



The 2018 Great Cocky Count:

A community-based survey for

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

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

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



Department of **Biodiversity,
Conservation and Attractions**

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Front cover: Some of the Stirling Range campout team doing a practice count. Stella Stewart-Wynne.

Back cover: Cheyne's Beach campout team. Pamela Jones.



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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 2018 GCC occurred on Sunday 8 April 2018. This year's GCC was the ninth consecutive count.
- The 2018 GCC surveyed roost sites for Carnaby's, Baudin's and Forest Red-tailed Black-Cockatoos (FRTBC). All are endemic to south western WA and listed as threatened species under State and Commonwealth legislation.
- An additional count of FRTBC was undertaken at 15 roosts in the Greater Perth-Peel region on Sunday October 14 2018
- This report builds on the substantial contribution made by previous Great Cocky Counts to our knowledge of black-cockatoos in the greater Perth Region and regional 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 – this year 750 registered volunteers surveyed 416 sites across the southwest of WA. Total volunteer participation likely exceeded 1,200 community members.
- The minimum population count for Carnaby's Black-Cockatoo in the Greater Perth-Peel Region was 13,145 (slightly higher than 2016 and 2017 and over twice the average for 2010-15). 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 (Table 4).
- Most (65%) of the Carnaby's Black-Cockatoos recorded in the Perth-Peel Coastal Plain were associated with the Gngangara pine plantation, north of Perth. The large number of Carnaby's Black-Cockatoos (8,072) recorded in roosts associated with the pine plantation is similar to 2016 and 2017. In previous years, the pine plantation has supported 28 – 73% of the Carnaby's Black-Cockatoos recorded in the Perth-Peel Coastal Plain during the non-breeding season, emphasising the importance of pines as both a roosting area and food resource during this period.
- A single roost site located east of Yanchep had a count of 6,226 Carnaby's Black-Cockatoos. This accounted for half of all of the Carnaby's Black-Cockatoos recorded on the Perth-Peel Coastal Plain, and is the highest single count ever recorded in a Great Cocky Count survey. The same site had counts of 4,897 and 3,528 in 2016 and 2017 respectively 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 2018 is a decline of 42%, or an average of 5% per year.



- Trend analysis of roost counts for Carnaby's Black-Cockatoo in the Perth-Peel Coastal Plain found significant declines in both the fraction of occupied roosts and average flock size over the past nine Great Cocky Counts (2010-2018). The combined effect of fewer occupied roosts with fewer birds in each roosting flock is an estimated current decline rate of 5% per year in the number of Carnaby's Black-Cockatoos on the Perth-Peel Coastal Plain. This trend estimate should be treated with some caution, however, given the 'snapshot' sampling method and the need to consider the assumptions underlying both the survey method and trend analysis. There are two potential explanations for the observed trend: the decline at known roost sites may be attributable to the loss of birds from the study area, or birds may have relocated from known to new roost sites, and the trend is the result of birds being displaced from existing to new sites each year. For the former, the trend analysis reported here is appropriate and provides an estimate of the losses from the region, although the true fate of such birds (mortality or emigration) is unknown. For the latter, the total counts provide a better estimate of abundance and population trend, provided that the birds at newly discovered roosts have relocated from previously occupied roosts. A combination of both these mechanisms may be the reason for the observed decline in mean roost counts and occupancy rate. However, there are no completed studies that provide support for either scenario and it would be prudent to take a precautionary approach until better information becomes available. Nonetheless, this apparent ongoing decline is of serious concern for Carnaby's Black-Cockatoo in the Perth-Peel Coastal Plain.
- On the Perth-Peel Coastal Plain, the majority of the Carnaby's Black-Cockatoos are restricted to relatively few roost sites. For example, 79% of all the birds recorded in the 2010-2018 Great Cocky Counts were in just 20 roost sites. Six of these sites are associated with pines. Trend analysis shows that the rate of decline in pine-associated roosts is similar to that of non pine-associated roosts. Provision of adequate roost sites and feeding habitat is needed to ensure the persistence of Carnaby's Black-Cockatoo in this region. Continued removal of pine without replacement from the Ngarara pine plantation, will remove significant roost and food resources for the Perth population.
- The overall estimated rate of decline in the total number of birds on the Northern Darling Scarp is 12% per year.
- The 2018 GCC confirmed the presence of FRTBC at various locations throughout the inner metropolitan suburbs of Perth. Their numbers rose from an average count of 559 (2014-2016) to 1,934 in 2017 and 4,037 in 2018. This may be due to a redistribution of birds from forested areas to more urbanised locations.
- With the total population estimated at 40,000 for Carnaby's Black-Cockatoo, 12,000 for Baudin's Black-Cockatoo and 15,000 for FRTBC, the 2018 GCC recorded approximately 40% of all black-cockatoos in south western WA.
- The Great Cocky Count is well-placed to continue monitoring Black-Cockatoos on the Perth-Peel Coastal Plain, and potentially across the south west, due to continued growth in volunteers and survey effort and the integration of statistically rigorous trend analyses.
- 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 180 sites in the Perth-Peel Coastal Plain and counted 12,465 Carnaby's Black-Cockatoos. The Perth-Peel Coastal Plain encompasses most of the Swan Coastal Plain between Lancelin and Waroona.
- Significant counts in the Perth-Peel Coastal Plain occurred in the Gnangara pine plantation (notably 6,226 in Yeal, 975 across two sites in Mariginiup, 315 in Pinjar, 279 in Yanchep and 157 in Gnangara; the total of 7,952 birds at these six sites was 64% of the total count) and at the Gingin town site (1148 birds), 1,047 across 4 sites in Dawesville, 470 in Como, 369 in Hamilton Hill, 259 in Floreat, 227 in Murdoch, 222 across two sites in Nedlands and 120 in Martin.
- The population of Carnaby's Black-Cockatoos inhabiting the Perth-Peel Coastal Plain is significant at a species-scale, with three of the five largest and seven of the ten largest known roosts in 2018.

Northern Darling Scarp and Plateau

- Volunteers surveyed 90 sites in the Northern Darling Scarp and Plateau areas, which encompasses the northern Jarrah-Marri Forest between Bindoon and Waroona, and counted 2,266 white-tailed black-cockatoos. Counts of white-tailed black-cockatoos in these areas include Baudin's Black-Cockatoo and Carnaby's Black-Cockatoo, of which 30% (680) were estimated to be Carnaby's Black-Cockatoos.
- Significant white-tailed black-cockatoo counts occurred at 13 sites in the Shire of Mundaring (717 birds), four sites in the City of Kalamunda (481 birds) and one site in Keysbrook (352 birds, known to be Baudin's Black-Cockatoos).

Regional areas

- Volunteers surveyed 146 sites in regional locations outside of the Greater Perth-Peel Region and recorded 5,585 white-tailed black-cockatoos. Counts of white-tailed black-cockatoos in forested areas may include Baudin's Black-Cockatoo and Carnaby's Black-Cockatoo.
- 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.
- Significant counts occurred on the northern Swan Coastal Plain (1,207 at Nilgen and 144 at two sites near Jurien Bay), in the Shire of Bridgetown-Greenbushes (712 across five sites), the Shire of Albany (557 birds across eight sites), the Shire of Carnamah (487 across two sites), the Shire of Busselton (401 across 10 sites), the Shire of Capel (385 across four sites), the Shire of Harvey (353 across five sites), the Shire of Esperance (298 birds across three sites), the Shire of Plantagenet (297 across four sites), 130 in the Chapman Valley and 101 in Dardanup.



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

- Volunteers documented 114 occupied roost sites, a large increase on previous years (29, 23, 71 and 95 occupied roosts in the years 2014 to 2017). 31 of these sites had both FRTBC and white-tailed black-cockatoos roosting.
- Occupied roosts were located in the Perth-Peel Coastal Plain (60), the Northern Darling Scarp and Plateau (30) and regional areas (24).
- 5,497 FRTBC were counted in 2018: 4,037 on the Perth-Peel Coastal Plain; 1,023 in the Northern Darling Scarp and Plateau, and 437 in regional areas. The total count was up markedly on previous years.
- 2018 recorded a large increase in the numbers of FRTBCs on the Perth-Peel Coastal Plain, up 100% on 2017.
- Significant FRTBC roosts occurred in the Shire of Gosnells (730 birds across five roosts), City of Cockburn (705 across eight roosts), the Shire of Kalamunda (475 across seven roosts), Murdoch (441 birds), the Town of Cambridge (403 birds across three roosts), Yokine (359 birds across two roosts), Morley (300 birds), Jandabup (156 birds), Ballajura (151 birds) and Kensington (108 birds).
- Over the past 5 years FRTBC have been recorded exclusively using 23 confirmed roost sites previously used by white-tailed black-cockatoos
- A similar roost count carried out in October 2018 count suggests that few FRTBC spend the whole year in the Perth-Peel region. The average count of 4 birds at each roost compares to the average of 109 in April 2014-2018.



▪ 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 in early to 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. This year's GCC occurred on Sunday 8 April 2018.

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.

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.

Formal roost survey: A *roost count* performed using the standard GCC survey protocol and completed by BirdLife Australia staff and volunteers, DBCA staff, or WA Museum staff.

Additional survey: A *formal roost survey* that is conducted before or after the GCC each year. Additional surveys may occur on designated dates (e.g. one month after the GCC).

White-tailed black-cockatoos: Two white-tailed black-cockatoos (Baudin's Black-Cockatoo *Calyptorhynchus baudinii* and Carnaby's Black-Cockatoo *Calyptorhynchus 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 2018 GCC the proportion of Carnaby's in the Darling Scarp and Plateau was set at 0.3 of white-tailed black-cockatoos. This is based on audio recordings, counts after the GCC by Tony Kirkby and known proportions at some sites (e.g. 100% Carnaby's at Bullsbrook and 100% Baudin's in Keysbrook). 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 triplet) represents a mated pair with the fledgling from the current or previous breeding season, and (3) the number of triplets 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 (≥ 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 and has been categorised as a *confirmed roost*, *unconfirmed roost*, *FRTBC roost* or *potential site*.

Confirmed roost: Any site where white-tailed black-cockatoos were recorded roosting as part of the GCC. This includes joint roosts, where both white-tailed and FRTBC have been recorded in the GCC.



Occupied roost: A *confirmed roost* that had a positive count (i.e. ≥ 1 bird roosting for the night) recorded in a particular GCC. The suite of occupied roosts varies between GCCs – while some roost sites are occupied in every GCC, most roosts are occupied in some GCCs and unoccupied in others.

Unconfirmed roost: Sites where roosting black-cockatoos have been reported, but have not had a positive count recorded (≥ 1 bird) during any GCC.

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 in these sites.

FRTBC roost: Any site where a positive count (i.e. ≥ 1 bird roosting for the night) of FRTBC has been recorded as part of a formal roost survey and no white-tailed black-cockatoos have been recorded.

New roost: An unconfirmed roost or potential site documented to be a *confirmed roost* during a 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: 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: 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 with the DBCA Swan Coastal District (a DBCA administrative area).

Northern Darling Scarp and Plateau: 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 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 approximately 6,000ha.

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>



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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 in early to 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. This year's GCC occurred on Sunday 8 April 2018.

The 2018 GCC is the ninth consecutive GCC and the tenth overall. BirdLife Australia coordinates the count each year with significant support from the Western Australian Department of Biodiversity, Conservation and Attractions (DBCA). Funding for the 2018 GCC came from a State NRM grant.

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 south western Australia

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

Internationally, Carnaby's and Baudin's Black-Cockatoos are listed as endangered under the IUCN Red List of Threatened Species (BirdLife International 2012a,b). Carnaby's and Baudin's Black-Cockatoos are listed as endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, while FRTBC are listed as vulnerable. 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.

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 *Wildlife Conservation Act 1950*. 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 Wildlife Conservation (Specially Protected Fauna) Notice 2017.

Descriptions of the biology and natural history of Carnaby's Black-Cockatoo and FRTBC are available in the recovery plans prepared for the species (see links below). Additional information is available at:

¹ This report uses the nomenclature (naming conventions) 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'.



