



Morton's Lane Wind Farm Bird and Bat Monitoring 2015 - 2019

Prepared for Morton's Lane Wind Farm Pty Ltd

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Contents

Summary	V
1 Introduction	7
1.1 Project background.....	7
1.2 Scope of assessment.....	7
1.3 Pre-construction studies.....	8
2 Methods.....	9
2.1 Yearly rainfall.....	9
2.2 Brolga utilisation surveys.....	9
2.2.1 Monitoring points.....	9
2.2.2 Methods.....	10
2.2.3 Timing and survey.....	11
2.3 Bat survey.....	12
2.3.1 Methods.....	12
2.3.2 Monitoring points and survey timing.....	14
2.3.3 Call identification and analysis.....	14
2.4 Turbine collision monitoring.....	15
2.4.1 Carcass searches.....	15
2.4.2 Searcher efficiency trials.....	15
2.4.3 Carcass persistence trials.....	16
2.4.4 Estimation of total collision mortality.....	17
3 Results.....	18
3.1 Yearly rainfall.....	18
3.2 Bird utilisation surveys.....	18
3.2.1 Significant species.....	19
3.2.2 Brolga.....	19
3.2.3 Raptors.....	20
3.3 Bats call surveys.....	21
3.4 Turbine collision monitoring.....	22
3.4.1 Carcass searches.....	22
3.4.2 Significant impacts.....	24
3.4.3 Searcher efficiency trials.....	25
3.4.4 Carcass persistence trials.....	25
3.5 Total collision mortality estimates.....	27
4 Conclusion.....	28
4.1 Brolga.....	28

4.2 Bats.....	28
4.3 Significant impacts	28
4.4 Fauna collision with turbines.....	28
References.....	29
Appendices.....	30

List of Figures

Figure 1: Location of bird utilisation / Brolga monitoring points & turbines at Morton's Lane Wind Farm	11
Figure 2: SM2 detector mounted on a fence post	13
Figure 3: SM2 ultrasonic bat detector mounted on the galvanised mesh platform located on the nacelle of the Goldwind turbines	13
Figure 4: Carcass persistence trial using Reconyx camera.....	16

List of Tables

Table 1 Bird utilisation monitoring points.....	10
Table 2 Bird utilisation monitoring point counts undertaken	12
Table 3 SM2 configuration settings.....	12
Table 4 Locations and timing of ultrasonic bat monitoring (all dates inclusive).....	14
Table 5 Annual rainfall records from The Gums (BOM Penshurst recording station)	18
Table 6 Significant species detected at Morton's Lane Wind Farm	19
Table 7 Raptors recorded at Morton's Lane Wind Farm	20
Table 8 Species summary of carcass and featherspots detected over 36 months of monitoring of 13 turbines at Morton's Lane Wind Farm.....	22
Table 9 Summary per turbine of carcass and featherspots detected over 36 months of monitoring at Morton's Lane Wind Farm.....	23
Table 10 Average numbers of bird and bat carcasses detected by month of the year from the complement of turbines at Morton's Lane Wind Farm 2015 - 2019	24
Table 11 Summary of searcher efficiency results at Morton's Lane Wind Farm.....	25
Table 12 Results of carcass persistence trials at Morton's Lane Wind Farm.....	26

Summary

Biosis Pty Ltd was commissioned by Morton's Lane Wind Farm Pty Ltd to implement the Bat and Avifauna Management Plan ('BAM Plan' SKM 2011) for the operational Morton's Lane Wind Farm (MLWF). The principal components of the BAM Plan undertaken included:

- Monitoring of Brolga utilisation of the wind farm during seasonal surveys in 2013, 2014, 2015 and 2019. During point count surveys all bird species observed were recorded.
- Surveys of a zone within 2 km of the wind farm for Brolga breeding or flocking.
- Monitoring of micro-bat activity using ultrasonic detectors bat-call detectors.
- Monitoring and documenting birds and bats found dead as a result of collisions with turbines.
- Trials to determine rates at which searchers detected collision carcasses and of the persistence times of carcasses.
- Analyses of data collected to estimate total mortalities of bird and bat species at the wind farm.

Over the duration of the studies monitoring of bird and bat collisions was undertaken in a total of 36 months. Other surveys and monitoring were carried out to meet the requirements of the BAM Plan and directions of DELWP.

This report has been prepared to collate the results of the entire program of monitoring in response to the BAM Plan.

Post-construction monitoring of Brolgas was during a total of six surveys conducted during spring and autumn periods between spring 2013 and spring 2015 and in autumn 2019 at Morton's Lane Wind Farm. Brolga utilisation was monitored at six points within the MLWF and at two reference sites outside the wind farm. These locations were selected to permit observation of all dams and other wetlands within 2 km of the wind farm. Surveys for Brolgas were also conducted at Blackwood Lake, a known site for the species, west of the wind farm during each survey period.

Observations of single Brolgas were made during spring bird utilisation surveys in each of 2013, 2014 and 2015. Prior to construction a record of two Brolgas at the site had been made in spring of 2005. The site does not appear to be of significant value to the species and there is no indication that construction and operation of the wind farm has had deleterious effects on the species. Eighty-three other native bird species and five introduced bird species were also recorded within Morton's Lane Wind Farm during the surveys.

Post-construction monitoring of bat usage of the wind farm site was undertaken during summer and autumn seasons between summer 2013 and summer 2015 and in autumn 2019 at Morton's Lane Wind Farm. Microbat call detectors were installed at four turbine locations, with one detector placed on the ground (1m high) and one mounted on the turbine nacelle during each session of bat utilisation monitoring.

Nine species of bats were recorded to species level during the bat call surveys. A further two were identified to genus level only. Higher levels of bat activity were recorded from detectors at ground level compared to turbine-mounted detectors in both autumn and spring, and both ground and turbine-mounted detectors recorded ultrasonic noise from non-bat sources. Although very few shrubs and trees are present within the site, revegetated shelter-belts provide foraging habitat for several bat species which are unlikely to be present in completely cleared areas. No significant bat species were recorded as collision mortalities.

Annual rainfall records from the Bureau of Meteorology Penshurst (The Gums) show a long-term annual average of 663 mm. Records for the years of bird and bat utilisation monitoring indicate that 2013 was a

somewhat wetter than average year, while 2014 and 2015 were both below average. As at the end of August, it appears that 2019 is also likely to be a little below average.

Carcass persistence trials used remote cameras and we believe this is the first such trial to have been undertaken in Australia. Carcass persistence varied between microbats and three size categories of birds and between seasons.

Data for detected bird and bat mortalities and for searcher efficiency and carcass persistence rates, were used to provide estimates of total mortality due to collisions.

Monthly monitoring of bird and bat collision fatalities for 36 months detected an annual average of 3.2 collisions per turbine by birds and bats, combined. However, the detected collision rate per turbine varied from 1.7 to 6.3 per annum. On the basis of carcasses detected, search interval, searcher efficiency and carcass persistence rates, it is estimated that approximately 238 birds and 677 bats collided with turbines at the wind farm over the 36 months in which carcass searches were carried out.

1 Introduction

1.1 Project background

The 13 turbine Morton's Lane Wind Farm (MLWF) located near Woodhouse in south-western Victoria, commenced operation in January 2013. The approved Bird and Avifauna Management Plan (BAM Plan) (SKM 2011) for the facility specifies monitoring and reporting requirements. These included bird utilisation studies in autumn and spring, with Brolga as the focal species; and monitoring of bat species utilising the wind farm.

The overall program of investigations was required to assess effects of the wind farm on bird and bat populations over a minimum of three years.

Biosis Pty Ltd began implementation of the various monitoring requirements of the BAM Plan in 2013 and continued with bird and bat utilisation studies during 2014, 2015 and early 2019. In early 2015, monitoring of bird and bat collisions with wind turbines was commenced and was undertaken during a total of 36 months until June 2019. Carcass collision monitoring was undertaken by Elmoby Ecology using purpose-trained dogs.

The BAM plan specifies that monitoring should be undertaken to assess activities of birds and bats during years of variable rainfall ('wet', 'intermediate' and 'dry' years).

Permit conditions and the BAM plan call for an assessment of the occurrence of bird and bat strike at turbines with aviation, obstacle, night-time lighting versus those without. No turbines at Morton's Lane Wind Farm are fitted with aviation lighting and there is thus no comparison to be made.

1.2 Scope of assessment

The objectives of the investigations and the studies undertaken for them are set out as follows.

Bird utilisation

This component was designed to document activity of birds ('bird utilisation') at the wind farm using the same methods and locations as used to record bird utilisation prior to construction of the wind farm. It also monitored Brolga utilisation during the annual flocking and breeding seasons.

Bat utilisation

Utilisation of the site by microbats was monitored during autumn and summer was monitored by the recording of bat-calls. The calls of the majority of microbats in Victoria are species-specific and calls, and the rate of calling, can thus be ascribed to particular taxa.

Bird & bat collision monitoring

This aspect detected and documented bird and bat mortalities due to collisions with turbines at MLWF. This was achieved by undertaking:

- monthly searches to detect and document bird and bat mortalities
- trials to determine the influence of searcher efficiency on detection rates
- trials to determine the influence of carcass persistence rates (as affected by scavengers and natural deterioration of carcasses)

The results of these investigations have been analysed to estimate annual mortality rates for bird and bat species at the entire wind farm.

Reporting

This report describes the methods and presents results of the three investigations conducted over the entire program of monitoring. Previous annual reports have been submitted, however a review by DELWP in late 2018 noted that some aspects of work had not been completed for a full three years. As a consequence, and as agreed by DELWP and Moyne and Southern Grampians Shires, some additional investigations have been undertaken in 2019 to fulfil a total of 36 months of collision carcass monitoring and to add an autumn survey for Brolga utilisation and for bats to complete a total of three summer and three autumn surveys for those species. The present report collates all of the investigations of birds and bats at Morton's Lane Wind Farm that have been undertaken over the period from 2013 to 2019.

1.3 Pre-construction studies

Pre-construction bird and bat utilisation studies were conducted at MLWF in 2006 by Biosis (formerly Biosis Research):

- Biosis Research (2006a). Bat Activity Report for the Proposed Morton's Lane Wind Farm, South West Victoria. Report prepared for NewEn Australia, July 2006.
- Biosis Research (2006b). Bird Utilisation Studies at the Proposed Morton's Lane Wind Farm, South West Victoria. Report prepared for NewEn Australia, July 2006.

Biosis also conducted the preliminary flora and fauna assessment of the proposed MLWF (Biosis Research 2005), and undertook a regional survey of Brolga utilisation in the area surrounding MLWF and the proposed Salt Creek Wind Farm (Biosis Research 2006c).

2 Methods

2.1 Yearly rainfall

The BAM plan specifies that monitoring of Brolga and bat utilisation should be undertaken during years of variable rainfall ('wet', 'intermediate' and 'dry' years). However, it is not feasible to determine if a particular year will fall into any of these categories until the monitoring regime for the year is completed. The utilisation monitoring for Brolgas and bats was substantially completed between November 2013 and December 2015. Additional utilisation monitoring was undertaken in April 2019 to provide for a third autumn session. Rainfall records were obtained from the Bureau of Meteorology site Penshurst (The Gums), which is the closest recording site to Morton's Lane Wind Farm.

An alternative to simple consideration of rainfall, and that is relevant to the ecology of both Brolgas and bats, is to assess the wetting and drying of wetlands. At the wind farm and its immediate vicinity the only wetlands are farm dams that are not reliant on rainfall and none of them were noted to vary substantially in level over the entire period of the monitoring program.

2.2 Brolga utilisation surveys

The BAM plan specifies a program of monitoring Brolga utilisation based on methods applied prior to construction of the wind farm (Biosis Research 2006b). This entailed the use of timed bird counts at a predetermined set of point locations.

2.2.1 Monitoring points

Monitoring was conducted at the same six point locations monitored in the pre-construction surveys (Biosis Research 2006) (Figure 1). Two reference points (RFN and RFS) were also used for surveys of the operational wind farm, as required by the BAM plan. The coordinates of the points are presented in Table 1.

Locations of point counts at the wind farm and the two reference sites are in areas of dryland farming where Brolgas may forage during the day.

The BAM Plan specifies that potential wetland habitats for Brolgas within 2 km of the wind farm should be surveyed during dawn and dusk periods and we understand that the intention was to document any roosting Brolgas. There are no documentary records of Brolga roost sites within 2 km of the wind farm. Within that radius of the wind farm there are a number of small dams and there is one large dam east of the wind farm. All of these dams are visible from point count locations, which had been intentionally selected prior to pre-construction surveys so that they would encompass the dams. Hence, the point count bird utilisation surveys were designed to monitor all of the wetlands within 2 km of the wind farm.

During each seasonal session of Brolga monitoring we also checked for the presence of Brolgas at Blackwood Lake, which is a wetland where there are records of Brolgas. Blackwood Lake is the closest known flocking site for Brolgas and any records of the species at that location would have added to our understanding of their presence in the local area. Blackwood Lake is approximately 8 km west of Morton's Lane Wind Farm.

2.2.2 Methods

Point count surveys were conducted at the eight monitoring points (Table 1 and Figure 1). During each survey the point was monitored by one stationary observer for a period of 20 minutes. Data was collected using electronic data tablets. The following information was recorded:

- Start time and date
- Weather conditions
- For all species of birds observed, the number of individuals, behaviour, distance from observer and height of observation were recorded.

