Waddi Wind Farm Project
Carnaby's Black-Cockatoo and Fork-tailed Swift
Utilisation Survey Report

Carnaby's Black-Cockatoo on Waddi Wind Farm adjacent Waddi Road. (Photo: Nathan Ducker)

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Executive Summary

Introduction

Bamford Consulting Ecologists (BCE) has been commissioned by Waddi Wind Farm Pty Ltd (the proponent) (via RPS AAP Consulting Pty Ltd (RPS)), to conduct a Bird Utilisation Survey for Carnaby's Black-Cockatoo (*Zanda latirostris*) and Fork-tailed Swift (*Apus pacificus*) on the proposed Waddi Wind Farm near Cataby in Western Australia. The wind farm was referred to the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in August 2023 and included survey data dating back to 2009.

The project was deemed likely to have a significant impact on Carnaby's Black-Cockatoos and Fork-tailed Swifts and given the decision of a Controlled Action. Carnaby's Black-Cockatoo is listed as Endangered while the Fork-tailed Swift is listed as Migratory under the EPBC Act. The DCCEEW requested additional information on flight paths, flight height information, breeding and roosting cockatoos. This survey was commissioned to satisfy these concerns and was conducted between August 2024 and January 2025. This report presents results of the surveys.

Project description

The Waddi Wind Farm project is located in Cooljarloo, Western Australia, and lies approximately 12 kilometres (km) north-west of the Dandaragan town site. Lying approximately 146 km north of Perth CBD, it covers an area of 10,490 ha although the area within which turbines will be located is likely to be substantially smaller than this.

The wind farm is designed to have up to 18 wind turbines and associated infrastructure, including access tracks and an export transmission line. The wind farm would be able to power up to 68,000 homes per year.

Carnaby's Black-Cockatoo

Carnaby's Black-Cockatoos were frequently encountered during surveys on Waddi Wind Farm between August 2024 and January 2025. Flight behaviours recorded were considered representative of Carnaby's during the late winter, spring and early summer, and included the entire breeding season. Observations were consistent with the authors' experience on other projects in the region. However, the maximum flock size of 52 birds was relatively low compared within other studied sites in the Cataby region.

The data demonstrate a moderate level of Carnaby's activities in the Waddi Wind Farm area displaying all seasonal/life stages expected during the sampling period. The number of encounters diminished into summer and it is thought the Carnaby's moved to over-wintering areas.

The original proposal of a rotor swept area (RSA) of 18-180 m above ground level would have placed 1.9% of Carnaby's in flight (adjusted for numbers in each group) at risk of flying at the same height as the turbine blades. Because of this level of activity and flight heights of up to 50 m were recorded (albeit over lower ground and outside the turbine array), the proponent changed the original RSA to

approximately 44 – 206 m above ground level. This reduces the Carnaby's at risk from 1.9% to 0.13% of birds in flight.

Factors justifying 40-50 m as the minimum height needed to eliminate the vast majority of risk to Carnaby's were:

I. only four flights were recorded of single birds flying at 40 m or above comprising 0.13% of the total bird/time, and these were in the lower areas of the landscape
II. supported by observations on other projects whereby Carnaby's are very seldom seen above 35-40 m.

Furthermore, raising the lower height of the RSA to 40-50 m will also help reduce potential casualties of other birds and bats.

Collision Risk Modelling (CRM) could not be conducted since none of the recorded flights were either within RSA or located inside the turbine array. Another factor that informs CRM is the ability of a species to avoid colliding with turbine blades. Monitoring activities on Yandin and Badgingarra Wind Farms in the same region reported a mixed response of Carnaby's over time; between impact and control sites, and between years but were still present within the wind farm arrays. While Carnaby's were still using the airspace within the turbine array, no mortalities were recorded from these facilities. Yandin has a lower RSA of approximately 27 m while Badgingarra is at 18 m and would pose a higher level of risk than the revised Waddi Wind Farm. Observations of Carnaby's during wind farm monitoring have witnessed Carnaby's adjusting their flight heights as they approach turbines (Mike Bamford pers. obs.).

Fork-tailed Swift

Despite a large amount of sampling during the period of year in which this species may be expected, no Fork-tailed Swifts were seen or heard. Storm front weather patterns that occurred during the survey period, were conducive of their presence. While this species is known to occur in this region, it has been recorded only twice in almost half a century of professional ornithological activity (M. Bamford pers. obs.). The risk to the Fork-tailed Swift is therefore considered negligible due to the infrequency of the species occurring in the area.

Conclusions

Carnaby's has been seen to have a moderate presence in the Waddi Wind Farm area during the winter, spring and early summer. This sampling period included the entire breeding period, and successful breeding was observed to have occurred close to the boundary of the wind farm. Overall, in the Waddi area and in the times of the year when surveys were undertaken, it appears that Carnaby's generally fly below the RSA when the lower height is >40m. It also appears, from other studies, that Carnaby's may learn to avoid turbines. Turbines proposed in the Referral had an RSA of 18 – 180 m. Following initial results for Carnaby's from this survey programme, the Proponent has sought to raise the turbine heights to a lower and upper swept pathway of between 44 and 206 m respectively (likely case). The rotor diameter and rated output of the wind turbines remain the same. This change has made a substantial difference to the potential impacts on Carnaby's Black-Cockatoo (and other birds). This suggests a very low risk to the species and the viability of Carnaby's is not predicted to be reduced as a result of the Waddi Wind Farm or in combination with other wind farms.

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1 Introduction

Bamford Consulting Ecologists (BCE) has been commissioned by Waddi Wind Farm Pty Ltd (the proponent) (via RPS AAP Consulting Pty Ltd (RPS)), to conduct a Bird Utilisation Survey for Carnaby's Black-Cockatoo (*Zanda latirostris*) and Fork-tailed Swift (*Apus pacificus*) in support of the proposed Waddi Wind Farm near Cataby in Western Australia. The location is shown in Figure 1-1.

The wind farm was referred under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in August 2023 and included survey data acquired between 2009 and 2023. These are summarised in RPS (2025). The project was deemed likely to have a significant impact on Carnaby's Black-Cockatoos and Fork-tailed Swifts and the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW) designated the project as a Controlled Action. Carnaby's Black-Cockatoo (Carnaby's) is listed as Endangered while the Fork-tailed Swift is listed as Migratory under the EPBC Act. The DCCEEW required further investigation into the risks of mortality on the two species due to bird strike from the turbine rotors. DCCEEW also requested further information on flight paths, flight heights, as well as breeding and roosting for Carnaby's Black-Cockatoos. This survey was commissioned to satisfy these concerns, and this report presents results of the surveys.

A meeting between the DCCEEW and the proponent project team was held on 23rd January 2025 in which the preliminary results were presented and discussed. During that meeting it was identified that critical thresholds of losses would need to be calculated depending on the predicted number of deaths from bird-strike following Collision Risk Modelling (CRM).

1.1.1 Background information

Background information supporting the project and this survey include the following key documents:

- *Output 1 – Desktop analysis of black-cockatoo tracking data to show movement and site utilisation of Carnaby's Black-Cockatoos in the Cataby Region with reference to the Waddi Wind Farm* (Kris Warren and Jill Shephard, Murdoch University 2024)
- *Yandin Wind Farm Avian Fauna Monitoring Program* (Ecologia Environment 2024)
- *Preliminary Documentation, Waddi Wind Farm* (RPS 2025)
- *Reconnaissance flora and vegetation assessment, Waddi Wind Farm* (RPS 2023)
- *Black-cockatoo habitat assessment for the Waddi Wind Farm transmission line alignment and the nominated areas in the adjacent farmland* (Terrestrial Ecosystems, 2022)
- *Carnaby's Black-Cockatoo and Other Birds Year One – Operational Monitoring* (Ecoscape 2018)
- *Waddi Wind Farm proposed action – Cataby Supplementary Flora, vegetation and Fauna Survey* (Ecologia Environment 2016)
- *Fauna Assessment, Waddi Wind Farm* (RPS 2014)
- *Waddi Wind Farm Spring Flora and Vegetation Survey and Black-Cockatoo Habitat Survey* (Outback Ecology 2024)
- *Avifauna Assessment Proposed Wind Farm Development Dandaragan Shire* (RPS 2010)
- *Targeted Level 1 Vegetation and Flora Assessment Waddi* (Outback Ecology 2010)

1.2 Description of the Waddi Wind Farm project

The Waddi Wind Farm project is located in Cooljarloo, Western Australia, and lies approximately 12 kilometres (km) north-west of Dandaragan. Lying approximately 146 km north of Perth's CBD, it

covers an area of 10,490 ha. The area in which turbines will be located is substantially smaller than this[1]. It is planned for the wind farm to have up to 18 wind turbines and associated infrastructure, including access tracks and an export transmission line. The wind farm would be able to power up to 68,000 homes per year and reduce carbon emissions by up to 286,000 tonnes.

Turbines proposed in the referral had a hub height of 99 m and rotor diameter of 162 m. This resulted in a rotor swept area (RSA) for the turbine blades of between 18 m at the lowest and 180 m at its highest. However, following acquisition of data for Carnaby's during this survey, the Proponent has sought to amend the turbine heights (subject to local government approvals) to a lower and upper swept pathway of between approximately 44 and 206 m respectively. The rotor diameter and rated output remain the same.

Construction of the wind farm is expected to take 16 months from commencement. Small areas of vegetation will require removal and this can have subsequent implications for Black-Cockatoos in the area, as assessed in RPS (2025).

Site layout of the Waddi Wind Farm is shown in Figure 1-1.

1.3 Description of project area and background environmental information

1.3.1 Landscape Overview

Landscape of the Waddi Wind Farm area is given in RPS (2025) and is summarised in the following. The landscape on which the wind farm is proposed is of rolling hills and creeklines in the valleys. A north to south ridgeline forms the higher ground along which the turbines are located. Elevation ranges from 140 m above mean sea level (MSL) in the southernmost parts of the brooks, to 295 m above MSL on the higher ground.

The wind turbines of Waddi Wind Farm are located exclusively on agricultural land. Agricultural management across the Project Area is a mixture of sheep farming and mixed arable, including grains and seeds such as wheat and Canola respectively. Several stands of remnant vegetation lie across the Project Area including several patches of Kwongan heath along the road reserve towards the southern end of Mullering Road, with the largest patch being central to the Project Area. Remnant woodland line the Mullering and Minyulo Brooks that lie along the west and south-east boundaries of the Project Area respectively. Both creeklines are dominated by Wandoo and Marri with varying degrees of understorey. Short sections of both creeklines have been cleared of vegetation, wholly or in part, and grazed. Remnant Dwutta (*Eucalyptus todtiana*) remain in several paddocks. Stands of ornamental eucalypts and pine trees are present in or close to the Project Area.

[1] The Project Area follows the cadastral boundaries for the Waddi Wind Farm and the proposed land tenure of the transmission line. The Project Area represents the area of land for which the Proponent has agreements in place with relevant parties to undertake the Proposed Action.

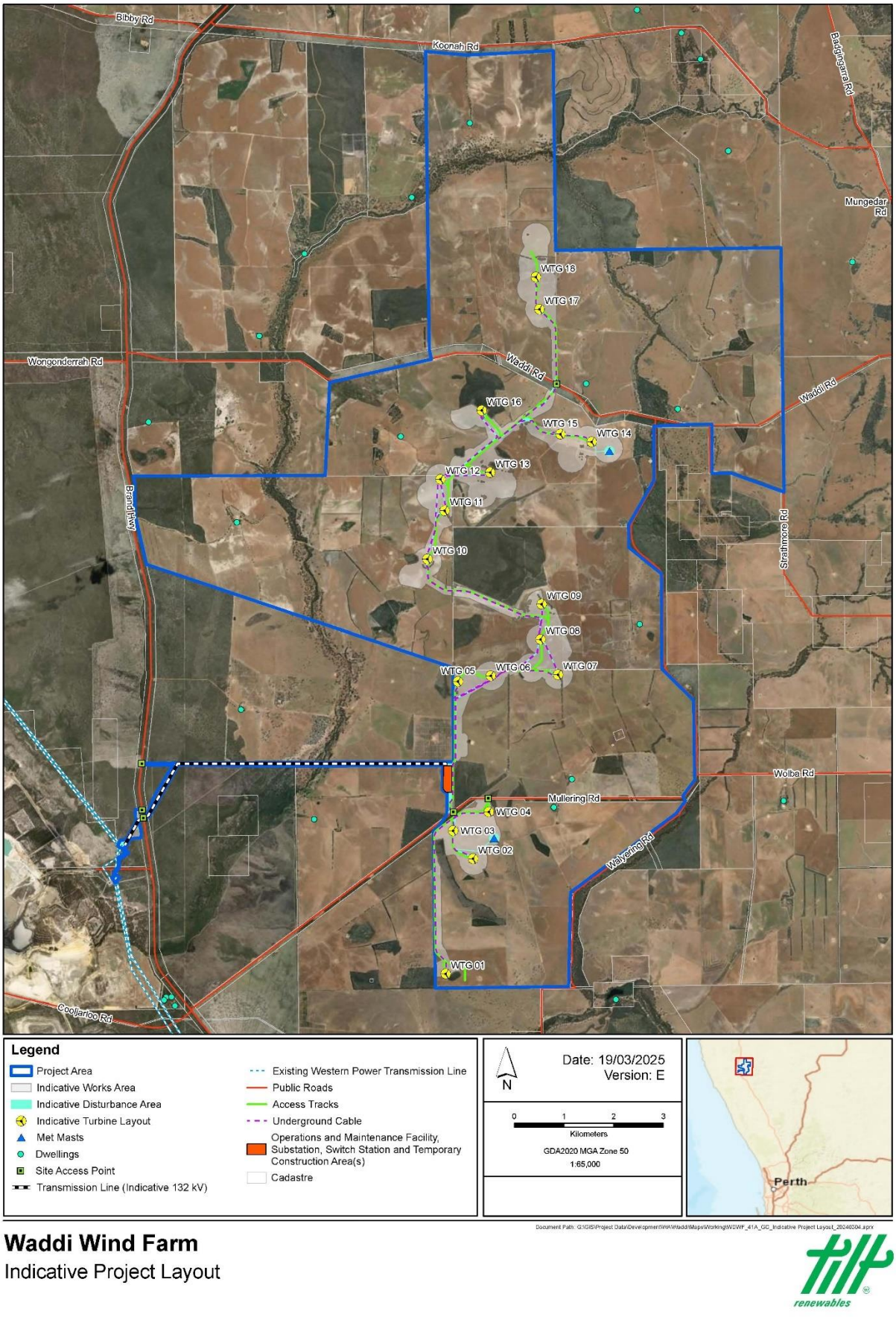

Figure 1-1. Location of Waddi Wind Farm and site layout

The areas to the north, east and south comprise a similar landscape to that found on the Project Area. The area to the west, however, is comprised mostly of Kwongan heath, occasional creeks and several lakes towards the coast, interspersed occasionally with small farmsteads. The Tronox Cooljarloo Mine Site lies on the opposite side of Brand Highway. A substantial part of the heath west of Brand Highway and Cooljarloo Mine Site was burnt in bushfires in early December 2024, while an area of similar Kwongan heath between Brand Highway and the Project Area was burnt recently; possibly summer 2023/2024. The extent of native vegetation and land under DBCA management is shown in Figure 1-2.

1.3.2 Recognised sensitive sites

The Minyulo Brook Reserve is a known nesting area for Carnaby's and the surrounding area offers foraging habitat critical to breeding success. Minyulo Brook lies along the southern and eastern boundaries of the Project Area.

All native vegetation and reserves under state management shown in Figure 1-2 form critical habitat for Carnaby's Black-Cockatoo, with woodlands providing important roosting and nesting, and woodland and heath used for foraging. Known roosts and breeding locations for Carnaby's in the Project Area are shown in Figure 1-3.

1.4 Background: Carnaby's Black-Cockatoo

A comprehensive review of available information and summary of survey previously undertaken in pursuit of the Waddi Wind Farm development is given in RPS (2025) with salient points taken from this document and summarised in the following. There has been no previous attempt to estimate the populations of either target species for the Project Area or the wider region.

