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Bird Utilisation Surveys Bashan Wind Farm, Tasmania Australia

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Goldwind

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Table of Contents

List of Tables

List of Figures

1. Introduction

Wildspot Consulting PTY LTD was commissioned by GoldWind Capital (Australia) PTY LTD to conduct a Bird Utilisation Survey (BUS) for the proposed Bashan Wind Farm development site in the Tasmanian Central Highlands, approximately 125 km northwest of Hobart. The site is adjacent to the Cattle Hill Wind Farm. The development will include 56 turbines, each with a capacity of 7.8 MW and a height of 216.5 m, along with the necessary power lines, access tracks, and infrastructure.

The aim of this study was to assess bird activity within the development site, providing crucial baseline data for future post-construction comparisons. Conducted in line with the "Level One" bird risk assessment standards from the Australian Wind Energy Association (Brett Lane and Associates Pty Ltd, 2005) endorsed by the Clean Energy Council's guidelines for the best practice for implementing wind energy projects in Australia (Clean Energy Council, 2023), this survey was carried out twice per season over a spring, summer, autumn and winter between 2021 and 2023. By evaluating species diversity, abundance, and behavioural patterns, the research aimed to inform impact mitigation strategies that balance renewable energy initiatives with bird conservation efforts.

The objectives of the study were to:

- Identify and Document Bird Species Diversity and Abundance: Conduct systematic surveys to create a comprehensive inventory of species, their abundance, and seasonal variations, providing essential baseline data.
- Evaluate Bird Flight Heights and Behaviours Relative to the Rotor-Swept Area (RSA): Analyse bird flight height data to understand avian flight patterns and behaviours relative to the RSA.
- Investigate Potential Impact on Threatened and Migratory Bird Species: Document and evaluate how specific threatened and migratory species utilise the study area to ensure their conservation is prioritised in the development process.

2. Methodology

2.1 Study Area Description

The proposed Bashan Wind Farm site is located in the Central Highlands of Tasmania, Australia, approximately 125 km northwest of Hobart, within the Central Highlands Council area. It lies near the Waddamana community to the northeast and is adjacent to the Cattle Hill Wind Farm to the north. The development will install 56 turbines, each with a capacity of 7.8 MW and a height of 216.5 m.

The study area, covering approximately 4026 hectares, is located at 473069E and 5323845N. Its elevation ranges from 600 to 900 meters above sea level, and it features undulating plains that support various land uses and vegetation types. The area includes private timber reserves with native eucalyptus forests, plantation forests, permanent timber production zones, grazing lands, modified pastures, and wetland areas. Farming activities such as sheep grazing, cattle production, and hunting are common.

The climate is temperate, with cool winters and mild summers. Soil types include peaty soils and alpine humus soils, rich in organic matter with poor drainage, along with sandy loams and clay loams. This diverse soil profile supports a range of sub-alpine and alpine vegetation adapted to the region's cold, wet conditions.

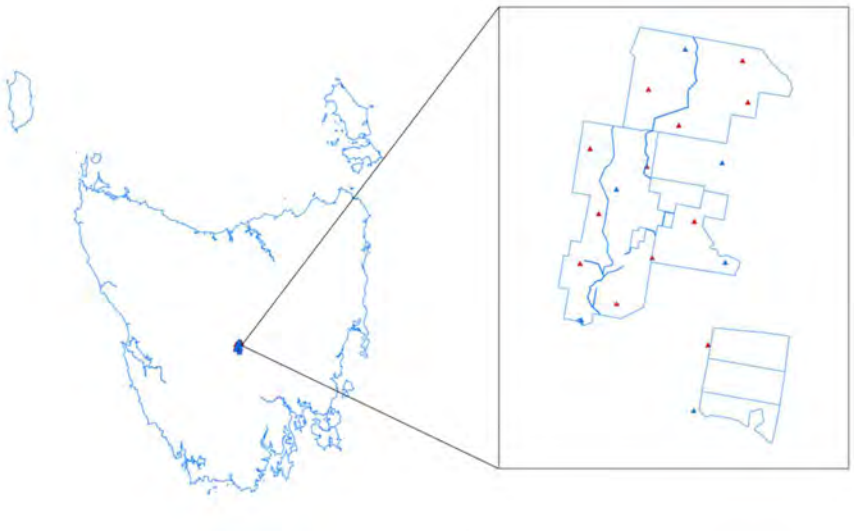

Figure 1. General location of the study area of the proposed Bashan Wind Farm site in Central Highlands, Tasmania.

2.3 Study Timeline

The survey timeline for study area was designed to ensure comprehensive coverage and representative data collection, capturing seasonal variations in bird activity. The following key aspects were incorporated:

- **Survey Duration:** The surveys were conducted over a three-year period, from 2021 to 2023.
- **Survey Frequency:** A total of eight surveys were conducted, two surveys per season to capture seasonal bird activity.
- **Observation hours:** Surveys were conducted exclusively during daylight hours to coincide with peak bird activity times. Night observations were not included as they were considered outside the scope of this study.
- **Total Observation Time:** The cumulative observation time across all surveys totalled 13,540 minutes (225.7 hours) (Table 1).

Table 1: The survey timeline for the bird utilisation surveys (BUS) over the four seasons across three years including key dates, total survey days, and number of observation time (minutes).

Survey No.	Season	Year	Days	Observation Time (mins)	% Survey Effort Completed
1	Spring	2021	3.5	1180	65.6
2	Spring	2021	5	1800	100
3	Summer	2021	5	1800	100
4	Summer	2022	5	1800	100
5	Autumn	2023	4.5	1560	86.7
6	Autumn	2023	5	1800	100
7	Winter	2023	5	1800	100
8	Winter	2023	5	1800	100
Total			**38**	**13540**	**94.0**

Note: Due to logistical issues no data was collected on 19/10 and only half a day's data was collected on 20/10 for survey No. 1 and only half a day's data was collected on the first day of survey No. 5. A year was omitted due to a pause in developmental process between spring of 2021 and summer of 2022.

2.4 Observation Points

Eighteen observation points were strategically established to maximise survey coverage and ensure representative data collection (Figure 2). These points were categorised into twelve disturbance points and six non-disturbance points to differentiate areas affected by wind farm development activities from those that will not be affected. The non-disturbance points will be used during post-construction surveys as control groups to provide points of comparison within the study area.

Disturbance Points: 12 (B1-B12), located within the development zone where wind turbines and associated infrastructure would be constructed.

Non-Disturbance Points: 6 (BR1-BR6), placed in areas less likely to be affected by the wind farm construction. These non-disturbance points, constituting one-third of the total observation points, served as control sites to provide baseline data for comparison (Figure 1).

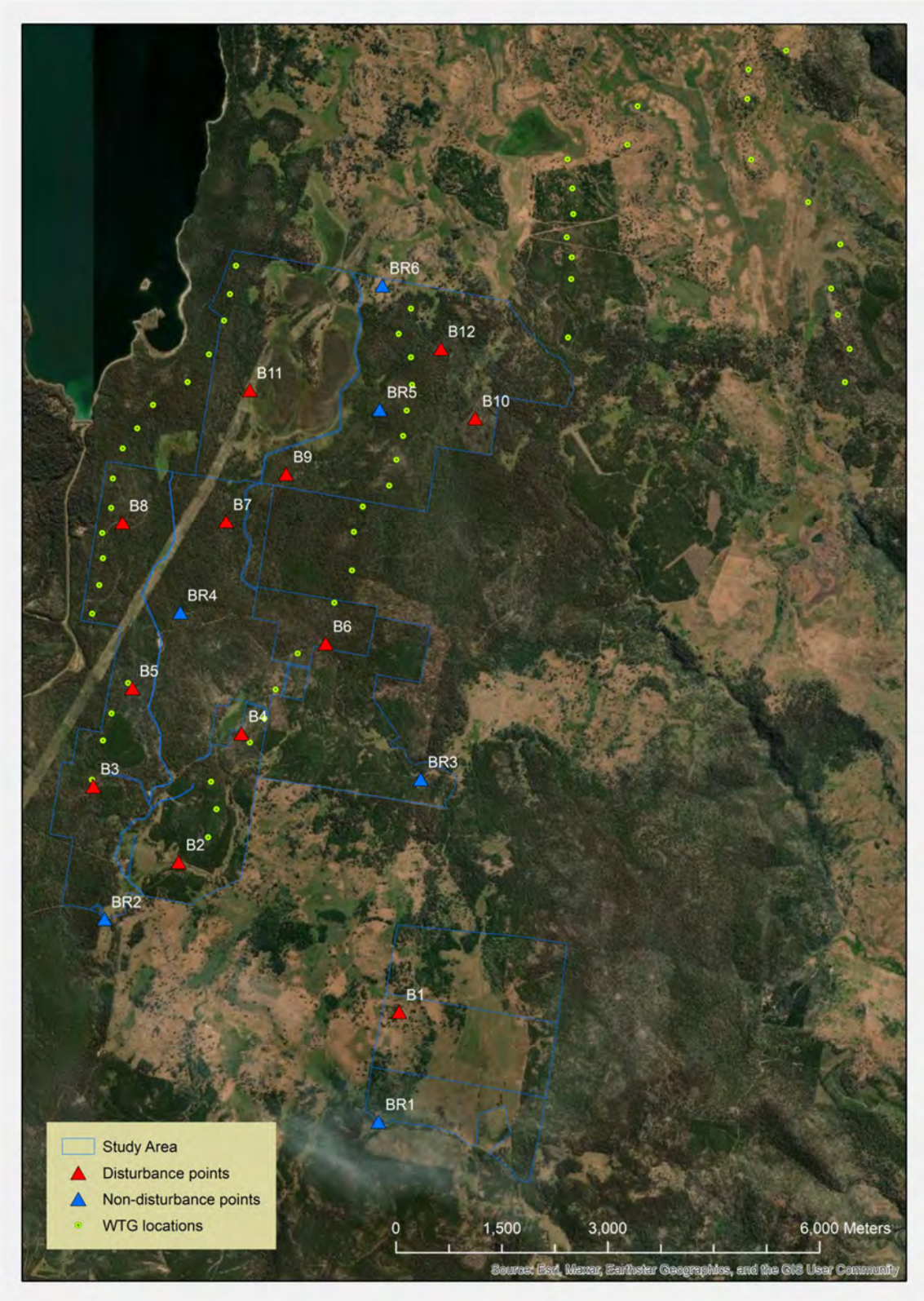

Figure 2. Study area of the proposed Bashan Wind Farm site in Central Highlands, Tasmania, highlighting key features, including disturbance points (B1-B12) and non-disturbance points (BR1-BR6), and provisional wind turbine (WTG) locations (green).