Table 1 Bird utilisation monitoring points

Point code	Location description	Easting	Northing
RFN	Northern reference site - Morton's Lane	629399	5813413
RFS	Southern reference site - Estate Road	630030	5807555
B1	Near turbine ML09	628657	5810734
B2	Near turbine ML08	628054	5810721
B3	Near turbine ML07	627378	5810845
B4	Near turbine ML04	629199	5810667
B5	Near turbine ML12	629537	5810229
B6	Near turbine ML05	630541	5810677

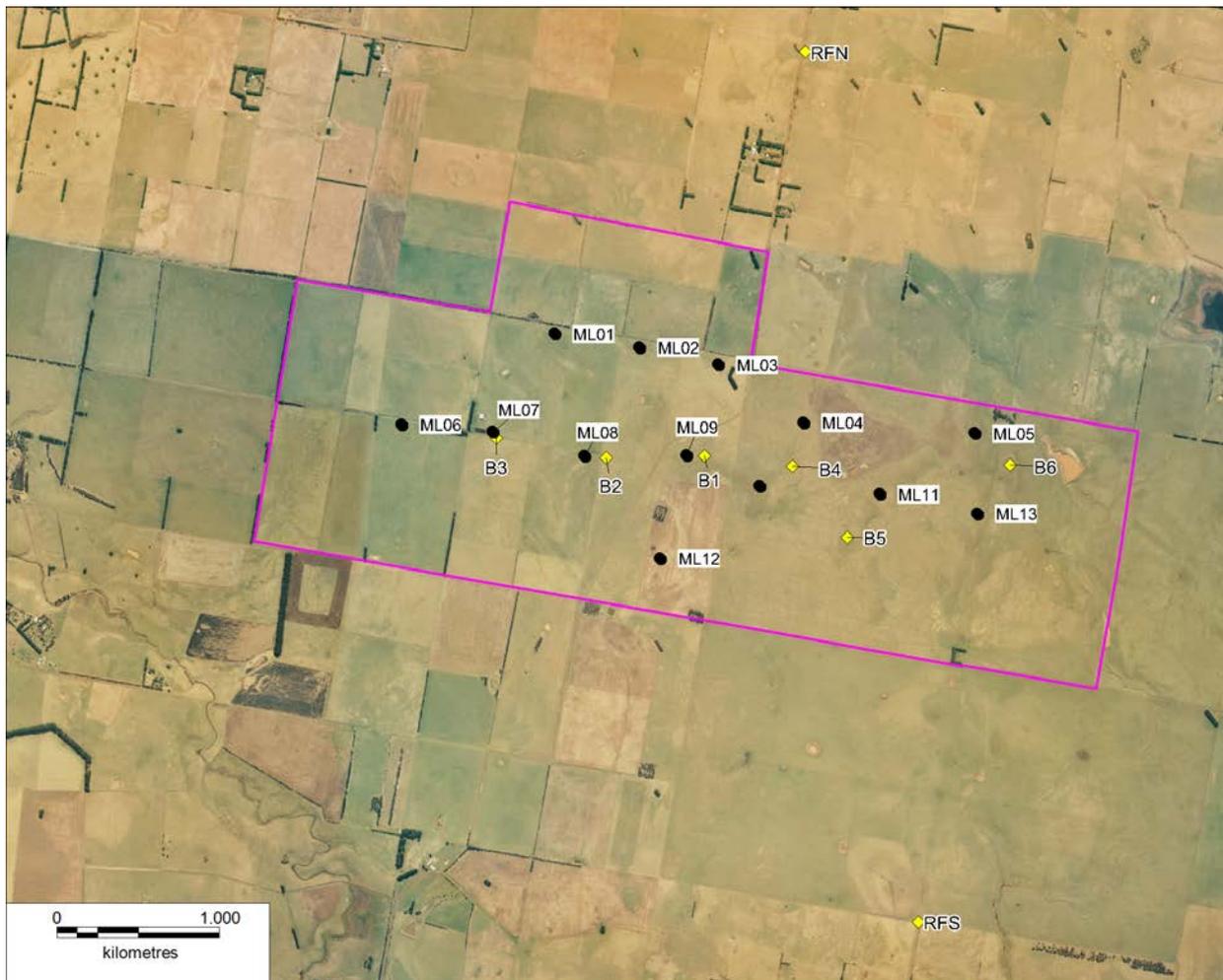


Figure 1: Location of bird utilisation / Brolga monitoring points & turbines at Morton's Lane Wind Farm

2.2.3 Timing and survey

Point counts were undertaken during daylight hours and times of counts at individual sites were randomised. The BAM Plan calls for monitoring before dawn and dusk but Brolgas are not likely to be present in the areas of the point counts at those times of day and for that reason monitoring was undertaken at more appropriate times.

The endorsed BAM Plan stipulates:

Two observers are to visit each of the eight points separately and carry out a survey twice on a single day. Surveys are to be completed at dawn and late afternoon prior to sunset. Surveys are to be repeated over four days during April (Flocking Season) and four days during October (Breeding Season). The sequence in which each of the eight points is visited will be rotated to minimise bias in the results.

We note that in the first monitoring session in November 2013 an attempt was made to complete the surveys in four days, as stipulated. It was found not to be feasible to achieve the required number of counts within that time allowance and it is unfortunate that the plan was written without an understanding of the practicalities involved. Additional days were added for that session and for all subsequent surveys. The southern reference point (RFS) is not directly accessible from the wind farm and access entailed a drive of approximately 30 km each way from the wind farm. This presented a significant constraint when counts were

truly randomised in early survey sessions. In later sessions the time constraint was significantly reduced by undertaking counts at that location at the beginning and end of survey days.

The post-construction bird utilisation survey program is summarised in Table 2.

Table 2 Bird utilisation monitoring point counts undertaken

Survey season	Survey dates span	Total point counts
Spring 2013	11 - 14 & 28 - 29 November	107
Autumn 2014	26 - 31 May	88
Spring 2014	20 - 25 October	129
Autumn 2015	20 - 25 April	133
Spring 2015	21 - 29 October	128
Autumn 2019	16 - 29 April	128

In 2016, after submission of bird and bat utilisation data collected to that time, DELWP provided feedback to the effect that utilisation components of the project could cease until further notice. In early 2019, the Department requested that an additional autumn round of broilga utilisation data should be collected to achieve a total of six seasonal surveys (in spring and autumn of three different years). This was done in April 2019.

2.3 Bat survey

2.3.1 Methods

Microbats were surveyed using ultrasonic detectors. Four detection sites were used. At each site one detector was placed approximately 1 m above the ground and one detector was placed 82 metres above the ground. Sites were selected to ensure a spread of monitoring points across the site. Ground detectors were mounted on fence posts, as close as possible to the base of the turbine (Figure 2).

Table 3 SM2 configuration settings

Setting	Value
Sample rate	192000
Channels	Mono-L
File Format	ZC
Division Ratio	16
Location Prefix	MLWF
Start time	19:00
Stop time	7:00



Figure 2: SM2 detector mounted on a fence post

Detectors at turbine height were mounted by Goldwind technicians on the galvanized steel mesh platform on the turbine nacelle (Figure 3). The microphone was aimed to the rear of the turbine.

Detectors were powered using internal D-cell batteries and calls were recorded onto 16 GB SD cards. Detectors were configured to record in zero-crossing (ZC) format between 19:00 (7 pm) and 07:00 (7 am) (Table 3).



Figure 3: SM2 ultrasonic bat detector mounted on the galvanised mesh platform located on the nacelle of the Goldwind turbines

2.3.2 Monitoring points and survey timing

Turbines ML02, ML05, ML06 and ML10 were selected for monitoring (Table 4, Figure 1). Detectors were deployed in autumn and summer of three different years, between the dates shown in Table 4. Detectors were installed at the four turbines (ground and at height) for a minimum of five nights during each monitoring round.

Table 4 Locations and timing of ultrasonic bat monitoring (all dates inclusive)

Detector site	Summer 2013 deployment	Autumn 2014 deployment	Summer 2014 deployment	Autumn 2015 deployment	Summer 2015 deployment	Autumn 2019 deployment
ML02 ground	16 - 23 Dec 2013	26 May - 5 Jun 2014	17 Dec 2014 - 16 Jan 2015	9 - 13 April 2015	22 - 26 Dec 2015	16 - 29 April 2019
ML02 turbine	17 - 23 Dec 2013	27 May - 5 Jun 2014	18 Dec 2014 - 16 Jan 2015	9 - 13 April 2015	22 - 26 Dec 2015	16 - 29 April 2019
ML05 ground	16 - 23 Dec 2013	26 May - 5 Jun 2014	17 Dec 2014 - 16 Jan 2015	9 - 13 April 2015	22 - 26 Dec 2015	16 - 29 April 2019
ML05 turbine	16 - 23 Dec 2013	27 May - 5 Jun 2014	18 Dec 2014 - 16 Jan 2015	9 - 13 April 2015	22 - 26 Dec 2015	16 - 29 April 2019
ML06 ground	17 - 23 Dec 2013	26 May - 5 Jun 2014	17 Dec 2014 - 16 Jan 2015	9 - 13 April 2015	22 - 26 Dec 2015	16 - 29 April 2019
ML06 turbine	16 - 23 Dec 2013	27 May - 5 Jun 2014	18 Dec 2014 - 16 Jan 2015	9 - 13 April 2015	22 - 26 Dec 2015	16 - 29 April 2019
ML10 ground	16 - 23 Dec 2013	26 May - 5 Jun 2014	17 Dec 2014 - 16 Jan 2015	9 - 13 April 2015	22 - 26 Dec 2015	16 - 29 April 2019
ML10 turbine	17 - 23 Dec 2013	27 May - 5 Jun 2014	18 Dec 2014 - 16 Jan 2015	9 - 13 April 2015	22 - 26 Dec 2015	16 - 29 April 2019

2.3.3 Call identification and analysis

Bat calls were analysed using the automated identification software AnaScheme, developed by Matthew Gibson and widely used in the automated analysis of microbat vocalisations within Australia. The system allows for development of identification keys based on analysis of reference calls. The key used to analyse bat calls for this project was developed and tested by Lindy Lumsden and Peter Griffioen of Arthur Rylah Institute, DELWP (Key to bats of south-west Victoria, dated 20 June 2011).

The AnaScheme system applies a conservative approach to identifying calls in that only clear, high quality calls are assigned to a species. The system also counts recordings which match the criteria to be considered true bat calls, but may be of insufficient quality to identify to species level. This allows a measure of overall bat activity to be calculated.

Any calls identified by the system as significant or uncommon species were checked manually, by visual comparison with published reference calls by an experienced bat expert, to ensure accurate results.

2.4 Turbine collision monitoring

2.4.1 Carcass searches

Searches for birds and bats that may have been killed in collisions with turbines were undertaken monthly at each of the thirteen turbines at the wind farm. Searches were designed to detect carcasses of birds and bats and featherspots of birds. A featherspot is a collection of 10 or more feathers in one location that is an indication of a bird death having occurred there. Searches were conducted in each month of the following inclusive periods: April – December 2015; May 2016 – April 2018; and April - June 2019. A total of 468 searches were conducted during those sessions under the 13 turbines at the wind farm. Due to farming management, particularly the presence of lambs, searches were conducted under 12, rather than all 13 turbines in six of the 36 months of the program. In 2017 the searches in July extended over the last few days of July until 1st of August and the August searches were conducted entirely within the final days of August. As a consequence, summary records (Table 2 Appendix 6) show 10 searches in July and 16 in August 2017.

The greatest capacity to detect carcasses has been shown to be obtained from intensive searches of defined areas of potential fall zones below turbines and the most valid estimates of mortality come from distance-based carcass-density models (Huso and Dalthorp 2014). Because the densities of carcasses diminish with horizontal distance from a turbine, searching of large areas including the outer extremities of potential fall zones were shown by those authors to add little to detection rates but may add substantially to search effort. The size of plots to be searched was determined from the primary fall zone for turbines of the size operating at Morton's Lane Wind Farm. The zone for these turbines was determined to be a radius of 140 metres from the turbine base.

Carcass searches at Morton's Lane were conducted by Elmoby Ecology using scent-dogs specifically trained for the purpose. It is well established that use of trained dogs is the most effective means to undertake carcass searches (Mathews et al. 2013; Bennett 2015). The method has the approval of DELWP because of its demonstrated higher capacity to detect carcasses and very significant time efficiency over human searchers. Using purpose-trained dogs obviated the need for formal transects to be established in the search zones as dogs use scent to detect carcasses and are permitted to roam to do so. The dogs wore GPS tracking devices and handlers carried an additional GPS with circular search plots preloaded on a hand held unit. Handlers ensured that the dog(s) are crossing the survey area across the direction of the wind and they monitored the dogs' movements in relation to the preloaded survey areas.

The age and sex of birds and bats cannot be determined for most species without detailed autopsy and is not applicable to decayed carcasses or to most featherspots. Autopsies were not carried out on carcasses detected at the wind farm.

Following the logic set out above, the searches covered a circular area with a total of 140 metres radius centred on the turbine tower for each of the thirteen turbines at the wind farm. This entailed a total search area of 6.16 ha at each turbine.

2.4.2 Searcher efficiency trials

Trials to establish the efficiency of searches are required to inform estimation of total collision mortality. The efficiency rate was determined by placing bird and bat carcasses within search plots during routine searches and documenting the efficiency with which search dogs detected them. Searcher efficiency trials undertaken at Morton's Lane Wind Farm are set out in detail in Appendix 4. In summary, a total of 17 separate trials using carcasses of six species of small to medium bird species and 15 separate trials using one species of microbat were carried out.

The 2017 searcher efficiency data was used to inform the estimations of total collision mortality.

2.4.3 Carcass persistence trials

Carcasses of bird and bats that collide with turbines may be removed by scavengers or will ultimately disappear due to decomposition. Carcass persistence affects the capacity for searches to detect dead birds and bats that collide with turbines and consequently influences estimation of the total number of fatalities for various species.

Carcass persistence trials were conducted in autumn and spring 2015 to ascertain the average persistence period of bats and of different size class of birds.

The trials monitored the persistence of carcasses of birds and bats sourced from outside the wind farm. These were placed under a subset of turbines and their persistence was monitored for up to 29 days.

We used remote cameras to record persistence of each carcass. Reconyx cameras used for the purpose were set to take a photograph every hour (day and night) and also when triggered by movement. This method is highly efficient and substantially reduced potential influence on scavengers that may occur when human observers visit routinely to check carcasses used in the trial. Cameras have the additional advantage of recording the precise time of carcass removal and the species of scavenger that removes a carcass can usually be determined. As a result of the precise documentation of the time of carcass removal there was also no need to estimate the period of carcass persistence which is required when carcasses are checked only at intervals of several days.

The field of view of cameras is limited and a carcass can simply be moved out of that view. In order to check for this, we timed placement of carcasses approximately one week before the next general dog search for carcasses. Since the dogs detected carcasses placed for the trials we were able to determine persistence of a small number of placed carcasses that had been simply moved but remained for a period on-site.



Figure 4: Carcass persistence trial using Reconyx camera.

Carcass persistence trials were conducted in autumn/winter (13 May – 14 June) and in spring (21 October – 19 November) 2015. The intent of the two trials was to evaluate carcass persistence under different seasonal conditions. In the autumn trial three size classes of birds were used (3 small birds, 6 medium birds and 5 large birds) and 3 microbats in 17 replicate persistence trials. These carcasses were kindly provided by Museum of Victoria. While the total number of carcasses used in autumn well exceeded the total of 10 carcasses required by the BAM Plan, the small number of each category gives some concern about the reliability of the resultant persistence rate for each category. Results of monthly carcass searches showed that, prior to the spring persistence trial, 67% (16 of 24) of bird and bat collision carcasses were medium birds. The remaining 33% were comprised of a small number of bats and large birds. No small birds had been found. As a consequence, it was decided to concentrate the spring persistence trial on a larger sample of medium-sized birds with a view to obtaining a more statistically robust understanding of persistence for this important size-class. To achieve this, 10 carcasses of medium sized birds were used (6 Australian Magpies and 4 Little Ravens) in 12 replicate persistence trials. Over the two seasons a total of 29 replicate trials were undertaken.

Results of the entire 36-month program of carcass monitoring show that 3% of birds detected were small species; 87% were medium sized species and 10% were large species.

Carcass persistence trials were conducted in autumn and spring 2015 under turbines ML1, ML7, ML8, ML11 and ML12.

In order to maximise the volume of data for carcass persistence, where a carcass was removed within a few days and a further carcass was available, a second carcass was placed in view of the camera. This was done only after a minimum interval of two days after disappearance of the first carcass.

2.4.4 Estimation of total collision mortality

Since the carcasses of all birds and bats that collide with turbines do not persist for the entire interval between monthly carcass searches, correction factors must be applied to the numbers of carcasses actually detected to calculate estimates for the total numbers of collisions. Searcher efficiency and carcass persistence rates inform the estimates.

At Morton's Lane Wind Farm plots under all 13 turbines have been searched each month and there is thus no necessity for estimates to include extrapolation to unsearched turbines. Searcher efficiency was demonstrated to be 97% at the site, and that rate was used in the estimations of total collision mortalities.