There is considerable published information on the ecology of, and threats to, the three taxa of black-cockatoo that occur in south-western Western Australia: Carnaby's, Baudin's and Forest Red-tailed Black-Cockatoos. Key references include:

- Action plans (Garnett and Baker 2021);
- Recovery plans (DEC 2008; DPaW 2013);
- EPBC Act referral guidelines (DAWE 2022; DSEWPaC 2012);
- Commonwealth listing and conservation advice (DEWHA 2009; TSSC 2009, 2018);
- The federal Department of Climate Change, Energy, the Environment and Water's (DCCEEW) Species Profile and Threats (SPRAT) Database (DCCEEW 2024a, 2024b, 2024c);
- Scientific (Saunders 1974, 1979a, 1979b, 1980, 1986; Saunders *et al.* 1982; Johnstone and Storr 1998; Higgins 1999; Johnston *et al.* 2016; Williams *et al.* 2016, 2017); and
- Major reports (Johnstone *et al.* 2011; Kabat *et al.* 2012; Peck *et al.* 2016, 2019).

Much of this information has been compiled by DCCEEW (2025a). Summarising this work further, salient ecology aspects for Carnaby's Black-Cockatoos are discussed in the following. It is important to acknowledge that key characteristics of Carnaby's ecology have changed in the last 30 years (Murdoch University 2024). This includes their seasonal distribution and foraging behaviour in

particular and is most likely in response to habitat loss as a result of clearing (Murdoch University 2024), fire, and altered climate (DPaW 2013).

1.4.1 Key ecology of Carnaby's

- Population of between 11,000 and 60,000 individuals
- The species is long-lived with low annual reproduction rates and cannot, therefore, rapidly increase their population size
- They undergo regular, seasonal migration between breeding (predominantly 'Wheatbelt' areas east of the Darling Range, from Mingenew to Ravensthorpe) and non-breeding areas (coastal south-west from Kalbarri to Esperance).
- Throughout the year they are dependent on large trees in which they roost overnight. Roosts vary substantially in size from a few to several thousand birds. Larger roosts are formed in the middle of spring, but non-breeding birds use similar roosts throughout the year
- In recent years there have been considerable shifts in the breeding ecology, distribution and movement patterns of Carnaby's Black-Cockatoo. These may be a response to habitat degradation/clearing and/or climatic factors.

1.4.2 Key habitat requirements

- Critically reliant on large tree-hollows in eucalypts, in which they breed
- Feed primarily on native plant seeds and flowers, but increasingly take crop and weed seeds
- Communal night roosting trees within 6-12 km of foraging habitat are used throughout the year by non-breeding birds, and which forms an important aspect of their behavioural ecology especially in autumn and winter
- Consumes wood-boring insect larvae when available and is an important resource during courtship and breeding.

It is important to note that the above habitat features act integrally by their proximity to each other without which the birds cannot persist.

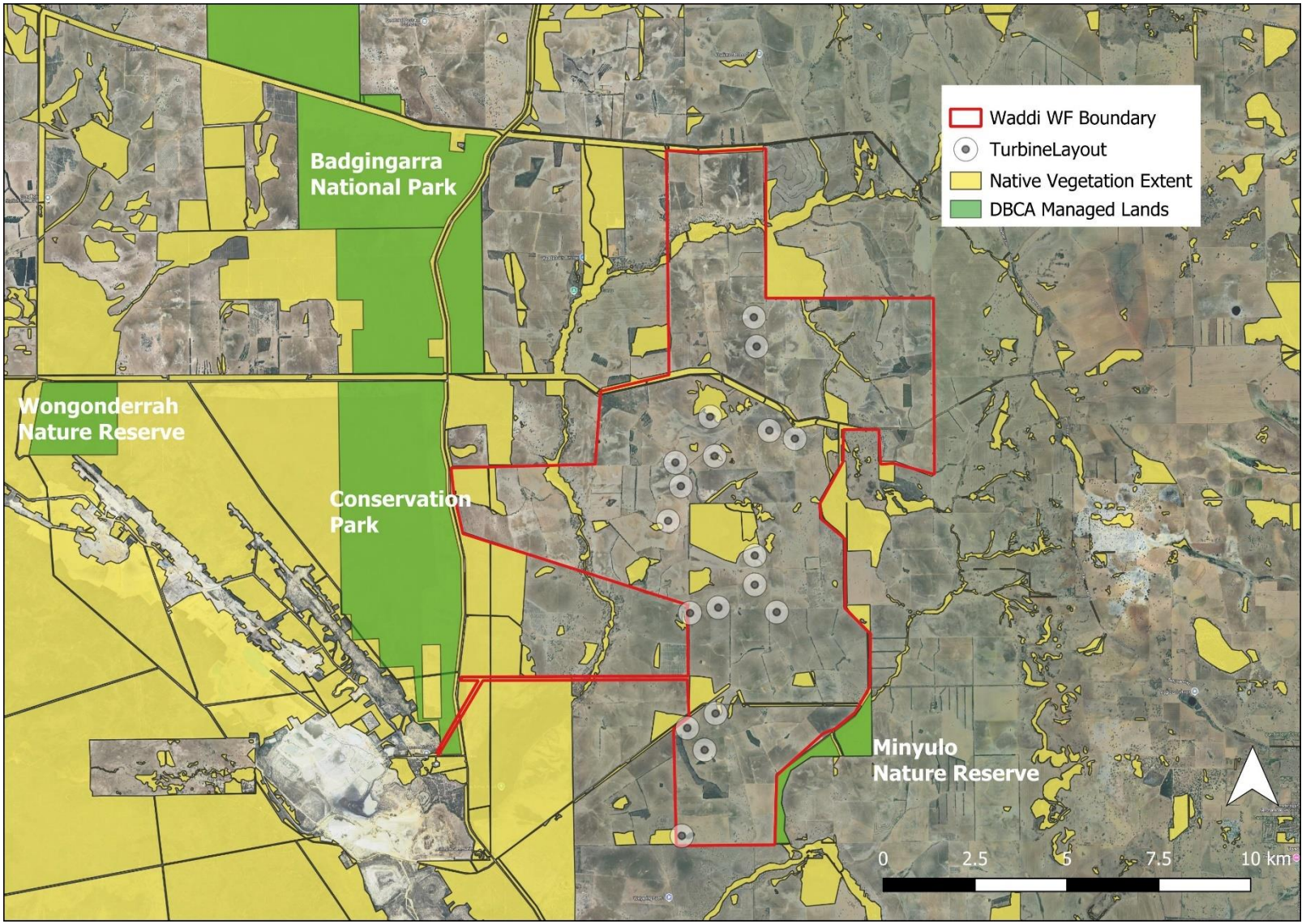

Figure 1-2. Native vegetation and land under DBCA management.

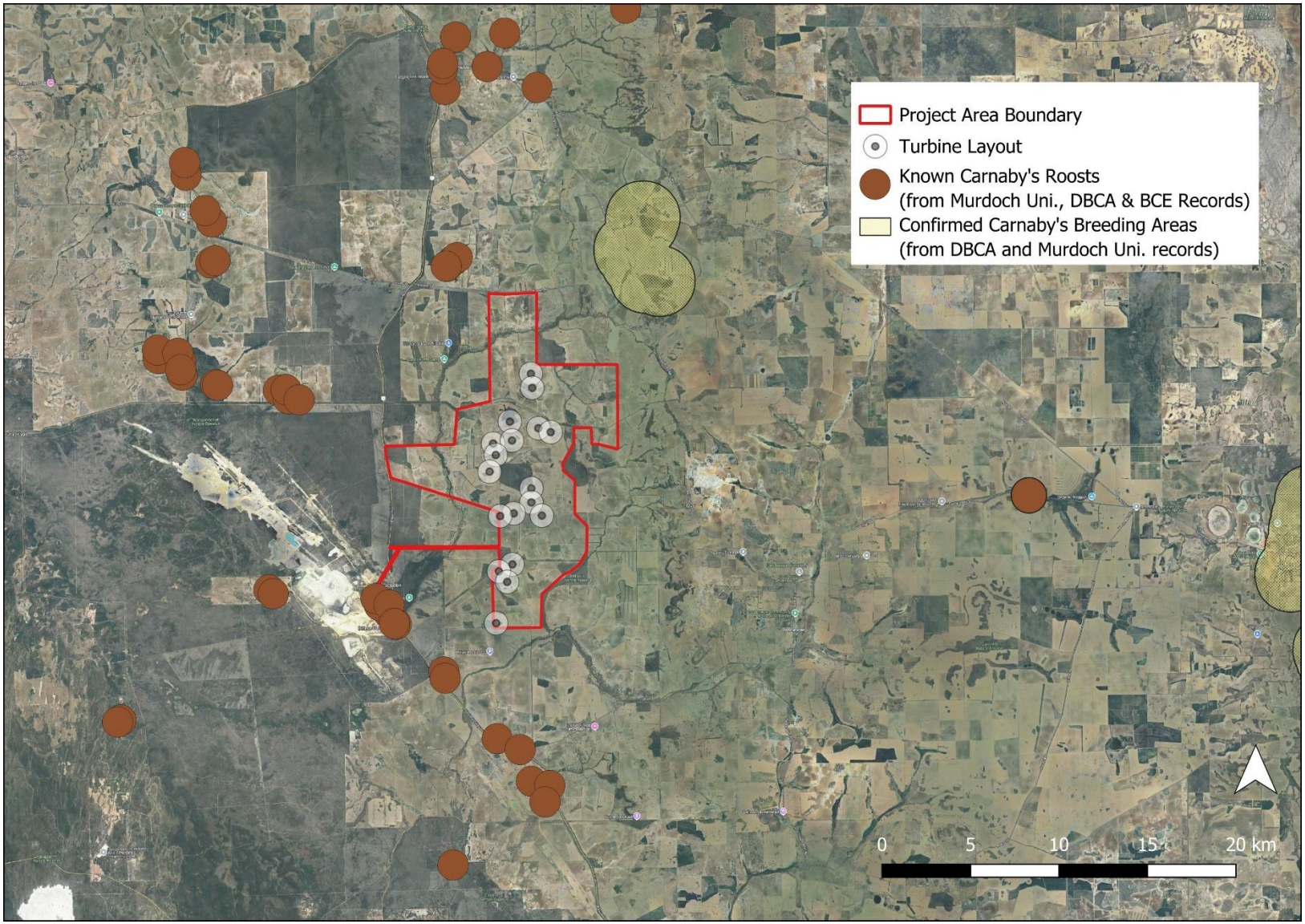

Figure 1-3. Known roosting and breeding habitat features of Carnaby's Black-Cockatoo.

1.4.3 Key threats

Key threatening processes include:

- Illegal shooting
- Foraging habitat loss/degradation
- Loss of breeding habitat and nest hollow shortage
- Fragmented habitat
- Collision with motor vehicles
- Inappropriate fire regimes
- Competition for available nest hollows from other parrots and feral Honeybees (*Apis mellifera*)
- Illegal trade
- Climate change and impacts from drought, vegetation change, temperature etc.

Several of these threatening processes are associated with climate change which is a critical factor that is likely to accelerate the severity and rate of impacts (DPaW 2013). Carnaby's primarily nest in tree hollows formed in Wandoo and Salmon Gum due to these trees' natural tendency to develop suitable hollows. However, Marri, Jarrah and other large tree species will also be used when locations and hollows meet the birds' needs. Carnaby's is a catholic feeder and targets many species of flowers and fruits of native shrubs and trees such as Banksia, Hakea, Grevillea and Marri. Wood-boring larvae of moths and weevils that occur in or on these are also taken and appear to be important breeding food. In recent years however, they have increasingly been observed feeding on introduced species such as Pines, Wild Radish and agricultural crops such as Canola and Lupins.

1.4.4 Known movement activities

On behalf of the Waddi Wind Farm project, Murdoch University (2024) collated data previously acquired from satellite tags attached to 14 Carnaby's between 2017 and 2022. The tagging programme was augmented by field observations of the same birds during the same period. These studies tagged birds during the breeding season from Coomallo between 2017-2022, from Cataby between 2021-2022, and from the Regan's Ford area in the non-breeding season of 2022. Fourteen individual birds were tagged that, on release, joined flocks and thus acted as markers for where the flocks went. The results provided by Murdoch University are shown in Figure 1-4.

Movements of those birds tagged were limited to the north, west and south of the Project Area. Only one bird movement from those tagged entered the Project Area and only in the extreme west as shown in Figure 1-4. It is considered likely that other flocks and potentially roosting groups were also using the Project Area at this same time, but remained unobserved. Direct observations of the birds showed that breeding birds foraged together in flocks. The results of these studies identified that Carnaby's will travel up to 12 km from night roosts to feed, with the mean distance being 6 km. While nesting however, their foraging range is much reduced and the birds seldom travel beyond 2-3 km from their nest sites (Saunders 1980). During the study, post-breeding birds continued to use the roosts located close by the nesting areas for several months. In that time, the number of birds at each roost increased and included newly fledged young. Clearly some birds leave nesting areas to roost elsewhere in the non-breeding areas, while others appear to remain within the breeding areas. It

remains unclear whether the same roosts are used each year or whether they change, but there are likely to be differences in the roosts being used due to changes in factors such as food supply, such as following fire. Following the breeding and fledging season, flocks may move to other roosting areas and birds tagged at Coomallo, for instance, were later recorded roosting just 3 km north-east of the Project Area. Whilst these birds were not tracked into the Project Area, it is close enough to expect that they could forage within the boundary.

Behavioural observations of foraging Carnaby's recorded by the authors in close proximity to the Project Area indicate that for the majority of time, pairs, family groups and flocks move sporadically through the landscape and settle frequently to feed and roost. Occasionally, longer flights were observed where flocks are intent on covering longer distances; longer movements are most often associated with movements soon after dawn and just before dusk. Throughout the day, flocks were seen not to be fixed, but instead individuals, pairs and smaller groups joined and left frequently. On several occasions, the smaller groups flew in the opposite direction from where they came from and for several kilometres. During these observations, Carnaby's were not observed flying higher than 35 m above ground level and this was only seen at the roost. Over urban environments Carnaby's have been seen to fly higher more regularly than over rural areas. On two separate occasions previously, the authors have witnessed flocks of Carnaby's flying higher than normal in a vortex or swirling pattern. Heights during vortex events are still modest and were estimated to be no higher than 30 m.

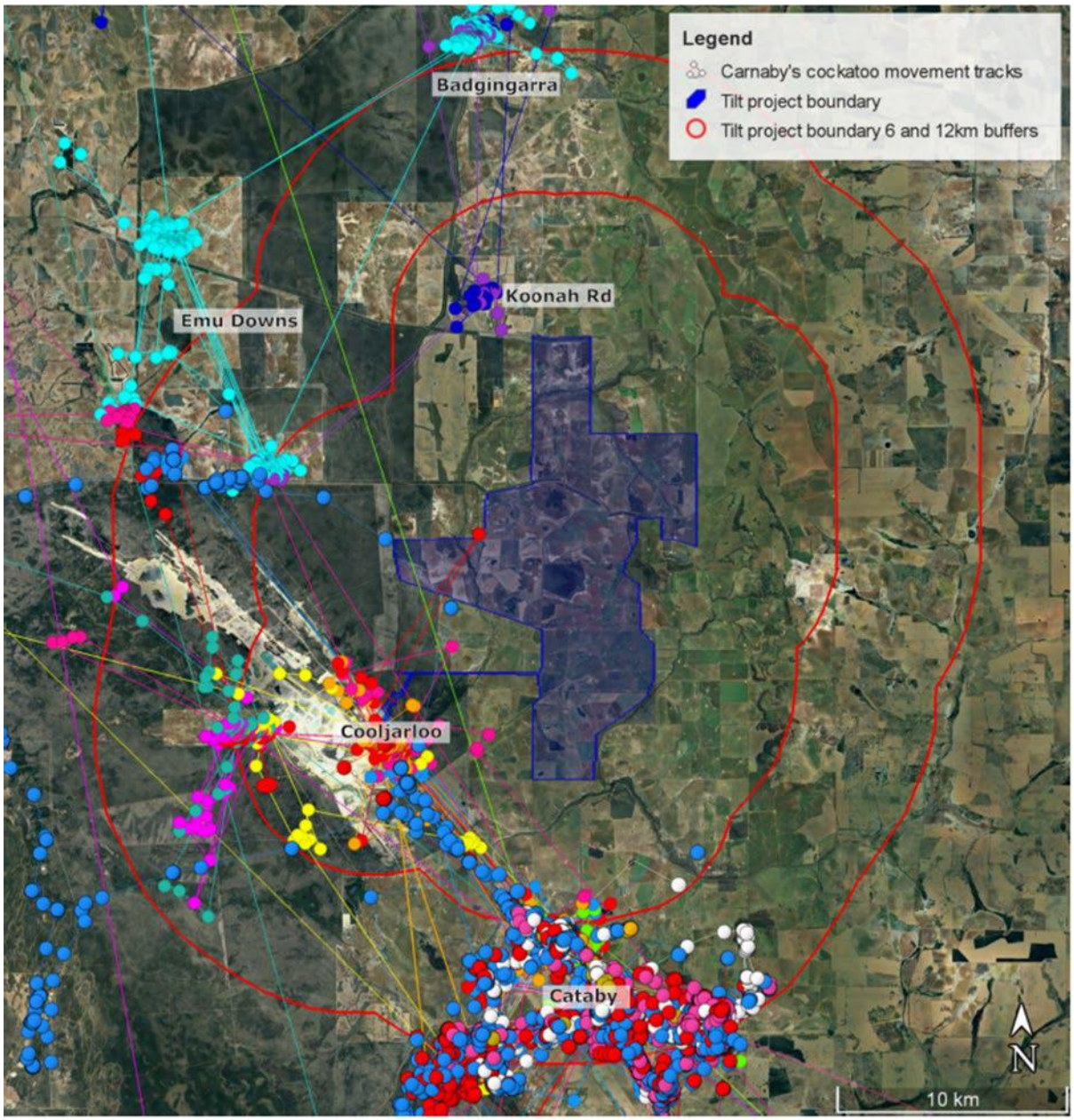

Figure 1-4. Plot of data acquired from 14 Carnaby's fitted with GPS and Argos satellite tags by Murdoch University (2024). Colours represent individual birds tagged at Coomallo and Cataby during the breeding season and Regan's Ford in the non-breeding season.

