbolix

Sapphire Wind Farm Mortality Estimate

Prepared for Nature Advisory, 25 March 2021, Ver. 1.0

This report outlines an analysis of the mortality data collected at Sapphire Wind Farm from 2018-07-26 to 2021-01-26. The analysis is broken into the three related components below:

- Searcher efficiency / detectability – estimated from trials in August 2019 and November 2020
- Scavenger loss rates – consisting of trials in August 2019, April 2020, November 2020, and February 2021
- Mortality estimates - based on monthly surveys at 19 turbines, from 2018-07-26 to 2021-01-26

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]. Additional Wedge-tailed Eagle scavenger data was taken from Victorian wind farms - see Stark and Muir (2020).

Methodology overview

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

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

[1] Sapphire WF mortality data for Symbolix updated 200324.xlsx

the range of searcher and scavenger efficiencies, and the survey frequency and coverage, and the true "found" details. After many simulations, we can estimate the likely range of mortalities that could have resulted in the recorded survey outcome.

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

Searcher efficiency

Three searcher efficiency trials were held (2019-08-08, 2020-11-21, and 2020-11-28). The detectability trials used both bird (30 replicates) and bat carcasses (10 replicates). A range of bird sizes were used, ranging from small (Myna), to medium (Australian magpie), to large (Wedge-tailed Eagle).

We found no evidence (using binomial regression) that the searcher efficiency differed between the surveys held in August 2019 and November 2020 ($z = -0.005$, $p = 0.996$).

We also found no evidence (via AIC) that searcher efficiency differed between bats and birds. Therefore, bird and bat detection efficiencies are aggregated in the following mortality estimate.

Table 1 summarises the result.

Bat and bird detectability is 92%, with a 95% confidence interval of [80%, 98%].

Table 1: Detection efficiencies for birds and bats.

Variable	Variable
Number found	37
Number placed	40
Mean detectability proportion	0.92
Detectability lower bound (95% confidence interval)	0.8
Detectability upper bound (95% confidence interval)	0.98

Scavenger efficiency

Scavenger efficiency trials were conducted during August 2019, April 2020, November 2020, and February 2021. Trials ran over 30 days, and used a similar set of species as the searcher efficiency trials.

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.

There is no evidence that scavenge rates were different between the different trials, based on AIC selection. Similarly, we found no evidence that birds (excluding Wedge-tailed Eagles) and bats have significantly different scavenger rates. Therefore, in the following mortality estimate, scavenger rates for bats and all bird species except WTEs are aggregated. WTEs were treated separately, as they generally have a very different scavenger rate profile from other birds.

The trials included 7 WTE carcasses, but none were scavenged during the 30-day trials. This is consistent with a recent analysis of data collected at Victorian wind farms which showed that the mean scavenge time for WTEs is much longer than for other bird species tested (Stark and Muir (2020)). Because none of the WTE carcasses in the trials at Sapphire Wind Farm were scavenged, it was not possible to model time until scavenge for WTEs using this data alone. However, we combined this data with data from scavenger trials at Victorian wind farms (Stark and Muir (2020)) to fit a survival curve for WTEs.

Due to results in Stark and Muir (2020), we have used a log-normal shape, which has been found to accurately describe the scavenger profile of carcasses in Victoria.

Figure 1 shows a survival curve fitted to the combined cohort of bats and birds (excluding WTEs) and a survival curve for WTEs. 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 we expect around 8% to 43% of bat and bird (excluding WTEs) carcasses to remain after ten days with the expectation being around 18%.

Under these assumptions, the mean time to total loss via scavenge for bats and birds (excluding WTEs) is 12.3 days, with a 95% confidence window of [5.4, 27.9] days.

For WTEs, the mean time to total loss via scavenge is 513 days, with a 95% confidence window of [269, 977] days.