<http://birdlife.org.au/documents/SWBC-SouthwestBlackCockatooID.pdf>. Further information on the ecology of black-cockatoos on the Swan Coastal Plain is available in Johnstone *et al.* (2010)², Stock *et al.* (2013)³ and Williams *et al.* (2017).

History of the Great Cocky Count

Origins

The GCC began in 2006 as a project initiated and led by BirdLife Australia (then Birds Australia). The aim for the 2006 GCC 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 second GCC was in 2010, after which it became an annual survey.

Methods for Surveying

The 2006 GCC 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 south-western Australia using roosts counts – has remained, the broader objectives of the GCC have evolved over time. The 2006 and 2010 GCCs 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 south western 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 FRTBC, and this has continued to date. BirdLife WA has appointed Rebecca Boyland as Forest Black-Cockatoo Project Coordinator in order to gain more data and awareness of FRTBC and Baudin's Black-Cockatoos. This has contributed to more regional sites being surveyed, giving us more data on these lesser-known species within the Jarrah-Marri and Karri forests. For the last 4 years 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 and 2017). The most recent (2015, 2016 and 2017) reports are available on the following webpage:

<http://birdlife.org.au/projects/southwest-black-cockatoo-recovery/publications-and-forms>

Earlier reports are also available online (see references for links).

² Available from: http://www.nrm.wa.gov.au/media/41434/black_cockatoos_on_swan_coastal_plain.pdf

³ Available from: <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0061145>



Contribution to Black-Cockatoo Conservation

Recovery plans exist to guide the conservation of Black-Cockatoos in south-western Australia and can be accessed at these web pages⁴:

- <http://www.environment.gov.au/biodiversity/threatened/publications/recovery/calyptorhynchus-latirostris-recovery-plan>
- <http://www.environment.gov.au/resource/forest-black-cockatoo-baudin%E2%80%99s-cockatoo-calyptorhynchus-baudinii-and-forest-red-tailed>

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 (DPaW 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 2018 GCC were to:

- (1) train and engage community members in the monitoring of black-cockatoos;
- (2) identify roost sites and conduct roost counts for Carnaby's Black-Cockatoo across the species range;
- (3) provide a minimum population count for Carnaby's Black-Cockatoo in the Perth-Peel Coastal Plain and the Greater Perth-Peel Region;
- (4) assess trends in roost counts for Carnaby's (2010-2018) and Forest Red-tailed Black-Cockatoos (2014-2018) within the Greater Perth-Peel region;
- (5) identify roost sites and conduct roost counts for the Forest Red-tailed and Baudin's Black-Cockatoo across the species range.

⁴ Webpages are current as at July 2018.



II. METHODS

Survey Timing and Area

Timing

This year's GCC occurred on Sunday 8 April 2018, consistent with the timing of previous GCCs.

Survey area

The GCC survey area encompasses the geographic range of Carnaby's Black-Cockatoo and FRTBC and extends across most of southwestern WA (Figure 1). The survey area includes part or all of six IBRA bioregions: Avon Wheatbelt, Esperance Plains, Geraldton Sandplains, Jarrah Forest, Swan Coastal Plain, and Warren.⁵

Greater Perth-Peel Region

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. This area encompasses the greater Perth-Peel metropolitan region and includes the *Perth and Peel Regional Sustainability and Strategic Assessment area*.⁶ 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 was 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 nearly all 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). 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 2018 GCC, we distributed information and invitations to participate to various community groups, NRM networks and their publications, via Facebook and emailed a BirdLife Australia contact list (this included all of the 2017 GCC counters). We updated the GCC webpage on BirdLife Australia's website⁷, which provides information about the GCC, including forms, protocols and previous reports. This was the third year that we used a Google Form for registrations. Most people registered this way and it makes

⁵ A map of the IBRA bioregions is available at: <http://www.environment.gov.au/land/nrs/science/ibra>

⁶ For information on the Strategic Assessment of the Perth & Peel Regions, see:

<http://www.environment.gov.au/node/18607> and

<http://www.dpc.wa.gov.au/Consultation/StrategicAssessment/Pages/Default.aspx>

⁷ <http://www.birdlife.org.au/projects/southwest-black-cockatoo-recovery/great-cocky-count-swbc>



updating the volunteer list much easier than in previous years. We also promoted the event on BirdLife WA's social media sites, including Instagram and Facebook.

To train volunteers to do surveys, we conducted several workshops at various locations within the greater Perth-Peel metropolitan area and in 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.

Volunteers who registered to undertake a survey for the 2018 GCC were allocated to a specific roost site, provided with information about the site and a roost count form (Appendix I), and given supporting material (including the 'how to' guide for conducting roost counts).

The volunteer engagement and training process followed that used in previous GCCs, which is described in the 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 and 2017).

Roost Site Identification

Information about the 2018 GCC also included a request to report roost sites for black-cockatoos. Sites reported to BirdLife Australia prior to the 2018 GCC, which came from community members, Sam Rycken and Karen Riley (PhD researchers with Murdoch University's Black-Cockatoo Ecology Project) and other sources, were collated into the GCC database. Sites in this database were assigned to one of four categories (confirmed roost, FRTBC roost, unconfirmed roost, or potential site) based on any prior roost count records for the site (see Key Terms and Abbreviations). For the 2018 GCC, we prioritised the allocation of observers to confirmed roosts and FRTBC roosts, and then to unconfirmed roosts; potential sites received the lowest priority. Not all of the sites in the database were assigned for survey. A subset of 15 sites was selected for a count of FRTBC on Sunday, October 14 2018. These sites were chosen as the 12 largest FRTBC roosts on the Perth-Peel region and three large Darling Scarp and Plateau roosts.

Roost Count Methodology

The 2018 GCC 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 and 2017). Roost count instructions were included on the roost count survey form and in other written materials provided to each volunteer. The October FRTBC roost count followed 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 Sunday 8 April 2018; (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 triplets, 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 may 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 FRTBC 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 combined the counts for white-tailed species because the distributions of Carnaby's and Baudin's Black-Cockatoos overlap in this area and due to the difficulty in distinguishing between the two white-tailed black-cockatoo species. 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. 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 (\pm standard errors) and as medians. We calculated roost occupancy rates by dividing the number of occupied roosts by the number of known roosts that were surveyed, for each year. 'Known roosts' were those sites that had been occupied at least once in any of the GCCs between 2010 and 2018.



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, WA Museum, personal communication). Across sites on the Northern Darling Scarp, the 2018 GCC assumed percentages of Carnaby's at 30% and Baudin's at 70% based on audio recordings, counts soon after the GCC by Tony Kirkby and known proportions at some sites (e.g. 100% Carnaby's at Bullsbrook and 100% Baudin's in Keysbrook). 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.

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 known roosts were not conducted, statistical analysis that accounted for these features of the data was needed.

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 and therefore any trends (Zuur *et al.* 2009), and may result in a large number of zero counts in the dataset ('zero-inflation' or 'excess zeros'). These excess zeros 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. Additionally, missing counts (i.e. where no survey was done, even though birds may have been present) also require some method of estimating the probable 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 these must be excluded from the analysis. Using only the 'raw' total counts, which do not account for excess zeros and variable sampling effort 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 a random site effect to allow for any 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 analysis of the population trend in Carnaby's Black-Cockatoo in the Perth-Peel Coastal Plain was the subject of a separate scientific paper published in the International Journal of Conservation, *Oryx*.⁸

We also assessed trends separately for roost sites within or associated with the Gngangara 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 Gngangara pine plantation (Shah 2006; Saunders 1980, Finn *et al.* 2009, Stock *et al.* 2013).

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 triplet – the adult mated pair and a fledgling from the most recent, or a previous, breeding season. As such, the number of triplets 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 triplets 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 triplets 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 test of independence was used to test whether the proportions of triplets to pairs differed across the years 2010–2018.

Statistical analysis

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.

⁸ Williams, M. R., C. J. Yates, H. Finn, W. Stock, and G. Barrett. 2015. Trend analysis of roost counts reveals a significant, ongoing decline of the endangered Carnaby's Black-Cockatoo. *Oryx*. <http://dx.doi.org/10.1017/S0030605315000320>.



RESULTS

A. Community Engagement and Training

Workshops

Approximately 300 people attended the 13 Great Cocky Count workshops conducted in February and March 2018. Workshops were held at locations throughout the south west, including one each at Albany, Armadale, Busselton, Chittering, Cockburn, Donnybrook, Kwinana, Manjimup, Margaret River, Melville, Mundijong, Murdoch University and York.

Supporters for the workshops included Greenskills Albany, the Shire of Armadale, South West Catchments Council (SWCC), Landcare Serpentine-Jarrahdale, Murdoch University, the Shire of Augusta-Margaret River, the Cape to Cape Catchments Group, Kwinana Council, City of Cockburn, City of Melville, Chittering Landcare and Wheatbelt NRM.

Volunteer participation

We assigned 440 survey sites to the 750 registered volunteers (Table 1). Roost counts were conducted at 416 (95%) of these sites. This compares well with previous completion rates for the 2017 and 2016 (93%), 2015 (97%), 2013 (92%), 2014 (90%), and 2012 (84%) GCCs. Of the volunteers that registered in 2018, approximately half were new to the GCC and half had registered previously. Since 2010, more than 2,900 people have participated in at least one GCC as a registered volunteer.

Actual volunteer participation for the 2018 GCC likely exceeded 1,200 community members, as registered volunteers often received support from non-registered volunteers (e.g. family and friends). In addition, Murdoch University and Aquinas College coordinated roost counts at the Murdoch University Campus and Salter Point, respectively, using volunteers, staff and students from those organisations. About 100 volunteers participated in total in these two surveys.

Many sites were surveyed using teams of volunteers. The largest multi-observer roost count was at Murdoch University, where more than 40 volunteers (including Murdoch students and staff and local residents) worked together to conduct a comprehensive survey of the University's South Street campus.



Table 1: Volunteer participation and survey effort for eight Great Cocky Counts (2010-2018). 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
Registered volunteers	250	263	294	335	592	606	707	895	750
Sites assigned for survey	unknown	248	244	262	322	301	426	504	440
Sites surveyed	187	165	205	241	290	293	398	469	416
In Greater Perth-Peel Region	183 (98%)	150 (91%)	157 (77%)	186 (77%)	230 (79%)	228 (78%)	310 (78%)	345 (74%)	270 (65%)
(i) Perth-Peel Coastal Plain	157 (84%)	124 (75%)	127 (62%)	144 (60%)	186 (64%)	185 (63%)	231 (58%)	240 (51%)	180 (43%)
(ii) N. Darling Scarp/Plateau	26 (14%)	26 (16%)	30 (15%)	42 (17%)	44 (15%)	43 (15%)	79 (20%)	105 (22%)	90 (22%)
– In Regional areas	4 (2%)	15 (9%)	48 (23%)	55 (23%)	60 (21%)	65 (22%)	88 (22%)	124 (26%)	146 (35%)



B. Carnaby's Black-Cockatoo: Roost Site Identification

51 new sites were added to the GCC database this year. This enabled 63 sites which had not previously been surveyed to be surveyed in 2018 (some were already on the database but had never been surveyed). Of these, 22 had just white-tailed species roosting, 19 had FRTBC roosting, 3 had both roosting and 19 were unoccupied. Of the 786 sites in the database, 57 have not been surveyed to date. No confirmed sites have been fully cleared since 2016 although one (WANPINR001) has been partially cleared, with the roost intact for now.

Table 2: Number of Carnaby's Black-Cockatoo confirmed roosts, unconfirmed roosts, potential sites, cleared sites and FRTBC roosts in the GCC site database (2010-2018). Cleared roosts are confirmed roosts that have been cleared of vegetation since 2010.

