The 2021 and 2022 Great Cocky Counts:

A community-based survey for

Carnaby's Black-Cockatoo (*Zanda latirostris*),

Baudin's Black-Cockatoo (*Zanda baudinii*) and

Forest Red-tailed Black-Cockatoo (*Calyptorhynchus banksii naso*)

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GOVERNMENT OF WESTERN AUSTRALIA

Department of **Biodiversity, Conservation and Attractions**

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Front cover: Carnaby's Black-Cockatoos by Keith Lightbody
Back cover: Forest Red-tailed Black-Cockatoos in flight by Keith Lightbody

Alcoa Foundation

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The Great Cocky Count takes place on the country of many groups of the Noongar and Yamatji Nations. We acknowledge them as the original custodians of these lands and pay our respects to their Elders past and present. We thank them for their care of the country of *Ngoolark* (white-tailed black-cockatoo) and *Kaarak* (red-tailed black-cockatoo).

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SUMMARY

Background

- The Great Cocky Count (GCC) is an annual citizen science survey for three threatened black-cockatoos in the southwest of Western Australia (WA). Volunteers are allocated to a known or potential roost site and use a standard protocol to record the numbers of black-cockatoos arriving at the site to roost for the night.
- The 2021 and 2022 GCCs occurred on Sunday 28th March and Sunday 3rd April, respectively.
- The GCC was run consecutively from 2010 to 2019 and continued in 2021 and 2022 after a hiatus in 2020 due to Covid-19 restrictions. The 2022 GCC was the 12th GCC to take place since 2010.
- The 2021 and 2022 GCCs surveyed roost sites for Carnaby's, Baudin's and Forest Red-tailed Black-Cockatoos (FRTBCs). All are endemic to southwestern WA and listed as threatened species under State and Commonwealth legislation.
- This report builds on the substantial contribution made by previous Great Cocky Counts to our knowledge of black-cockatoos in the Greater Perth-Peel Region and regional southwest Western Australia.

Key Outcomes

- The Great Cocky Count is one of the largest citizen science surveys of its kind in Australia. Community interest is significant with over 750 registered volunteers surveying 462 sites in 2021 and over 600 registered volunteers surveying 362 sites across the southwest of WA in 2022. Total volunteer participation likely exceeded 1,200 community members in both years when taking into account unregistered family and friends.
- The minimum population count for Carnaby's Black-Cockatoo in the Greater Perth-Peel Region was 8,992 in 2021 and 11,857 in 2022. The Greater Perth-Peel Region consists of the Perth-Peel Coastal Plain, which encompasses all of the Perth-Peel metropolitan area along the Swan Coastal Plain, and the Northern Darling Scarp and Plateau, which includes the northern Jarrah-Marri Forest.
- Most (63% and 68% in 2021 and 2022 respectively) of the Carnaby's Black-Cockatoos recorded in the Perth-Peel Coastal Plain were associated with the Gnangara pine plantation, north of Perth. Since 2010, the pine plantation has supported between 28 – 73% of the Carnaby's Black-Cockatoos recorded in the Perth-Peel Coastal Plain during the non-breeding season each year, emphasising the importance of pines as both a roosting area and foraging resource during this period.
- The highest single count of Carnaby's Black-Cockatoos was 1,982 at a roost site located east of Yanchep in 2021. The highest single count of Carnaby's in 2022 was 5,032 at the same roost site. This accounted for 24% and 44% of all Carnaby's Black-Cockatoos recorded on the Perth-Peel Coastal Plain in 2021 and 2022 respectively. The same site had counts of 6,226, 5,145, 4,897 and 3,528 in the last four years and has come to be known as the 'Mega Roost'.
- The estimated change in the population of Carnaby's Black-Cockatoo in the Perth-Peel Coastal Plain indicates a decline during the early years of the GCC (2010 – 2015) with the population being approximately constant since then. However, the overall change in the estimated population of Carnaby's Black-Cockatoos on the Perth-Peel Coastal Plain between 2010 and 2022 is a decline of 25%, or an average of 2% per year.
- Trend analysis of roost counts for Carnaby's Black-Cockatoo in the Perth-Peel Coastal Plain found a significant decline in the fraction of occupied roosts over the past twelve Great Cocky Counts (2010-2022). The average size of roosting flocks is now the same as in 2010, after declining in the early years and increasing in more recent years.

- On the Perth-Peel Coastal Plain, the majority of the Carnaby's Black-Cockatoos are restricted to relatively few roost sites. For example, 55% of all the birds recorded in the 2010-2022 Great Cocky Counts were counted at just five roost sites. Three of these sites are associated with pines. Trend analysis shows that the rate of decline is similar, regardless of whether the roosts were associated with pine or not.
- The overall estimated rate of decline in the total number of white-tailed black-cockatoos (Carnaby's and Baudin's combined) on the Northern Darling Scarp is 7% per year, with significant declines in both the fraction of occupied roosts and the average size of roosting flocks.
- In contrast to recent years demonstrating an increase in FRTBC numbers in both the Greater Perth-Peel and Northern Darling Scarp and Plateau regions, analysis of the data 2014 – 2022 showed no change in population size, influenced by an extraordinarily low count of FRTBCs in both regions in 2022.
- With current population estimates of 34,000 for Carnaby's Black-Cockatoo (Saunders et al. 2021), 3,250 for Baudin's Black-Cockatoo (Johnstone et al. 2021a) and 16,800 for FRTBC (Johnstone et al. 2021b), the 2021 and 2022 GCCs recorded approximately 45% and 43% of all black-cockatoos in southwestern WA respectively.
- The Great Cocky Count is well-placed to continue monitoring black-cockatoos across the southwest, due to consistent survey protocol, high volunteer numbers and survey effort with broad geographic spread resulting in a robust, long-term dataset that is not able to be replicated in any other way.
- The Great Cocky Count is a valuable way to educate the public and raise awareness of the plight of black-cockatoos and ways in which the public can help protect the three local species.

Results for Carnaby's and Baudin's Black-Cockatoos

Perth-Peel Coastal Plain

- Volunteers surveyed 187 sites in the Perth-Peel Coastal Plain (PPCP) and counted 8,428 Carnaby's Black-Cockatoos in 2021. 132 sites were surveyed in 2022 with 11,493 Carnaby's recorded. The Perth-Peel Coastal Plain (PPCP) encompasses most of the Swan Coastal Plain between Lancelin and Waroona.
- Four of the largest ten roost sites in both the 2021 and 2022 GCCs were in the Perth-Peel Coastal Plain.
- In 2021 significant counts in the Perth-Peel Coastal Plain occurred in the Gnangara pine plantations (4,801 birds from six sites), at the Gingin town site (510), in Como (353 birds), at two sites in Yanchep (301 and 193), and in Nedlands (299), Eglington (296), Spearwood (257), Murdoch (245) and Floreat (242).
- In 2022 significant counts in the PPCP occurred in the Gnangara pine plantations (7,242 birds from five sites), Gingin (783), Dawesville (617 birds from two sites), Como (333), Nedlands (250) and Murdoch (222).

Northern Darling Scarp and Plateau

- Volunteers surveyed 115 sites in the Northern Darling Scarp and Plateau areas, which encompasses the northern Jarrah-Marri Forest between Bindoon and Waroona, and counted 1,879 white-tailed black-cockatoos in 2021. In 2022 volunteers counted at 108 sites in the region with a total of 1,213 birds recorded. Counts of white-tailed black-cockatoos in these areas include Baudin's Black-Cockatoo and Carnaby's Black-Cockatoo, of which 30% (564 and 364 in 2021 and 2022 respectively) were estimated to be Carnaby's Black-Cockatoos.
- In 2021 significant numbers of white-tailed black-cockatoo were counted in the City of Kalamunda (798 birds from 5 sites) and Shire of Mundaring (368 birds from 10 sites), with the largest single count occurring in Piesse Brook with a total of 500 birds.
- In 2022 significant numbers of white-tailed black-cockatoos were counted in the Shire of Mundaring (448 birds from 7 sites), which also had the largest single count of 187 birds recorded in Parkerville.

Regional areas

- Volunteers surveyed 160 sites in regional locations outside of the Greater Perth-Peel Region and recorded 7,466 white-tailed black-cockatoos in 2021. In 2022 volunteers surveyed 122 sites in regional areas and counted 8,571 white-tailed black-cockatoos. Counts of white-tailed black-cockatoos in forested areas may include Baudin's Black-Cockatoo and Carnaby's Black-Cockatoo.
- Five of the largest ten roost sites in the 2021 GCC and six of the largest ten roosts in the 2022 GCC were in regional areas.
- In regional areas, volunteers surveyed roosts ranging from Chapman Valley in the north, inland to Narrogin, east to Esperance, and along the south and west coasts.
- The average size of roosting flocks continue to decline in both the Albany and Esperance areas demonstrating a decline in the number of birds in both areas.
- In 2021 significant counts occurred on the northern Swan Coastal Plain (1,416 at Nilgen), in Glenlynn (655), in Balingup (555), the Shire of Esperance (824 birds across four sites), the Shire of Ravensthorpe (750 birds across two sites), the shire of Carnamah (561 birds across 3 sites), the Shire of Harvey (367 birds across four sites), the Shire of Busselton (363 birds across 5 sites) and the Shire of Dandaragan (336 birds across 3 sites).
- In 2022 significant counts occurred in the Shire of Harvey (2,182 birds across five sites), in Nilgen on the northern Swan Coastal Plain (1,510 birds), in the Shire of Bridgetown-Greenbushes (1,230 birds across two sites), the Shire of Dandaragan (1,009 birds across three sites and the Shire of Esperance (723 birds from four sites).

Results for Forest Red-tailed Black-Cockatoo (FRTBC)

- Volunteers documented 161 occupied roost sites in 2021, a 35 - 41% increase to 2018 and 2019. In 2022, volunteers documented 109 occupied roost sites, the lowest number since 2017. 48 of the sites in 2021 and 25 of the sites in 2022 had both FRTBCs and white-tailed black-cockatoos roosting.
- In 2021 occupied roosts were located in the Perth-Peel Coastal Plain (58), the Northern Darling Scarp and Plateau (63) and regional areas (40). In 2022, 34 occupied roosts were recorded in the Perth-Peel Coastal Plain, 49 were recorded on the Northern Darling Scarp and Plateau and 26 were recorded in regional areas.
- 6,692 FRTBCs were counted in 2021: 3,881 on the Perth-Peel Coastal Plain; 1,890 in the Northern Darling Scarp and Plateau, and 921 in regional areas. The total count was similar to 2018 and 2019, and up markedly on previous years.
- 2,066 FRTBCs were counted in 2022: 509 on the Perth-Peel Coastal Plain, 979 on the Northern Darling Scarp and Plateau and 578 in regional areas. The total count was the lowest count since 2016 and less than a third of the 2021 total count.
- The 2018, 2019 and 2021 GCCs recorded a large increase in the numbers of FRTBCs on the Perth-Peel Coastal Plain, up 100% on 2017, before a drop in numbers in 2022.
- In 2021 significant FRTBC roosts occurred in Floreat (728 birds across two roosts), Murdoch (382 birds), Kensington (307 birds across two roosts), Morley (302 birds across two roosts), Yokine (301 birds across two roosts), Jandabup (243 birds) and Maida Vale (210 birds).
- In 2022 significant FRTBC counts occurred in Teesdale (130 birds), Floreat (125 birds across two roosts), Mumballup (124 birds across two roosts) and Byford (108 birds).

Key Terms and Abbreviations

General terms and abbreviations

Great Cocky Count (GCC): An annual, community-based survey for black-cockatoos in Western Australia. The survey occurs at sites across the southwest of the state on a single evening between late March and mid-April each year. Volunteers are allocated to a particular *roost site* and use a standard protocol to count the numbers of black-cockatoos that arrive at the site to roost for the night. The 2021 GCC occurred on Sunday 28 March 2021, and the 2022 GCC occurred on Sunday 3 April.

DBCA: Western Australian Department of Biodiversity, Conservation and Attractions; formerly known as the Departments of Parks and Wildlife (DPaW), Environment and Conservation (DEC), and Conservation and Land Management (CALM).

FRTBC: Forest Red-tailed Black-Cockatoo, *Calyptorhynchus banksii naso*.

Roost count: A count of the number of black-cockatoos arriving at a location at dusk to roost for the night. A roost count only includes birds that remain overnight at the roost site.

White-tailed black-cockatoos (WTBC): Two white-tailed black-cockatoos (Baudin's Black-Cockatoo, *Zanda baudinii* and Carnaby's Black-Cockatoo, *Zanda latirostris*) are endemic to the southwest of WA. In areas where both species occur, volunteers record a single "white-tailed black-cockatoo" count unless they are sure which species they are.

Corrected count: For the 2021 and 2022 GCCs the proportion of Carnaby's in the Northern Darling Scarp and Plateau was set at 30% of white-tailed black-cockatoos. This is based on counts in previous years around GCC time by Tony Kirkby and known proportions at some sites. Between 2010 and 2018 the proportion of Carnaby's has consistently been between 0.2 and 0.4, therefore a decision was made to standardise the corrected count for all years at 0.3.

Berry recruitment model: A model which assumes that (1) a pair of cockatoos flying together represents an adult mated pair, (2) a group of three cockatoos flying together (i.e. a trio) represents a mated pair with the fledgling from the current or previous breeding season, and (3) the number of trios present correlates positively with breeding success for the current or previous breeding season (Berry and Owen, 2010).

Great Cocky Count roost site database: A database of known or potential roost sites for black-cockatoos, maintained jointly by Birdlife WA and DBCA.

Terms relating to roosts

Roost: An area or site with *roost trees* where black-cockatoos congregate at dusk to rest overnight.

Roost trees: All large trees (>8m height) within 1000m of the main roosting area for large roosts ($\geq$150 cockatoos) and within 500m for smaller roosts (<150 cockatoos) are considered to be *roost trees* or potential *roost trees* (Glossop *et al*. 2011).

Roost site: Any location that has been recorded in the GCC roost site database as being used by black-cockatoos. Could be used by white-tailed, FRTBCs or be a joint roost. Could be categorised as a *confirmed or unconfirmed roost*.

Confirmed roost: Any site where black-cockatoos were recorded roosting as part of the GCC. This could be a site used by white-tailed black-cockatoos only, FRTBCs only, or joint roosts, where both white-tailed and FRTBC have been recorded. Note some confirmed roosts are consistently used by black-cockatoos in every GCC, but other roosts may only be occupied periodically.

Unconfirmed roost: Sites where roosting black-cockatoos have been reported, but have not had a positive count recorded (≥1 bird) during any GCC. Note these sites may be used at other times of year, or may have only recently been added to the GCC database.

Potential site: Any area that is considered a likely roost site for black-cockatoos, based on factors such as proximity to other roosting birds, potential roost trees, feeding habitat and standing water nearby. Cockatoos have not yet been reported as roosting at these sites.

Joint roost: Any roost where a positive count (i.e. ≥1 bird roosting for the night) of both white-tailed black-cockatoos and FRTBC has been recorded in the GCC, either in the same year or different years.

New roost: An unconfirmed roost or potential site documented to be a *confirmed roost* during the most recent GCC.

Roost codes: The first three letters refer to the shire/local council; the next three to the location/suburb; R stands for roost; the code ends with three numbers (e.g. COCHAMR001 is in Cockburn, in the suburb of Hamilton Hill and was the first roost recorded in that suburb).

Terms and abbreviations relating to localities

Greater Perth-Peel Region (GPPR): This region includes the greater Perth-Peel metropolitan area (from Moore River in the north to Waroona in the south) and the northern Darling Plateau (from Bindoon in the north to Boddington in the south). The region includes parts of two IBRA (Interim Biogeographical Regionalisation for Australia) bioregions – the Jarrah Forest and Swan Coastal Plain bioregions. The Greater Perth-Peel Region coincides with the DBCA Swan Region (a DBCA administrative area).

Perth-Peel Coastal Plain (PPCP): This area comprises the coastal (and western) portions of the Greater Perth-Peel Region and encompasses most of the Swan Coastal Plain between Lancelin and Moore River south to Lake Clifton and Waroona. The Perth-Peel Coastal Plain coincides closely with the DBCA Swan Coastal District (a DBCA administrative area).

Northern Darling Scarp and Plateau (NDSP): This area comprises the eastern portions of the Greater Perth-Peel Region and encompasses the Darling Scarp and Plateau from north of Bindoon to south of Boddington. Most of this area occurs within the Jarrah (*Eucalyptus marginata*)-Marri (*Corymbia calophylla*) forest. The Northern Darling Scarp and Plateau coincides closely with the DBCA Perth Hills District (a DBCA administrative area).

Gnangara pine plantation: A pine plantation, managed by the Forest Products Commission, located north of Perth. The plantation system includes three sections: Gnangara (southern), Pinjar (middle), and Yanchep (north). At its peak, the plantation encompassed 23,000 ha of pine. The plantation system is an important feeding habitat for Carnaby's Black-Cockatoos during the non-breeding season (January – June) (Saunders 1974, 1980; Finn *et al.* 2009; Stock *et al.* 2013). The plantation currently stands at less than 6,000ha, with less than 4,000ha of remaining mature pine and approximately 2,000ha of pines planted between 2012 and 2017.

Regional areas: All locations containing black-cockatoo roosts that are outside the Greater Perth-Peel Region.

IBRA: Interim Biogeographical Regionalisation for Australia – further information is available at:

http://www.environment.gov.au/topics/land/national-reserve-system/science-maps-and-data/australias-bioregions-ibra

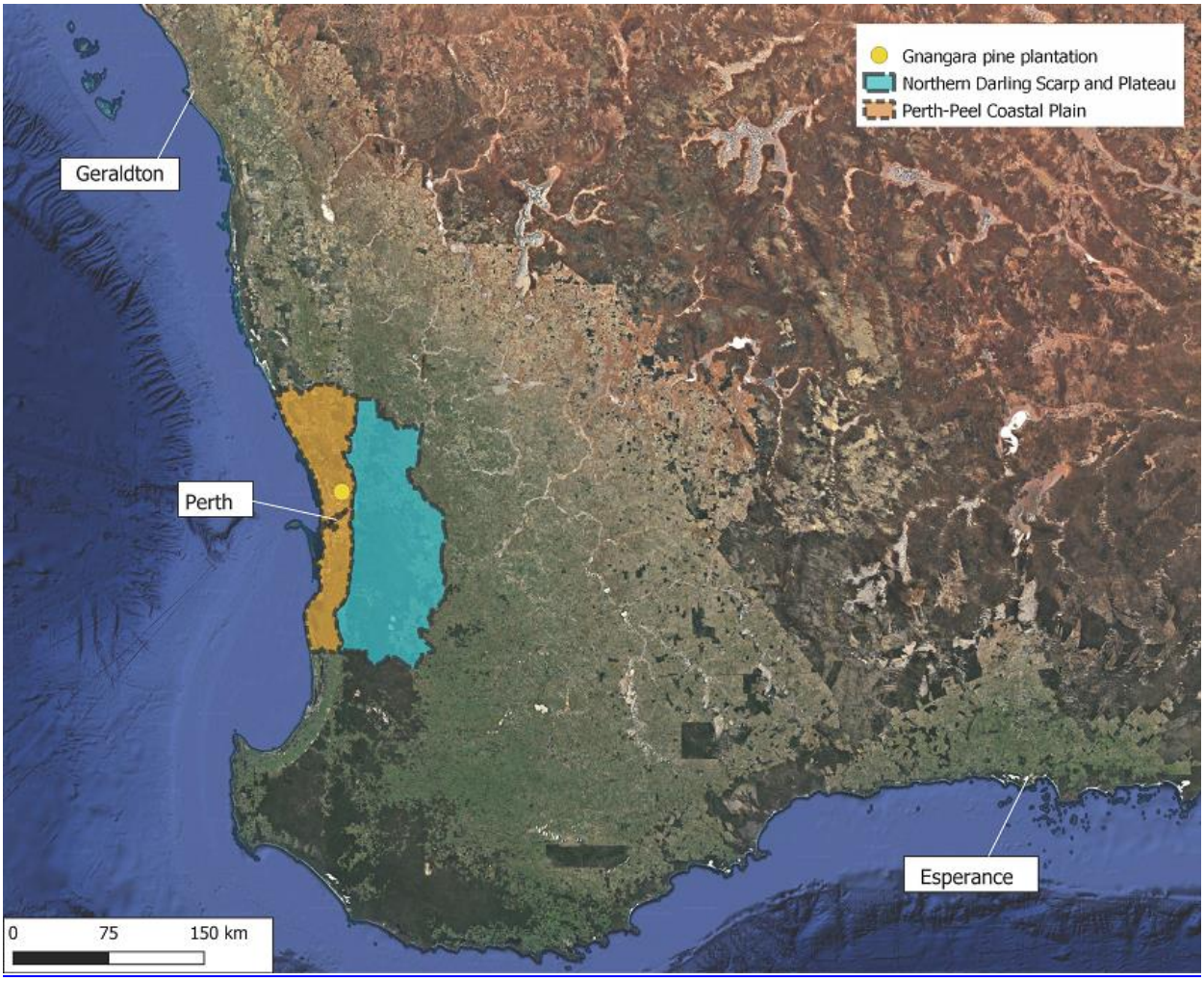

Figure 1: Map showing the locality divisions of the Perth-Peel Coastal Plain and Northern Darling Scarp and Plateau used in this report. Any areas outside the highlighted areas shown are classified as regional.

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I. INTRODUCTION

Background

The Great Cocky Count is an annual, community-based survey for black-cockatoos in Western Australia. The survey occurs at sites across the southwest of the state on a single evening between late-March and mid-April each year. Volunteers are allocated to a particular roost site and use a standard protocol to count the number of black-cockatoos that arrive at the site to roost for the night. The 2021 GCC occurred on Sunday 28th March and the 2022 GCC occurred on Sunday 3rd April.

The 2021 and 2022 GCCs were the 11th and 12th annual GCCs respectively. A trial count of Carnaby's on the northern SCP was conducted in 2006, after which the larger Great Cocky Count was held consecutively in the years 2010 to 2019. The 2020 Great Cocky Count was scheduled for the 5th April, but was cancelled in the week leading up to the event due to Covid-19 restrictions and concerns. BirdLife Australia coordinates the count each year, with funding for the 2021 and 2022 GCCs coming from The Alcoa Foundation.

Key aims for the GCC are to improve the scientific basis for the conservation of threatened black-cockatoos in Western Australia and to engage the community in conservation and monitoring efforts.

For ease of comparison with previous years' findings, this report uses a similar structure and analysis to previous reports, in particular the 2014 Great Cocky Count Report (Finn *et al.* 2014).

Conservation Status of Black-Cockatoos in Southwestern Australia

Three black-cockatoos are endemic to the southwest of Western Australia: Carnaby's Black-Cockatoo (*Zanda latirostris*), Baudin's Black-Cockatoo (*Zanda baudinii*), and Forest Red-tailed Black-Cockatoo (*Calyptorhynchus banksii naso*) (FRTBC).[1]

Internationally, Carnaby's are listed as Endangered and Baudin's as Critically Endangered under the IUCN Red List of Threatened Species (BirdLife International 2022a, b). Carnaby's and Baudin's Black-Cockatoos are listed as endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, while FRTBCs are listed as vulnerable. It was recently recommended that Baudin's Black-Cockatoo be upgraded to Critically Endangered in the latest Action Plan for Australian Birds (Johnstone *et al.* 2021a). While they have been formally upgraded under the IUCN Red List, their status has yet to be reviewed under Australian legislation. Any potential impacts on listed threatened species constitute a Matter of National Environmental Significance (MNES) under the act and require assessment by the Commonwealth government (Department of the Environment 2013).

At the state level, all three black-cockatoos are listed as fauna that are "rare or likely to become extinct and therefore in need of special protection" under the Western Australia *Biodiversity Conservation Act 2016*. Carnaby's Black-Cockatoo and Baudin's Black-Cockatoo are listed as endangered, and the Forest Red-tailed Black-Cockatoo is listed as vulnerable on the Biodiversity Conservation (Listing of Native Species) (Fauna) Order 2022.

Descriptions of the biology and natural history of Carnaby's and Baudin's Black-Cockatoo and FRTBC are available in the recovery plans prepared for the species (Chapman 2008; DBCA 2013).

[1] This report uses the nomenclature (naming conventions) of English names from Christidis and Boles (2008). The WA Museum and DBCA use the alternate nomenclature 'Carnaby's Cockatoo', 'Baudin's Cockatoo', and 'Forest Red-tailed Black Cockatoo'.

Further information on the ecology of black-cockatoos on the Swan Coastal Plain is available in Johnstone *et al.* (2010), Stock *et al.* (2013) and Williams *et al.* (2017).

History of the Great Cocky Count

Origins

The first count for Carnaby's Black-Cockatoos occurred in 2006 as a project initiated and led by BirdLife Australia (then Birds Australia). The aim for the 2006 count was to document patterns of abundance for Carnaby's Black-Cockatoo on the northern Swan Coastal Plain and to provide a minimum population estimate for the species in that area (Shah 2006). The next count, now known as the Great Cocky Count, was held in 2010, after which it became an annual survey.

Methods for Surveying

The 2006 Carnaby's count determined that counting black-cockatoos as they flew into night-time roosts was the best available method for assessing their local abundance and distribution. Since 2010, roost counts have been completed using a standard methodology developed by Ron Johnstone and Tony Kirkby from the WA Museum. This methodology was trialled in the 2006 GCC (Shah 2006) and now includes refinements developed by Paddy Berry to assess the demographic structure of flocks (Berry 2008; Berry and Owen 2010).

Evolution of the GCC

While the principal aim of the GCC – to conduct a community-based survey of black-cockatoos in southwestern Australia using roosts counts – has remained, the broader objectives of the GCC have evolved over time. The original 2006 count and the 2010 GCC focused on Carnaby's Black-Cockatoo on the Swan Coastal Plain and the adjacent Darling Plateau, with the surveyed roost sites occurring almost exclusively within the Greater Perth-Peel Region. In 2011, the GCC was broadened to include the whole of southwestern WA, with the expanded aim of gathering information about Carnaby's Black-Cockatoo across the species range. In 2014, the GCC was further extended to include the identification and survey of roost sites for FRTBCs, and this has continued to date. In 2018 BirdLife WA appointed a Forest Black-Cockatoo Project Coordinator in order to gain more data and awareness of FRTBCs and Baudin's Black-Cockatoos. This has contributed to more regional sites being surveyed, giving more data on these lesser-known species within the Jarrah-Marri and Karri forests. Since 2015 Murdoch University has been tracking all three species of Black-Cockatoos using both satellite and GPS trackers. This work has allowed them to locate new roosts which are then added to BirdLife's database and targeted for survey in the GCC. In this way the GCC has been able to survey more roosts each year.

Additional background information on the GCC can be found in previous reports (Shah 2006; Burnham *et al.* 2010; Kabat *et al.* 2012a; Kabat *et al.* 2012b, 2013; Finn *et al.* 2014, Byrne *et al.* 2015 and Peck *et al*. 2016, 2017, 2018 and 2019).

Contribution to Black-Cockatoo Conservation

Recovery plans exist to guide the conservation of Black-Cockatoos in southwestern Australia (Chapman 2008; DBCA 2013). The GCC contributes to the recovery actions identified in these recovery plans, as listed below.

Carnaby's Black-Cockatoo

The Carnaby's Black-Cockatoo Recovery Plan (DBCA 2013) identifies six recovery actions for Carnaby's Black-Cockatoo. The Great Cocky Count addresses three of these:

- **Action 14.3** – *Undertake regular monitoring*
- **Action 14.5** – *Undertake information and communication activities*
- **Action 14.6** – *Engage with the broader community*

Forest Black-Cockatoos

The GCC addresses two of the recovery actions identified in the Forest Black Cockatoo (Baudin's Cockatoo *Calyptorhynchus baudinii* and Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso*) Recovery Plan (Chapman 2008):

- **Action 14.9** – *Identify and manage important sites and protect from threatening processes*
- **Action 14.11** – *Monitor population numbers and distribution*

Objectives of the Great Cocky Count

The objectives of the 2021 and 2022 GCCs were to:

(1) train and engage community members in the monitoring of black-cockatoos;

(2) identify roost sites and conduct roost counts for all three species of Black-Cockatoo across the species range;

(3) provide a minimum population count for Carnaby's Black-Cockatoo and Forest Red-tailed Black-Cockatoos in the Perth-Peel Coastal Plain and the Greater Perth-Peel Region;

(4) assess trends in roost counts for white-tailed black-cockatoos (2010-2022) within the Greater Perth-Peel Region and the regional areas of Albany and Esperance, and Forest Red-tailed Black-Cockatoos (2014-2022) within the Greater Perth-Peel region.

II. METHODS

Survey Timing and Area

Timing

The 2021 GCC occurred on Sunday 28th March. This is the first time that the GCC has been held in March. It was held on this date to avoid the peak school holiday period and Easter, which had the potential to impact participation rates. The 2022 GCC occurred on Sunday 3rd April.

Survey area

The GCC survey area encompasses the geographic range of all three species of black-cockatoo and extends across most of southwestern WA (Figure 2; Figure 4). The survey area includes part or all of six IBRA bioregions: Avon Wheatbelt, Esperance Plains, Geraldton Sandplains, Jarrah Forest, Swan Coastal Plain, and Warren.

The Greater Perth-Peel Region remains a key focus for the GCC because this area: (a) maintains significant populations of Carnaby's Black-Cockatoo and FRTBC; and (b) experiences ongoing habitat changes due to urban and industrial development, agriculture, forestry, and other land uses. Threatening processes for black-cockatoos in the Greater Perth-Peel Region include habitat loss through land-clearing, collisions with cars, disease, climate change, altered fire and hydrological regimes and competitive interactions with other native and non-native species. These threats are discussed further in the recovery plans.

In this report, the Greater Perth-Peel Region is divided into two sub-areas: the Perth-Peel Coastal Plain and the Northern Darling Scarp and Plateau. The Perth-Peel Coastal Plain sub-area encompasses much of the Swan Coastal Plain and includes most of the densely-populated portions of the Perth-Peel metropolitan area. Habitats important for cockatoos in the Perth-Peel Coastal Plain include coastal heathland, Banksia woodland (principally mixed *Banksia attenuata* and *B. menziesii*), Tuart (*Eucalyptus gomphocephala*) woodland, other eucalypt woodlands, pine plantations, and various anthropogenic habitats (e.g. street trees, urban and market gardens, nut orchards etc.). The Northern Darling Scarp and Plateau sub-area lies largely within the northern Jarrah-Marri Forest.

Community Engagement and Training

To recruit volunteers for the 2021 and 2022 GCCs, BirdLife advertised the event on the BirdLife WA and Birdlife Australia Facebook pages, as well as in the BirdLife WA eNews, *WA Bird Notes* and *Cocky Notes* publications. The GCC was also promoted through various environment, community and NRM networks and their publications, newsletters and Facebook pages. Volunteers were directed to register for the event through a form on Google Forms.

Training in black-cockatoo identification and counting techniques was provided in the form of workshops in the lead up to the Great Cocky Counts, held at various locations within the greater Perth-Peel metropolitan area and regional centres. The workshops provided information about the GCC, including the general ecology of black-cockatoos, threats, information about their occurrence in the local area and guidelines for identifying and counting black-cockatoos at roost sites. An online webinar was also held for people unable to make a workshop, a recording of which was also uploaded to BirdLife Australia's YouTube channel for anyone to access. 2021 was also the first year we made training materials and information available on an online learning platform, which registered volunteers could sign up for and explore at their leisure. This resource was also made available to registered volunteers in the leadup to the 2022 GCC.

Registered volunteers received an email with their specific roost site allocation in the three weeks leading up to the Great Cocky Counts. The allocation email provided detailed information about their assigned site, a roost count form and counting instructions.

Roost Site Identification

Communications in the lead up to the 2021 and 2022 GCCs also included requests to report possible new roost sites for black-cockatoos. Reports of new sites came from community members, researchers with Murdoch University's Black-Cockatoo Ecology Project, and other sources, and were all collated into the existing GCC database. The database records roost site locations and also tracks the survey history of each roost site, noting whether they had been surveyed during a previous GCC and had black-cockatoos roosting there (confirmed roost), had been surveyed but with no black-cockatoos recorded roosting there in a GCC (unconfirmed), as well as information on yet unsurveyed areas that were likely to be roost sites (potential site). The database also tracks the numbers and taxa (WTBC, FRTBC or joint roost) at each roost over time. This enables prioritisation of the survey effort for each year's count. For the 2021 and 2022 GCCs, we prioritised the allocation of observers to confirmed roosts, and then to unconfirmed roosts; potential sites received the lowest priority. Not all of the sites in the database were assigned for survey.

Subsets of confirmed FRTBC roost sites have been used each year since 2018 for a spring count of FRTBCs, to better understand the seasonal movements of this species, given their relatively recent incursion onto the Swan Coastal Plain in the last 20 years.

Roost Count Methodology

The 2021 and 2022 GCCs followed the standard survey methodology described in previous GCC reports (Burnham *et al.* 2010; Kabat *et al.* 2012a; Kabat *et al.* 2012b, 2013; Finn *et al.* 2014, Byrne *et al.* 2015 and Peck *et al.* 2016, 2017, 2018 and 2019). Roost count instructions were included on the roost count survey form and in other written materials provided to each volunteer (Appendix I). The October Spring FRTBC Count follows the same methodology as the GCC.