As mentioned above, the use of remote cameras for persistence trials provides precise information about the periods for which carcasses remain and there is no need to allow for uncertainty in persistence times in the way that is required when such trials are conducted by observers visiting at intervals. In persistence trials at Morton's Lane, a number of carcasses of medium-sized birds remained beyond the month-long trials. A consequence is that the calculated persistence times for that category of birds may actually be underestimates.

A number of mathematical models have been developed to calculate estimates from search regimes for total wildlife fatalities. Specific recent applications for wind turbine collisions are reviewed in Bernardino et al. (2013) and Huso et al. (2017). The estimations of total collisions over the 36 months of study at Morton's Lane Wind Farm were undertaken using Monte-Carlo simulations by Symbolix and methods used are detailed in Appendix 7. The methods are benchmarked against those described in Huso (2011) and Korner-Nievergelt et al. (2012).

3 Results

3.1 Yearly rainfall

Annual rainfall records from the Bureau of Meteorology Penshurst (The Gums) recording station for all relevant years are shown in Table 5. The long-term annual average for the recording station is 663 mm of rain. The records indicate that 2013 was a somewhat wetter than average year, while 2014 and 2015 were both below average. As at the end of August, it appears that 2019 is also likely to be below average.

As noted above, there is no means to determine beforehand how wet any year will be and wetting and drying of farm dams in the local area has varied little over the period of the investigations.

Table 5 Annual rainfall records from The Gums (BOM Penshurst recording station)

Year	Rainfall (mm)
2013	704.0
2014	516.8
2015	555.6
2019	385.4 (up to and including August)
Mean	663.1

3.2 Bird utilisation surveys

All species of birds recorded at Morton's Lane Wind Farm site are listed in Appendix 2. During bird utilisation surveys prior to construction of the wind farm, in spring 2005 and summer and autumn 2006, a total of 39 bird species were recorded. During a total of six surveys conducted during spring and autumn period post-construction (between spring 2013 and spring 2015 and in autumn 2019), a total of 89 bird species were recorded. Five species recorded prior to construction were not recorded during post-construction surveys. They were Chestnut Teal, Flame Robin, Musk Lorikeet, Purple-crowned Lorikeet and Red-necked Stint. These are common species and all have capacity for long-distance dispersal and/or migrations. There is no suggestion that the presence of the wind farm may have influenced their occurrence at the site.

Throughout the pre- and post-construction periods the most abundant species recorded were the introduced Eurasian Skylark and the native Little Raven and Australian Magpie.

Wetland dependent species were largely confined to the vicinity of the permanent wetland near point 6 and few wetland species were recorded flying through the wind farm area.

Open country and generalist species were most abundant within the site, but there were also records of woodland-dependent species at points near planted shrubs and trees, including Grey Shrike-thrush, Red Wattlebird, Superb Fairy-wren, Silvereye, Brown Thornbill, Grey Fantail, New Holland Honeyeater and Restless Flycatcher.

During the spring 2015 bird utilisation surveys we became aware anecdotally that landowners at, or near the wind farm site had used gas guns in preceding weeks to scare birds from a large broad-bean crop. This is not an unusual practice but it is possible that it may have influence bird numbers or activity at the site, including during the spring 2015 surveys.

3.2.1 Significant species

Over the pre- and post-construction monitoring program seven listed species of threatened or migratory birds were observed during bird utilisation counts at Morton's Lane Wind Farm. They are listed in Table 6. Four of them are ducks that were observed from point 6 during a number of point counts in the immediate vicinity of the permanent wetland to the east of point 6, outside the wind farm itself. Red-necked Stints were observed once during pre-construction surveys. Observations of a single Brolga were made during both pre- and post-construction monitoring (see Section 3.2.2). Latham's Snipe and the four duck species were observed only in the post-construction period, however it is worth noting that the pre-construction monitoring spanned a single year, while post-construction monitoring was undertaken during two years (spring 2013 – spring 2015) and in autumn 2019. None of these species were found to have collided with wind turbines (see Section 3.4.2).

Table 6 Significant species detected at Morton's Lane Wind Farm

Common Name	Scientific Name	Status	Recorded prior to construction	Recorded post-construction
Australasian Shoveler	<i>Anas rhynchos</i>	vulnerable (DSE 2013)		✓
Hardhead	<i>Aythya australis</i>	vulnerable (DSE 2013)		✓
Blue-billed Duck	<i>Oxyura australis</i>	endangered (DSE 2013)		✓
Freckled Duck	<i>Stictonetta naevosa</i>	endangered (DSE 2013)		✓
Brolga	<i>Antigone rubicunda</i>	vulnerable (DSE 2013)	✓	✓
Red-necked Stint	<i>Calidris ruficollis</i>	migratory species (EPBC Act)	✓	
Latham's Snipe	<i>Gallinago hardwickii</i>	migratory species (EPBC Act)		✓

3.2.2 Brolga

In November 2013 one individual sub-adult Brolga was observed within the wind farm on four of the first five days of survey. Most records of this bird were in the Tussock Grass wetland to the north-east of turbine ML04.

No Brolgas were observed in May 2014. One Brolga was during spring point counts in October 2014 east of point 6 near the permanent wetland located outside the boundary of the wind farm. The bird was observed during a number of point counts between the 20th and 24th of October.

No Brolgas were recorded during the autumn 2014 utilisation monitoring session nor during spring or autumn point counts at the wind farm in 2015. However a single bird was observed in the morning of 27th October 2015 between two point counts. It was observed from near point 4, flying low to the ground and appeared to be near turbine ML12 but dipped below the horizon and disappeared from view. It could not be found during a subsequent search and was not seen again throughout the utilisation surveys.

From the records of Brolgas observed at or adjacent to the wind farm site the following information about their flights was recorded. Observations from November 2013 include 8 records comprised of one flight of 5m high and seven of the bird sitting or standing. In October 2014, there were nine records of a single bird and it was observed sitting, preening, walking or foraging, and no flights were observed.

A single bird was recorded in October 2015 while the observer was driving between point count sites. The bird was noted as “flying low to the ground and appeared to be near turbine ML12 but dipped below the horizon and disappeared from view”. The circumstances of this observation did not allow a more precise height estimate to be made.

During pre-construction surveys a pair of Brolgas were observed foraging within a grassy wetland portion of the site and an adjacent paddock to the north of the site during the spring 2014 bird utilisation studies (Biosis 2006b). Brolgas were not detected again during bird utilisation studies in summer and autumn 2006.

The locations of point counts allowed for observation of all wetlands (all of which are farm dams) within 2 km of the wind farm. The only observations of Brolgas in the entire post-construction monitoring period are those detailed above.

During all utilisation survey sessions checks were made twice daily of Blackwood Lake. The lake is on the route from the wind farm to point count site RFS. In addition, specific visits were made to observe the lake for the hour prior to sunset on three occasions during the spring survey sessions. The lake supported multiple wetland bird species, but no Brolgas were seen there during any visits.

3.2.3 Raptors

Four species of raptors were recorded at Morton’s Lane Wind Farm site prior to construction. A total of 12 species were observed during post-construction surveys. These included the four species observed previously. None of the raptors recorded at the site are listed as threatened, although the Spotted Harrier is listed as near threatened (DSE 2013). Brown Falcons were by far the most frequently recorded raptor species at the wind farm. Spotted Harrier was recorded at the site in spring 2015. Our five observations of that species appeared to be of the same individual.

All species of raptors recorded at the wind farm are shown in Table 7.

Table 7 Raptors recorded at Morton’s Lane Wind Farm

Common Name	Scientific Name	Recorded prior to construction	Recorded post-construction
Black-shouldered Kite	<i>Elanus axillaris</i>		✓
Whistling Kite	<i>Haliastur sphenurus</i>		✓
Collared Sparrowhawk	<i>Accipiter cirrhocephalus</i>		✓
Brown Goshawk	<i>Accipiter fasciatus</i>	✓	✓
Little Eagle	<i>Hieraaetus morphnoides</i>		✓
Wedge-tailed Eagle	<i>Aquila audax</i>	✓	✓
Spotted Harrier	<i>Circus assimilis</i>		✓
Swamp Harrier	<i>Circus approximans</i>		✓
Brown Falcon	<i>Falco berigora</i>	✓	✓
Nankeen Kestrel	<i>Falco cenchroides</i>	✓	✓
Peregrine Falcon	<i>Falco peregrinus</i>		✓
Australian Hobby	<i>Falco longipennis</i>		✓

3.3 Bats call surveys

A summary of records of bat calls recorded during all sessions of bat-call monitoring is set out in Appendix 3. The following nine species of bats were identified from recordings of their ultrasonic calls:

- **White-striped Freetail Bat** *Austronomus australis*
- **Gould's Wattled Bat** *Chalinolobus gouldii*
- **Chocolate Wattled Bat** *Chalinolobus morio*
- **Eastern Falsistrelle** *Falsistrellus tasmaniensis*
- **Southern Bent-wing Bat** *Miniopterus schreibersii bassanii*
- **Inland Broad-nosed Bat** *Scotorepens balstoni*
- **Large Forest Bat** *Vespadelus darlingtoni*
- **Little Forest Bat** *Vespadelus vulturnus*
- **Southern Forest Bat** *Vespadelus regulus*

At least two further species were recorded as present but were identified only to genus level. These cannot be definitively ascribed to particular species because the characteristics of the calls of various species within the same genus overlap. These are:

- **Freetail Bats** *Mormopterus* sp.
Calls recorded during this study are most likely to be calls of the Southern Freetail Bat *Mormopterus* sp. 4 (undescribed) (Churchill 2008).
- **Long-eared Bats** *Nyctophilus* sp.
Ultrasonic calls of the three Victorian Long-eared Bat species cannot be reliably distinguished. Most or all of the calls recorded at Morton's Lane are likely to be from the Lesser Long-eared Bat *Nyctophilus geoffroyi*, while some may be from Gould's Long-eared Bat *Nyctophilus gouldi*. Both *Nyctophilus geoffroyi* and *Nyctophilus gouldi* have been recorded in the carcass searches at Morton's Lane Wind Farm. In Victoria, the threatened Greater Long-eared Bat *Nyctophilus corbeni* is limited to the north-west of the State.

Appendix 3 shows the number of recordings of these species and species-groups, and lists the numbers of calls recorded by each detector during each survey period. A large number of poor-quality calls could not be identified to species or species-group level and are not included in the summary. Many of those recordings were clearly bat calls, but were of insufficient duration or quality to allow confident identification. Additionally, most detectors recorded high levels of extraneous noise, which may have limited the potential for these detectors to record bat calls. Noise may be generated by a range of factors, including background noise, insects and potentially electrical interference. Very few identifiable bat calls (mostly of *Austronomus australis*) were recorded in the summer 2016 recording session and these are not presented in this report as they are not considered representative of activity at the site.

Nonetheless, results for sessions in which detectors mounted on turbine nacelles did record bat calls (2013, 2014 and 2019) showed very substantially fewer calls were recorded from those detectors than from detectors close to the ground.

3.4 Turbine collision monitoring

3.4.1 Carcass searches

A total of 125 fauna collisions, comprised of 53 bird carcasses, 31 featherspots and 41 bat carcasses, were detected and documented during the dog searches over the 36 months of monitoring between April 2015 and June 2019, inclusive. All identified species of birds and bats found to have collided with turbines were common species. Twelve species of birds and five species of bats were identified as collision casualties, but additional species may have been included among bat carcasses and featherspots that could not be identified. A summary of the total of carcasses and featherspots found during searches under the thirteen turbines is set out in Table 8. Appendix 5 provides details and results for each of 468 searches under turbines at the wind farm.

Table 8 Species summary of carcass and featherspots detected over 36 months of monitoring of 13 turbines at Morton’s Lane Wind Farm

Species	Total carcasses detected
Australian Wood Duck	1
Black Swan	1
Whistling Kite	1
Nankeen Kestrel	23
Brown Falcon	8
Wedge-tailed Eagle	5
Sulphur Crested Cockatoo	1
cockatoo / corella (<i>Cacatua</i> sp.)	3
Red-browed Finch	1
Australian Magpie	13
raven (<i>Corvus</i> sp.)	12
Australasian Pipit	1
unidentifiable bird	14
all birds	84
Eastern Falsistrelle	2
Gould's Long-eared Bat	3
Gould's Wattled Bat	11
Large Forest Bat	2
White-striped Freetail Bat	18
unidentifiable bat	5
all bats	41
total	125

Results of carcass searches for birds include whole and partial carcasses as well as featherspots (a collection of 10 or more feathers at a single location). Our carcass persistence trials using remote cameras demonstrated that carcasses are quite often moved but not completely removed by scavengers. It is thus possible that a featherspot and a carcass found nearby may be from the same bird and counting each as a separate collision event for the species in question may involve some double counting and consequent

overestimation of total mortality. However, in our analyses here each carcass and featherspot is counted separately.

The carcasses detected include 10 identified species of birds and five identified species of bats. Some additional species of birds, mainly detected as featherspots, were not able to be identified to species level and five carcasses of bats were also not able to be identified to that level.

A single Black Swan is included as a potential collision fatality. The carcass of the swan was detected by the search dog in the back of a fox den 31 metres from the base of a turbine. It is unknown whether the swan was killed in a collision, but it has been included as such. One Nankeen Kestrel carcass was found 268 metres from the nearest turbine and also may not have been a collision victim but has also been included as such.

Australian Ravens and Little Ravens are present at the wind farm. Mortality records are included as 'raven sp.' covering both species because a number of those records are of featherspots or carcasses in poor condition when found.

Table 9 provides a summary of carcasses detected under each of the 13 turbines during the entire 36 months of searches. The highest incidence of bird collisions (whole birds and featherspots combined) were at turbines 1 and 5, while the highest incidence of bat collisions were at turbines 5 and 13. We are not aware of an obvious reason why bird mortalities might be higher at turbine 1 and, as noted above, deriving a total number of bird collisions from a combination of whole carcasses and featherspots may possibly incorporate some element of overestimation. Turbines 5 and 13 are at the eastern end of the wind farm and are the closest to a large dam on an adjacent property. It is possible that this may have influenced heightened bat activity in that area. The average per-annum rate of detected collisions for birds and bats combined is also shown for each turbine. The overall average per-annum rate of detected collisions for the 13 turbines at the wind farm was 3.2.

Table 9 Summary per turbine of carcass and featherspots detected over 36 months of monitoring at Morton's Lane Wind Farm

Turbine	Bird carcasses	Feather spots	Bat carcasses	Total carcasses detected	Average detected collisions per annum
1	8	4	2	14	4.7
2	5	4	1	10	3.3
3	5	2	0	7	2.3
4	3	1	5	9	3.0
5	9	1	9	19	6.3
6	3	5	4	12	4.0
7	4	2	2	8	2.7
8	3	1	1	5	1.7
9	3	4	0	7	2.3
10	3	2	1	6	2.0
11	2	3	4	8	2.7
12	1	0	4	5	1.7
13	4	2	8	14	4.7
Per turbine	4.1	2.4	3.2	9.6	3.2
Whole of wind farm	53	31	41	125	41.7

Seasonal variation may influence collisions and all detected collisions are tabulated by month and date in Appendix 6. As a consequence of the overall span of searches from April 2015 to June 2019 and interruptions to the search program, the searches were carried out in the following months:

- January 2017, 2018
- February 2017, 2018
- March 2017, 2018
- April 2015, 2016, 2017, 2018
- May 2015, 2017, 2019
- June 2015, 2017, 2019
- July 2015, 2016
- August 2015, 2016, 2017
- September 2015, 2016, 2017
- October 2015, 2016, 2017
- November 2015, 2017
- December 2015, 2016, 2017

The number of collisions detected for particular months of the year were collated as per Appendix 6 and were then averaged for the given month. Results of this analysis indicate seasonal variation and are set out in Table 10. While there are no apparent trends in bird collisions over the annual cycle, a clear trend is evident for bats. The number of bat collisions was clearly higher in February, March and April than in other months and there were no bat mortalities detected in June, July or August of any year. The latter result aligns with the fact that many bats will be in torpor or a period of low activity during winter.