1.4.5 Local context for Carnaby's

The following are known key values for Carnaby's in and around the Waddi Wind Farm:

- Breeding is known to occur at the following locations and close enough for Carnaby's to forage in the Project Area:
    - Minyulo Brook immediately adjacent the Project Area (DBCA)
    - Cataby 7 km south
    - Badgingarra 3 km north-east
- The large Coomallo Creek breeding group lies approximately 36 km north of the Project Area but some birds from this group have been recorded roosting in Badgingarra 3 km north

- Large trees along the Minyulo and Mullering brooks to the south and west of the Project Area contain known roosts
- Remnant native vegetation comprises critical roosting, nesting and foraging habitat. Some of these remnant parcels are privately owned and some in state management
- Kwongan heath, Eucalypt woodland (especially Marri) and Dwutta (*Eucalyptus todtiana*) comprise important native vegetation foraging habitat
- Pine plantations and agricultural crops (in particular Canola) offer important non-native food resources
- Available standing freshwater throughout the year including field dams, livestock water troughs and natural pools along the river courses.

Carnaby's are regularly recorded in the Cataby area formally and informally, and were regularly recorded throughout surveys for the various wind farms in the Badgingarra and Dandaragan area. In studies undertaken for Tronox at the nearby Cooljarloo Mineral Sand Mine, they have been recorded regularly in the area by BCE over the last 30 years in flocks frequently exceeding 100 and occasionally up to 700 birds, with the larger groups being recorded during the winter. They appear to be present throughout the year and have been recorded breeding at a number of sites, including the Minyulo Brook Reserve adjacent the eastern boundary of the Project Area. It seems uncertain whether the same individuals are present year-round, or whether there is a turnover in individuals. Therefore, it remains unclear whether they are breeding and non-breeding visitors, or are resident breeders.

1.5 Background: Fork-tailed Swift Ecology

DCCEEW (2025d) details the distribution of Fork-tailed Swift in Australia. These swifts visit Australia outside their breeding season between October and April. It is a wide-ranging migrant that visits most of Australia down to the southern coast. They are regular visitors to northern Western Australia but become less regular further south.

In Australia, they are exclusively aerial and hunt, often in large flocks, across a wide range of environments including woodlands and plains. As such, they are relatively disassociated with the land use and environment types. It is noted that they associate with storm fronts and hunt from just above the ground to several hundred metres up (Boehm 1962).

There is one record of Fork-tailed Swift in DBCA's database which was recorded 29 km north of the Project Area. BCE staff have been conducting regular bird surveys throughout the south-west of Western Australia for more than 30 years and have recorded Fork-tailed Swifts very infrequently. Dr Mike Bamford has observed the species only twice in the region over a bird-watching career spanning nearly half a century. BCE is also engaged on a long-term monitoring project (30 years) in the adjacent Cooljarloo minesite (Tronox). That project has sampled birds biannually (late winter and late spring/early summer) for more than 30 years, amounting to about 1,320 person-days of observation by experienced ornithologists, and has not encountered Fork-tailed Swifts.

Relevant demographics of Fork-tailed Swift are summarised as follows:

A. The global population of this species is expected to exceed 100,000 breeding pairs (BirdLife DataZone 2025)

B. The population of Swifts visiting Australia has not been estimated, but previous flocks of up to 90,000 have been recorded in the 1960s (DCCEEW 2025)
C. It is listed as Least Concern by the International Union for Nature Conservation (IUCN 2025) and its population is Stable throughout its range (with exception of Pakistan) (IUCN 2025).

2 Methods

2.1 Overview

This survey was commissioned to specifically address the concerns raised by DCCEEW regarding the risks to Carnaby's and Fork-tailed Swifts as set out above; DCCEEW suggested to focus on the following:

1. Flight pathways through the Waddi Wind Farm
2. Flight heights
3. Roosting activities on site or nearby
4. Breeding activities on site or nearby.

While there are no prescriptive guides that define how utilisation surveys for wind farms in Australia should be conducted, the following documents have been referred to in deriving the sampling plan for Waddi Wind Farm:

- *Onshore wind farm guidance* (Draft for consultation) (DCCEEW, 2024)
- *EPBC Act referral guidelines for three threatened black cockatoo species* (DSEWPaC 2012)
- *Referral Guideline for 3 WA threatened black cockatoo species* (DAWE 2022)
- *Recommended bird survey methods to inform impact assessment of onshore wind farms* (Scottish Natural Heritage 2017)
- *Terrestrial vertebrate fauna surveys for environmental impact assessment* (Environmental Protection Authority 2020)

In addition, survey methodology followed the recommendations listed on the DCCEEW's Species Profile and Threats Database (DCCEEW 2025b, 2025c, 2025a). Ecological values for black-cockatoos within the site were based on the definitions of breeding, foraging and roosting habitat as per the EPBC Act referral guidelines for black-cockatoos (DAWE 2022).

DCCEEW (2024) suggests that bird surveys for wind farms are undertaken once in each of the four seasons. However, to achieve higher resolution of Carnaby's seasonal movements and to capture potential in-flight behaviours through its various annual stages, it was decided to sample more often. A bushfire outbreak in late November 2024 forced the schedule laid out in the Survey Plan to be changed with the resultant campaigns shown in Table 2-1. Surveyors also visited the Project Area on 17th August 2024 while passing through, and on 4th March 2025 on behalf of the wind farm whereby opportunistic sightings were recorded.

Table 2-1. Field campaign schedule including additional days on which control sites were visited.

Campaign No	From	To	Personnel
Reconnaissance	26-Aug-24	27-Aug-24	5
1	7-Oct-24	9-Oct-24	2
2	20-Oct-24	22-Oct-24	4
Control Site	6-Dec-24	6-Dec-24	1
3	16-Dec-24	17-Dec-24	3
Control Site	20-Dec-24	20-Dec-24	1
4	6-Jan-25	7-Jan-25	4
Control Site	10-Jan-25	10-Jan-25	1

To provide a robust suite of data to satisfy the above requirements and through drawing on the above guidance, a Survey Plan was formulated (BCE 2024) and employed three complementary sampling methods:

A. Vantage Point (VP)
B. Focal Follows (FF)
C. Acoustic (audible for bird calls)

In addition to the above formal sampling, surveyors recorded all other encounters with Carnaby's (and Swifts) as opportunistic records. While the above was intended to focus on Carnaby's, surveyors would remain vigilant for visual or audible cues of Fork-tailed Swifts if encountered. All other bird and fauna species were ignored. The acoustic files were analysed for the two target species, but also contain an acoustic baseline of the general fauna assemblage.

The objective of VP sampling is to establish distribution across the Project Area, flight heights and duration of flights through the turbine array. A primary objective of VP survey is to generate bird densities (flux) as input to CRM should adequate data be acquired of birds flying within the RSA. The principal output from CRM is an estimate of the annual mortality of birds caused by the wind turbines for a given layout.

The objective of FF is to assure the capture of adequate data on flight profiles and to identify roosts, nesting sites and better identify foraging activities. Both methods help to identify routinely used flight paths (if any), but VP aims to identify those within the turbine array. Each method addresses the other's weaknesses; VP sampling locations are systematically spaced across the Project Area and intended to capture bird density (or flux) through the turbine array. However, the VP approach does not allow movements to be identified and followed if they do not occur at the time and location of a survey. In contrast, FF surveys are deliberately biased to following bird movements, so are not as systematic and cannot be used to calculate flux or inform CRM. FF may also lead to movements of birds outside of the project area; though such data provide good flight data, they become less relevant to the wind farm the further afield they are. The strength of the FF approach is that it provides additional and potentially abundant data on flight height behaviour.

For the Waddi Wind Farm, both FF and VP sampling was strictly focused on Carnaby's, but all surveyors remained vigilant when on site for Fork-tailed Swifts during the period this species was expected to be present (from October to April).

Throughout all site activities, surveyors remained vigilant for sightings and signs of Carnaby's (and swifts), collecting opportunistic data accordingly. If the birds were followed during such opportunistic encounters, the record would be treated as FF.

2.2 Focal Follow Survey

Throughout each field campaign, a surveyor was dedicated to the FF task and would search for Carnaby's Black-Cockatoos within the Project Area and up to six kilometres outside the boundary. Searches began with known habitat such as roosts, foraging or nesting locations, but can also be where they had been encountered the previous day or through local knowledge. Surveyors on VP would also notify the whereabouts of Carnaby's when encountered to the rest of the group. Once Carnaby's were

discovered, the surveyor tracked and observed the bird flights for as long as is possible given the landscape, property access etc. Birds were tracked using audible and visual cues and with the help of binoculars. Where groups fragmented, the surveyor focused on birds that entered the development footprint or on the largest group. FF was conducted primarily from vehicles with forays on foot to increase precision in locations, confirm activities and define the number of birds. The surveyor would maintain a distance of at least 50 m but generally 100 m or more from the group being studied. The Project Area was expected to have frequent public vehicle and farm plant movements, including road trains carrying livestock and agricultural produce. Therefore, disturbance to the birds caused by survey vehicles was expected to be negligible.

Bird flights and movements over the landscape were recorded using points entered into a GIS field application (QField) that corresponded to the geographic position in the landscape. Each record noted number of birds, behaviour and flight heights. As birds move and change flight behaviours, new data points were entered. By locating each record according to their estimated position in the landscape in which they are found, the characteristics of the environment in which they occur are recorded by default. Following completion of the survey, the data were plotted and individual points linked to form flight lines. Each flight therefore consisted of a varying number of records. Flights are used to describe the changing heights and direction of movement patterns, whereas records define the heights and group size at each location.

It is important to note that flight heights are taken to be from the ground the birds were observed flying over, and used to describe their general flight behaviour including ascent and descent in the Project Area. Because of this, birds flying at 44 m over lower ground will not be within the area swept by the rotor blades, but are used to indicate the potential for Carnaby's to fly within the RSA.

Throughout all FF surveys, roosting, nesting and foraging activities or signs thereof, were recorded. This task lay principally with the FF surveyor, but all field personnel took such records throughout the reconnaissance survey and opportunistically when moving around the project area. Time at sunset was set aside specifically to follow birds to night roosts wherever possible. Sites identified as potential roosts the night before, were targeted the following morning to confirm the overnight use of the suspected roost. Specific points were monitored at dusk to help detect and establish night-time roosts, and these locations are shown in Figure 2-1.

2.3 Vantage Point Survey

The site was inspected in August 2024 to establish sampling locations and five VPs were located on higher ground within sight of turbine locations that also provide the least obstructed vision. Two control sites were located outside of what was considered to be the zone of influence from the wind farm (or other wind farms). Sampling locations are shown in Figure 2-1. Each VP was sampled during each field campaign, for periods of up to three hours during the early morning, late morning or early PM, and late PM. During this time the surveyor scanned the skies for birds generally out to 2 km from the VP, but if Carnaby's were spotted outside of this, they were still recorded. Carnaby's were recorded whenever seen including on the ground and under RSA. Each VP was accessed via 4X4 vehicle using farm tracks. Vehicles would be parked nearby without the engine running, and always at a location regularly visited by farm vehicles to ensure survey activities were not unusual to the area.

On detecting Carnaby's (or swifts), they were tracked through the airspace and each flight recorded in a GIS field app (QField). Records were taken as frequently as possible, enabling each flight to be plotted on a map. For each georeferenced data point, the following information was recorded:

- Number of birds
- Flight height
- Flight behaviour
- Gender and age classes (where possible).

Noting that flight height relates to the ground over which the birds are located, and not strictly to turbine height, unless within the turbine array. In locating the flight records against the background mapping, the landscape features over which each flight occurs are recorded by default. QField was pre-programmed to allow surveyors to complete each record as quickly as possible so that birds are not lost from view. Surveyors primarily used visual cues aided by binoculars and spotting scopes to help confirm species (including Fork-tailed Swifts) and spot Carnaby's in vegetation.

2.4 Acoustic Survey

Two Titley Chorus acoustic recording units (ARUs) were programmed for audible data collection via an acoustic microphone and deployed in late August 2024. Acoustic sampling was used primarily as a back-up and to augment data on Carnaby's and Fork-tailed Swift to achieve:

- a longer period of sampling than ecologists could attend the site
- when hot weather would be a risk to surveyors
- rarer events that have very low likelihood of being detected by survey alone
- bioacoustics as a representation of biodiversity to support long term monitoring.

Data were downloaded and batteries changed in December 2024, and the ARUs were finally retrieved in early January 2025. Deployment dates and settings for the ARUs are shown in Table 2-2. Battery life limited the endurance of each unit.

Table 2-2. Deployment details and settings for the two ARUs used for recording birds

Name	Deployed	Retrieved	Eastings	Northings	Days/hrs Active
ARU31	27-Aug-24	6-Jan-24	359433	6615066	34/168
ARU33	27-Aug-24	6-Jan-24	359177	6609661	25/118.5

Sample Rate	Acoustic Gain	File Duration
44.1 ksps	+12 dB	30 mins

Target Taxa	From	To	Mode	Days/week
Diurnal Birds	45 min before sunrise	30 min after sunset	30 min on, 60 min off	3

GPS tracks, VPs and locations of ARUs are plotted onSampling points and recording unit locations for Waddi Wind Farm, with GPS tracks for the surveyors recorded throughout campaigns.

2.5 Survey Limitations

The EPA Guidance Statement 56 (EPA, 2004) and the EPA (2020) outline a number of limitations that may arise during field investigations for Environmental Impact Assessment. These survey limitations are discussed in the context of the BCE investigation of the Project Area in

Table 2-3. No limitations were identified.

Table 2-3. **Survey limitations as outlined by EPA** (2020)**.**

EPA Survey Limitations	BCE Comment
Availability of data and information	Sufficient information from databases and previous studies. Not a limitation.
Competency/experience of the survey team, including experience in the bioregion surveyed	The ecologists have had extensive experience in conducting field surveys for environmental impact assessment fauna studies, particularly for black-cockatoo and other bird survey and habitat assessments and have undertaken a number of similar studies within the region. Not a limitation.
Scope of the survey (e.g. where faunal groups were excluded from the survey)	The scope of the assessment was a targeted survey for Carnaby's Black-Cockatoo and Fork-tailed Swift presence, and identification of habitat. Not a limitation.
Timing, weather and season	Seasonality is of great importance for this type of assessment, and, together with previous studies was undertaken during appropriate times of the year. Not a limitation.
Disturbance that may have affected results	Surveyors were mindful not to disturb the black-cockatoos being studied and took appropriate actions for their dress, vehicles and behaviours to ensure bird activities were unaffected during survey campaigns. Not a limitation.
The proportion of fauna identified, recorded or collected	The sampling regime provided a very high chance for detecting and recording the two targeted species if present. Not a limitation.
Adequacy of the survey intensity and proportion of survey achieved (e.g. the extent to which the area was surveyed)	The project area was adequately sampled to the level appropriate for distribution and flight survey of the two targeted species. Not a limitation.
Access problems	Some access limitations were encountered due to local bushfire and farm practices, but the survey schedule was adjusted to achieve the same sampling effort. Not a limitation.
Problems with data and analysis, including sampling biases	There were no data problems. Not a limitation.