	2010	2011	2012	2013	2014	2015	2016	2017	2018
No. of confirmed roosts	52	90	124	153	177	197	234	287	328
No. of unconfirmed roosts	unknown	48	73	110	126	133	159	154	166
No. of potential sites	unknown	161	158	184	194	193	187	203	181
No. of cleared roosts (accumulative)	0	1	4	5	5	5	9	9	9
FRTBC only roosts	n/a	n/a	n/a	n/a	14	21	49	82	102
Total no. of sites	222	300	359	452	516	549	638	735	786



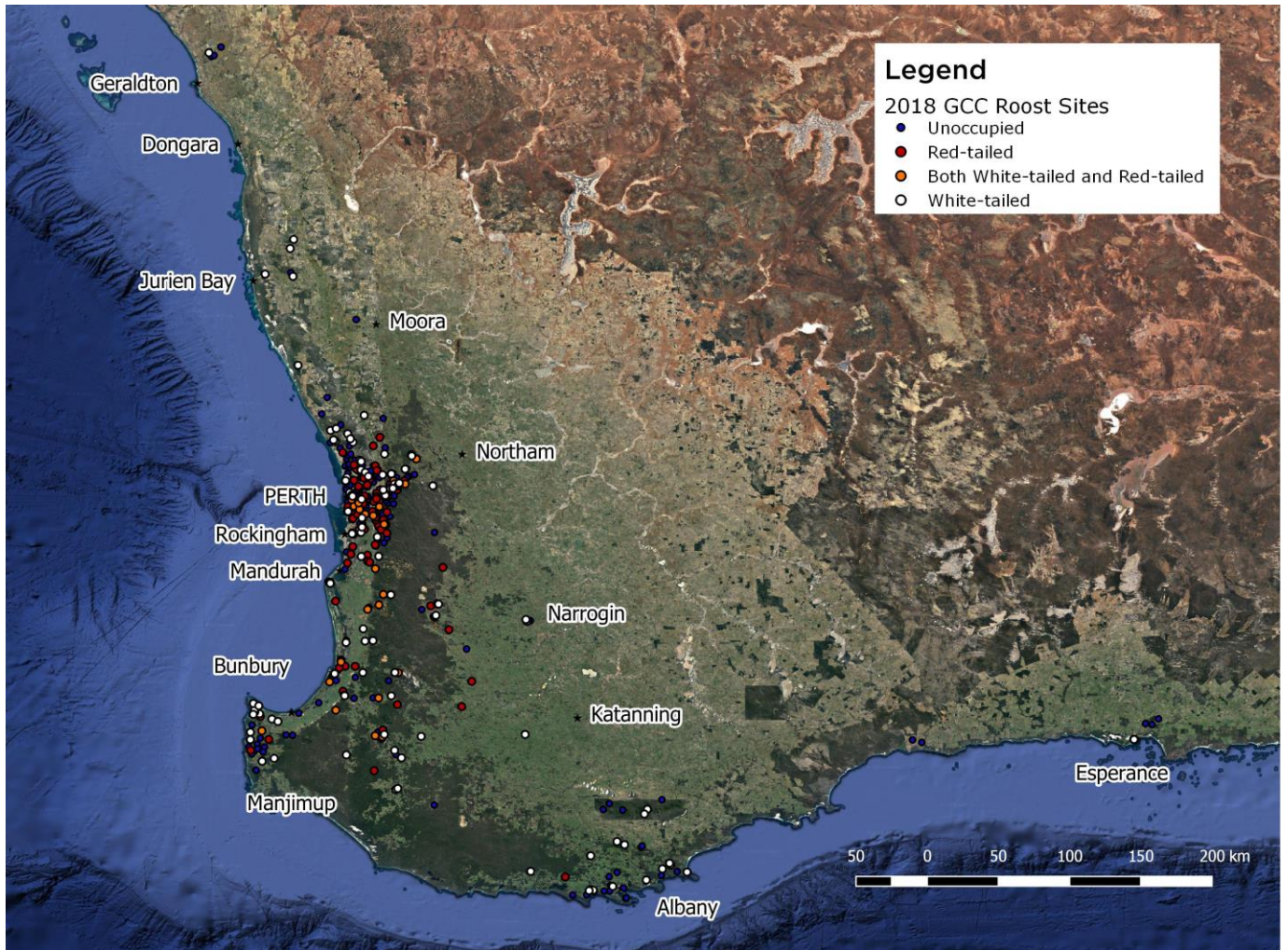


Figure 1: The locations of the 416 sites where surveys were conducted for the 2018 Great Cocky Count. Sites are classified as either unoccupied (no black-cockatoos roosting), white-tailed black-cockatoo roost sites, Forest Red-tailed Black-Cockatoo roost sites, or sites where both red- and white-tailed black-cockatoos roosted. Figure credit: Tegan Douglas.



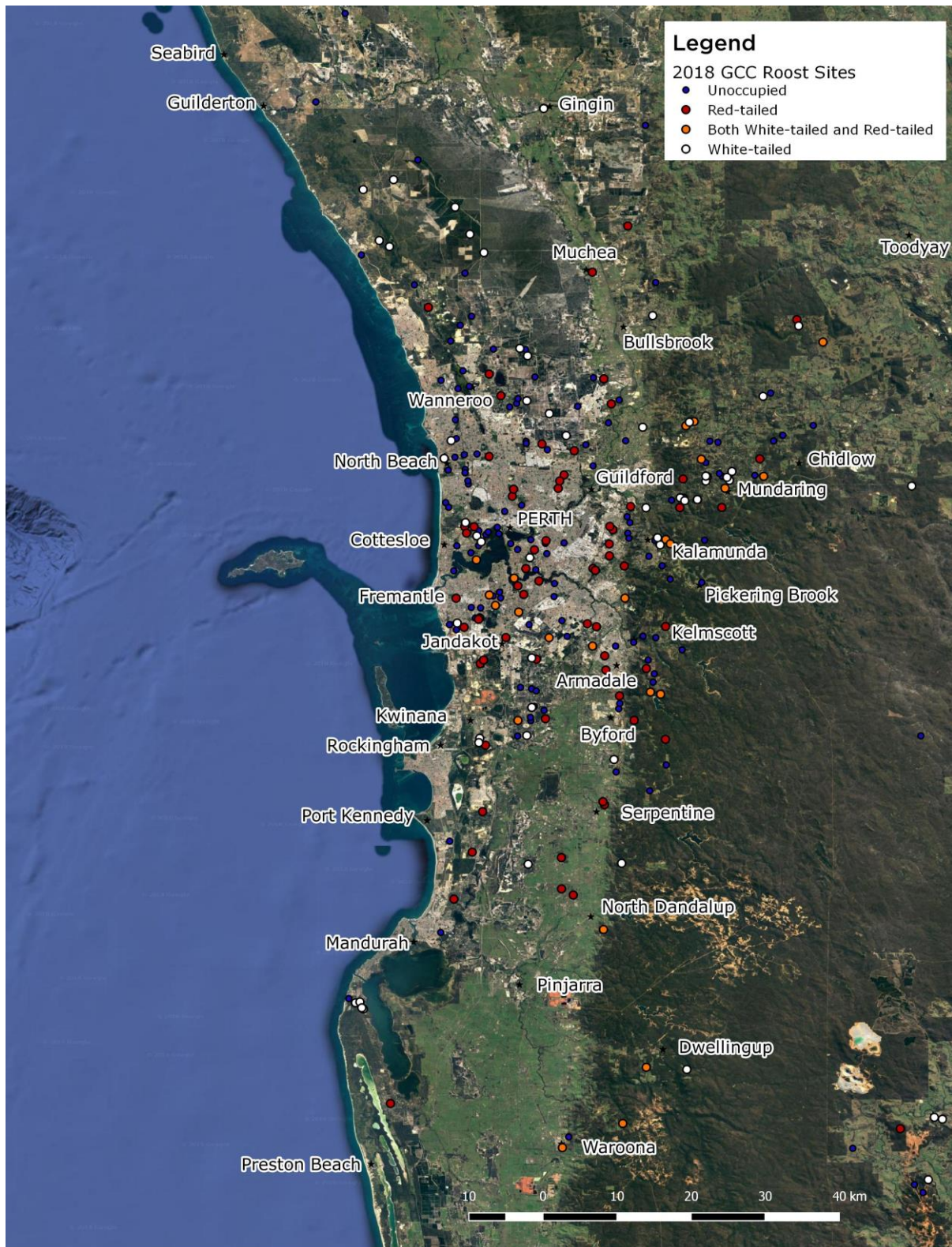


Figure 2: The locations of the 270 sites in the Greater Perth-Peel Region where roost counts were conducted for the 2018 Great Cocky Count. Roosting sites are classified as either unoccupied (no black-cockatoos roosting), white-tailed black-cockatoo roost sites, Forest Red-tailed Black-Cockatoo roost sites, or sites where both red- and white-tailed black-cockatoos roosted in 2018. The map includes the Perth-Peel Coastal Plain and the Northern Darling Scarp and Plateau. Figure credit: Tegan Douglas.



C. Carnaby's Black-Cockatoo: Roost Counts

Survey effort

Greater Perth-Peel Region

Volunteers surveyed 270 sites in the Greater Perth-Peel Region. Roost counts occurred in 37 local government areas (LGA), with occupied roosts recorded in 22 (59%) of these (Appendix II). Survey effort was greatest in the Cities of Mundaring, Swan, Serpentine-Jarrahdale and Wanneroo, with 28, 27, 24 and 23 sites surveyed respectively. Of these, 13 occupied roosts were recorded in the City of Mundaring, eight in the Cities of Swan and Wanneroo and five in Serpentine-Jarrahdale.

Regional areas

Volunteers surveyed 146 sites in regional areas (Table 1). Roost counts occurred in 26 LGAs, with occupied (White-tailed Black-Cockatoo) roosts recorded in 21 (81%) of these (Appendix II). The greatest survey effort in regional areas occurred in the Shires of Albany (22), Augusta-Margaret River (19), Busselton (14) and Donnybrook-Balingup (11). Of these, 10 occupied roosts were recorded in Busselton, eight in Albany and five in Donnybrook-Balingup.

Across GCCs (2010-2018)

The number of sites surveyed dipped in the Greater Perth-Peel Region but increased in regional areas (Table 1). This year the regional count increased to 35% of all sites surveyed.

Total counts

Greater Perth-Peel Region

In 2018 the GCC recorded 13,145 Carnaby's Black-Cockatoos in the region. This is slightly higher than 2016 and 2017 (11,668 and 10,902 respectively) and is over double the average for the years 2010-15 (5,468 birds) (Table 4).

Regional areas

The count for regional areas of 5,585 white-tailed black-cockatoos is similar to 2017 (5,106) and a marked increase on previous years (average of 3,527 birds between 2012 and 2016), with more sites being surveyed this year (Table 4).

Across species range

The total count of 20,316 birds is higher than 2016 and 2017 (16,755 and 17,534) and is over double the average of the years 2010-15 (8,705 birds) (Table 4).

Roost counts – across species range

At occupied roosts, counts of white-tailed black-cockatoos in the 2018 GCC ranged from 1 to 6,226, with a mean of 145 ± 46 (standard error) and a median of 38 (140 roost counts). Roost count sizes varied across the three principal survey areas. The lowest was for the Northern Darling Scarp and Plateau (mean 66 ± 15); then Regional areas (mean 89 ± 22), with the Perth Peel Coastal Plain being the highest (mean 297 ± 149).



Across the species range, the five largest roosts accounted for 48% (9,820 of 20,316 birds) of the total number of white-tailed black-cockatoos counted (Appendices III and IV). The ten largest roosts accounted for 59% (11,981) of the total number of white-tailed black-cockatoos counted. Three of the five largest roosts, and seven of the ten largest, occurred in the Perth-Peel Coastal Plain.

Roost counts – Perth-Peel Coastal Plain

Within the Perth-Peel Coastal Plain, the five largest roosts (counts of 6226, 1148, 625, 566 and 470 birds) accounted for 72% (9,035 of 12,465) of the Carnaby's Black-Cockatoo counted in this region (Appendix IIIa). Two of these were within the Gnangara pine plantation north of Perth (Appendix IIIb). The roost occupancy rate was 39% for the Perth-Peel Coastal Plain (42 occupied roosts of the 107 previously occupied roosts that were surveyed) (Table 5).