Table 10 Average numbers of bird and bat carcasses detected by month of the year from the complement of turbines at Morton’s Lane Wind Farm 2015 - 2019

Month	Bird carcass	Featherspot	Bat carcass	Total collisions
January	1.0	1.5	0.5	3.0
February	2.0	1.0	4.5	7.5
March	2.5	0.5	7.0	10.0
April	3.5	1.8	3.5	8.8
May	1.0	0.7	0.7	2.3
June	1.3	0.3	0.0	1.7
July	1.0	1.5	0.0	2.5
August	2.3	0.0	0.0	2.3
September	0.7	1.3	0.3	2.3
October	1.3	2.3	0.3	4.0
November	1.5	0.5	1.0	3.0
December	1.0	0.7	0.7	2.3

3.4.2 Significant impacts

With regards to numbers of bird or bat mortalities that might be considered significant the BAM plan says (p. 19):

A significant impact on Birds and Bats arising from the operation of the Morton's Lane Wind Farm that requires the implementation of mitigation measures and offsetting is defined as follows as determined in consultation with DSE (Richard Hill, pers comm.):

- 1 Any death of bird or bat species listed under the EPBC Act, FFG Act or on the Advisory List, identified within 130 m radius of a wind turbine once the operation of the wind farm has commenced.
- 2 In any two successive monthly carcass searches, two or more carcasses are found at the same or adjacent turbines (i.e. a total of four or more carcasses of an individual species in two successive searches). This criteria applies to common (non-listed) species.

Criterion 1 did not occur during the entire period of monitoring as none of the species detected by the searches are listed as threatened or migratory and all are common species of agricultural environments of western Victoria. Criterion 2 also did not occur for any species for which carcasses or featherspots were detected during the entire period of monitoring.

3.4.3 Searcher efficiency trials

Searcher efficiency trials demonstrated that the dogs used to conduct carcass searches were 97 percent effective at locating placed carcasses (Table 11). Searcher efficiency trials undertaken at Morton's Lane Wind Farm are set out in detail in Appendix 4. Due to the very high success rate of the searchers, there was no need to account for different environmental or biological conditions.

Table 11 Summary of searcher efficiency results at Morton's Lane Wind Farm

Variable	Value
Number of placed carcasses	32
Number carcasses found	31
Mean detectability	97%
Detectability lower bound (95% confidence interval)	84%
Detectability upper bound (95% confidence interval)	100%

3.4.4 Carcass persistence trials

During the autumn carcass persistence trials Little Ravens were photographed eating and/or moving 10 carcasses under four of the five turbines. In the spring trials no ravens were photographed scavenging any carcasses. In the autumn trials Red Foxes were documented scavenging carcasses placed under four of the five turbines. Whilst the spring carcass persistence trial was underway we became aware anecdotally that landowners in the local area had recently conducted a concerted fox control effort. A fox was observed on-site during establishment of the trial and foxes were photographed by remote cameras removing carcasses under turbines ML1 and ML7. Nonetheless, it is feasible that a reduction in the local fox population may have affected the spring carcass persistence trial. This, and other land-management activities, may affect scavengers and bird and bat activities at the site separately from any possible influence of the wind farm itself.

Average carcass persistence times and rates varied widely between bats and the three size-classes of birds. For medium-sized birds they were also very different between autumn and spring and for medium and large birds the ranges of persistence times were large. Average carcass persistence times for all categories determined from autumn and spring persistence trials are shown in Table 12.

Table 12 Results of carcass persistence trials at Morton's Lane Wind Farm

Category	Autumn 2015			Spring 2015		
	Number of replicates	Mean persistence time (days)	Range (days)	Number of replicates	Mean persistence time (days)	Range (days)
Microbats	3	1.8	0.9 - 3.1			
Small birds	3	0.7	0.2 - 1.0			
Medium birds	6	11.5	0.1 - 65.0*	12	19.6*	1.3 - 29.0
Large birds	5	27.0	0.8 - 65.0*			

* results are right censored, see text below.

Note that persistence times of some medium and large birds in autumn/winter exceeded the length of the trials (results are right censored) and three of the carcasses used were found still to be on-site during dog searches 65 days after the trial commenced. Similarly for medium birds in spring, while 4 of 12 placed carcasses in this group were scavenged by foxes between 0.3 and 1.5 days after the trial commenced, the remaining 8 carcasses persisted until the termination of the trial 29 days after they were placed. As a consequence, the mean persistence times for medium and large birds in autumn and medium birds in spring was limited by termination of the trials.

Due to the small number of bat carcasses available for use in the trials at Morton's Lane Wind Farm, distinctions between the persistence rates for birds and bats could not be made and in analyses provided in previous reporting of results a mean persistence period of 17 days was used in calculations of overall collision estimates for all species of birds and bats detected as casualties.

However, the small trial of bat carcass persistence at the site and general information from other sites in similar agricultural landscapes in western Victoria (E. Bennett, Elmoby Ecology; L. Stark, Symbolix pers. comm.), suggest that microbat carcasses are likely to persist for much shorter periods. For those reasons, DELWP has requested that analyses in the present report should be made using both 17 days and 3 days for microbats. Under assumptions for the wind farm as set out by Symbolix (Appendix 7) a mean persistence period of 2.9 days (95% CI = 0.9, 9.1 days) has been calculated for Morton's Lane Wind Farm. This is in close harmony with the 3 days proposed by DELWP, and has been used for bat carcasses. Comparative estimates of total bat collisions are thus provided for the two average persistence rates of 2.9 and 17 days. We note that the recent DELWP ARI report (Moloney et al. 2019) calculated a mean persistence time of 7.9 days for microbats from four wind farms in Victoria. Our use of 2.9 days will return a higher mortality estimate for bats than would a persistence time of 7.9 days.

After separation of birds and bats in the analysis Symbolix (Appendix 7) has calculated the mean carcass persistence period of birds at the site to be 20.5 days (95% CI = 11.7, 36.2 days) and that rate has been used in calculating estimates of total bird collisions over the 36 months of the study. As a result of the right-censored results for medium and large birds it is possible that total mortality estimates for these categories of birds may be overestimated. Moloney et al. (2019) calculated a mean persistence time of 33.1 days for birds from four wind farms in Victoria. Our use of 20.5 days will return a higher mortality estimate for birds than would a persistence time of 33.1 days.

For the purposes of the analyses, all bat species are pooled as are all bird species. This provides for estimates that are more robust than estimates for individual species might be. As no significant species were found to have collided with turbines, this is considered to be a reasonable approach.

3.5 Total collision mortality estimates

The documented results of monthly searches for carcasses, searcher efficiency rate and carcass persistence rates were used to calculate total mortality estimates for the wind farm for the 36 months of the investigation in the overall period from April 2015 to June 2019, inclusive. The detailed methods, assumptions used and results of the calculations are set out in Symbolix (Appendix 7) and should be read in conjunction with the summary provided here.

Bats

As noted above, the recent DELWP ARI report (Moloney et al. 2019) found a mean persistence time of 7.9 days for microbats from four wind farms in Victoria. As suggested by DELWP Environment for Morton's Lane Wind Farm, in calculating overall bat mortality estimates we have here used a short bat carcass persistence time of 2.9 days and a long persistence time of 17 days. A persistence time of 17 days is not likely to be realistic but is provided for comparative purposes. Our use of 2.9 days will return a higher mortality estimate for bats than would a persistence time of 7.9 days as used by Moloney et al. (2019).

Short carcass persistence rate

During the 36 months of formal carcass searches a total of 41 bats were found. On the assumption that bat carcasses persist for an average of 2.9 days (with an associated 95% confidence interval of 0.9 - 9.1 days) and using the searcher efficiency rate documented at the wind farm, the Monte Carlo simulations indicate that there was an estimated mean of 677 bat collisions at the 13 turbines over the period of investigation. We can be 95% confident that fewer than 1147 bats were killed.

Long carcass persistence rate

Using the less realistic assumption that bat carcasses persist for an average of 17 days and using the searcher efficiency rate documented at the wind farm, the Monte Carlo simulations indicate that there would have been approximately 129 bat collisions at the 13 turbines over the period of investigation and under these assumptions there would be 95% confidence that fewer than 214 bats were killed.

Birds

On the conservative assumption that each bird carcass and every featherspot found represented a different bird, a total of 84 birds were detected as turbine casualties during the 36 months of carcass search regime. On the assumption that bird carcasses persist for an average of 20.5 days (with an associated 95% confidence interval of 11.7 - 36.2 days) and using the searcher efficiency rate documented at the wind farm, the Monte Carlo simulations indicate that there was an estimated 238 collisions at the 13 turbines over the period of investigation. We can be 95% confident that fewer than 321 birds were killed. Moloney et al. (2019) calculated a mean persistence time of 33.1 days for birds from four wind farms in Victoria. Our use of 20.5 days will have returned a higher mortality estimate for birds than would a persistence time of 33.1 days.

4 Conclusion

4.1 Brolga

Observations of Brolgas since the wind farm has been operational are of single birds at or adjacent to the wind farm in spring of most years. Two Brolgas were observed in and close to the site prior to construction of the wind farm during one seasonal monitoring session. It does not appear that the wind farm site is of particular importance to the species and overall it cannot be said that its use of the area has substantially altered. To-date there is no evidence of any detrimental effect of Morton's Lane Wind Farm on Brolgas.

4.2 Bats

At least nine bat species were recorded during the bat call survey, which included the five species recorded as collision fatalities during the carcass searches.

These two most commonly recorded species in the carcass searches (Gould's Wattled Bat and White-striped Freetail Bat) are abundant high-flying bats which inhabit open areas, so their presence in both the ultrasonic recordings and carcass searches is to be expected.

As described in section 3.3, equipment failure and ultrasonic interference limited the utility of the ultrasonic bat data particularly from detectors mounted on turbine nacelles. Results for sessions in which detectors mounted on turbine nacelles did record bat calls (2013, 2014 and 2019) showed very substantially fewer calls were recorded from those detectors than from detectors close to the ground.

4.3 Significant impacts

No significant impact, as defined in the BAM Plan for the facility, was detected by monthly dog searches monitoring all turbines for collisions.

4.4 Fauna collision with turbines

At least twelve species of birds and five species of bats were found to have collided with turbines. On the basis of the numbers of carcasses detected, searcher efficiency rates ascertained from the site and relevant carcass persistence rates, it is likely that approximately 238 birds and 677 bats collided with turbines over the 36 months of the study. If carcasses of birds and bats persist for longer mean times, as indicated by Moloney et al. (2019), the numbers of birds and bats that collided with turbines at Morton's Lane Wind Farm may have been lower than our estimates using shorter carcass persistence times.

No species listed as threatened or migratory under Commonwealth or Victorian legislation were found to have collided with turbines and all the species detected are considered to have secure populations in agricultural environments of Victoria.

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Appendices

Appendix 2: Bird species recorded pre- & post-construction

Common Name	Scientific Name	Status	Recorded prior to construction	Recorded post-construction
Yellow-rumped Thornbill	<i>Acanthiza chrysorrhoa</i>	Native		✓
Brown Thornbill	<i>Acanthiza pusilla</i>	Native		✓
Yellow Thornbill	<i>Acanthiza nana</i>	Native		✓
Striated Fieldwren	<i>Calamanthus fuliginosus</i>	Native		✓
White-browed Scrubwren	<i>Sericornis frontalis</i>	Native		✓
Collared Sparrowhawk	<i>Accipiter cirrhocephalus</i>	Native		✓
Brown Goshawk	<i>Accipiter fasciatus</i>	Native	✓	✓
Wedge-tailed Eagle	<i>Aquila audax</i>	Native	✓	✓
Swamp Harrier	<i>Circus approximans</i>	Native		✓
Spotted Harrier	<i>Circus assimilis</i>	Native		✓
Black-shouldered Kite	<i>Elanus axillaris</i>	Native		✓
Whistling Kite	<i>Haliastur sphenurus</i>	Native		✓
Little Eagle	<i>Hieraaetus morphnoides</i>	Native		✓
Eurasian Skylark	<i>Alauda arvensis</i>	Native	✓	✓
Grey Teal	<i>Anas gracilis</i>	Native	✓	✓
Chestnut Teal	<i>Anas castanea</i>	Native	✓	
Australasian Shoveler	<i>Anas rhynchotis</i>	Native – vulnerable (DSE 2013)		✓
Pacific Black Duck	<i>Anas superciliosa</i>	Native	✓	✓
Hardhead	<i>Aythya australis</i>	Native – vulnerable (DSE 2013)		✓
Australian Wood Duck	<i>Chenonetta jubata</i>	Native	✓	✓
Black Swan	<i>Cygnus atratus</i>	Native	✓	✓
Pink-eared Duck	<i>Malacorhynchus membranaceus</i>	Native	✓	✓
Blue-billed Duck	<i>Oxyura australis</i>	Native – endangered (DSE 2013)		✓
Freckled Duck	<i>Stictonetta naevosa</i>	Native – endangered (DSE 2013)		✓
Australian Shelduck	<i>Tadorna tadornoides</i>	Native	✓	✓
White-necked Heron	<i>Ardea pacifica</i>	Native		✓
White-faced Heron	<i>Egretta novaehollandiae</i>	Native		✓
Australian Magpie	<i>Cracticus tibicen</i>	Native	✓	✓
Sulphur-crested Cockatoo	<i>Cacatua galerita</i>	Native		✓
Little Corella	<i>Cacatua sanguinea</i>	Native		✓
Long-billed Corella	<i>Cacatua tenuirostris</i>	Native	✓	✓
Yellow-tailed Black-cockatoo	<i>Calyptorhynchus funereus</i>	Native	✓	✓
Galah	<i>Eolophus roseicapillus</i>	Native		✓