Observation points were selected to cover the major habitat types present within the study area, including native eucalyptus forests, wetlands, grazing and modified pastures, and plantation forests. Points were also located near substantial ecological features such as wetlands, feeding grounds, and nesting sites to capture bird activities in critical areas (Table 2).

Table 2. Description of observation points, including categorisation (disturbance 'B' or non-disturbance 'BR'), geographical coordinates, vegetation types, and visibility range (low: 0-1.5 km, medium: 1.5-3.0 km, high: 3.0-5.0 km).

Observation Point ID	Geographical Coordinates (55G)	Vegetation and Land Use Types	Visibility range
B1	474550 E 5318409 N	Grazing and modified pastures. Native eucalyptus forest.	High
B2	471650 E 5319731 N	Plantation forest. Grazing and modified pastures.	Medium
B3	470491 E 5320999 N	Native eucalyptus forest. Plantation forest.	Low
B4	472775 E 5321183 N	Native eucalyptus forest. Plantation forest. Marsh and wetlands.	Medium
B5	471084 E 5322583 N	Native eucalyptus forest.	Low
B6	474113 E 5322335 N	Native eucalyptus forest. Plantation forest.	Medium
B7	472608 E 5324084 N	Native eucalyptus forest.	Low
B8	470806 E 5324645 N	Native eucalyptus forest.	Low
B9	473620 E 5325385 N	Native eucalyptus forest.	Low
B10	475812 E 5326119 N	Native eucalyptus forest. Plantation forest.	Medium
B11	472662 E 5326533 N	Native eucalyptus forest. Marsh and wetlands.	Medium
B12	475645 E 5327446 N	Native eucalyptus forest.	Low
BR1	474093 E 5316327 N	Native eucalyptus forest.	Low
BR2	470527 E 5319209 N	Native eucalyptus forest. Plantation forest.	Medium
BR3	475094 E 5321033 N	Native eucalyptus forest. Plantation forest.	Low
BR4	471643 E 5323356 N	Native eucalyptus forest.	Medium
BR5	475001 E 5324199 N	Native eucalyptus forest.	Low
BR6	473827 E 5327804 N	Native eucalyptus forest. Marsh and wetlands. Grazing and modified pastures.	High

Accessibility and Visibility: Observation points were chosen based on their accessibility to ensure that observers could reach them consistently and safely throughout the survey period. Locations with clear lines of sight were selected and prioritised to ensure accurate observations of bird species, behaviours, and flight patterns, however, to achieve adequate study site coverage it was necessary to establish observation points in densely forested areas. Points in open areas allowed for broader visibility, while points in denser vegetation had more restricted views, potentially limiting the detection range for some species.

Figure 3. Observer view from observation points B4 (top), BR6 (middle), and B8 (bottom) capturing the landscape and location used for collecting bird utilisation data.

Seasonal and Temporal Considerations: Points were selected to account for seasonal changes in bird habitat use. Observations were timed to capture data across different times of the day, considering variations in bird activity from dawn to dusk.

Figure 4. Aerial view from observation point BR6 capturing native eucalyptus forest, marsh and wetlands, and grazing and modified pastures.

2.5 Data Collection Methods

Fixed-point Bird Count

Data were collected through fixed-point count surveys, with a field observer visiting each of the 18 observation points once per day. The method involved an observer recording all birds seen from a fixed observation point within a set observation period of 20 minutes. Two bird observers were scheduled to complete the point count surveys to ensure comprehensive coverage of the site and where possible surveys were scheduled during suitable weather conditions to avoid periods of limited bird movement in adverse conditions.

To account for diurnal variations in bird activity, each observer visited nine observation points per day, starting at different times throughout the survey week. There was a minimum 10-minute interval between finishing observations at one point and beginning the next to ensure an even distribution of surveys throughout the day. Considering the large survey area, the schedule was also designed to optimise travel distances between observation points, to minimise observer fatigue, fuel consumption, and vehicle wear and tear. Additionally, each observer began at a different observation point each day and followed a different sequence from the previous day, helping to distribute observations as evenly as possible across all points and times of day, and minimising potential biases in the data collected (Table 3).

Table 3. Example 5-Day Rotation Schedule for Observation Points.

Date	Start	Observer	Observation point sequence								
14/08/23	6:15	MB	B1	B2	B5	B11	B12	B10	BR4	B7	BR3
14/08/23	6:15	GM	BR1	BR2	B3	BR6	B9	BR5	B8	B4	B6
15/08/23	9:00	MB	B6	B4	B8	B3	BR2	BR1	BR6	B9	BR5
15/08/23	9:00	GM	BR3	B7	BR4	B5	B2	B1	B11	B12	B10
16/08/23	7:30	MB	B11	B12	B10	BR4	B7	BR3	B5	B2	B1
16/08/23	7:30	GM	BR6	B9	BR5	B8	B4	B6	B3	BR2	BR1
17/08/23	9:00	MB	B3	BR2	BR1	B6	B4	B8	BR5	B9	BR6
17/08/23	9:00	GM	B5	B2	B1	BR3	B7	BR4	B10	B12	B11
18/08/23	6:15	MB	B11	B12	B10	BR4	B7	BR3	B5	B2	B1
18/08/23	6:15	GM	BR6	B9	BR5	B8	B4	B6	B3	BR2	BR1

Data Recorded

All bird flight data was recorded electronically using a mobile application (Fast Field Mobile Forms) eliminating paper use and reducing manual input errors. Mandatory baseline data were recorded for each observation session, including the observer point location, date, start and finish survey times, and survey weather conditions such as precipitation, cloud cover, and wind direction.

Observers were equipped with binoculars and compasses and were required to scan their designated observation area regularly as far afield as possible. When a bird was observed, the following details were recorded: species, number of birds, average height, direction from the observer, movement direction, distance from the observation point, and behaviour. The behaviour categories included flying, perched, and foraging. If multiple birds were observed moving in the same direction in a flock, the number of individuals in the flock was recorded. If threatened or migratory bird species were observed outside of the designated survey times, these sightings were labelled as incidental, and their approximate coordinates were recorded.

2.6 Data analysis Techniques

Microsoft Excel, Version 16.86, was used for all data analysis. This software facilitated the organisation, calculation, and visualisation of the data.

Species Diversity and Abundance

Species diversity and abundance were assessed to provide a comprehensive inventory of bird species present at the study site as well as demonstrate the adequacy of the sampling effort. This included analysing the cumulative increase in species observed, the total number of sightings, the total bird movements, and highlighting both common and threatened species. This information is crucial for understanding the baseline diversity and population dynamics of the avifauna in the area.

Bird Movements and Behavioural Patterns

Bird movements and behavioural patterns were analysed to highlight spatial and temporal patterns of bird activity. The data were categorised by movements at disturbance and non-disturbance points across different seasons. This analysis focused particularly on threatened species to understand how these species utilise the landscape and to identify potential impacts of wind farm development.

Flight Heights Relative to Rotor-Swept Area (RSA)

Bird flight heights were categorised into three zones relating to the RSA of the wind turbine model proposed for the site:

- **Below Rotor-Swept Area (BRSA):** 0 to 43.5 metres
- **Rotor-Swept Area (RSA):** 43.5 to 216.5 metres
- **Above Rotor-Swept Area (ARSA):** Above 216.5 metres

This categorisation provided insights into the number of bird movements within each flight zone by species, however, since birds flying ARSA must originate from BRSA, and pass through the RSA range at some point, these zones are inherently linked. This means that the categorisation is not mutually exclusive and should be interpreted accordingly. In the results, this interdependence implies that while flight heights provide a useful framework for analysis, they should be understood as part of a continuum of bird movements rather than separate categories.

Listed Bird Species Observations

Observations of bird species listed under the Tasmanian Threatened Species Protection Act 1995 (TSPA) and the Environment Protection and Biodiversity Conservation Act 1999 (EPBC) were summarised, including incidental sightings of threatened and migratory species.