Gnangara pine plantation

Volunteers recorded 8,072 birds at 11 occupied roosts located within or immediately adjacent to (i.e. < 1 km from the boundary of) the Gnangara pine plantation, and at three 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 65% (8,072 of 12,465) of the Carnaby's Black-Cockatoo counted in the Perth-Peel Coastal Plain. In previous GCCs (2010-2017), birds roosting in the Gnangara pine plantation have accounted for 27% to 73% of the Carnaby's Black-Cockatoo counted in the Perth-Peel Coastal Plain, with total counts ranging from 1077 to 7450 birds.

Other large roosts

Large counts were recorded at Gingin (1,148), Dawesville (566, 201 and 200), Kensington (470), Hamilton Hill (369), Floreat (259), Murdoch (227) and Nedlands (175).

Roost counts – Northern Darling Scarp and Plateau

Within the Northern Darling Scarp and Plateau, the five largest roosts accounted for 57% (1294 of 2266) of the white-tailed black-cockatoos counted. These counts were recorded at two sites in the Shire of Kalamunda (210 and 163), one in Serpentine-Jarrahdale (352 Baudin's), one in Parkerville (309) and one in Bullsbrook (260 Carnaby's) (Appendix IIIc). The roost occupancy rate was 59% (32 occupied roosts of the 54 previously occupied roosts that were surveyed) (Table 5).

White-tailed black-cockatoos were recorded at 13 sites in the Shire of Mundaring (28 sites surveyed and 717 birds), four sites in Kalamunda (19 sites surveyed and 481 birds) and three in the City of Armadale (16 sites surveyed and 51 birds) (Appendix IIIc). Roosts were also recorded at sites in Toodyay (131 birds at two sites) and Gidgegannup (173 birds at four sites).

Roost counts – Regional areas

In regional areas, the five largest roosts (1207, 694, 404, 250 and 219 birds) accounted for 48% (2694 of 5585) of the white-tailed black-cockatoos counted regionally (Appendix IV). These sites were located at Nilgen, Glenlynn, Warradarge, Many Peaks and Kalgan.



Sites with large counts were recorded in the Shire of Bridgetown-Greenbushes (712 at five sites), northern Swan Coastal Plain (1207 at Nilgen), in the Shire of Albany (557 at eight sites), Carnamah (487 at two sites), Busselton (401 at 10 sites), Capel (385 at four sites), Harvey (353 at five sites) and Esperance (298 at three sites) (Appendix IV).

Breeding success

The fraction of white-tailed black-cockatoo groups returning to roosts as either pairs or triplets was recorded at 49 sites in 2018. The proportion of groups flying into roosts as triplets (47%) was significantly higher ($\chi^2 = 13.6$, $p = 0.0002$) than the average proportion recorded over previous GCCs (average 39% between 2010-2017, range 31% – 46%) (Table 3). Further analysis and a comparison of the fraction of triplets 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 triplets, 2010– 2018, 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-Cockatoos.

Year	Pairs	Triplets	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



Table 4: Roost count summary for Carnaby’s Black-Cockatoo across nine Great Cocky Counts (2010-2018). 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 due to uncertainty on appropriate ratios. The number of roosts is the number of occupied roosts (i.e. roosts where at least one white-tailed black-cockatoo roosted). WT=white-tailed Black-Cockatoo. * Assumption of 30% Carnaby's and 70% Baudin's. **represents a total count for white-tailed Black-Cockatoos

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Greater Perth-Peel Region									
No. of Carnaby’s Black-Cockatoo counted in Perth-Peel Coastal Plain	6330	3912	3791	5591	6662	4692	10919	10248	12465
	(35 roosts)	(37 roosts)	(25 roosts)	(35 roosts)	(37 roosts)	(37 roosts)	(43 roosts)	(42 roosts)	(42 roosts)
No. of Carnaby’s Black-Cockatoo counted in Northern Darling Scarp and Plateau (corrected)	579*	118*	248*	305*	418*	162*	749*	654*	680*
	(total WT count = 1929; 15 roosts)	(total WT count = 393; 13 roosts)	(total WT count = 826; 15 roosts)	(total WT count = 1016; 14 roosts)	(total WT count = 1393; 13 roosts)	(total WT count = 540; 9 roosts)	(total WT count = 2496; 29 roosts)	(total WT count = 2180; 27 roosts)	(total WT count = 2266; 35 roosts)
No. of Carnaby’s Black-Cockatoo counted in Greater Perth-Peel Region	6909	4030	4039	5896	7080	4854	11668	10902	13145
	(50 roosts)	(50 roosts)	(40 roosts)	(49 roosts)	(50 roosts)	(46 roosts)	(72 roosts)	(69 roosts)	(77 roosts)
Regional areas									
No. of white-tailed black-cockatoos counted in Regional areas**	246	610	3329	3744	4041	3182	3340	5106	5585
	(2 roosts)	(9 roosts)	(23 roosts)	(26 roosts)	(29 roosts)	(21 roosts)	(32 roosts)	(56 roosts)	(63 roosts)
Across Species Range									
No. of white-tailed black-cockatoos counted across species range**	8505	4915	7946	10351	12096	8414	16755	17534	20316
	(52 roosts)	(59 roosts)	(63 roosts)	(75 roosts)	(79 roosts)	(67 roosts)	(104 roosts)	(125 roosts)	(140 roosts)

Table 5: The numbers of sites surveyed, occupied roosts, new roosts discovered, and roost occupancy rates for Carnaby's Black-Cockatoo in the Perth-Peel Coastal Plain, and for white-tailed black-cockatoos in the Northern Darling Scarp and Plateau and Regions, for each of the nine Great Cockey Counts 2010 – 2018.

Sites with a positive count in a GCC had >1 white-tailed black-cockatoo roosting in at least one GCC up to that year. Percentage (%) of all sites with a positive count in a GCC up to that year is the percentage of the total number of sites with a positive count in a GCC up to that year that were surveyed. 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
No. of sites surveyed, of those that had a positive count in a GCC up to that year									
Perth-Peel Coastal Plain		29	24	44	68	70	76	83	102
Northern Darling Scarp and Plateau	n/a	8	8	19	23	27	30	35	48
Regional		1	2	6	30	28	34	40	81
% of sites surveyed, of those that had a positive count in a GCC up to that year (not including cleared sites)									
Perth-Peel Coastal Plain		83% (n=35)	43% (n=56)	67% (n=66)	87% (n=78)	80% (n=87)	77% (n=99)	77% (n=108)	84% (n=122)
Northern Darling Scarp and Plateau	n/a	53% (n=15)	33% (n=24)	68% (n=28)	72% (n=32)	73% (n=37)	79% (n=38)	67% (n=52)	77% (n=62)
Regional		20% (n=2)	20% (n=10)	20% (n=30)	70% (n=43)	53% (n=53)	57% (n=60)	54% (n=74)	79% (n=103)
No. of new roost sites discovered									
Perth-Peel Coastal Plain	35	21	10	12	9	12	9	14	5
Northern Darling Scarp and Plateau	15	9	4	4	5	1	14	10	9
Regional	2	8	20	13	10	7	14	29	27
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%)
Northern Darling Scarp and Plateau	15 (58%)	13 (50%)	15 (50%)	14 (33%)	13 (29%)	9 (22%)	30 (38%)	27 (26%)	35 (39%)
Regional	2 (50%)	9 (60%)	23 (49%)	26 (48%)	29 (49%)	21 (33%)	32 (36%)	55 (44%)	63 (43%)
Roost occupancy rate (% of confirmed sites surveyed)									
Perth-Peel Coastal Plain	51%	60%	39%	47%	40%	41%	42%	38%	39%
Northern Darling Scarp and Plateau	83%	68%	68%	48%	39%	31%	58%	43%	59%
Regional	67%	82%	74%	67%	63%	54%	59%	71%	58%

D. Carnaby's Black-Cockatoo: Trend Analysis for the Perth-Peel Coastal Plain and Darling Scarp and Plateau (2010-2018)

Perth-Peel Coastal Plain

General survey trends

The number of sites surveyed in the Perth-Peel Coastal Plain has varied from 124 to 240 across the nine GCCs (2010-2018; Table 1). The number of occupied roosts varied between 25 and 43, with occupied roosts representing 18-30% of the total number of sites surveyed each year (Table 4). The discovery rate of new roost sites was high in 2010 and 2011 and has dropped since then.

Positive counts (i.e. ≥ 1 Carnaby's Black-Cockatoo roosting in at least one GCC, not including cleared sites) have now been recorded from 127 sites.

Seven 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) and four before the 2016 count (SWALEXR002, WANJANR007, WANPINR005 and WANYANR004) (Appendix IIIa).

Largest roosts

Within the Perth-Peel Coastal Plain, the ten largest roosts (based on combined counts across years) accounted for almost two thirds (65%, or 41,764 of 64,610) of the Carnaby's Black-Cockatoos counted in the 2010-2018 GCCs (Appendix IIIa). Four of these are within the Gngara pine plantation (GINYEAR003, WANPINR001, WANMARR003 and SWAMELR001), 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).

The next ten largest roosts accounted for a further 14% (9,354 of 64,610) of the Carnaby's Black-Cockatoos counted in the nine GCCs. Seven of these are within or associated with the Gngara pine plantation (GINYEAR001, WANPINR011, WANPINR002, WANTWOR001, WANYANR006, WANGNAR001 and WANMARR001) and the others are in Hamilton Hill (COCHAMR001 and COCHAMR002) and Dawesville (MANDAWR007).

Overall, the 40 largest roosts accounted for 91% (59,068 of 64,610) of the Carnaby's Black-Cockatoos counted in the Perth-Peel Coastal Plain across the nine GCCs.

Occupancy rate

The fraction of occupied roosts within the Perth-Peel Coastal Plain is estimated to be declining at a rate of approximately 3% per year. This decline is statistically significant ($p=0.0004$), and equates to the loss of about 4 of the 127 known roosts each year. The trends for both pine-associated ($n=27$, estimated decline of 4% per year) and non-pine-associated roosts ($n=100$, estimated decline of 2% 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 declining, but not at a fixed rate. Between 2010 and 2015 it is estimated to have declined by a total of approximately 36% (about 7% per year), but since 2015 has increased slightly, so that the overall decline between 2010 and 2018 is about 21% (about 3% per year). The trends for pine-associated (n=27) and non-pine-associated roosts (n=100) are not significantly different.

Estimated trend in the Perth-Peel Region

The estimated change in the total count of Carnaby's Black-Cockatoo over the period 2010 – 2018 indicates a decline during the early years of the GCC (2010 – 2015) with the count being approximately constant since then (Figure 3). The roost occupancy rate is estimated to be declining at a rate of about 3% 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 overall change in the estimated total count of Carnaby's Black-Cockatoos on the Perth-Peel Coastal Plain between 2010 and 2018 is a decline of 42%, or an average of 5% per year.