Common Name	Scientific Name	Status	Recorded prior to construction	Recorded post-construction
Black-fronted Dotterel	<i>Euseyornis melanops</i>	Native		✓
Masked Lapwing	<i>Vanellus miles</i>	Native		✓
Golden-headed Cisticola	<i>Cisticola exilis</i>	Native		✓
Crested Pidgeon	<i>Oreoica gutturalis</i>	Native		✓
Australian Raven	<i>Corvus coronoides</i>	Native	✓	✓
Little Raven	<i>Corvus mellori</i>	Native	✓	✓
Horsfield's Bronze-Cuckoo	<i>Chalcites basalis</i>	Native		✓
Brown Falcon	<i>Falco berigora</i>	Native	✓	✓
Nankeen Kestrel	<i>Falco cenchroides</i>	Native	✓	✓
Australian Hobby	<i>Falco longipennis</i>	Native		✓
Peregrine Falcon	<i>Falco peregrinus</i>	Native		✓
European Goldfinch	<i>Carduelis carduelis</i>	Introduced	✓	✓
Common Greenfinch	<i>Carduelis chloris</i>	Introduced		✓
Brolga	<i>Antigone rubicunda</i>	Native – vulnerable (DSE 2013)	✓	✓
Welcome Swallow	<i>Hirundo neoxena</i>	Native	✓	✓
Fairy Martin	<i>Petrochelidon ariel</i>	Native		✓
Tree Martin	<i>Petrochelidon nigricans</i>	Native		✓
Whiskered Tern	<i>Chlidonias hybrida</i>	Native		✓
Silver Gull	<i>Chroicocephalus novaehollandiae</i>	Native	✓	✓
Superb Fairy-wren	<i>Malurus cyaneus</i>	Native	✓	✓
Brown Songlark	<i>Cincloramphus cruralis</i>	Native	✓	✓
Eastern Spinebill	<i>Acanthorhynchus tenuirostris</i>	Native		✓
Red Wattlebird	<i>Anthochaera carunculata</i>	Native	✓	✓
White-fronted Chat	<i>Epthianura albifrons</i>	Native		✓
Yellow-faced Honeyeater	<i>Lichenostomus chrysops</i>	Native		✓
White-plumed Honeyeater	<i>Lichenostomus penicillatus</i>	Native		✓
White-naped Honeyeater	<i>Melithreptus lunatus</i>	Native		✓
New Holland Honeyeater	<i>Phylidonyris novaehollandiae</i>	Native	✓	✓
Flame Robin	<i>Petroica phoenicea</i>	Native	✓	
Magpie-lark	<i>Grallina cyanoleuca</i>	Native	✓	✓
Restless Flycatcher	<i>Myiagra inquieta</i>	Native		✓
Australasian Pipit	<i>Anthus novaeseelandiae</i>	Native	✓	✓
Common Blackbird	<i>Turdus merula</i>	Introduced		✓
Mistletoebird	<i>Dicaeum hirundinaceum</i>	Native		✓
Grey Shrike-thrush	<i>Colluricincla harmonica</i>	Native		✓
House Sparrow	<i>Passer domesticus</i>	Introduced	✓	✓
Great Cormorant	<i>Phalacrocorax carbo</i>	Native		✓

Common Name	Scientific Name	Status	Recorded prior to construction	Recorded post-construction
Little Black Cormorant	<i>Phalacrocorax sulcirostris</i>	Native		✓
Pied Cormorant	<i>Phalacrocorax varius</i>	Native		✓
Stubble Quail	<i>Coturnix pectoralis</i>	Native		✓
Hoary-headed Grebe	<i>Poliiocephalus poliocephalus</i>	Native		✓
Australasian Grebe	<i>Tachybaptus novaehollandiae</i>	Native		✓
Musk Lorikeet	<i>Glosopsitta concinna</i>	Native	✓	
Purple-crowned Lorikeet	<i>Glosopsitta porphyrocephala</i>	Native	✓	
Rainbow Lorikeet	<i>Trichoglossus haematodus</i>	Native		✓
Blue-winged Parrot	<i>Neophema chrysostoma</i>	Native		✓
Crimson Rosella	<i>Platycercus elegans</i>	Native		✓
Red-rumped Parrot	<i>Psephotus haematonotus</i>	Native	✓	✓
Eurasian Coot	<i>Fulica atra</i>	Native		✓
Purple Swamphen	<i>Porphyrio porphyrio</i>	Native		✓
Banded Stilt	<i>Cladorhynchus leucocephalus</i>	Native		✓
Black-winged Stilt	<i>Himantopus himantopus</i>	Native		✓
Red-necked Stint	<i>Calidris ruficollis</i>	Native – Migratory species (EPBC Act)	✓	
Grey Fantail	<i>Rhipidura albiscapa</i>	Native		✓
Willie Wagtail	<i>Rhipidura leucophrys</i>	Native	✓	✓
Latham's Snipe	<i>Gallinago hardwickii</i>	Native – Migratory species (EPBC Act)		✓
Common Starling	<i>Sturnus vulgaris</i>	Introduced	✓	✓
Yellow-billed Spoonbill	<i>Platalea flavipes</i>	Native	✓	✓
Australian White Ibis	<i>Threskiornis molucca</i>	Native	✓	✓
Straw-necked Ibis	<i>Threskiornis spinicollis</i>	Native	✓	✓
Silvereye	<i>Zosterops lateralis</i>	Native		✓

Appendix 3: Summary records of calls of bat species recorded during all sessions of post-construction monitoring

Monitoring session	Species	Common name	Ground detectors				Turbine mounted detectors				Total calls
			ML02	ML05	ML06	ML10	ML02	ML05	ML06	ML10	
December 2013 (6-7 nights)	<i>Austronomus australis</i>	White-striped Freetail Bat	8		8					16	
	<i>Chalinolobus gouldii</i>	Gould's Wattled Bat	4	3	8		3	2		20	
	<i>Chalinolobus morio</i>	Chocolate Wattled Bat	6	2	13	3				24	
	<i>Mormopterus</i> sp.	Freetail Bats	12		5	2				19	
	<i>Nyctophilus</i> sp.	Long-eared Bats	3	5	8					16	
	<i>Vespadelus darlingtoni</i>	Large Forest Bat	12	2	32	4				50	
	<i>Vespadelus regulus</i>	Southern Forest Bat	11	3	35					49	
	<i>Vespadelus vulturnus</i>	Little Forest Bat	4	5	4	5				18	
May - June 2014 (9 nights)	<i>Austronomus australis</i>	White-striped Freetail Bat	14			27				41	
	<i>Chalinolobus gouldii</i>	Gould's Wattled Bat	76	195		36	3			310	
	<i>Chalinolobus morio</i>	Chocolate Wattled Bat	24	148		77	2			251	
	<i>Mormopterus</i> species 4	Freetail Bats	132	11		278	1			422	
	<i>Nyctophilus</i> sp.	Long-eared Bats	49	21		101				171	
	<i>Scotorepens balstoni</i>	Western Broad-nosed Bat		2		5				7	
	<i>Vespadelus darlingtoni</i>	Large Forest Bat		16						16	
	<i>Vespadelus regulus</i>	Southern Forest Bat		7						7	
	<i>Vespadelus vulturnus</i>	Little Forest Bat	11	41		55				107	
December 2014 - January 2015 (30 nights)	<i>Austronomus australis</i>	White-striped Freetail Bat			6	3	3		2	14	
	<i>Chalinolobus gouldii</i>	Gould's Wattled Bat			16	1			1	18	
	<i>Chalinolobus morio</i>	Chocolate Wattled Bat			59	2	3			64	
	<i>Mormopterus</i> species 4	Freetail Bats			22	1				23	
	<i>Nyctophilus</i> sp.	Long-eared Bats			18	4				22	
	<i>Vespadelus darlingtoni</i>	Large Forest Bat			5					5	

Monitoring session	Species	Common name	Ground detectors				Turbine mounted detectors				Total calls
			ML02	ML05	ML06	ML10	ML02	ML05	ML06	ML10	
	<i>Vespadelus regulus</i>	Southern Forest Bat			3						3
	<i>Vespadelus vulturnus</i>	Little Forest Bat	1		1	3		1			5
April 2015 (5 nights)	<i>Austronomus australis</i>	White-striped Freetail Bat			3	10					13
	<i>Chalinolobus gouldii</i>	Gould's Wattled Bat		1	1	8					10
	<i>Chalinolobus morio</i>	Chocolate Wattled Bat			11	3					14
	<i>Mormopterus</i> species 4	Freetail Bats			4	2					6
	<i>Nyctophilus</i> sp.	Long-eared Bats			4	6					10
	<i>Vespadelus darlingtoni</i>	Large Forest Bat				1					1
	<i>Vespadelus regulus</i>	Southern Forest Bat				1					1
	<i>Vespadelus vulturnus</i>	Little Forest Bat				5					5
Monitoring over 5 nights in December 2016 failed to record identifiable calls											
April 2019 (14 nights)	<i>Austronomus australis</i>	White-striped Freetail Bat	211	100	25	51	13	416	10	10	836
	<i>Chalinolobus gouldii</i>	Gould's Wattled Bat	19	12	105	26		1			163
	<i>Chalinolobus morio</i>	Chocolate Wattled Bat		4	163	6					173
	<i>Falsistrellus tasmaniensis</i>	Eastern Falsistrelle			3						3
	<i>Mormopterus</i> species 4	Freetail Bats	13	4	23	12					52
	<i>Miniopterus schreibersii bassanii</i>	Southern Bent-wing Bat			4	2					6
	<i>Nyctophilus</i> sp.	Long-eared Bats	7	1	12	4					24
	<i>Scotorepens balstoni</i>	Western Broad-nosed Bat	1								1
	<i>Vespadelus darlingtoni</i>	Large Forest Bat	11	7	15	1					34
	<i>Vespadelus regulus</i>	Southern Forest Bat	13	3	33	1					50
	<i>Vespadelus vulturnus</i>	Little Forest Bat	7		15						22

Appendix 4: Searcher efficiency trial data for Morton's Lane Wind Farm

Species	Type	Surveyor	Distance from base of turbine	Direction from base of turbine	Success
Black-shouldered Kite	bird	LU	38	SW	yes
Black-shouldered Kite	bird	FR	38	SW	yes
Black-shouldered Kite (head only)	bird featherspot	LU	42	W	yes
Black-shouldered Kite (head only)	bird featherspot	FR	42	W	yes
Brown Falcon	bird	LU	62	E	yes
Brown Falcon	bird	FR	62	E	yes
European Starling	Bird	FR	88	SW	yes
Little Raven	bird	LU	130	W	yes
Little Raven	bird	FR	130	W	yes
Nankeen Kestrel	Bird	LU	63	NW	yes
Nankeen Kestrel	bird featherspot	LU	71	NW	yes
Nankeen Kestrel	bird	LU	69	SW	yes
Nankeen Kestrel	bird	FR	69	SW	yes
Nankeen Kestrel	Bird	FR	63	NW	yes
Nankeen Kestrel	bird featherspot	FR	71	NW	yes
Rock Pigeon	bird	LU	93	S	no
Rock Pigeon	bird	FR	93	S	yes
White-striped Freetail Bat	bat	LU	12	SW	yes
White-striped Freetail Bat	bat	LU	70	SW	yes
White-striped Freetail Bat	bat	LU	6	SW	yes
White-striped Freetail Bat	bat	LU	40	E	yes
White-striped Freetail Bat	bat	LU	60	N	yes
White-striped Freetail Bat	bat	LU	59	W	yes
White-striped Freetail Bat	bat	LU	16	SE	yes
White-striped Freetail Bat	bat	FR	60	N	yes
White-striped Freetail Bat	bat	FR	59	W	yes
White-striped Freetail Bat	bat	FR	16	SE	yes
White-striped Freetail Bat	bat	FR	40	E	yes
White-striped Freetail Bat	bat	FR	12	SW	yes
White-striped Freetail Bat	bat	FR	35	SE	yes
White-striped Freetail Bat	bat	FR	70	SW	yes
White-striped Freetail Bat	bat	FR	6	SW	yes

Appendix 5: Carcass searches & results Morton's Lane Wind Farm 2015 - 2019

Date	Turbine	Bird carcass	Feather spot	Bat carcass	Species
21/04/2015	6	0	0	1	unidentifiable
21/04/2015	7	0	0	1	Gould's Wattled Bat
21/04/2015	9	1	0	0	Black Swan
22/04/2015	3	0	0	0	
22/04/2015	2	1	1	0	Brown Falcon
22/04/2015	1	0	0	0	
22/04/2015	8	1	0	0	Whistling Kite
23/04/2015	13	2	1	0	Nankeen Kestrel
23/04/2015	5	1	0	0	Wedge-tailed Eagle
23/04/2015	12	0	0	0	
24/04/2015	11	0	0	0	
24/04/2015	4	0	0	1	unidentifiable
24/04/2015	10	0	0	0	
19/05/2015	3	0	0	0	
19/05/2015	2	0	0	0	
19/05/2015	1	0	0	0	
19/05/2015	6	0	0	1	unidentifiable
19/05/2015	7	0	1	0	unidentifiable
20/05/2015	4	0	0	0	
20/05/2015	10	0	0	0	
20/05/2015	8	0	0	0	
20/05/2015	9	0	0	0	
21/05/2015	11	0	0	0	
21/05/2015	12	0	0	0	
21/05/2015	13	0	0	0	
21/05/2015	5	0	0	0	
16/06/2015	3	0	0	0	
16/06/2015	2	0	0	0	
16/06/2015	1	1	0	0	Australian Magpie
16/06/2015	6	0	0	0	
16/06/2015	7	0	0	0	
17/06/2015	4	0	0	0	
17/06/2015	10	0	0	0	
17/06/2015	9	0	0	0	
17/06/2015	8	0	0	0	
18/06/2015	11	1	0	0	Nankeen Kestrel
18/06/2015	13	0	0	0	
18/06/2015	5	0	0	0	
22/07/2015	3	0	0	0	
22/07/2015	2	0	0	0	
22/07/2015	1	0	1	0	Australian Magpie
22/07/2015	6	0	0	0	
23/07/2015	4	0	0	0	
23/07/2015	7	0	0	0	

Date	Turbine	Bird carcass	Feather spot	Bat carcass	Species
23/07/2015	8	0	0	0	
23/07/2015	9	0	0	0	
23/07/2015	10	0	0	0	
24/07/2015	5	0	0	0	
24/07/2015	13	0	0	0	
24/07/2015	12	0	0	0	
24/07/2015	11	0	0	0	
18/08/2015	4	0	0	0	
18/08/2015	3	0	0	0	
18/08/2015	2	1	0	0	cockatoo / corella sp.
18/08/2015	1	0	0	0	
19/08/2015	6	0	0	0	
19/08/2015	9	0	0	0	
19/08/2015	8	0	0	0	
19/08/2015	7	0	0	0	
20/08/2015	5	0	0	0	
20/08/2015	13	0	0	0	
20/08/2015	12	0	0	0	
20/08/2015	11	0	0	0	
20/08/2015	10	0	0	0	
15/09/2015	10	0	0	0	
15/09/2015	6	0	0	0	
15/09/2015	7	0	0	0	
15/09/2015	9	0	0	0	
16/09/2015	4	0	0	0	
16/09/2015	8	0	0	0	
16/09/2015	1	0	2	0	unidentifiable & Australian Magpie
16/09/2015	11	0	0	0	
17/09/2015	3	0	0	0	
17/09/2015	5	0	0	0	
17/09/2015	13	0	0	1	Gould's Wattled Bat
17/09/2015	12	0	0	0	
17/09/2015	2	0	0	0	
13/10/2015	10	0	1	0	unidentifiable
13/10/2015	9	0	1	0	raven sp.
13/10/2015	8	1	1	0	Australian Magpie
13/10/2015	7	0	0	0	
14/10/2015	11	0	0	0	
14/10/2015	4	0	0	0	
14/10/2015	5	0	0	0	
14/10/2015	13	0	0	0	
14/10/2015	12	0	0	0	
15/10/2015	3	0	0	0	
15/10/2015	2	0	0	0	
15/10/2015	1	0	0	0	
15/10/2015	6	0	1	0	unidentifiable
17/11/2015	3	0	0	0	
17/11/2015	2	1	0	0	Brown Falcon
17/11/2015	1	0	0	1	White-striped Freetail Bat
18/11/2015	6	0	0	0	