Counting protocol

Volunteers were instructed to: (a) count the number of black-cockatoos that arrived to roost at a designated site at sunset on the night of the Great Cocky Count (28th March in 2021 and 3rd April in 2022); (b) conduct the roost count for at least 30 minutes before and 30 minutes after sunset; (c) exclude any black-cockatoos that arrived at the site but subsequently departed to roost elsewhere; (d) ignore any black-cockatoos that flew over, but did not roost at the site; and (e) record the number of cockatoos that arrived at the site within each of several sub-groups (i.e. whether the birds arrived in trios, pairs, as single individuals, or other multiples).

Species identification protocol

The distributions of Baudin's and Carnaby's Black-Cockatoo overlap in portions of the southwest, particularly in forested areas. Distinguishing between Carnaby's and Baudin's Black-Cockatoos can be difficult, particularly during roost count surveys when large numbers of birds may arrive together. Another difficulty is that the two species commonly occur together in mixed flocks. To avoid potential errors associated with incorrect species attributions, volunteers were instructed to record just one overall count of the number of white-tailed black-cockatoos roosting at the site.

In contrast, even inexperienced observers can easily distinguish between the FRTBC and the white-tailed black-cockatoo species, because FRTBC calls and markings are markedly different from those of the two white-tailed black-cockatoos. Thus, volunteers were instructed to record the number of Red-tailed Black-Cockatoos that roosted at the site and if FRTBC and white-tailed black-cockatoos both roosted at a site, to record separate counts for each.

Data Analysis

Organisation of roost count data

We used the roost survey results from each site to estimate the total number of Carnaby's Black-Cockatoo (or white-tailed black-cockatoos) and FRTBCs counted within five areas:

(1) The Perth-Peel Coastal Plain,

(2) The Northern Darling Scarp and Plateau,

(3) The Greater Perth-Peel Region (i.e., (1) + (2)),

(4) Regional Areas (i.e. outside the Greater Perth-Peel Region), and

(5) Across the species' range (i.e., all sites, (3) + (4)).

The total counts for regional areas and across the species range are presented as the total number of white-tailed and Forest Red-tailed Black-Cockatoos counted. We do not distinguish between Carnaby's and Baudin's black-cockatoo in regional areas as the distributions of Carnaby's and Baudin's Black-Cockatoos overlap in this area and due to the difficultly in distinguishing between them. Unlike in the Northern Darling Scarp and Plateau area, we did not have estimates from expert observers from which to infer species proportions for Baudin's and Carnaby's Black-Cockatoo in those areas where mixed flocks may occur, so they are reported together as white-tailed black-cockatoos. The procedure for determining total counts of Carnaby's Black-Cockatoo in the Northern Darling Scarp and Plateau and the Greater Perth-Peel Region is described below.

The roost counts are presented as means (± standard errors) and as medians. We calculated roost occupancy rates by dividing the number of occupied roosts by the number of confirmed roosts that were surveyed, for each year. 'Confirmed roosts' were those sites that had been occupied at least once in any of the GCCs between 2010 and 2022 by either white-tailed or FRTBCs.

Total counts for the Greater Perth-Peel Region

All roosting flocks in the Perth-Peel Coastal Plain were assumed to contain only Carnaby's Black-Cockatoo because the distribution of Baudin's Black-Cockatoos within the Greater Perth-Peel Region is generally confined to the Northern Darling Scarp and Plateau, particularly in early April (Johnstone *et al.* 2010; Tony Kirkby, personal communication). Across sites on the Northern Darling Scarp, the 2021 and 2022 GCCs assumed percentages of Carnaby's at 30% and Baudin's at 70%. This is based on counts in previous years around GCC time by Tony Kirkby and known proportions at some sites. Between 2010 and 2018 the proportion of Carnaby's has consistently been between 0.2 and 0.4, therefore a decision was made to standardise the corrected count for all years at 0.3. We therefore multiplied the total white-tailed black-cockatoo count by 0.3 to derive a 'corrected' count of the numbers of Carnaby's Black-Cockatoo for the Northern Darling Scarp and Plateau area.

Statistical analysis

Breeding success

Black-cockatoos are commonly observed in small groups, believed to comprise a mated pair of birds and, often, their offspring ('family units'). For Carnaby's Black-Cockatoo, these family units comprise a trio – the adult mated pair and a fledgling from the most recent, or a previous, breeding season. As such, the number of trios in roosting flocks should correlate positively with the level of breeding success for the most recent or previous breeding seasons. If pairs of birds represent breeding pairs without offspring, the ratio of trios to pairs will provide a measure of breeding success. We refer to this as the Berry recruitment model (Berry 2008; Berry and Owen 2010).

In determining the proportions of trios versus pairs, we included data from all GCC surveys and from all sites, on the basis that flocks observed anywhere in the southwest in April would contain pairs that bred (or failed to breed) during the previous breeding season (July – December each year; Saunders 1982). We did not adjust counts for the presence of any Baudin's Black-Cockatoos. The chi-square goodness-of-fit was used to test whether the proportions of trios to pairs differed across the observed average between years 2010 – 2019 and years 2021 and 2022.

Roost occupancy, flock size and population trend analysis

A key aim for the Great Cocky Count is to assess population trends for Black-Cockatoos. As many surveys recorded counts of zero and there are instances where surveys of confirmed roosts were not conducted, statistical analysis that accounted for these features of the data was used.

Counts of zero at a surveyed site may reflect variation in the use of the roost (for example, the site is sometimes occupied, but not during a particular survey), inaccuracy in counting (the site was occupied, but no birds were observed), or may reflect changes that have occurred at the site (birds no longer roost at the site because it is now unsuitable). Zero counts affect estimates of average roost size which consequently influence trend estimates (Zurr *et al.* 2009). Zero counts often arise in citizen science surveys (Kery and Schmid 2004; Schmeller *et al.* 2012) and especially in count data for rare species (Cunningham and Lindenmayer 2005), where the number of observers may exceed the number of occupied sites – as is the case for the Great Cocky Count. As such, there are a large number of zero counts in the dataset ('zero-inflation' or 'excess zeros'). Additionally, missing counts at some sites (i.e. where no survey was done, even though birds may have been present) also require some method of estimating the likely number of birds present, in order to obtain an accurate trend estimate. Some roosts have been cleared and are no longer available to the birds and post-clearing data points (all zeros) were excluded from the analysis. Using only the 'raw' total counts, which do not account for excess zeros, variable sampling effort and roost site clearing may give inaccurate and potentially misleading results.

To deal with these issues, we used a statistical model that accounted for the large number of zero counts present in the GCC data and for the variation in survey effort each year. This model uses a zero-inflated, generalised Poisson distribution to account for the excess zeros, and for the likely over-dispersion in the counts due to any other sources of variation, such as differences between observers (Link and Sauer 1997; Dobbie and Welsh 2001; Sauer *et al.* 2004). Following expert statistical advice, we have modified the method of analysis slightly from that used in previous years (Potts 2018) by treating roost sites as a random effect. The roost count data were modelled in two stages: a logistic regression model was used to estimate any trend in roost occupancy rate; and then a log-linear regression model was used to estimate any trend in average roost size. The model for the occupied roosts assumes a generalised Poisson distribution for the count data (with the mean being determined by an annual trend in average roost size) with site as a random effect to allow for any serial correlation in the repeated surveys at each site. A generalised Poisson distribution was appropriate because it allows for the potentially excess variation that may arise through any unmodelled sources of variation in the roost counts. Further details about this approach, including its advantages and limitations, are

discussed in Dobbie and Welsh (2001), Sauer *et al.* (2004), Cunningham and Lindenmayer (2005), and Humbert *et al.* (2009). This statistical approach models variation in counts more realistically than simple linear regression models of counts or log-transformed counts (Cunningham and Lindenmayer 2005). This analytical approach has been used previously to measure population trends in Carnaby's Black-Cockatoo in the Perth-Peel Coastal Plain (Williams *et al.* 2015).

Similarly, the zero-inflated generalized Poisson (ZIGP) regression model requires initial estimates ('starting values') to be provided for each fixed effect including the intercept, and for the variances and the covariance of the random site effects in both the occupancy and count parts of the model. The method of fitting the model requires successive iterations to eventually converge on stable estimates for each parameter. Typically, these starting values are set at the values determined in the previous year's analysis, or, if necessary, by using estimates determined from initially fitting the model with site parameters set as fixed rather than random, or, failing that, by incorporating one random effect at a time. To further improve the likelihood of the model converging on the correct parameter estimates, the successive iterations used the method of Gauss-Hermite quadrature. Similarly, the initial estimates for some parameters can be assigned a range of starting values; the parameters requiring such additional care in estimating can be determined from examination of the asymptotic correlation matrix of parameter estimates – the correlations between successive estimates of each parameter during the iteration process. Parameters that are highly intercorrelated typically require more precise initial estimates or a range of initial values. As the dataset increases in size with each successive GCC survey, the model becomes progressively easier to fit as the parameters become increasingly stable over time.

In addition, trend analysis poses other potential challenges, as fitting the model successfully requires estimation of many intercorrelated parameters. To resolve these issues, it is often best to initially fit the model with the site parameters set as fixed – thus enabling the overall mean and variance of the site count estimates to be determined. These values can then be used as initial estimates when the site parameters are estimated as a random effect with mean zero, with the intercept parameter adjusted to account for the estimated overall mean count.

We also assessed trends separately for roost sites within or associated with the Gnangara pine plantation (see Key Terms and Abbreviations) and for those not associated with the pine plantation. We defined 'pine-associated' sites as sites that occurred within or immediately adjacent to (<1 km from the boundary) of the plantation system, or have been documented as roost sites for Carnaby's Black-Cockatoo feeding in the Gnangara pine plantation (Shah 2006, Saunders 1980, Finn *et al.* 2009, Stock *et al.* 2013).

We used Microsoft Office Excel 2010 and SPSS Statistics Version 22 for basic statistical analyses. The trend analyses were performed using generalised linear mixed model procedures (GLIMMIX and NLMIXED) of the SAS software (SAS Institute Inc., 2011). The SAS programming code used to analyse the data is included in Appendix VIII.

III. RESULTS

Community Engagement and Training

Workshops

2021

Approximately 400 people attended the 12 Great Cocky Count workshops conducted in February and March 2021. Workshops were held in Mandurah, Lake Clifton, Ellenbrook, Melville, Forrestfield, Bridgetown, Byford, Victoria Park, Kalamunda, Margaret River, North Dandalup and online (webinar).

Supporters for the workshops included Peel Harvey Catchment Council, City of Swan, City of Melville Libraries, WA Naturalists' Club – Darling Range Branch, Bridgetown-Greenbushes Community Landcare, Landcare Serpentine-Jarrahdale, Friends of Jirdarup Bushland, City of Kalamunda and Nature Conservation Margaret River Region.

2022

Approximately 300 people attended the 13 Great Cocky Count workshops conducted in February and March 2022. Workshops were held in Esperance, Coolup, Midland, Jarrahdale, Collie, Wilson, Murdoch, Rockingham, Gosnells, Boddington, Bremer Bay, Denmark and online (webinar). Supporters for the workshops included South Coast NRM, Landcare Serpentine-Jarrahdale, City of Swan, Leschenault Catchment Council, Canning River Eco Education Centre, Murdoch University, City of Rockingham, City of Gosnells, Peel Harvey Catchment Council, City of Stirling and Denmark Bird Group.

135 volunteers have registered for, and accessed, the information and training material on the online learning platform since 2021. The recorded webinar from 2021 has had 255 views on BirdLife Australia's YouTube channel.

Volunteer participation

2021

496 survey sites were assigned to the 755 registered volunteers for the 2021 Great Cocky Count (Table 1). Roost counts were conducted at 462 (93%) of these roost sites. This compares well with previous completion rates of between 90% and 97% from the year 2013 onwards. Of the volunteers that registered in 2021, just under half (45%) were new to the GCC, with the rest having previously registered for one or more GCCs.

2022

392 survey sites were assigned to the 612 registered volunteers for the 2022 Great Cocky Count (Table 1). Roost counts were conducted at 362 (92%) of these roost sites. This compares well with previous completion rates of between 90% and 97% from the year 2013 onwards. Of the volunteers that registered in 2022, 35% were new to the GCC, with the rest having previously registered for one or more GCCs.

Actual volunteer participation for the 2021 and 2022 GCC was likely ranged from 1,000 to 1,500 community members, as registered volunteers often reported that they were bringing one or more non-registered volunteers (e.g. family and friends) to assist. In addition, Aquinas College and Northern Agricultural Catchment Council coordinated roost counts at Salter Point and in the Geraldton/Chapman Valley area respectively, using volunteers, staff and students from those organisations.

Table 1: Volunteer participation and survey effort for all Great Cocky Counts (2010-2022). The percentages show the proportion of the sites that were surveyed in each GCC in the Greater Perth-Peel Region (further subdivided into the Perth-Peel Coastal Plain and the Northern Darling Scarp and Plateau), or in regional areas.

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2021**	**2022**
Registered volunteers	250	263	294	335	592	606	707	895	750	752	755	612
Sites assigned for survey	Un-known	248	244	262	322	301	426	504	440	427	496	392
Sites surveyed	187	165	205	241	290	293	398	469	416	397	462	362
In Greater Perth-Peel Region	183 (98%)	150 (91%)	157 (77%)	186 (77%)	230 (79%)	228 (78%)	310 (78%)	345 (74%)	270 (65%)	252 (63%)	302 (65%)	240 (66%)
(i) PPCP	157 (84%)	124 (75%)	127 (62%)	144 (60%)	186 (64%)	185 (63%)	231 (58%)	240 (51%)	180 (43%)	161 (41%)	187 (40%)	132 (36%)
(ii) NDSP	26 (14%)	26 (16%)	30 (15%)	42 (17%)	44 (15%)	43 (15%)	79 (20%)	105 (22%)	90 (22%)	91 (23%)	115 (25%)	108 (30%)
In regional areas	4 (2%)	15 (9%)	48 (23%)	55 (23%)	60 (21%)	65 (22%)	88 (22%)	124 (26%)	146 (35%)	145 (37%)	160 (35%)	122 (34%)

Roost Site Identification

In 2021, 57 survey sites were surveyed for the first time in a GCC, including sites that were newly reported, and some which had been on the database but had never been surveyed. Of these, 11 had just white-tailed species roosting, 25 had FRTBC roosting, 8 had both roosting and 13 were unoccupied. In 2022, a further 16 sites were also surveyed for the first time on the evening of the 2022 GCC. Of these, 4 had only white-tailed black-cockatoos roosting, 8 had just FRTBCs roosting, one had both roosting and three were unoccupied. Of the 901 sites reported to the database, 57 have not been surveyed to date. One confirmed roost site and one joint roost site were cleared in between the 2019 and 2021 GCCs. Five unconfirmed roost sites, which have not been counted during a GCC, have been confirmed as being used in October when counted during the Spring FRTBC Counts (Table 2).

Table 2: Numbers of confirmed WTBC, confirmed FRTBC, confirmed joint, unconfirmed, potential and cleared roosts in the GCC site database for each Great Cocky Count (2010-2022). Cleared roosts are previously confirmed roosts that have been cleared of vegetation since 2010, so no longer available to the Black-Cockatoos. These cleared roosts do not contribute to the database total. Numbers for confirmed WTBC roosts and FRTBC roosts include joint sites. Joint roosts are sites where >0 white-tailed black-cockatoo and >0 FRTBC have been counted since 2010. *Five unconfirmed roosts have returned a positive count during the Spring FRTBC Count but not during a GCC.

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2021**	**2022**
Confirmed WTBC roosts	52	90	124	153	163	175	188	216	237	238	242	244
Confirmed FRTBC roosts	n/a	n/a	n/a	n/a	14	21	49	81	102	118	137	142
Joint roosts	n/a	n/a	n/a	n/a	14	22	46	71	91	119	147	154
Unconfirmed roosts	unknown	48	73	110	126	133	159	154	166	170	176	180*
Potential roosts	unknown	161	158	184	194	193	187	203	181	187	181	181
Total no. of sites	**unknown**	**299**	**355**	**447**	**511**	**544**	**629**	**725**	**777**	**832**	**883**	**901**
Cleared roosts	0	1	4	4	5	5	9	9	9	10	12	12

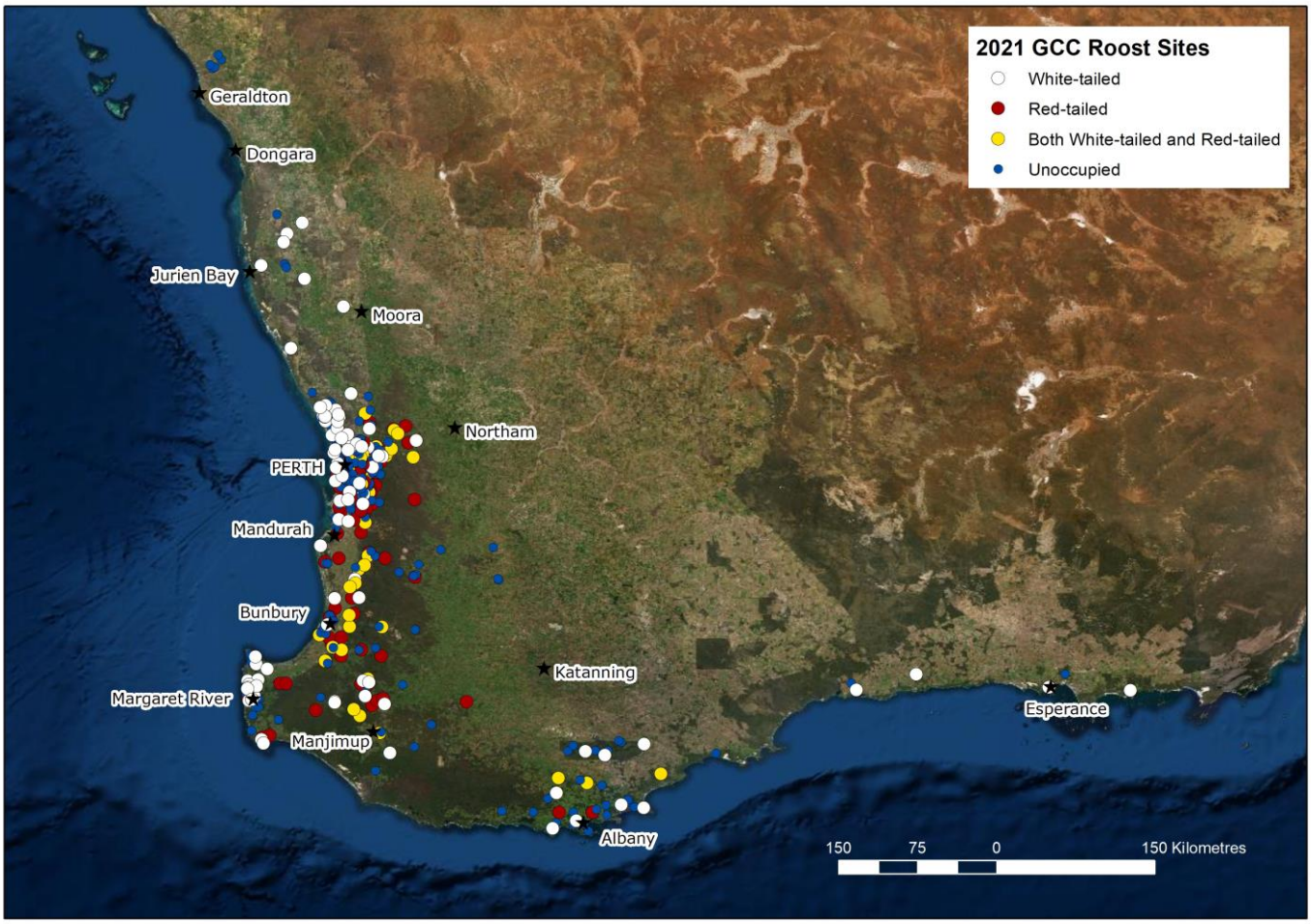

Figure 2: The locations of the 462 sites where surveys were conducted for the 2021 Great Cocky Count. Sites are classified as either unoccupied (no black-cockatoos roosting), white-tailed black-cockatoo roost sites, Forest Red-tailed Black-Cockatoo roost sites, or sites where both red- and white-tailed black-cockatoos roosted.

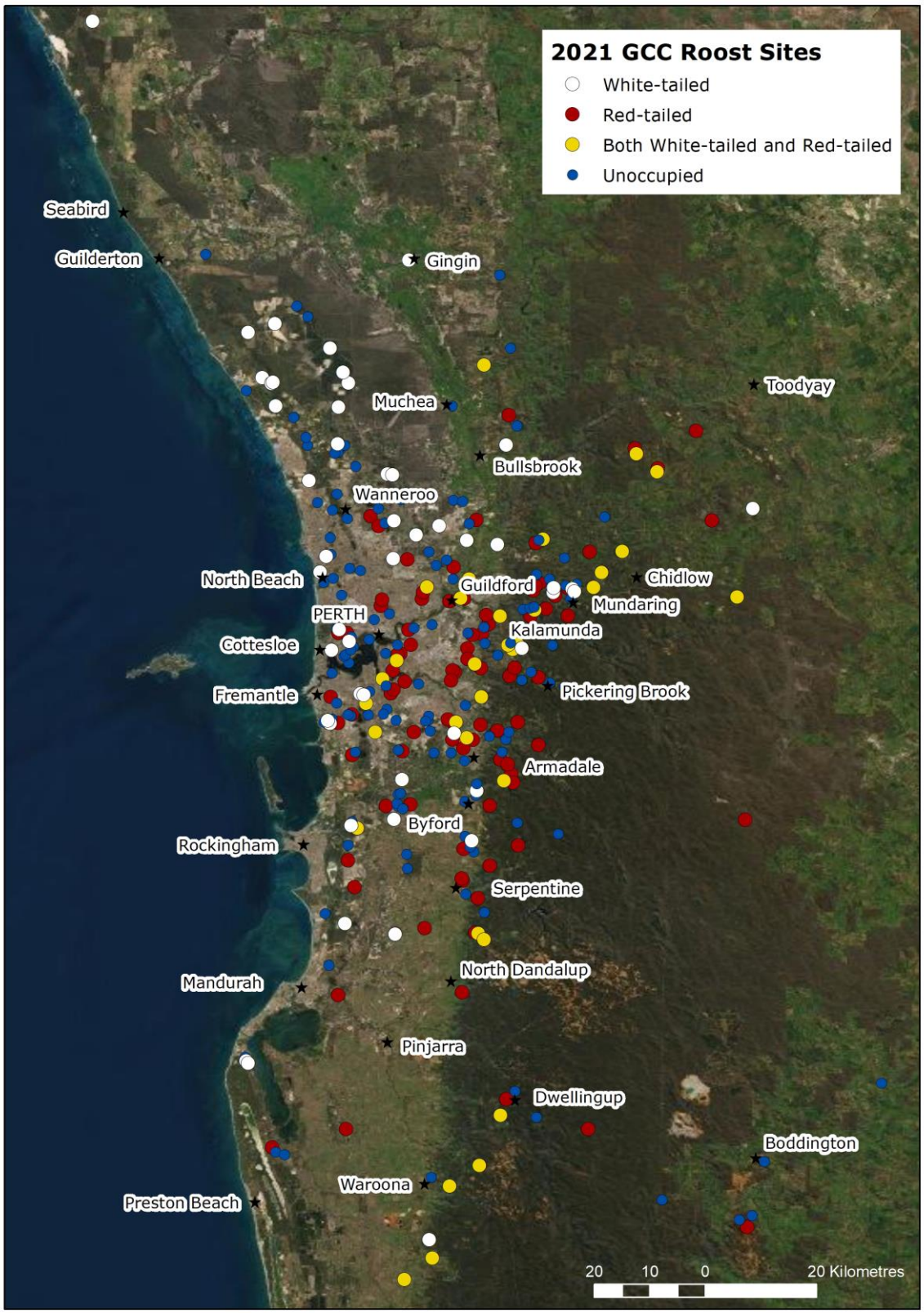

Figure 3: The locations of the 302 sites in the Greater Perth-Peel Region where roost counts were conducted during the 2021 Great Cocky Count. Roosting sites are classified as either unoccupied (no black-cockatoos roosting), white-tailed black-cockatoo roost sites, Forest Red-tailed Black-Cockatoo roost sites, or sites where both red- and white-tailed black-cockatoos roosted. The map includes the Perth-Peel Coastal Plain and the Northern Darling Scarp and Plateau.

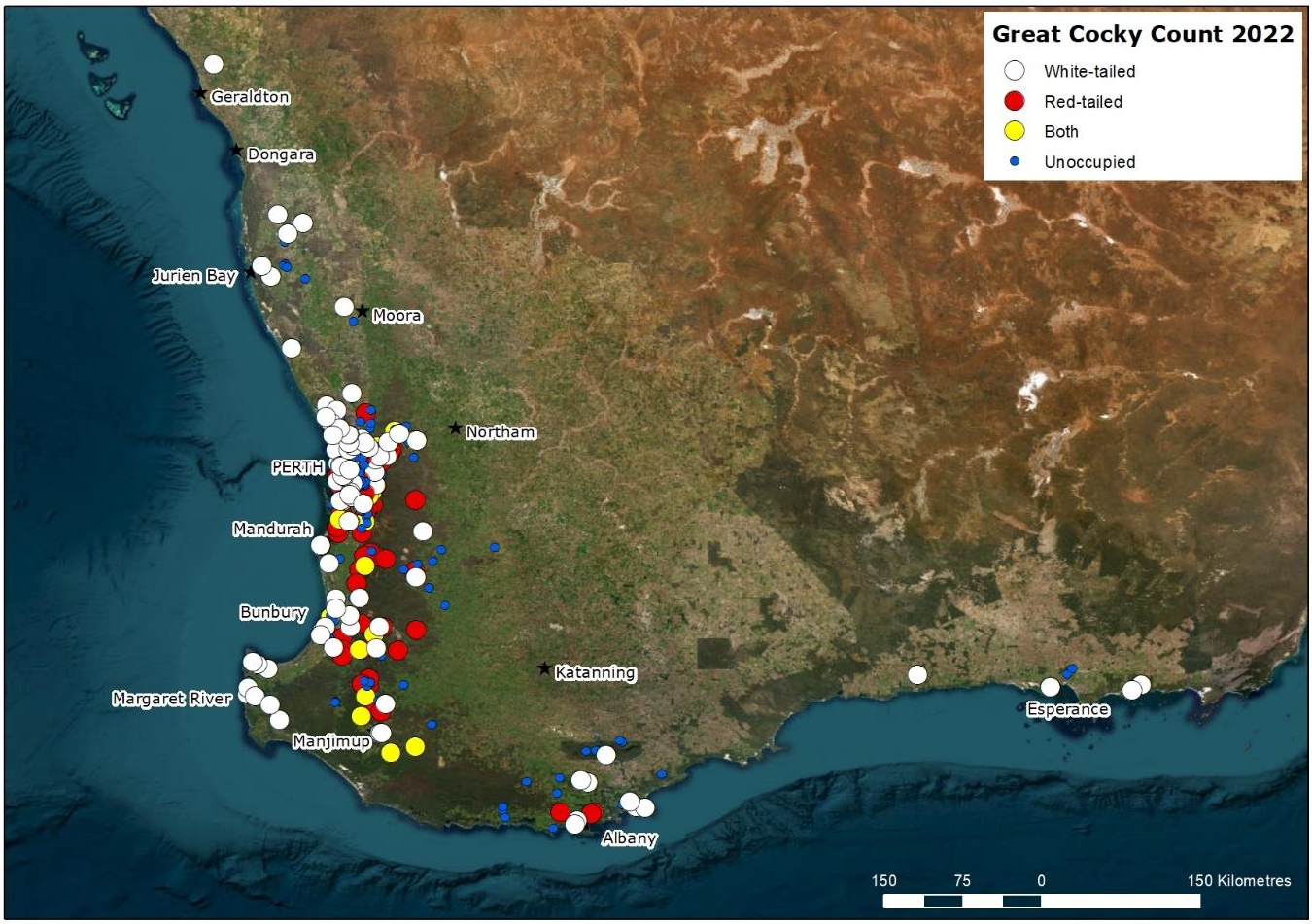

Figure 4: The locations of the 362 sites where surveys were conducted for the 2022 Great Cocky Count. Sites are classified as either unoccupied (no black-cockatoos roosting), white-tailed black-cockatoo roost sites, Forest Red-tailed Black-Cockatoo roost sites, or sites where both red- and white-tailed black-cockatoos roosted.

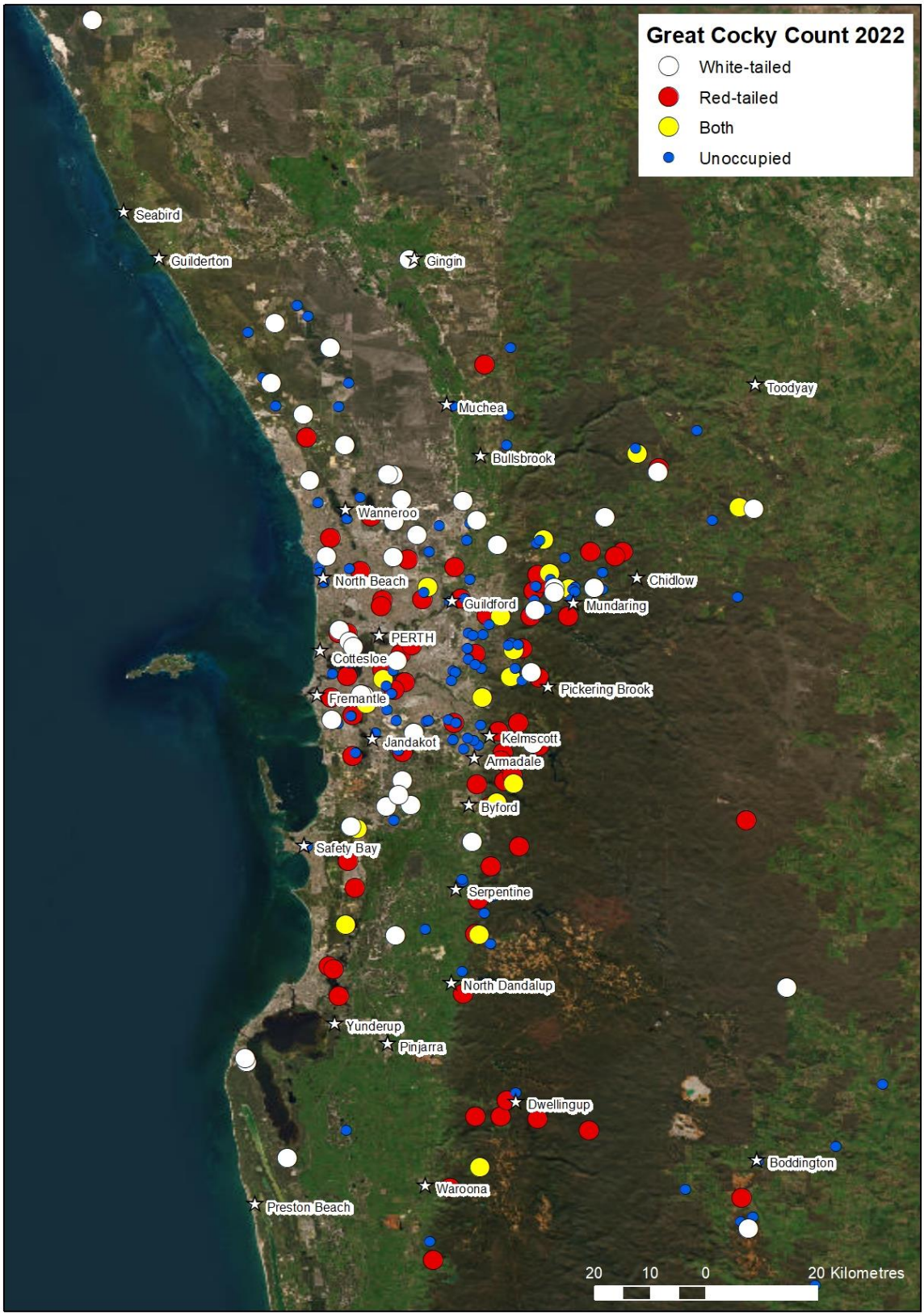

Figure 5: The locations of the 240 sites in the Greater Perth-Peel Region where roost counts were conducted during the 2022 Great Cocky Count. Roosting sites are classified as either unoccupied (no black-cockatoos roosting), white-tailed black-cockatoo roost sites, Forest Red-tailed Black-Cockatoo roost sites, or sites where both red- and white-tailed black-cockatoos roosted. The map includes the Perth-Peel Coastal Plain and the Northern Darling Scarp and Plateau.

Overall Survey Effort

Survey effort

2021

Greater Perth-Peel Region

Volunteers surveyed 302 sites in the Greater Perth-Peel Region within 37 local government areas (LGAs) (Table 1; Figure 3). Occupied WTBC roosts were recorded in 25 (67%) LGAs and occupied FRT roosts in 26 (70%) of LGAs (Appendix IIa; Appendix IIb). Survey effort was greatest in the Cities of Serpentine-Jarrahdale (32), Swan, (29), Mundaring and Wanneroo (28 each), Kalamunda (24) and Armadale (22).

Regional areas

Volunteers surveyed 160 sites in regional areas across 26 LGAs (Table 1; Figure 2). Roosting WTBCs were recorded in 19 (73%) of the LGAs and roosting FRTs in 13 (50%) LGAs (Appendix IIa; Appendix IIb). Survey effort was greatest in the Shires of Augusta-Margaret River (27), Albany (19), Donnybrook-Balingup (12), Busselton (11), Harvey and Bridgetown-Greenbushes (10 each).