3. Results and Discussion

The aim of this study was to assess bird activity within the proposed Bashan Wind Farm development site, providing crucial baseline data for future post-construction comparisons. Conducted in line with the "Level One" bird risk assessment standards from the Australian Wind Energy Association (AusWEA 2005), the surveys were carried out twice per season across four seasons. This resulted in a cumulative observation time of 13,540 minutes (225.7 hours).

The data analysis techniques provided comprehensive insights into bird species diversity, abundance, movements, and potential impacts of wind farm construction. Species diversity and abundance were assessed to create a detailed inventory of bird species at the study site, highlighting both common and threatened species. Bird movements and behavioural patterns were analysed across disturbance and non-disturbance points to understand spatial and temporal activity, focusing on threatened species. Flight heights were categorised into three zones relative to the rotor-swept area to provide evidence to evaluate species at low risk versus high risk, while observations of listed bird species under TSPA and EPBC acts were summarised to document and assess their utilisation of the study area. These analyses were crucial for understanding how the bird populations interact with the proposed wind farm site, identifying potential impacts, and informing conservation priorities.

The results and discussion section are structured to first present the key findings of the entire study, followed by a detailed analysis of species diversity and abundance, movements and behavioural patterns, flight heights relative to the RSA, and the impact on threatened and migratory species.

3.1 Key Findings

Species Diversity and Abundance:

- The bird utilisation surveys documented a high level of bird species diversity, with 55 unique species observed.
- Although not included in the 55 unique species observed during the formal bird utilisation surveys, the Swift Parrot and White-throated Needletail, both threatened species, were incidentally observed.
- A total of 2,751 individual sightings and 5,503 movements were recorded.
- The Black Currawong was the most frequently observed species, accounting for 26.9% of total movements.
- The Forest Raven (12.8%) and Yellow Wattlebird (8.18%) also showed substantial movement counts.

Species Diversity at Observation Points:

- Disturbance points showed species diversity ranging from 17 to 25 species, with B4 having the highest diversity at 25 species (45.5% of total species).
- Non-disturbance points like BR1 and BR2 each observed 24 species (43.6% of total species).
- No single observation point recorded more than half of the 55 species observed during the surveys.
- Points with higher visibility and diverse vegetation types recorded higher species diversity and bird movements.

Movements and Behavioural Patterns:

- The heat scale revealed substantial seasonal and spatial variations in species diversity and movements at both disturbance and non-disturbance points.
- Bird movements peaked in winter at disturbance points like B6 and B12, and at non-disturbance points like BR6.
- Non-disturbance points BR1 and BR6, with high visibility and diverse habitats, showed substantial bird movements, especially of common flocking species like Black Currawong and Forest Raven.

Flight Heights Relative to Rotor-Swept Area:

- Most bird movements were recorded BRSA with 3094 movements.
- Movements within the RSA range totalled 425, and ARSA movements totalled 19.
- Key species like the Black Currawong and Forest Raven exhibited the highest number of movements within the RSA range indicating substantial activity at this height level.

- The Tasmanian Wedge-tailed Eagle showed notable movements within the RSA range emphasising its potential activity within the critical height zone of the turbine swept area.

Threatened and Migratory Species:

- The surveys identified four bird species listed under TSPA and/or EPBC: Swift Parrot, Wedge-tailed Eagle, Blue-winged Parrot, and White-throated Needletail.
- The Wedge-tailed Eagle exhibited 62.3% of its movements within the RSA range at disturbance points and 71.7% at non-disturbance points.
- Blue-winged Parrot movements were predominantly BRSA (52.8%), but 47.2% were within the RSA range.
- Swift Parrots were observed during their breeding season, and White-throated Needletails were seen during their migratory period.

3.2 Species Diversity and Abundance

The cumulative species richness curve demonstrated a steady increase in the number of species observed with the increase in total number of sightings, indicating the adequacy of the sampling effort (Figure 5). There was a rapid initial increase in species richness, which suggested that a substantial proportion of the total species were observed early during the survey, with the trend slowing down as the number of sightings increased. Towards the end of the graph, the curve begins to plateau, indicating that additional 20-minite surveys were less likely to result in the detection of new species. This suggested that the survey effort was thorough and successfully captured most of the species in the study area present at the time of investigation. The final count indicated that approximately 55 unique species (Figure 5).

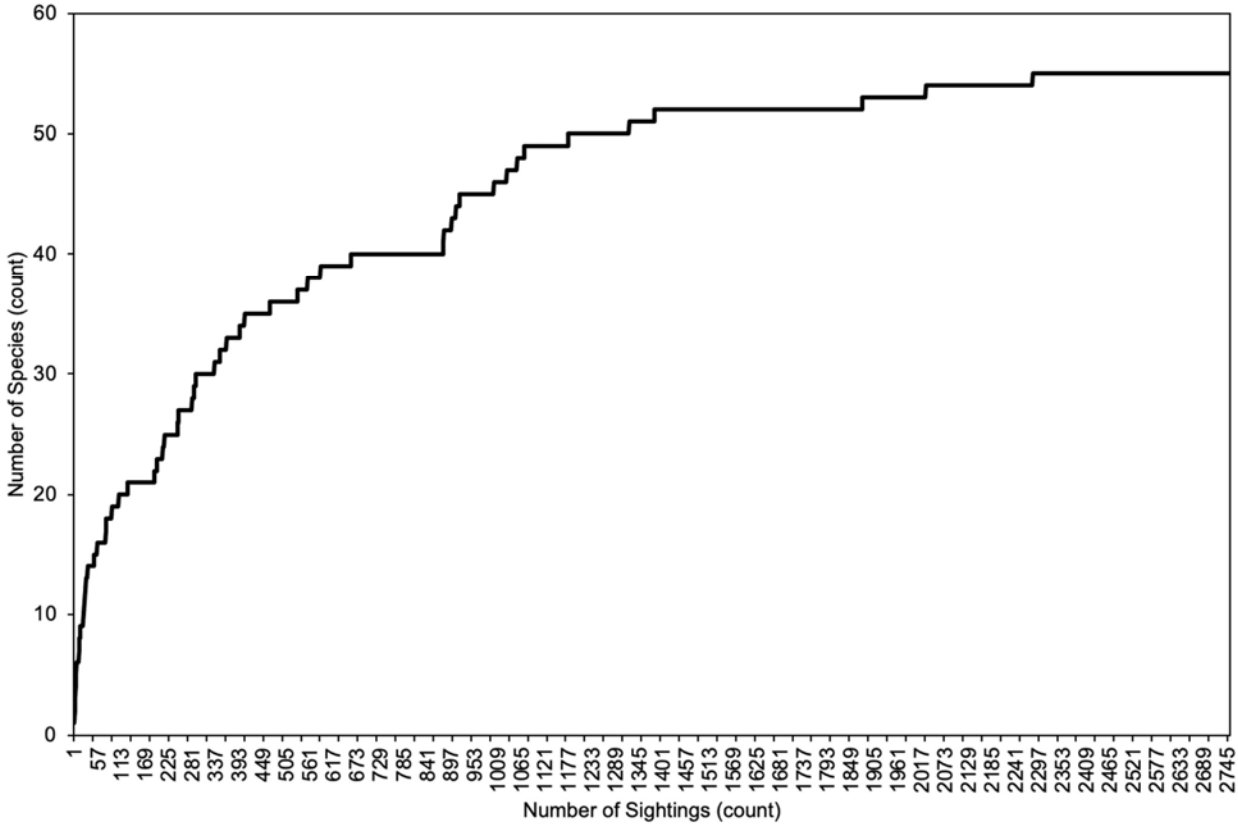

Figure 5. Cumulative Species Richness Over Total Individual Sightings during Bird Surveys.

The surveys at the proposed Bashan Wind Farm site documented a high level of bird species diversity, with a total of 55 species observed (Figure 5, Table 4). In total, 2,751 individual sightings and 5,503 movements were recorded, and provided a robust dataset for understanding avian activity at the site (Table 4). The Black Currawong was the most frequently observed species, accounting for 26.9% of total movements. Other dominant species included the Forest Raven (12.8%) and the Yellow Wattlebird (8.18%). Notable contributions to bird movements were also made by the Yellow-throated Honeyeater, Green Rosella, and Noisy Miner (Table 4).

The presence of threatened species highlights the ecological significance of the area. The Tasmanian Wedge-tailed Eagle subspecies (*Aquila audax fleayi*), which is listed as endangered under the Tasmanian Threatened Species Protection Act 1995 (TSPA) and the Environment Protection and Biodiversity Conservation Act 1999 (EPBC), was observed with 84 individual sightings and 123 movements, representing 2.24% of all avian movements across the study area (Table 4). This indicated that the Wedge-tailed Eagle is a relatively active species within the area, necessitating careful consideration in the development of mitigation strategies to reduce potential impacts. Similarly, the Blue-winged Parrot, another threatened species listed as vulnerable under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC), was recorded with 7 individual sightings and 36 movements, accounting for 0.654% of all avian movements (Table 4).

Table 4. List of bird species observed including the number of individual sightings, number of movements, and the proportion of total movements (%) recorded for each species.