Date	Turbine	Bird carcass	Feather spot	Bat carcass	Species
18/11/2015	7	0	0	0	
18/11/2015	8	0	0	0	
19/11/2015	10	0	0	0	
19/11/2015	12	0	0	0	
19/11/2015	4	0	0	0	
20/11/2015	9	0	0	0	
20/11/2015	11	0	1	0	White-striped Freetail Bat
20/11/2015	5	0	0	0	
20/11/2015	13	0	0	0	
15/12/2015	3	0	0	0	
15/12/2015	2	0	1	0	Australian Magpie
15/12/2015	1	0	0	0	
15/12/2015	6	0	0	0	
16/12/2015	9	0	0	0	
16/12/2015	8	0	0	0	
16/12/2015	7	0	0	0	
17/12/2015	11	0	0	1	White-striped Freetail Bat
17/12/2015	12	0	0	0	
17/12/2015	4	0	0	0	
18/12/2015	10	0	0	1	White-striped Freetail Bat
18/12/2015	13	0	0	0	
18/12/2015	5	0	0	0	
24/05/2016	3	0	0	0	
24/05/2016	2	0	0	0	
24/05/2016	6	0	0	0	
24/05/2016	7	0	0	0	
25/05/2016	10	0	0	0	
25/05/2016	9	0	0	0	
25/05/2016	8	0	0	1	White-striped Freetail Bat
25/05/2016	1	0	0	0	
26/05/2016	5	0	0	0	
26/05/2016	13	0	0	0	
26/05/2016	12	0	0	0	
26/05/2016	11	0	0	0	
26/05/2016	4	0	0	0	
22/06/2016	3	0	0	0	
22/06/2016	2	0	0	0	
22/06/2016	1	0	0	0	
22/06/2016	6	0	0	0	
23/06/2016	10	0	0	0	
23/06/2016	9	0	0	0	
23/06/2016	8	0	0	0	
23/06/2016	7	0	0	0	
24/06/2016	13	0	0	0	
24/06/2016	5	0	0	0	
24/06/2016	12	0	0	0	
24/06/2016	11	0	0	0	
24/06/2016	4	0	0	0	
26/07/2016	5	0	0	0	
26/07/2016	13	1	0	0	Wedge-tailed Eagle

Date	Turbine	Bird carcass	Feather spot	Bat carcass	Species
26/07/2016	12	0	0	0	
26/07/2016	11	0	0	0	
27/07/2016	4	0	0	0	
27/07/2016	10	0	0	0	
27/07/2016	8	0	0	0	
27/07/2016	7	0	0	0	
28/07/2016	6	0	2	0	unidentifiable
28/07/2016	1	0	0	0	
28/07/2016	2	0	0	0	
28/07/2016	1	1	0	0	Australian Magpie
28/07/2016	9	0	0	0	
24/08/2016	3	0	0	0	
24/08/2016	5	0	0	0	
24/08/2016	13	0	0	0	
24/08/2016	12	0	0	0	
25/08/2016	11	0	0	0	
25/08/2016	4	0	0	0	
25/08/2016	10	0	0	0	
25/08/2016	9	0	0	0	
26/08/2016	2	0	0	0	
26/08/2016	1	0	0	0	
26/08/2016	7	0	0	0	
26/08/2016	8	0	0	0	
26/08/2016	6	1	0	0	raven sp.
19/09/2016	3	0	0	0	
19/09/2016	2	0	0	0	
19/09/2016	1	0	0	0	
19/09/2016	10	0	1	0	unidentifiable
21/09/2016	9	0	0	0	
21/09/2016	8	0	0	0	
21/09/2016	7	1	0	0	Australian Magpie
21/09/2016	6	0	0	0	
22/09/2016	5	0	1	0	Australian Magpie
22/09/2016	13	0	0	0	
22/09/2016	12	0	0	0	
22/09/2016	11	0	0	0	
22/09/2016	4	0	0	0	
17/10/2016	3	1	0	0	Red-browed Finch (?)
17/10/2016	2	0	0	0	
17/10/2016	1	2	0	0	Brown Falcon & raven sp.
17/10/2016	6	0	1	0	unidentifiable
17/10/2016	7	0	0	0	
18/10/2016	13	0	0	0	
18/10/2016	12	0	0	0	
18/10/2016	11	0	0	0	
18/10/2016	4	0	1	0	Australian Magpie
19/10/2016	5	0	0	0	
19/10/2016	8	0	0	0	
19/10/2016	9	0	0	0	
19/10/2016	10	0	0	0	

Date	Turbine	Bird carcass	Feather spot	Bat carcass	Species
22/11/2016	5	0	0	0	
22/11/2016	13	0	0	0	
22/11/2016	11	0	0	0	
22/11/2016	4	0	0	0	
23/11/2016	3	0	0	0	
23/11/2016	2	0	0	0	
23/11/2016	1	0	0	0	
23/11/2016	6	0	0	0	
23/11/2016	7	0	0	0	
23/11/2016	8	0	0	0	
24/11/2016	9	0	0	0	
24/11/2016	10	0	0	0	
24/11/2016	11	0	0	0	
20/12/2016	6	0	0	0	
20/12/2016	7	0	0	0	
20/12/2016	1	0	0	0	
20/12/2016	2	0	0	0	
21/12/2016	9	0	1	0	raven sp.
21/12/2016	8	0	0	0	
21/12/2016	4	0	0	0	
21/12/2016	11	1	0	0	raven sp.
21/12/2016	12	0	0	0	
22/12/2016	5	0	0	0	
22/12/2016	3	0	0	0	
22/12/2016	13	0	0	0	
22/12/2016	10	0	0	0	
23/01/2017	3	0	0	0	
23/01/2017	2	0	1	0	cockatoo / corella sp.
23/01/2017	1	0	0	0	
24/01/2017	10	0	0	0	
24/01/2017	9	0	2	0	unidentifiable & Australian Magpie
24/01/2017	8	0	0	0	
24/01/2017	7	0	0	0	
24/01/2017	6	0	0	0	
25/01/2017	5	0	0	0	
25/01/2017	13	0	0	1	White-striped Freetail Bat
25/01/2017	12	0	0	0	
25/01/2017	11	0	0	0	
25/01/2017	4	0	0	0	
20/02/2017	1	1	1	0	Wedge-tailed Eagle & Nankeen Kestrel
20/02/2017	3	0	1	0	unidentifiable
20/02/2017	2	0	0	0	
20/02/2017	6	0	0	0	
20/02/2017	7	0	0	0	
21/02/2017	9	0	0	0	
21/02/2017	8	0	0	0	
21/02/2017	10	0	0	0	
23/02/2017	4	0	0	0	
23/02/2017	5	0	0	1	Gould's Wattled Bat
23/02/2017	13	0	0	4	2x White-striped Freetail Bat & 2x Gould's Wattled

Date	Turbine	Bird carcass	Feather spot	Bat carcass	Species
23/02/2017	12	0	0	1	Bat
23/02/2017	11	0	0	0	Gould's Long-eared Bat
21/03/2017	13	0	0	0	
21/03/2017	5	0	0	4	2x Eastern Falsistrelle & 2x White-striped Freetail Bat
22/03/2017	12	0	0	1	Gould's Wattled Bat
22/03/2017	11	0	0	1	Gould's Wattled Bat
22/03/2017	4	0	0	1	Gould's Wattled Bat
22/03/2017	10	0	0	0	
23/03/2017	9	0	0	0	
23/03/2017	8	0	0	0	
23/03/2017	7	0	0	0	
23/03/2017	6	0	1	1	Gould's Wattled Bat & Brown Falcon
24/03/2017	1	1	0	1	Large Forest Bat & unidentifiable bird
24/03/2017	2	0	0	0	
24/03/2017	3	0	0	0	
24/04/2017	13	0	0	1	Eastern Falsistrelle
24/04/2017	10	0	1	0	Nankeen Kestrel
24/04/2017	12	0	0	0	
24/04/2017	5	1	0	4	4x White-striped Freetail Bat & 1x Nankeen Kestrel
24/04/2017	11	0	0	0	
24/04/2017	9	0	0	0	
25/04/2017	8	0	0	0	
25/04/2017	7	0	0	0	
25/04/2017	6	0	0	0	
27/04/2017	3	0	1	0	unidentifiable
27/04/2017	2	0	1	0	unidentifiable
27/04/2017	4	0	0	0	
27/04/2017	1	0	0	0	
23/05/2017	13	0	0	0	
23/05/2017	12	0	0	0	
25/05/2017	6	1	0	0	unidentifiable
25/05/2017	10	0	0	0	
26/05/2017	4	0	0	0	
26/05/2017	2	0	0	0	
26/05/2017	3	1	0	0	unidentifiable
23/05/2017	5	0	0	0	
23/05/2017	11	0	0	0	
25/05/2017	7	0	0	0	
25/05/2017	9	0	0	0	
26/05/2017	8	0	0	0	
26/05/2017	1	0	0	0	
26/06/2017	13	1	0	0	Nankeen Kestrel
26/06/2017	12	0	0	0	
26/06/2017	4	0	0	0	
26/06/2017	5	0	0	0	
26/06/2017	11	0	0	0	
26/06/2017	10	0	0	0	

Date	Turbine	Bird carcass	Feather spot	Bat carcass	Species
27/06/2017	8	0	0	0	
27/06/2017	7	0	0	0	
27/06/2017	2	0	0	0	
27/06/2017	9	0	0	0	
27/06/2017	6	0	0	0	
27/06/2017	1	0	0	0	
27/06/2017	3	0	0	0	
28/07/2017	13	0	0	0	
28/07/2017	12	0	0	0	
28/07/2017	1	0	0	0	
28/07/2017	5	0	0	0	
28/07/2017	11	0	0	0	
28/07/2017	4	0	0	0	
28/07/2017	2	0	0	0	
31/07/2017	10	0	0	0	
31/07/2017	6	0	0	0	
31/07/2017	8	0	0	0	
1/08/2017	7	1	0	0	raven sp.
1/08/2017	9	1	0	0	Sulphur Crested Cockatoo
1/08/2017	3	0	0	0	
22/08/2017	6	1	0	0	Australian Wood Duck
22/08/2017	2	1	0	0	Australian Magpie
24/08/2017	13	0	0	0	
24/08/2017	11	0	0	0	
24/08/2017	4	0	0	0	
25/08/2017	8	0	0	0	
25/08/2017	3	1	0	0	raven sp.
22/08/2017	7	0	0	0	
22/08/2017	1	0	0	0	
24/08/2017	5	0	0	0	
24/08/2017	12	0	0	0	
25/08/2017	9	0	0	0	
25/08/2017	10	0	0	0	
25/09/2017	7	0	0	0	
25/09/2017	8	0	0	0	
25/09/2017	10	0	0	0	
25/09/2017	9	0	0	0	
26/09/2017	6	0	0	0	
26/09/2017	1	0	0	0	
26/09/2017	2	0	0	0	
25/09/2017	5	1	0	0	Brown Falcon
25/09/2017	13	0	0	0	
25/09/2017	12	0	0	0	
26/09/2017	11	0	0	0	
26/09/2017	4	0	0	0	
26/09/2017	3	0	0	0	
23/10/2017	13	0	0	0	
23/10/2017	11	0	0	0	
23/10/2017	4	0	0	0	
23/10/2017	5	0	0	0	

Date	Turbine	Bird carcass	Feather spot	Bat carcass	Species
23/10/2017	12	0	0	0	
23/10/2017	10	0	0	0	
25/10/2017	1	0	0	0	
25/10/2017	2	0	0	0	
25/10/2017	3	0	0	0	
25/10/2017	9	0	0	0	
25/10/2017	7	0	1	0	raven sp.
25/10/2017	6	0	0	1	unidentifiable
27/11/2017	13	0	0	0	
27/11/2017	11	0	0	0	
27/11/2017	10	1	0	0	Wedge-tailed Eagle
27/11/2017	7	0	0	0	
27/11/2017	5	0	0	0	
27/11/2017	12	0	0	0	
27/11/2017	4	0	0	1	White-striped Freetail Bat
27/11/2017	6	0	0	0	
28/11/2017	9	1	0	0	Nankeen Kestrel
28/11/2017	2	0	0	0	
28/11/2017	1	0	0	0	
28/11/2017	8	0	0	0	
28/11/2017	3	0	0	0	
20/12/2017	5	0	0	0	
20/12/2017	13	0	0	0	
20/12/2017	12	1	0	0	Wedge-tailed Eagle
21/12/2017	4	0	0	0	
21/12/2017	10	0	0	0	
21/12/2017	8	0	0	0	
21/12/2017	6	0	0	0	
21/12/2017	11	0	0	0	
21/12/2017	7	0	0	0	
22/12/2017	9	0	0	0	
22/12/2017	1	0	0	0	
22/12/2017	2	1	0	0	Nankeen Kestrel
22/12/2017	3	0	0	0	
22/01/2018	5	0	0	0	
22/01/2018	12	0	0	0	
22/01/2018	11	0	0	0	
22/01/2018	3	0	0	0	
22/01/2018	13	0	0	0	
22/01/2018	4	0	0	0	
22/01/2018	10	0	0	0	
24/01/2018	9	0	0	0	
24/01/2018	7	0	0	0	
24/01/2018	1	2	0	0	raven sp. & Australian Magpie
24/01/2018	8	0	0	0	
24/01/2018	6	0	0	0	
24/01/2018	2	0	0	0	
26/02/2018	5	2	0	1	2x Nankeen Kestrel & 1x White-striped Freetail Bat
26/02/2018	13	0	0	1	White-striped Freetail Bat

Date	Turbine	Bird carcass	Feather spot	Bat carcass	Species
26/02/2018	12	0	0	1	White-striped Freetail Bat
26/02/2018	8	0	0	0	
26/02/2018	4	1	0	0	Nankeen Kestrel
26/02/2018	11	0	0	0	
26/02/2018	10	0	0	0	
28/02/2018	7	0	0	0	
28/02/2018	3	0	0	0	
28/02/2018	9	0	0	0	
28/02/2018	1	0	0	0	
28/02/2018	6	0	0	0	
28/02/2018	2	0	0	0	
26/03/2018	11	0	0	2	White-striped Freetail Bat & Gould's Wattled Bat
26/03/2018	7	0	0	1	Gould's Wattled Bat
26/03/2018	4	1	0	1	Nankeen Kestrel & White-striped Freetail Bat
26/03/2018	10	1	0	0	Nankeen Kestrel
26/03/2018	8	1	0	0	Australasian Pipit
26/03/2018	5	1	0	0	Nankeen Kestrel
26/03/2018	12	0	0	0	
26/03/2018	6	0	0	0	
28/03/2018	3	0	0	0	
28/03/2018	9	0	0	0	
28/03/2018	1	0	0	0	
28/03/2018	2	0	0	1	White-striped Freetail Bat
26/04/2018	13	0	0	1	White-striped Freetail Bat
26/04/2018	12	0	0	1	Gould's Wattled Bat
26/04/2018	11	0	0	0	
26/04/2018	5	3	0	0	2x Nankeen Kestrel & 1x Australian Magpie
26/04/2018	4	1	0	1	Large Forest Bat & Brown Falcon
26/04/2018	10	0	0	0	
27/04/2018	9	0	0	0	
27/04/2018	8	0	0	0	
27/04/2018	1	0	0	0	
27/04/2018	6	0	0	0	
27/04/2018	2	0	0	0	
27/04/2018	3	0	0	0	
27/04/2018	7	0	0	0	
2/04/2019	6	0	0	2	Gould's Long-eared Bat & unidentifiable bat
2/04/2019	1	0	0	0	
2/04/2019	2	0	0	0	
2/04/2019	3	0	0	0	
9/04/2019	10	1	0	0	unidentifiable
9/04/2019	9	0	0	0	
9/04/2019	7	2	0	0	raven sp. & Brown Falcon
9/04/2019	8	0	0	0	
26/04/2019	4	0	0	0	
26/04/2019	11	0	1	0	Nankeen Kestrel
26/04/2019	12	0	0	0	
26/04/2019	13	0	1	1	Gould's Long-eared Bat & Nankeen Kestrel
3/05/2019	5	0	0	0	
3/05/2019	6	0	0	0	