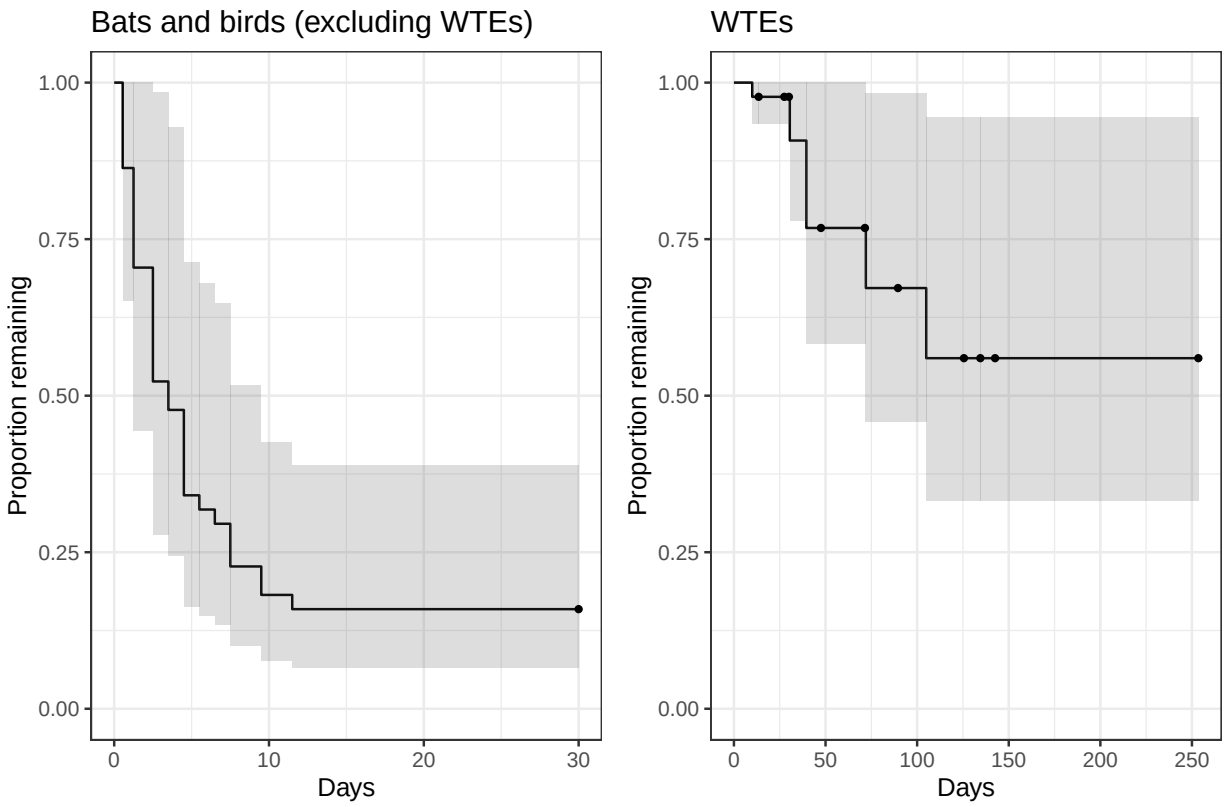

Figure 1: Survival curves with 95% confidence interval shaded.

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. 19 turbines were surveyed throughout the 31-month period, with between eight and 19 turbines generally surveyed twice each month. Turbines were surveyed out to a radius of 120 metres in standard surveys and to a radius of 60 metres in pulse surveys.

Table 2: Number of surveys per month.

Date	Number of surveys
2018 Jul	16
2018 Aug	16
2018 Sep	16
2018 Oct	16
2018 Nov	16
2018 Dec	16
2019 Jan	16
2019 Feb	36
2019 Mar	36
2019 Apr	36
2019 May	36
2019 Jun	36
2019 Jul	36
2019 Aug	36
2019 Sep	36
2019 Oct	36
2019 Nov	36
2019 Dec	36
2020 Jan	36
2020 Feb	36
2020 Mar	36
2020 Apr	36
2020 May	36
2020 Jun	36
2020 Jul	36
2020 Aug	36
2020 Sep	36
2020 Oct	36
2020 Nov	19
2020 Dec	20
2021 Jan	20

Mortality estimate

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 Sapphire Wind Farm from 2018-06-26 to 2021-01-26 (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 75 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 (2018-07-26) and until the final surveyed date (2021-01-26).
- 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.
- 19 turbines were selected at random to be surveyed, and were searched out to a 120 metre radius for standard surveys and 60 metres for pulse survey. 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 75% for birds (excluding WTEs), 61% for WTEs, 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 31 months.