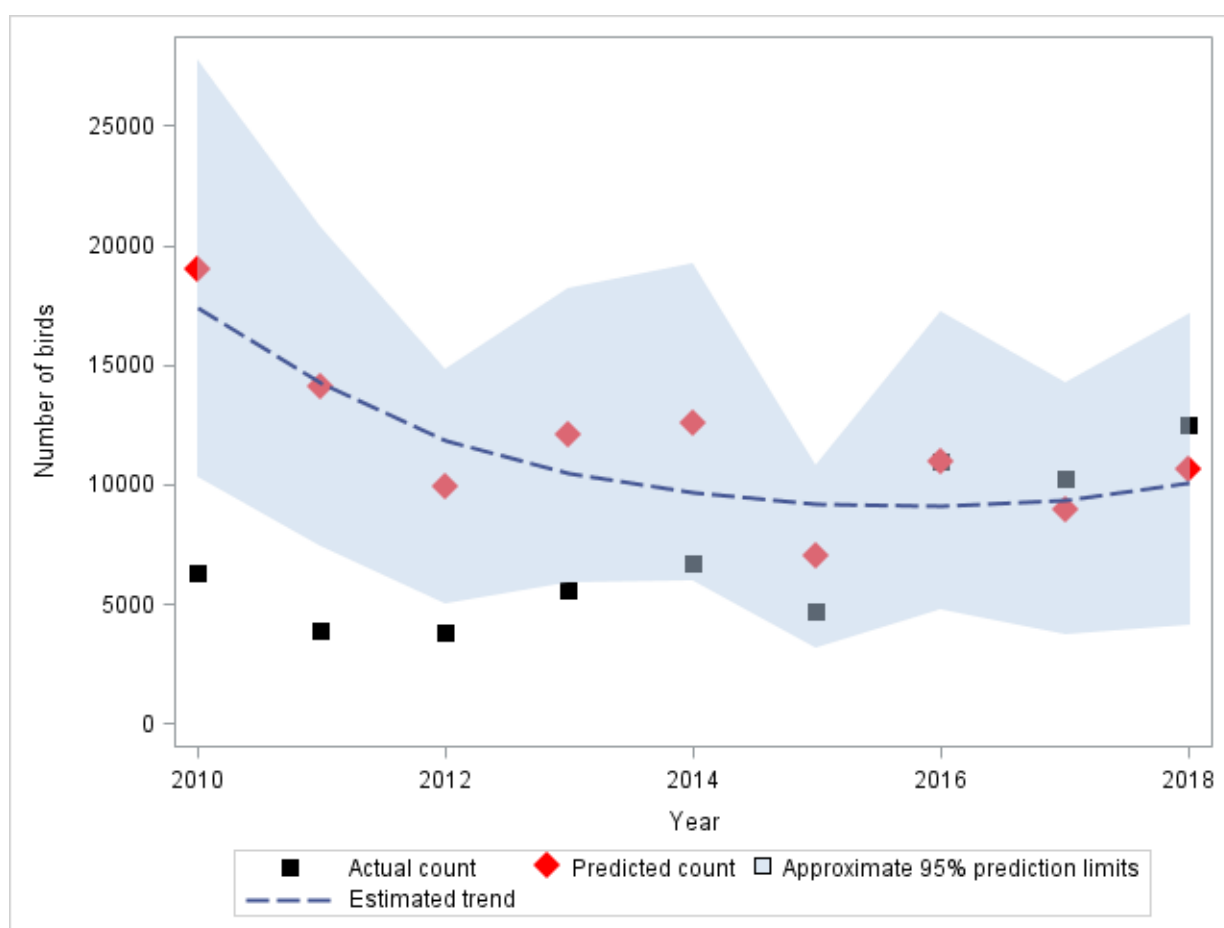


Figure 3: Change in the estimated abundance of Carnaby's Black-Cockatoo in the Perth-Peel Coastal Plain region 2010–2018 based on results of the Great Cocky Counts. The estimated trend in abundance (dashed line) is based on the predicted total count (red diamonds, with approximate 95% prediction limits) 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 105 across the nine GCCs (2010-2018; Table 1). The number of occupied roosts varied between 9 and 35, 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 but declined to 2015. This trend has been reversed in the last three years with 33 new roosts discovered.

Positive counts (i.e. ≥ 1 white-tailed black-cockatoo roosting in at least one GCC, not including cleared sites) have now been recorded from 72 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 49% (6,415 of 13,024) of the white-tailed black-cockatoos counted in the 2010-2018 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 6% per year. This decline is statistically significant ($p = 0.0013$), and equates to the loss of about 4 of the 72 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 6% per year. This decline is statistically significant ($p = 0.015$), and equates to the loss of about 4 birds per year from the overall average of around 66 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 is thus 12% per year (Figure 4). 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 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 9 – 15 in 2010 – 2015, to 27 – 35 in 2016 – 2018.



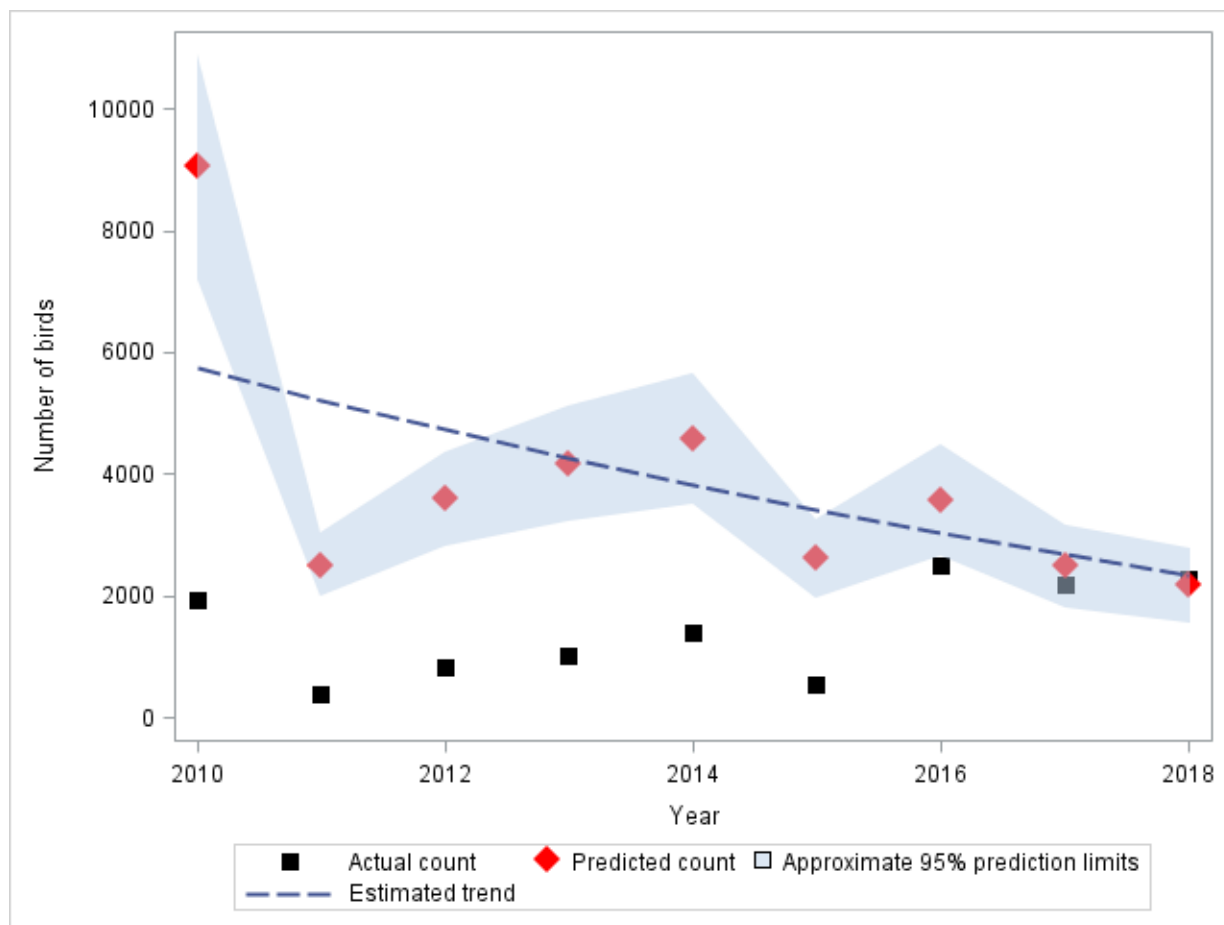


Figure 4: Change in the estimated abundance of White-tailed Black-Cockatoo in the Northern Darling Scarp and Plateau region 2010–2018 based on results of the Great Cocky Counts. The estimated trend in abundance (dashed line) is based on the predicted total count (red diamonds, with approximate 95% prediction 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 146 across the nine GCCs (2010-2018; Table 1). The number of occupied roosts varied between two and 63, with occupied roosts representing 54-82% of the total number of sites surveyed each year (Table 5). The discovery rate for new roosts has been good since 2012, with 70 new roosts discovered in the last three years. Positive counts (i.e. ≥ 1 white-tailed black-cockatoo roosting in at least one GCC, not including cleared sites) have now been recorded from 131 sites. Only one confirmed roost has been cleared, prior to the 2012 GCC (HARMYAR002) (Appendix IIIc).

Estimated trend in Regional areas

Trend analysis of two regional areas (Albany and Esperance) was performed but no significant results were found. We hope to provide trends for regional areas as more data become available in the future.



E. Forest Red-tailed Black-Cockatoo

Roost Site Identification

Perth-Peel Coastal Plain

FRTBC were recorded at roosts in 20 LGAs across the Perth-Peel Coastal Plain: Armadale, Bayswater, Cambridge, Canning, Chittering, Cockburn, Fremantle, Gosnells, Kwinana, Mandurah, Melville, Nedlands, Rockingham, Serpentine-Jarrahdale, South Perth, Stirling, Swan, Victoria Park, Wanneroo and Waroona.

Northern Darling Scarp and Plateau

Volunteers recorded FRTBC at roost sites in 10 LGAs within the Northern Darling Scarp and Plateau: Armadale, Boddington, Chittering, Kalamunda, Mundaring, Serpentine-Jarrahdale, Swan, Toodyay, Waroona and Wandering.

Regional areas

FRTBC were recorded at roost sites in nine Regional LGAs: Augusta-Margaret River, Bridgetown-Greenbushes, Busselton, Capel, Dardanup, Denmark, Donnybrook-Balingup, Harvey, West Arthur and Williams.

Overall, occupied roosts have risen dramatically from 28 in 2014 to 114 in 2018 (Table 6). This increase has been greatest in the Greater Perth-Peel region.

Roost Counts

FRTBC were recorded roosting at 114 sites across the GCC survey area, with relatively few sites in regional areas (Table 6; Appendix V). 22 of these (19%) were new sites that had not been surveyed prior to the 2018 GCC. Of the 114 occupied roosts 83 had only FRTBC, while 31 had both FRTBC and white-tailed black-cockatoos.

Roost counts at sites in the Greater Perth-Peel Region accounted for 92% of the total number of FRTBC counted. The five largest counts of FRTBC (441, 365, 360, 334 and 300 birds) were in the Perth-Peel Coastal Plain. They accounted for 33% of the total number of FRTBC counted across the species range.

FRTBC were recorded at 27% of all sites surveyed across the GCC survey area (114 of 416 sites) and 16% of sites outside of the Greater Perth-Peel Region (24 of 146 sites). Within the Greater Perth-Peel Region, volunteers recorded FRTBC at 33% of sites in the Perth-Peel Coastal Plain (60 of 180 sites) and 33% of sites in the Northern Darling Scarp and Plateau (30 of 90 sites).

Volunteers recorded 31 roosts where both FRTBC and white-tailed black-cockatoos roosted (Appendix V). This is higher than previous years (eight, four, 24 and 19 joint roosts respectively from 2014 to 2017). FRTBC have been exclusively recorded at 23 confirmed sites that were previously occupied by white-tailed black-cockatoos : four confirmed roosts in 2014, another four in 2015, a further two in 2016, seven in 2017 and six in 2018 (Appendix Vd). Of these, eight were in the Perth-Peel Coastal Plain and 12 in the Northern Darling Scarp and Plateau.

Roost counts for FRTBC ranged from 1 to 441, with a mean of 48 ± 8 with a median of 17. This compares to a mean of 32 ± 8 with a median of 17 in 2014, a mean of 20 ± 5 and a median of 13.5 in 2015, a mean of 29 ± 3.5 and a median of 20.5 in 2016, and a mean of 31 ± 4.9 (standard error) and a median of 12 in 2017. The average



roosts count was significantly higher on the Perth-Peel Coastal Plain (67 ± 13) compared to both the Darling Scarp and Plateau (34 ± 7) and regions (18 ± 4).