2.6 Personnel

Personnel involved in the field investigations and report preparation (including desktop review) are listed in Table 2-4.

Table 2-4. Personnel involved in the field investigations and report preparation.

Personnel	EIA/Wildlife Survey Experience	Field Investigations	Report Preparation
Dr Mike Bamford *BSc (Biology), Hons (Biology), PhD (Biology)*	40 years	+	+
Nathan Ducker	7 years	+	
Alice Reavely	1 year	+	
Katherine Chuk	15 years	+	
Mike Griffiths	10 years	+	
Dr Barry Shepherd *BSc Hons. (Env. Biol.), PhD (Ecology)*	30 years	+	+
Peter Smith *Assoc. Dip. Agric. (Farm Management)*	30 years	+	

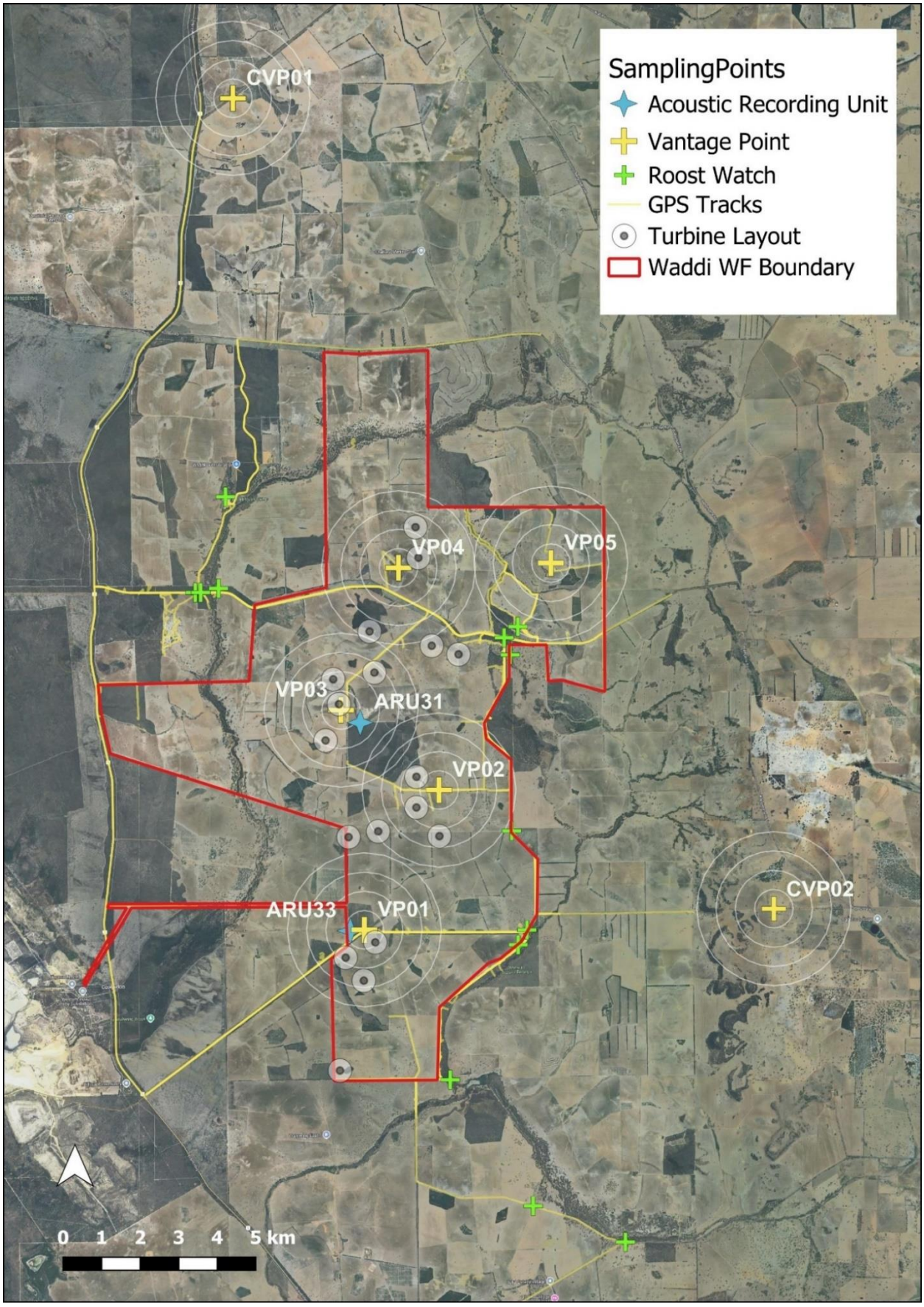

Figure 2-1. Sampling points and recording unit locations for Waddi Wind Farm, with GPS tracks for the surveyors recorded throughout campaigns.

3 Results

This section presents the results of the field surveys and includes findings on:

- Carnaby's Black-Cockatoo
    - Habitat
    - Behaviours and activities
    - Distribution and flights
- Fork-tailed Swifts

Marri nuts with chew marks consistent with Forest Red-tailed Black-Cockatoo were found under a tree just north of Waddi Road. The marks were recent but not fresh. Landowners advised that Forest Red-tailed Black-Cockatoos are seen and heard in the area very infrequently and possibly not every year. Because of this, surveyors were reminded to be vigilant to distinguish between the two species.

There are few records and a scant amount of evidence that Forest Red-tailed Black-Cockatoo (*Calyptorhynchus banskii naso*) also occurs in the Project Area. It is considered that this Endangered species is an irregular visitor and would be recorded if encountered. The Project Area is considered outside of the range of Baudin's Black-Cockatoo (*Zanda baudinii*) which is the third Endangered Black-Cockatoo endemic to the south-west.

3.1 General Summary

Conditions were generally very amenable to bird surveys. Significant rainfall events occurred during the August visit and on the last day of the early October visit. Survey was not affected in August, but during the October visit, visibility was reduced sufficiently by low cloud and mist that the survey was ended prematurely. Sampling effort in following campaigns was increased to ensure sufficient data were acquired. Recorded temperatures throughout sampling periods were considered appropriate and the ranges of conditions encountered ensured data would be representative of normal conditions across the Project Area.

Selection of suitable VP control sites posed a challenge, as some sites inspected were either too close to other wind farms, had substantially compromised viewsheds, or Carnaby's were not recorded despite three 2-3 hour watches. Control site CVP02 proved to be very good and roosting activity was recorded from the VP.

The sampling effort achieved is presented in Table 3-1. This represents a large volume of work from pre-dawn to dusk across five survey campaigns. The full sampling schedule is provided in Appendix Table A2-1. It should be noted that surveyors spent all day in the Project Area when deployed, and were vigilant to record all encounters with Carnaby's (or Forest Red-tailed) and Fork-tailed Swifts. The overall sampling effort is therefore substantially greater than formal records show.

Batteries used in the ARUs vary in endurance and the two recorders likewise had different durations of sampling. The overall intent of the acoustic devices (eg augment surveyor presence on site), met their objectives. Results of the acoustic analysis are presented in Table 3-2.

Table 3-1. Sampling effort achieved during VP and FF sampling.

Dates	FF Hours	VP Hours	VP01	VP02	VP03	VP04	VP05	CVP01	CVP02
26/08/2024	1								
27/08/2024	16	8.1	3.1		3.1	2			
28/08/2024	16								
7/10/2024	15.5	6.1	3.1	3					
8/10/2024	13	7.2			2.1	2	3		
9/10/2024	3							2.22	
21/10/2024	11	10.9	3	3		1.9	3		
22/10/2024	12	12.5	3	3		3	3.5		2.94
6/12/2024								3.0	
16/12/2024	13	17.6	5	4.3	3.1	3.1	2		
17/12/2024	12	5.0	2		3				2.98
20/12/2024								3.07	3.11
6/01/2025	12	39.4	6	6.1	9	9.1	9.1		
7/01/2025	12	9.3	3.1	3.1			3.1		
10/01/2025								3.04	
Grand Total	**136.5**	**136.2**	**28.3**	**22.5**	**20.3**	**21.1**	**23.7**	**11.3**	**9**

Table 3-2. Summary of acoustic records taken from two ARUs deployed showing the number of days on which Carnaby's or Swifts were detected by the recorders and number of days the recorders were actively recording. Dashes denote where batteries had failed prematurely.

ARU Ref	Target Spp	Number of days Carnaby's were recorded / days actively recording				
		August	September	October	December	January
ARU31 (Central)	Carnaby's	1/2	2/13	2/10	2/6	3/3
	Fork-tailed Swift	NA	NA	0/10	0/6	0/3
ARU33 (South)	Carnaby's	2/2	8/13	2/10	-	-
	Fork-tailed Swift	NA	NA	0/10	-	-

3.3 Carnaby's Black-Cockatoo

Carnaby's Black Cockatoos were recorded throughout each survey campaign on and around the Project Area, during which time 148 separate flights were recorded, and were defined by 625 separate point records. Each flight can comprise of one-to-many birds. 110 flights were recorded during FF and 38 during VPs, amounting to an estimated total of 15 hours and 30 minutes of Carnaby's observations. The number of flight records per day of sampling are shown in Figure 3-1. Seven flights of Carnaby's were recorded at CVP02 through 34 records. The largest group recorded from CVP02 was of 12 birds and the highest flight was 30 m following a "vortexing" event. Carnaby's were not recorded on CVP01.

Surveyors on FF covered a large area when searching for Carnaby's and together with the VP sampling, the resultant data are considered a good representation of Carnaby's presence and distribution in the area.

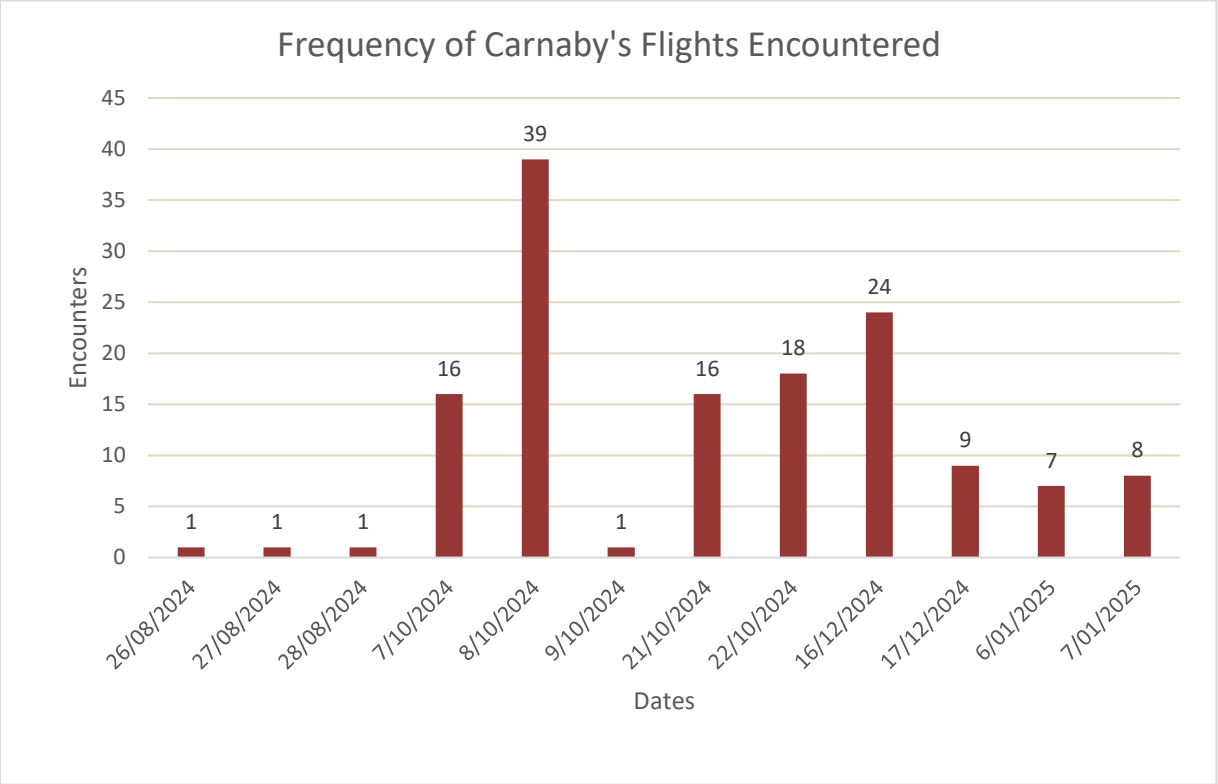

Figure 3-1. Plot of Carnaby's flights against date. This has not been adjusted to account for sampling effort. It is noted however, that during the winter and early spring, Carnaby's were easier to find and occurred in larger flocks. Adverse weather on 9th October, prevented formal sampling from occurring, hence only one opportunistic record.

3.3.1 Distribution

All records of Carnaby's taken on VP, FF or opportunistically are plotted in Figure 3-2 and displayed according to group size. Average group size was six and maximum was of 52 birds. Carnaby's data recorded from the control site CVP02 are plotted against group size in Figure 3-3.

Most of these records were obtained during FF and on VPs 01, 02 and 05. One sighting was detected from VP04, while VP03 had none. Opportunistic sightings also accounted for a number of records. The

majority of sightings were located in the lower landscape along the eastern boundary, with occasional forays of small groups across higher ground in the south and centre in particular. The aggregation of sightings adjacent to VP01 in the south saw several groups of Carnaby's take advantage of the Banksia heath in that area, where they were observed feeding on *Banksia sessillis* in particular.

Carnaby's were recorded on both ARUs (see Table 3-2) with more records taken on the southern ARU than in the central Project Area. This is not surprising since Carnaby's were detected fairly regularly at VP01, whereas none were detected on VP03 nearby where ARU31 was deployed. ARU31 was within 600 m of VP03 indicating that Carnaby's visit this area despite having no formal sightings during VP. Most of the acoustic records of Carnaby's were obtained during mid to late morning and late afternoon. Batteries in ARU33 failed prematurely and did not return data for either December or January.