2022

Greater Perth-Peel Region

Volunteers surveyed 240 sites in the Greater Perth-Peel Region within 31 LGAs (Table 1; Figure 5). Occupied WTBC roosts were recorded in 23 (74%) LGAs and occupied FRT roosts in 27 (87%) LGAs (Appendix IIc; Appendix IId). Survey effort was greatest in the Cities/Shires of Mundaring (28), Swan (25), Kalamunda (20), Serpentine-Jarrahdale (19), Wanneroo (17) and Armadale (16).

Regional areas

Volunteers surveyed 122 sites in regional areas across 26 LGAs (Table 1; Figure 4). Roosting WTBCs were recorded in 18 (69%) of the LGAs and roosting FRTs in 9 (35%) LGAs (Appendix IIc; Appendix IId). Survey effort was greatest in the Shires of Bridgetown-Greenbushes (12), Albany (11), Donnybrook-Balingup (10), Augusta-Margaret River and Harvey (9 each).

Across GCCs (2010-2022)

The number of sites surveyed increased in both the Greater Perth-Peel Region and regional areas in the 2021 GCC compared to the 2019 GCC, before decreasing during the 2022 GCC. The ratio of sites surveyed in regional areas to the Greater Perth-Peel Region has remained relatively stable over the last four GCCs with 34-37% of sites surveyed in regional areas.

White-tailed Black-Cockatoos Roost Counts

Total counts

2021

Greater Perth Peel Region

In 2021 the GCC recorded 8,992 Carnaby's Black-Cockatoos in the Greater Perth Peel Region. This is the lowest count in the region since 2015 and only just over two thirds the total number counted in 2019 (13,343 birds) (Table 4).

Regional areas

The count for regional areas of 7,376 white-tailed black-cockatoos was similar to the 2019 count (7,167 birds) (Table 4).

2022

Greater Perth Peel Region

In the 2022 GCC 11,857 Carnaby's Black-Cockatoos were recorded in the Greater Perth Peel region. This count was higher than the 2021 (8,992) count but lower than both the 2018 and 2019 GCCs (13,145 and 13,984 respectively) (Table 4).

Regional areas

8,571 white-tailed black-cockatoos were counted in regional areas, which is the highest recorded for a GCC to date and over one thousand more than the previous year (Table 4).

Across species range

The total count of 17,773 white-tailed black-cockatoos in 2021 was less than both 2018 and 2019 (20,316 and 22,647 respectively), though still more than double the average of the years 2010-15 (8,705 birds) (Table 4). The lower count reflected the low numbers recorded in the Greater Perth-Peel Region. The total count was higher in 2022 with 20,428 birds counted, which was less than the 2019 count but very similar to the 2018 count. It should be noted that this total includes an unknown number of Baudin's Black-Cockatoos outside the Perth-Peel Coastal Plain.

Roost counts – across species range

2021

At occupied roosts, counts of white-tailed black-cockatoos in the 2021 GCC ranged from 1 to 1,982, with a mean of 125 $\pm$ 22 (standard error) and a median of 35 (from 142 roost counts). Roost count sizes varied across the three principal survey areas. The lowest was for the Northern Darling Scarp and Plateau (mean 59 $\pm$ 17); then regional areas (mean 122 $\pm$ 28), with the Perth Peel Coastal Plain being the highest (mean 172 $\pm$ 50).

Across the species range, the five largest roosts accounted for 31% (5,511 of 17,773 birds) of the total number of white-tailed black-cockatoos counted (Appendix III; Appendix IV). The ten largest roosts accounted for 49% (8,711) of the total number of white-tailed black-cockatoos counted. Of the 10 largest roosts, five occurred in regional areas, four on the Perth Peel Coastal Plain and one on the Northern Darling Scarp and Plateau.

2022

Counts of white-tailed black-cockatoos ranged from 1 to 5,032 at occupied roosts in the 2022 GCC, with a mean of 185 $\pm$ 49 (standard error) and a median of 56 from 115 roosts. Roost count sizes again varied across the three principal survey areas with the lowest recorded on the Northern Darling Scarp and Plateau (mean 51 $\pm$ 13), followed by regional areas (mean 168 $\pm$ 47) and the Perth Peel Coastal Plain (mean 287 $\pm$ 126).

Across the species range, the five largest roosts counted for 46% (9,868 of 21,277 birds) of the total number of birds counted (Appendix III; Appendix IV). The ten largest roosts accounted for 60% (12,757) of the total

number of white-tailed black-cockatoos counted. Of the 10 largest roosts, six occurred in regional areas and four on the Perth Peel Coastal Plain.

Roost counts – Perth-Peel Coastal Plain

2021

Within the Perth-Peel Coastal Plain, the five largest roosts (counts of 1982, 1186, 927, 510 and 353) accounted for 59% (4,958 of 8,428) of the Carnaby's Black-Cockatoo counted in this region (Appendix IIIa). Three of these were within the Gnangara pine plantation north of Perth (Appendix IIIb) and the other two in Gingin and Como. The roost occupancy rate was 43% for the Perth-Peel Coastal Plain (49 occupied roosts of the 114 confirmed roosts surveyed) (Table 5).

Gnangara pine plantation

Volunteers recorded 5,325 birds at ten occupied roosts located within or immediately adjacent to (i.e. < 1 km from the boundary of) the Gnangara pine plantation, and at four roosts in the Yanchep National Park that has, historically, been used by Carnaby's Black-Cockatoo feeding in the Gnangara pine plantation (Saunders 1980, Finn *et al.* 2009, Stock *et al.* 2013) (Appendix IIIb). These roosts accounted for 63% (5,325 of 8,428) of the Carnaby's Black-Cockatoo counted in the Perth-Peel Coastal Plain.

Other large roosts

Large counts were recorded at Nedlands (299), Eglinton (296), Spearwood (257), Murdoch (245) and Floreat (242).

2022

In 2022, within the Perth-Peel Coastal Plain, the five largest roosts (counts of 5,032, 783, 756, 733 and 421) accounted for 67% (7,725 of 11,493) of the Carnaby's Black-Cockatoo counted in this region (Appendix IIIa). Four of these were within, or in close vicinity to, the Gnangara pine plantation north of Perth (Appendix IIIb) and the other one was in Gingin. The roost occupancy rate was 48% for the Perth-Peel Coastal Plain (40 occupied roosts of the 83 confirmed roosts surveyed) (Table 5).

Gnangara pine plantation

7,811 birds were recorded at nine occupied roosts located within or immediately adjacent to (i.e. < 1 km from the boundary of) the Gnangara pine plantation, and at one roost in the Yanchep National Park that has, historically, been used by Carnaby's Black-Cockatoo feeding in the Gnangara pine plantation (Saunders 1980, Finn et al. 2009, Stock et al. 2013) (Appendix IIIb). These roosts accounted for 68% (7,811 of 11,493) of the Carnaby's Black-Cockatoo counted in the Perth-Peel Coastal Plain. In previous GCCs (2010-2022), birds roosting in the Gnangara pine plantation have accounted for 28% to 73% of the Carnaby's Black-Cockatoo counted in the Perth-Peel Coastal Plain, with total counts ranging from 1,077 to 9,422 birds.

Other large roosts

Large counts were also recorded at Dawesville (377 and 240), Como (333), Nedlands (250) and Murdoch (222).

Roost counts – Northern Darling Scarp and Plateau

2021

Within the Northern Darling Scarp and Plateau, the five largest roosts accounted for 60% (1,125 of 1,879) of the white-tailed black-cockatoos counted in this region. These counts were recorded at three sites in Piesse Brook (500, 132 and 131), Wagerup (217) and Bullsbrook (145) (Appendix IIIc). The roost occupancy rate was 43% (32 occupied roosts of the 75 confirmed roosts surveyed) (Table 5).

White-tailed black-cockatoos were recorded at five sites in the Shire of Kalamunda (24 sites surveyed and 798 birds) and 10 sites in the Shire of Mundaring (28 sites surveyed and 368 birds) and three in the City of Armadale (18 sites surveyed and 138 birds) (Appendix IIa).

2022

The five largest roosts within the Northern Darling Scarp and Plateau accounted for 62% (755 of 1,213) of the white-tailed black-cockatoos counted in this region. These counts were recorded in Parkerville (187 and 141), Roleystone (150), Bakers Hill (144) and Morangup (133) (Appendix lllc). The roost occupancy rate was 33% (24 occupied roosts of 72 confirmed roosts surveyed) (Table 5). Shire of Mundaring had the greatest survey effort and highest numbers with seven sites of 28 surveyed being occupied (448 birds) (Appendix IIc).

Roost counts – Regional areas

2021

In regional areas, the five largest roosts (1,416, 655, 555, 500 and 480) accounted for 48% (3,606 of 7,466) of the white-tailed black-cockatoos counted regionally (Appendix IV). These sites were located at Nilgen, Glenlynn, Balingup, Munglinup and Warradarge.

Sites with large counts were recorded in the Shires of Gingin (1,416 at one site), Esperance (824 at four sites), Ravensthorpe (750 at two sites), Bridgetown-Greenbushes (716 at four sites), Donnybrook-Balingup (587 at four sites and Carnamah (561 at three sites) (Appendix IIa).

2022

The five largest roosts in regional areas accounted for 59% (5,028 of 8,571) of the white-tailed black-cockatoos counted in this area (Appendix IV). These sites were located in Wellesley (1,738), Nilgen (1,510), Glenlynn (805), Dandaragan (527) and Munglinup (448).

Sites with large counts were recorded in the Shires of Harvey (2,182 at five sites), Gingin (1,510 at one site), Bridgetown-Greenbushes (1,230 at two sites), Dandaragan (1,009 at three sites) and Esperance (723 at four sites) (Appendix IIc).

Breeding success

The proportion of white-tailed black-cockatoo groups returning to roosts as either pairs or trios was recorded at 75 sites in 2021. The proportion of groups flying into roosts as trios (40%) was not significantly greater (χ^2 = 0.002, p = 0.97) than the average proportion recorded over previous GCCs (average 39% between 2010-2019, range 31% – 47%) (Table 3). The proportion of white-tailed black-cockatoo groups returning to roosts as either pairs or trios was recorded at 55 sites in 2022. The proportion of groups flying into roosts as trios (36%) was not significantly lower (χ^2 = 0.38, p = 0.54) than the average proportion recorded over previous GCCs (average 39% between 2010-2021, range 31% – 47%). Further analysis and a comparison of the proportion of trios recorded in the GCC with breeding rates in the Wheatbelt should be undertaken to determine if this measure is correlated with breeding success.

Table 3: The number of white-tailed black-cockatoos arriving at roosts in pairs or trios across all GCCs (2010 – 2022), with percentages in parentheses. N sites is the number of sites at which the observations were taken. The totals are not corrected for proportions of Baudin's Black-Cockatoos and Carnaby's Black-Cockatoo.

Year	Pairs	Trios	N sites
2010	329 (64%)	186 (36%)	32
2011	175 (60%)	118 (40%)	36
2012	317 (62%)	197 (38%)	36
2013	349 (69%)	157 (31%)	36
2014	250 (60%)	170 (40%)	37
2015	156 (54%)	132 (46%)	38
2016	391 (57%)	299 (43%)	57
2017	266(43%)	158 (37%)	56
2018	280 (53%)	245 (47%)	49
2019	452 (67%)	227 (33%)	43
2021	666 (60%)	443 (40%)	75
2022	322 (64%)	182 (36%)	55

Table 4: Roost count summary for Carnaby's Black-Cockatoos and white-tailed black-cockatoos across all Great Cocky Counts (2010-2022). The counts for the Perth-Peel Coastal Plain are assumed to include only Carnaby's Black-Cockatoo, whereas the counts for the Northern Darling Scarp and Plateau are corrected to account for the mixed flocks of Baudin's and Carnaby's Black-Cockatoos. The counts for the Greater Perth-Peel Region are the combined counts for Carnaby's Black-Cockatoo from the two areas. The counts for regional areas and across the species range are the totals for white-tailed black-cockatoos and not corrected for the presence of both white-tailed cockatoo species. The number of roosts is the number of occupied roosts (i.e. roosts where at least one white-tailed black-cockatoo roosted).

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2021**	**2022**
Greater Perth-Peel Region												
No. of Carnaby's Black-Cockatoo counted in **Perth-Peel Coastal Plain**	6330 (35 roosts)	3912 (37 roosts)	3791 (25 roosts)	5591 (35 roosts)	6662 (37 roosts)	4692 (37 roosts)	10919 (43 roosts)	10248 (42 roosts)	12465 (42 roosts)	13343 (34 roosts)	8428 (49 roosts)	11493 (40 roosts)
No. of Carnaby's Black-Cockatoo counted in **Northern Darling Scarp and Plateau** (corrected)	579 (total WTBC count = 1929; 15 roosts)	118 (total WTBC count = 393; 13 roosts)	248 (total WTBC count = 826; 15 roosts)	305 (total WTBC count = 1016; 14 roosts)	418 (total WTBC count = 1393; 13 roosts)	162 (total WTBC count = 540; 9 roosts)	749 (total WTBC count = 2496; 29 roosts)	654 (total WTBC count = 2180; 27 roosts)	680 (total WTBC count = 2266; 35 roosts)	641 (total WTBC count = 2137; 36 roosts)	564 (total WTBC count = 1879; 32 roosts)	364 (total WTBC count = 1213; 24 roosts)
No. of Carnaby's Black-Cockatoo counted in **Greater Perth-Peel Region**	6909 (50 roosts)	4030 (50 roosts)	4039 (40 roosts)	5896 (49 roosts)	7080 (50 roosts)	4854 (46 roosts)	11668 (72 roosts)	10902 (69 roosts)	13145 (77 roosts)	13984 (70 roosts)	8992 (81 roosts)	11857 (64 roosts)
Regional areas												
No. of white-tailed black-cockatoos counted **in regional areas**	246 (2 roosts)	610 (9 roosts)	3329 (23 roosts)	3744 (26 roosts)	4041 (29 roosts)	3182 (21 roosts)	3340 (32 roosts)	5106 (56 roosts)	5585 (63 roosts)	7167 (60 roosts)	7466 (61 roosts)	8571 (51 roosts)
Across Species Range												
No. of white-tailed black-cockatoos counted **across species range**	8505 (52 roosts)	4915 (59 roosts)	7946 (63 roosts)	10351 (75 roosts)	12096 (79 roosts)	8414 (67 roosts)	16755 (104 roosts)	17534 (125 roosts)	20316 (140 roosts)	22647 (130 roosts)	17773 (142 roosts)	21277 (115 roosts)

Table 5: The numbers of occupied roosts, new roosts discovered and roost occupancy rates for Carnaby's Black-Cockatoos in the Perth-Peel Coastal Plain and white-tailed black-cockatoos in the Northern Darling Scarp and Plateau and regional areas for each Great Cocky Count (2010 – 2022).

New roosts discovered are sites that were surveyed and had white-tailed black-cockatoos present for the first time. Occupied roosts are sites at which at least one white-tailed black-cockatoo was recorded roosting. Percentage (%) of all sites surveyed is the number of occupied roosts divided by the total number of sites volunteers surveyed during that GCC. Roost occupancy rate is the number of occupied roosts divided by the number of sites surveyed with a positive count in at least one GCC up to that year.

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021	2022
No. of new roost sites discovered												
Perth-Peel Coastal Plain	35	22	12	12	9	12	13	14	5	5	10	2
Northern Darling Scarp and Plateau	15	9	5	4	5	1	14	10	9	8	7	3
Regional	2	8	20	14	10	7	14	29	27	17	18	4
No. of occupied roosts (% of all sites surveyed)												
Perth-Peel Coastal Plain	35 (22%)	37 (30%)	25 (20%)	35 (24%)	37 (20%)	37 (22%)	43 (19%)	42 (18%)	42 (23%)	34 (21%)	49 (26%)	40 (30%)
Northern Darling Scarp and Plateau	15 (58%)	13 (50%)	15 (50%)	14 (33%)	13 (29%)	9 (22%)	30 (38%)	27 (26%)	35 (39%)	36 (40%)	32 (28%)	24 (22%)
Regional	2 (50%)	9 (60%)	23 (49%)	26 (48%)	29 (49%)	21 (33%)	32 (36%)	56 (45%)	63 (43%)	60 (41%)	61 (38%)	51 (42%)
Roost occupancy rate (% of confirmed sites surveyed)												
Perth-Peel Coastal Plain	51%	60%	38%	47%	40%	41%	41%	37%	39%	37%	43%	48%
Northern Darling Scarp and Plateau	83%	68%	68%	50%	39%	31%	57%	42%	58%	59%	43%	33%
Regional	67%	82%	74%	65%	63%	53%	58%	70%	57%	57%	51%	54%

White-tailed Black-Cockatoo Trend Analysis for the PPCP, NDSP and Regional Areas

Perth-Peel Coastal Plain (Carnaby's Black-Cockatoo)

General survey trends

The number of sites surveyed in the Perth-Peel Coastal Plain has varied from 124 to 240 across the twelve GCCs (2010-2022; Table 1). The number of occupied roosts varied between 25 and 49, with occupied roosts representing 18-30% of the total number of sites surveyed each year (Table 5). The 2021 GCC recorded the highest number of occupied roosts to date. The discovery rate of new roost sites was high in 2010 and 2011 (35 and 22), averaged 12 per year between 2012 and 2017 and rose back up to 10 in 2021 (but note that no surveys were conducted in 2020) after dropping to five per year for both 2018 and 2019 (Table 5). Only two new roosts were recorded on the Perth-peel Coastal Plain in 2022, which is the lowest number of new roosts recorded during a GCC.

Positive counts (i.e. $\geq$ 1 Carnaby's Black-Cockatoo roosting in at least one GCC, not including cleared sites) have now been recorded from 139 uncleared sites. Eight confirmed roosts have been cleared since the 2010 GCC: One was cleared prior to the 2011 GCC (COCSCCR001); two more before the 2012 GCC (COCSCCR002 and ROCBALR001), four before the 2016 count (SWALEXR002, WANJANR007, WANPINR005 and WANYANR004) and one last year (WANMARR005) (Appendix IIIa).

Largest roosts

Within the Perth-Peel Coastal Plain, the ten largest roosts (based on combined counts across years) accounted for just over two thirds (68%, or 66,619 of 97,574) of the Carnaby's Black-Cockatoos counted in the 2010-2022 GCCs (Appendix IIIa). Four of these are within the Gnangara pine plantation (GINYEAR003, WANPINR001, WANMARR003 and WANGNAR001), another two are within smaller suburban pine plantings (SOUCOMR001 in Kensington and MELMURR001 at Murdoch University). The other four are at Gingin (GINGINR001), Underwood Avenue in Floreat (CAMFLOR001), Hollywood Hospital in Nedlands (NEDNEDR001) and Dawesville (MANDAWR002).

Overall, the 40 largest roosts accounted for 92% (90,133 of 97,574) of the Carnaby's Black-Cockatoos counted in the Perth-Peel Coastal Plain across the twelve GCCs.

Occupancy rate

The fraction of occupied roosts within the Perth-Peel Coastal Plain is estimated to be declining at a rate of approximately 1.7% per year. This decline is statistically significant (p=0.0005), and equates to a reduction of about 2-3 of the 139 known roosts each year. The trends for both pine-associated (n=33, estimated decline of 2% per year) and non-pine-associated roosts (n=106, estimated decline of 3% per year) are not significantly different; both are declining.

Average size of roosting flocks

Within the Perth-Peel Coastal Plain, the average number of birds in each roosting flock is estimated to be increasing over recent years. Between 2010 and 2016 it is estimated to have declined by a total of approximately 23% (about 4% per year), but since 2016 has increased, so that the average roost size is now the same as 2010. However, it is important to note that at least 8 confirmed roosts have been cleared since 2010, and that other roosts sites may also have been cleared prior to being identified. The trends for pine-associated and non-pine-associated roosts are not significantly different.

Estimated trend in the Perth-Peel Coastal Plain region

The estimated change in the total count of Carnaby's Black-Cockatoo over the period 2010 – 2022 indicates a decline during the early years of the GCC (2010 – 2015) with the count being approximately constant since then (Figure 6). The roost occupancy rate is estimated to be declining at a rate of about 1.7% each year. Removal of the Mega Roost (which could be seen as an outlier) had no effect on these results. Between 2010 and 2014 it is estimated that the total counts of Carnaby's Black-Cockatoo were substantial underestimates of the number of birds present in the region, whereas counts after 2015 have been in close agreement with the predicted total count. This is consistent with a change in the number of occupied roosts surveyed, from 25 – 37 in 2010 – 2014, to 42 – 43 in 2016 – 2018. The low number of occupied roosts in 2019 (34) is likely due to the slightly fewer surveys undertaken that year and that several roosts in the Gnangara-Pinjar pine plantation were not surveyed. The number of occupied roosts rose in 2021 to 49, as the number of surveys rose from the previous year, but returned to around average (40) in 2022. The overall change in the estimated total count of Carnaby's Black-Cockatoos on the Perth-Peel Coastal Plain between 2010 and 2022 is a decline of 25%, or an average of 2% per year.

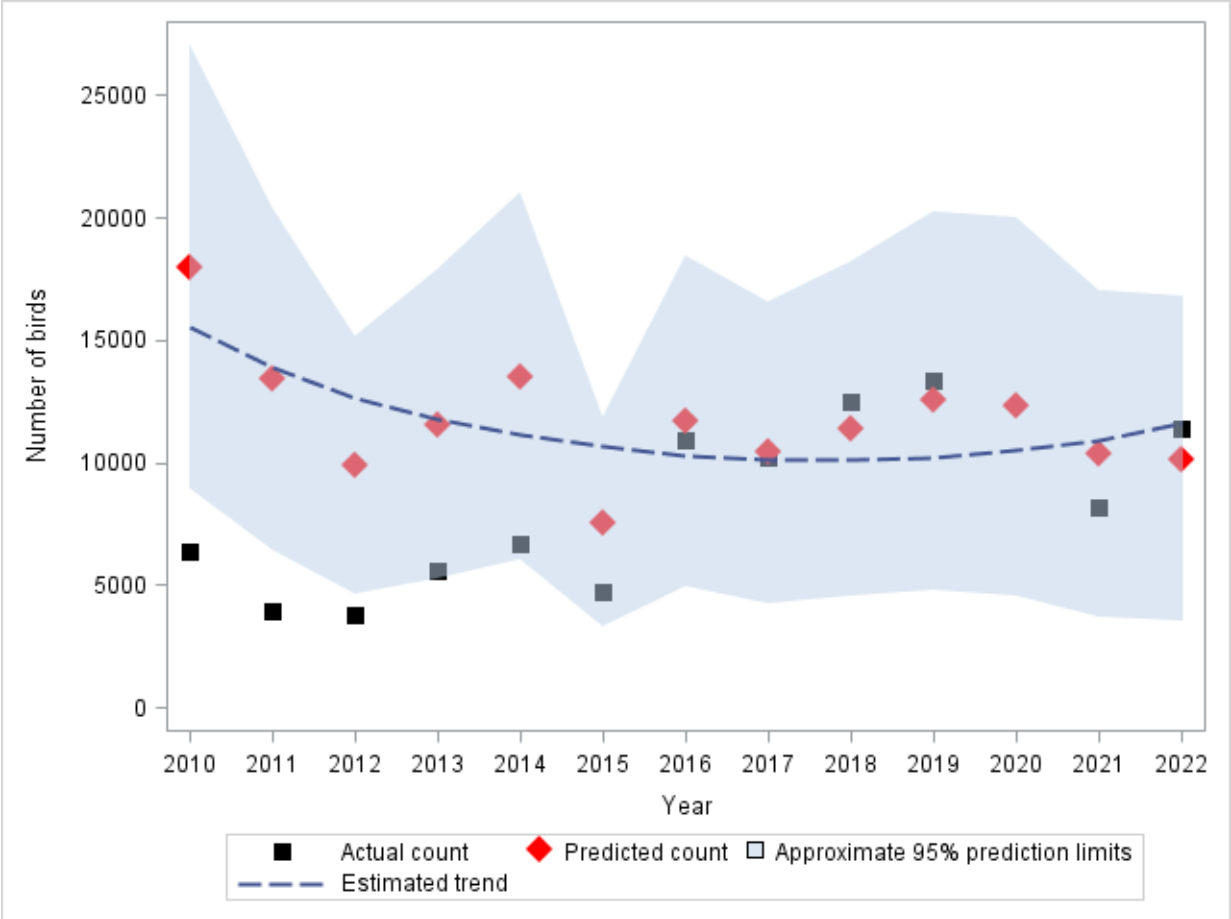

Figure 6: Change in the estimated abundance of Carnaby's Black-Cockatoo in the Perth-Peel Coastal Plain region (2010 – 2022) based on results of the Great Cocky Counts. The estimated trend in abundance (dashed line) is based on the predicted total count (red diamonds, with approximate 95% prediction limits) after accounting for roosts that were not surveyed or had been cleared. The actual roost counts for each year are shown as black squares.

Northern Darling Scarp and Plateau (white-tailed black-cockatoos, including Baudin's and Carnaby's)

General survey trends

The number of sites surveyed in the Northern Darling Scarp and Plateau has varied from 26 to 115 across the twelve GCCs (Table 1). 2021 saw the highest number of roosts surveyed in a single year. The number of occupied roosts varied between 9 and 36, with occupied roosts representing 22-58% of the total number of sites surveyed each year (Table 5). The discovery rate for new roosts was high in 2010 and 2011 with 35 and 22 roosts discovered, respectively, but declined to 2015 with an average of only 11 roosts discovered per year between 2012 and 2015.. This trend was reversed in the next five years with 48 new roosts discovered between 2016 to 2021. New roost discovery was low again in 2022 with only three new roosts confirmed.

Positive counts (i.e. $\geq$ 1 white-tailed black-cockatoo roosting in at least one GCC, not including cleared sites) have now been recorded from 92 sites. Only one confirmed roost has been cleared, prior to the 2015 GCC (MUNCHIR001) (Appendix IIIc).

Largest roosts

Within the Northern Darling Scarp and Plateau, the ten largest roosts (based on combined counts across years) accounted for 47% (8,726 of 18,522) of the white-tailed black-cockatoos counted in the 2010-2022 GCCs (Appendix IIIc).

Occupancy rate

The fraction of occupied roosts within the Northern Darling Scarp and Plateau is estimated to be declining at a rate of approximately 5% per year. This decline is statistically significant ($p < 0.0001$), and equates to the loss of about 4-5 of the 90 known roosts each year.

Average size of roosting flocks

Within the Northern Darling Scarp and Plateau, the average number of birds in each roosting flock is estimated to be declining at approximately 7% per year. This decline is statistically significant ($p < 0.0001$), and equates to the loss of about 4 birds per year from the overall average of around 57 birds at each roost.

Estimated trend in the Northern Darling Scarp and Plateau

Combining the estimated annual declines in average roost size and roost occupancy rate, the overall estimated rate of decline in the total number of birds has been 7% per year (Figure 7). Between 2010 and 2015 it is estimated that the total counts of white-tailed black cockatoos were substantial underestimates of the number of birds present in the region, whereas counts since 2017 have been in close agreement with the predicted total count. This is consistent with a substantial increase in the number of occupied roosts surveyed, from 9 – 15 in 2010 – 2015, to 27 – 36 in 2016 – 2022.

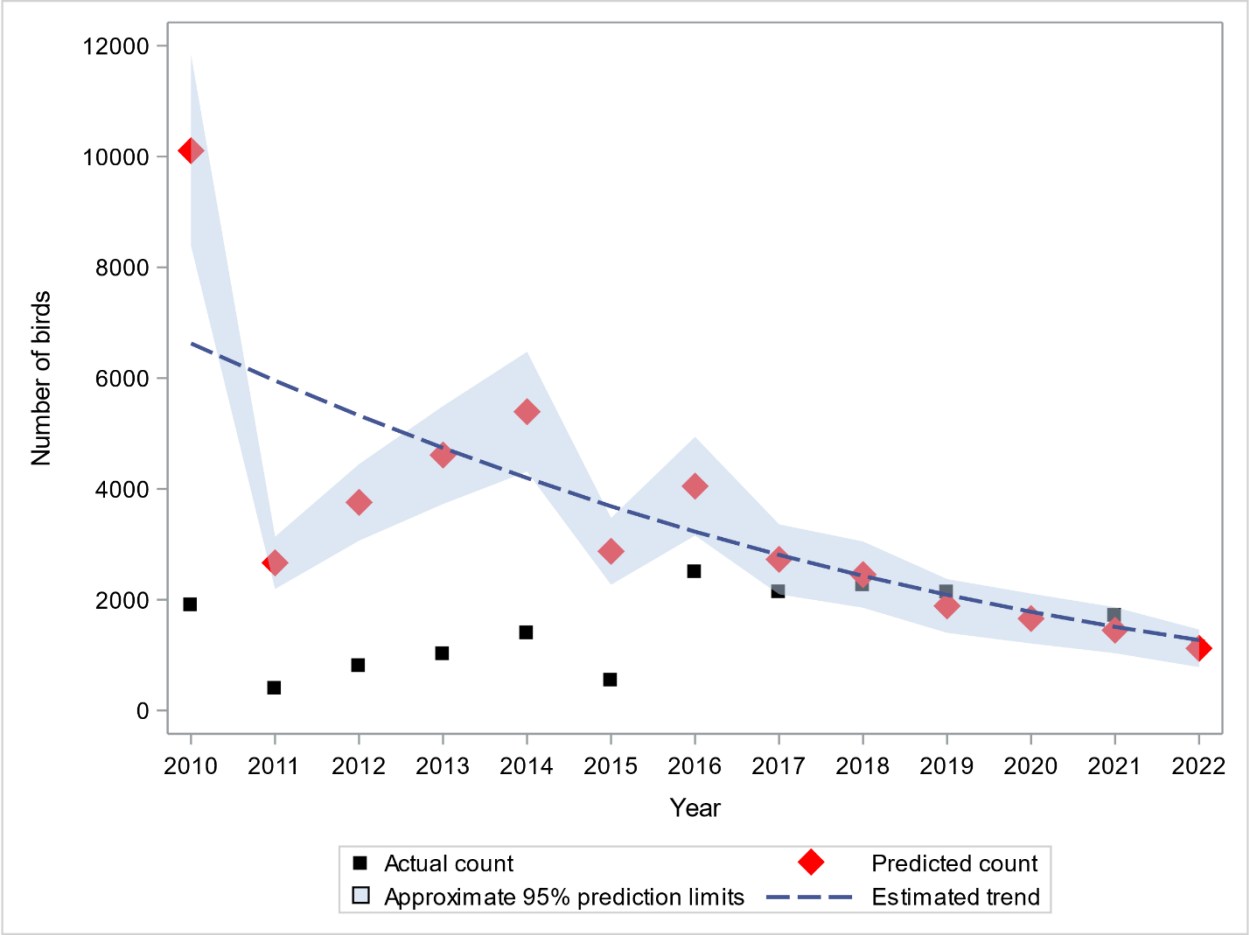

Figure 7: Change in the estimated abundance of white-tailed black-cockatoo in the Northern Darling Scarp and Plateau region (2010 – 2022) based on results of the Great Cocky Counts. The estimated trend in abundance (dashed line) is based on the predicted total count (red diamonds, with approximate 95% prediction limits) after accounting for roosts that were not surveyed or had been cleared. The actual roost counts for each year are shown as black squares.

Regional areas (white-tailed black-cockatoos, including Baudin's and Carnaby's)

General survey trends

The number of sites surveyed in regional areas has varied from four to 160 across the twelve GCCs (Table 1). The number of occupied roosts varied between two and 63, with occupied roosts representing 33-60% of the total number of sites surveyed each year (Table 5). The discovery rate for new roosts has been good since 2012, with 105 new roosts discovered in the five years between 2016 and 2021. The number of new roosts dropped in 2022 with only four new confirmed roosts discovered. Positive counts (i.e. $\geq$ 1 white-tailed black-cockatoo roosting in at least one GCC, not including cleared sites) have now been recorded from 167 sites. Three confirmed roosts have been cleared, one prior to the 2012 GCC (HARMYAR002) and two prior to the 2021 GCC (ALBKALR004 and HARWELR002) (Appendix IV).

Estimated trend in regional areas

Albany region

Occupancy rate

There was no statistically significant change in the fraction of occupied roosts within the Albany region ($p = 0.66$).

Average size of roosting flocks

Within the Albany region, the average number of birds in each roosting flock is estimated to be declining at approximately 10% per year, which is statistically significant (p=0.024).

Estimated trend in the Albany region

Combining the estimated annual changes in average roost size and roost occupancy the overall estimated rate of decline in the total number of birds is, over the past 11 years, about 7% per year (Figure 8).