In the October 14 FRTBC roost count, 15 sites were surveyed. The average count was 4, which compares to an average of 109 for the same sites between 2014 and 2018 in the April surveys conducted as part of the GCC (Appendix Ve).

Table 6: Roost count summary for FRTBC across five Great Cocky Counts (2014-2018). The number of roosts is the number of occupied roosts (i.e. roosts where at least one FRTBC roosted).

	2014	2015	2016	2017	2018
Greater Perth-Peel Region					
No. of FRTBC counted in Perth-Peel Coastal Plain	601	305	771	1934	4037
	(13 roosts)	(10 roosts)	(24 roosts)	(39 roosts)	(60 roosts)
No. of FRTBC counted in Northern Darling Scarp and Plateau	211	107	859	836	1023
	(9 roosts)	(7 roosts)	(26 roosts)	(38 roosts)	(30 roosts)
No. of FRTBC counted in Greater Perth-Peel Region	812	412	1630	2770	5060
	(22 roosts)	(17 roosts)	(50 roosts)	(77 roosts)	(90 roosts)
Regional areas					
No. of FRTBC counted in Regional areas	84	39	374	219	437
	(6 roosts)	(5 roosts)	(20 roosts)	(18 roosts)	(24 roosts)
Across Species Range					
No. of FRTBC counted across species range	896	451	2004	2989	5497
	(28 roosts)	(22 roosts)	(70 roosts)	(95 roosts)	(114 roosts)

Trend analysis

Perth-Peel Coastal Plain

General survey trends

The number of sites surveyed in the Perth-Peel Coastal Plain varied from 185 to 240 (2014-2018; Table 1). The number of occupied roosts varied between 10 and 60, with occupied roosts representing 7-33% of the total number of sites surveyed each year. The discovery rate of new roosts was fairly low in 2014 and 2015 but has increased since then.

Positive counts (i.e. ≥ 1 FRTBC roosting in at least one GCC, not including cleared sites) have now been recorded from 77 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 almost two thirds (65%, or 4,969 of 7,648) of the FRTBCs counted in the 2014-2018 GCCs (Appendix Va).



Occupancy rate

The fraction of occupied roosts within the Perth-Peel Coastal Plain is estimated to be increasing at a rate of approximately 10% per year. This increase is statistically significant ($p < 0.0001$), and equates to an addition of about 8 roosts to the 77 known roosts each year.

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 at approximately 25% per year. This increase is statistically significant ($p = 0.0033$), and equates to an increase of about 17 birds per year to the overall average of around 67 birds at each roost.

Estimated trend in the Perth-Peel region

Combining the estimated annual increase in average roost size and roost occupancy the overall estimated rate of increase in the total number of birds is about 44% per year (Figure 5). The total counts of FRTBC have been in close agreement with the predicted total count.

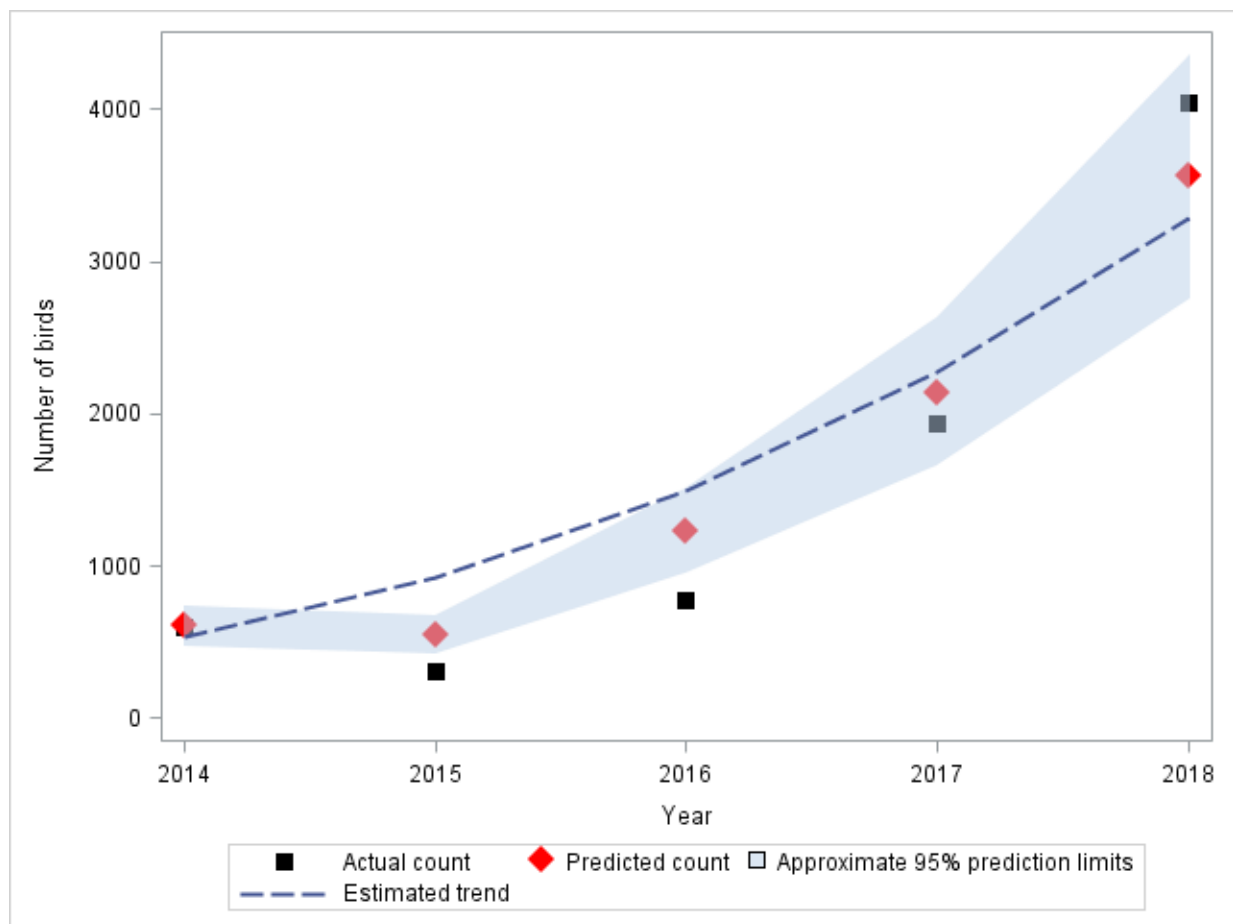


Figure 5: Change in the estimated abundance of Forest Red-tailed Black-Cockatoo in the Perth-Peel Coastal Plain region 2014–2018 based on results of the Great Cocky Counts. The estimated trend in abundance (dashed line) is based on the predicted total count (red diamonds, with approximate 95% prediction 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 105 (2014-2018; Table 1). The number of occupied roosts varied between 7 and 38, with occupied roosts representing 20-36% of the total number of sites surveyed each year. The discovery rate of new roosts was fairly low in 2014 and 2015 but has increased since then.

Positive counts (i.e. ≥ 1 FRTBC roosting in at least one GCC) have now been recorded from 68 sites.

No confirmed FRTBC roosts have been cleared since 2014.

Largest roosts

Within the Northern Darling Scarp and Plateau, the ten largest roosts (based on combined counts across years) accounted for over half (51%, or 1,557 of 3,036) of the FRTBCs counted in the 2014-2018 GCCs (Appendix Vb).

Occupancy rate

The fraction of occupied roosts within the Northern Darling Scarp and Plateau is estimated to be increasing at a rate of approximately 2% per year, but is not statistically significant. This equates to an increase of 1 roost of the 68 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 steady at approximately 0% per year (Figure 13).



Estimated trend in the Northern Darling Scarp and Plateau

The overall estimated rate of increase in the total number of birds is 3 % per year (Figure 6). 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 close 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 – 38 in 2017 – 2018.

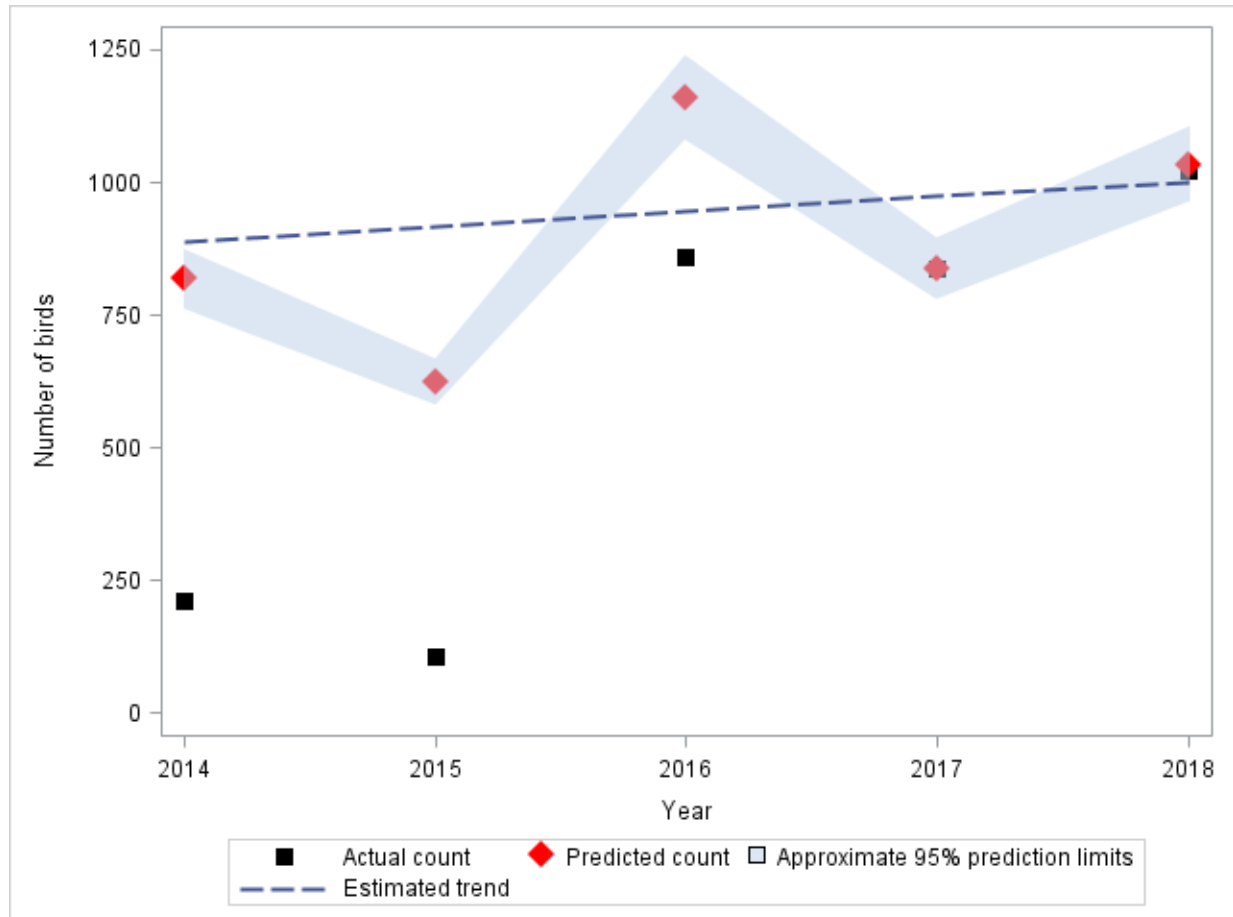


Figure 6: Change in the estimated abundance of Forest Red-tailed Black-Cockatoo in the Northern Darling Scarp and Plateau region 2014–2018 based on results of the Great Cocky Counts. The estimated trend in abundance (dashed line) is based on the predicted total count (red diamonds, with approximate 95% 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.



F. Baudin's Black-Cockatoo

The estimated number of Baudin's counted has varied between 275 and 1,747 over the last nine GCCs, with an average of 1,014.

Table 7: Roost count summary for Baudin's Black-Cockatoo across nine Great Cocky Counts (2010-2018). 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).