Date	Turbine	Bird carcass	Feather spot	Bat carcass	Species
3/05/2019	1	0	1	0	Nankeen Kestrel
3/05/2019	2	0	0	0	
3/05/2019	3	1	0	0	Australian Magpie
13/05/2019	7	0	0	0	
13/05/2019	9	0	0	0	
13/05/2019	8	0	0	0	
13/05/2019	10	0	0	0	unidentifiable
20/05/2019	12	0	0	0	
29/05/2019	11	0	0	0	
12/06/2019	6	0	0	0	
12/06/2019	1	0	0	0	
12/06/2019	2	0	0	0	
12/06/2019	3	1	0	0	raven sp.
17/06/2019	7	0	0	0	
17/06/2019	8	0	0	0	
17/06/2019	9	0	0	0	
17/06/2019	10	0	0	0	
24/06/2019	11	0	1	0	Nankeen Kestrel
24/06/2019	12	0	0	0	
24/06/2019	5	0	0	0	
24/06/2019	13	0	0	0	
24/06/2019	4	0	0	0	

Appendix 6: Carcasses detected by month and date at Morton's Lane Wind Farm 2015 - 2019

Month	Date	Turbine	Bird carcass	Feather spot	Bat carcass	Species
January	23/1/217	2		1		cockatoo / corella sp.
	24/1/217	9		1		unidentifiable bird
	24/1/217	9		1		Australian Magpie
	25/1/217	13			1	White-striped Freetail Bat
	24/1/218	1	1			raven sp.
	24/1/218	1	1			Australian Magpie
February	2/2/217	1	1			Wedge-tailed Eagle
	2/2/217	1		1		Nankeen Kestrel
	2/2/217	3		1		unidentifiable bird
	23/2/217	5			1	Gould's Wattled Bat
	23/2/217	12			1	Gould's Long-eared Bat
	23/2/217	13			1	White-striped Freetail Bat
	23/2/217	13			1	White-striped Freetail Bat
	23/2/217	13			1	Gould's Wattled Bat
	23/2/217	13			1	Gould's Wattled Bat
	26/2/218	4	1			Nankeen Kestrel
	26/2/218	5	1			Nankeen Kestrel
	26/2/218	5	1			Nankeen Kestrel
	26/2/218	5			1	White-striped Freetail Bat
	26/2/218	12			1	White-striped Freetail Bat
	26/2/218	13			1	White-striped Freetail Bat
March	21/3/217	5			1	Eastern Falsistrelle
	21/3/217	5			1	Eastern Falsistrelle
	21/3/217	5			1	White-striped Freetail Bat
	21/3/217	5			1	White-striped Freetail Bat
	22/3/217	4			1	Gould's Wattled Bat
	22/3/217	11			1	Gould's Wattled Bat
	22/3/217	12			1	Gould's Wattled Bat
	23/3/217	6			1	Gould's Wattled Bat
	23/3/217	6		1		Brown Falcon
	24/3/217	1			1	Large Forest Bat
	24/3/217	1	1			unidentifiable bird
	26/3/218	4	1			Nankeen Kestrel
	26/3/218	4			1	White-striped Freetail Bat

Month	Date	Turbine	Bird carcass	Feather spot	Bat carcass	Species
	26/3/218	5	1			Nankeen Kestrel
	26/3/218	7			1	Gould's Wattled Bat
	26/3/218	8	1			Australasian Pipit
	26/3/218	1	1			Nankeen Kestrel
	26/3/218	11			1	White-striped Freetail Bat
	26/3/218	11			1	Gould's Wattled Bat
	28/3/218	2			1	White-striped Freetail Bat
April	21/4/215	6			1	unidentifiable bat
	21/4/215	7			1	Gould's Wattled Bat
	21/4/215	9	1			Black Swan
	22/4/215	2	1	1		Brown Falcon
	22/4/215	8	1			Whistling Kite
	23/4/215	5	1			Wedge-tailed Eagle
	23/4/215	13	2	1		Nankeen Kestrel
	24/4/215	4			1	unidentifiable bat
	24/4/217	5			1	White-striped Freetail Bat
	24/4/217	5			1	White-striped Freetail Bat
	24/4/217	5			1	White-striped Freetail Bat
	24/4/217	5			1	White-striped Freetail Bat
	24/4/217	5	1			Nankeen Kestrel
	24/4/217	1		1		Nankeen Kestrel
	24/4/217	13			1	Eastern Falsistrelle
	27/4/217	2		1		unidentifiable bird
	27/4/217	3		1		unidentifiable bird
	26/4/218	4			1	Large Forest Bat
	26/4/218	4	1			Brown Falcon
	26/4/218	5	1			Nankeen Kestrel
	26/4/218	5	1			Nankeen Kestrel
	26/4/218	5	1			Australian Magpie
	26/4/218	12			1	Gould's Wattled Bat
	26/4/218	13			1	White-striped Freetail Bat
	2/4/219	6			1	Gould's Long-eared Bat
	2/4/219	6			1	unidentifiable bat
	9/4/219	7	1			raven sp.
	9/4/219	7	1			Brown Falcon
	9/4/219	1	1			unidentifiable bird
	26/4/219	11		1		Nankeen Kestrel
26/4/219	13			1	Gould's Long-eared Bat	

Month	Date	Turbine	Bird carcass	Feather spot	Bat carcass	Species
	26/4/219	13		1		Nankeen Kestrel
May	19/5/215	6			1	unidentifiable bat
	19/5/215	7		1		unidentifiable bird
	25/5/216	8			1	White-striped Freetail Bat
	25/5/217	6	1			unidentifiable bird
	26/5/217	3	1			unidentifiable bird
	3/5/219	1			1	Nankeen Kestrel
	3/5/219	3	1			Australian Magpie
	13/5/219	1				unidentifiable bird
June	16/6/215	1	1			Australian Magpie
	18/6/215	11	1			Nankeen Kestrel
	26/6/217	13	1			Nankeen Kestrel
	12/6/219	3	1			raven sp.
	24/6/219	11		1		Nankeen Kestrel
July	22/7/215	1		1		Australian Magpie
	26/7/216	13	1			Wedge-tailed Eagle
	28/7/216	1	1			Australian Magpie
	28/7/216	6		2		unidentifiable bird
August	18/8/215	2	1			cockatoo / corella sp.
	26/8/216	6	1			raven sp.
	1/8/217	7	1			raven sp.
	1/8/217	9	1			Sulphur Crested Cockatoo
	22/8/217	2	1			Australian Magpie
	22/8/217	6	1			Australian Wood Duck
	25/8/217	3	1			raven sp.
September	16/9/215	1		1		unidentifiable bird
	16/9/215	1		1		Australian Magpie
	17/9/215	13			1	Gould's Wattled Bat
	19/9/216	1		1		unidentifiable bird
	21/9/216	7	1			Australian Magpie
	22/9/216	5		1		Australian Magpie
	25/9/217	5	1			Brown Falcon
October	13/1/215	8	1	1		Australian Magpie
	13/1/215	9		1		raven sp.
	13/1/215	1		1		unidentifiable bird
	15/1/215	6		1		unidentifiable bird
	17/1/216	1	1			Brown Falcon
	17/1/216	1	1			raven sp.

Month	Date	Turbine	Bird carcass	Feather spot	Bat carcass	Species
	17/1/216	3	1			Red-browed Finch (?)
	17/1/216	6		1		unidentifiable bird
	18/1/216	4		1		Australian Magpie
	25/1/217	6			1	unidentifiable bat
	25/1/217	7		1		raven sp.
November	17/11/215	1			1	White-striped Freetail Bat
	17/11/215	2	1			Brown Falcon
	2/11/215	11		1		White-striped Freetail Bat
	27/11/217	4			1	White-striped Freetail Bat
	27/11/217	1	1			Wedge-tailed Eagle
	28/11/217	9	1			Nankeen Kestrel
December	15/12/215	2		1		Australian Magpie
	17/12/215	11			1	White-striped Freetail Bat
	18/12/215	1			1	White-striped Freetail Bat
	21/12/216	9		1		raven sp.
	21/12/216	11	1			raven sp.
	2/12/217	12	1			Wedge-tailed Eagle
	22/12/217	2	1			Nankeen Kestrel

Appendix 7: Morton's Lane Wind Farm mortality estimate – Symbolix 2019



symbolix

Morton's Lane Wind Farm Mortality Estimate - Year 4

Prepared for Biosis, 16 September 2019, Ver. 0.9.1 - For review

This report outlines an analysis of the mortality data collected at the Morton's Lane Wind Farm from 2015-04-21 to 2019-06-24. The analysis is broken into the three related components below:

- Searcher efficiency / detectability – estimated from trials in April 2017
- Scavenger loss rates – consisting of trials in May 2015 and October 2015
- Mortality estimates - based on monthly surveys at 13 turbines, from 2015-04-21 to 2019-06-24

The data was collected and provided by Elmoby Ecology via canine searchers, provided by Biosis¹, 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.

Methodology overview

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

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

¹Raw carcass survey data - ML carcass search ALL DATA April 2015 - Jun 2019.20190906.xlsx. Raw find summary data - ML carcass search ALL DATA April 2015 - Jun 2019.20190822.xlsx. Methodology - 24186.MethodDetailsforSymbolix.20170621.docx



Searcher efficiency

Two (canine) searcher efficiency trials were held (2017-04-26). For birds, generally small and medium sized species were used (e.g. Black-shouldered Kite and Pigeon), as well as some feather spots. Only White-striped Freetail Bat carcasses were used for bats.

Table 1 summarises the result. These numbers came from 15 trials using bats, and 13 using birds. Due to the very high success rate of the searchers, there was no need to account for different environmental or biological conditions.

The overall detectability is 97%, with a 95% confidence interval of [84%, 100%].

Table 1: Combined detection efficiency.

Variable	Value
Number found	31
Number placed	32
Mean detectability proportion	0.97
Detectability lower bound (95% confidence interval)	0.84
Detectability upper bound (95% confidence interval)	1

Scavenger efficiency

Scavenger efficiency trials were held in May 2015 and October 2015. Trials used camera monitoring technology to determine when carcasses were scavenged, which gave close to exact scavenge times. 20 carcasses used were birds (e.g. mostly medium-sized such as the Australian Magpie), as well as a three bat carcasses. We ran the scavenger analysis on 23 replicates, although three additional entries with missing data had to be removed prior to analysis.

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, only an interval in which the scavenge event happened. In this data, we had eight cases of “right-censored” intervals, as eight birds were still found on the ground on the final day of the survey. By performing survival analysis we can estimate the average survival percentage after a given length of time, despite these unknowns.

Two non-scavenged carcasses were replaced mid-way through the trial. As we are using the “perfect” scavenger shape in our modelling (see below) we are assuming scavengers find carcasses with constant efficiency, so the replacement doesn't affect the results of the analysis.

Only three bats were used in the scavenger trial. Usually we wouldn't separate bats and birds with such a small sample size, but in this case, combining the bird and bat into an aggregated model results in a bat estimate which roughly 5 times larger than one would expect for bats. We



have therefore separated the bird and bat estimates (we call this “Bat Only” in later sections). This gives the most accurate estimate, at the cost of more variance (uncertainty) around the estimate.

For consistency with previous estimates however, we have also provided a supplementary bat estimate using a combined scavenger rate. We call this “Aggregated” in later sections. This gives a more precise estimate (less variance) but at the cost of bias. The aggregated scavenger rate is 17 days with a 95% confidence interval of [10.3, 28.2] days.

Figure 1 shows a fitted survival curve, under the model with birds and bats separated. The survival curve (solid line) 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 4% to 72% of carcasses to remain after three days with the average being around 36%.

Under these assumptions, for bats, the mean time to total loss via scavenge is 2.9 days, with a 95% confidence window of [0.9, 9.1] days.

For birds, the mean time to total loss via scavenge is 20.5 days, with a 95% confidence window of [11.7, 36.2] days.

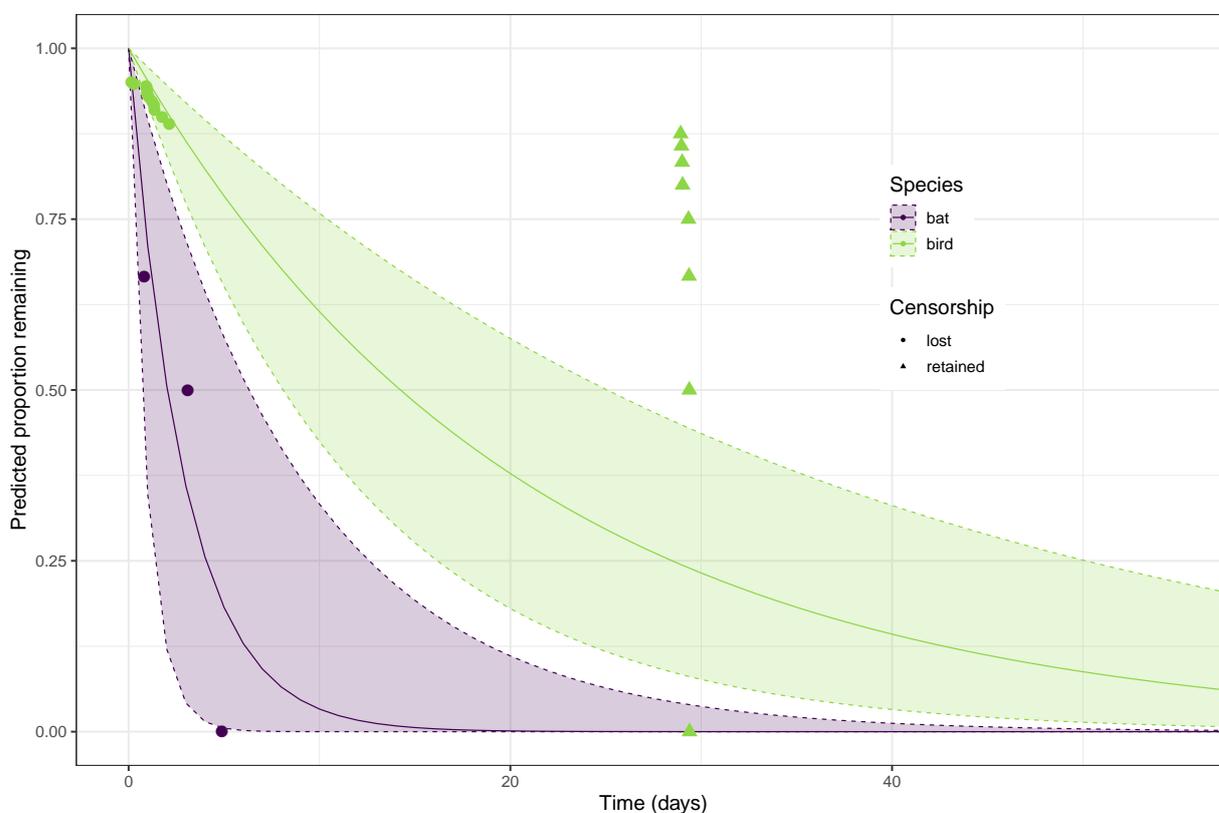


Figure 1: Survival curves for birds and bats with respective 95% confidence intervals, using the model with bats and birds separated. The circles on the survival curves are actual losses, with triangles indicating right-censored points.