Species	Individual Sightings (count)	Movements (count)	% Total Movements
Black Currawong	486	1481	26.9
Forest Raven	395	704	12.8
Yellow Wattlebird	351	450	8.18
Yellow-throated Honeyeater	302	370	6.72
Green Rosella	101	278	5.05
Noisy Miner	135	268	4.87
Superb Fairy Wren	93	236	4.29
Black-headed Honeyeater	56	186	3.38
Australian Magpie	80	152	2.76
Eastern Rosella	26	134	2.44
Wedge-tailed Eagle	84	123	2.24
Black-faced Cuckoo Shrike	68	113	2.05
Grey Shrike Thrush	97	101	1.84
Brown Thornbill	45	95	1.73
Laughing Kookaburra	67	91	1.65
Tasmanian Thornbill	32	79	1.44
Welcome Swallow	44	67	1.22
Yellow-tailed Black-cockatoo	11	56	1.02
Silvereye	12	54	0.981
Masked Lapwing	20	51	0.927
Strong-billed Honeyeater	11	46	0.836
Blue-winged Parrot	7	36	0.654
Spotted Pardalote	25	35	0.636
Crescent Honeyeater	23	34	0.618
Scarlet Robin	28	33	0.600
Yellow-rumped Thornbill	10	31	0.563
Grey Butcherbird	19	25	0.454
Grey Fantail	22	24	0.436
Tasmanian Scrubwren	12	22	0.400
Eastern Spinebill	9	21	0.382
Pink Robin	10	13	0.236
Tree Martin	10	13	0.236
Dusky Woodswallow	7	11	0.200
Tasmanian Native Hen	6	11	0.200
Common Starling	5	11	0.200
Fan-tailed Cuckoo	5	5	0.0909
Flame Robin	5	5	0.0909
Striated Pardalote	5	5	0.0909
Superb Lyrebird	3	4	0.0727
Australian Wood Duck	2	4	0.0727
Brown Falcon	3	3	0.0545
Little Corella	2	3	0.0545

Pacific Black Duck	2	3	0.0545
Brown Goshawk	2	2	0.0363
Common Bronzewing	2	2	0.0363
Little Wattle Bird	2	2	0.0363
Australian Shelduck	1	2	0.0363
Bassian Thrush	1	1	0.0182
Brush Bronzewing	1	1	0.0182
Dusky Robin	1	1	0.0182
Grey Currawong	1	1	0.0182
New Holland Honeyeater	1	1	0.0182
Shining-bronze Cuckoo	1	1	0.0182
Sulphur-crested Cockatoo	1	1	0.0182
Swamp Harrier	1	1	0.0182
Total	**2751**	**5503**	**100.0**

The surveys at the proposed Bashan Wind Farm site recorded species diversity and bird movements at both disturbance (B1-B12) and non-disturbance (BR1-BR6) observation points (Table 5). Species diversity at disturbance points ranged from 17 to 25 species, with B4 having the highest diversity (25 species, 45.5% of total species) (Table 5). Non-disturbance points showed similar diversity, with BR1 and BR2 each observing 24 species (43.6% of total species) (Table 5).

Notably, no observation point recorded more than half of the 55 species observed during the surveys. This suggested that while overall species diversity was high across the study site, individual observation points had lower diversity, with many species rarely recorded. Over half of the bird species detected were sighted 10 times or fewer, this suggested lower population densities for less frequently observed birds.

Visibility from observation points, ranging from low to high, likely impacted species detectability. For example, B1 and BR6, with high visibility, showed substantial movements (460 and 658, respectively), likely due to easily visible and common flocking birds like Black Currawong and Forest Raven (Table 5). These points, with more open terrain such as grazing and modified pastures, facilitated easier bird observation. Conversely, species like Brush Bronzewing, Common Bronzewing, and Superb Lyrebird, which dwell in dense vegetation and have low flying and foraging tendencies, were rarely detected (Table 5).

The median number of species observed at disturbance points was 20.5, with 303 movements, while non-disturbance points had a median of 20.0 species and 304 movements (Table 5). This similarity suggested that the study data will provide a suitable baseline if future post-construction bird utilisation surveys are conducted at the proposed Bashan Wind Farm.

Table 5. Species diversity and movements at disturbance points (B1-B12) and non-disturbance points (BR1-BR6). The table shows the number of species observed, the proportion of the total species observed across the study site (55 unique species), the number of movements observed, and the proportion of the total movements observed across the study site (5503 movements).

Observation Points	No. Species Observed	% Total Species	Movements	% Total Movements
B1	19	34.5	460	8.36
B2	23	41.8	444	8.07
B3	21	38.2	308	5.60
B4	25	45.5	309	5.62
B5	24	43.6	298	5.42
B6	17	30.9	521	9.47
B7	21	38.2	190	3.45
B8	17	30.9	136	2.47
B9	17	30.9	154	2.80
B10	20	36.4	199	3.62
B11	22	40	315	5.72
B12	20	36.4	204	3.71
BR1	24	43.6	349	6.34
BR2	24	43.6	335	6.09
BR3	21	38.2	273	4.96
BR4	17	30.9	165	3.00
BR5	16	29.1	185	3.36
BR6	19	34.5	658	12.0
Total	**-**	**-**	**5503**	**100**
Disturbance median	**20.5**	**37.3**	**303**	**5.51**
Non-disturbance median	**20.0**	**36.4**	**304**	**5.53**

3.3 Movements and Behavioural Patterns

The heat scale illustrated substantial seasonal and spatial variations in bird species diversity and movements at both designated disturbance (B1-B12) and non-disturbance (BR1-BR6) observation points during (Table 6). Species diversity at disturbance points varied across seasons, with B4 consistently showing higher diversity, particularly in spring and autumn (median 24.5%) (Table 6). Points like B4, which have medium visibility and a mix of native eucalyptus forest, plantation forest, and marsh and wetlands, supported a greater variety of species (Table 2).

Non-disturbance points such as BR1, BR2, and BR6 also demonstrated high species diversity, peaking in autumn and winter (medians 26.4%, 22.7%, and 21.8%, respectively) (Table 6). These points had either medium or high visibility and included diverse vegetation types, which likely contributed to the observed higher species diversity (Table 2).

Bird movements at disturbance points varied substantially across seasons (Table 7). B6, with medium visibility and a combination of native eucalyptus and plantation forests, consistently recorded high avian movement, peaking at 3.74% in winter (Table 2, Table 7).

Non-disturbance points like BR6 showed the highest bird movements, also peaking in winter at 6.16% (Table 7). This suggested increased flocking activity during the winter months, which is more easily detectable at observation points with medium to high visibility. BR6's high visibility and diverse habitat, including marshes and grazing lands, likely made it an attractive site for various bird species (Table 2).

The seasonal medians for species diversity at disturbance points ranged from 15.5% in spring to 20.0% in autumn and winter, while non-disturbance points peaked at 22.7% in autumn and winter (Table 7). This highlights a seasonal shift where bird diversity peaked at non-disturbance points during these times. For bird movements, the seasonal median at disturbance points ranged from 0.800% in summer to 1.45% in winter (Table 7). Non-disturbance points showed a similar trend but with higher winter movements (2.32%) (Table 7). This indicated that winter is a critical season for bird movements, especially in non-disturbance areas.

Observation points with higher visibility and a variety of vegetation types recorded higher species diversity and bird movements (Table 6, Table 7). For example, B1 and BR6, with high visibility and diverse habitats, showed substantial movements and higher species diversity (Table 2, Table 7). This suggested that visibility and habitat diversity are key factors influencing bird detection and activity. Points with lower visibility and less varied vegetation, like B8 and BR4, recorded lower species diversity and movements, possibly due to compromised detectability and habitat suitability for fewer or more cryptic species (Table 2, Table 7).

Table 6. Heat scale of the proportion of unique bird species (%) at disturbance (B1-B12) and non-disturbance (BR1-BR6) points across four seasons. Each cell represents the percentage of the total 55 unique species recorded at each point per season. Seasonal medians and overall medians are included for comparative analysis. Higher values indicate greater species diversity, with colour gradients from low (white) to high (green). This visual representation helps understand spatial and temporal patterns of bird species diversity relative to potential impact areas (disturbance points) versus control areas (non-disturbance points).

Disturbance Points

Season	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	Seasonal Median
Spring	18.2	29.1	14.5	25.5	25.5	9.09	7.27	16.4	10.9	12.7	18.2	9.09	**15.5**
Summer	29.1	16.4	21.8	21.8	25.5	14.5	18.2	7.27	14.5	18.2	20.0	10.9	**18.2**
Autumn	14.5	20.0	20.0	30.9	18.2	21.8	23.6	21.8	18.2	18.2	23.6	14.5	**20.0**
Winter	16.4	18.2	20.0	23.6	21.8	18.2	29.1	10.9	18.2	20.0	25.5	23.6	**20.0**
Obs. Point Median	**17.3**	**19.1**	**20.0**	**24.5**	**23.6**	**16.4**	**20.9**	**13.6**	**16.4**	**18.2**	**21.8**	**12.7**	

Non-disturbance Points

Season	BR1	BR2	BR3	BR4	BR5	BR6	Seasonal Median
Spring	23.6	23.6	18.2	14.5	14.5	23.6	**20.9**
Summer	25.5	18.2	21.8	20.0	12.7	21.8	**20.9**
Autumn	30.9	21.8	25.5	20.0	23.6	21.8	**22.7**
Winter	27.3	23.6	29.1	14.5	16.4	21.8	**22.7**
Obs. Point Median	**26.4**	**22.7**	**23.6**	**17.3**	**15.5**	**21.8**	

Table 7. Heat scale of the proportion of bird movements (%) at disturbance (B1-B12) and non-disturbance (BR1-BR6) points across four seasons. Each cell represents the percentage of the total 5503 bird movements recorded at each point per season. Seasonal medians and overall medians are included for comparative analysis. Higher values indicate greater bird movement frequency, with colour gradients from low (white) to high (green). This visual representation helps understand spatial and temporal patterns of bird activity relative to potential impact areas (disturbance points) versus control areas (non-disturbance points).