WT=white-tailed Black-Cockatoo

	2010	2011	2012	2013	2014	2015	2016	2017	2018
No. of Baudin's Black-Cockatoo counted in Northern Darling Scarp and Plateau (corrected)	1350	275	578	711	975	378	1747	1526	1586
	(total WT count = 1929; 15 roosts)	(total WT count = 393; 13 roosts)	(total WT count = 826; 15 roosts)	(total WT count = 1016; 14 roosts)	(total WT count = 1393; 13 roosts)	(total WT count = 540; 9 roosts)	(total WT count = 2496; 29 roosts)	(total WT count = 2180; 27 roosts)	(total WT count = 2266; 35 roosts)



III. DISCUSSION

Community Engagement and Training

Participation in the 2018 count

The 2018 Great Cocky Count included 750 registered volunteers and is likely to have exceeded 1,200 participants overall, making the GCC once again one of the largest citizen science field surveys in Australia. Volunteers surveyed 416 sites throughout the southwest of the state. Surveying was a collective activity at most locations, with many sites surveyed by teams of volunteers, including large (>40 participants) groups at Murdoch University and Salter Point (Aquinas College).

Workshops

About 300 people attended training workshops in 2018. Informal feedback from GCC participants and NRM staff indicated strong support for holding workshops in regional areas. The workshops focus on Black-Cockatoo behaviour, identification, ecology and threats, as well as training in counting them for the GCC. They 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.

Volunteer retention

More than 2,900 volunteers have participated in at least one GCC since 2010. Volunteer retention from year to year has been reasonably strong, with 26-50% of the volunteers for the 2012-2018 GCCs having participated in at least one previous GCC. Some participants volunteer to survey particular sites each year, leading to the accumulation of skill and experience for survey of those roosts. Nonetheless, many volunteers participate only once and the annual turnover in volunteers is approximately 50%. This may be because many survey sites were unoccupied at the time of the GCC, and some volunteers have expressed disappointment at not being able to survey black-cockatoos at their site. 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 reflecting this in the database. Nil results as a percentage of all surveys fell below 50% for the first time this year. They have fallen in the last three years and we expect this trend to continue in future years (Table 8). A survey of volunteers after the count showed that an overwhelming majority (96%) enjoyed participating in the GCC and 99% said they would participate in the future. However, 2% of respondents expressed disappointment and 4% felt instructions on counting and how to locate their site were poor (Appendix VI). This is an issue which is being addressed and improvements have been made.

Table 8: Number of sites with a nil count as a percentage of all sites surveyed in the GCC (2010-2018)

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





Figure 7: The Chapman Valley GCC team. Photo by Vanessa Brown.

Ongoing monitoring

Many volunteers undertake ongoing, systematic monitoring of several sites in the Greater Perth-Peel Region, including Collier Park (Appendix VIIb), Hollywood Hospital roost in Nedlands (Berry, 2008), the Underwood Avenue roost in Floreat, roosts in the towns of Gingin (Appendix VIIa) and Bullsbrook, and roosts in Yanchep National Park and surrounds. This monitoring provides valuable data on Carnaby's numbers throughout the year.

Evaluation of community engagement and training

The Great Cocky Count remains an effective program for training and engaging community members in the monitoring of black-cockatoos. While building a skilled and engaged citizenry is essential for the GCC to meet its primary objective – to conduct a community-based survey of black-cockatoos in southwestern Australia using roost counts – it is also important to evaluate whether the Great Cocky Count is succeeding as a community engagement initiative and what improvements could be made in this regard.



Positive aspects of the volunteer experience

For volunteers, positive aspects of the GCC experience may include (1) active, field-based participation in a scientific activity, (2) satisfaction that decision-makers use the information volunteers collected, (3) confidence that observations are collected according to a valid scientific protocol, (4) increased awareness about black-cockatoo ecology and conservation, (5) competence in species identification and counting techniques and (6) relationships with particular places (roost sites) and with other volunteers (co-observers).

Adverse aspects of the volunteer experience

Adverse aspects of the volunteer experience may include (1) disappointment if black-cockatoos are not present, (2) costs (e.g. in time and fuel) and inconvenience associated with surveying sites, (3) difficulties and stress involved in locating the roost site, (4) any injuries or property damage sustained while surveying, (5) anxiety about the quality of the observations collected and (6) insufficient positive reinforcement for involvement.

Improving community training and engagement

The expertise and dedication of the GCC volunteers are essential to the success of the Great Cocky Count. As the coordinating organisation for the GCC, BirdLife Australia strives to continually improve the scientific quality of the GCC and the experience of the volunteers involved. Changes made in 2018 included the development of a [GCC FAQ sheet](#), more information on land tenure and land owner contact details, more information given on adjacent roosts and increased coverage in regional areas via campouts. Strategies under consideration for improving future GCCs include:

- online booking of some survey sites to be trialled
- increasing engagement with volunteers in regional, rural and peri-urban areas
- keeping volunteers engaged in black-cockatoo recovery events throughout the year
- facilitating interaction between GCC staff and the community of GCC volunteers



Carnaby's Black-Cockatoo: Roost site identification

Community reporting of roost sites remains a useful means of identifying previously unknown roosts for white-tailed black-cockatoos in rural and peri-urban areas in the Greater Perth-Peel Region and in regional areas across the species range. Significant roosts for this species continue to be identified in these areas.

In 2018 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 Carnaby's Black-Cockatoos may occupy new sites if existing roosts are degraded or cleared, or the availability of nearby food resources changes.

The rate of discovery of previously undetected roosts in the Perth-Peel Coastal Plain was high in 2010 and 2011. Between 2012 and 2017 new roosts continued to be detected at a rate averaging 11 per year. In 2018 only five new roosts were detected. Many of the confirmed roosts identified since 2012 have been identified through a research program, combining satellite tracking of Carnaby's Black-Cockatoos released from rehabilitation centres with field surveys to inspect potential roost sites and conduct roost counts when birds are present (Christine Groom, DBCA, unpublished data; Groom *et al.* 2013). Field surveys by Mark Blythman (DBCA) have also identified previously unknown sites within the Perth-Peel Coastal Plain and Northern Darling Scarp and Plateau. Since 2016, research at Murdoch University led by Dr Kris Warren has identified many new roosts by tracking birds which have been injured, rehabilitated and released. These have been incorporated into the GCC database and many of these sites are now confirmed roosts.

It is likely that important 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. Additional roosts also continue to be identified within the northern portions of the Northern Darling Scarp and Plateau, particularly between Gidgegannup and Bindoon. 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).



Carnaby's Black-Cockatoo: Perth-Peel Coastal Plain

The GCC surveys a substantial (but unknown) fraction of the Carnaby's Black-Cockatoos present

The number of new roost sites discovered has declined over the years, suggesting that the GCC now surveys a substantial fraction of the Carnaby's Black-Cockatoo roosting sites in the Perth-Peel Coastal Plain and, thus, of the birds present in the region at the time of the survey. 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. As a result, the fraction of roost sites surveyed each year has increased. The large roosts identified since 2010 in the Perth-Peel Coastal Plain have – with a few exceptions (e.g. City of Stirling Nursery – STIKARR001) – generally been roosts associated with the Gngangara pine plantation.

While there are strong indications that a large proportion of the Carnaby's Black-Cockatoos present in the Perth-Peel Coastal Plain is now counted in each GCC, 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.

The timing of the GCC is appropriate for the Perth-Peel region

The GCC started out as a Perth-Peel survey of Carnaby's Black-Cockatoo and data show that April is a good time of year to survey the species in this area. The charts in Appendix VII show average monthly counts for the Gingin town site roost (GINGINR001) in 2016 and 2017 and counts at Collier Park in Bentley (SOUCOMR001) between 2009 and 2015. The Gingin site is a large roost with three main roosting areas. The counts fluctuate from month to month, with a low of 218 in early September and a high of 952 in early April (GCC day). The data from Collier Park are similar, with a peak in March and trough between September and November. Data from a site in the western suburbs show similar patterns (Berry, 2008). These fluctuations reflect both seasonal changes in local availability of food and water, and the migration pattern of the species (most adult Carnaby's migrate to the Wheatbelt breeding areas between June and December). These data show that April is a good time to do a survey of the population, as they are present in high numbers at this time of year. This timing, however, may be less appropriate for other areas and species and may change from year to year depending on availability of food and water. This is because in some areas of WA black-cockatoos are not present or are present in low numbers in April. The availability of food and water may also be affected by climate change, since rainfall and temperature patterns influence these critical resources. Since the GCC takes place roughly in the middle of the non-breeding season it is well placed to continue each April. This will also enable the continuation of trend analysis which relies on data that is comparable between years. In future years it is possible that counts outside the Perth region may take place at a different time (in addition to the GCC in April).

Abundance and distribution of Carnaby's Black-Cockatoo on the Perth-Peel Coastal Plain

Based on the 2018 GCC and previous GCCs, several inferences can be made about the abundance and distribution of Carnaby's Black-Cockatoo in the Perth-Peel Coastal Plain, which encompasses all of the Perth-Peel metropolitan area on the Swan Coastal Plain.

(1) Carnaby's Black-Cockatoo occurs throughout the Perth-Peel Coastal Plain.

Large roosts occur in densely-populated urban landscapes as well as peri-urban and rural landscapes.



(2) The number of birds inhabiting the Perth-Peel Coastal Plain is a substantial fraction of the species' population.

The current recovery plan estimates that the total population size of Carnaby's Black-Cockatoo is around 40,000 individuals (DPaW 2013, p. 7), meaning that at least 31% of the species' population occurred within the Perth-Peel Coastal Plain at the time of the 2018 count.

(3) The number of birds associated with the Gnangara pine plantation is substantial at a species-scale.

A species population estimate of 40,000 birds means that about 20% of the population occurred within the remaining portions of the Gnangara pine plantation in early April 2018.

(4) Outside the pine plantation, birds are concentrated at several roosts that are used consistently.

Sites where Carnaby's Black-Cockatoos roost consistently in large numbers (>90 birds) include the Gingin townsite; Curtin University/Collier Park/Technology Park in South Perth; bushland in Dawesville; Murdoch University and associated roosts in nearby reserves; Manning Lake and associated roosts in Spearwood; Underwood Avenue in Floreat; Hollywood Hospital and associated roosts in Nedlands. Some of these sites were unoccupied in 2018 but would be expected to remain as active roosts.

(5) Important roosts also occur in the southern metropolitan area between Banjup and Keysbrook.

Use of individual roosts in this area is intermittent, suggesting that birds may move between roosts, rather than occupying them consistently.

The large count in the Perth-Peel Coastal Plain over the past three years indicates that previous surveys missed large roosts, or that birds are concentrating in fewer roosts

Each successive GCC has recruited more volunteers and the number of roosts surveyed has risen correspondingly. In contrast, more roosting habitat is lost each year and it is possible that the birds may become more concentrated into fewer roosts. This is particularly relevant to Carnaby's Black-Cockatoo utilising the Gnangara pine plantation, which is currently being cleared at about 1,000ha per year, with four confirmed roosts in the Gnangara plantation cleared since 2015. This clearing may have contributed to the congregation of birds at the 'mega roost' (GINYEAR003). This roost is in one of the few remaining large contiguous areas of uncleared pines. In summary, as more habitat is lost and more volunteers are conducting surveys, the likelihood of overlooking large roosts is decreasing.

Another theory is that bush fires have contributed to the concentration of birds to remaining unburnt sites. It has been suggested that recent (2016) fires in Yarloop and Moore River may have caused birds to move to the Gnangara area for suitable feeding and roosting sites. Further work is needed to better understand roost dynamics before these hypotheses can be confirmed.