Species	Bat	Bird	Feather Spot
White-striped Freetail Bat	6	0	0
Chocolate Wattled Bat	1	0	0
Grey-headed Flying Fox	1	0	0
Little Forest Bat	1	0	0
Little Red Flying Fox	1	0	0
Australian Magpie	0	4	3
Collared Sparrowhawk	0	2	0
Wedge-tailed Eagle	0	2	0
Australian Wood Duck	0	1	2
Red-rumped Parrot	0	1	2
Nankeen Kestrel	0	1	1
Tawny Frogmouth	0	1	1
Forest Kingfisher	0	1	0
Grey Butcherbird	0	1	0
Crimson Rosella	0	0	1
Eastern Rosella	0	0	1
Galah	0	0	1
Sacred Kingfisher	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
Wedge-tailed Eagle	4
Crested Pigeon	3
Little Eagle	1
Australian Magpie	1
Eastern Rosella	1
Australian Wood Duck	1
White-striped Freetail Bat	1

Bat mortality estimate – results

During the 31 months of surveys a total of 10 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 166 and a median of 158 bats lost on site over the 31 months.

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

Based on the detected carcasses and measured detectability and scavenge rate, we expect that there was a total site loss of around 166 bats over the survey period, and are 95% confident that fewer than 252 individuals were lost.

Table 5: Percentiles of estimated total bat losses over the 31 months of surveys.