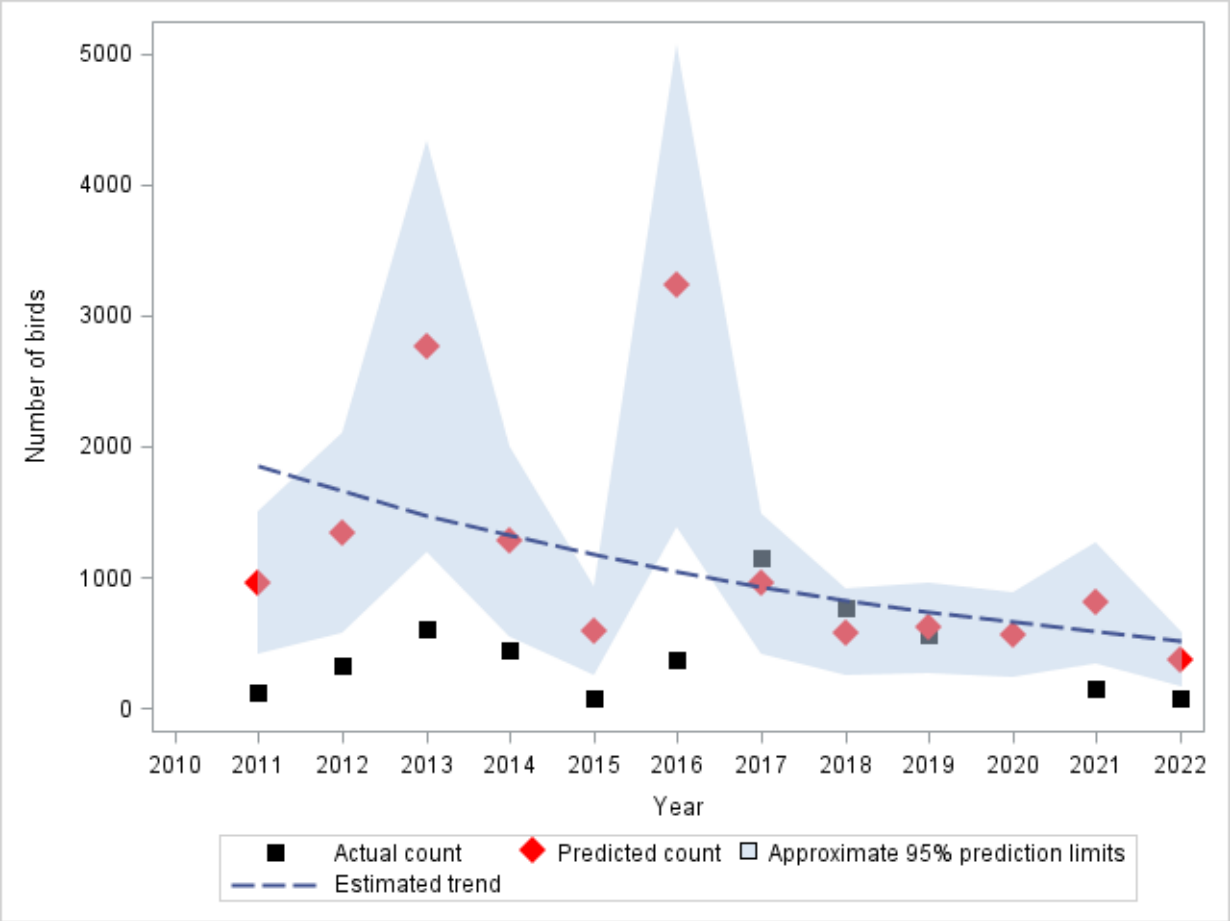

Figure 8: Change in the estimated abundance of white-tailed black-cockatoo in the Albany region (2011–2022) based on results of the Great Cocky Counts. The estimated trend in abundance (dashed line) is based on the predicted total count (red diamonds, with approximate 95% prediction limits) after accounting for roosts that were not surveyed or had been cleared. The actual roost counts for each year are shown as black squares.

Esperance region

Occupancy rate

There was no statistically significant change in the fraction of occupied roosts within the Esperance region (p=0.28).

Average size of roosting flocks

Within the Esperance region, the average number of birds in each roosting flock is estimated to be decreasing at a rate of approximately 10% per year. This decrease is statistically significant (p=0.040) and equates to a decrease of about 20 birds per year in the overall average of around 201 birds at each roost.

Estimated trend in the Esperance region

Combining the estimated annual decrease in average roost size and roost occupancy the overall estimated rate of decline in the total number of birds is about 8% per year (Figure 9). The total counts of WTBC, however, are based on relatively few roost surveys each year (between 2 and 7) and so results must be treated with caution.

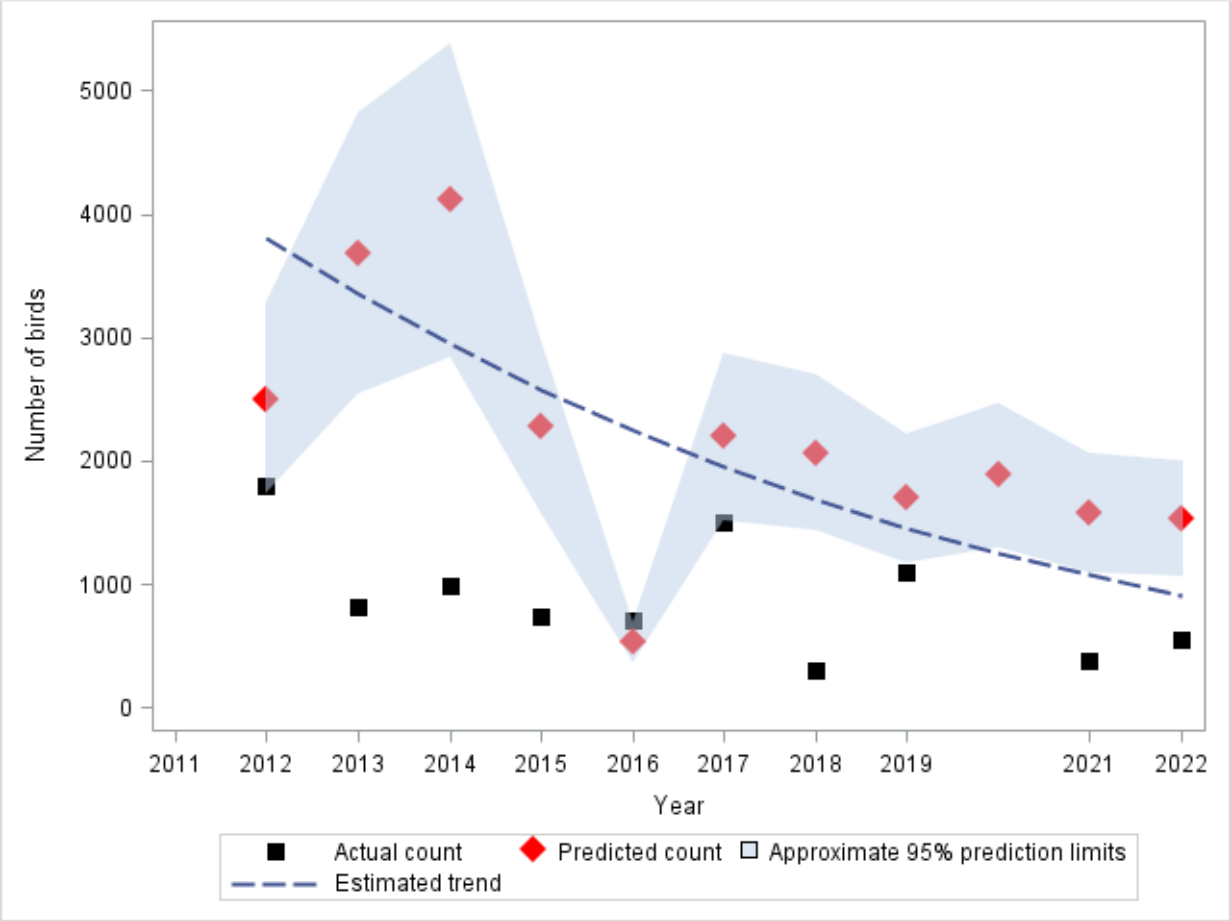

Figure 9: Change in the estimated abundance of white-tailed black-cockatoo in the Esperance region (2012 – 2022) based on results of the Great Cocky Counts. The estimated trend in abundance (dashed line) is based on the predicted total count (red diamonds, with approximate 95% prediction limits) after accounting for roosts that were not surveyed or had been cleared. The actual roost counts for each year are shown as black squares.

Forest Red-tailed Black-Cockatoo Roost Counts

Total counts

Greater Perth-Peel Region

In 2021 the GCC recorded 5,771 FRTBCs in the region. This is similar to 2018 and 2019, and much higher than the years before (Table 6). In 2022 the GCC recorded 1,488 FRTBCs in the region, less than a third of the number counted in 2021 and the lowest number counted since 2015.

Regional areas

The 2021 count for regional areas of 921 FRTBC is the highest number of FRTBCs recorded during a GCC to date (Table 6). The count in 2022 was 578 in regional areas, the lowest count since 2018.

Across species range

The total count of 6,692 birds in 2021 was similar to 2018 and 2019, and more than twice that of 2017 (Table 6). The total count of 2,066 FRTBCs in 2022 was the lowest count since 2016 and less than a third of the total count in 2021. Only one confirmed FRTBC roost has been cleared, prior to the 2021 GCC (ALBKALR004) (Appendix Vc).

Table 6: Roost count summary for Forest Red-tailed Black-Cockatoos across eight Great Cocky Counts (2014-2022). The number of roosts is the number of occupied roosts (i.e. roosts where at least one FRTBC roosted).

	2014	2015	2016	2017	2018	2019	2021	2022
Greater Perth-Peel Region								
No. of FRTBC counted in **Perth-Peel Coastal Plain**	601 (13 roosts)	305 (10 roosts)	771 (24 roosts)	1934 (39 roosts)	4037 (60 roosts)	3499 (44 roosts)	3881 (58 roosts)	509 (34 roosts)
No. of FRTBC counted in **Northern Darling Scarp and Plateau**	211 (9 roosts)	107 (7 roosts)	859 (26 roosts)	836 (38 roosts)	1023 (30 roosts)	1816 (47 roosts)	1890 (63 roosts)	979 (49 roosts)
No. of FRTBC counted in **Greater Perth-Peel Region**	812 (22 roosts)	412 (17 roosts)	1630 (50 roosts)	2770 (77 roosts)	5060 (90 roosts)	5315 (91 roosts)	5771 (121 roosts)	1488 (83 roosts)
Regional areas								
No. of FRTBC counted **in regional areas**	84 (6 roosts)	39 (5 roosts)	374 (20 roosts)	219 (18 roosts)	437 (24 roosts)	789 (28 roosts)	921 (40 roosts)	578 (26 roosts)
Across Species Range								
No. of FRTBC counted **across species range**	896 (28 roosts)	451 (22 roosts)	2004 (70 roosts)	2989 (95 roosts)	5497 (114 roosts)	6104 (119 roosts)	6692 (161 roosts)	2066 (109 roosts)

Roost counts – across species range

2021

FRTBC were recorded roosting at 161 sites across the GCC survey area, with approximately one quarter of the roosts occurring in regional areas and the remainder in the Greater Perth-Peel Region (Table 6; Figure 2). Of the 161 occupied roosts 113 had only FRTBCs, while 48 had both FRTBCs and white-tailed black-cockatoos.

At occupied roosts, counts of FRTBCs in the 2021 GCC ranged from 1 to 689, with a mean of 42 ± 6 (standard error) and a median of 21 (161 roost counts). Roost count sizes varied across the three principal survey areas. The lowest was for the regional areas (mean 23 ± 3); then the Northern Darling Scarp and Plateau (mean 30 ± 4), with the Perth Peel Coastal Plain being the highest (mean 67 ± 15).

Across the species range, the five largest roosts accounted for 29% (1,912 of 6,692 birds) of the total number of FRTBC counted (Appendix V), with all five roosts occurring on the Perth-Peel Coastal Plain. The ten largest roosts accounted for 42% (2,825 of 6,692 birds) of the total number of FRTBC counted. Eight of these roosts were located on the Perth-Peel Coastal Plain and one each on the Northern Darling Scarp and Plateau and in the regional area.

2022

FRTBCs were recorded roosting at 109 roost sites across the GCC survey area, with just under one quarter of the sites occurring in regional areas and the remainder in the Greater Perth-Peel Region (Table 6; Figure 4). Of the 109 occupied roosts 84 had only FRTBCs, while 25 had both FRTBCs and white-tailed black-cockatoos roosting.

At occupied roosts, counts of FRTBCs ranged from 1 to 130, with a mean of 19 ± 2 (standard error) and a median of 11 (109 roost counts). Roost count sizes once again varied across the three principal survey areas, with the lowest recorded in the Perth Peel Coastal Plain (mean 15 ± 3), followed by the Northern Darling Scarp and Plateau (mean 20 ± 4) and the highest recorded in regional areas (mean 22 ± 5).

Across the species range, the five largest roosts accounted for approximately 25% (507 of 2,066 birds) of the total number of FRTBCs counted (Appendix V), with two of these roosts located in the Northern Darling Scarp and Plateau, two in regional areas and one in the Perth Peel Coastal Plain. The ten largest roosts accounted for 38% (783 of 2,066 birds) of the total number of FRTBCs counted.

Roost counts – Perth-Peel Coastal Plain

2021

Within the Perth-Peel Coastal Plain, the five largest roosts (counts of 689, 382, 287, 285 and 269) accounted for 49% (1,912 of 3,881) of the FRTBC counted in this region (Appendix Va). These counts were recorded at Floreat (689), Murdoch (382), Kensington (287), Morley (285) and Jandabup (269). The roost occupancy rate was 64% for the Perth-Peel Coastal Plain (58 occupied roosts of the 90 confirmed roosts surveyed) (Table 7).

2022

In 2022, within the Perth Peel Coastal Plain, the five largest roosts (counts of 99, 54, 36, 31 and 31) accounted for 49% (251 of 509) of the FRTBCs counted in this region (Appendix Va). These counts were recorded at Floreat, Munster, Murdoch, Barragup and Yokine. The roost occupancy rate was 41% for the Perth Peel Coastal Plain (34 occupied roosts of the 82 confirmed roosts surveyed) (Table 7).

Roost counts – Northern Darling Scarp and Plateau

2021

Within the Northern Darling Scarp and Plateau, the five largest roosts accounted for 31% (578 of 1,890) of the FRTBC counted. These counts were recorded at sites in Waroona (186), Roleystone (107), Pickering Brook (99),

Byford (95) and Carmel (91) (Appendix Vb). The roost occupancy rate was 70% (63 occupied roosts of the 90 confirmed roosts surveyed) (Table 7).

City of Kalamunda recorded the highest number of birds on the Northern Darling Scarp and Plateau with 673 birds recorded from 13 roost sites of the 24 surveyed (Appendix IIb).

2022

Within the Northern Darling Scarp and Plateau, the five largest roosts accounted for 42% (410 of 979) of the FRTBCs counted. These counts were recorded at sites in Teesdale (130), Byford (108), Waroona (60 and 53) and Inglehope (59) (Appendix Vb). The roost occupancy rate was 52% for the Northern Darling Scarp and Plateau (49 occupied roosts of the 94 confirmed roosts surveyed) (Table 7).

Roost counts – Regional areas

2021

In regional areas, the five largest roosts (115, 68, 63, 48 and 42 birds) accounted for 36% (336 of 921) of the FRTBC counted (Appendix Vc). These sites were located at Donnelly River, Boyanup, Noggerup, Yarloop and Wandillup.

FRTBC were recorded at seven sites in the Shire of Donnybrook-Balingup (12 sites surveyed and 271 birds), six sites in the Shire of Capel (9 sites surveyed and 168 birds) and five sites in the Shire of Bridgetown-Greenbushes (10 sites surveyed and 130 birds) (Appendix IIb).

2022

In 2022, the five largest roost sites accounted for 53% (307 of 578) of the FRTBCs counted in regional areas (Appendix Vc). These sites were located in Mumballup (97), Greenbushes (73), Donnelly River (50), Balingup (45) and Worsley (42).

FRTBCs were recorded at seven sites in the Shire of Donnybrook-Balingup (10 sites surveyed with 142 birds counted) and five sites in the Shire of Bridgetown-Greenbushes (12 sites surveyed with 139 birds recorded) (Appendix IId).

Table 7: The numbers of occupied roosts, new roosts discovered, and roost occupancy rates for Forest Red-tailed Black-Cockatoos for each Great Cocky Count (2014 – 2022).
New roosts discovered are sites that were surveyed and had FRTBC present for the first time. Occupied roosts are sites at which at least one FRTBC was recorded roosting. Percentage (%) of all sites surveyed is the number of occupied roosts divided by the total number of sites volunteers surveyed during that GCC. Roost occupancy rate is the number of occupied roosts divided by the number of sites surveyed with a positive count in at least one GCC up to that year.

	2014	2015	2016	2017	2018	2019	2021	2022
No. of new roost sites discovered								
Perth-Peel Coastal Plain	13	5	16	25	18	13	11	2
Northern Darling Scarp and Plateau	9	6	22	21	10	17	19	6
Regional	6	4	14	11	13	14	18	5
No. of occupied roosts (% of all sites surveyed)								
Perth-Peel Coastal Plain	13 (7%)	10 (6%)	24 (10%)	39 (16%)	60 (33%)	44 (27%)	58 (31%)	34 (26%)
Northern Darling Scarp and Plateau	9 (20%)	7 (17%)	26 (33%)	38 (36%)	30 (33%)	47 (52%)	63 (55%)	49 (45%)
Regional	6 (10%)	5 (8%)	20 (23%)	18 (15%)	24 (16%)	28 (19%)	40 (25%)	26 (21%)
Roost occupancy rate (% of confirmed sites surveyed)								
Perth-Peel Coastal Plain	39%	34%	47%	63%	78%	56%	64%	41%
Northern Darling Scarp and Plateau	41%	44%	60%	61%	48%	69%	70%	52%
Regional	75%	63%	83%	51%	55%	57%	68%	47%

Forest Red-tailed Black-Cockatoo Trend Analysis for the PPCP and NDSP

Perth-Peel Coastal Plain

General survey trends

The number of sites surveyed in the Perth-Peel Coastal Plain has varied from 132 to 240 (Table 1). The number of occupied roosts varied between 10 and 60, with occupied roosts representing 6-33% of the total number of sites surveyed each year (Table 7). The discovery rate of new roosts has averaged at 13 per year since FRTBCs were incorporated into the count in 2014, however only two new roosts were discovered in 2022.

Positive counts (i.e. $\geq$ 1 FRTBC roosting in at least one GCC, not including cleared sites) have now been recorded from 99 sites. No confirmed FRTBC roosts have been cleared since 2014, although one (VICLATR001) has been partially cleared.

Largest roosts

Within the Perth-Peel Coastal Plain, the ten largest roosts (based on combined counts across years) accounted for 68% (10,798 of 15,884) of the FRTBCs counted in the 2014-2022 GCCs (Appendix Va).

Estimated trend in the Perth-Peel Coastal Plain region

Despite a recent history of an increased proportion of occupied roosts, there is no statistically significant change of occupied roosts within the Perth-Peel Coastal Plain from 2014 - 2022 ($p = 0.63$).

Likewise, there is no statistically significant change of average roosting flock size 2014 – 2022 ($p = 0.38$).

With no statistically significant change in roost occupancy nor in the average size of roosting flocks, there is no linear trend in the total number of FRTBCs in the Perth-Peel Coastal plain from 2014 - 2022 (Figure 10). Note as survey coverage of FRTBC roosts has increased, the total counts of FRTBC have been in close agreement with the predicted total count.

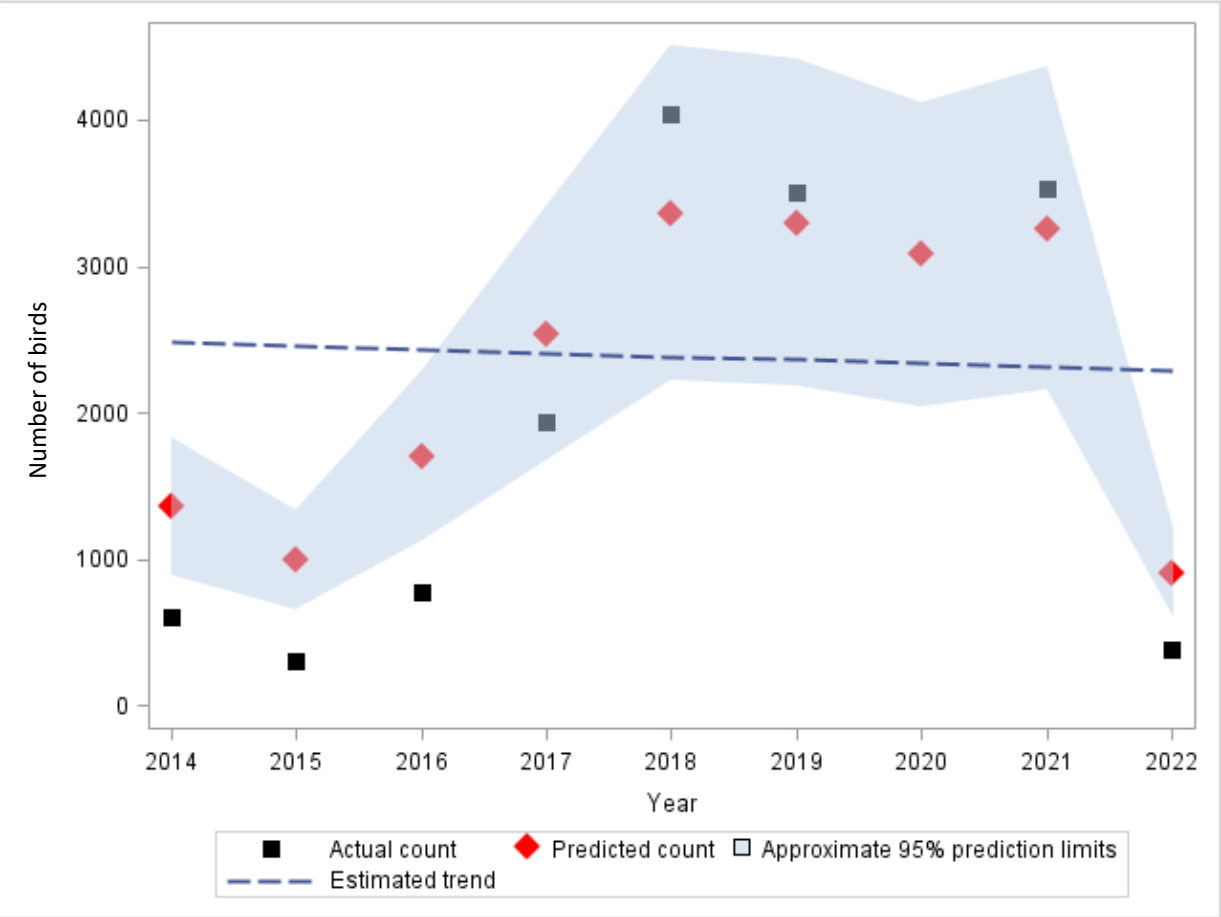

Figure 10: Change in the estimated abundance of Forest Red-tailed Black-Cockatoo in the Perth-Peel Coastal Plain region (2014 – 2022) based on results of the Great Cocky Counts. The estimated trend in abundance (dashed line) is based on the predicted total count (red diamonds, with approximate 95% prediction limits) after accounting for roosts that were not surveyed or had been cleared. The actual roost counts for each year are shown as black squares.

Northern Darling Scarp and Plateau

General survey trends

The number of sites surveyed in the Northern Darling Scarp and Plateau varied from 43 to 115 (2014-2022) (Table 1). The number of occupied roosts varied between 7 and 63, with occupied roosts representing 17-55% of the total number of sites surveyed each year (Table 7). The discovery rate of new roosts was fairly low in 2014 and 2015, averaged 18 per year between 2016 and 2021, and dropped back down to 6 new roosts in 2022.

Positive counts (i.e. $\geq$ 1 FRTBC roosting in at least one GCC) have now been recorded from 115 sites.

Largest roosts

Within the Northern Darling Scarp and Plateau, the ten largest roosts (based on combined counts across years) accounted for 31% (2,339 of 7,482) of the FRTBCs counted in the 2014-2022 GCCs (Appendix Vb).

Occupancy rate

There is no statistically significant change of occupied roosts within the Northern Darling Scarp and Plateau ($p = 0.60$).

Average size of roosting flocks

There is no statistically significant change of the average size of roosting flock within the Northern Darling Scarp and Plateau (p = 0.42).

Estimated trend in the Northern Darling Scarp and Plateau

The period 2014 – 2021 showed an upward trend in counts of FRTBC, but this trend was arrested by the markedly lower count in 2022 (Figure 11).

In 2014 and 2015 it is estimated that the total counts of FRTBC were substantial underestimates of the number of birds present in the region, whereas counts since 2017 have been in closer agreement with the predicted total count. This is consistent with a change in the number of occupied roosts surveyed, from 7 – 9 in 2014 – 2015, to 30 – 47 in 2017 – 2019.

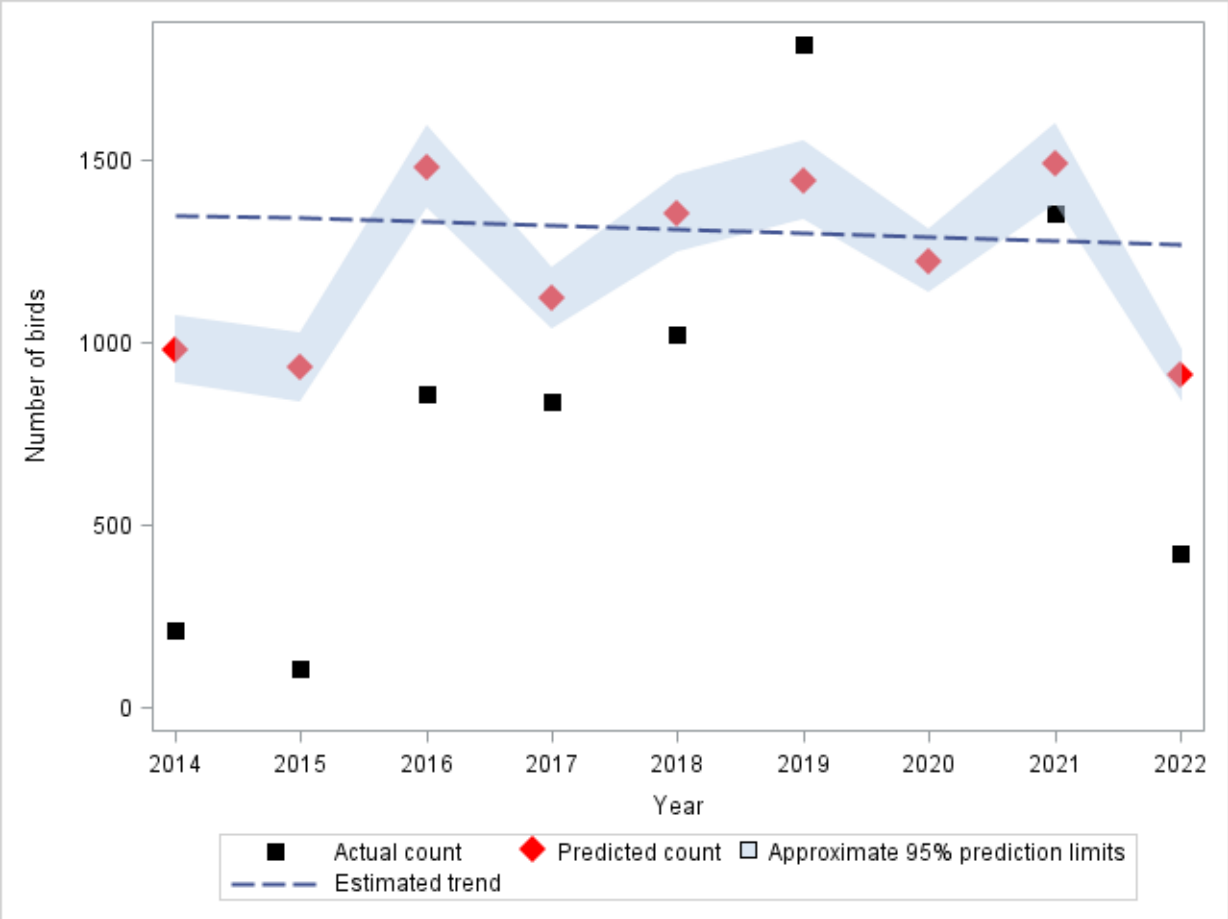

Figure 11: Change in the estimated abundance of Forest Red-tailed Black-Cockatoos in the Northern Darling Scarp and Plateau region (2014 – 2022) based on results of the Great Cocky Counts. The estimated trend in abundance (dashed line) is based on the predicted total count (red diamonds, with approximate 95% prediction limits) after accounting for roosts that were not surveyed or had been cleared. The actual roost counts for each year are shown as black squares.

Spring Forest Red-tailed Black-Cockatoo Counts

Survey coverage of FRTBC roosts included during the Spring FRTBC Counts has increased from 15 in 2018 to 66 in 2022 (Table 8) (Appendix Vd; Appendix Ve). As the number of roost sites has risen, so has the total number of FRTBCs counted, with 1,290 birds recorded across the Greater Perth-Peel Region compared to just 43 in 2018. Site coverage and survey effort for the smaller Spring FRTBC Count in October is still much lower than that for the FRTBCs incorporated into the March/April GCC, so analysing both together is not appropriate. Instead, Table 8 outlines the count results collected during the annual Spring FRTBC Counts to date.

Table 8: The numbers and locations of sites surveyed, number of occupied roost (as a percentage of all sites surveyed), average roost counts ± standard error and total numbers of FRTBCs counted during the Spring FRTBC Counts.

	2018	**2019**	**2020**	**2021**	**2022**
Sites Surveyed					
Northern Darling Scarp and Plateau	2	18	26	28	34
Perth-Peel Coastal Plain	13	18	19	37	32
Greater Perth-Peel Region	15	36	45	65	66
Sites Occupied (Occupancy Rate)					
Northern Darling Scarp and Plateau	1 (50%)	11 (61%)	18 (69%)	20 (71%)	27 (79%)
Perth-Peel Coastal Plain	2 (15%)	11 (61%)	9 (47%)	18 (49%)	19 (59%)
Greater Perth-Peel Region	3 (20%)	22 (61%)	27 (60%)	38 (58%)	46 (70%)
Average Roost Counts					
Northern Darling Scarp and Plateau	15 ± 15	23 ± 11	15 ± 4	24 ± 6	26 ± 5
Perth-Peel Coastal Plain	1 ± 1	20 ± 6	13 ± 4	7 ± 2	13 ± 5
Greater Perth-Peel Region	3 ± 2	21 ± 6	14 ± 3	14 ± 3	20 ± 3
Total Counts					
Northern Darling Scarp and Plateau	29	419	402	670	890
Perth-Peel Coastal Plain	14	353	246	251	400
Greater Perth-Peel Region	43	772	648	921	1290

Baudin's Black-Cockatoo Roost Counts in the NDSP Region

The estimated number of Baudin's counted has varied between 275 and 1,747 over the last twelve GCCs, with an average of 1,066 (Table 9). Counts for white-tailed black-cockatoos can be used as a proxy for Baudin's Black-Cockatoos in the Northern Darling Scarp and Plateau since we estimate that 70% of these are Baudin's. The estimated decline in this region is 7% per year since 2010 (Figure 7).

Table 9: Roost count summary for Baudin's Black-Cockatoo across all Great Cocky Counts (2010-2022). The counts are corrected to account for the mixed flocks of Baudin's (70%) and Carnaby's Black-Cockatoos (30%). For regional counts see Table 4 for total counts of white-tailed black-cockatoos. The number of roosts is the number of occupied roosts (i.e. roosts where at least one white-tailed black-cockatoo roosted).

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021	2022
No. of Baudin's Black-Cockatoo counted in **Northern Darling Scarp and Plateau** (corrected)	1350 (total WTBC count = 1929; 15 roosts)	275 (total WTBC count = 393; 13 roosts)	578 (total WTBC count = 826; 15 roosts)	711 (total WTBC count = 1016; 14 roosts)	975 (total WTBC count = 1393; 13 roosts)	378 (total WTBC count = 540; 9 roosts)	1747 (total WTBC count = 2496; 29 roosts)	1526 (total WTBC count = 2180; 27 roosts)	1586 (total WTBC count = 2266; 35 roosts)	1496 (total WTBC count = 2137; 36 roosts)	1315 (total WTBC count = 1879; 32 roosts)	849 (total WTBC count = 1213; 24 roosts)

IV. DISCUSSION

Community Engagement and Training

Participation in the 2021 and 2022 Counts

The 2021 and 2022 Great Cocky Counts included 755 and 612 registered volunteers respectively, but both are likely to have exceeded 1,200 participants each, making the GCC once again one of the largest citizen science field surveys in Australia. Volunteers surveyed 462 sites throughout the southwest of the state in 2021, the second largest number of sites surveyed in a year (469 sites were surveyed in 2017). In 2022 volunteers surveyed 362 sites throughout the southwest. Although the lower number of volunteers in 2022 was likely influenced by the recent spread of COVID-19 throughout southwest WA in the lead up to the GCC, the impact of volunteer illness on the count was minimised by an altered site allocation process that prioritised counters at important roost sites and where possible allocated two volunteers to each site as a contingency. This method seemed to work better than previous approaches and will be considered for future years. Although less sites were surveyed, since the approach prioritised the most frequented and important roost sites, it is unlikely to have significantly influenced the numbers of birds counted between years. In fact, more birds were recorded in 2022 than in 2021, despite 100 fewer roost sites being surveyed.

Workshops

Despite running the GCC for many years, workshops remain popular with approximately 400 people attending 11 training workshops in 2021, and 300 people attending 13 training workshops in 2022. Workshop locations continue to be scheduled to target locations where volunteers are needed most and in areas close to active GCC roost sites, as well as with the added focus of increasing our presence in regional areas.

The workshops focus on Black-Cockatoo behaviour, identification, ecology and threats, as well as training in counting them for the GCC. When a workshop venue is close to a roost site, we sometimes incorporate a visit to the roost site so people can get a sense of how to count birds as they come in to roost firsthand. Sometimes workshops are held in conjunction with other presentations relating to local conservation and biodiversity projects. The Black-Cockatoo and Great Cocky Count Workshops have multiple goals: education, training, awareness raising and community networking. Every attempt is made to make them engaging and entertaining and they will continue to evolve and be an integral part of the GCC calendar.

The introduction of the online LMS GCC course in 2021 and 2022 is another way BirdLife is trying to make the GCC and training more accessible for prospective volunteers. The course allows registrants to go through the information at their own pace, and gives access to additional information and a forum where they can ask questions of other participants or staff. We will continue to develop the online resources and make the LMS material available to registered volunteers of the Great Cocky Count each year.