Other scavenger patterns

There are three general types of scavenger behaviour:

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

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

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

Mortality projection inputs

Carcass search data

The mortality estimate was based on a dated list of turbine surveys. The survey frequency is summarised in Table 2. 13 turbines were surveyed, and were generally surveyed once each month. All turbines were surveyed out to a radius of 140 metres.

**Table 2: Number of surveys per month.**

Date	Number of surveys
2015 Apr	13
2015 May	13
2015 Jun	12
2015 Jul	13
2015 Aug	13
2015 Sep	13
2015 Oct	13
2015 Nov	13
2015 Dec	13
2016 May	13
2016 Jun	13
2016 Jul	12
2016 Aug	13
2016 Sep	13
2016 Oct	13
2016 Nov	13
2016 Dec	13
2017 Jan	13
2017 Feb	13
2017 Mar	13
2017 Apr	13
2017 May	13
2017 Jun	13
2017 Jul	10
2017 Aug	16
2017 Sep	13
2017 Oct	12
2017 Nov	13
2017 Dec	13
2018 Jan	13
2018 Feb	13
2018 Mar	12
2018 Apr	13
2019 Apr	12
2019 May	11
2019 Jun	13



Mortality estimate - years one to four combined

Mortality estimation – methodology

With estimates for scavenge loss and searcher efficiency we then converted the number of bat and bird carcasses detected into an estimate of overall mortality at Mortons Lane from 2015-03-21 to 2019-06-24 (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 13 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 (2015-04-21) and until the final surveyed date (2019-06-24).
- Birds are on-site at all times during this period.
- Bats are on-site at all times during this period.
- Finds are random and independent, and not clustered with other finds.
- There was equal chance of any turbine individually being involved in a collision / mortality.
- We assumed an exponential scavenge shape (“perfect” scavengers).
- We took scavenge loss and search efficiency rates as outlined above.
- Turbines were searched out to a 140 metre radius. 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 99% for birds and 100% 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 four years.**

Species	Bat	Bird	Feather Spot
Nankeen kestrel	0	16	7
Australian magpie	0	8	5
Raven sp.	0	8	3
Brown falcon	0	6	2
Wedge-tailed eagle	0	5	0
Unknown bird	0	3	11
Australasian pipit	0	1	0
Australian wood duck	0	1	0
Black swan	0	1	0
Cockatoo sp	0	1	1
Corella sp.	0	1	0
Red-browed finch?	0	1	0
Unid finch chick	0	1	0
Whistling kite	0	1	0
Corvus spp.	0	0	1
Eastern falsistrelle	2	0	0
Large forest bat	2	0	0
Gould's long-eared bat	3	0	0
Unknown Bat	5	0	0
Gould's wattled bat	11	0	0
White-striped freetail bat	18	0	0

Bat mortality estimate – results

During the four years of surveys a total of 41 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 677 and a median of 705 bats lost on site over the time period.

Table 4 and Figure 2 display the percentiles of the distribution, to show the confidence interval in this average. We note the high uncertainty (but greater accuracy) on this estimate due to the large degree of uncertainty on the bat scavenger estimate. We also note that this combined (four year) estimate is not directly comparable with previous reports' annual estimates as we have changed the bat scavenger rate estimate.

Based on the detected carcasses and measured detectability and scavenge rate, we expect that there was a total site loss of around 677 bats over the survey period, and are



95% confident that fewer than 1147 individuals were lost.

Table 4: Percentiles of estimated total bat losses over the four years of survey period, under the bat-only estimate of scavenging.

0%	50% (median)	90%	95%	99%	99.9%	Source
92	705	1026	1147	1257	1317	Bat Only

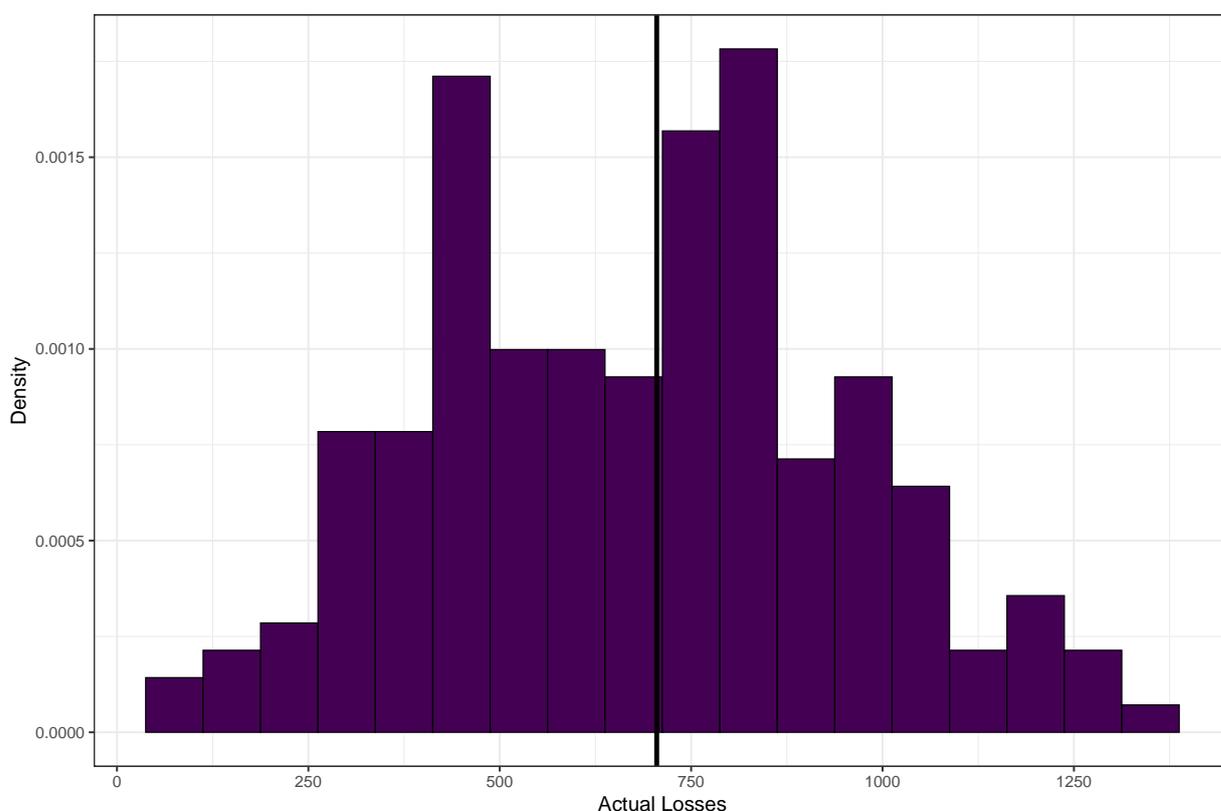


Figure 2: Histogram of the total losses distribution (bats), given 41 were detected on-site, under the bat-only estimate of scavenging. The black solid line shows the median.

Under the aggregated rate

For reference and comparison with previous years' estimates, Table 5 and Figure 2 give the bat estimate using the aggregated bird-bat scavenger rate of previous reports. This has a higher precision, but lower accuracy.

We recommend using the bat-only scavenger rate results to obtain the most accurate estimate of bat mortality at the wind farm.



Table 5: Percentiles of estimated total bat losses over the four years of survey period, under the aggregated estimate of scavenge.

0%	50% (median)	90%	95%	99%	99.9%	Source
73	129	177	191	211	214	Aggregated

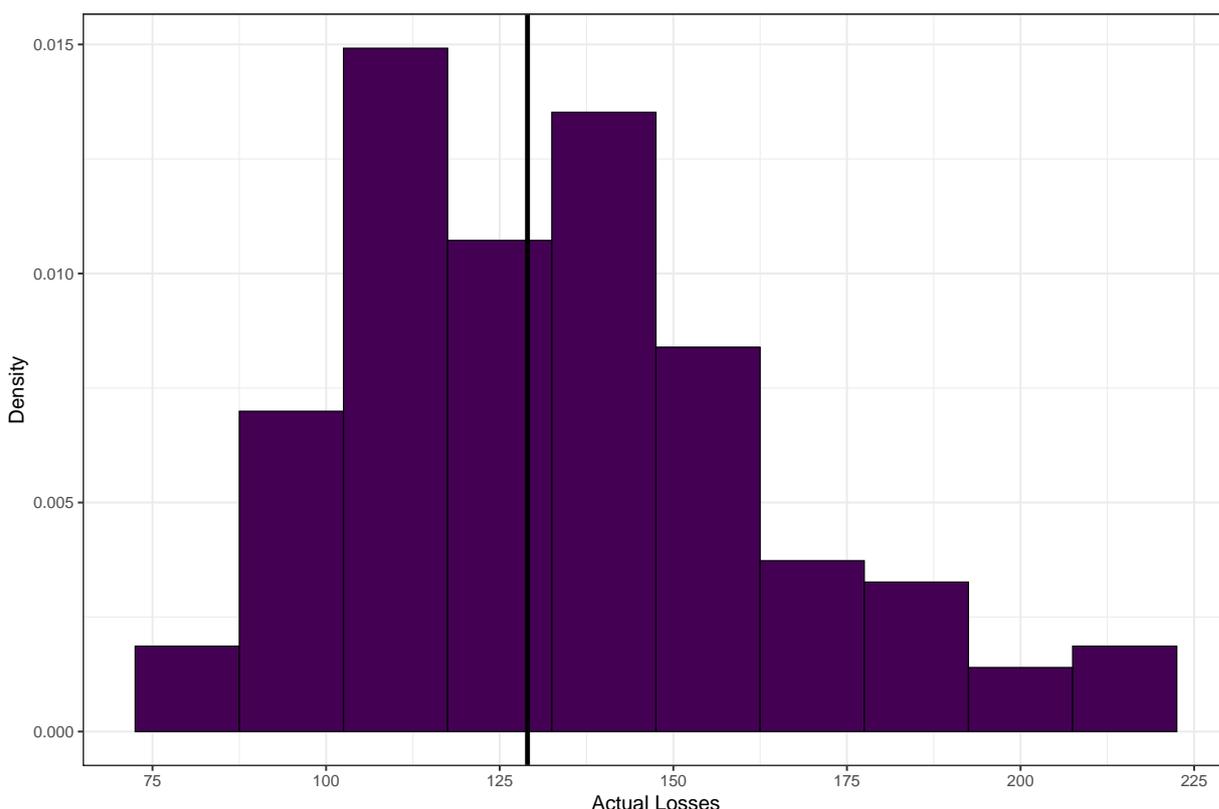


Figure 3: Histogram of the total losses distribution (bats), given 41 were detected on-site, under the aggregated estimate of scavenge. The black solid line shows the median.

Bird mortality estimate - results

During the four years of surveys a total of 84 birds were found during formal surveys (Table 3). The resulting estimate of total mortality, accounting for searcher efficiency, scavenge rate, search area and timing of surveys is an expectation (mean) of 238 and a median of 236 birds lost on site over the time period.

Table 6 and Figure 4 display the percentiles of the distribution, to show the confidence interval in this average.

In determining the estimate, we have used the standard practice of assuming that all carcasses and all feather spots (regardless of size or composition) are attributable to the wind turbines.



Based on the detected carcasses and feather spots and measured detectability and scavenger rate, we expect that there was a total site loss of around 238 birds over the survey period, and are 95% confident that fewer than 321 individuals were lost.

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

0%	50% (median)	90%	95%	99%	99.9%
154	236	302	321	338	343

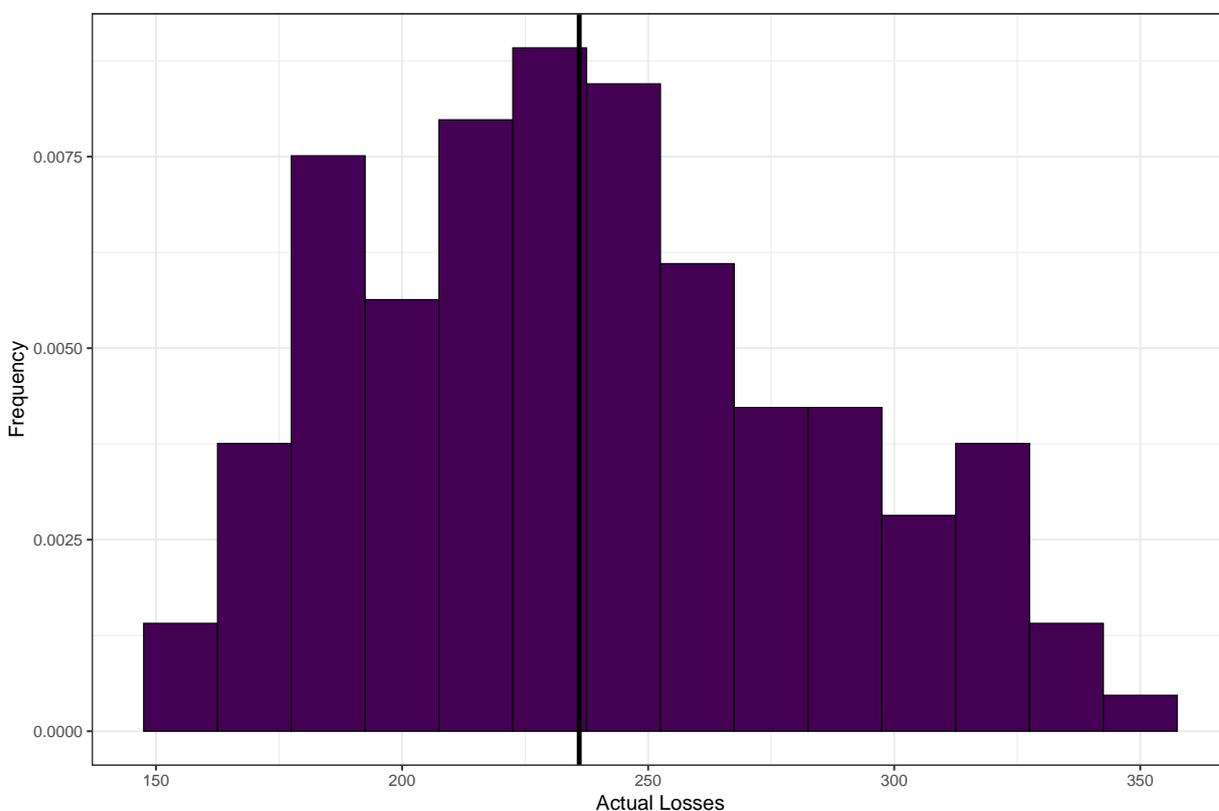


Figure 4: Histogram of the total losses distribution (birds), given 84 were detected on-site. The black solid line shows the median.



References

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