Disturbance Points

Season	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	Seasonal Median
Spring	2.94	1.16	1.00	1.25	2.11	0.963	0.436	0.672	0.491	0.218	0.709	0.545	**0.836**
Summer	1.31	1.25	0.636	1.44	1.07	0.872	0.527	0.636	0.654	0.727	1.45	0.709	**0.800**
Autumn	2.00	2.14	1.40	1.73	1.29	3.89	0.945	0.672	0.909	1.29	2.04	1.09	**1.34**
Winter	2.11	3.51	2.56	1.20	0.945	3.74	1.54	0.491	0.745	1.38	1.53	1.36	**1.45**
Obs. Point Median	**2.05**	**1.70**	**1.20**	**1.34**	**1.18**	**2.35**	**0.736**	**0.654**	**0.700**	**1.01**	**1.49**	**0.900**	

Non-disturbance Points

Season	BR1	BR2	BR3	BR4	BR5	BR6	Seasonal Median
Spring	1.56	0.909	0.636	0.672	0.872	1.16	**0.890**
Summer	1.14	1.16	1.24	0.781	0.436	1.44	**1.15**
Autumn	1.78	1.76	1.49	0.618	1.42	3.20	**1.63**
Winter	1.85	2.25	1.60	0.927	0.636	6.16	**1.73**
Obs. Point Median	**1.67**	**1.46**	**1.36**	**0.727**	**0.754**	**2.32**	

3.4 Flight Heights Relative to Rotor-Swept Area

The analysis of bird movements by species at disturbance points, categorised by flight height relative to the swept area of the turbines revealed substantial variation (Table 8). Overall trends in the data indicate that most bird movements across the study area were recorded BRSA, with a total of 3094 movements in this category (Table 8). This was followed by 425 movements within the RSA range and 19 movements above ARSA (Table 8). This trend was consistent across various species and indicated that most bird activity occurs at heights BRSA area of the wind turbines.

The Black Currawong recorded the highest number of movements with a total of 1080, predominantly within the RSA range with 929 movements (Table 8). Similarly, the Forest Raven exhibited substantial movements totalling 410, with 328 within the RSA range (Table 8). Wedge-tailed Eagles showed a total of 77 movements, with 48 within the RSA range, indicating notable activity within this height zone (Table 8). The Blue-winged Parrot displayed 36 total movements, with 17 within the RSA range (Table 8). These results emphasised that a considerable number of movements for key species occur within the RSA range.

Movements across different flight heights showed distinct patterns. Many species, including the Forest Raven and Black Currawong, had movements BRSA but substantially fewer than within the RSA range. Most movements for species like the Black Currawong, Forest Raven, and Wedge-tailed Eagle were concentrated within the RSA range (Table 8). Few species had substantial movements ARSA, with only occasional sightings of Wedge-tailed Eagle in this area, however, flights recorded ARSA must be considered as a continuum of bird movement and consequently would have originated from BRSA, and passed through the RSA range at some point (Table 8).

Table 8. Number of bird movements by species at disturbance points (B1-12) categorised below the swept area (BRSA), within the swept area (RSA) range, and above the swept area (ARSA). Includes total bird counts for each flight height category and the grand total of movements for each species and for each observation point.

Species	B1			B2			B3		B4			B5		B6			B7		
	BRSA	RSA	ARSA	BRSA	RSA	ARSA	BRSA	RSA	BRSA	RSA	ARSA	BRSA	RSA	BRSA	RSA	ARSA	BRSA	RSA	ARSA
Australian Magpie	57			25			1		15										
Australian Shelduck				2															
Australian Wood Duck		2		2															
Bassian Thrush																	1		
Black Currawong	16	2		131	65		134	1	37	5		43	6	288	4		57	7	
Black-faced Cuckoo Shrike	4	5		2			14	7	16	6		1		15			1	1	
Black-headed Honeyeater							4		24			6		23			3	1	
Blue-winged Parrot				2					8	2		3		6	15				
Brown Falcon					1		1												
Brown Goshawk													1						
Brown Thornbill				1					4			10					19		
Brush Bronzewing																			
Common Starling	6			1															

Species	B1			B2			B3		B4			B5		B6			B7		
	BRSA	RSA	ARSA	BRSA	RSA	ARSA	BRSA	RSA	BRSA	RSA	ARSA	BRSA	RSA	BRSA	RSA	ARSA	BRSA	RSA	ARSA
Crescent Honeyeater									3			13					6		
Dusky Robin												1							
Dusky Woodswallow				1				1	3										
Eastern Rosella	16																		
Fan-tailed Cuckoo							1												
Flame Robin																			
Forest Raven	104	23		66	10		20		29	2		7	7	22	9		8	4	
Green Rosella	61	1		4			16		6			4	1	23			6	1	
Grey Butcherbird	1			5			1		4										
Grey Fantail				2			2		1			4					2		
Grey Shrike Thrush	2	1		1			4		12			7	2	4			4		
Laughing Kookaburra	7			26					5					6					
Little Wattle Bird																			
Masked Lapwing	12								21										
Noisy Miner	93	14		38					4										

Species	B1			B2			B3		B4			B5		B6			B7		
	BRSA	RSA	ARSA	BRSA	RSA	ARSA	BRSA	RSA	BRSA	RSA	ARSA	BRSA	RSA	BRSA	RSA	ARSA	BRSA	RSA	ARSA
Pacific Black Duck				3															
Pink Robin												5					1		
Scarlet Robin				1										1			3		
Shining-bronze Cuckoo																	1		
Silvereye							2												
Spotted Pardalote	1						4		6			4		3			2		
Strong-billed Honeyeater							9					21							
Sulphur-crested Cockatoo					1														
Superb Fairy Wren							18		5			7		10			8		
Superb Lyrebird												2							
Swamp Harrier																			
Tasmanian Native Hen									4										
Tasmanian Scrubwren												4					4		
Tasmanian Thornbill							1		13			4		1			10		
Tree Martin	2								2										

Species	B1			B2			B3		B4			B5		B6			B7		
	BRSA	**RSA**	**ARSA**	**BRSA**	**RSA**	**ARSA**	**BRSA**	**RSA**	**BRSA**	**RSA**	**ARSA**	**BRSA**	**RSA**	**BRSA**	**RSA**	**ARSA**	**BRSA**	**RSA**	**ARSA**
Wedge-tailed Eagle	2	4	2		7	1		1	3	8	3	1	2	1		2			1
Welcome Swallow	17			30					2					2					
Yellow Wattlebird	4			15	1		12	9	31	3		48	23	25	2		12	3	
Yellow-rumped Thornbill							3					7		18					
Yellow-tailed Black-cockatoo													3				11		
Yellow-throated Honeyeater	1						34	8	22			51		41			11	2	
Grand Total	**406**	**52**	**2**	**358**	**85**	**1**	**281**	**27**	**280**	**26**	**3**	**253**	**45**	**489**	**30**	**2**	**170**	**19**	**1**

Species	B8		B9			B10			B11			B12			Total			Grand Total
	BRSA	RSA	BRSA	RSA	ARSA	BRSA	RSA	ARSA	BRSA	RSA	ARSA	BRSA	RSA	ARSA	BRSA	RSA	ARSA	
Australian Magpie						7			12						**117**			**117**
Australian Shelduck															**2**			**2**
Australian Wood Duck															**2**	**2**		**4**
Bassian Thrush															**1**			**1**
Black Currawong	41	14	16	4		76	18		71	16		19	9		**929**	**151**		**1080**
Black-faced Cuckoo Shrike			5			5			1						**64**	**19**		**83**
Black-headed Honeyeater	1		2			1			2			32			**98**	**1**		**99**
Blue-winged Parrot															**19**	**17**		**36**
Brown Falcon															**1**	**1**		**2**
Brown Goshawk						1									**1**	**1**		**2**
Brown Thornbill	13		3			3			3			12			**68**			**68**
Brush Bronzewing									1						**1**			**1**
Common Starling															**7**			**7**
Crescent Honeyeater	3		1									1			**27**			**27**
Dusky Robin															**1**			**1**
Dusky Woodswallow															**4**	**1**		**5**

Species	B8		B9			B10			B11			B12			Total			Grand Total
	BRSA	RSA	BRSA	RSA	ARSA	BRSA	RSA	ARSA	BRSA	RSA	ARSA	BRSA	RSA	ARSA	BRSA	RSA	ARSA	
Eastern Rosella															**16**			**16**
Fan-tailed Cuckoo												2			**3**			**3**
Flame Robin									3						**3**			**3**
Forest Raven	2	4	3	1		5	3		22	6		40	13		**328**	**82**		**410**
Green Rosella	12		14						13	2		3			**162**	**5**		**167**
Grey Butcherbird									1						**12**			**12**
Grey Fantail	2					1									**14**			**14**
Grey Shrike Thrush	2		4			5						4			**49**	**3**		**52**
Laughing Kookaburra						2			6			2			**54**			**54**
Little Wattle Bird						1						1			**2**			**2**
Masked Lapwing									4						**37**			**37**
Noisy Miner									9						**144**	**14**		**158**
Pacific Black Duck															**3**			**3**
Pink Robin	1											1			**8**			**8**
Scarlet Robin	3					2			4						**14**			**14**
Shining-bronze Cuckoo															**1**			**1**