Volunteer retention

26-66% of the volunteers for the 2012-2022 GCCs having participated in at least one previous GCC. While some participants volunteer to survey particular sites each year, leading to the accumulation of skill and experience for survey of those roosts, many volunteers participate only once. Some volunteers have expressed disappointment at there not being black-cockatoos at their allocated site, yet scarcity is an inescapable aspect of monitoring threatened species, and expending effort to confirm unoccupied roosts is central to an accurate assessment of black-cockatoo population trajectories. Birdlife has endeavoured to communicate the importance of nil results in building our overall understanding of the black-cockatoo species in the southwest, and we are strongly encouraging participants to return each year to help build on previous GCC's findings. Some roosts in the database may be day roosts or feeding areas and Birdlife is in the process of amending this

in the database. Nil results as a percentage of all surveys have been below 50% for the last four years, remaining steady at 45% to 46% (Table 10). This is much lower than the average from 2010 to 2017 of 66% of roost surveyed producing nil results.. A survey of volunteers after the count showed that an overwhelming majority (95%) enjoyed participating in the 2021 and 2022 GCCs and 98% said they would participate in future Great Cocky Counts. However, 3% of respondents expressed disappointment and 6% felt instructions on counting and how to locate their site were poor (Appendix VI). These are issues that we are continually trying to address and improve on.

Table 10: Nil results as a percentage of all sites surveyed in the GCC (2010-2022)

2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021	2022
72%	64%	69%	69%	66%	71%	62%	57%	46%	46%	45%	45%

Improving community training and engagement

The Great Cocky Count remains an effective program for training and engaging community members in the monitoring of black-cockatoos. The expertise and dedication of the GCC volunteers are essential to the success of the Great Cocky Count, and BirdLife Australia strives to continually improve the scientific quality of the GCC and the experience of the volunteers involved.

Considerations for improving future GCCs and roost site data collection include:

- trialling online booking of some survey sites,
- increasing engagement and support for volunteers in regional and peri-urban areas,
- increasing access to training materials by expanding online LMS information,
- keeping volunteers engaged in black-cockatoo recovery events throughout the year,
- exploring different ways to distribute and convey the results of the GCCs, and
- recording the presence and location of occupied roosts at different times of year.

BirdLife believes in giving back to volunteers and community by being transparent in our results through the production of annual GCC reports. Unfortunately, considerable delays were experienced in the analysis of results and production of the final report in 2021 and 2022. This was due to a combination of staff turnover, software issues and the legacy of covid. In previous years, DBCA staff were responsible for the advanced trend analysis using SAS code and software. With this resource no longer available, from 2023 the plan is to convert the SAS Code into R Code and transfer the responsibility of all data analysis to BirdLife. Once this has been achieved it is hoped that this will prevent any future delays in analysis and reports. We appreciate that the delay has been frustrating to many and thank all our dedicated volunteers and stakeholders for their patience.

Roost site identification and timing of the Great Cocky Count

Roost Site Identification

Community reporting identifying previously unknown roosts for black-cockatoos in rural and peri-urban areas in the Greater Perth-Peel Region and in regional areas across the species range continues.

In 2022 it is likely that nearly all of the larger, frequently utilised roosts in the urban portions of the Perth metropolitan area have now been identified, keeping in mind that many roost sites are used infrequently (making their use difficult to document) and that black-cockatoos may occupy new sites if existing roosts are degraded or cleared, or the availability of nearby food resources changes.

In 2021, 10 previously undetected roosts for Carnaby's Black-Cockatoos in the Perth-Peel Coastal Plain were discovered, and in 2022 only two new roosts on the Perth-Peel Coastal Plain were discovered, the lowest number of roosts discovered since the counts started in 2010 (Table 5). This provides further indication that the majority of roost sites have been discovered in this area. The trend in the discovery of new roost sites for white-tailed black-cockatoos in regional areas was the opposite to that of the Perth-Peel Coastal Plain, with low discovery in rates in the first two years when the focus was on the Greater Perth-Peel Region, before increasing in the following years peaking at 29 new roosts discovered in 2018, as more attention was placed on regional areas. Discovery of new roosts on the Northern Darling Scarp and Plateau has been more variable over the years compared with other two regions. The discovery of new roosts was notably low across all regions in 2022 with only nine new roost sites discovered overall. It is unknown if there was a particular reason behind the low detection rate this year.

The discovery of new Forest Red-tailed Black-Cockatoo (FRTBC) roost sites remained strong in 2021 similar to recent years with 48 new roost sites discovered overall. The discovery of new roosts in 2022 was substantially lower with only 13 new roosts discovered overall, a trend also seen in white-tailed black-cockatoo roost detection. The discovery rate of new FRTBC roost sites has been decreasing on the Perth-Peel Coastal Plain since 2017 and it is possible that, like the Carnaby's, the majority of new roosts have already been detected in this area.

Since 2015, research at Murdoch University has identified many new roosts across the southwest by satellite and GPS tracking black-cockatoos of all three species which have been injured, rehabilitated and released. These roosts continue to be incorporated into the GCC database, with many of the sites reported from earlier years now classified as confirmed roosts within the database having had a positive count in one or more GCCs.

It is likely that some roosts remain to be identified in the rural and semi-urban portions of the Perth-Peel Coastal Plain, particularly in the northern (Moore River catchment) and southern (Lake Clifton) extremities of the region. The southern and eastern portions of the Northern Darling Scarp and Plateau remain less well surveyed for roosts of Carnaby's Black-Cockatoo (Johnstone *et al.* 2010; Lee *et al.* 2013) and large roosts for all three species will most probably continue to be discovered in regional areas.

Survey Timing

Ongoing monthly monitoring at several sites in the Greater Perth-Peel Region, including at Collier Park (SOUCOMR001) from 2009 to 2015 (Appendix VIIb) and Hollywood Hospital (NEDNEDR001) from 2006 to 2009 (Berry and Owen 2009), as well as regional counts at Gingin townsite undertaken from 2016 to January 2023 (Appendix VIIa), continue to support that March-April remains the optimal time to conduct the Great Cocky Count. Although monitoring has recorded changes in numbers of Carnaby's throughout the year on the Swan Coastal Plain, peak abundance occurs from February to May, in the noongar seasons of Bunuru and Djeran, and lowest abundance occurs from September to November, in the Noongar seasons of Djilba and Kambarang. These fluctuations throughout the year reflect both seasonal changes in local availability of food and water, and the migration pattern of the species (most adult Carnaby's migrate to their Wheatbelt breeding areas

between June and December). These data also support the timing of the GCC in March-April, as they are present in high numbers in coastal areas at this time of year and hence this presents the best opportunity to collect robust population estimates. Despite aiming to continue to hold future GCCs at the same time of year, continuing to encourage year-round reports of black-cockatoo roosting sites remains important to identify critical habitat and follow seasonal movements.

Over time the GCC has grown from a Perth-Peel survey of Carnaby's Black-Cockatoo to a southwest survey of all three species of southwest black-cockatoos. Baudin's Black-Cockatoo move northward to the central and northern parts of the Darling Scarp in early February and March to forage during the non-breeding season, before beginning to move southwards again to their breeding range in August to October (Johnstone *et al.* 2010). The presence of Baudin's in more populated areas on the Northern Darling Scarp and Plateau during the time of the GCC, also indicates that the autumn months are the best time to survey for population numbers of the species. Comparison of the GCC and Spring FRTBC Count data indicate that more FRTBCs are present on both the Perth-Peel Coastal Plain and at known roost sites on the Northern Darling Scarp and Plateau during the autumn months, making it easier to record and count FRTBCs during this time (see further discussion on page 45 - 46). Although annual movement patterns of these species may vary with food availability and the timing of breeding, as seen by the change in FRTBC numbers in 2022, long-term studies such as this one remain important to detect these trends. Since the GCC takes place in the non-breeding season for Carnaby's and Baudin's and in many years for FRTBCs, it is well placed to continue each April, and facilitate ongoing, robust trend analysis.

In addition, the exact timing of the GCC is influenced by other factors that enable maximum volunteer participation. April coincides with the Easter period and school holidays. Therefore, the timing of the GCC can vary over the space of several weeks as efforts are made to avoid the Easter long weekend and peak school holiday time when people may be away and unable to participate. This is the main reason why the 2021 GCC occurred in late March instead of April.

White-tailed Black-Cockatoo Counts and Trends

Perth-Peel Coastal Plain – Carnaby's Black-Cockatoos

The decline in the number of new roost sites detected in recent years lends confidence to the notion that a substantial proportion of the Carnaby's Black-Cockatoo roosting sites in the Perth-Peel Coastal Plain are being effectively incorporated in the GCC. In the earlier GCCs, between 2010 and 2015, we estimate that the number of birds counted was substantially less than the number present in the region, simply because not all of the roost sites had been identified or were surveyed each year. The shortfall in the number of birds counted has reduced each year, as more of the roosts were located and more volunteers joined the GCC. The only large roosts identified since 2010 in the Perth-Peel Coastal Plain have, with a few exceptions, generally been roosts associated with the Gnangara pine plantation.

Despite confidence in GCC survey coverage, there is currently no reliable method of estimating the proportion of Carnaby's Black-Cockatoos that go undetected. Without this information, the GCC count data can only provide a minimum population estimate. Should a method for estimating the proportion of undetected birds become available, it will be possible to estimate the overall population size for Carnaby's Black-Cockatoo. The statistical approach applied here and the focus on trends in measurable parameters (i.e. roosting flock size and occupancy rates), are appropriate, given these limitations.

While the estimated change in the total count of Carnaby's Black-Cockatoos on the Perth-Peel Coastal Plain between 2010 and 2022 continues to show an overall decline, counts over the last six years have remained approximately constant, indicating that the estimated total numbers of Carnaby's Black-Cockatoos may have stabilised in recent years. Taking into account the stabilising effects of the 2021 and 2022 counts, the overall decline since 2010 is now estimated at 25%, or on average 2% per year, compared to an overall decline of 35%

based on the 2019 data. It is not clear whether the overall decline reflects mortality of adult birds, reduced survivorship of juvenile birds, reduced breeding effort or success, emigration of birds from the Perth-Peel Coastal Plain region, reduced food resources, or the displacement of birds from existing to new roost sites. Similarly, the increase in the count since 2016 may be the result of birds moving from other regions onto the coastal plain. Further research is needed to elucidate the relative contribution of these factors to the decline. Nonetheless, it would be prudent to take a precautionary approach and focus conservation efforts on addressing all of these factors, until a better understanding of the demographics of Carnaby's Black-Cockatoo emerges.

The total count of Carnaby's Black-Cockatoos on the Perth-Peel Coastal Plain was the lowest count recorded since 2015, despite a record number of roosts in the region being surveyed (49 roosts). This contributed to the lowest overall total count of white-tailed black-cockatoos counted across the species range since 2017. A major contributing factor to the low count on the Perth-Peel Coastal Plain was likely the much lower count at what has become known as the Mega Roost (GINYEAR003) in the Gnangara Pine Plantations (Appendix IIIb). In 2021 a total of 1,982 Carnaby's Black-Cockatoos were counted at the Mega Roost, compared to an average of 4,949 birds between 2016 and 2019. There are several possible reasons behind the lower-than-expected count at the Mega Roost this year –

1. Reduction in extent of Gnangara Pine Plantation, harvesting of former roost sites and fragmentation of remaining stands. Reports from experienced site volunteers noted changes in the Carnaby's behaviour, including birds flying lower in the landscape through valleys making them harder to count, birds quieter than normal and that their flight patterns were less predictable between nights. While we tried to account for this in the placement of counters at the Mega Roost, it is possible that the roost was undercounted and that a substantial number of birds were missed due to the changes in their behaviour and unpredictable flight patterns.
2. Poor seed set in the pines across the Perth-Peel Coastal Plain in 2021 (Peter Mawson, pers. comm.). Considering this, Carnaby's may have already moved on from the Mega Roost by the time of the Great Cocky Count to other undetected roost sites due to the lack of food in the pines. Later site visits also seemed to support the theory that there were less Carnaby's present within the pines than normal.

To address this, in 2022 a new method of counting the Carnaby's Black-Cockatoos within the Gnangara Pine Plantation was adopted. Volunteers were stationed at fifteen strategic locations surrounding the larger Gnangara Pine Plantation region and recorded all Carnaby's Black-Cockatoos flying into the Pine Plantation area. The time of sightings and the direction the birds were moving were also recorded to eliminate double counting by adjacent teams. This approach worked well, and 5,032 birds were recorded in the vicinity of the Mega Roost during the 2022 GCC. With the pine plantations continuing to be cleared, we plan to continue using this method in future years.

The Great Cocky Count continues to demonstrate the importance of the Gnangara Pine Plantations to Carnaby's Black-Cockatoos. During the 2021 and 2022 Great Cocky Counts, 63% and 68% of all Carnaby's Black-Cockatoos counted on the Perth-Peel Coastal Plain were recorded roosting at sites within or associated with the Gnangara Pine Plantations. The proportion of Carnaby's recorded in the pine plantations during the GCC has remained steady since the Mega Roost was discovered in 2016 at between 62 and 73%. The importance of the Gnangara pines to the Perth-Peel population has been well documented over the years through observations and studies (Perry 1948; Saunders 1974, 1980; Shah 2006; Finn et al. 2009; Johnstone et al. 2010; Stock et al. 2013). Satellite and GPS telemetry studies by Murdoch University have also demonstrated that Carnaby's forage and roost in most of the remaining plantations. GCCs prior to 2016 are likely to have underestimated the number of birds present in the Gnangara pine plantation as it is problematic to survey, for several reasons. Firstly, at their maximum the plantations covered an area of more than 23,000 ha and extended for over 50 km from north to south. Secondly, the density of the pine stands makes it difficult to obtain clear sightlines for locating roost sites or counting birds as they fly into roosts. Thirdly, Carnaby's Black-Cockatoos feed throughout the plantation system (Stock et al. 2013) and may roost at sites within the

plantation system where they are harder to locate (Finn et al. 2009). Fourthly, much of the plantation is remote from human settlement, with few roads, creating issues of access and volunteer safety. Finally, within the plantation there is a high density of food and ample roosting locations – so we expect that Carnaby's Black-Cockatoos may shift between roosting locations, both from day to day and from year to year, making it problematic to select reliable survey sites.

A population viability analysis of Carnaby's in the Gnangara pine plantations (Williams et al. 2017) estimated that clearing of the pine plantations north of Perth without revegetation would result in a 56% decline in the Perth-Peel subpopulation of Carnaby's Black-Cockatoos by 2050 and an overall decline of up to 11% as a species. Despite ongoing concerns raised by BirdLife Australia and other environmental organisations demonstrating how clearing the pines without replacement would significantly impact the Carnaby's population, there has been very little action taken to date. There are now approximately 4,000ha of mature pine plantations remaining which are being harvested at roughly 1,000 hectares/year. Small scale revegetation of fallow land with native plant species has been occurring over the last few years, carried out by DBCA. A commitment to a cessation of harvesting until large-scale revegetation can provide suitable alternative food sources is needed to support the Carnaby's population in the post-pine era.

Northern Darling Scarp and Plateau

The percentage of occupied roosts and the average number of birds in each roosting flocks in the Northern Darling Scarp and Plateau region have both continued to decline significantly. Combined, the overall estimated rate of decline in the total number of birds is 7% per year. Despite 2022 having the second highest number of roost sites counted across the region since the start of the Great Cocky Count in 2010, only 22% were occupied by white-tailed black-cockatoos, the equal lowest percentage recorded. The roost occupancy rate (percentage of confirmed sites surveyed) of 33% was also the second lowest recorded since 2010.

The 7% per year decline in the total number of birds on the Northern Darling Scarp and Plateau is much steeper than the 2% decline per year on the Perth-Peel Coastal Plain. Unlike the trend on the Perth-Peel Coastal Plain there has been no evidence of stabilisation in recent years. It is not clear to what extent this decline reflects mortality of adult birds, reduced survivorship of juvenile birds, reduced breeding effort or success, emigration of birds from the region or the displacement of birds from existing to new roost sites. Further research is needed to identify the reasons for the decline and to inform land management strategies to mitigate it.

A 7% yearly decline is of particular concern for population estimates for the Critically Endangered Baudin's. Over the past few years, a ratio of 30% Carnaby's to 70% Baudin's was used to estimate count abundance across sites on the northern Darling Scarp based on previous years counts and known proportions at some sites. Historically Baudin's Black-Cockatoos have accounted for the majority of white-tailed black-cockatoos observed at roosts in the Armadale-Kalamunda-Mundaring area, and are also likely to have been the predominant species at roosts in other sections of the Northern Darling Scarp and Plateau (Johnstone and Kirkby 2008). However, Carnaby's Black-Cockatoo is still present at low densities throughout the Jarrah-Marri Forest (e.g. Lee et al. 2013). There have been anecdotal reports from several experienced long-term counters that the numbers of Baudin's Black-Cockatoos have been decreasing at their regular roost sites. Closer investigation is necessary to reassess the proportions of Carnaby's to Baudin's in this area, to inspect whether this decline is the result of a reduction in one or both of these species.

Regional areas

The total count of white-tailed black-cockatoos in regional areas continued to rise in 2021 and 2022, with 2022 recording the highest count to date at 8,571 birds. Sites incorporated much of the species range, with roost counts conducted at sites in the Chapman Valley to the north, Esperance to the east, around the western and southern coasts, and inland to Narrogin and Kojonup.

Unlike the Perth-Peel Coastal Plain and the Northern Darling Scarp and Plateau, an overall trend analysis can't be performed for the remainder of the southwest, due to the variation in broadscale site coverage. Trend analysis has been conducted for the regional centres of Albany and Esperance, where consistent monitoring has been achieved. Both the proportion of occupied roosts and the average size of roosting flocks have decreased in both locations, producing overall declines in the total number of birds. While these trend analyses should be treated cautiously due to the relatively few roost sites surveyed each year in these areas, reports from local residents in these areas note an observable decline in the number of birds seen within these regions, anecdotally associated with changes in land use and the clearing of pine and blue gum plantations in the vicinity of roost sites. Once again, it is unclear what factors are behind the local declines, however there is more scope for displaced birds to move from existing to currently undiscovered roosts. In regional areas, aside from the Murdoch University tracking program, new roosts are predominantly discovered through reports from residents. Given the lower human population densities in rural and regional areas, it is likely that many roosts, including new roosts, remain undetected.

Although trend analysis is not possible for most of the regional areas, the GCC still provides us with information about the regional distribution of white-tailed black-cockatoos. The Nilgen (GINNILR001) and Jurien Bay (DANJURR001) roosts along the west coast north of Perth remain active and important roost sites for Carnaby's. Although there are relatively few known roosts north of the Perth-Peel Coastal Plain, many of these roosts record larger counts. In agricultural landscapes and areas lacking tall trees (e.g. coastal heathlands), the availability of water and suitable roosting trees may lead to birds concentrating in large numbers at particular roost sites. The same is often observed along the south coast between Albany and Cape Arid National Park. On-going monitoring of these sites and discovery of additional sites will provide valuable information about population trends in regional areas. Carnaby's Black-Cockatoo are also present, sometimes in high numbers, along the southern Swan Coastal Plain south of Lake Preston with roosts occurring near pine plantations in the Myalup and Wellesley areas. They also occur, albeit generally in lower numbers, along the margin of the Darling Scarp, though some of these roosts have reported the presence of Baudin's as well as Carnaby's. There is a noticeable lack of roosts in the largely cleared areas of the southern Swan Coastal Plain between the scarp and the coast. In the southwest, the majority of other discovered roosts have been in more populated areas, such as in the Capes region, Donnybrook and Bridgetown areas. Finally, the current distribution of Carnaby's Black-Cockatoo in the Wheatbelt at this time of year is less clear, but birds do occur at Narrogin and Kojonup.

Fire also seems to have influenced the occupancy of some roosts in regional areas. Since a bushfire burnt through 40,000 hectares in the Stirling Range National Park in December 2019, numbers recorded in the Stirling Range have decreased. One known roost was burnt out and subsequent monitoring has shown that the birds are yet to return. With such a large area burnt, the foraging and movement patterns of white-tailed black-cockatoos within the region are likely to have been impacted, in turn influencing where they roost. Residents within the Augusta-Margaret River area have also reported a decrease in black-cockatoo activity in some areas after a fire burnt through over 5,000 hectares of Boranup Forest.

Forest Red-tailed Black-Cockatoo Counts and Trends

Perth-Peel Coastal Plain

The 2018, 2019 and 2021 GCCs displayed a large increase in numbers of FRTBC roosting in the Perth-Peel region (average of 3,806 birds compared to an average of 903 between 2014 and 2017). In 2021 volunteers recorded sizable counts (counts > 100) in Floreat, Murdoch, Kensington, Morley, Jandabup, Yokine, Maida Vale, and Munster. These counts are much larger than flock sizes reported for FRTBC in forested regions (Lee *et al.* 2013). The 2021 average roost size of 67 for FRTBCs in the Perth-Peel region is also much higher than that of the Darling Scarp and Plateau (30) and regional areas (23).

The continued occupancy of significant roosts are consistent with, and extend, previous observations about recent shifts in the abundance and distribution of FRTBCs onto the Swan Coastal Plain (Johnstone *et al.* 2013, Rycken *et al.* 2022). Over the last 25 years, an increasing number of FRTBC flocks have developed regular movements onto the Swan Coastal plain from the forests on the Northern Darling Scarp and Plateau (Johnstone *et al.* 2017). Possible explanations behind this movement in range have been attributed to FRTBCs making use of novel food resources, particularly Cape Lilac Trees, a decline in water availability in the Jarrah Forest as a result of a drying climate (Craig *et al.* 2022), and loss of foraging and roosting habitat in the Jarrah-Marri Forests on the Northern Darling Scarp and Plateau. As FRTBC are very slow breeding birds, producing only a single egg every other year (Johnstone et al, 2017), the observed increase in numbers in the Perth-Peel coastal Plain is well above the maximum possible breeding rate and therefore more likely to be evidence of movement rather than an increase in population.

In the 2022 GCC the number of FRTBCs recorded on the Perth-Peel Coastal Plain was 509, well below the 3,806 average of the previous three years. This was the lowest count since 2015, and lower than usual roost counts were recorded at major roost sites throughout the Perth-Peel Coastal Plain region, accompanied by the lowest number of occupied roosts was recorded since 2016. The average roost size fell to 15 birds from an average size of 67 birds in 2021. Rather than a cause for alarm, these low GCC count tallies are explained by concurrent reports of Forest Red-tailed Black-Cockatoos breeding up on the Scarp, and high numbers of juvenile FRTBCs in care at Kaarakin Black-Cockatoo Rehabilitation Centre. FRTBCs have previously been recorded breeding in all months of the year, with peaks observed in the months of April – June and August – October (Johnstone et al. 2013), but also coinciding with the fruiting of either Jarrah or Marri, their main food sources. It is therefore believed that the decrease in abundance observed during the count was most likely a result of flocks of FRTBCs that normally visit the Perth-Peel Coastal Plain during the first half of the year remaining in the forested areas on the scarp to breed, and that this coincided with an abundance in fruiting of either Marri or Jarrah in the area. Preliminary results from the 2023 GCC indicate that numbers have returned to 2018 – 2021 levels (average 3,806 birds).

From 2017 to 2019 the fraction of occupied roosts and average size of roosting flocks of FRTBCs on the Perth-Peel Coastal Plain both increased significantly each year, producing a trend of increasing abundance overall. This pattern was not detected in 2021 and 2022, and the ongoing impact of these breeding-related movements on this recently arrived population remains to be fully understood.

Northern Darling Scarp and Plateau

The trend analysis of the change in abundance of FRTBCs on the Northern Darling Scarp and Plateau followed a similar pattern to that of the Perth-Peel Coastal Plain. After overall increases in abundance from 2017 – 2019, this pattern did not continue in 2022. Approximately half the birds (979) were counted in 2022 in comparison to the 2019 and 2021 counts (1,816 and 1,890 respectively) and the average size of roosting flock fell to 20 birds compared to 30 in 2021. The lower count on the Northern Darling Scarp and Plateau in 2022 was, once again, likely due to the strong FRTBC breeding season that was occurring at the time.

Regional Areas

After increasing steadily from 219 FRTBCs counted in regional areas in 2017 to 921 birds in 2021, numbers fell by 59% in 2022 to 578, following a similar pattern in counts on the Perth-Peel Coastal Plain and the Northern Darling Scarp and Plateau.

Trend analysis is yet to be conducted in any regional areas. As more roost sites are discovered and more data from subsequent Great Cocky Counts is accumulated it is hoped that enough roost sites and data will be present in some regions to perform a reliable analysis.

Spring Forest Red-tailed Black-Cockatoo Count

Since 2018 a Spring Forest Red-tailed Black-Cockatoo count has been held in the first couple of weeks of October each year, specifically focused on FRTBC roosts within the Greater Perth-Peel Region. Five counts have occurred since the inaugural count in 2018. The Spring FRTBC Count was instigated with the aim to monitor the movements of Forest Red-tailed Black-Cockatoos more closely during the spring, given the large jump in numbers recorded on the Swan Coastal Plain in the 2017 and 2018 autumn GCCs, and investigate any seasonal movements the birds may exhibit.

The number of roost sites surveyed during the Spring FRTBC Count has increased over 4-fold since 2018. Unsurprisingly, given the increase in roost sites, the total number of FRTBCs counted each year has also increased to reach a maximum of 1,290 in 2022. The results of the Spring FRTBC Counts contrast markedly with those in autumn, although comparisons cannot be drawn directly, due to differences in survey effort between the two events. In general, during the GCC, a greater proportion of FRTBCs are recorded on the Perth-Peel Coastal Plain than on the Northern Darling Scarp and Plateau. The reverse is seen in the Spring FRTBC Counts, with more FRTBCs recorded on the scarp rather than the plain in all counts to date. This temporal difference in roosting behaviour suggests that most FRTBCs follow a similar breeding movement pattern to Carnaby's, favouring the return to forested regions to breed, and spending non-breeding times foraging in coastal areas. The return to forested areas may relate to where there are more suitable breeding hollows available (Johnstone et al. 2013). While previous GCC and Spring FRTBC Counts may have coincided with a stronger spring breeding season, the low numbers of FRTBCs recorded on the Perth-Peel Coastal Plain during the 2022 GCC and other evidence demonstrate a breeding peak on the Northern Darling Scarp and Plateau during the autumn and winter months rather than during spring. Numbers in both regions increased during the 2022 Spring FRTBC Count despite a similar number of roost sites being surveyed to the previous year, indicating that the birds may be returning to the spring breeding movement pattern they exhibited up until 2021. The seasonal pattern may also reflect the availability of food resources, such as Cape Lilac and native plants (e.g. Marri, Jarrah), at different times of year.

Conclusion

The 2021 and 2022 Great Cocky Counts have continued to gather important roost count data to add to the long running Great Cocky Count dataset, while also engaging local communities in the monitoring of the three threatened species of southwest black-cockatoos. The GCCs have continued to attract a high volunteer participation rate, essential to the ongoing success of the count. In the Greater Perth-Peel Region, the GCC provides valuable information on the location and use of black-cockatoo roosts and estimates of population trends, while roosts continue to be identified and counted in regional areas. This information has improved land-use planning and environmental impact assessment, and informed and prioritised conservation efforts for black-cockatoos at all levels of government. More broadly, the GCC continues to raise community and industry awareness about the threatened status of black-cockatoos and the need to protect them, their roosts and feeding habitat. These are tangible successes and reflect the contributions of thousands of community members. Ongoing investment in this monitoring program is needed, including volunteer training and engagement, both to improve the scientific quality of the survey and to enhance the experience of the community members involved. The Great Cocky Count succeeds because of the tremendous goodwill of the Western Australia community. The GCC demonstrates how harnessing people power and using citizen science can gather much-needed data on threatened southwest black-cockatoos and is well placed to continue tracking the population trends of these species into the future.

The trend analyses from 2010 – 2022 continue to highlight several issues that have important implications for black-cockatoo conservation efforts. Firstly, while the population seems to have stabilised in more recent years, the Carnaby's population on the Perth-Peel Coastal Plain has experienced a severe, recent decline that it is yet to recover from. While a population stabilisation can cautiously be viewed optimistically, it is important to note that around two thirds of the remaining Carnaby's recorded on the Perth-Peel Coastal Plain in the non-breeding season are observed in the Gnangara Pine Plantation, which continues to be harvested without adequate replacement or revegetation. Therefore, the future of the Perth-Peel population of Carnaby's remains uncertain. The GCC also continues to track the significant change in the roosting behaviour of Forest Red-tailed Black-Cockatoos from forested areas to the urban parts of the Perth-Peel metropolitan area, and most recently the influence of a good breeding season on the movement of the species. Finally, the Great Cocky Count continues to demonstrate a declining trend in white-tailed black-cockatoo abundance on the Northern Darling Scarp and Plateau which warrants further investigation and close monitoring. These findings provide an important focus for decision-making about the future of the remaining Gnangara pine plantation and revegetation of ex-pine plantations, the conservation of urban and peri-urban Banksia woodland and mature Marri trees, and the protection of roosts and food resources throughout the region.

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2022 Great Cocky Count

Survey Form

Name of lead observer(s):	Telephone:	Email:
Name of additional observer(s):	Telephone:	Email:

Date:	Sunday 3rd April 2022	Start time:		Finish time:	
Site code:		GPS location:	Latitude		Longitude
Site Address / Location:					

What is the main type of tree that the cockatoos are roosting in: *(tick box)*

☐Pine ☐Eucalypt ☐Marri ☐Jarrah ☐Tuart Other: _____ ☐Not Known

White-Tailed Black-Cockatoo Count You may wish to tally cockatoos as they fly across an imaginary line in the sky: *(for example: 2, 2, 2, 3, 2, 17, 2, 24, 2, 3, 3, 1, ...)*	Sub-totals
Total Number of White-Tailed Cockatoos at the Roost	
General direction from which cockatoos arrived:	☐North ☐South ☐East ☐West ☐Other (e.g. SW):

Red-Tailed Black-Cockatoo Count You may wish to tally cockatoos as they fly across an imaginary line in the sky: *(for example: 2, 2, 2, 3, 2, 17, 2, 24, 2, 3, 3, 1, ...)*	Sub-totals
Total Number of Red-Tailed Cockatoos at the Roost	
General direction from which cockatoos arrived:	☐North ☐South ☐East ☐West ☐Other (e.g. SW):

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Great Cocky Count Survey Form

Observational Comments

Please provide any additional observational comments.

For example, you may wish to record the numbers and direction of flocks passing by your roost tree that you have not recorded if you are unsure if they will be picked up by someone else (this may particularly be the case in rural areas). ***If you are 100% sure whether the White-tailed Cockatoos are Carnaby's or Baudin's please tell us here.***

Other birds roosting. Please tell us below if there are other birds roosting here, e.g. Rainbow Lorikeets or Corellas:

If you don't see any cockatoos, please let us know!

Please return your survey results even if you get a nil result – it is equally important for us to know if the cockies aren't there. Please tell us if you did not end up participating, you won't get in trouble ☺

** **Once you have completed this form, please return to BirdLife as soon as possible** **

via email:

greatcockycount@birdlife.org.au

via post:

Merryn Pryor, BirdLife Australia
Peregrine House, 167 Perry Lakes Drive
Floreat WA, 6014

birdlife AUSTRALIA

Alcoa Foundation

Department of Biodiversity, Conservation and Attractions

Great Cocky Count Survey Form

How to Do a Roost Count

1) **We strongly advise you do a practice count in the week before the GCC**, especially if this is the first time you have surveyed your allocated roost (best to do this at sunset). This will guide you as to travel time and best route, the time birds arrive, best spot to survey from, etc.

2) **Arrive at your allocated roost site at least 45 minutes before sunset** so you are ready to record birds as they arrive. **Start counting from 5:30pm (or when they start to arrive).**

3) **Remain at your site until at least 30 minutes after sunset, counting all black-cockatoos that roost at the site** (ie. count until at least **6:45 - 7:00pm**). Note that sometimes cockies arrive late and you may need to stay until after 7:00pm, until you are sure no more cockies are coming in.

   - Count flying cockatoos as they approach and land at the roost site. Counting cockatoos already in trees is generally not accurate.
   - Draw an imaginary line across the sky and count the number of cockatoos as they cross the line. Roads or powerlines work well.
   - When possible, record the count of cockatoos in each group as they cross the count line (e.g. 4, 1, 3, 10 3, 2, 6, 1, 3). This helps us to estimate breeding success rates.
   - For large flocks, work out how big a group of 10 cockatoos is and use this to decide the size of the whole flock, e.g. if the group of 10 cockatoos fits into the flock four times, there are 40 cockatoos in the flock.
   - Do not count cockatoos that fly over the top of your roost site and do not stop there – these birds may be going to another person's survey site.
   - Subtract any black-cockatoos that subsequently leave the roost site after arriving. This can be noted in the same box as your tally with a minus sign (e.g. -3). Only include the number of black-cockatoos **remaining** at the roost site overnight in the "totals" boxes.
   - **Count ALL white-tailed black-cockatoos** landing at your site – don't worry about telling apart Baudin's and Carnaby's Black-Cockatoos *unless you are certain of the difference.*
   - **Count ALL red-tailed black-cockatoos** landing at your site.
   - If you don't see any cockatoos, don't despair – it is just as important to record that no cockatoos were present at that roost site. Records of presence and absence help us determine patterns of roost occupancy across the GCC survey area.

4) **Equipment to bring:** survey form, clipboard, pen/pencil, tally/click counter, torch, binoculars, GPS (if you have one), compass, watch, map, chair/blanket, water/snacks, insect repellent.