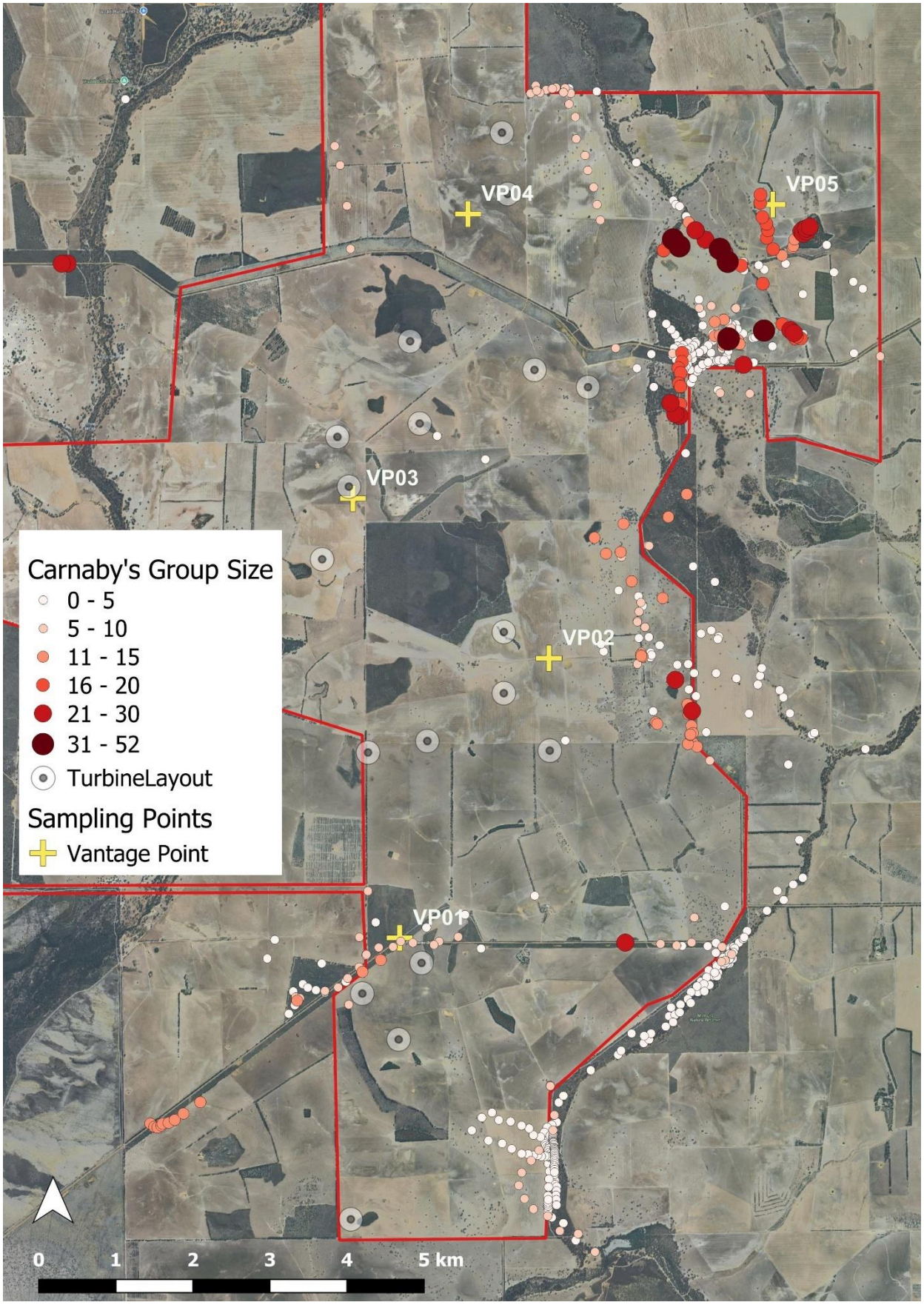

Figure 3-2. Carnaby's data taken throughout the survey programme (VP, FF and opportunistic) plotted against group size.

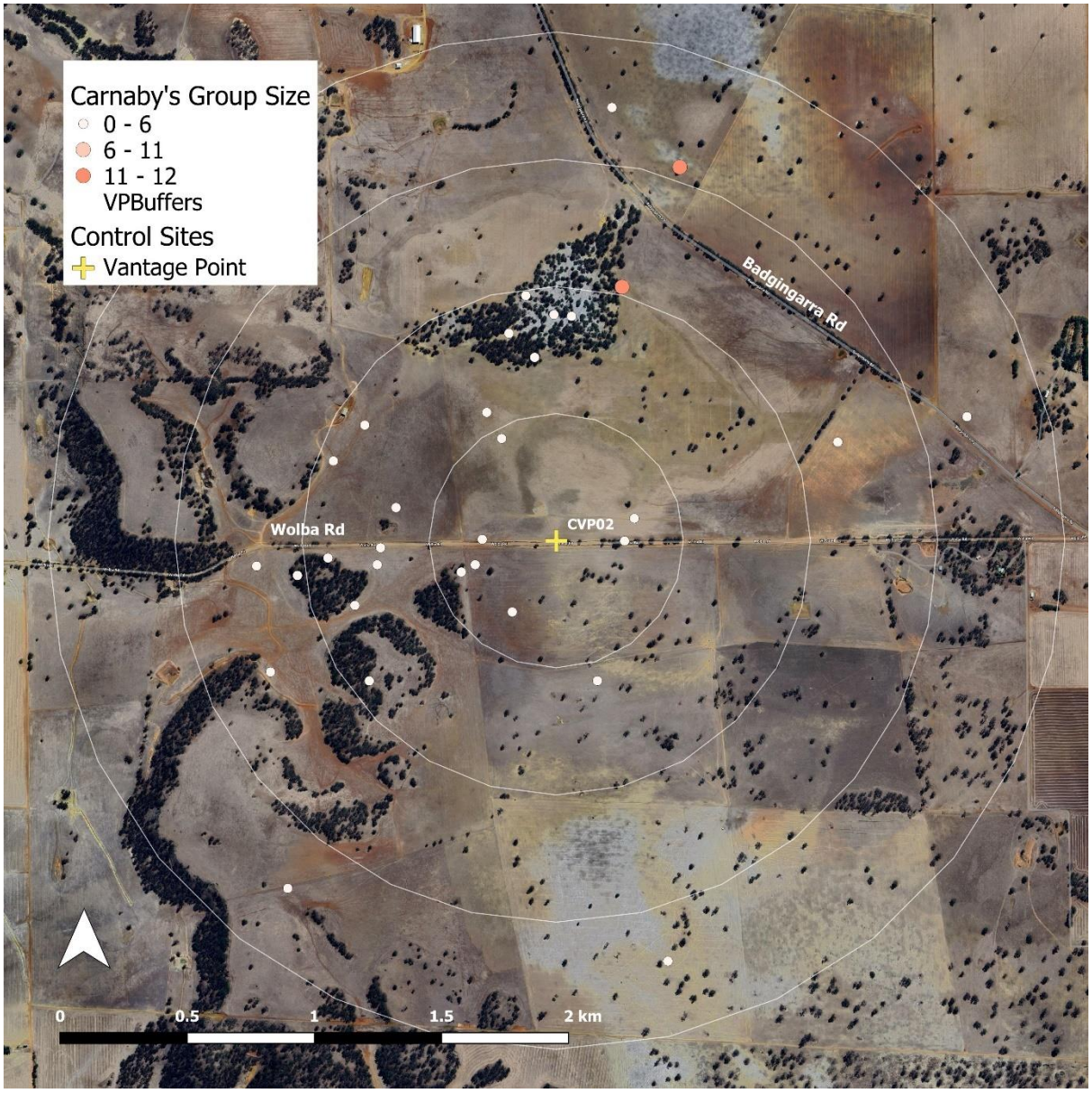

Figure 3-3. Carnaby's data collecting during sampling at CVP02 (control site). The group of 12 Carnaby's to the north was of a vortexing event of up to 30 m height following a Wedge-tailed Eagle passing overhead.

3.3.2 Habitat

Carnaby's were observed foraging and feeding at various locations across the Project Area throughout the survey programme. Foraging chew-marks on Hakea, Banksia, Marri and Pines consistent with Carnaby's were also recovered and plotted in Figure 3-4. Banksia heath and Marri woodland was frequently targeted by Carnaby's, but a substantial amount of foraging was observed in cropped paddocks of Canola and Lupin, and on Wild Radish as weed species. Birds were often observed on the perimeter of paddocks (see Plate 3-1), often within easy reach of freshwater, especially in the north-east part of the Project Area. On several occasions, they were also observed far within paddocks as a mixed flock with Western Corellas (*Cacatua pastinator*). Flocks were seen using perches in Dwutta, Banksia and exotic eucalypts while foraying into the paddocks. On several occasions, Carnaby's were observed feeding and roosting in pine trees in the south and north of the Project Area.

Plate 3-1. Group of 16 Carnaby's observed foraging on the perimeter of a crop of Canola in the north-eastern roost area. A field dam was located 50 m away and birds would take turns roosting on the fencing and foraging in the paddock.

Evidence for night roosts was recorded at six separate locations on or near the Project Area. These are plotted in Figure 3-4. These were defined by the presence of Carnaby's flocks active at dusk, and in the same location the following morning around sunrise. Areas separated by more than 500 m were considered separate roosts. Maximum numbers observed at each roost are shown in Figure 3-4 with the largest roost of 52 birds being in the north. Trees used for roosting would change between nights and flocks congregating towards dusk were highly dynamic and often very vocal. Flocks were observed splitting and regrouping several times and moving often several hundred metres deep into twilight. Roosts were considered as areas and not individual trees. Roosts lying in or adjacent to the eastern boundary of the Project Area were confirmed active on every campaign. The roost at Waddi Bush Resort (north-western) was detected during one night only through the campaigns despite surveyors using this as a base. The remaining roosts were not checked on every visit. Carnaby's recorded at VP04 in October were observed late in the afternoon flying towards Mullering Brook and, therefore, a roost to the north of Waddi Bush Resort is suspected. Separate groups of Carnaby's were recorded simultaneously using the three roosts along the eastern boundary of the Project Area on one evening. From these data, it remains unclear whether individual birds show fidelity to specific roosts or whether they move readily between roosts over different nights or during each season.

Nesting was observed in one Wandoo on Minyulo Brook (refer Figure 3-4) and a fledgling seen. Importantly, this was despite a pair of Western Corellas observed frequently inspecting the active

nesting hollow throughout the occupancy by Carnaby's and being highly vocal when Carnaby's flew to or away from the nest. Of note was that the head of the female Carnaby's was virtually bare of feathers. Whether this was common or caused by rubbing against the tree or through harassment from the Corellas remains unclear. The observation of Corellas harassing Carnaby's at nesting sites was consistent with reports from local farmers. Several Wandoo and Marri trees with chewed hollows consistent with nesting Black-Cockatoos were recorded at several locations along the Minyulo Brook and in woodland north of Waddi Road.

Plate 3-2. Confirmed Carnaby's nest with parent inside tree hollow on 7th October 2024. Western Corellas were observed on several occasions harassing parent birds. Parents were observed feeding a young bird at the same location later in October.

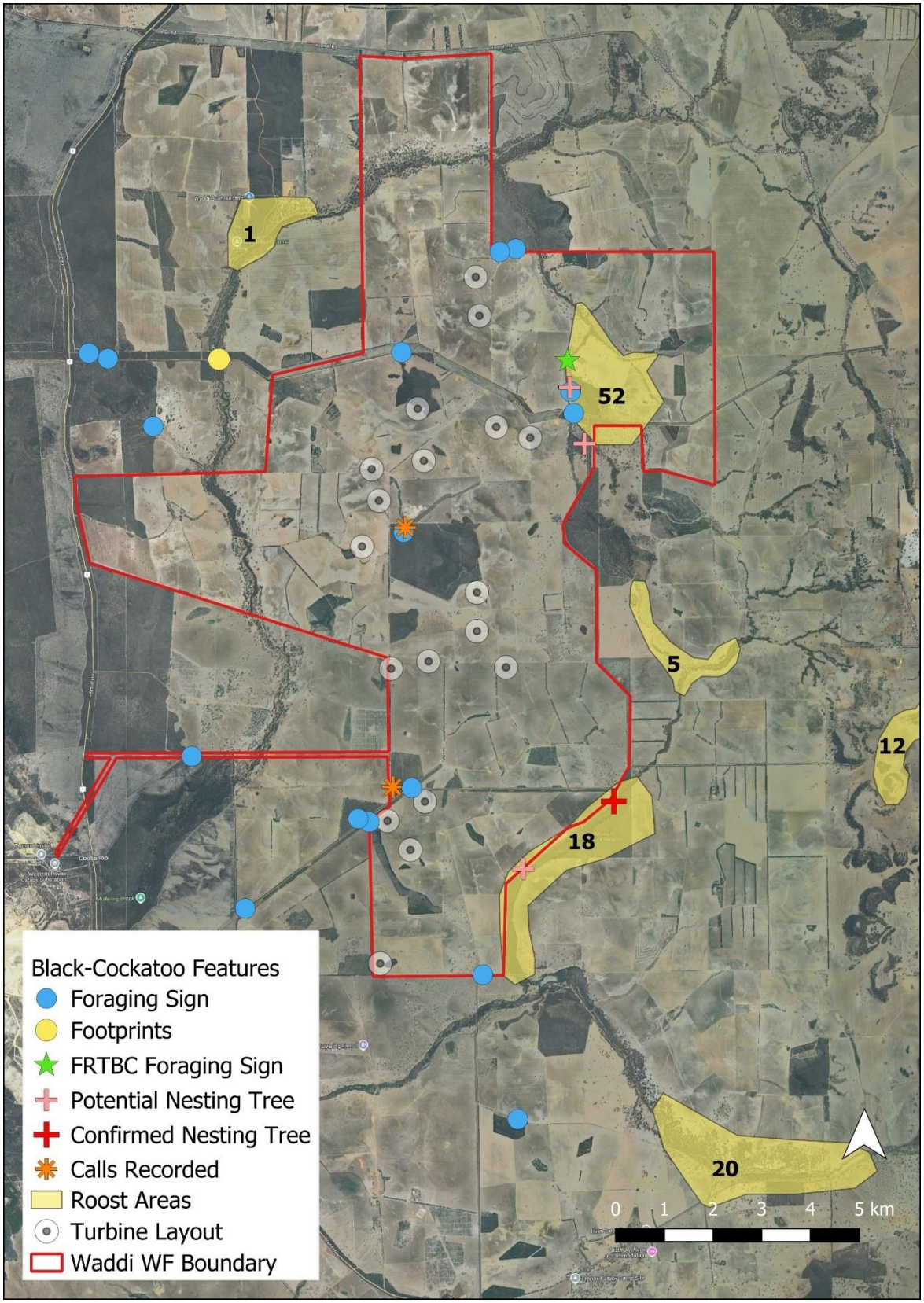

Figure 3-4. Signs and habitat features of Black-Cockatoos recorded throughout the survey programme. Numbers allocated to roost areas are the approximate maximum number of birds observed in each roost at dusk. Note the one foraging sign from Forest Red-tailed Black-Cockatoo (FRTBC) in north.

3.3.3 Behaviours and Flight Activities

The largest flock recorded was of 52 birds, which is small compared with other areas in which the authors have observed Carnaby's. Flocks of 20-50 were seen regularly during the winter and early spring campaigns. Group size declined through December and into January when most observations were of 12 birds or fewer, with only one record of a group of 22 birds. The flocking behaviour was highly dynamic with birds from small to large flocks joining and leaving throughout the day.

Throughout observations, Carnaby's spent the majority of their time roosting and foraging, either on the ground or in vegetation. This included individual birds to the largest flocks. When foraging and roosting in paddocks or native vegetation, groups would slowly move through the vegetation by individual birds taking turns to leapfrog those birds that were perched or on the ground. Flights were often meandering, but direct flight was observed occasionally in birds transiting larger distances and this defined the majority of flights above 30 m.

Data on flight activities were analysed and adjusted to take account of the number of birds in each record, and these are presented in Figure 3-5 as "bird-hours" for each height band. This graphic demonstrates that Carnaby's seldom spend much time above 18 m of elevation, which was the original lower limit of the area swept by the rotor blades. Flights below 18 m comprised 98.34% of all bird time recorded. Only 1.66% of Carnaby's time was above 18 m. Conversely, flights above 44 m (the revised height of the lower swept path), comprised 0.13% of the recorded bird time. As discussed above, on one occasion only were Carnaby's observed flying as high as 25 m over higher ground, and this involved a group of six birds adjacent to VP04. While there was also a cluster of flights observed around VP01, which is also on relatively high ground, they were never recorded higher than 10 m. The highest that Carnaby's were observed was 50 m on four separate occasions and each time they were of single birds.