Species	B8		B9			B10			B11			B12			Total			Grand Total
	BRSA	RSA	BRSA	RSA	ARSA	BRSA	RSA	ARSA	BRSA	RSA	ARSA	BRSA	RSA	ARSA	BRSA	RSA	ARSA	
Silvereye			9			6						11			**28**			**28**
Spotted Pardalote	2											1			**23**			**23**
Strong-billed Honeyeater			8												**38**			**38**
Sulphur-crested Cockatoo																**1**		**1**
Superb Fairy Wren	2		4			9			23			1			**87**			**87**
Superb Lyrebird															**2**			**2**
Swamp Harrier						1									**1**			**1**
Tasmanian Native Hen			1												**5**			**5**
Tasmanian Scrubwren	7		5									1			**21**			**21**
Tasmanian Thornbill	14		12						4			3			**62**			**62**
Tree Martin									4						**8**			**8**
Wedge-tailed Eagle		1			4		7	3	3	18	2			1	**10**	**48**	**19**	**77**
Welcome Swallow									5						**56**			**56**
Yellow Wattlebird	2	1	29	2		17			55	1		12	1		**262**	**46**		**308**
Yellow-rumped Thornbill						1									**29**			**29**

Species	B8		B9			B10			B11			B12			Total			Grand Total
	BRSA	RSA	BRSA	RSA	ARSA	BRSA	RSA	ARSA	BRSA	RSA	ARSA	BRSA	RSA	ARSA	BRSA	RSA	ARSA	
Yellow-tailed Black-cockatoo						6				18		11			**28**	**21**		**49**
Yellow-throated Honeyeater	9		27			19			4	2		23			**242**	**12**		**254**
Grand Total	**116**	**20**	**143**	**7**	**4**	**168**	**28**	**3**	**250**	**63**	**2**	**180**	**23**	**1**	**3094**	**425**	**19**	**3538**

Note: BRSA is from 0 to 43.5 metres, RSA is from 43.5 to 216.5 metres, and ARSA is above 216.5 metres. Columns for movements ARSA at points where no bird were observed ARSA were omitted.

The analysis of bird movements by species at non-disturbance points, categorised by flight height relative to the swept area of the turbine, provided a comparative insight into bird activity. The overall trends show that most bird movements across the non-disturbance points were recorded BRSA, with a total of 1786 movements in this category (Table 9). This was followed by 171 movements within the RSA range and 8 ARSA (Table 9). This trend is consistent with the patterns observed at disturbance points and indicated that most of the bird activity occurs at heights BRSA.

Key species exhibiting substantial movements at non-disturbance points include the Black Currawong, which recorded a total of 401 movements, predominantly BRSA (374 movements) (Table 9). The Forest Raven also showed considerable activity with 294 total movements, with 232 movements BRSA (Table 9). These results closely mirror the patterns seen at disturbance points, highlighting the Black Currawong and Forest Raven as the most active species within the study area.

Regarding threatened species, the Tasmanian Wedge-tailed Eagle exhibited a total of 46 movements at non-disturbance points, with 33 movements within the RSA range (Table 9). This was consistent with the findings at disturbance points and underscored the substantial presence of this endangered species active within the RSA range. The Blue-winged Parrot, however, was not recorded at non-disturbance points.

Comparing disturbance and non-disturbance points, the overall movement patterns are similar, with most species exhibiting higher activity levels BRSA (Table 8, Table 9). Non-disturbance points showed a relatively high level of activity per point. Non-disturbance points like BR6, which had high visibility and diverse habitats including marshes and grazing lands, recorded substantial movements, particularly for species like the Black Currawong and Forest Raven (Table 2, Table 9).

Overall, the data on bird movements at non-disturbance points highlighted similar patterns of activity as seen at disturbance points, with most movements occurring below the swept area. The presence of key species, particularly the Tasmanian Wedge-tailed eagle and Blue-winged Parrot, within the RSA range across both disturbance and non-disturbance points emphasised the importance of monitoring and mitigating potential impacts on bird populations at the proposed Bashan Wind Farm site.

Table 9. Number of bird movements by species at non-disturbance points (BR1-6) categorised below the swept area (BRSA), within the swept area (RSA) range, and above the swept area (ARSA). Includes total bird counts for each flight height category and the grand total of movements for each species and for each observation point.

Species	BR1		BR2		BR3		BR4		BR5			BR6			Totals			Grand Total
	BRSA	RSA	BRSA	RSA	BRSA	RSA	BRSA	RSA	BRSA	RSA	ARSA	BRSA	RSA	ARSA	BRSA	RSA	ARSA	
Australian Magpie	6		7									22			35			**35**
Black Currawong	20	2	28	13	15	5	31	6	27			253	1		374	27		**401**
Black-faced Cuckoo Shrike	4	7	1				4		8	2		4			21	9		**30**
Black-headed Honeyeater	45	3	13		20		3		3						84	3		**87**
Brown Falcon				1												1		**1**
Brown Thornbill	4		3		14		2		4						27			**27**
Common Bronzewing					2										2			**2**
Common Starling												4			4			**4**
Crescent Honeyeater	1		3		3										7			**7**
Dusky Woodswallow	2						4								6			**6**
Eastern Rosella	1											117			118			**118**
Eastern Spinebill			21												21			**21**
Fan-tailed Cuckoo									2						2			**2**
Flame Robin			2												2			**2**
Forest Raven	44	23	61	1	33	18	5	9	35	8		54	3		232	62		**294**

Species	BR1		BR2		BR3		BR4		BR5			BR6			Total			Grand Total
	BRSA	RSA	BRSA	RSA	BRSA	RSA	BRSA	RSA	BRSA	RSA	ARSA	BRSA	RSA	ARSA	BRSA	RSA	ARSA	
Green Rosella	24	3	27		27		4		4			22			108	3		**111**
Grey Butcherbird	2				1							10			13			**13**
Grey Currawong							1								1			**1**
Grey Fantail			2		6		2								10			**10**
Grey Shrike Thrush	18	1	5		10		10		5						48	1		**49**
Laughing Kookaburra	8		1		19							8	1		36	1		**37**
Little Corella			2			1									2	1		**3**
Masked Lapwing												14			14			**14**
New Holland Honeyeater					1										1			**1**
Noisy Miner	25	2										83			108	2		**110**
Pink Robin							5								5			**5**
Scarlet Robin	6		12		1										19			**19**
Silvereye	2		2						22						26			**26**
Spotted Pardalote			1		11										12			**12**
Striated Pardalote	2		1		2										5			**5**
Strong-billed Honeyeater	8														8			**8**

Species	BR1		BR2		BR3		BR4		BR5			BR6			Total			Grand Total
	BRSA	RSA	BRSA	RSA	BRSA	RSA	BRSA	RSA	BRSA	RSA	ARSA	BRSA	RSA	ARSA	BRSA	RSA	ARSA	
Superb Fairy Wren	10		94		16		22		4			3			149			**149**
Superb Lyrebird							1		1						2			**2**
Tasmanian Native Hen												6			6			**6**
Tasmanian Scrubwren					1										1			**1**
Tasmanian Thornbill	5		3				3		6						17			**17**
Tree Martin												5			5			**5**
Wedge-tailed Eagle		1		6	1	6		3		6	2	4	11	6	5	33	8	**46**
Welcome Swallow	2											9			11			**11**
Yellow Wattlebird	33		18		38	1	8	11	20	3		9	1		126	16		**142**
Yellow-rumped Thornbill									2						2			**2**
Yellow-tailed Black-cockatoo												7			7			**7**
Yellow-throated Honeyeater	31	4	7		20	1	25	6	20	1		1			104	12		**116**
Grand Total	**303**	**46**	**314**	**21**	**241**	**32**	**130**	**35**	**163**	**20**	**2**	**635**	**17**	**6**	**1786**	**171**	**8**	**1965**

Note: BRSA is from 0 to 43.5 metres, RSA is from 43.5 to 216.5 metres, and ARSA is above 216.5 metres.

3.5 Threatened and Migratory Species

The bird utilisation surveys at the proposed Bashan Wind Farm site identified four bird species listed under the Tasmanian Threatened Species Protection Act 1995 (TSPA) and/or the Environment Protection and Biodiversity Conservation Act 1999 (EPBC) (Table 10). The key threatened and migratory bird species observed included the Swift Parrot, Tasmanian Wedge-tailed Eagle, Blue-winged Parrot, and White-throated Needletail (Table 10). The presence of these species, particularly those classified as endangered or critically endangered, highlighted conservation concerns at the development site.

Table 10. Summary of listed bird species recorded during bird surveys and incidentally observed (*) including their conservation status under the Tasmanian Threatened Species Protection Act 1995 (TSPA) and Environment Protection and Biodiversity Conservation Act 1999 (EPBC).