0%	50% (median)	90%	95%	99%	99.9%
60	158	231	252	326	381

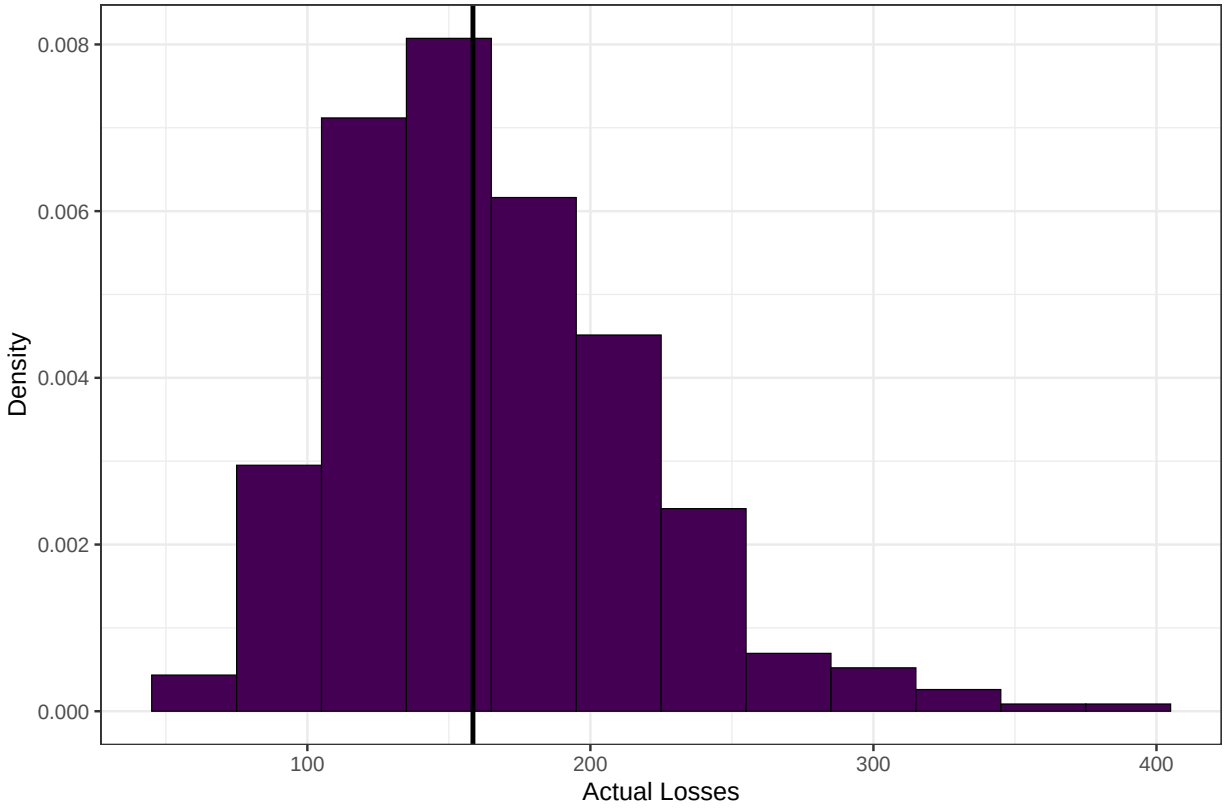

Figure 2: Histogram of the total losses distribution (bats), given 10 were detected on-site. The black solid line shows the median.

Bird mortality estimate - results

During the 31 months of surveys a total of 25 birds (excluding WTEs, which are analysed separately due to their unique scavenger rate profile) 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 457 and a median of 442 birds lost on site over the 31 months.

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

In addition, a total of 2 WTEs were found during formal surveys. The resulting estimate of total mortality is an expectation (mean) of 13 and a median of 121 WTEs lost on site over the 31 months.

Table 7 and Figure 4 display the percentiles of the distribution, to show the confidence interval in this average.

In determining these estimates, 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 457 birds (excluding WTEs) over the survey period, and are 95% confident that fewer than 658 individuals were lost.

For WTEs, we expect that there was a total site loss of around 13 WTEs over the survey period, and are 95% confident that fewer than 27 individuals were lost.

Table 6: Percentiles of estimated total bird losses (excluding WTEs) over the 31 months of survey period.