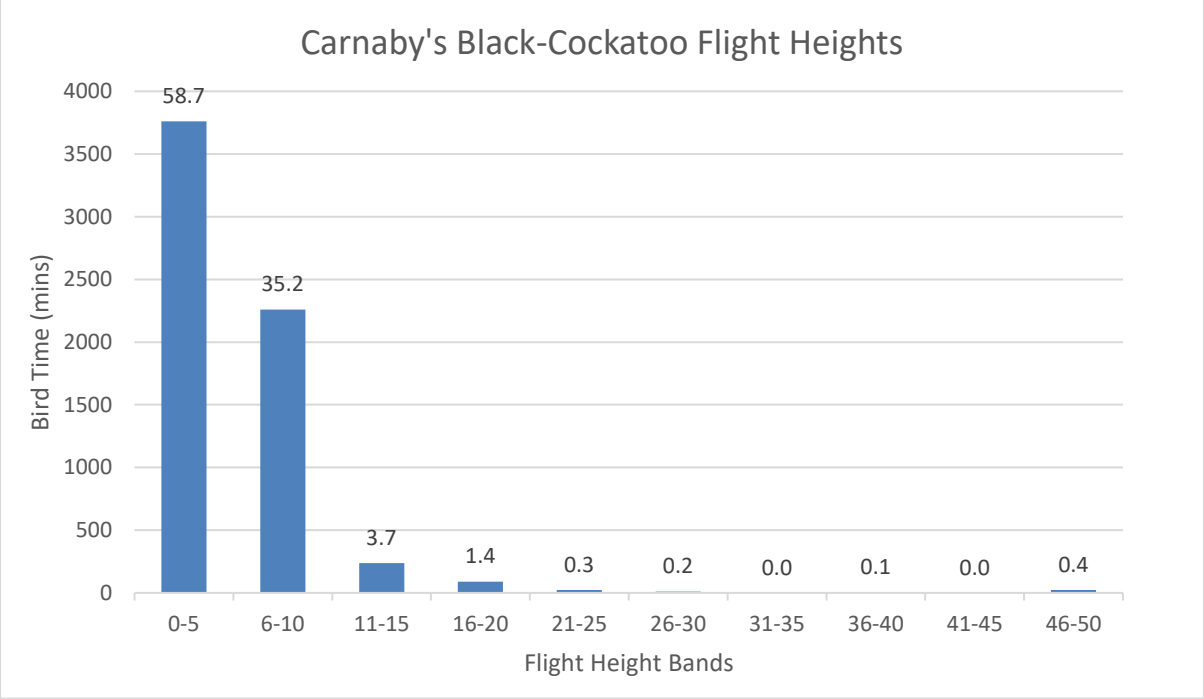

Figure 3-5. Recorded heights of Carnaby's adjusted for group size acquired from VP, FF and Opportunistic data. Percentage of flight records (N = 145) indicated for each column.

Table 3-3. Mean bird heights against group size for each record (note that this is not the same as each flight which may have several different heights as bird ascend or descend). Note that the number of records that describe each flight is somewhat arbitrary; some flights were described by many records because flight heights or direction changed frequently, while others were described with few when compared with the distance or time over which the record occurred.

Group size	No Records	Height Range (m)	Mean Height (m)
1	162	0-50	13.0
2	137	0-30	8.7
3	17	0-30	7.9
4-5	73	0-20	4.4
6-10	109	0-25	6.4
11-20	86	0-16	6.3
21-52	34	0-25	8.1

Vortexing was observed three times during the campaigns on Waddi Wind Farm. This is a phenomenon observed occasionally elsewhere and often in response to disturbance. The first occasion was observed on 7th October 2024 of 20 Carnaby's and 12 Western Corellas. This mixed flock was being recorded during FF feeding on the ground in a paddock, and flight was triggered by the close overhead pass of a crop-dusting aircraft. While the Corellas reached a height of around 18 m, the highest Carnaby's was estimated at around 12 m. Once the aircraft had passed, the birds settled back in the paddock and continued to feed. The entire event took around 30 seconds. An excerpt from a video of this event is shown in Plate 3-3. This event took place between VP02 and Mullering Road. The second vortex occurred during a watch on VP05 on 22nd October 2024. A group of 25 roosting Carnaby's was being monitored to the S-E in pine trees, when a group of Corellas passed close by. The Carnaby's responded and flew upwards in a circular fashion to a maximum height of 25 m. This event lasted just under a minute. The third vortexing event occurred on 17th December 2024 and was observed from the control site CVP02. A group of 12 Carnaby's was spotted spiralling upwards, from under a Wedge-tailed Eagle that was being followed by the observer. The group rose to around 30 m very briefly before descending to a straight flight of around 10 m height.

Plate 3-3. Vortexing mixed group of 20 Carnaby's and 12 Western Corellas, apparently flushed by an aircraft flying low overhead. The maximum height of birds was estimated to be 18 m for Corellas and 12 m for Carnaby's.

Individual data points recorded for each flight during VP or FF were joined to demonstrate flight movements, and these are plotted according to flight height in Figure 3-6. While this strongly indicates distinct concentrations of bird movements, it must also be acknowledged that they are not isolated and, by necessity, birds would also have moved between certain of these areas but this was not captured in the sampling. Many observations were of birds moving along and over native vegetation, but there were also records of birds flying across paddocks. A typical observation was of a group of six birds foraging in kwongan and a line of pine trees on the northern edge of the Project Area in the afternoon, and then just before sunset all flying low (<5m) across paddocks and eventually disappearing over a ridge. It was later confirmed that they had been heading towards a regular roost site.

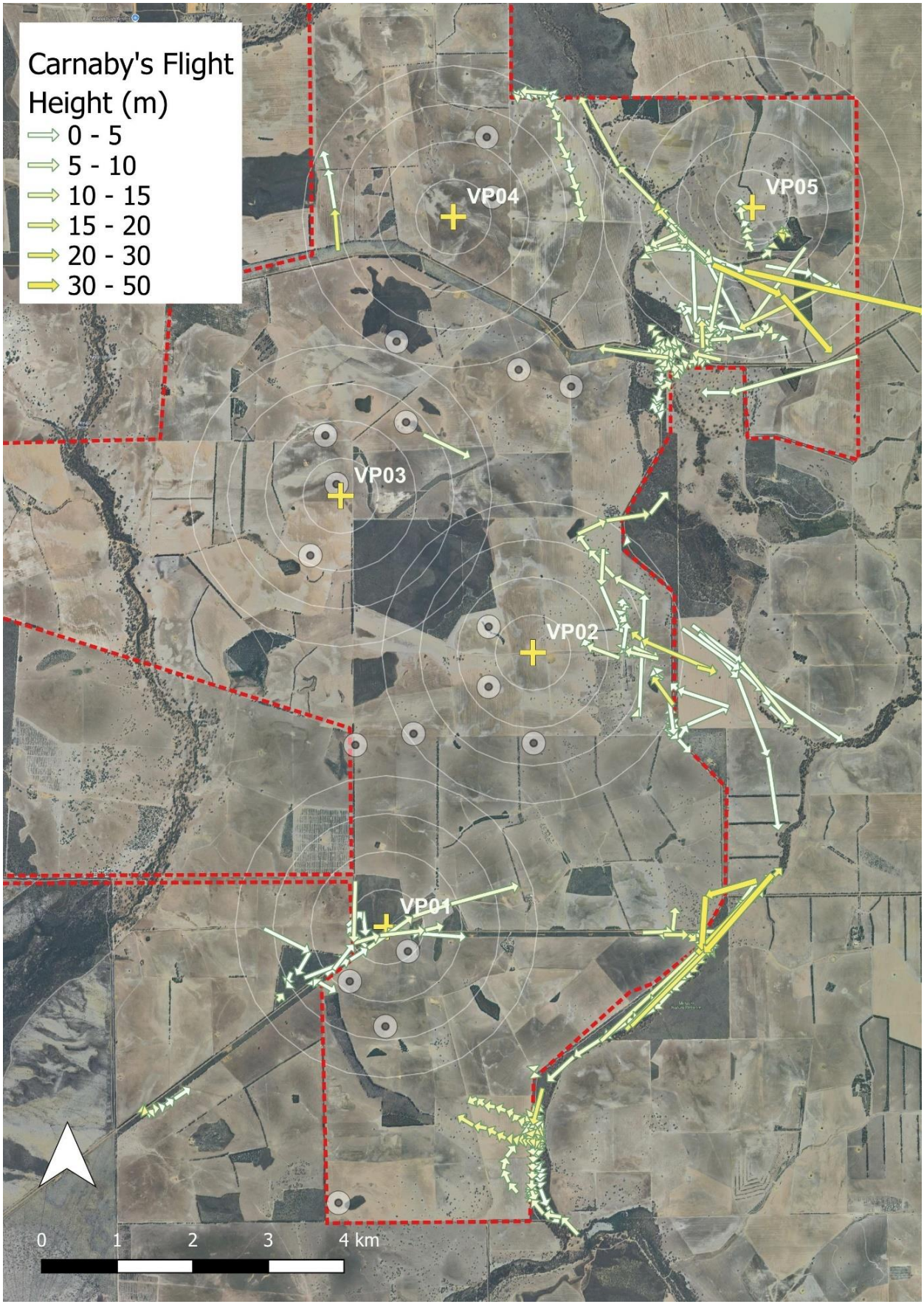

Figure 3-6. Flight lines for each group of Carnaby's recorded showing flight height and general distribution.

3.4 Collision Risk Modelling

It is routine during wind farm impact assessment to seek to utilise CRM to estimate the number of birds of a conservation significant species that may collide with the turbine blades. One of the objectives of the VP sampling was to generate bird density estimates over space and time (otherwise known as flux) that drives CRM. In addition, the FF sampling helps inform CRM by providing a more robust flight height profile. Generation of robust estimates of annual mortality through collision, requires a reasonable number of flights of target bird species within the turbine array and within the RSA. The extensive sampling across the Project Area recorded no flights of Carnaby's that meet these criteria and therefore CRM cannot be performed. As a result, the risk to Carnaby's from colliding with the turbine blades can only be defined qualitatively and is low to negligible.

In addition to the risk of Carnaby's colliding with turbines, there is also the possibility that the export cables (in form of overhead transmission lines) could present a risk of injury through collision with cables or tower, or through electrocution. While these threats may have real potential and electrocution of Black-Cockatoos has been recorded (Perth Zoo 2017; Western Power 2025), collision with overhead cables or electrocution are not identified as a threat to Carnaby's in any of the formal conservation texts (DAWE 2022; DCCEEW 2025; DPaW 2013). Perth Zoo (2017) acknowledges that discovery of electrocuted black-cockatoos is rare. These risks are therefore considered to have a very low likelihood of occurrence. Carnaby's behaviour is thought to help them avoid the risk of collision as they have been observed avoiding turbines and road traffic (M. Bamford personal observation). They also regularly perch on fence posts and wires (see 3-1), so are aware of and capable of distinguishing cables. Overhead cables were present in roosting areas established during this survey, and across which birds flew during poor light of dusk, and seem very aware of the man-made features in the landscape. Carnaby's were not recorded perching on overhead transmission cables, towers or poles during this survey on several similar projects in their range. However, it may take some time for the birds to acclimatise to new structures in the landscape and to learn to avoid them as a threat. However, the export transmission route traverses an area in which Carnaby's were only recorded on a couple of occasions and doesn't appear to be in an area highly trafficked by Carnaby's.

Together, the behavioural adaptability of Carnaby's and the location of the export transmission route, is unlikely to cause more than a negligible to low risk to Carnaby's.

3.5 Population Viability Analysis for Carnaby's Black-Cockatoo

The purpose of population viability analysis (PVA) is to assess the risks from a given predicted impact on a population or sub-population of a species of interest, while taking into account all other key threats (Chaudhary and Oli 2019). Through the PVA process, the critical thresholds of losses can be estimated to examine what the losses from the wind farm would mean for the wider population viability.

Data acquired throughout the survey programmes supporting the Waddi Wind Farm and other surveys being conducted by the authors that focus on Carnaby's Black-Cockatoos, have shown that Carnaby's rarely fly high enough to risk being struck by the rotor blades. This has been especially so with the survey programme described in this report, having acquired a large data set that focusses on the flight behaviours of Carnaby's. Furthermore, operational risk from collision with turbine blades on Carnaby's has also been shown to be negligible through the ongoing monitoring of operational wind farms in the

region (Ecoscape 2018). Since PVA is driven by defined losses from a given stressor or stressors, only a partial assessment can be undertaken here that focuses only on losses from collision risk and not to the large-scale decline of quality foraging habitat or loss of nesting hollows which is beyond the influence of the Proponent or the Waddi Wind Farm Project. The following offers a discussion on the various factors that affect the population of birds that use the Waddi Wind Farm Project Area and their likely exposure to losses that may affect its ongoing viability.

It is essential however, that protection of the wider critical habitat on which Carnaby's relies is of paramount importance if this species is to survive. Operational monitoring on other wind farms in the region have shown wind turbines to be relatively benign for Carnaby's, but may have the potential to deter individuals from using the area within a wind turbine array.

The DCCEEW does not prescribe a procedure for PVA but the following model for undertaking PVA has been used in submissions to DCCEEW (eg Grant et al 2023):

1. Conceptualise key life-history for species of interest
2. Parameterise demographic model
3. Define the population and spatial structure
4. Define PVA parameters
5. Develop PVA scenario including estimates of mortality resulting from the Waddi Wind Farm

These stages will be broadly examined in the context of information presented above. For the sakes of the Waddi Wind Farm development, this must be limited to collision risk and displacement.

3.5.1 Key Life-history and Demographic Parameters

Carnaby's are typical of large parrot species in having a relatively long life-expectancy of up to 40-50 years in the wild with a generation period of approximately 15 years. Sexual maturity occurs around four years of age but breeding has been observed in females as young as three years of age. Site fidelity for females with the areas in which they fledged is strong and they will return to the same nesting hollows in subsequent years. Site fidelity with nesting hollows is strong but not absolute, and will occupy other hollows in the vicinity if their preferred hollows are not available. Suitable nesting hollows are possibly their most limiting ecological resource; such hollows are created in mature trees (mostly Wandoo, Salmon Gum, Marri and Jarrah) and are not commonly created. Nesting hollows only have a usable lifespan of up to 20 years. Suitable hollows must also be less that 2 km from available water and within 6-12 km of foraging habitat.

One or two eggs can be laid but generally only one chick is reared. The female incubates the eggs while the male forages for both of them. Both share the feeding once the chick is too big for the female to fit in the hollow as well. Fledglings and sub-adults maintain a close relationship with the parent birds for the first year and are seldom seen more than two or three metres from an adult when flying. This close bonding ensures the young birds are less likely to exhibit different flight behaviours than those observed during sampling. It also ensures the flight behaviours are likely passed from one generation to the next and thus the chances that future generations become more prone to collision risk is unlikely.

Similar site fidelity is shown towards roosting locations, but observations during this programme, suggest that roosting locations seem flexible within an area. Observations from other surveys identify that established roosts aren't occupied every year and the roosts occupied by Carnaby's are likely to be dependent on availability of water and foraging habitat in the surrounding landscape in any one

year. Availability of foraging habitat is affected by drought and fire, and if a suitable quantity or quality of foraging habitat is not available in any given year, Carnaby's behaviour appears flexible enough to use another roost which has preferable resources.

3.5.2 Population and Spatial Structure

Defining the population of Carnaby's using the Project Area is a difficult task. The spatial flux of birds within a certain area or group is highly dynamic with individual birds and small groups leaving and joining frequently. It cannot be said with any certainty whether a group observed at the beginning of a sampling period contains the same birds as those observed at the end. However, a relatively reliable opportunity for estimating a population exists when flocks of Carnaby's are gathering at night roosts. While roost use varied through the survey programme, the use of each roost was observed to be relatively consistent throughout each campaign. Six Carnaby's roosts were identified during the survey programme (see Figure 3-4). Based on observed flight activities, five of these were considered to be used by birds that visit the Project Area. The roost near CVP02 was not considered to be formed of birds that use the Project Area. Assuming these were all used simultaneously and were occupied by different birds, the late winter and spring population would be around 86 Carnaby's. Allowing for some underestimation of the number of birds at dusk or dawn, it is assumed the population may be as large as 100-120 individual birds. Birds observed throughout the programme included adults of both sexes, sub-adults and a fledgling, demonstrating that the full demographics of a population were present in the area.

Carnaby's are known to use different regions through the seasons. Historically, these were the Wheatbelt during the breeding season whereby nesting hollows provided by Wandoo and Salmon Gum were occupied, and the coastal plain region during the non-breeding season. Nesting resources in the wheatbelt have diminished substantially and instead, more western areas are targeted, including many locations in the Cooljarloo area as shown in Figure 1-3. Satellite tagging undertaken by Murdoch University (2024) has sown that seasonal movements may now be only a few tens of kilometres instead of the many hundreds they took historically. It is therefore fair to suggest that the 120 or so Carnaby's that use the Project Area may similarly move only several tens of kilometres between their breeding and overwintering areas. The birds recorded using the Project Area are therefore co-dependent on the area used during the non-breeding season. Maintenance of critical habitat outside the Project Area is outside of the influence of the Proponent or Project but must be factored into the conservation management of this species across its entire range.

Data acquired suggest some spatial separation of the birds using each specific roosts may exist when foraging, if only loosely. This is also supported in observations from other project areas in the region.