Common Name	Scientific Name	TSPA	EPBC
Blue-winged Parrot	*Neophema chrysostoma*	-	Vulnerable
Wedge-tailed Eagle	*Aquila audax fleayi*	Endangered	Endangered
Swift Parrot*	*Lathamus discolor*	Endangered	Critically Endangered
White-throated Needletail*	*Hirundapus caudacutus*	-	Vulnerable

3.5.1 Tasmanian Wedge-tailed Eagle

The Tasmanian Wedge-tailed Eagle exhibited a substantial proportion of its movements at all heights relative to the RSA. At disturbance points, 62.3% of Wedge-tailed Eagle movements were observed within the RSA range, 24.7% ARSA, and 13.0% BRSA (Table 8). At non-disturbance points, 71.7% of Wedge-tailed Eagle movements were observed within the RSA range, 17.4% ARSA, and 10.9% BRSA (Table 9). This high proportion of flights within the critical height range of the wind turbine blades underscored that the resident Wedge-tailed Eagles are considerably active within the potential swept area of the turbines across the study site.

Seasonally, Wedge-tailed Eagle movements varied across both disturbance and non-disturbance points. At disturbance points, winter exhibited the highest movement percentage, with B12 recording 16.0% of movements (Table 11). Autumn and summer also showed notable activity, with several disturbance points recording movements between 1.0% and 6.0% (Table 11). Non-disturbance points followed a similar trend, with winter and spring having higher percentages of movements. BR6 recorded the highest movement percentage in both winter (9.0%) and spring (3.0%) (Table 11).

The breeding season for Wedge-tailed Eagles typically occurs from August to January (late winter into summer). Observations indicated that the highest activity was recorded during winter at several disturbance points, particularly B12, and during spring at non-disturbance points such as BR6 (Table 11). This timing suggests that the breeding season overlaps with periods of substantial movement within the study area.

Table 11. Heat scale of the proportion of Wedge-tailed Eagle movements (%) at disturbance (B1-B12) and non-disturbance (BR1-BR6) points across four seasons. Each cell represents the percentage of the total 5503 bird movements recorded at each point per season. Seasonal medians and overall medians are included for comparative analysis. Higher values indicate greater bird movement frequency, with colour gradients from low (white) to high (green). This visual representation helps understand spatial and temporal patterns of bird activity relative to potential impact areas (disturbance points) versus control areas (non-disturbance points).

Disturbance Points

Season	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	Seasonal Median
Spring	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	**0.00**
Summer	0.00	3.00	1.00	3.00	0.00	2.00	1.00	0.00	0.00	5.00	2.00	0.00	**1.00**
Autumn	1.00	1.00	0.00	6.00	3.00	0.00	0.00	1.00	0.00	0.00	5.00	1.00	**1.00**
Winter	7.00	4.00	0.00	4.00	0.00	1.00	0.00	0.00	2.00	5.00	16.00	0.00	**1.50**
Obs. Point Median	**0.50**	**2.00**	**0.00**	**3.50**	**0.00**	**0.50**	**0.00**	**0.00**	**1.00**	**2.50**	**3.50**	**0.00**	

Non-disturbance Points

Season	BR1	BR2	BR3	BR4	BR5	BR6	Seasonal Median
Spring	0.00	2.00	2.00	0.00	2.00	3.00	**2.00**
Summer	0.00	0.00	0.00	2.00	5.00	0.00	**0.00**
Autumn	0.00	0.00	3.00	0.00	1.00	9.00	**0.500**
Winter	1.00	4.00	2.00	1.00	0.00	9.00	**1.50**
Obs. Point Median	**0.00**	**1.00**	**2.00**	**0.50**	**1.50**	**6.00**	

3.5.2 Blue-winged Parrot

During surveys at the proposed Bashan Wind Farm, the Blue-winged Parrot (*Neophema chrysostoma*) was recorded primarily below the swept area (BRSA) at 52.8%, however 47.2% of its movements were recorded within the swept area (RSA) (Table 12). This parrot is a migratory species, known to breed in Tasmania and migrate to mainland Australia, particularly southern Victoria, during the non-breeding season from autumn to early spring.

The heat scale analysis indicated that Blue-winged Parrot movements were predominantly observed at specific disturbance points (B4 and B6) during spring and summer, with notable proportions at 66.7% and 70.0% respectively (Table 12). These observations align with the breeding season in Tasmania, which occurs from spring through summer. The absence of movements during autumn and winter at the surveyed points suggested that the Blue-winged Parrots had migrated to their wintering grounds on mainland Australia during these periods.

Table 12. Heat scale of the proportion of Blue-winged Parrot movements (%) at disturbance (B1-B12) points across four seasons. Each cell represents the percentage of the total 5503 bird movements recorded at each point per season. Seasonal medians and overall medians are included for comparative analysis. Higher values indicate greater bird movement frequency, with colour gradients from low (white) to high (green). This visual representation helps understand spatial and temporal patterns of bird activity relative to potential impact areas (disturbance points).

Disturbance Points

Season	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	Seasonal Median
Spring	0.00	33.3	0.00	66.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Summer	0.00	0.00	0.00	20.0	10.0	70.0	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Autumn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Winter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Obs. Point Median	**0.00**	**0.00**	**0.00**	**10.0**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	

3.5.3 Incidental Migratory Birds

During the pre-construction surveys at the proposed Bashan Wind Farm, two migratory bird species were incidentally observed active on the study site and highlighted potential interaction with the wind farm developments (Table 13).

Table 13. Locations and dates of incidental observations of threatened and migratory bird species.

Species	Dates	Closest Obs. Point	Geographical Coordinates (55G)
Swift Parrot	23/10/23	B8	471552 E 5323972 N
Swift Parrot	23-27/10/23	B7	470852 E 5324620 N
Swift Parrot	19-23/11/23	BR4	470947 E 5323402 N
White-throated Needletail	16/02/24	B6	474392 E 5322881 N

The Swift Parrot (*Lathamus discolor*), a critically endangered species, was observed on multiple occasions in October and November (Table 13). These parrots migrate from mainland Australia to Tasmania during their breeding season from September to January and rely on flowering eucalyptus trees for nectar, which are prevalent across the study site. Swift Parrots were consistently observed in flight above canopy level, perched at the canopy's apex, or in small groups ranging from approximately 5 to 15 individuals, as well as pairs and solitary birds. Notably, these activities were concentrated at the top canopy level, with occasional canopy foraging on flowering eucalypt species. Given they were observed in the height of the breeding season and there are hollow-bearing trees within the study area, evidence suggested there may be nesting sites within the study area.

The White-throated Needletail (*Hirundapus caudacutus*), observed in February, migrates to Tasmania from Central Asia and south-eastern Siberia during the Australian summer (Table 13). This species is known for its rapid flight and spends most of its time in the air, feeding on flying insects. Observations included the White-throated Needletails soaring in large groups of 20+ birds above canopy level, the birds appeared to be feeding. White-throated Needletails are typically seen flying at high altitudes, often above the swept area of wind turbines, though their exact flight heights were not recorded during the survey.

The presence of these migratory species, particularly during their breeding or migratory seasons, underscores the ecological significance of the proposed Bashan Wind Farm area. The study site's diverse vegetation, including flowering eucalyptus and hollow-bearing trees, supports a variety of bird species, providing essential resources for both resident and migratory birds. While the surveys did not record flight heights for these species, Swift Parrots generally forage at lower altitudes within the canopy, while White-throated Needletails are often observed at higher altitudes, utilising air currents for dynamic soaring.

These findings emphasise the need to consider the presence and behaviours of these migratory species in the planning and management of the Wind Farm to minimise potential impacts on their populations.

3.6 Limitations of the Study

The study on bird activity within the proposed Bashan Wind Farm development site has several limitations that may impact the results. Each limitation is discussed below along with potential measures to mitigate their effects:

Change in Turbine Layout:

Impact: Alterations to the turbine layout post-establishment of observation points led to a blurred distinction between disturbance and non-disturbance points.

Mitigation: If post-construction surveys occur, reassess and potentially reclassify the 18 original observation points to accurately differentiate "disturbance" and "non-disturbance" points based on the final turbine layout.

Lack of Nocturnal Bird Data:

Impact: Surveys conducted exclusively during daylight hours omit data on nocturnal bird species. This exclusion is significant for understanding the usage of the study area by nocturnal species like the endangered Masked Owl, which might rely on the hollow-bearing trees within the study area.

Mitigation: Implement nocturnal surveys using appropriate methods such as audio recording devices and night-vision equipment to capture nocturnal bird activity and provide a more complete assessment of the avian community.

Survey Effort

Impact: The uneven survey effort between spring and autumn due to logistical issues could potentially skew the data, leading to inaccurate representations of seasonal bird activity and species diversity. However, the effect was likely minimal as 94% of the planned survey effort was completed, and the logistical issues affected only 2 out of 8 surveys.

Mitigation: Logistical problems are likely in remote, poorly serviced areas, but all efforts should be made to minimize the risk of lost time and ensure consistent survey efforts.

Habitat Changes During Study:

Impact: Any habitat alterations during the study period, such as vegetation changes or land use modifications, could impact bird activity and diversity. These changes might confound the interpretation of results and the assessment of bird usage of the proposed development site.

Mitigation: Monitor and document any habitat changes throughout the study period. Include habitat assessments as part of the survey protocol to correlate bird activity with habitat conditions.

Species-Specific Behaviour Variability:

Impact: The study's methodology might not fully account for species-specific behaviours and habitat preferences. Different species might have varying responses to disturbance and habitat features, affecting their detectability and the accuracy of activity patterns recorded.

Mitigation: Tailor survey methods to account for species-specific behaviours and habitat preferences. Use targeted approaches for threatened species and incorporate varied survey techniques to capture a broader range of behaviours.