5) **Send completed forms to BirdLife WA (see previous page for details).**

6) **More questions?** See the FAQ sheet here.

Please note our safety advice for volunteers taking part in the survey:

- We wish to remind you that you are responsible for your own safety while taking part in roost counts. In addition, you must complete our volunteer registration process before undertaking roost counts.
- Please follow all government advice and regulations relating to **Covid 19** - we will keep you updated on this closer to the date if there are any changes which affect the survey
- Always let someone know where you are going and when you expect to return.
- Wear sturdy, enclosed shoes or walking boots, protective clothing and be prepared for adverse conditions. Carry sufficient food and water. Consider bringing a phone and camera with you.
- You must be fully capable of physical mobility & moderately physically fit to participate in the survey.
- If children are present, they must be supervised by an adult.
- Avoid working under the tree canopy where you are at risk of falling branches and pine cones.
- Survey in groups of at least two people to maximise safety & improve the reliability of survey results.
- If surveying a site close to a road, be aware of traffic.

For inquiries about the 2022 Great Cocky Count please contact Merryn Pryor, WA Black-Cockatoo Project Coordinator, at greatcockycount@birdlife.org.au or 0424 735 770.

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APPENDIX IIa: Number of sites surveyed across local government areas (2021) and WTBC numbers

Number of roost sites surveyed, occupied roosts and total counts of white-tailed black-cockatoos.

Shire	N sites surveyed	N sites occupied	Total count	Shire	N sites surveyed	N sites occupied	Total count
Regional areas							
Albany	19	5	207	**Donnybrook-Balingup**	12	4	587
Augusta-Margaret River	27	9	289	**Esperance**	5	4	824
Bridgetown-Greenbushes	10	4	716	**Gingin**	1	1	1416
Bunbury	3	0	0	**Gnowangerup**	5	1	6
Busselton	11	5	363	**Harvey**	10	4	367
Capel	9	3	249	**Jerramungup**	1	0	0
Carnamah	4	3	561	**Kojonup**	1	0	0
Chapman Valley	5	0	0	**Manjimup**	6	2	91
Cranbrook	3	1	56	**Nannup**	5	3	216
Cuballing	1	0	0	**Narrogin**	2	0	0
Dandaragan	5	3	336	**Plantagenet**	7	4	221
Dardanup	2	2	208	**Ravensthorpe**	3	2	750
Denmark	2	0	0	**Waroona**	1	1	3
Greater Perth-Peel Region							
Armadale	22	2	13	**Melville**	6	3	409
Bayswater	5	1	6	**Mosman Park**	1	0	0
Belmont	1	0	0	**Mundaring**	28	10	368
Beverley	1	0	0	**Murray**	7	1	4
Bindoon	1	0	0	**Nedlands**	6	1	299
Boddington	5	0	0	**Northam**	3	2	25
Cambridge	4	1	242	**Rockingham**	5	1	40
Canning	5	0	0	**Serpentine-Jarrahdale**	32	6	113
Chittering	3	1	1	**South Perth**	3	2	363
Claremont	1	1	7	**Stirling**	9	1	60
Cockburn	16	3	373	**Subiaco**	1	0	0
Fremantle	2	0	0	**Swan**	29	9	349
Gingin	6	3	2755	**Toodyay**	5	2	109
Gosnells	12	3	121	**Victoria Park**	5	0	0
Joondalup	5	1	19	**Vincent**	1	0	0
Kalamunda	24	5	798	**Wandering**	1	0	0
Kings Park	1	0	0	**Wanneroo**	29	14	3325
Kwinana	5	3	129	**Waroona**	7	3	238
Mandurah	5	2	141				

APPENDIX IIb: Number of sites surveyed across local government areas (2021) and FRTBC numbers

Number of roost sites surveyed, occupied roosts and total counts of Forest Red-tailed Black-Cockatoos.

Shire	N sites surveyed	N sites occupied	Total count	Shire	N sites surveyed	N sites occupied	Total count
Regional areas							
Albany	19	3	58	**Donnybrook-Balingup**	12	7	271
Augusta-Margaret River	27	5	71	**Esperance**	5	0	0
Bridgetown-Greenbushes	10	5	130	**Gingin**	1	0	0
Bunbury	3	0	0	**Gnowangerup**	5	0	0
Busselton	11	0	0	**Harvey**	10	6	104
Capel	9	6	168	**Jerramungup**	1	0	0
Carnamah	4	0	0	**Kojonup**	1	1	6
Chapman Valley	5	0	0	**Manjimup**	6	1	9
Cranbrook	3	0	0	**Nannup**	5	2	22
Cuballing	1	0	0	**Narrogin**	2	0	0
Dandaragan	5	0	0	**Plantagenet**	7	2	7
Dardanup	2	1	27	**Ravensthorpe**	3	0	0
Denmark	2	0	0	**Waroona**	1	1	48
Greater Perth-Peel Region							
Armadale	22	13	360	**Melville**	6	1	382
Bayswater	5	4	383	**Mosman Park**	1	0	0
Belmont	1	0	0	**Mundaring**	28	15	271
Beverley	1	1	53	**Murray**	7	5	215
Bindoon	1	0	0	**Nedlands**	6	0	0
Boddington	5	1	31	**Northam**	3	2	18
Cambridge	4	2	728	**Rockingham**	5	2	67
Canning	5	3	140	**Serpentine-Jarrahdale**	32	12	209
Chittering	3	1	4	**South Perth**	3	2	4
Claremont	1	0	0	**Stirling**	9	2	301
Cockburn	16	6	356	**Subiaco**	1	0	0
Fremantle	2	1	60	**Swan**	29	11	318
Gingin	6	0	0	**Toodyay**	5	5	80
Gosnells	12	7	203	**Victoria Park**	5	4	385
Joondalup	5	0	0	**Vincent**	1	0	0
Kalamunda	24	13	673	**Wandering**	1	0	0
Kings Park	1	0	0	**Wanneroo**	29	2	281
Kwinana	5	2	8	**Waroona**	7	3	231
Mandurah	5	1	10				

APPENDIX IIc: Number of sites surveyed across local government areas (2022) and WTBC numbers

Number of roost sites surveyed, occupied roosts and total counts of white-tailed black-cockatoos.

Shire	N sites surveyed	N sites occupied	Total count	Shire	N sites surveyed	N sites occupied	Total count
Regional areas							
Albany	11	5	86	**Denmark**	3	0	0
Augusta-Margaret River	9	6	491	**Donnybrook-Balingup**	10	3	103
Bridgetown-Greenbushes	12	2	1230	**Esperance**	6	4	723
Bunbury	3	2	8	**Gingin**	1	1	1510
Busselton	5	3	64	**Gnowangerup**	4	0	0
Capel	7	2	81	**Harvey**	9	5	2182
Carnamah	4	3	267	**Manjimup**	5	4	39
Chapman Valley	3	1	165	**Nannup**	2	0	0
Collie	4	2	9	**Plantagenet**	6	3	46
Cranbrook	1	0	0	**Ravensthorpe**	1	1	448
Cuballing	1	0	0	**Waroona**	1	0	0
Dandaragan	8	3	1009	**West Arthur**	2	0	0
Dardanup	3	1	110	**Williams**	2	0	0
Greater Perth-Peel Region							
Armadale	16	2	153	**Mosman Park**	1	0	0
Bayswater	3	1	4	**Mundaring**	28	7	448
Beverley	1	0	0	**Murray**	9	0	0
Boddington	7	1	5	**Nedlands**	4	2	263
Cambridge	3	1	158	**Northam**	4	2	148
Canning	4	0	0	**Rockingham**	4	1	6
Chittering	3	0	0	**Serpentine-Jarrahdale**	19	6	294
Cockburn	13	2	221	**South Perth**	3	2	383
Fremantle	1	0	0	**Stirling**	6	0	0
Gingin	5	3	5885	**Swan**	25	8	857
Gosnells	9	1	61	**Toodyay**	5	2	149
Joondalup	4	1	74	**Victoria Park**	3	0	0
Kalamunda	20	3	34	**Wandering**	2	1	12
Kwinana	5	4	275	**Wanneroo**	17	7	2136
Mandurah	6	2	617	**Waroona**	4	2	162
Melville	5	3	361				

APPENDIX IId: Number of sites surveyed across local government areas (2022) and FRTBC numbers

Number of roost sites surveyed, occupied roosts and total counts of Forest Red-tailed Black-Cockatoos.

Shire	N sites surveyed	N sites occupied	Total count	Shire	N sites surveyed	N sites occupied	Total count
Regional areas							
Albany	11	3	23	**Denmark**	3	0	0
Augusta-Margaret River	9	0	0	**Donnybrook-Balingup**	10	7	142
Bridgetown-Greenbushes	12	5	139	**Esperance**	6	0	0
Bunbury	3	0	0	**Gingin**	1	0	0
Busselton	5	0	0	**Gnowangerup**	4	0	0
Capel	7	2	46	**Harvey**	9	1	9
Carnamah	4	0	0	**Manjimup**	5	2	20
Chapman Valley	3	0	0	**Nannup**	2	0	0
Collie	4	3	87	**Plantagenet**	6	0	0
Cranbrook	1	0	0	**Ravensthorpe**	1	0	0
Cuballing	1	0	0	**Waroona**	1	1	2
Dandaragan	8	0	0	**West Arthur**	2	2	110
Dardanup	3	0	0	**Williams**	2	0	0
Greater Perth-Peel Region							
Armadale	16	9	111	**Mosman Park**	1	0	0
Bayswater	3	2	8	**Mundaring**	28	11	92
Beverley	1	1	5	**Murray**	9	6	240
Boddington	7	1	4	**Nedlands**	4	0	0
Cambridge	3	2	125	**Northam**	4	1	13
Canning	4	2	18	**Rockingham**	4	3	33
Chittering	3	1	21	**Serpentine-Jarrahdale**	19	8	215
Cockburn	13	3	60	**South Perth**	3	2	11
Fremantle	1	1	8	**Stirling**	6	3	48
Gingin	5	0	0	**Swan**	25	5	86
Gosnells	9	2	8	**Toodyay**	5	2	26
Joondalup	4	1	3	**Victoria Park**	3	2	25
Kalamunda	20	5	90	**Wandering**	2	0	0
Kwinana	5	1	2	**Wanneroo**	17	2	31
Mandurah	6	3	52	**Waroona**	4	2	113
Melville	5	2	40				

APPENDIX III: Roost counts for white-tailed black-cockatoos in the Greater Perth-Peel Region.

Appendix IIIa: Great Cocky Count (2010-2022) roost counts for Carnaby's Black-Cockatoo at **confirmed roosts** in the Perth-Peel Coastal Plain. Sites with an asterisk are or have been recorded as having both WTBC and FRTBC roosting. A period in a cell means that the site was not surveyed in that year.

Site code	Locality	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021	2022	Totals
ARMCHAR001*	Champion Lakes	.	.	.	.	.	.	.	0	3	0	0	0	**3**
ARMFORR001	Forrestdale	.	.	.	0	0	18	0	0	.	0	0	.	**18**
ARMHARR001	Harrisdale	.	0	0	.	0	1	3	0	0	0	0	.	**4**
ARMKELR001*	Kelmscott	14	0	0	0	0	.	.	.	0	0	0	0	**14**
ARMKELR005*	Kelmscott	.	.	.	.	.	.	.	.	.	.	4	0	**4**
BAYMORR001*	Morley	0	.	.	.	0	0	0	0	0	0	6	4	**10**
CAMCITR001*	City Beach	.	.	.	.	2	0	0	0	.	0	0	.	**2**
CAMFLOR001	Floreat	237	151	148	157	159	86	239	281	259	283	242	158	**2400**
CANFERR001	Ferndale	.	.	.	5	0	0	0	0	0	.	0	.	**5**
CANWILR001*	Willetton	0	0	0	0	68	0	0	0	0	0	0	0	**68**
CLASWAR001	Swanbourne	.	.	0	0	3	0	0	0	0	0	7	.	**10**
COCBANR001*	Banjup	.	.	.	.	.	45	.	0	20	0	0	27	**92**
COCBANR002*	Banjup	.	.	.	.	53	.	0	0	0	0	0	0	**53**
COCBANR003	Banjup	.	.	.	.	.	.	.	6	16	0	0	0	**22**
COCCOCR001*	Cockburn Central	.	.	.	.	.	.	.	.	0	0	7	0	**7**
COCCOOR005	Coolbellup	.	.	.	.	.	.	.	38	0	0	0	.	**38**
COCHAMR001	Hamilton Hill	0	169	215	0	168	68	101	0	0	0	109	0	**830**
COCHAMR002	Hamilton Hill	.	.	.	.	.	263	194	0	369	506	0	194	**1526**
COCMUNR003*	Munster	.	.	.	.	.	.	0	0	0	3	0	0	**3**
COCSCCR001	Success	252	cleared											**252**
COCSCCR002	Success	15	3	cleared										**18**
COCSPER001	Spearwood	0	2	.	323	.	0	0	40	0	.	257	0	**622**
COCSPER002	Spearwood	.	5	0	.	.	0	24	0	.	.	0	.	**29**
GINGINR001	Gingin	392	378	432	686	879	784	1023	880	1148	544	510	783	**8439**
GINNEER001	Neergabby	.	.	.	.	.	.	70	.	.	.	.	.	**70**
GINNEER002	Neergabby	.	.	.	.	.	.	.	34	.	.	.	.	**34**
GINWANR001	Wanerie	0	0	.	.	0	.	.	50	0	.	.	.	**50**
GINWOOR001	Woodridge	113	119	0	30	0	0	0	0	0	.	0	.	**262**
GINYEAR001	Yeal	.	.	387	.	782	.	.	6	0	0	0	0	**1175**
GINYEAR002	Yeal	49	92	.	.	.	20	.	.	15	369	263	70	**878**
GINYEAR003	Yeal	.	.	.	.	.	750	4897	3528	6226	5145	1982	5032	**27560**
GINYEAR004	Yeal	.	.	.	.	.	.	.	0	.	239	0	0	**239**
GOSCNVR001*	Canning Vale	0	19	.	.	0	0	0	0	.	80	0	0	**99**
GOSCNVR002*	Canning Vale	.	.	26	52	0	0	151	0	0	0	0	0	**229**
GOSSOUR001	Southern River	.	.	.	.	.	.	0	.	.	0	9	.	**9**
GOSSOUR002*	Southern River	.	.	.	.	.	.	50	0	0	0	2	0	**52**
JOODUNR001	Duncraig	.	.	60	0	0	17	43	110	80	0	19	74	**403**
JOOEDGR001	Edgewater	0	0	.	0	0	23	0	0	0	.	0	.	**23**
JOOPADR001*	Padbury	0	.	1	17	7	7	0	0	0	0	0	0	**32**
JOOWARR001	Warwick	0	60	.	0	0	0	0	0	.	0	.	.	**60**
KALMAIR002*	Maida Vale	.	.	.	.	0	.	0	0	0	11	0	0	**11**
KINPERR001	Perth	0	.	0	.	0	0	0	8	0	0	0	.	**8**
KWICASR001*	Casuarina	2	.	.	0	19	.	.	0	59	0	0	64	**144**
KWIWANR001	Wandi	63	0	0	1	0	0	0	0	0	.	.	.	**64**
KWIWANR002	Wandi	.	.	.	0	0	0	0	5	0	0	.	.	**5**
KWIWANR004	Wandi	.	.	.	.	.	.	.	73	0	0	90	88	**251**
KWIWELR001*	Wellard	.	.	15	50	0	62	0	0	4	40	0	0	**171**
KWIWELR002	Wellard	.	.	.	.	.	.	.	.	4	133	24	119	**280**
KWIWELR003*	Wellard	.	.	.	.	.	.	.	.	0	0	15	4	**19**
MANCOOR002*	Coodanup	.	.	.	21	0	0	2	0	0	0	.	.	**23**
MANDAWR002*	Dawesville	371	199	11	0	257	135	214	86	71	501	94	377	**2316**

Site code	Locality	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021	2022	Totals
MANDAWR004	Dawesville	159	.	.	0	24	22	0	61	210	.	.	.	**476**
MANDAWR005	Dawesville	.	30	.	0	0	0	0	.	0	.	.	.	**30**
MANDAWR006	Dawesville	.	.	.	.	.	11	132	0	200	0	0	240	**583**
MANDAWR007*	Dawesville	.	.	.	.	.	277	167	9	566	414	47	0	**1480**
MELBATR001	Bateman	8	0	0	0	0	0	0	0	0	0	.	.	**8**
MELKARR002	Kardinya	0	0	0	.	0	55	0	0	0	0	.	.	**55**
MELLEER001*	Leeming	0	0	12	0	70	0	0	0	15	2	0	0	**99**
MELMURR001*	Murdoch	700	60	142	127	234	24	78	0	227	249	245	222	**2308**
MELWINR001	Winthrop	.	56	81	70	41	0	21	0	0	12	9	12	**302**
MELWINR003*	Winthrop	117	130	.	.	.	0	7	54	64	108	155	127	**762**
MELWINR004	Winthrop	0	0	0	0	2	0	0	0	0	.	0	.	**2**
NEDDALR002*	Dalkeith	0	.	.	.	.	.	0	0	12	0	0	0	**12**
NEDDALR003	Dalkeith	40	90	0	0	0	0	0	0	0	0	0	.	**130**
NEDNEDR001	Nedlands	73	103	304	183	114	106	216	242	175	353	299	250	**2418**
NEDNEDR002	Nedlands	.	.	.	.	0	11	0	0	0	3	0	0	**14**
NEDNEDR003	Nedlands	.	.	.	.	0	2	33	96	47	0	0	13	**191**
ROCBALR001	Baldivis	346	.	cleared										**346**
ROCBALR003*	Baldivis	.	78	0	4	0	0	0	.	0	0	0	0	**82**
ROCBALR004	Baldivis	.	40	0	0	0	.	0	0	.	.	0	.	**40**
ROCKARR002*	Karnup	.	.	.	.	.	.	.	0	0	0	40	6	**46**
ROCSECR001	Secret Harbour	0	.	0	0	6	0	0	.	0	.	0	.	**6**
SERDARR001*	Darling Downs	.	.	.	.	.	.	8	0	0	0	0	0	**8**
SERKEYR001*	Keysbrook	0	.	.	100	3	14	53	0	3	0	4	72	**249**
SERMUNR002*	Mundijong	.	.	.	.	.	.	10	12	.	0	0	.	**22**
SEROAKR001	Oakford	0	110	.	0	0	.	.	0	0	.	0	.	**110**
SEROAKR002*	Oakford	0	0	0	2	.	.	.	0	0	0	0	2	**4**
SEROAKR003	Oakford	167	0	0	0	0	0	.	.	0	0	0	.	**167**
SEROAKR004	Oakford	45	3	0	0	50	0	26	2	33	.	0	51	**210**
SEROAKR005	Oakford	31	0	.	0	0	0	0	0	0	.	.	.	**31**
SEROAKR007	Oakford	.	.	.	.	.	.	.	2	0	.	0	.	**2**
SERWELR002	Wellard	.	.	.	.	.	.	.	298	75	0	8	0	**381**
SERWHIR001	Whitby	.	.	.	.	.	.	34	.	56	.	42	43	**175**
SOUCOMR001*	Como	408	645	558	301	402	460	242	289	470	563	353	333	**5024**
SOUSALR001*	Salter Point	12	0	0	0	5	0	20	0	2	0	10	50	**99**
SOUSOUR002	South Perth	0	35	0	0	0	0	0	0	0	0	0	.	**35**
STIHAMR001	Hamersley	.	.	.	.	0	.	24	0	0	62	0	0	**86**
STIINNR001	Innaloo	0	.	0	0	0	0	0	3	0	0	0	.	**3**
STIKARR001	Karrinyup	.	.	.	121	92	2	45	10	0	0	0	0	**270**
STINORR001	North Beach	0	230	0	267	0	6	0	23	19	8	60	0	**613**
SUBSHER001	Shenton Park	0	0	0	9	0	0	0	0	0	0	0	.	**9**
SWABALR001	Ballajura	0	40	0	92	0	35	0	0	0	0	.	60	**227**
SWABALR004	Ballajura	0	.	.	.	0	5	105	0	0	0	2	0	**112**
SWABULR003	Bullsbrook	.	.	.	.	.	.	8	0	0	.	0	.	**8**
SWABULR005*	Bullsbrook	.	.	.	.	.	.	.	.	0	0	0	43	**43**
SWACAVR002*	Caversham	.	.	.	.	.	.	.	.	.	.	6	0	**6**
SWAELLR001	Ellenbrook	.	.	.	.	14	.	280	0	0	.	17	0	**311**
SWAHAZR002*	Hazelmere	.	.	.	.	.	.	.	.	.	.	6	0	**6**
SWAHENR002	Henley Brook	.	.	.	.	.	.	.	50	0	0	10	0	**60**
SWALEXR001	Lexia	0	80	0	0	181	0	0	0	34	753	150	158	**1356**
SWALEXR002	Lexia	185	0	.	0	0	0	cleared						**185**
SWAMELR001*	Melaleuca	500	41	0	20	480	0	.	268	0	0	0	421	**1730**
SWAMILR001	Millendon	.	.	.	.	0	.	250	0	40	0	10	162	**462**
SWAVINR003*	The Vines	.	.	.	.	.	.	21	0	0	3	0	8	**32**
SWAWHIR001*	Whiteman	.	69	13	.	.	0	0	7	15	.	0	0	**104**
VICKENR001*	Kensington	0	.	0	0	0	0	0	0	0	2	0	0	**2**
VICVICR001	Victoria Park	2	0	0	0	0	0	6	0	0	0	0	.	**8**
WANCARR001	Carabooda	.	.	2	.	.	0	0	.	0	.	0	.	**2**
WANCARR004	Carabooda	.	.	.	.	7	.	.	.	.	.	.	6	**13**

Site code	Locality	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021	2022	Totals
WANCRRR001	Carramar	.	.	.	191	0	0	0	0	0	.	.	.	**191**
WANEGLR001	Eglinton	.	.	.	.	.	.	.	.	.	.	296	0	**296**
WANGNAR001	Gnangara	0	.	.	.	0	.	454	316	157	255	1186	733	**3101**
WANGNAR003	Gnangara	0	14	0	0	0	0	0	0	0	0	0	.	**14**
WANGNAR004	Gnangara	27	0	0	0	0	0	0	0	0	12	.	.	**39**
WANGNAR005*	Gnangara	.	.	.	100	0	14	0	260	.	.	.	.	**374**
WANGNAR006*	Gnangara	.	.	.	.	40	.	3	6	0	.	0	.	**49**
WANJANR007	Jandabup	.	16	.	0	.	0	cleared						**16**
WANMARR001	Mariginiup	0	20	.	0	.	71	0	770	0	0	5	150	**1016**
WANMARR002*	Mariginiup	0	.	2	3	3	0	0	0	0	0	3	0	**11**
WANMARR003	Mariginiup	542	152	10	16	147	280	4	1260	625	739	293	756	**4824**
WANMARR004	Mariginiup	0	0	0	.	.	.	.	8	0	0	.	.	**8**
WANMARR005	Mariginiup	.	.	.	.	.	.	.	0	350	cleared			**350**
WANNEER001	Neerabup	.	29	.	.	0	.	0	.	.	.	0	.	**29**
WANNEER002	Neerabup	604	0	0	0	0	0	0	0	0	.	0	.	**604**
WANNOWR001	Nowergup	.	.	35	10	0	0	0	4	.	.	0	.	**49**
WANNOWR005*	Nowergup	0	.	.	.	.	.	3	0	0	.	0	0	**3**
WANNOWR006	Nowergup	.	.	.	.	.	.	.	.	.	.	11	.	**11**
WANPINR001	Pinjar	.	.	853	35	1521	616	1232	900	315	1830	927	0	**8229**
WANPINR002	Pinjar	.	312	276	0	138	101	0	0	0	.	7	0	**834**
WANPINR003	Pinjar	64	0	0	0	0	0	0	0	.	.	.	.	**64**
WANPINR005	Pinjar	275	.	.	.	0	0	cleared						**275**
WANPINR006	Pinjar	13	0	0	0	2	0	0	0	.	0	0	.	**15**
WANPINR011	Pinjar	0	.	.	800	0	179	0	0	0	12	0	300	**1291**
WANTAMR001	Tamala Park	.	.	0	103	20	10	0	0	.	0	88	6	**227**
WANTWOR001	Two Rocks	0	.	7	573	200	30	0	0	18	8	3	0	**839**
WANWANR001	Wanneroo	0	11	6	0	0	0	0	0	0	0	0	.	**17**
WANYANR001	Yanchep	61	.	.	.	450	82	0	.	16	.	5	.	**614**
WANYANR003	Yanchep	.	16	0	564	0	0	0	0	37	.	301	0	**918**
WANYANR004	Yanchep	.	0	0	192	0	0	cleared						**192**
WANYANR006	Yanchep	342	305	129	0	0	0	0	136	279	0	193	185	**1569**
WANYANR007	Yanchep	.	0	0	.	0	.	173	0	.	60	7	0	**240**
WANYANR008	Yanchep	.	.	.	.	.	.	.	5	0	.	0	.	**5**
WARLAKR001	Lake Clifton	1	0	0	.	.	0	0	.	.	.	.	.	**1**
WARLAKR004	Lake Clifton	.	.	.	.	.	.	.	.	.	5	0	.	**5**
WARLAKR006	Lake Clifton	.	.	.	.	.	.	.	.	.	.	.	90	**90**
WARPRER001	Preston Beach	.	.	66	330	19	.	158	0	.	.	.	.	**573**
WARPRER002	Preston Beach	100	.	0	.	0	0	0	.	.	.	.	.	**100**

Appendix IIIb: Great Cocky Count (2010-2022) roost counts for Carnaby's Black-Cockatoo at **confirmed roosts** that: (a) are within or immediately adjacent (<1 km) to the **Gnangara pine plantations** or (b) have historically been used as a roost by cockatoos feeding within the plantation system. Use of the roosts located in Yanchep National Park (YNP) is documented in Saunders (1980); Shah (2006); Finn *et al.* (2009); and Stock *et al.* (2013). The plantation includes three sections: Gnangara (southern), Pinjar (central), and Yanchep (northern).
Sites with an asterisk are or have been recorded as having both white-tailed and FRTBC roosting. A period in a cell means that the site was not surveyed in that year.

Site code	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021	2022	Totals
GINYEAR001	.	.	387	.	782	.	.	6	0	0	0	0	**1175**
GINYEAR002	49	92	.	.	.	20	.	.	15	369	263	70	**878**
GINYEAR003	.	.	.	.	.	750	4897	3528	6226	5145	1982	5032	**27560**
GINYEAR004	.	.	.	.	.	.	.	.	.	239	0	0	**239**
SWALEXR001	0	80	0	0	181	0	0	0	34	753	150	158	**1356**
SWALEXR002	185	0	.	0	0	0	cleared						**185**
SWAMELR001*	500	41	0	20	480	0	.	268	0	0	0	421	**1730**
WANCARR004	.	.	.	.	7	.	.	.	.	.	.	6	**13**
WANGNAR001	0	.	.	.	0	.	454	316	157	255	1186	733	**3101**
WANGNAR003	0	14	0	0	0	0	0	0	0	0	0	.	**14**
WANGNAR004	27	0	0	0	0	0	0	0	0	12	.	.	**39**
WANGNAR005*	.	.	.	100	0	14	0	260	.	.	.	.	**374**
WANGNAR006*	.	.	.	.	40	.	3	6	0	.	0	.	**49**
WANJANR007	.	16	.	0	.	0	cleared						**16**
WANMARR001	0	20	.	0	.	71	0	770	0	0	5	150	**1016**
WANMARR002	0	.	2	3	3	0	0	0	0	0	3	0	**11**
WANMARR003	542	152	10	16	147	280	4	1260	625	739	293	756	**4824**
WANMARR004	0	0	0	.	.	.	.	8	0	0	.	.	**8**
WANMARR005	.	.	.	.	.	.	.	0	350	cleared			**350**
WANNEER001	.	29	.	.	0	.	0	.	.	.	0	.	**29**
WANNEER002	604	0	0	0	0	0	0	0	0	.	0	.	**604**
WANPINR001	.	.	853	35	1521	616	1232	900	315	1830	927	0	**8229**
WANPINR002	.	312	276	0	138	101	0	0	0	.	7	0	**834**
WANPINR003	64	0	0	0	0	0	0	0	.	.	.	.	**64**
WANPINR005	275	.	.	.	0	0	cleared						**275**
WANPINR006	13	0	0	0	2	0	0	0	.	0	0	.	**15**
WANPINR011	0	.	.	800	0	179	0	0	0	12	0	300	**1291**
WANTWOR001	0	.	7	573	200	30	0	0	18	8	3	0	**839**
WANYANR001	61	.	.	.	450	82	0	.	16	.	5	.	**614**
WANYANR003	.	16	0	564	0	0	0	0	37	.	301	0	**918**
WANYANR004	.	0	0	192	0	0	cleared						**192**
WANYANR006	342	305	129	0	0	0	0	136	279	0	193	185	**1569**
WANYANR007	.	0	0	.	0	.	173	0	.	60	7	0	**240**
Total	**2662**	**1077**	**1664**	**2303**	**3951**	**2143**	**6763**	**7458**	**8072**	**9422**	**5325**	**7811**	**58651**
% of total Perth-Peel Coastal Plain count	**42%**	**28%**	**44%**	**41%**	**59%**	**46%**	**62%**	**73%**	**65%**	**71%**	**63%**	**68%**	**60%**
No. of pine-associated sites surveyed	**19**	**19**	**18**	**20**	**26**	**24**	**22**	**24**	**22**	**19**	**23**	**18**	**33**

Appendix IIIc: Great Cocky Count (2010-2022) roost counts for white-tailed black-cockatoos at **confirmed roosts** in the Northern Darling Scarp and Plateau. Sites with an asterisk have been recorded as having both white-tailed and FRTBC roosting. The counts are for white-tailed black-cockatoos generally and are not corrected for the relative proportions of Baudin's and Carnaby's Black-Cockatoos. A period in a cell means that the site was not surveyed in that year.