3.5.3 Estimates of Mortality

The construction or operation of the Waddi Wind Farm is unlikely to result in the loss of roosting or nesting locations. These critical habitat features lie at least 1 km and 2 km respectively from any single turbine. While a small amount of foraging habitat within 6-12 km of roosts or nests, is to be cleared to facilitate construction, it is insignificant compared to the area of quality foraging habitat remaining. Furthermore, an offsets plan is being sought to compensate for the small amount of foraging habitat to be lost. Foraging habitat necessarily includes the presence of Canola and Lupins crops and weed species such as Wild Radish. These non-native species are sown to seed at the time of year coinciding

with the peak breeding season of Carnaby's, and need to be factored into their viability. Provision of available drinking water is not expected to change through construction or operation of the wind farm.

Therefore, it is unlikely that these natural features will be impacted to the extent breeding, roosting or foraging opportunities are reduced as a result of the development of the wind farm.

Mortality of Carnaby's in the Project Area other than by natural causes, are likely to be from feral predators and vehicle collisions. Signs of Red Foxes were observed in the area and Cats are known to be present. Control of these feral predators would be advantageous especially since Cats have been recently observed accessing nests to take nestling black-cockatoos. Most vehicles that use the roads in the Project Area are light vehicles associated with farms. However, road trains frequent these roads on a daily basis and have been observed travelling at speed. Collision with larger vehicles is known as a cause of mortality of black-cockatoos. During both construction and operation, road vehicle speeds will need to be reduced across a large proportion of the Project Area and therefore will reduce the risk to black-cockatoos.

Only a few Carnaby's were observed over the higher ground in which turbines are to be located and none of those were within RSA. Given also their recorded propensity for avoiding turbines and absence from carcass monitoring, it is concluded that annual mortality resulting from the Wind Farm on the suggested population of 120 Carnaby's is nil.

3.5.4 Population Viability Analysis

Should all things remain equal, the viability of the population of Carnaby's that have been recorded on or in close proximity to the Project Area, is concluded to be sustainable. Many outside factors have far more influence on the viability of the Carnaby's population in this area than the Waddi Wind Farm would have through construction or operations. Of primary importance are the following factors that need to be addressed to maintain the population of Carnaby's:

- Protection of nesting areas and in particular trees and woodland in which nesting hollows form
- Invest in recruitment of trees and woodland to facilitate the future development of nesting hollows
- Provision of artificial nesting opportunities until natural woodland regeneration provides adequate nesting hollows
- Maintenance of foraging habitat
- Control of introduced feral predators (eg cats) and competing species (eg bees)
- Control of unnaturally high populations of native fauna that compete for nesting hollows (eg Western Corellas)
- Reversal of climate change in the hope that climate extremes can be avoided and help with maintenance of the native vegetation.

3.5.5 In-combination Effects

No unusual behaviour has been observed in bird movement patterns that suggest flight behaviours change when moving between seasonal roosting, foraging and breeding grounds. Since it seems their selection of roosting and foraging grounds can change depending on resource availability, flight patterns through the regional landscape will likewise change. Because of these varied patterns

through the landscape, flight pathways are unlikely to exist and instead Carnaby's exhibit a diffuse and fairly random use of the airspace.

It is not possible to predict whether Carnaby's occupy or transit through other wind farms in the region or further afield. However, considering that they exhibit similar behaviours wherever they have been studied and have been recorded actively avoiding individual turbines, it is concluded likely that they are at low risk of mortality through collision with turbine blades. Reduced abundance has been detected during one wind farm monitoring programme, but given the highly varied use of specific areas through and between seasons, it is not possible to determine whether this is a result of the presence of the wind farm or background. At this time, it is not possible to identify whether Carnaby's would be impacted by the combined effects of Waddi Wind Farm and that of the others in the region.

3.6 Fork-tailed Swifts

This species only visits Australia between October and April and therefore were potentially present during the field campaigns in late October, December and January and during a short site visit in March 2025. Fork-tailed Swifts were not encountered during any of the VP or FF campaigns and have not been detected in three decades of bi-annual surveys at the nearby Cooljarloo Mineral Sands Mine. During the December field campaign, a storm-front was observed to the north-east of the project area, and therefore conditions were considered conducive for this species. Further, none was recorded during a brief visit to the western boundary of the Project Area in March 2025 during a storm event. Acoustic data obtained over 19 days of two ARUs deployed between October and January did not contain any recordings of Fork-tailed Swifts.

It can be concluded that Fork-tailed Swifts are likely to occur very infrequently over the Project Area. The paucity of data is such that the frequency and abundance of the birds cannot be predicted.

4 Discussion and Conclusions

Carnaby's Black-Cockatoos were encountered during all surveys on Waddi Wind Farm between August 2024 and January 2025. The maximum group size was only 52 birds and was relatively low compared to 300 birds in a single flock near Cooljarloo, up to 300 near Badgingarra, and 400 near Ledge Point for the same period. However, the total number of birds using the area throughout the survey programme was estimated to be up to 120 individual birds. It is therefore considered that the Project Area has a low to moderate level of Carnaby's abundance and activities. The three methods used to sample Carnaby's returned a large amount of data on behaviours and flight height. Flight behaviours recorded were considered representative of Carnaby's during the late winter, spring and early summer, and included the entire breeding season. Observations were consistent with the authors' experience on other projects in the region. No Fork-tailed Swifts were encountered or recorded acoustically throughout the survey or during three decades of sampling at a site nearby, and the presence of this species is considered highly unlikely.

Activities observed included foraging, roosting, transiting and nesting, with one pair successfully raising a chick out of the nest. It is not feasible to ascertain with the observations obtained whether any of the birds were transiting between breeding grounds and non-breeding grounds as is documented for this species. The 2024 breeding season was reported to either be depressed or late (Ron Johnson pers. comm. 2024). The principal cause of this was considered to be failure in flowering food plant species caused by hot temperatures and prolonged drought in the summer of 2023/2024. Throughout the sampling period in the Project Area, pines and Banksias in particular were observed dying or dropping leaves, and extremely few Banksias had inflorescences from the 2024 flowering season. In other years therefore, more nesting behaviour may have been observed, but this is unlikely to significantly alter conclusions about the anticipated impact of the wind farm on the species. Intriguingly, the back of the head of the nesting female was bare of feathers and the nesting tree was frequently visited by noisy Western Corellas thought to be harassing the nesting pair. Uncommonly observed behaviour included a flight pattern dubbed as "vortexing" whereby birds spiral upwards in response to disturbance; this has been observed in response to raptors (at other sites), and in response to other birds and human activities.

Based on the flight direction before birds were lost from view, and signs of Carnaby's presence (eg foraging, footprints etc), the following airspace was seen to be used by Carnaby's on a regular basis:

- South-west of VP01 broadly along Mullering Road
- VP01 east to the Minyulo Brook Reserve
- Between and around the three roosting locations along the eastern boundary

Several birds were also observed flying east and west along Waddi Road but this appeared to be used less frequently than the above. At no time did Carnaby's follow any defined route that could be considered a "flight pathway". Even along short sections of Mullering Road or Minyulo Brook where birds were observed on occasion to follow the linear features, they could be seen to break away from these routes at any time and fly perpendicular or even turn around. The term 'flight pathway' is used in Australian guidance and applies to migration routes or transit routes between fixed habitat features used regularly by a great many birds. At least in the current project area, Carnaby's did not appear to have the luxury of transiting routinely from a specific roost to a specific foraging ground to define a flight pathway.

The data demonstrate a low to moderate level of Carnaby's activities in the Project Area displaying all seasonal/life stages expected during the sampling period. The encounters declined as the programme progressed into summer and it is thought many of the Carnaby's moved to areas in which they over-winter. The authors have observed similar declines elsewhere and, conversely, have observed increases at other locations in the summer and autumn. It is not known where the birds from the Project Area have moved to, but a bird tagged at Coomalo breeding area in the spring was observed to move approximately 33 km southeast to a roost just south of Badgingarra (Murdoch University 2024). This suggests that since the wholesale clearance of woodlands in the Wheatbelt, regional movements may not be as extensive as they once were. It is not possible to differentiate local birds from those transiting between breeding and over-wintering grounds. However, none of the flight activities observed on the Waddi Wind Farm or other similar projects, during late spring or summer have given any indication that the flight heights and behaviours change. The one significant seasonal behaviour outside the sampling period was the autumn roosting, which would be outside the sampling period.

The original proposal of an RSA of 18-180 m above ground level would have placed 1.9% of Carnaby's in flight (adjusted for numbers in each group) at risk of flying at the same height as the turbine blades. Because of this level of activity and flight heights of up to 50 m were recorded (albeit over lower ground and outside the turbine array), the Proponent has sought to change the original RSA to a minimum of 44 m above ground level. This reduces the Carnaby's at risk from 1.9% to 0.13% of birds in flight.

Factors justifying 40-50 m as the minimum height needed to eliminate the vast majority of risk to Carnaby's were:

III. only four flights were recorded of single birds flying at 40 m or above comprising 0.13% of the total bird/time, and these were in the lower areas of the landscape
IV. supported by observations on other projects whereby Carnaby's are very seldom seen above 35-40 m.

Furthermore, raising the lower height of the RSA to 40-50 m will also help reduce casualties of other birds and bats; a difference of 20-30 m is likely to lead to substantial reductions in casualties.

Collision Risk Modelling (CRM) was not feasible with 1.9% of flying birds in the RSA and with only one of those within the turbine array (adjacent VP04). On elevating the RSA to a minimum of 44 m, no data were acquired to drive CRM. Furthermore, given the extremely few flights over 44 m and the authors' experience on similar projects, increase sampling effort would not be expected to change that. However, one factor used to inform CRM is how birds of a given species are able to avoid turbine blades and this is discussed below.

Monitoring activities on Yandin and Badgingarra Wind Farms in the same region reported a mixed response from Carnaby's Black-Cockatoo numbers during operations compared with baseline abundance, between impact sites and control sites, and between years, but Carnaby's were still detected within the turbine arrays. Even though Carnaby's were using the airspace within the wind farms no Carnaby's were found during carcass searches. Yandin Wind Farm has a lower RSA of approximately 27 m while Badgingarra Wind Farm is at 18 m and are broadly compatible with Waddi Wind Farm. Observations of Carnaby's during wind farm monitoring have witnessed Carnaby's adjusting their flight heights as they approach turbines (Mike Bamford pers. obs.). Similar behaviour has been noted when a flock of Carnaby's crossed the Brand Highway, with a loose flock of about 30

bird flying up to about 10 m when crossing the highway despite the absence of traffic; this suggested that the birds were aware of the risk from traffic (Mike Bamford pers obs.). Despite this observation, Carnaby's do suffer from roadkill under at least some circumstances, notably when drinking or feeding (on spilt grain) on the roadside.

Overall, in the Waddi area and in the times of the year when surveys were undertaken, it appears that Carnaby's generally fly below the RSA when the lower height is >40 m. It also appears, from other studies, that Carnaby's may learn to avoid turbines. This strongly indicates a very low risk to Carnaby's Black-Cockatoos from the Waddi Wind Farm. The risk to the Fork-tailed Swift is negligible due to the infrequency of the species occurring in the area.

A brief examination of the viability of the population of Carnaby's in the Project Area was undertaken. It is concluded that the construction and operation of the Waddi Wind Farm, is unlikely to have any effect on the population of around 120 Carnaby's that utilise the Project Area. This assumes that the critical habitat throughout their range is maintained and even improved, since certain critical resources such as nesting hollows are decreasing in abundance.

5 Reference List

BirdLife Australia. (2023). Birdata. BirdLife Australia. https://birdata.birdlife.org.au/

BCE (2024). *Waddi Wind Farm Utilisation Survey Plan.* A report prepared for Waddi Wind Farm Pty Ltd.

Boehm, E. F. (1962). Some Habits of the Fork-tailed Swift. *Emu - Austral Ornithology*. 61(4) pp. 281-282.

Chaudhary, V. and Oli, M. K. (2019). A critical appraisal of population viability analysis. *Conservation Biology.* Vol 34 No. 1, pp 26-40.

DAWE (2022). *Referral guideline for 3 WA threatened black cockatoo species.*

DBCA. (2023c). Black Cockatoo Roosting Sites—Buffered (DBCA-064). Department of Biodiversity, Conservation and Attractions. https://catalogue.data.wa.gov.au/dataset/black-cockatoo-roosting-sites-buffered

DCCEEW (2024). *Onshore Wind Farm Guidance. Best practice approaches when seeking approval under Australia's national environment law*.

DCCEEW. (2025a). Zanda latirostris - Carnaby's Black Cockatoo, Short-billed Black-cockatoo in Species Profile and Threats Database. Zanda latirostris — Carnaby's Black Cockatoo, Short-billed Black-cockatoo

DCCEEW. (2025b). Listed Key Threatening Processes. EPBC Listed Key Threatening Processes

DCCEEW (2025c). The Threatened Species Action Plan, Carnaby's Cockatoo. in Carnaby's Cockatoo - DCCEEW

DCCEEW. (2025d). Apus pacificus in Species Profile and Threats Database. Apus pacificus — Fork-tailed Swift

DEC (2008). *Forest Black Cockatoo (Baudin's Cockatoo* Calyptorhynchus baundinii *and Forest Red-tailed Black Cockatoo* Calyptorhynchus banksii naso) Recovery Plan.

DEWHA (2009). *Matters of National Environmental Significant. Significant Impact Guidelines 1.1* - Environment Protection and Biodiversity Conservation Act 1999.

DotE. (2013). *Matters of National Environmental Significance. Significant impact guidelines 1.1.* Environment Protection and Biodiversity Conservation Act 1999. Department of the Environment.

DPaW (2013). *Carnaby's Cockatoo (*Calyptorhynchus latirostris*) Recovery Plan*. Western Australian Wildlife Management Program No. 52.

DSEWPaC (2012). *EPBC Act referral guidelines for three threatened black cockatoo species: Carnaby's cockatoo (endangered)* Calyptorhynchus latirostris*, Baudin's cockatoo (vulnerable)* Calyptorhynchus baudinii*, Forest red-tailed black cockatoo (vulnerable)* Calyptorhynchus banksii naso*.* Department of Sustainability, Environment, Water, Population and Communities

DSEWPaC (2013). *Actions on, or impacting upon, Commonwealth land, and actions by Commonwealth agencies. Significant impact guidelines 1.2.* Environment Protection and Biodiversity Conservation Act 1999. Department of Sustainability, Environment, Water, Population and Communities.

Ecologia Environment (2016). *Waddi Wind Farm proposed action – Cataby Supplementary Flora, vegetation and Fauna Survey*.

Ecologia Environment (2023). *Yandin Wind Farm Avian Fauna Monitoring Program. Report prepared on behalf of Alinta Energy.*

Ecologia Environment (2024). *Wind Farm Avian Fauna Monitoring Program*. A report prepared for Alinta Energy.

Ecoscape (2018). *Carnaby's Black-Cockatoo and Other Birds Year One – Operational Monitoring.* Report prepared on behalf of APA Group.

EPA. (2002). *Terrestrial Biological Surveys as an Element of Biodiversity Protection. Position Statement No. 3.* Environmental Protection Authority.

EPA. (2016). *Environmental Factor Guideline—Terrestrial Fauna.* Environmental Protection Authority. https://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/Guideline-Terrestrial-Fauna-131216_3.pdf

EPA. (2020). *Technical Guidance—Terrestrial vertebrate fauna surveys for environmental impact assessment.* Environmental Protection Authority. https://www.epa.wa.gov.au/policies-guidance/technical-guidance-terrestrial-

Garnett, S. T. and Baker, G. B. (2021). *The Action Plan for Australian Birds 2020.* CSIRO Publishing.

Grant, M. I., Moreno, D., Semmens, J. and Simpfendorfer, C. A. (2023). *Population viability analysis of the Maugean skate* Zearaja maugeana. Report prepared for DCCEEW.

Higgins P. J. ed (1999) *Handbook of Australian, New Zealand and Antarctic Birds. Volume 4: Parrots to Dollarbird*. Oxford University Press, Melbourne, Australia

IUCN (2025). Apus pacificus in IUCN Red List of Threatened Species

Johnstone R. E., Johnstone C. & Kirkby T. (2011) *Black-cockatoos on the Swan Coastal Plain*. Report prepared for the Department of Planning, Western Australia, by the Western Australian Museum, Welshpool, Western Australia.

Johnston, T. R., Stock, W. D., & Mawson, P. R. (2016). Foraging by Carnaby's Black-Cockatoo in Banksia woodland on the Swan Coastal Plain, Western Australia. *Emu*, *116*(3), 284–293.