By addressing these limitations through targeted mitigation strategies, future studies could be strengthened, providing a more accurate and comprehensive understanding of bird activity at the proposed Bashan Wind Farm site.

4. Conclusion

The comprehensive bird surveys at the proposed Bashan Wind Farm in the Tasmanian Central Highlands have provided essential baseline data on bird species diversity, abundance, flight heights, and behavioural patterns. This information is crucial for understanding the potential impacts of wind farm development on avian populations and for informing effective mitigation strategies.

Key findings indicate that the study area supports a high level of bird species diversity, with 55 unique species recorded. The most frequently observed species, including the Black Currawong and Forest Raven, demonstrated substantial activity, particularly within the RSA range of the proposed wind turbines. The presence of threatened and migratory species such as the Tasmanian Wedge-tailed Eagle, Blue-winged Parrot, Swift Parrot, and White-throated Needletail underscores the ecological significance of the area. These species exhibited notable movements within the RSA range, emphasising the importance of targeted conservation measures to protect these vulnerable populations.

Seasonal and spatial variations in bird movements and behaviours were evident, with higher activity observed in winter and at points with high visibility and diverse habitats. These insights are valuable for developing site-specific mitigation strategies that account for the dynamic nature of bird activity across the study area.

Overall, the data collected provide a robust foundation for future post-construction monitoring and impact assessments. By understanding the baseline conditions and identifying key areas of concern, the proposed Bashan Wind Farm can implement informed management practices to balance renewable energy development with the conservation of bird populations. Continued monitoring and adaptive management will be essential to ensure the long-term sustainability of the avian species that inhabit the region.

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APPENDIX

Table 14. List of 55 unique bird species recorded during surveys including their conservation status under the Tasmanian Threatened Species Protection Act 1995 (TSPA) and Environment Protection and Biodiversity Conservation Act 1999 (EPBC).

Common name	Scientific name	TSPA	EPBC
Australian Magpie	*Gymnorhina tibicen*	-	-
Australian Shelduck	*Tadorna tadornoides*	-	-
Australian Wood Duck	*Chenonetta jubata*	-	-
Bassian Thrush	*Zoothera lunulata*	-	-
Black Currawong	*Strepera fuliginosa*	-	-
Black-faced Cuckoo Shrike	*Coracina novaehollandiae*	-	-
Black-headed Honeyeater	*Melithreptus affinis*	-	-
Blue-winged Parrot	*Neophema chrysostoma*	-	Vulnerable
Brown Falcon	*Falco berigora*	-	-
Brown Goshawk	*Accipiter fasciatus*	-	-
Brown Thornbill	*Acanthiza pusilla*	-	-
Brush Bronzewing	*Phaps elegans*	-	-
Common Bronzewing	*Phaps chalcoptera*	-	-
Common Starling	*Sturnus vulgaris*	-	-
Crescent Honeyeater	*Phylidonyris pyrrhopterus*	-	-
Dusky Robin	*Melanodryas vittata*	-	-
Dusky Woodswallow	*Artamus cyanopterus*	-	-
Eastern Rosella	*Platycercus eximius*	-	-
Eastern Spinebill	*Acanthorhynchus tenuirostris*	-	-
Fan-tailed Cuckoo	*Cacomantis flabelliformis*	-	-
Flame Robin	*Petroica phoenicea*	-	-
Forest Raven	*Corvus tasmanicus*	-	-
Green Rosella	*Platycercus caledonicus*	-	-
Grey Butcherbird	*Cracticus torquatus*	-	-
Grey Currawong	*Strepera versicolor*	-	-
Grey Fantail	*Rhipidura albiscapa*	-	-
Grey Shrike Thrush	*Colluricincla harmonica*	-	-
Laughing Kookaburra	*Dacelo novaeguineae*	-	-
Little Corella	*Cacatua sanguinea*	-	-
Little Wattle Bird	*Anthochaera chrysoptera*	-	-
Masked Lapwing	*Vanellus miles*	-	-
New Holland Honeyeater	*Phylidonyris novaehollandiae*	-	-
Noisy Miner	*Manorina melanocephala*	-	-
Pacific Black Duck	*Anas superciliosa*	-	-
Pink Robin	*Petroica rodinogaster*	-	-
Scarlet Robin	*Petroica boodang*	-	-

Shining-bronze Cuckoo	*Chrysococcyx lucidus*	-	-
Silvereye	*Zosterops lateralis*	-	-
Spotted Pardalote	*Pardalotus punctatus*	-	-
Striated Pardalote	*Pardalotus striatus*	-	-
Strong-billed Honeyeater	*Melithreptus validirostris*	-	-
Sulphur-crested Cockatoo	*Cacatua galerita*	-	-
Superb Fairy Wren	*Malurus cyaneus*	-	-
Superb Lyrebird	*Menura novaehollandiae*	-	-
Swamp Harrier	*Circus approximans*	-	-
Tasmanian Native Hen	*Tribonyx mortierii*	-	-
Tasmanian Scrubwren	*Sericornis humilis*	-	-
Tasmanian Thornbill	*Acanthiza ewingii*	-	-
Tree Martin	*Petrochelidon nigricans*	-	-
Wedge-tailed Eagle	*Aquila audax*	Endangered	Endangered
Welcome Swallow	*Hirundo neoxena*	-	-
Yellow Wattlebird	*Anthochaera paradoxa*	-	-
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	-	-
Yellow-tailed Black-cockatoo	*Calyptorhynchus funereus*	-	-
Yellow-throated Honeyeater	*Nesoptilotis flavicollis*	-	-
Total	**55**		

Table 15. The proportion of bird movements (%) by species at disturbance points (B1-12) categorised BRSA, within the RSA range and ARSA Includes total bird counts for each flight height category and the grand total of movements for each species and for each observation point.

Species	BRSA %	RSA %	ARSA %
Australian Magpie	100		
Australian Shelduck	100		
Australian Wood Duck	50.0	50.0	
Bassian Thrush	100		
Black Currawong	86.0	14.0	
Black-faced Cuckoo Shrike	77.1	22.9	
Black-headed Honeyeater	99.0	1.01	
Blue-winged Parrot	52.8	47.2	
Brown Falcon	50.0	50.0	
Brown Goshawk	50.0	50.0	
Brown Thornbill	100		
Brush Bronzewing	100		
Common Starling	100		
Crescent Honeyeater	100		
Dusky Robin	100		
Dusky Woodswallow	80.0	20.0	
Eastern Rosella	100		
Fan-tailed Cuckoo	100		
Flame Robin	100		
Forest Raven	80.0	20.0	
Green Rosella	97.0	2.99	
Grey Butcherbird	100		
Grey Fantail	100		
Grey Shrike Thrush	94.2	5.77	
Laughing Kookaburra	100		
Little Wattle Bird	100		
Masked Lapwing	100		
Noisy Miner	91.1	8.86	
Pacific Black Duck	100		
Pink Robin	100		
Scarlet Robin	100		
Shining-bronze Cuckoo	100		
Silvereye	100		
Spotted Pardalote	100		

Strong-billed Honeyeater	100		
Sulphur-crested Cockatoo		100	
Superb Fairy Wren	100		
Superb Lyrebird	100		
Swamp Harrier	100		
Tasmanian Native Hen	100		
Tasmanian Scrubwren	100		
Tasmanian Thornbill	100		
Tree Martin	100		
Wedge-tailed Eagle	13.0	62.3	24.7
Welcome Swallow	100		
Yellow Wattlebird	85.1	14.9	
Yellow-rumped Thornbill	100		
Yellow-tailed Black-cockatoo	57.1	42.9	
Yellow-throated Honeyeater	95.3	4.72	

Table 16. The proportion (%) of bird movements by species at non-disturbance points (BR1-6) categorised BRSA, within the *RSA range* and *ARSA*. Includes total bird counts for each flight height category and the grand total of movements for each species and for each observation point.

Species	BRSA %	RSA %	ARSA %
Australian Magpie	100		
Black Currawong	93.3	6.73	
Black-faced Cuckoo Shrike	70.0	30.0	
Black-headed Honeyeater	96.6	3.45	
Brown Falcon		100.0	
Brown Thornbill	100		
Common Bronzewing	100		
Common Starling	100		
Crescent Honeyeater	100		
Dusky Woodswallow	100		
Eastern Rosella	100		
Eastern Spinebill	100		
Fan-tailed Cuckoo	100		
Flame Robin	100		
Forest Raven	78.9	21.1	
Green Rosella	97.3	2.70	
Grey Butcherbird	100		
Grey Currawong	100		
Grey Fantail	100		
Grey Shrike Thrush	98.0	2.04	
Laughing Kookaburra	97.3	2.70	
Little Corella	66.7	33.3	

Masked Lapwing	100		
New Holland Honeyeater	100		
Noisy Miner	98.2	1.82	
Pink Robin	100		
Scarlet Robin	100		
Silvereye	100		
Spotted Pardalote	100		
Striated Pardalote	100		
Strong-billed Honeyeater	100		
Superb Fairy Wren	100		
Superb Lyrebird	100		
Tasmanian Native Hen	100		
Tasmanian Scrubwren	100		
Tasmanian Thornbill	100		
Tree Martin	100		
Wedge-tailed Eagle	10.9	71.7	17.4
Welcome Swallow	100		
Yellow Wattlebird	88.7	11.3	
Yellow-rumped Thornbill	100		
Yellow-tailed Black-cockatoo	100		
Yellow-throated Honeyeater	89.7	10.3	