Site code	Locality	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021	2022	Totals
ARMBEDR001*	Bedfordale	57	0	.	0	0	0	0	6	0	98	0	0	161
ARMBEDR002*	Bedfordale	70	22	.	3	0	.	0	0	0	0	.	.	95
ARMBEDR003*	Bedfordale	385	.	.	0	0	60	6	3	12	5	9	0	480
ARMBEDR005*	Bedfordale	.	.	.	.	.	.	.	0	36	0	0	3	39
ARMKELR002	Kelmscott	0	10	.	0	0	0	0	0	0	.	0	.	10
ARMROLR001*	Roleystone	108	13	140	40	0	0	157	70	0	0	.	150	678
ARMROLR003*	Roleystone	.	0	0	50	0	0	0	0	0	0	0	.	50
ARMROLR004*	Roleystone	.	.	.	.	0	.	28	0	0	0	0	0	28
ARMROLR005*	Roleystone	.	.	.	.	.	.	0	0	0	35	0	0	35
BEVFLYR002*	Flynn	.	.	.	.	.	.	.	19	0	0	0	0	19
BODBODR001	Boddington	.	.	.	.	.	.	9	0	25	.	.	0	34
BODBODR002	Boddington	.	.	.	.	.	.	.	0	2	.	0	.	2
BODCROR002	Crossman	10	0	.	.	.	3	.	0	.	.	.	0	13
BODMARR001*	Marradong	.	.	.	.	.	.	16	0	0	.	0	5	21
BODMARR002	Marradong	.	.	.	.	.	.	141	0	11	.	0	0	152
CHICHIR001*	Chittering	.	.	.	.	.	.	.	0	0	0	1	0	1
GOSMARR001*	Martin	.	.	.	.	.	.	.	0	120	36	110	61	327
KALCANR001*	Canning Mills	.	.	.	.	.	.	.	.	.	1	.	.	1
KALCARR002*	Carmel	.	.	.	.	.	.	.	90	.	8	0	11	109
KALCARR003*	Carmel	.	.	.	.	.	.	.	.	.	0	0	3	3
KALKALR001	Kalamunda	30	.	25	0	0	0	0	0	.	0	0	.	55
KALKALR002	Kalamunda	.	25	23	85	28	10	58	107	48	0	0	0	384
KALKALR004*	Kalamunda	.	.	.	.	.	.	65	215	0	5	31	0	316
KALLESR001	Lesmurdie	.	0	0	0	0	8	0	0	.	.	.	.	8
KALMAIR003	Maida Vale	.	.	.	.	.	.	0	5	.	0	0	.	5
KALPICR001	Pickering Brook	.	.	.	.	.	.	.	5	0	.	0	.	5
KALPICR002*	Pickering Brook	.	.	.	.	2	.	0	0	.	.	0	0	2
KALPIER001*	Piesse Brook	.	82	46	0	0	0	163	.	210	133	500	0	1134
KALPIER002*	Piesse Brook	.	.	.	.	.	.	.	6	60	89	132	0	287
KALPIER003*	Piesse Brook	.	.	.	.	.	.	97	132	163	145	131	20	688
KALWALR001*	Walliston	0	5	0	0	0	0	.	0	0	.	0	0	5
KALWATR003*	Wattle Grove	.	.	.	.	.	.	.	.	.	0	4	0	4
MUNCHIR001	Chidlow	16	0	.	0	0	cleared							16
MUNCHIR002*	Chidlow	.	.	.	.	0	.	0	0	0	0	2	0	2
MUNDARR001	Darlington	443	7	147	0	0	0	.	0	0	0	0	.	597
MUNGLER001	Glen Forrest	.	.	32	51	45	25	65	5	51	0	0	0	274
MUNGLER002	Glen Forrest	.	.	13	0	0	0	0	0	0	.	0	.	13
MUNGLER003*	Glen Forrest	.	.	.	.	45	.	0	335	17	11	4	3	415
MUNHELR001*	Helena Valley	.	3	16	42	124	0	44	0	3	0	50	4	286
MUNHOVR001*	Hovea	.	.	40	0	.	0	0	0	0	0	0	0	40
MUNHOVR002	Hovea	243	22	10	0	0	0	18	0	.	.	0	0	293
MUNMTHR001*	Mt Helena	.	.	.	8	0	0	0	0	2	.	.	0	10
MUNMTHR002*	Mt Helena	.	.	.	.	0	.	147	0	0	60	87	77	371
MUNMTHR003*	Mt Helena	.	.	.	.	.	.	24	0	0	1	6	0	31
MUNMUNR001*	Mundaring	78	.	.	85	45	36	0	0	82	0	0	0	326
MUNMUNR003*	Mundaring	.	.	.	.	.	.	0	0	4	0	0	0	4
MUNPARR002	Parkerville	.	.	.	.	182	.	66	157	58	145	8	187	803
MUNPARR003*	Parkerville	.	.	.	.	.	.	320	70	80	45	26	141	682
MUNPARR004*	Parkerville	.	.	.	.	.	.	209	213	309	38	0	0	769
MUNPARR005*	Parkerville	.	.	.	.	.	.	.	152	50	62	.	34	298
MUNSTOR001*	Stoneville	.	.	.	.	141	0	7	0	0	0	118	0	266
MUNSTOR002	Stoneville	.	86	0	.	0	0	0	0	7	0	0	.	93

Site Code	Locality	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021	2022	Totals
MUNSTOR003*	Stoneville	.	.	.	.	48	.	30	0	0	20	0	2	100
MUNSTOR004*	Stoneville	.	.	.	.	.	.	90	0	0	0	0	.	90
MUNSTOR005*	Stoneville	.	.	.	.	.	.	19	21	12	0	46	0	98
MUNSTOR006	Stoneville	.	.	.	.	.	.	.	.	42	0	21	0	63
MURDWER001*	Dwellingup	.	40	.	.	.	0	.	8	.	0	0	0	48
MURDWER002*	Dwellingup	.	.	.	.	0	.	.	45	6	5	4	0	60
MURDWER003*	Dwellingup	.	.	.	.	.	.	.	.	15	0	0	0	15
MURNORR001*	North Dandalup	.	.	.	.	.	.	20	14	33	6	0	0	73
MURNORR002*	North Dandalup	.	.	.	.	.	.	.	.	.	50	.	0	50
MURTEER001	Teesdale	21	0	0	0	.	0	.	.	.	0	.	.	21
NORBAKR001	Bakers Hill	217	.	.	.	.	.	94	52	.	160	6	144	673
NORBAKR002*	Bakers Hill	.	.	.	.	.	.	.	.	.	.	.	4	4
NORWOOR002*	Woottating	.	.	.	.	.	.	.	.	8	0	19	0	27
NORWUNR001*	Wundowie	125	.	8	0	.	0	0	0	.	15	0	0	148
SERBYFR003*	Byford	.	.	.	.	.	.	0	.	0	.	4	.	4
SERBYFR004*	Byford	.	.	.	.	.	.	111	7	0	0	0	0	118
SERBYFR006*	Byford	.	.	.	.	.	.	.	.	.	11	.	4	15
SERJARR001	Jarrahdale	0	60	0	.	.	0	.	0	0	.	.	.	60
SERKEYR002*	Keysbrook	25	.	0	30	.	0	.	0	.	.	0	0	55
SERKEYR003*	Keysbrook	.	.	.	.	.	.	.	255	352	211	47	122	987
SERKEYR007*	Keysbrook	.	.	.	.	.	.	.	.	.	0	8	.	8
SERKEYR009*	Keysbrook	.	.	.	.	.	.	.	.	.	2	0	0	2
SERSERR008*	Serpentine	.	.	.	.	.	.	.	.	.	23	0	0	23
SWABULR002*	Bullsbrook	.	18	117	120	328	.	178	0	260	172	145	0	1338
SWABULR004*	Bullsbrook	.	.	.	.	.	.	0	5	0	.	0	0	5
SWAGIDR002	Gidgegannup	101	.	23	40	.	217	129	93	0	2	0	0	605
SWAGIDR003	Gidgegannup	.	.	3	.	.	.	0	0	0	.	.	.	3
SWAGIDR005	Gidgegannup	.	.	.	197	163	169	152	0	113	10	0	3	807
SWAGIDR007*	Gidgegannup	.	.	.	.	.	.	0	0	51	0	0	0	51
SWAGIDR008*	Gidgegannup	.	.	.	.	.	.	0	3	2	7	3	2	17
SWAGIDR009*	Gidgegannup	.	.	.	.	.	.	0	0	7	47	0	0	54
TOOMORR001*	Morangup	.	.	183	29	56	12	140	44	99	58	86	133	840
TOOMORR003*	Morangup	.	.	.	.	.	.	.	55	32	36	0	0	123
TOOMORR005*	Morangup	.	.	.	.	.	.	.	.	.	.	23	16	39
WARWAGR001*	Wagerup	.	.	.	236	186	.	.	.	.	.	217	0	639
WARWARR002*	Waroona	.	.	.	36	0	0	4	0	11	0	.	.	51
WARWARR003*	Waroona	.	.	.	.	.	.	.	.	4	34	14	72	124
WARWARR004*	Waroona	.	.	.	.	.	.	.	.	.	.	7	0	7
WNDNORR001	North Bannister	.	.	.	.	.	.	4	.	.	.	.	.	4
WNDSPRR001*	Springs	.	.	.	.	.	.	0	0	0	.	.	12	12
WNDWANR003	Wandering	.	.	.	.	.	.	.	.	.	321	0	0	321

APPENDIX IV: Roost counts for white-tailed black-cockatoos in regional areas.

Appendix IV: Great Cocky Count (2010-2022) roost counts for white-tailed black-cockatoo at **confirmed roosts** in regional areas. Sites with an asterisk have been recorded as having both WTBC and FRTBC roosting. A period in a cell means that the site was not surveyed in that year.

Site code	Locality	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021	2022	Totals
ALBCHER001	Cheynes	.	.	70	.	.	.	.	.	.	0	.	.	70
ALBCHER002	Cheynes	.	.	0	.	60	0	0	.	0	8	0	15	83
ALBCHER004	Cheynes	.	.	.	.	.	.	.	.	8	0	28	26	62
ALBCHER005	Cheynes	.	.	.	.	.	.	.	.	14	.	0	2	16
ALBCHER006	Cheynes	.	.	.	.	.	.	.	.	13	.	0	.	13
ALBCHER007	Cheynes	.	.	.	.	.	.	.	.	.	14	0	.	14
ALBGOOR001	Goode Beach	.	.	.	84	62	.	0	3	0	0	.	.	149
ALBGOOR002	Goode Beach	.	111	.	0	120	0	0	0	0	.	0	.	231
ALBGRER002	Green Valley	.	.	.	.	.	.	.	15	0	.	.	.	15
ALBKALR001	Kalgan	.	.	213	472	141	73	0	0	.	.	.	.	899
ALBKALR004*	Kalgan	.	.	.	.	.	.	.	760	219	498	cleared		1477
ALBKROR002*	Kronkup	.	.	.	.	.	.	.	7	0	0	45	0	52
ALBLOWR003	Lowlands	.	.	.	.	.	.	.	6	0	0	.	.	6
ALBMANR002	Manypeaks	.	.	.	.	.	.	.	.	250	0	37	0	287
ALBMCKR001*	McKail	.	.	33	.	18	0	107	110	49	4	12	3	336
ALBMETR001	Mettler	.	.	40	145	.	.	.	.	.	.	.	.	185
ALBMETR002*	Mettler	.	.	.	.	.	.	.	0	.	.	85	0	85
ALBMTCR001	Mt Clarence	.	4	.	.	0	0	0	.	.	.	0	.	4
ALBROBR001	Robinson	.	.	0	43	0	.	0	31	0	.	0	40	114
ALBSEPR001	Seppings	.	0	0	0	0	2	.	3	0	0	.	.	5
ALBTORR002	Torbay	.	.	.	.	.	.	.	.	2	0	.	.	2
ALBTORR005	Torbay	.	.	.	.	.	.	.	0	2	0	.	.	2
AUGAUGR001	Augusta	.	.	.	.	.	.	.	.	.	21	.	.	21
AUGAUGR002	Augusta	.	.	.	.	.	.	.	.	.	.	71	.	71
AUGAUGR003	Augusta	.	.	.	.	.	.	.	.	.	.	41	.	41
AUGCHAR002*	Chapman Hill	.	.	.	.	.	.	.	23	0	0	0	.	23
AUGCOWR003	Cowaramup	.	.	.	.	.	.	.	.	0	.	17	.	17
AUGFORR002*	Forest Grove	.	.	.	.	.	.	6	0	0	.	0	.	6
AUGGRAR001	Gracetown	.	.	.	.	1	12	2	12	0	0	0	6	33
AUGGRAR002	Gracetown	.	.	.	7	85	4	26	3	54	89	28	185	481
AUGGRAR003	Gracetown	.	.	.	.	.	.	.	.	.	7	38	0	45
AUGGRAR004	Gracetown	.	.	.	.	.	.	.	.	.	.	8	198	206
AUGHAMR001	Hamelin Bay	.	.	.	.	.	.	0	2	.	.	0	.	2
AUGMARR001	Margaret River	.	.	11	1	47	0	57	0	0	0	0	.	116
AUGMARR004	Margaret River	.	.	.	.	.	.	6	0	.	21	6	.	33
AUGMARR005*	Margaret River	.	.	.	.	.	.	.	0	.	10	0	.	10
AUGMARR006	Margaret River	.	.	.	.	.	.	.	2	0	19	0	.	21
AUGMARR007	Margaret River	.	.	.	.	.	.	.	5	0	39	0	0	44
AUGMARR008*	Margaret River	.	.	.	.	.	.	.	16	0	0	33	9	58
AUGMARR012	Margaret River	.	.	.	.	.	.	.	20	0	4	.	0	24
AUGMARR013	Margaret River	.	.	.	.	.	.	.	13	0	0	0	.	13
AUGMARR014	Margaret River	.	.	.	.	.	.	.	60	0	.	47	.	107
AUGNILR001	Nillup	.	.	.	.	.	.	.	.	.	15	0	4	19
AUGROSR001	Rosa Glen	.	.	.	.	.	.	.	46	29	0	.	89	164
AUGWITR002	Witchcliffe	.	.	.	.	.	.	.	7	3	2	0	.	12
BRIBOYR001	Boyup Brook	.	.	.	.	.	.	.	.	28	0	0	0	28
BRIBRIR003	Bridgetown	.	.	.	.	.	.	.	5	0	10	.	.	15
BRIBRIR004	Bridgetown	.	.	.	.	.	.	.	.	23	0	.	.	23
BRIGLER001	Glenlynn	.	.	70	250	0	.	.	.	614	532	655	805	2926
BRIGRER003*	Greenbushes	.	.	.	.	.	.	5	0	2	0	0	0	7
BRIGRER004*	Greenbushes	.	.	.	.	.	.	0	0	0	0	32	0	32

Site Code	Locality	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021	2022	Totals
BRIMARR001*	Maranup	.	.	.	.	.	.	.	.	.	0	20	425	445
BRINORR001	North Greenbushes	.	.	.	.	74	44	2	.	0	0	9	0	129
BRINORR002*	North Greenbushes	.	.	.	.	.	.	39	27	45	68	.	0	179
BUNCOLR001	College Grove	.	.	0	20	0	7	0	22	0	0	.	6	55
BUNCOLR002	College Grove	.	.	.	.	0	.	0	3	0	0	0	.	3
BUNGLER001	Glen Iris	.	.	25	0	.	0	0	62	0	9	0	2	98
BUNGLER002	Glen Iris	.	.	.	8	4	0	.	41	79	24	0	0	156
BUSCARR001	Carbunup	.	.	.	.	.	.	.	121	108	4	88	34	355
BUSDUNR001	Dunsborough	.	.	.	32	99	0	0	0	5	87	5	0	228
BUSDUNR002	Dunsborough	.	.	.	.	.	.	82	8	10	0	0	.	100
BUSJINR001	Jindong	.	.	.	.	.	0	.	.	30	10	.	.	40
BUSJINR002*	Jindong	.	.	.	.	0	.	0	1	.	.	.	.	1
BUSMEER002	Meelup	.	.	.	.	.	.	.	14	.	67	0	.	81
BUSMETR002*	Metricup	.	.	.	.	.	.	.	22	3	150	56	.	231
BUSQUIR001	Quindalup	.	.	.	71	107	31	64	30	137	251	133	8	832
BUSWILR002	Wilyabrup	.	.	.	.	.	.	.	.	45	10	81	0	136
BUSYALR001	Yallingup	.	.	.	0	57	.	.	.	0	.	0	22	79
BUSYALR004	Yallingup	.	.	.	.	.	.	8	0	30	0	0	.	38
BUSYALR005	Yallingup	.	.	.	.	.	.	.	0	30	0	0	.	30
BUSYALR006	Yallingup	.	.	.	.	.	.	.	.	3	.	.	.	3
CAPCAPR001	Capel	.	.	.	.	0	.	.	7	0	0	.	.	7
CAPCAPR002*	Capel	.	.	.	.	.	.	.	.	64	31	90	.	185
CAPGELR001	Gelorup	.	.	38	6	0	0	4	0	0	0	0	.	48
CAPGELR002*	Gelorup	.	.	.	.	0	21	2	12	5	89	49	54	232
CAPGWIR001*	Gwindinup	194	.	14	0	119	175	216	48	193	181	110	27	1277
CAPGWIR002	Gwindinup	.	.	.	.	.	.	.	.	123	.	0	0	123
CAPNORR001	North Boyanup	.	.	.	4	0	0	26	0	0	0	0	0	30
CARENNR001	Eneabba	.	.	.	.	.	.	40	.	.	.	.	.	40
CARENNR002	Eneabba	.	.	.	.	.	.	.	0	83	0	10	0	93
CARENNR003	Eneabba	.	.	.	.	.	.	.	.	.	39	0	98	137
CARENNR004	Eneabba	.	.	.	.	.	.	.	.	.	.	71	24	95
CARWARR001	Warradarge	.	.	.	.	.	.	.	.	404	221	480	145	1250
CHAHOWR001	Howatharra	.	.	.	.	.	.	0	.	130	0	0	.	130
CHANABR003	Nabawa	.	.	.	.	.	.	.	.	.	.	.	165	165
CHANANR001	Nanson	.	.	.	302	262	300	270	0	0	0	0	0	1134
CHANANR002	Nanson	.	.	.	0	189	.	0	0	0	0	0	0	189
CRASTIR004	Stirling Range NP	.	.	.	.	.	.	.	.	0	.	56	0	56
DANBADR001	Badgingarra	.	.	.	.	.	.	.	.	.	205	2	0	207
DANDANR001	Dandaragan	.	.	313	228	460	2	0	144	0	357	67	527	2098
DANHILR001	Hill River	.	.	160	0	250	0	0	0	0	70	0	0	480
DANHILR002	Hill River	.	.	136	.	.	11	.	.	.	.	.	.	147
DANHILR003	Hill River	.	.	.	.	131	.	.	0	.	.	.	0	131
DANHILR004	Hill River	.	.	.	.	.	.	.	.	16	.	0	0	16
DANHILR005	Hill River	.	.	.	.	.	.	.	.	.	.	.	200	200
DANJURR001	Jurien Bay	.	.	51	225	52	143	436	230	128	400	267	282	2214
DANREGR001	Regans Ford	0	22	0	.	.	.	.	.	.	.	.	.	22
DARBURR001*	Burekup	.	.	.	.	.	.	.	0	101	4	192	110	407
DAREATR001	Eaton	.	4	19	14	0	0	.	20	0	2	16	0	75
DENSCOR001	Scotsdale	.	.	.	.	.	.	70	.	.	.	.	.	70
DENSCOR003*	Scotsdale	.	.	.	.	.	.	.	.	2	99	.	0	101
DONBALR002*	Balingup	.	.	.	.	.	.	.	0	3	0	0	0	3
DONBALR003	Balingup	.	.	.	.	.	.	.	0	0	0	555	0	555
DONCOLR001	Collie	.	.	.	.	.	.	.	.	15	.	0	5	20
DONCOLR002*	Collie	.	.	.	.	.	.	.	.	6	0	15	0	21
DONDONR001*	Donnybrook	.	.	.	11	0	0	.	0	0	0	10	0	21
DONLOWR001*	Lowden	.	.	.	.	.	.	0	0	0	28	0	2	30
DONLOWR002*	Lowden	.	.	.	.	.	.	.	.	.	3	0	0	3
DONMUMR001	Mumballup	.	29	.	0	.	7	.	.	.	.	.	.	36

Site Code	Locality	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021	2022	Totals
DONMUMR003	Mumballup	.	.	.	.	.	.	0	20	33	56	0	75	184
DONMUNR001*	Mungalup	.	.	.	.	.	.	4	0	0	0	.	4	8
DONNOGR001*	Noggerup	.	.	.	.	.	.	0	14	0	0	0	0	14
DONRIVR001*	Donnelly River	.	.	.	.	.	.	.	.	0	26	7	26	59
DONYABR001*	Yabberup	.	.	.	.	.	.	.	9	1	.	.	.	10
ESPCONR002	Condingup	.	.	.	.	.	.	.	.	.	416	.	320	736
ESPCONR003	Condingup	.	.	.	.	.	.	.	.	.	.	450	170	620
ESPESPR001	Esperance	.	196	226	230	202	.	665	125	36	107	116	148	2051
ESPESPR002	Esperance	.	.	.	.	.	360	.	0	0	0	.	.	360
ESPESPR003	Esperance	.	.	.	.	.	60	.	111	163	71	76	85	566
ESPESPR004	Esperance	.	.	.	.	.	316	.	205	99	121	182	.	923
ESPMYRR001	Myrup	.	.	555	589	791	0	32	0	0	.	.	.	1967
ESPMYRR002	Myrup	.	.	1018	0	.	.	.	500	0	0	0	0	1518
ESPMYRR003	Myrup	.	.	.	.	.	.	.	559	0	375	.	0	934
GINNILR001	Nilgen	.	.	.	583	376	995	500	855	1207	650	1416	1510	8092
GNOGNOR001	Gnowellen	.	.	.	.	.	.	.	.	.	.	6	.	6
GNOSTIR001	Stirling Range NP	.	.	52	.	38	.	.	187	90	.	0	0	367
GOOGOOR001	Goomalling	.	9	.	.	.	.	0	.	.	.	.	.	9
HARBEER001*	Beela	.	.	.	.	.	.	.	.	.	.	6	56	62
HARCOOR001*	Cookernup	.	.	.	.	.	.	.	.	68	17	4	.	89
HARHARR001*	Harvey	.	.	.	.	0	.	10	.	14	0	0	0	24
HARLESR001*	Leschenault	.	.	.	.	.	.	14	11	21	0	0	7	53
HARMYAR001	Myalup	.	0	0	0	35	0	349	0	0	.	.	.	384
HARMYAR002	Myalup	52	155	cleared										207
HARMYAR003	Myalup	.	.	.	.	.	570	33	123	167	.	.	.	893
HARMYAR004	Myalup	.	.	.	.	.	.	.	.	.	127	131	268	526
HARSUNR001*	Harvey	.	.	.	.	.	24	.	.	83	120	226	113	566
HARWELR002	Wellesley	.	.	.	.	.	.	.	.	.	616	cleared		616
HARWELR003*	Wellesley	.	.	.	.	.	.	.	.	.	.	0	1738	1738
IRWMILR001	Milo	.	.	1	.	0	.	.	.	.	.	.	.	1
JERBOXR001	Boxwood Hill	.	.	11	0	.	0	.	.	.	.	0	.	11
KOJKOJR001	Kojonup	.	.	.	.	.	.	.	48	27	8	.	.	83
MNJCROR001	Crowea	.	.	.	5	0	.	.	0	.	.	0	.	5
MNJMNJR001*	Manjimup	.	.	.	.	.	.	17	0	0	44	0	17	78
MNJMNJR002	Manjimup	.	.	.	.	.	.	.	.	27	0	0	.	27
MNJMNJR003*	Manjimup	.	.	.	.	.	.	.	.	66	0	74	18	158
MNJMNJR004	Manjimup	.	.	.	.	.	.	.	.	.	.	.	3	3
MNJPERR002*	Perup	.	.	.	.	.	.	.	.	.	2	0	0	2
MNJQUIR001*	Quinninup	.	.	.	.	.	.	.	.	.	.	17	1	18
NANEASR001*	East Nannup	.	.	.	.	.	.	.	.	.	.	6	.	6
NANNANR001	Nannup	.	.	.	.	.	.	.	16	16	0	179	0	211
NANNANR005	Nannup	.	.	.	.	.	.	.	.	.	.	31	0	31
NARNARR002	Narrogin	.	.	16	19	36	.	21	77	17	.	0	.	186
NARNARR004	Narrogin	.	.	0	9	.	0	.	.	0	.	.	.	9
NARNARR005	Narrogin	.	80	0	0	.	.	0	.	45	.	0	.	125
PLAFORR001*	Forest Hill	.	.	.	.	.	.	.	.	.	23	.	0	23
PLAMOUR001	Mount Barker	.	.	3	0	0	0	.	.	.	.	.	.	3
PLAMOUR006*	Mount Barker	.	.	.	.	.	.	.	.	.	.	9	0	9
PLANARR001*	Narrikup	.	.	.	.	.	.	191	0	7	40	36	0	274
PLANARR002*	Narrikup	.	.	.	.	45	.	0	.	.	0	0	.	45
PLAPORR003*	Porongurup	.	.	.	.	.	.	.	9	137	4	20	12	182
PLAPORR006	Porongurup	.	.	.	.	.	.	.	200	0	.	.	.	200
PLAPORR007	Porongurup	.	.	.	.	.	.	.	.	67	0	0	2	69
PLASTIR001	Stirling Range NP	.	.	254	316	.	25	.	76	86	.	156	32	945
RAVHOPR001	Hopetoun	.	.	.	.	30	.	0	0	0	0	250	.	280
RAVHOPR002	Hopetoun	.	.	.	.	150	.	0	.	0	.	.	.	150
RAVHOPR003	Hopetoun	.	.	.	.	.	.	.	.	.	640	0	.	640
RAVNMUNR001	Munglinup	.	.	.	.	.	.	.	.	.	.	500	448	948

Site Code	Locality	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021	2022	Totals
THRARRR002	Arrino	.	.	.	70	.	.	.	.	.	.	.	.	70
VCTOLDR001	Old Plains	.	.	.	0	.	0	.	.	.	2	.	.	2
WARYARR001*	Yarloop	.	.	.	.	.	.	36	.	.	.	3	0	39

APPENDIX V: Roost counts for Forest Red-tailed Black-Cockatoo

Appendix Va: Great Cocky Count (2014-2022) roost counts for FRTBC at **confirmed roosts** in the Perth-Peel Coastal Plain. Sites with an asterisk have been recorded as having both WTBC and FRTBC roosting. A period in a cell means that the site was not surveyed in that year.

Site code	Locality	2014	2015	2016	2017	2018	2019	2021	2022	Totals
ARMARMR002	Armadale	.	.	17	.	15	0	0	.	32
ARMARMR004	Armadale	.	.	.	0	6	4	11	0	21
ARMCHAR001*	Champion Lakes	.	.	.	11	16	0	4	0	31
ARMKELR001*	Kelmscott	0	.	.	.	0	0	2	0	2
ARMKELR004	Kelmscott	.	.	.	.	.	6	16	0	22
ARMKELR005*	Kelmscott	.	.	.	.	.	.	6	0	6
BAYEMBR002	Embleton	.	.	.	.	34	.	56	2	92
BAYMAYR001	Maylands	.	.	0	0	.	4	25	.	29
BAYMORR001*	Morley	0	0	36	130	300	299	285	6	1056
BAYMORR002	Morley	.	.	.	8	30	2	17	0	57
CAMCITR001*	City Beach	0	0	0	0	.	19	0	.	19
CAMFLOR002	Floreat	109	.	49	261	360	837	689	99	2404
CAMFLOR003	Floreat	.	.	.	.	40	0	39	26	105
CAMKARR001	Karrakatta	.	.	.	.	3	0	.	.	3
CANRIVR001	Riverton	.	.	6	11	7	16	51	4	95
CANROSR001	Rossmoyne	.	.	0	0	14	2	0	0	16
CANWILR001*	Willetton	4	7	7	5	16	82	56	0	177
CANWILR004	Willetton	.	.	.	.	.	.	33	14	47
CHIMUCR001	Muchea	.	.	.	43	26	0	0	0	69
COCBANR001*	Banjup	.	0	.	6	17	0	27	0	50
COCBANR002*	Banjup	3	.	32	24	109	15	22	4	209
COCCOCR001*	Cockburn Central	.	.	.	.	15	102	37	0	154
COCCOOR001	Coolbellup	.	13	0	0	8	0	0	0	21
COCCOOR003	Coolbellup	.	.	57	6	71	33	75	2	244
COCMUNR001	Munster	92	.	73	0	365	259	149	54	992
COCMUNR003*	Munster	.	.	38	0	108	0	0	0	146
COCSPER003	Spearwood	.	.	.	35	12	0	46	0	93
FREWHIR001	White Gum Valley	0	.	0	38	29	28	60	8	163
GOSCNVR001*	Canning Vale	2	0	0	0	.	0	0	0	2
GOSCNVR002*	Canning Vale	0	4	0	0	0	0	0	0	4
GOSGOSR004	Gosnells	19	.	31	32	79	0	53	0	214
GOSKENR001	Kenwick	.	.	.	51	334	35	6	0	426
GOSKENR002	Kenwick	.	.	.	.	72	0	10	0	82
GOSKENR003	Kenwick	.	.	.	.	.	.	3	0	3
GOSSOUR002*	Southern River	.	.	0	36	208	15	21	0	280
GOSSOUR003	Southern River	.	.	.	.	.	0	99	3	102
JOOPADR001*	Padbury	0	0	0	0	0	9	0	3	12
KALHIGR001	High Wycombe	.	.	.	7	78	5	0	0	90
KALMAIR002*	Maida Vale	25	.	56	98	137	304	205	0	825
KWICASR001*	Casuarina	0	.	.	75	16	0	5	0	96
KWIWELR001*	Wellard	0	0	9	0	0	0	0	0	9
KWIWELR003*	Wellard	.	.	.	.	14	0	3	2	19
MANBARR001	Barragup	.	.	.	.	.	46	10	31	87
MANBARR002	Barragup	.	.	.	.	.	57	.	.	57
MANCOOR002*	Coodanup	0	0	30	0	0	0	.	.	30
MANDAWR002*	Dawesville	0	38	0	0	0	0	0	0	38
MANDAWR007*	Dawesville	.	0	2	0	0	0	0	0	2
MANPARR001	Parklands	0	.	16	0	14	0	0	8	38

Site code	Locality	2014	2015	2016	2017	2018	2019	2021	2022	Totals
MANPARR002	Parklands	.	.	.	.	.	13	.	13	26
MELATTR002	Attadale	.	.	.	.	.	.	.	4	4
MELLEER001*	Leeming	0	0	11	25	5	0	0	0	41
MELMURR001*	Murdoch	199	33	125	209	441	214	382	36	1639
MELWINR003*	Winthrop	.	0	0	0	1	0	0	0	1
MOSMOSR001	Mosman Park	0	0	0	0	0	3	0	0	3
MURWESR001	West Coolup	.	.	.	.	.	.	20	0	20
NEDDALR002*	Dalkeith	.	.	0	0	1	0	0	0	1
ROCBALR003*	Baldivis	17	25	24	.	45	65	64	6	246
ROCBALR006	Baldivis	.	.	.	.	.	.	3	3	6
ROCKARR002*	Karnup	.	.	.	5	37	9	0	24	75
SERDARR001*	Darling Downs	.	.	26	0	24	0	0	2	52
SERKEYR001*	Keysbrook	0	0	0	0	0	3	0	0	3
SERKEYR004	Keysbrook	.	.	.	14	26	9	5	0	54
SERKEYR005	Keysbrook	.	.	.	0	8	0	.	.	8
SERKEYR006	Keysbrook	.	.	.	6	3	.	.	.	9
SERMUNR002*	Mundijong	.	.	0	4	.	0	13	.	17
SEROAKR002*	Oakford	.	.	.	4	15	0	6	0	25
SERSERR003	Serpentine	0	0	3	0	9	3	10	0	25
SERSERR005	Serpentine	.	.	12	0	4	.	3	0	19
SOUCOMR001*	Como	0	0	0	0	0	1	2	0	3
SOUCOMR003	Como	.	.	.	.	.	.	.	5	5
SOUSALR001*	Salter Point	2	0	0	0	8	0	2	6	18
STIBALR001	Balga	0	0	0	0	10	11	0	12	33
STIMENR002	Menora	0	.	0	5	0	0	0	.	5
STIYOKR002	Yokine	0	1	0	.	83	142	43	5	274
STIYOKR003	Yokine	47	28	0	239	276	391	258	31	1270
SWABALR003	Ballajura	.	.	0	120	151	151	55	29	506
SWABULR005*	Bullsbrook	.	.	.	.	41	0	0	0	41
SWACAVR002*	Caversham	.	.	.	.	.	.	42	0	42
SWAGUIR001	Guildford	0	0	.	.	.	.	7	0	7
SWAHAZR001	Hazelmere	.	.	.	.	.	12	72	0	84
SWAHAZR002*	Hazelmere	.	.	.	.	.	.	16	2	18
SWAMELR001*	Melaleuca	0	0	.	129	0	0	0	0	129
SWAVINR002	The Vines	0	.	.	0	6	0	0	0	6
SWAVINR003*	The Vines	.	.	31	5	0	0	1	0	37
SWAWESR001	West Swan	.	.	0	0	36	.	0	.	36
SWAWESR002	West Swan	.	.	.	.	.	.	54	9	63
SWAWHIR001*	Whiteman	.	0	0	4	0	.	0	0	4
VICKENR001*	Kensington	94	121	0	116	108	140	287	16	882
VICKENR002	Kensington	.	35	42	0	.	.	20	.	97
VICLATR001	Lathlain	0	0	0	0	15	32	28	9	84
VICWATR002	Waterford	.	.	0	45	85	51	50	.	231
WANGNAR005*	Gnangara	0	0	0	7	.	.	.	.	7
WANGNAR006*	Gnangara	3	.	0	4	0	.	12	.	19
WANJANR008	Jandabup	.	.	.	102	156	243	269	28	798
WANMARR002*	Mariginiup	0	0	0	0	11	20	0	0	31
WANNOWR005*	Nowergup	.	.	0	0	2	.	0	3	5
WANWANR003	Wanneroo	.	.	.	.	.	3	0	0	3
WARLAKR002	Lake Clifton	.	.	.	4	.	.	0	.	4
WARLAKR003	Lake Clifton	.	.	.	6	26	29	36	.	97

Appendix Vb: Great Cocky Count (2014-2022) roost counts for FRTBC at **confirmed roosts** in the Northern Darling Scarp and Plateau. Sites with an asterisk have been recorded as having both WTBC and FRTBC roosting. A period in a cell means that the site was not surveyed in that year.