Johnstone, R. E., & Storr, G. M. (1998). *Handbook of Western Australian birds. Volume 1: Non-passerines (Emu to Dollarbird)* (Vol. 1). Western Australian Museum.

Kabat A. P., Scott R., Kabat T. J. & Barrett G. (2012) *2011 Great Cocky Count: Population estimates and identification of roost sites for the Carnaby's Cockatoo (Calyptorhynchus latirostris)*. Report prepared for the Western Australian Department of Environment and Conservation by BirdLife Australia, Floreat, Western Australia.

Murdoch University (2024). Warren, K. and Shephard, J. (Authors). *Output 1 - Desktop analysis of clack cockatoo tracking data to show movement and site utilisation of Carnaby''s cockatoos in the Cataby Region with reference to the Waddi Wind Farm.* A letter to Peta Brunel, 12th June 2024.

Outback Ecology (2010). *Targeted Level 1 Vegetation and Flora Assessment Waddi.* Report prepared on behalf of Wind Prospect Pty Ltd.

Outback Ecology (2024). *Waddi Wind Farm Spring Flora and Vegetation Survey and Black-Cockatoo Habitat Survey*. Report prepared on behalf of Wind Prospect Pty Ltd.

Peck A., Barrett G. & Williams M. (2016) *The 2016 Great Cocky Count: A community-based survey for Carnaby's Black-Cockatoo (Calyptorhynchus latirostris) and Forest Red-tailed Black Cockatoo (Calyptorhynchus banksii naso)*. BirdLife Australia and Department of Parks and Wildlife, Perth, Western Australia.

Peck A., Barrett G. & Williams M. (2019) *The 2019 Great Cocky Count: a community-based survey for Carnaby's Black-Cockatoo (Calyptorhynchus latirostris), Baudin's Black-Cockatoo (Calyptorhynchus baudinii) and Forest Red-tailed Black-Cockatoo (Calyptorhynchus banksii naso)*. BirdLife Australia, Perth, Western Australia.

Perth Zoo (2017). Website: Perth Zoo Vets Give Injured Cockatoo New Wings | Perth Zoo, accessed on 6/04/2025.

RPS (2010). *Avifauna Assessment Proposed Wind Farm Development Dandaragan Shire.* Report prepared on behalf of Wind Prospect Pty Ltd.

RPS (2014). *Fauna Assessment, Waddi Wind Farm.* Report prepared on behalf of Wind Prospect Pty Ltd.

RPS (2023). *Reconnaissance flora and vegetation assessment, Waddi Wind Farm.* Report prepared on behalf of Waddi Wind Farm Pty Ltd.

RPS (2025). *Preliminary Documentation Waddi Wind Farm (EPBC 2023/09639)*. Report prepared on behalf of Waddi Wind Farm Pty Ltd.

Saunders D. A. (1974) Breeding biology of the Short-billed form of the White-tailed Black Cockatoo Calyptorhynchus baudinii latirostris (Carnaby). *Emu*.

Saunders D. A. (1979a) Distribution and taxonomy of the White-tailed and Yellow-tailed Black-Cockatoos Calyptorhynchus spp. *Emu* **79**.

Saunders D. A. (1979b) The availability of tree hollows for use as nest sites by White-tailed Black Cockatoos. *Australian Wildlife Research*.

Saunders D. A. (1980). Food and movements of the short-billed form of the White-tailed Black Cockatoo. *Australian Wildlife Research*.

Saunders D. A. (1986). Breeding season, nestling success and nestling growth in Carnaby's Black-Cockatoo, *Calyptorhynchus funereus latirostris*, over 16 years at Coomallo Creek, and a method for assessing the viability of populations in other areas. *Australian Wildlife Research*.

Saunders D. A., Smith G. T. & Rowley I. (1982). The availability and dimensions of tree hollows that provide nest sites for cockatoos (Psittaciformes) in Western Australia. *Australian Wildlife Research* **9** , 541–556

SNH (2017). *Recommended bird survey methods to inform impact assessment of onshore wind farms*. Scottish Natural Heritage.

Terrestrial Ecosystems (2022). *Black-cockatoo habitat assessment for the Waddi Wind Farm transmission line alignment and the nominated areas in the adjacent farmland.* Report prepared on behalf of Waddi Wind Farm Pty Ltd.

TSSC (2009) *Commonwealth Listing Advice on Calyptorhynchus banksii naso (Forest Red-tailed Black Cockatoo)*. Threatened Species Scientific Committee, Department of the Environment, Water, Heritage and the Arts, Canberra, Australian Capital Territory.

TSSC (2018) *Conservation Advice Calyptorhynchus baudinii Baudin's cockatoo*. Threatened Species Scientific Committee, Department of the Environment and Energy, Canberra, Australia. [online]. Available from: https://www.environment.gov.au/biodiversity/threatened/species/pubs/769-conservation-advice-15022018.pdf.

Western Power (2025). Website: How we're keeping WA's threatened bird species safe accessed on 06/04/2025.

Williams M. R., Yates C. J., Saunders D. A., Dawson R. & Barrett G. W. (2017) Combined demographic and resource models quantify the effects of potential land-use change on the endangered Carnaby's cockatoo (*Calyptorhynchus latirostris*). *Biological Conservation*.

Williams M. R., Yates C. J., Stock W. & Barrett G. (2016) Citizen science monitoring reveals a significant, ongoing decline of the Endangered Carnaby's black-cockatoo *Calyptorhynchus latirostris*. *Oryx* 50 , 626–635

6 Appendices

Appendix 1. Sampling schedule and sampling point locations for Vantage Point and ARUs.

Table A1-1. Point sampling (Camera, ARU, Vantage Point) locations and descriptions.

<table>
<tr><th colspan="5">ACOUSTIC RECORDING UNITS</th></tr>
<tr><td>Site Ref</td><td>ARU31</td><td>Model/Type</td><td>Titley Chorus</td><td rowspan="3">  </td></tr>
<tr><td>Eastings</td><td>359433</td><td>Northings</td><td>6615066</td></tr>
<tr><td>Elevation</td><td>211</td><td></td><td></td></tr>
<tr><td colspan="4">Description:
Placed in a Nuytsia floribunda tree, in a stand of low Kwongan heath adjacent VP03. Carnaby's had only been recorded near here opportunistically while aerial crop spraying was in operation.</td></tr>
<tr><td>Site Ref</td><td>ARU33</td><td>Model/Type</td><td>Ranger</td><td rowspan="3"></td></tr>
<tr><td>Eastings</td><td>359177</td><td>Northings</td><td>6609661</td></tr>
<tr><td>Elevation</td><td>209</td><td></td><td></td></tr>
</table>

Description:
In a dead Nuytsia floribunda tree in a stand of Kwongan heath near VP01.

VANTAGE POINTS

Site Ref	**VP01**	**Model/Type**	Vantage Point
Eastings	359542	**Northings**	6609688
Elevation	226		

Description:
In road reserve adjacent Mullering Rd. Kwongan heath with Banksia, Hakea food plants of Carnaby's. Left photo looks west and right looks east.

Site Ref	VP02	Model/Type	Vantage Point
Eastings	361479	Northings	6613317
Elevation	281		

Description:
On hill adjacent water tanks and farm track. Overlooking arable paddocks and square stand of ornamental eucalypts in valley. Some Dwutta in paddock.

Site Ref	VP03	Model/Type	Vantage Point
Eastings	358936	Northings	6615390
Elevation	252		

Description:
On a regolith outcrop on small hill overlooking canola crops to north, west and south. Grazed paddock to east and stand of Kwongan heath to south-east where ARU31 is deployed.
Left photo looks east and right looks west.

Site Ref	VP04	Model/Type	Vantage Point
Eastings	360427	Northings	6619083
Elevation	287		

Description:
In a grassed paddock to north of Waddi Rd. No livestock were present throughout. Some lupins present. Left photo looks north and right looks south.

Site Ref	VP05	Model/Type	Vantage Point
Eastings	364383	Northings	6619205
Elevation	250		

Description:
On hillside surrounded by arable crops of oats and barley. Hillside overlooking field dam and wooded creekline in valley below. Stand of ornamental eucalypts surrounds dam and there is a treeline running away to north.

Site Ref	CVP01	Model/Type	Vantage Point
Eastings	356129	Northings	6631267
Elevation	212		

Description:
Road side verge

Site Ref	CVP02	Model/Type	Vantage Point
Eastings	370170	Northings	6610236
Elevation	310		

Description:
Located 6.1 km east of the Waddi WF boundary on Wolba Rd. Harvested wheat paddock to the north and grazed paddocks to south with scattered clusters of large eucalypts. Stand of heavily grazed Wandoo woodland lies 700 m north.
Top view looks north and bottom view is looking south.

Appendix 2. Sampling schedule for Vantage Points

Table A2-1. Sampling schedule for Vantage Points.

Date	VP	Sample Type	Observer	Start Time	End Time	Duration	Hrs	Temp (Degrees)	Cloud Cover (Okta)	Wind Speed (KmH)	Wind Dir	Visibility
27/08/2024	VP01	Vantage Point	PMS	07:22:00	10:26:00	03:04:00	3.07	14	6	Strong breeze	SSW	Good
27/08/2024	VP04	Vantage Point	PMS	14:15:01	16:15:01	02:00:00	2.00	17	6	Strong breeze	SSW	Good
27/08/2024	VP03	Vantage Point	BS	07:34:00	10:37:00	03:03:00	3.05	14	6	Strong breeze	SSW	Good
7/10/2024	VP01	Vantage Point	BS	06:45:00	09:53:00	03:08:00	3.13	16-20	6-8	6-10	SSE	Good
7/10/2024	VP02	Vantage Point	BS	10:30:01	13:30:01	03:00:00	3.00	24-30	1-3	10	S	Bright with some haze
8/10/2024	VP05	Vantage Point	BS	06:37:16	09:40:00	03:02:44	3.05	22	3	14	S	Good
8/10/2024	VP03	Vantage Point	BS	12:18:45	14:25:52	02:07:07	2.12	20-25	4-6	15	S	Good
8/10/2024	VP04	Vantage Point	BS	15:00:01	17:00:01	02:00:00	2.00		3	15	SW	Bright, good
9/10/2024	CVP01	Vantage Point	BS	08:10:23	10:23:32	02:13:09	2.22	15	8	Moderate wind	S	Poor, low cloud to start with and some rain.
21/10/2024	VP04	Vantage Point	BS	14:10:01	16:01:01	01:51:00	1.85	24	4-5	Moderate	SW - SSE later	Good, bright, haze affecting mediate to long range
21/10/2024	VP05	Vantage Point	BS	08:21:01	11:22:01	03:01:00	3.02	18	3-5	Light	SSE	Bright, very good, haze in far distance
21/10/2024	VP01	Vantage Point	AR	14:00:00	17:00:00	03:00:00	3.00	20	0-4	Moderate. Strong later	SW	Clear, a little atmosphere haze
21/10/2024	VP02	Vantage Point	KC	13:59:00	16:59:00	03:00:00	3.00		1-4	Light/Moderate	West	
22/10/2024	VP01	Vantage Point	AR	8:15:00	11:13:00	02:58:00	2.97	20-22	6-6.4	Slight	S	Clear
22/10/2024	VP05	Vantage Point	AR	13:30:00	17:00:00	03:30:00	3.50	15-23	5-6	Slight/Moderate	SW	Hazy in distance
22/10/2024	VP02	Vantage Point	KC	07:30:00	10:30:00	03:00:00	3.00					
22/10/2024	VP04	Vantage Point	KC	13:37:24	16:36:42	02:59:18	2.99		2-6	Moderate. Light later	S - SW later	Some heat haze
22/10/2024	CVP02	Vantage Point	BS	07:45:20	10:41:48	02:56:28	2.94	19	6	Light	S	Light haze later in VP
6/12/2024	CVP01	Vantage Point	BS	13:18:45	16:18:51	03:00:06	3.00	18	4-5	Moderate	SW	Haze
16/12/2024	VP05	Vantage Point	BS	6:59:24	09:01:30	02:02:06	2.03	25	5	18.4	S	Good
16/12/2024	VP04	Vantage Point	BS	11:46:53	14:51:04	03:04:11	3.07	25	0.5	21	S	Bright
16/12/2024	VP03	Vantage Point	MG	14:31:11	17:39:39	03:08:28	3.14	23-26	0	Moderate. Strong later	SW	Very good, haze only affecting long distance observations
16/12/2024	VP02	Vantage Point	MG	10:51:30	13:01:37	02:10:07	2.17	25-27	1	Light/Moderate	SW	Very good, minimal dust and heat haze
16/12/2024	VP01	Vantage Point	BS	15:59:32	18:29:43	02:30:11	2.50	25	0	19.5	S	Clear, a little atmosphere haze
16/12/2024	VP01	Vantage Point	MG	07:33:29	10:05:33	02:32:04	2.53	20-24	1-6	Light/Moderate	SW	Excellent
17/12/2024	VP03	Vantage Point	BS	07:47:35	10:48:25	03:00:50	3.01	25-32	0	30-31	E - EN later	Excellent but shaken by wind, Excellent but shaken by wind later
17/12/2024	VP01	Vantage Point	BS	12:19:00	14:20:02	02:01:03	2.02	37	0	11-14	NE	Moderate low heat haze
17/12/2024	CVP02	Vantage Point	BS	15:11:46	18:10:22	02:58:36	2.98	32	0	8-18	NE	Good but some haze
20/12/2024	CVP02	Vantage Point	BS	09:41:27	12:47:48	03:06:20	3.11	28-31	0	22-30	E	Good and very little haze
20/12/2024	CVP01	Vantage Point	MG	10:00:38	13:04:43	03:04:05	3.07	26-34	0	Moderate	E	Excellent
6/01/2025	VP01	Vantage Point	AR	07:07:18	10:11:08	03:03:50	3.06	25-31.8	0	30-33	ENE	
6/01/2025	VP01	Vantage Point	AR	12:23:13	15:20:03	02:56:50	2.95	36-37.4	0	15	ENE	Hazy
6/01/2025	VP02	Vantage Point	AR	15:45:53	18:47:30	03:01:37	3.03	37.5-38		15	ESE - S later	
6/01/2025	VP02	Vantage Point	MG	07:00:01	10:02:18	03:02:17	3.04	24-32	0.5	Moderate. Strong later	E	Excellent. Distant smoke and heat haze otherwise very good later
6/01/2025	VP05	Vantage Point	MG	12:33:40	15:32:41	02:59:00	2.98	37-38	0	Moderate/Strong	E	Very good, heat and minimal smoke haze affecting distance viewing
6/01/2025	VP05	Vantage Point	MG	15:35:28	18:40:00	03:04:32	3.08	30-38	4	Moderate/Strong	E - S later	Very Good
6/01/2025	VP04	Vantage Point	AR	06:23:06	09:33:59	03:10:53	3.18	24-32		Moderate. Strong later	E	Hazy
6/01/2025	VP03	Vantage Point	AR	12:03:03	15:03:48	03:00:45	3.01	32		33	SSW	Poor, haze and smokey
6/01/2025	VP03	Vantage Point	AR	15:20:09	18:20:55	03:00:46	3.01	29-30.8		30-33	SSW	Hazy and smokey. Very poor later
6/01/2025	VP03	Vantage Point	PMS	07:08:19	10:08:57	03:00:38	3.01					
6/01/2025	VP04	Vantage Point	PMS	12:31:31	15:31:49	03:00:18	3.00					
6/01/2025	VP04	Vantage Point	PMS	15:36:03	18:33:19	02:57:16	2.95					

6/01/2025	VP05	Vantage Point	MG	15:38:22	18:40:56	03:02:34	3.04					
7/01/2025	VP05	Vantage Point	MG	06:46:58	09:51:33	03:04:35	3.08	26-30	0.5	Light. Moderate later	E - W later	Excellent
7/01/2025	VP01	Vantage Point	MG	15:30:14	18:38:27	03:08:13	3.14	24-30	0.5-1	Strong	West	Excellent through distant smoke haze
7/01/2025	VP02	Vantage Point	MG	11:28:55	14:35:25	03:06:30	3.11	30-31	0.5	Strong	West	Excellent, smoke and heat haze affecting distance visibility
10/01/2025	CVP01	Vantage Point	MG	12:03:36	15:05:48	03:02:12	3.04					

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