0%	50% (median)	90%	95%	99%	99.9%
241	442	611	658	766	846

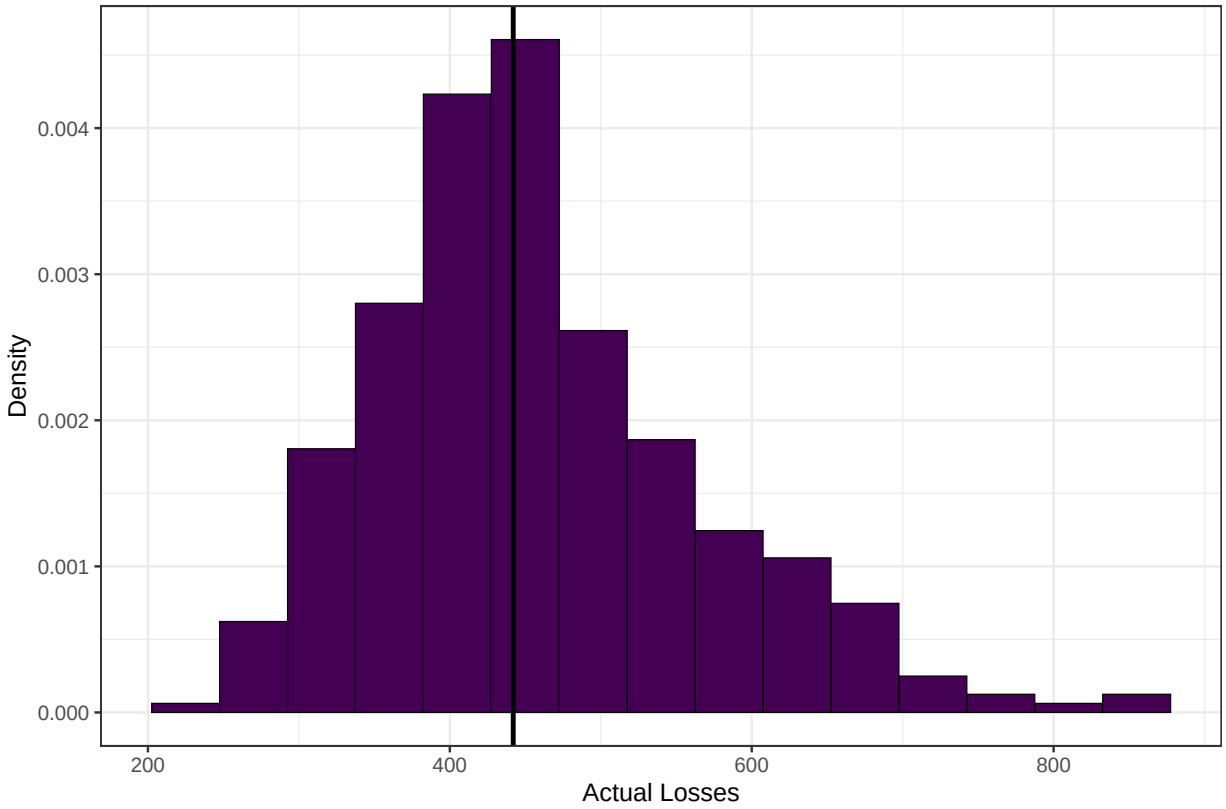

Figure 3: Histogram of the total losses distribution (birds, excluding WTEs), given 25 were detected on-site. The black solid line shows the median.

Table 7: Percentiles of estimated total WTE losses over the 31 months of surveys.

0%	50% (median)	90%	95%	99%	99.9%
2	12	24	27	37	45

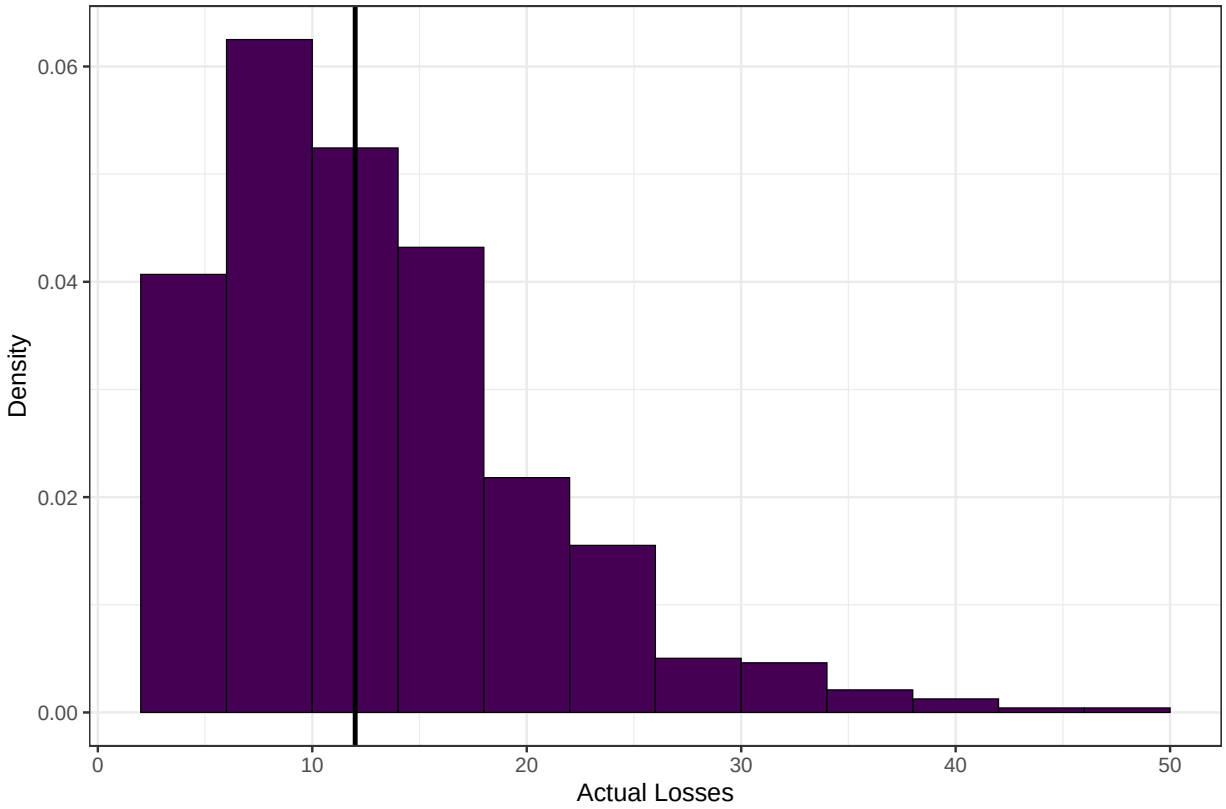

Figure 4: Histogram of the total losses distribution (WTEs), given 2 were detected on-site. The black solid line shows the median.