Site code	Locality	2014	2015	2016	2017	2018	2019	2021	2022	Totals
ARMASHR001	Ashendon	.	.	.	3	.	.	0	.	3
ARMBEDR001*	Bedfordale	21	0	0	0	0	13	0	10	44
ARMBEDR002*	Bedfordale	0	.	0	22	0	0	.	.	22
ARMBEDR003*	Bedfordale	0	0	0	0	3	21	8	7	39
ARMBEDR004	Bedfordale	.	.	18	6	0	7	14	17	62
ARMBEDR005*	Bedfordale	.	.	.	0	4	18	9	4	35
ARMBEDR006	Bedfordale	.	.	.	14	14	15	21	6	70
ARMBEDR007	Bedfordale	.	.	.	.	.	.	86	40	126
ARMROLR001*	Roleystone	0	0	0	9	0	3	.	0	12
ARMROLR003*	Roleystone	0	0	0	4	0	0	0	.	4
ARMROLR004*	Roleystone	0	.	35	0	0	50	46	6	137
ARMROLR005*	Roleystone	.	.	0	36	40	12	107	3	198
ARMROLR007	Roleystone	.	.	.	.	.	.	30	18	48
BEVFLYR002*	Flynn	.	.	.	83	0	0	53	5	141
BEVFLYR003	Flynn	.	.	.	.	.	14	.	.	14
BINBINR002	Bindoon	.	.	.	15	0	.	0	.	15
BODMARR001*	Marradong	.	.	16	0	0	.	31	0	47
BODMARR004	Marradong	.	.	.	18	0	134	.	0	152
BODMARR005	Marradong	.	.	.	.	2	.	.	.	2
BODMARR006	Marradong	.	.	.	.	.	13	0	.	13
BODMARR007	Marradong	.	.	.	.	.	.	.	4	4
CHICHIR001*	Chittering	.	.	.	52	71	0	4	21	148
CHICHIR002	Chittering	.	.	.	.	.	27	0	0	27
GOSMARR001*	Martin	.	.	.	75	37	18	11	5	146
KALCANR001*	Canning Mills	.	.	.	.	.	5	.	.	5
KALCARR001	Carmel	.	.	0	12	0	.	0	0	12
KALCARR002*	Carmel	.	.	.	0	.	24	0	0	24
KALCARR003*	Carmel	.	.	.	.	.	76	91	15	182
KALFORR002	Forrestfield	.	.	.	.	42	65	58	0	165
KALFORR003	Forrestfield	.	.	.	.	31	10	7	0	48
KALFORR004	Forrestfield	.	.	.	.	.	.	.	13	13
KALGOOR002	Gooseberry Hill	.	.	.	.	.	.	34	0	34
KALHIGR003	High Wycombe	.	.	0	7	0	.	.	.	7
KALKALR004*	Kalamunda	.	.	0	0	0	0	5	0	5
KALMAIR004	Maida Vale	.	.	.	0	.	.	5	0	5
KALMAIR005	Maida Vale	.	.	3	0	0	0	0	.	3
KALMAIR006	Maida Vale	.	.	.	3	.	.	.	.	3
KALPICR002*	Pickering Brook	42	.	0	7	.	.	0	0	49
KALPICR003	Pickering Brook	.	.	.	.	.	.	99	23	122
KALPIER001*	Piesse Brook	0	0	25	.	29	6	34	0	94
KALPIER002*	Piesse Brook	.	.	.	2	8	0	0	17	27
KALPIER003*	Piesse Brook	.	.	0	0	0	0	3	22	25
KALWALR001*	Walliston	43	1	.	0	0	.	24	0	68
KALWATR002	Wattle Grove	.	.	150	31	150	23	87	0	441
KALWATR003*	Wattle Grove	.	.	.	.	.	0	21	0	21
MUNCHIR002*	Chidlow	12	.	49	65	0	0	22	11	159
MUNCHIR003	Chidlow	.	.	4	4	0	.	.	9	17
MUNGLER003*	Glen Forrest	0	.	0	0	0	0	4	0	4
MUNGLER004	Glen Forrest	.	.	33	4	41	.	40	3	121

Site code	Locality	2014	2015	2016	2017	2018	2019	2021	2022	Totals
MUNHELR001*	Helena Valley	0	0	4	31	0	13	6	4	58
MUNHELR002	Helena Valley	.	.	.	.	79	66	33	10	188
MUNHOVR001*	Hovea	.	14	52	21	78	52	33	5	255
MUNHOVR004	Hovea	.	.	.	3	.	4	.	0	7
MUNHOVR005	Hovea	.	.	.	.	.	27	2	0	29
MUNHOVR006	Hovea	.	.	.	.	.	.	8	17	25
MUNMTHR001*	Mt Helena	0	0	0	0	2	.	.	0	2
MUNMTHR002*	Mt Helena	0	.	0	0	0	0	4	0	4
MUNMTHR003*	Mt Helena	.	.	41	0	2	2	23	0	68
MUNMUNR001*	Mundaring	0	0	0	0	8	0	0	0	8
MUNMUNR002	Mundaring	.	20	16	32	7	3	7	9	94
MUNMUNR003*	Mundaring	.	.	59	0	0	0	8	0	67
MUNPARR003*	Parkerville	.	.	12	8	0	0	0	0	20
MUNPARR004*	Parkerville	.	.	0	4	0	0	0	0	4
MUNPARR005*	Parkerville	.	.	.	4	2	0	.	2	8
MUNPARR006	Parkerville	.	.	.	.	.	.	0	15	15
MUNPARR007	Parkerville	.	.	.	.	.	.	31	0	31
MUNSTOR001*	Stoneville	0	24	0	0	0	0	13	0	37
MUNSTOR003*	Stoneville	0	.	9	0	0	9	37	7	62
MUNSTOR004*	Stoneville	.	.	3	0	0	0	0	.	3
MUNSTOR005*	Stoneville	.	.	15	0	0	0	0	0	15
MUNWOOR001	Wooroloo	17	.	.	.	0	.	.	.	17
MURDWER001*	Dwellingup	.	0	.	0	.	97	0	0	97
MURDWER002*	Dwellingup	3	.	.	0	60	120	30	16	229
MURDWER003*	Dwellingup	.	.	.	.	0	167	0	5	172
MURDWER005	Dwellingup	.	.	.	.	.	32	43	13	88
MURINGR001	Inglehope	.	.	.	.	.	.	61	59	120
MURNORR001*	North Dandalup	.	.	26	0	3	8	61	17	115
MURNORR002*	North Dandalup	.	.	.	.	.	50	.	0	50
MURTEER002	Teesdale	.	.	.	.	.	.	.	130	130
NORBAKR002*	Bakers Hill	.	.	.	.	.	.	.	13	13
NORWOOR002*	Woottating	.	.	.	.	0	0	14	0	14
NORWUNR001*	Wundowie	.	6	0	8	.	0	4	0	18
SERBYFR002	Byford	.	.	0	2	0	.	0	.	2
SERBYFR003*	Byford	.	.	6	.	0	.	0	.	6
SERBYFR004*	Byford	.	.	88	32	9	0	95	7	231
SERBYFR006*	Byford	.	.	.	.	.	0	.	108	108
SERJARR002	Jarrahdale	.	.	.	7	0	0	0	.	7
SERJARR003	Jarrahdale	.	.	30	59	0	5	24	29	147
SERJARR004	Jarrahdale	.	.	.	.	.	45	15	14	74
SERKARR001	Karrakup	.	.	.	.	8	.	0	.	8
SERKEYR002*	Keysbrook	.	37	.	0	.	.	0	0	37
SERKEYR003*	Keysbrook	.	.	.	0	0	5	6	4	15
SERKEYR007*	Keysbrook	.	.	.	.	.	63	7	.	70
SERKEYR009*	Keysbrook	.	.	.	.	.	11	3	9	23
SERSERR006	Serpentine	.	.	.	.	.	38	.	0	38
SERSERR008*	Serpentine	.	.	.	.	.	41	22	42	105
SWABULR002*	Bullsbrook	0	.	0	26	0	0	0	0	26
SWABULR004*	Bullsbrook	.	.	0	0	0	.	10	0	10
SWAGIDR001	Gidgegannup	.	.	3	0	0	.	.	.	3
SWAGIDR007*	Gidgegannup	.	.	86	44	12	3	8	0	153
SWAGIDR008*	Gidgegannup	.	.	25	21	27	54	45	25	197
SWAGIDR009*	Gidgegannup	.	.	15	0	0	56	0	0	71
SWAGIDR010	Gidgegannup	.	.	.	.	.	.	8	21	29

Site code	Locality	2014	2015	2016	2017	2018	2019	2021	2022	Totals
TOOMORR001*	Morangup	0	5	0	0	0	0	13	2	20
TOOMORR002	Morangup	.	.	.	36	11	35	18	0	100
TOOMORR003*	Morangup	.	.	.	23	23	23	24	24	117
TOOMORR004	Morangup	.	.	.	.	.	.	18	0	18
TOOMORR005*	Morangup	.	.	.	.	.	.	7	0	7
WARWAGR001*	Wagerup	38	.	.	.	.	.	0	0	38
WARWARR001	Waroona	.	.	0	.	0	3	0	.	3
WARWARR002*	Waroona	10	0	0	0	20	63	.	.	93
WARWARR003*	Waroona	.	.	.	.	35	8	9	53	105
WARWARR004*	Waroona	.	.	.	.	.	.	186	60	246
WILQUIR002	Quindanning	.	.	38	0	14	0	.	0	52
WNDSPRR001*	Springs	.	.	74	7	16	.	.	0	97

Appendix Vc: Great Cocky Count (2014-2022) roost counts for FRTBC at **confirmed roosts** in regional areas. Sites with an asterisk have been recorded as having both WTBC and FRTBC roosting. A period in a cell means that the site was not surveyed in that year.

Site code	Locality	2014	2015	2016	2017	2018	2019	2021	2022	Totals
ALBKALR003	Kalgan	.	.	27	12	.	26	31	2	98
ALBKALR004*	Kalgan	.	.	.	0	0	10	cleared		10
ALBKROR002*	Kronkup	.	.	.	0	0	5	0	0	5
ALBLKIR001	Lower King	.	.	.	.	.	.	.	3	3
ALBMARR001	Marbellup	.	.	.	.	.	.	20	18	38
ALBMCKR001*	McKail	0	0	0	10	0	0	0	0	10
ALBMETR002*	Mettler	.	.	.	7	.	.	7	0	14
ALBTORR003	Torbay	.	2	.	0	0	.	0	.	2
ALBTORR004	Torbay	.	5	.	.	.	.	.	.	5
AUGAUGR004	Augusta	.	.	.	.	.	.	9	.	9
AUGCHAR001	Chapman Hill	.	.	.	21	0	.	26	.	47
AUGCHAR002*	Chapman Hill	.	.	.	35	0	0	26	.	61
AUGCOWR004	Cowaramup	.	.	.	.	4	0	.	.	4
AUGFORR002*	Forest Grove	.	.	9	0	0	.	0	.	9
AUGMARR005*	Margaret River	.	.	.	0	.	4	0	.	4
AUGMARR008*	Margaret River	.	.	.	0	0	96	0	0	96
AUGMARR015	Margaret River	.	.	.	.	3	49	2	.	54
AUGMOLR001	Molloy Island	.	.	.	.	.	.	8	.	8
BRIBRIR005	Bridgetown	.	.	.	.	.	.	8	0	8
BRIBRIR006	Bridgetown	.	.	.	.	.	.	34	0	34
BRIGRER002	Greenbushes	20	0	6	27	31	7	0	0	91
BRIGRER003*	Greenbushes	.	.	7	5	26	53	27	15	133
BRIGRER004*	Greenbushes	.	.	7	0	2	28	19	73	129
BRIMARR001*	Maranup	.	.	.	.	.	0	0	24	24
BRINORR002*	North Greenbushes	.	.	1	0	0	0	.	0	1
BRIWANR001	Wandillup	.	.	.	.	.	.	42	24	66
BRIYORR001	Yornup	.	.	.	.	.	13	.	3	16
BUSABBR001	Abba River	.	.	.	.	.	6	.	.	6
BUSJINR002*	Jindong	2	.	0	0	.	.	.	.	2
BUSMETR002*	Metricup	.	.	.	0	27	0	0	.	27
BUSQUIR003	Quindalup	.	.	5	.	.	.	.	.	5
BUSQUIR004	Quindalup	.	.	.	.	9	.	.	.	9
BUSYELR001	Yelverton	.	.	.	.	.	7	.	.	7
CAPBOYR001	Boyanup	.	15	10	0	17	5	68	15	130
CAPCAPR002*	Capel	.	.	.	.	8	6	31	.	45
CAPFERR001	Ferguson	.	.	.	2	.	34	28	31	95
CAPGELR002*	Gelorup	0	11	4	15	17	0	30	0	77
CAPGWIR001*	Gwindinup	0	0	0	0	0	0	6	0	6
CAPNORR002	North Boyanup	.	.	.	.	.	.	5	0	5
COLWORR001	Worsely	.	.	.	.	.	.	.	42	42
DARBURR001*	Burekup	.	.	.	2	0	0	27	0	29
DAREATR002	Eaton	.	.	.	0	22	0	.	0	22
DENHAYR001	Hay	.	.	.	.	8	0	0	.	8
DENSCOR003*	Scotsdale	.	.	.	.	0	17	.	0	17
DONBALR002*	Balingup	.	.	.	13	71	75	8	45	212
DONBOWR001	Bowelling	.	.	.	.	.	66	0	13	79
DONCOLR002*	Collie	.	.	.	.	27	0	12	9	48
DONDONR001*	Donnybrook	14	6	.	0	0	0	24	4	48
DONLOWR001*	Lowden	.	.	3	7	0	8	0	1	19

Site code	Locality	2014	2015	2016	2017	2018	2019	2021	2022	Totals
DONLOWR002*	Lowden	.	.	.	.	.	33	32	10	75
DONMUMR002	Mumballup	.	.	7	.	.	.	.	97	104
DONMUMR004	Mumballup	.	.	.	.	.	.	.	27	27
DONMUNR001*	Mungalup	.	.	84	0	0	0	.	36	120
DONNOGR001*	Noggerup	.	.	49	0	21	0	63	0	133
DONPAYR001	Paynedale	.	.	.	.	.	.	17	5	22
DONRIVR001*	Donnelly River	.	.	.	.	70	82	115	50	317
DONYABR001*	Yabberup	.	.	.	0	3	.	.	.	3
HARBEER001*	Beela	.	.	.	.	.	.	11	0	11
HARBRUR002	Brunswick	.	.	9	29	.	0	12	0	50
HARCOOR001*	Cookernup	.	.	.	.	0	0	7	.	7
HARHARR001*	Harvey	6	.	11	.	0	0	34	0	51
HARLESR001*	Leschenault	.	.	23	7	5	3	14	9	61
HARLESR002	Leschenault	.	.	.	.	16	6	0	0	22
HARROER002	Roelands	3	.	29	0	24	0	0	0	56
HARROER003	Roelands	.	.	0	2	3	0	.	.	5
HARSUNR001*	Harvey	.	0	.	.	0	6	0	0	6
HARWELR003*	Wellesley	.	.	.	.	.	.	26	0	26
KOJORCR001	Orchid Valley	.	.	.	.	.	.	6	.	6
MNJMNJR001*	Manjimup	.	.	16	0	0	35	0	11	62
MNJMNJR003*	Manjimup	.	.	.	.	0	0	9	0	9
MNJPERR002*	Perup	.	.	.	.	.	68	0	0	68
MNJQUIR001*	Quinninup	.	.	.	.	.	.	0	9	9
NANEASR001*	East Nannup	.	.	.	.	.	.	11	.	11
NANJALR001	Jalbarragup	.	.	.	.	.	.	11	.	11
NANNANR004	Nannup	.	.	.	.	.	9	.	.	9
PLAFORR001*	Forest Hill	.	.	.	.	.	32	.	0	32
PLAMOUR006*	Mount Barker	.	.	.	.	.	.	4	0	4
PLANARR001*	Narrikup	.	.	0	8	0	0	0	0	8
PLANARR002*	Narrikup	39	.	29	.	.	0	0	.	68
PLAPORR003*	Porongurup	.	.	.	2	0	0	3	0	5
WARYARR001*	Yarloop	.	.	0	.	.	.	48	2	50
WESDARR002	Darkan	.	.	.	.	5	.	.	.	5
WESMOOR001	Moodiarrup	.	.	0	.	4	.	.	.	4
WILQUIR001	Quindanning	10	.	0	15	0	0	.	0	25

Appendix Vd: Spring FRTBC Count (2018 - 2022) roost counts for FRTBC on the Perth-Peel Coastal Plain. A period in a cell means that the site was not surveyed in that year.

Site code	Locality	2018	2019	2020	2021	2022	Totals
BAYEMBR002	Embleton	.	.	.	4	3	7
BAYMORR001	Morley	0	0	.	0	0	0
BAYMORR002	Morley	.	.	.	0	.	0
CAMFLOR002	Floreat	0	35	47	47	22	151
CAMFLOR003	Floreat	.	.	.	0	0	0
CANRIVR001	Riverton	.	.	.	0	.	0
CANWILR001	Willetton	.	.	3	1	2	6
COCBANR001	Banjup	.	.	.	2	.	2
COCBANR002	Banjup	0	0	.	0	6	6
COCCOCR001	Cockburn Central	.	.	0	.	.	0
COCCOOR003	Coolbellup	.	.	0	.	0	0
COCMUNR001	Munster	0	8	0	.	0	8
COCMUNR003	Munster	0	0	0	.	0	0
COCSPER003	Spearwood	.	.	.	3	0	3
FREWHIR001	White Gum Valley	.	.	0	0	2	2
GOSGOSR004	Gosnells	.	46	22	0	.	68
GOSKENR001	Kenwick	0	0	44	0	.	44
GOSSOUR002	Southern River	0	7	27	0	0	34
JOOPADR001	Padbury	.	.	.	0	0	0
KALHIGR001	High Wycombe	.	0	.	.	.	0
KALMAIR002	Maida Vale	0	1	59	62	68	190
MANBARR001	Barragup	.	.	.	9	32	41
MANBARR002	Barragup	.	.	.	0	.	0
MELMURR001	Murdoch	4	46	26	0	1	77
ROCBALR003	Baldivis	.	19	15	3	.	37
ROCBALR006	Baldivis	.	.	.	3	3	6
ROCKARR002	Karnup	.	.	.	.	10	10
ROCSAFR001	Safety Bay	.	.	.	5	0	5
SERHOPR002	Hopeland	.	.	.	5	.	5
SERSERR003	Serpentine	.	.	.	21	18	39
SERWHIR003	Whitby	.	.	.	.	149	149
SOUSALR001	Salter Point	.	.	.	3	.	3
STIBALR001	Balga	.	.	.	3	0	3
STIYOKR002	Yokine	.	0	0	0	0	0
STIYOKR003	Yokine	0	73	3	32	19	127
SWABALR003	Ballajura	0	43	0	.	10	53
SWABULR005	Bullsbrook	.	.	.	6	11	17
SWAHAZR001	Hazelmere	.	.	.	0	.	0
SWAHAZR002	Hazelmere	.	.	.	.	0	0
SWAMELR001	Melaleuca	.	.	0	.	.	0
SWAVINR003	The Vines	.	.	.	0	.	0
SWAWESR002	West Swan	.	.	.	.	3	3
VICKENR001	Kensington	0	26	.	25	20	71
VICKENR002	Kensington	.	.	.	0	.	0
VICLATR001	Lathlain	.	.	.	.	0	0
VICWATR002	Waterford	.	0	0	0	.	0
WANGNAR001	Gnangara	.	.	.	0	.	0
WANJANR008	Jandabup	10	49	0	0	6	65
WARLAKR003	Lake Clifton	.	.	.	17	15	32

Appendix Ve: Spring FRTBC Count (2018 - 2022) roost counts for FRTBC on the Northern Darling Scarp and Plateau. A period in a cell means that the site was not surveyed in that year.

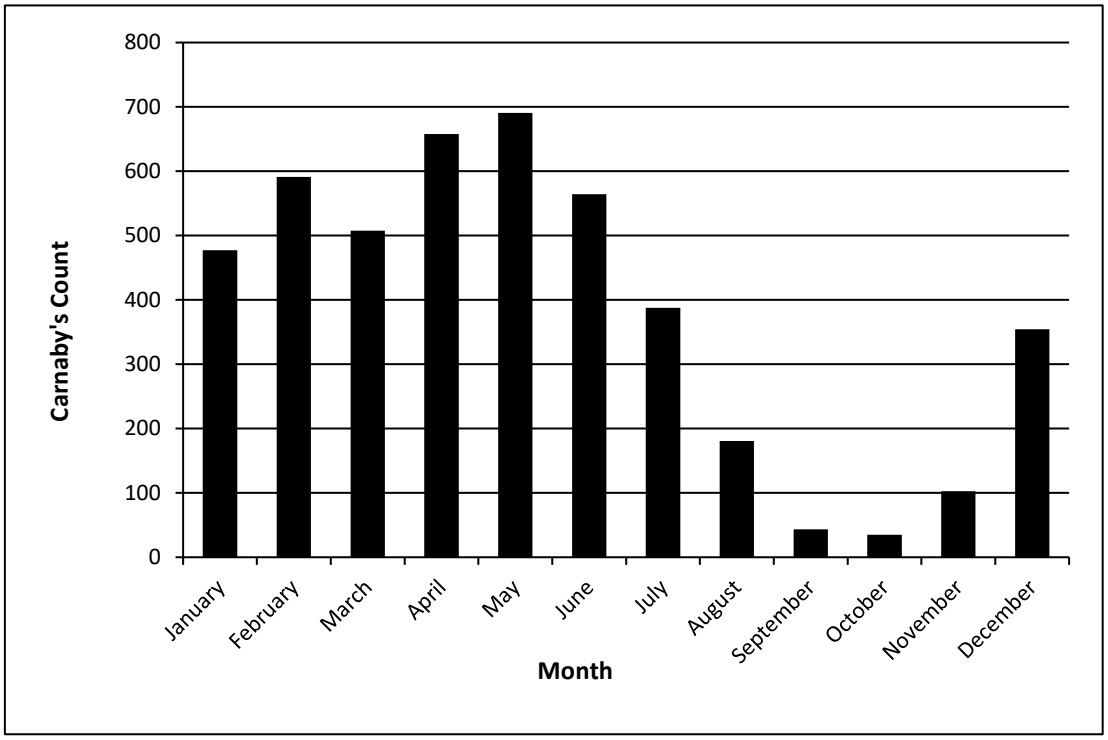
Site code	Locality	2018	2019	2020	2021	2022	Totals
ARMBEDR004	Bedfordale	.	.	.	.	22	22
ARMBEDR006	Bedfordale	.	.	.	18	32	50
ARMBEDR007	Bedfordale	.	.	.	34	55	89
ARMROLR004	Roleystone	.	3	18	38	.	59
ARMROLR005	Roleystone	.	3	50	65	68	186
ARMROLR007	Roleystone	.	.	.	.	16	16
BODMARR004	Marradong	.	0	.	.	.	0
BODMARR006	Marradong	.	.	0	.	.	0
CHICHIR001	Chittering	.	.	0	0	6	6
GOSMARR001	Martin	.	43	54	38	39	174
KALCARR003	Carmel	.	6	18	.	34	58
KALFORR002	Forrestfield	.	0	5	31	34	70
KALFORR003	Forrestfield	.	.	.	0	.	0
KALGOOR002	Gooseberry Hill	.	.	.	0	.	0
KALPICR002	Pickering Brook	.	.	0	.	.	0
KALPICR003	Pickering Brook	.	.	.	.	22	22
KALPIER001	Piesse Brook	.	.	24	19	36	79
KALPIER003	Piesse Brook	.	.	.	.	27	27
KALWATR002	Wattle Grove	0	0	0	13	0	13
MUNGLER004	Glen Forrest	.	0	12	43	23	78
MUNHELR001	Helena Valley	.	.	0	0	.	0
MUNHELR002	Helena Valley	.	.	.	54	71	125
MUNHOVR001	Hovea	29	9	32	52	19	141
MUNHOVR006	Hovea	.	.	.	.	2	2
MUNMTHR003	Mt Helena	.	.	20	.	.	20
MUNMUNR002	Mundaring	.	15	5	15	7	42
MUNMUNR003	Mundaring	.	.	0	.	.	0
MUNSTOR003	Stoneville	.	.	.	17	.	17
MURDWER002	Dwellingup	.	150	5	0	100	255
MURDWER003	Dwellingup	.	145	.	.	0	145
MURDWER005	Dwellingup	.	.	.	.	0	0
MURNORR001	North Dandalup	.	.	4	0	.	4
MURTEER001	Teesdale	.	.	.	.	44	44
NORBAKR002	Baker's Hill	.	.	.	.	12	12
SERBYFR004	Byford	.	.	83	150	12	245
SERBYFR006	Byford	.	.	.	.	0	0
SERJARR003	Jarrahdale	.	.	.	0	.	0
SERKEYR007	Keysbrook	.	13	14	.	.	27
SERKEYR008	Keysbrook	.	0	.	.	.	0
SERKEYR009	Keysbrook	.	0	0	.	.	0
SERKEYR011	Keysbrook	.	.	.	.	3	3
SERSERR008	Serpentine	.	.	.	.	42	42
SWAGIDR007	Gidgegannup	.	0	6	7	10	23
SWAGIDR008	Gidgegannup	.	30	18	.	.	48
SWAGIDR009	Gidgegannup	.	.	0	8	0	8
SWAGIDR010	Gidgegannup	.	.	.	.	0	0
SWAGIDR011	Gidgegannup	.	.	.	11	.	11
TOOMORR002	Morangup	.	2	11	0	.	13
TOOMORR003	Morangup	.	.	23	24	0	47
WARWARR002	Waroona	.	.	.	.	92	92
WARWARR003	Waroona	.	.	.	15	22	37
WARWARR004	Waroona	.	.	.	18	40	58

APPENDIX VI: Summary of 2021 and 2022 GCC Survey Monkey results

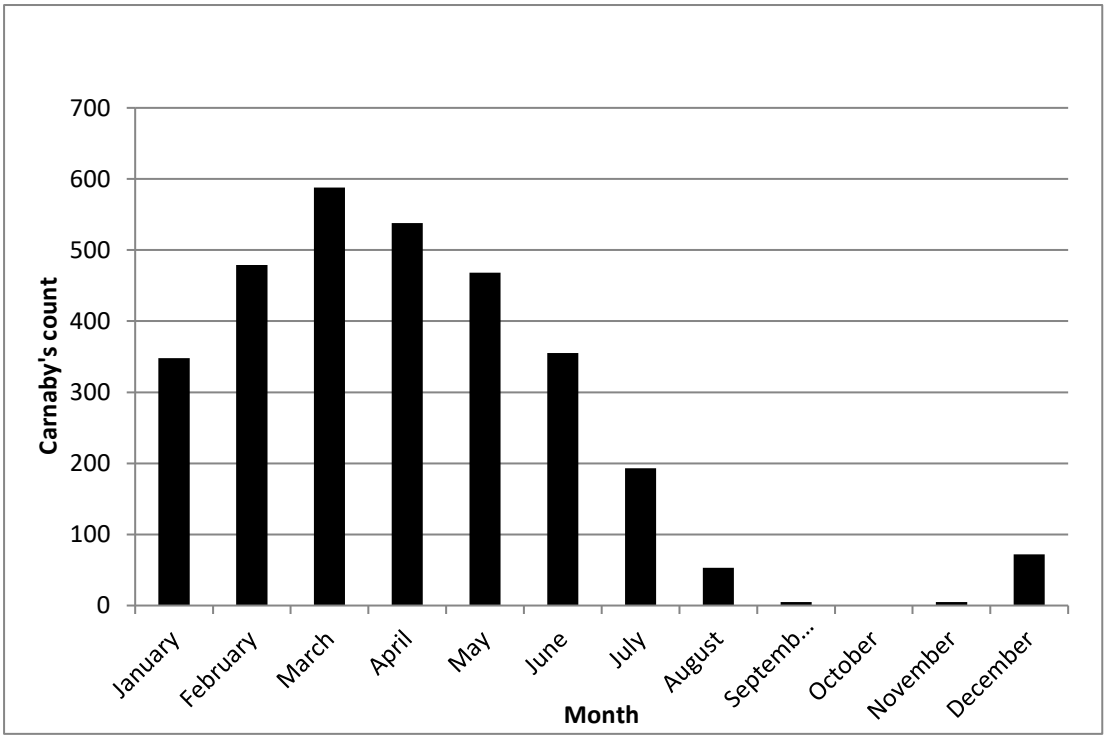
Appendix VI: Summary of 2021 and 2022 GCC Survey Monkey results (531 respondents) from optional post GCC questionnaire sent to participants.							
Was 2021 or 2022 the first time you participated in the GCC?	Yes 38%	No 62%					
Did you attend a GCC information workshop prior to the count?	Yes 23%	No 77%					
Did you access the online learning resource and/or watch the recorded GCC webinar?	Yes 34%	No 66%					
How would you rate your 2021 and/or 2022 GCC experience?	Excellent 56%	Good 32%	Satisfactory 7%	Disappointing 3%	I did not participate in the end 2%		
Do you feel we communicated the information about your roost site and counting instructions clearly?	Yes 94%	No 6%					
Were you allocated a site with other volunteers?	Yes 49%	No 51%					
Did you bring along a friend and/or family member who was not registered for the count?	Yes 54%	No 46%					
Are you a BirdLife member?	Yes 24%	No 76%					
If you took part in a GCC campout, how would you rate your experience (50 respondents)?	Excellent 62%	Good 26%	Satisfactory 8%	Disappointing 4%			
Do you intend to participate in future Great Cocky Counts?	Yes 98%	No 2%					
Age bracket (529 respondents)	Under 20 1%	20-30 4%	30-40 10%	40-50 16%	50-60 20%	60-70 29%	Over 70 19%

APPENDIX VII: Monthly monitoring results at two Carnaby's Black-Cockatoo roosts

Appendix VIIa: Average monthly counts of Carnaby's Black-Cockatoos at the Gingin roost (GIGGINR001) 2016-2022. Data provided by the Chittering Landcare Group.



Appendix VIIb: Maximum counts or average of top three counts of Carnaby's Black-Cockatoos at the Bentley roost (SOUCOMR001), 2009 to 2015. Data provided by Geoff Barrett, DBCA.



APPENDIX VIII: Example of SAS code used for GCC trend analysis

Appendix VIII: Sample of the SAS code used to analyse the Great Cocky Count results for Carnaby's Black-Cockatoo. Example is from 2019 trend analysis.

```
/* Program to analyse the roost survey data from the annual Great Cocky Counts, 2010-2019 */
/* Matt Williams, Dept of Biodiversity, Conservation & Attractions                        */
/* July 2019 */

options ls=78;

/* Read data */
/* Site    is site code name */
/* Pine    indicates if roost site is in or adjacent to pine plantation (1) or not (0)  */
/* Count   is the number of birds counted at the roost site                               */
/*         with . used to indicate no count undertaken ie missing value                  */
/*         and -1 used to indicate a cleared roost site ie no count could be undertaken */

data a;
length site $10.;
input Site $ pine @@;
 do year=2010 to 2019;
   input count @@;
   output;
 end;
 cards;
GINYEAR003  1        .        .        .        .        .        750      4897     3528     6226     .
GINGINR001  0        392      378      432      686      879      784      1023     880      1148     .
WANPINR001  1        .        .        853      35       1521     616      1232     900      315      .
…etc
;
/* Make year = 2010 become yr = 1                */
/* remove cleared sites                          */
/* compute yr squared for quadratic models       */
/* and remove 2019 (which may be used for prediction */
data a;
 set a;
 if year  = 2019 then delete;
 if count =  -1 then delete;
 yr = year-2009;
 yr2=yr*yr;
/* calculate number of surveys conducted each year for potential use as an offset variable */
proc sort data=a;
 by year;

proc means n noprint data=a;
 var count;
 by year;
 output out=nsurveys n=nsurvs;
```

```
* add offset variable to data and log transform;
data xx;set a;
proc sort;by year site;
data a;
 merge nsurveys xx;
 by year;
 * effort is the proportion of sites surveyed (nsurvs) of those available for survey (_FREQ_);
 effort = nsurvs/_FREQ_;
 lneff  = log(effort);
 * code dummy variables for individual years ;
 if year=2010 then yr2010=1;else yr2010=0;
 if year=2011 then yr2011=1;else yr2011=0;
 if year=2012 then yr2012=1;else yr2012=0;
 if year=2013 then yr2013=1;else yr2013=0;
 if year=2014 then yr2014=1;else yr2014=0;
 if year=2015 then yr2015=1;else yr2015=0;
 if year=2016 then yr2016=1;else yr2016=0;
 if year=2017 then yr2017=1;else yr2017=0;
 if year=2018 then yr2018=1;else yr2018=0;

proc sort data=a;
 by site;

* Select subsets of data (pine sites, non-pine sites or all sites except mega roost);
data pines;
 set a;
 if pine=1;

data nopines;
 set a;
 if pine=0;

data nomega;
 set a;
 * remove mega roost;
 if site='GINYEAR003' then delete;


proc freq data=pines;
 tables site*pine;
 run;


* Initial ZINB model with fixed site effects to provide initial parameter estimates
  for random effects models                                    ;
proc genmod data=a;
 class site year;
 model count = yr site / noint dist=zinb offset=lneff;
 zeromodel yr site;
 run;
```

```
/* Zero-inflated Generalised Poisson (ZIGP) model incorporating overdispersion   */
/* including random site effects in both the count (u) and zero model (v)       */
/* with quadratic year effect                                                   */
proc nlmixed cov data = a method=gauss qpoints=25;
 parms b0=5.6 b1=-0.11  b2=0 a0=-0.44 a1=0.128 sigma1=0.52 cov12=-0.7 sigma2=1.367 xi=0.949;
 logit0 = a0 + v + a1*yr;
 prob0  = 1 / (1 + exp(-logit0));
 mu     = exp(b0 + u + b1*yr + b2*yr2);
 mustar = mu - xi*(mu - count);

 if count = 0 then
    ll = log(prob0 + (1 - prob0)*exp(-mu));
 else
         ll = log(1 - prob0) + log(mu*(1-xi)) + (count-1)*log(mustar) - mustar - lgamma(count + 1);
 model  count ~ general(ll);
 random     u v ~ normal([0,0],[sigma1,cov12,sigma2]) subject=site;
 predict (1 - prob0)*mu out=ZIGPquad;
run;

/* ZIGP year-by-year model including a random site effect in the zero model and individual year
effects for count                */
proc nlmixed data = a method=gauss qpoints=25;
 parms b0=5.6 b21=0 b22=0 b23=0 b24=0 b25=0 b26=0 b27=0 b28=0 a0=-0.44 a1=0.128
sigma1=0.52 cov12=-0.7 sigma2=1.367 xi=0.949; * old parms b0=4.3398 b1=-0.05 a0=-0.18
a1=0.0785 sigma1=1 cov12=-.3 sigma2=1.5 xi=0.05;
 logit0 = a0 + v + a1*yr;
 prob0  = 1 / (1 + exp(-logit0));

 mu     = exp(b0 + u + b21*yr2010 + b22*yr2011+ b23*yr2012+ b24*yr2013+ b25*yr2014+
 b26*yr2015+ b27*yr2016+ b28*yr2017);
 mustar = mu - xi*(mu - count);
 if count = 0 then
    ll = log(prob0 + (1 - prob0)*exp(-mu));
 else
         ll = log(1 - prob0) + log(mu*(1-xi)) + (count-1)*log(mustar) - mustar - lgamma(count + 1);
 model  count ~ general(ll);
 random     u v ~ normal([0,0],[sigma1,cov12,sigma2]) subject=site;
 predict (1 - prob0)*mu out=ZIGPyr;
run;
```

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