Comparison of year one and year two results

Bat results

During the first year of surveys (2018-06-26 to 2019-07-31) a total of 1 bat was found during formal surveys. The resulting estimate of total mortality is an expectation (mean) of around 33 bats over the survey period, and we are 95% confident that fewer than 81 individuals were lost.

In comparison, in the second year of surveys (2019-08-01 to 2020-07-31) a total of 3 bats were found during formal surveys. The resulting estimate of total mortality an expectation of 53 bats over the survey period, and we are 95% confident that fewer than 103 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 is not significantly different from the distribution of year two mortalities (the test statistic $D = 0.33$ is lower 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 is not significantly different from the number of losses in year two.

Bird results

Birds - general

During the first year of surveys a total of 3 birds (excluding WTEs) were found during formal surveys. The resulting estimate of total mortality is an expectation of around 80 birds over the survey period, and we are 95% confident that fewer than 161 individuals were lost.

In comparison, in the second year of surveys a total of 10 birds (excluding WTEs) were found during formal surveys. The resulting estimate of total mortality an expectation of 162 birds over the survey period, and we are 95% confident that fewer than 264 individuals were lost.

Using the Kolmogorov-Smirnov test, we find the distribution of bird mortalities (excluding WTEs) of the first year to be shifted left, compared to the distribution of year two mortalities (the test statistic $D = 0.64$ 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 (excluding WTEs) losses in year one was significantly lower than the number of losses in year two.

WTEs

Additionally, a total of zero WTEs were found during formal surveys in the first year. The resulting estimate of total mortality is an expectation of around five WTEs over the survey period, and we are 95% confident that fewer than 14 individuals were lost.

In comparison, in the second year of surveys a total of two WTEs were found during formal surveys. The resulting estimate of total mortality an expectation of 12 birds over the survey period, and we are 95% confident that fewer than 14 individuals were lost.

We find the distribution of WTE mortalities of the first year to be shifted left, compared to the distribution of year two mortalities (the test statistic $D = 0.53$ is greater than the critical value $D^* = 0.35$ at the 0.05 significance level).

This suggests that the true total number of WTE losses in year one was significantly lower 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 4: Raw data for the Spring 2021 impact and reference BUS points at Sapphire Wind Farm

Impact points

Site	BUS1									BUS2										BUS3										BUS4							
Replicate	1		2	3	4	5	6	7	8	1		2	3	4	5	6		7	8		1	2	3	4		5	6	7		8	1	2	3	4	5	6	7	8
Height class	A	B	A	A	A	A	A	A	A	A	B	A	A	A	A	A	B	A	A	B	A	A	A	A	B	A	A	A	B	A	A	A	A	A	A	A	A	A
Australian King Parrot																															1							
Australian Magpie			3	2	4	4	3	1				3	1	3	1	2		2	1			3	1	2		1	3			1		3	3	2	2	5	2	1
Australian Raven	3												1	1	2								1												1			
Black-faced Cuckoo-shrike			1			1				1																1	1						1					
Brown Falcon																																						
Brown Goshawk																													1									
Crested Pigeon				2									2																									
Crimson Rosella			1			2	1																								3	6	1		2			
Double-barred Finch								2																														
Eastern Rosella	2		4	1	2	5	6	2	2	2		6	16	3	9	6		7	8		2	4		3		2				1	2	1	2	1	2	2	2	
Galah			2		12					4		2	4	1	5			2				1	3	1								5				4	2	1
Grey Butcherbird					1							1	1	1	1			1				1		1		1	1	1				1						1
Grey Fantail					1																																	
Grey Shrike-thrush									1																													
Laughing Kookaburra					1							2	2						1		1																	
Little Corella													1																		1							
Little Eagle																	1																					
Magpie-lark			1			1																																
Maned Duck																		1																				
Mistletoe-bird						3			3																													
Musk Lorikeet				4		6		2	2	6																						1	3					
Nankeen Kestrel										1																												
Noisy Friarbird	1		4	1		3	1		2																		1	1									
Noisy Miner	8		6	8	3	5	8	5	8	3		3	5	4	7	6		4	3		9	5	5	3		4		5		1	5	9	8	5	4	3	7	2
Peaceful Dove																																						
Pied Currawong	1		5		1	1		1	1																			1			1						
Rainbow Lorikeet			6			2																										2						
Red Wattlebird			1		1	1	1		1																						1						
Red-rumped Parrot			2			4	1			8		4	14	14	2	10		14	5																		
Restless Flycatcher							1																															
Speckled Warbler					3																																	
Spotted Pardalote			1	2																		1															
Striated Pardalote			4			2		2	1				1								2		2								2							
Striated Thornbill			3		4																																	
Sulphur-crested Cockatoo		1	3	28	5	2					13	4	20	4	4	1		11		1						2	7										1	
Superb Fairywren					2			2																		3	7			3								
Wedge-tailed Eagle																									2													
Weebill			3	3	4	2	4	3				2		2								3	3			2	2			1	6							

Site	BUS1									BUS2										BUS3									BUS4							
White-faced Heron																															1					
White-throated Gerygone																																				
White-throated Treecreeper					2																						2									
White-winged Chough																																				
Willie Wagtail			1			1			1												1									1			1			
Yellow-rumped Thornbill					2																															
rand Total	15	1	51	51	48	45	26	20	22	25	13	27	68	33	31	25	1	42	18	1	14	19	15	10	2	16	24	8	1	7	23	28	19	8	10	16	14	5

Reference points

Site	RF1									RF2								
Replicate	1	2	3		4	5	6	7	8	1	2	3		4	5	6	7	8
Height class	A	A	A	B	A	A	A	A	A	A	A	A	B	A	A	A	A	A
Australian King Parrot											2							
Australian Magpie		8	1		4	1	2	3			4	1		1	1	3		
Australian Raven							2								2	1		
Black-faced Cuckoo-shrike											1							
Brown Falcon																		1
Brown Goshawk		1				1												
Crested Pigeon									1							2		
Crimson Rosella		1						2	1			2				2		
Double-barred Finch																		
Eastern Rosella	16	6	4		8	3	4	8	6	4	9	9		2	1	2	3	1
Galah	2		2			2	3	1			13	1				1		
Grey Butcherbird		2	1		1	1	1	1		1	1	1			1	1	1	
Grey Fantail																		
Grey Shrike-thrush			1															
Laughing Kookaburra		1				1	1	1		5	1							
Little Corella																		
Little Eagle																		
Magpie-lark					1		1	1										
Maned Duck								4			1							
Mistletoe-bird																		
Musk Lorikeet							4											
Nankeen Kestrel																		
Noisy Friarbird			1												1			
Noisy Miner	7	6	8		8	8	9	6	7	8	13	13		5	2	9	13	3
Peaceful Dove									1									
Pied Currawong	1	1			3	1	1				1	2			1			1
Rainbow Lorikeet			2		2		2				1							
Red Wattlebird																1		
Red-rumped Parrot														4	2			
Restless Flycatcher																		
Speckled Warbler																		
Spotted Pardalote																		
Striated Pardalote						2					3	2						
Striated Thornbill																		
Sulphur-crested Cockatoo	5	8	2			4	21	9		1	5	4			1	2	8	
Superb Fairywren											3	3					4	
Wedge-tailed Eagle				1									1					
Weebill										6	3	3		2		1	2	

Site	RF1									RF2								
White-faced Heron																		
White-throated Gerygone										3	1						1	
White-throated Treecreeper		1						1										1
White-winged Chough											6							
Willie Wagtail									1		1							
Yellow-rumped Thornbill																		
Grand Total	31	35	22	1	27	24	51	37	17	28	69	41	1	14	12	25	32	7