Population of Carnaby's Black-Cockatoo is declining in the Perth-Peel Coastal Plain

Despite the high count this year, there are strong indications that Carnaby's Black-Cockatoo in the Perth-Peel Coastal Plain has experienced decline. Analysis of roost counts over the last nine GCCs found a substantial decline between 2010 and 2015, but the estimated total number of Carnaby's Black-Cockatoo on the Perth-Peel Coastal Plain may have stabilised over the past three years. It is not clear whether this decline reflects, for example, 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. 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 significance of the Gngangara pine plantation for Carnaby's Black-Cockatoo

Urban areas have been shown to support substantially more threatened species (particularly animals) than non-urban areas on a unit area basis (Ives *et al.* 2016). Perth is no exception to this and Carnaby's Black-Cockatoo is a good example of a species which flourishes in a highly urbanised area. Ives *et al.* explain why this may be (p124):

"Cities may be especially valuable to these kinds of species, as they can provide more stable resources throughout the year as a result of human planting selection and supplementary watering"

For Carnaby's, this stability of resources is in large part due to pine plantations which provide a rich food source to supplement native food sources. 8,072 Carnaby's Black-Cockatoos (65%) were recorded in roosts within or associated with the Gngangarapine plantations in the 2018 GCC. This is consistent with or higher than previous reports on Carnaby's Black-Cockatoo in the plantation system (Perry 1948; Saunders 1974, 1980; Shah 2006; Finn *et al.* 2009; Johnstone *et al.* 2010; Stock *et al.* 2013). Johnstone *et al.* (2010) reported several large aggregations in the Gngangara pine plantation, including flocks of 7,000 in Mariginiup in March 2004, 2,000 in Ellenbrook in February 2005, 3,000 in Gngangara in February 2005, 3,000 in Landsdale in March 2005, 5,000-7,000 in Tamala Park in April 2003, 7,000 in Yanchep National Park in July 2006, and 8,000-10,000 in the pine plantation along Military Road north of Wanneroo in July 2006. Shah (2006) reported that 2,789 birds roosted at sites within or associated with the Gngangara pine plantation in April 2006, as part of the 2006 GCC.⁹ Based on observations conducted between January and May 2009, Finn *et al.* (2009) reported that large (~3,000 birds) concentrations of Carnaby's Black-Cockatoo use the pine plantations during the non-breeding season. Given these records, and their consistency with the count recorded for the Gngangara plantation system in the 2018 GCC, it is clear that several thousand Carnaby's Black-Cockatoos feed within the Gngangara pine plantation each year.

GCCs prior to 2016 are likely to have underestimated the number of birds present in the Gngangara 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 roosting 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. For example, 800 birds were recorded at a pine roost (WANPINR011) along the western edge of Lake Pinjar in the 2013 GCC, with 35 birds roosting at another pine roost (WANPINR001) at the northern edge of the lake (10km away), near the Pinjar power station. In contrast, during the 2014 GCC no birds were recorded at WANPINR011, but 1521 roosted at WANPINR001. The ongoing harvesting has reduced the extent of the plantations, to about 6,000 ha at present, but has also increased the ability of roosting flocks to be identified and surveyed.

⁹ Another 574 Carnaby's Black-Cockatoo roosted in the Karnup pine plantation in Baldivis which is now cleared.



Carnaby's Black-Cockatoo: Northern Darling Scarp and Plateau (Jarrah-Marri Forest)

Based on data from the last four GCCs, several inferences can be made about the abundance and distribution of Carnaby's Black-Cockatoo in the Northern Darling Scarp and Plateau, which encompasses the Jarrah-Marri Forest (and Darling Plateau) from north of Bindoon to south of Boddington.

(1) Carnaby's Black-Cockatoo occurs in low densities along the western margin of the Jarrah-Marri Forest between Mundaring and Waroona.

In each GCC, 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). Nonetheless, it is clear that Carnaby's Black-Cockatoo occurs consistently throughout the western margin of the Jarrah-Marri Forest, although in low densities.

(2) The abundance and distribution of Carnaby's Black-Cockatoo within the southern and eastern portions of the Northern Darling Scarp and Plateau is not well understood.

There are few GCC records for roosts along the southern and eastern portions of the Northern Darling Scarp and Plateau. Carnaby's Black-Cockatoo appears to be present at low densities throughout the Jarrah-Marri Forest (e.g. Lee *et al.* 2013), with breeding records from many locations in northern portions of the forest (Johnstone *et al.* 2010). Two new, significant roosts were discovered and counted for the first time in Parkerville in 2016 (MUNPARR003 and 004). Anecdotal evidence also suggests that there are other roosts in the Northern Darling Scarp and Plateau which are not yet in the GCC database (Tony Kirkby pers comm). This means that the area is under-surveyed and should be a priority for future GCCs.

(3) Significant roosts occur in the Jarrah-Marri Forest north of Mundaring.

Large roosts have been recorded at Bullsbrook, Toodyay, and Gidgegannup in GCCs since 2010. Substantial roosts also occur around Bindoon (Johnstone *et al.* 2010). The Jarrah-Marri Forest becomes more fragmented north of Mundaring and may sustain greater abundances of Carnaby's Black-Cockatoo than areas of forest to the south. This region should be a priority for future survey.

(4) Variation in the abundance of white-tailed black-cockatoos may reflect differences in the timing of the northward migration of Baudin's Black-Cockatoos during their non-breeding season.

Baudin's Black-Cockatoo breeds in the Karri and southern Jarrah-Marri Forests between October and March each year, then migrate northwards through the northern Jarrah-Marri Forest from late March (Johnstone and Kirkby 2008). As the timing of this northward migration varies between years, both the relative proportions of Baudin's Black-Cockatoos and Carnaby's Black-Cockatoos present, and the overall abundance of white-tailed black-cockatoos at roosts in the Northern Darling Scarp and Plateau, can be expected to vary from year to year.

(5) Trend analysis shows that white-tailed black-cockatoo numbers are declining in the Northern Darling Scarp and Plateau.

The current estimated rate of decline is 12%, which is a much steeper decline than that of the Carnaby's population on the Perth-Peel Coastal Plain. Again, it is not clear to what extent this decline reflects (e.g.) 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 in order to confirm the decline, explain the reasons for the decline and to inform land management decisions.



Carnaby's Black-Cockatoo: Regional Areas

The Great Cocky Count continues to expand in regional areas, with on-going increases in the number of sites surveyed, the number of occupied roosts recorded, and the total number of white-tailed black-cockatoos counted. Sites were surveyed across much of the species range, with roost counts conducted at sites in Chapman Valley to the north, Esperance to the east, around the western and southern coasts, and inland to Narrogin. Roost counts have been conducted for at least three years at 63 regional sites, for at least four consecutive years at 41 sites and for at least five years at 26 sites. Trend analysis has not shown any significant results to date, but there are still too few data and in future years this should be possible.

Some initial inferences can be made about the distribution of Carnaby's Black-Cockatoo in this region. Firstly, along the west coast, large numbers are present in Chapman Valley, in the Jurien Bay/Hill River area (adjacent to the Coomallo breeding area; Saunders 1982), and the northern Swan Coastal Plain from Guilderton north to Nilgen. Secondly, Carnaby's Black-Cockatoo are present, but at low abundances, along the southern Swan Coastal Plain south of Lake Preston with roosts occurring near pine plantations (e.g. Myalup) and along the margin of the Darling Scarp (possibly in association with Baudin's Black-Cockatoos). Thirdly, white-tailed black-cockatoos occur in reasonable abundances in the Capes Region and along the south coast from Albany through to Esperance, with some large roosts associated with pine plantations. Finally, the current distribution of Carnaby's Black-Cockatoo in the Wheatbelt and inland portions of the Great Southern is less clear, but birds do occur at Narrogin and large numbers were recorded in the Stirling Range National Park.

Counts at five large roosts (>200 birds) accounted for almost half of white-tailed black-cockatoos recorded in regional areas in the 2018 GCC (2694 of 5585 birds or 48%). 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 at particular roost sites. On-going monitoring of these sites and continued location of similar additional sites will provide valuable information about population trends in regional areas.



Forest Red-tailed Black-Cockatoo

Identification of roost sites for FRTBC

The 2018 GCC built on the previous GCCs as the only broad-scale survey for the Forest Red-tailed Black-Cockatoo, with volunteers documenting 114 roosts across southwest WA. This survey, conducted in tandem with the survey for Carnaby's Black-Cockatoo, relied on the existing GCC roost site database which was developed specifically for Carnaby's Black-Cockatoo. Many new FRTBC specific sites were identified and confirmed in the 2018 GCC. This is the result of an increased focus on this species by Birdlife Australia, with the recruitment of a Forest Black-Cockatoo Project Coordinator. It is also the result of roost site information from Sam Rycken and Karen Riley at Murdoch University obtained from satellite telemetry studies. There are now 193 known roost sites for FRTBC.

This year, 31 of the 114 FRTBC roosts were also occupied by White-tailed Black-Cockatoos. Also, FRTBC roosts sometimes occur very close to Carnaby's Black-Cockatoo roosts. Examples of the latter situation include the roosts in Kensington (SOUCOMR001 and VICKENR002).

Distribution of FRTBC in the Perth metropolitan area

The 2018 GCC showed a large increase in numbers of FRTBC roosting in the Perth-Peel region (4,037 birds compared to 1,934 in 2017 and an average of 559 between 2014 and 2016). Observations from the 2014 to 2018 GCCs confirmed roosts in 20 LGAs in the Perth-Peel Coastal Plain. In 2018 volunteers recorded sizable counts at Murdoch University, Munster, Floreat, Kenwick, Morley, Yokine, Southern River, Jandabup, Ballajura, Banjup and Kensington. These counts are roughly double those at the same sites in 2017. These counts are much larger than flock sizes reported for FRTBC in forested regions (Abbott 1998, Lee *et al.* 2013). Indeed, the 2018 average roost size of 67 for the Perth-Peel region is much higher than that of the Darling Scarp and Plateau (34) and regional areas (18) and much higher than in previous years (e.g 32 in 2016 and 50 in 2017).

These outcomes are consistent with, and extend, previous observations about recent shifts in the abundance and distribution of FRTBC on the Swan Coastal Plain. In reviewing information about FRTBC on the Swan Coastal Plain, Johnstone *et al.* (2010, p. 24) noted that:

On Swan Coastal Plain status uncertain, listed as rare in early 1900s (Alexander 1921), but possibly resident (although patchily distributed) at Mundijong, Baldivis, Karnup, Stakehill, near McLarty, Pinjarra, Coolup, Meelup, Goodale Sanctuary, Lake Clifton area, Dawesville and Wokalup (Storr-Johnstone Bird Data Bank) and also a casual visitor mainly in search of Cape Lilac (*Melia azedarach*) to some Perth suburbs (e.g. Mosman Park, Belmont, Kensington, Murdoch, Kewdale, Bentley, Queens Park, Lynwood, Gosnells, Forrestdale and Armadale). In recent years there has been a very dynamic expansion of foraging from the Darling Range, both west onto the Swan Coastal Plain and east into the wheatbelt.

Johnstone *et al.* (2013, p. 153) also observed that:

The changing foraging ecology of some [FRTBC] populations in the northern Jarrah-Marri forest in recent times has meant that some flocks that were largely sedentary have now developed regular movements onto the Swan Coastal Plain including the establishment of new roost and breeding sites. The movement out onto the coastal plain has, however, led to the erroneous assumption in the Perth area that this subspecies is more common than it really is.

Counts from the 2018 GCC demonstrate the extent of this expansion onto the Swan Coastal Plain and suggest that significant roosts now occur throughout the Perth area. Additional surveys conducted by GCC volunteers in 2014 also indicate that FRTBCs show strong roost fidelity and year-round residency in at least three locations – Kensington bushland and adjacent reserves, Murdoch University, and the Floreat/Underwood Avenue area (unpublished data: Greg Bell, Department of Fire and Emergency Services; L. Knapp, Murdoch University; and



Margaret Owen, Friends of Underwood Avenue Bushland). FRTBC have also bred successfully in artificial nest hollows installed at Murdoch University (Leah Knapp, Murdoch University, personal communication). The roost occupancy rate is much higher for FRTBC compared to white-tailed black-cockatoos, but this may be due to greater roost fidelity rather than their population being more stable.

The apparent expansion of FRTBC on the Perth-Peel Coastal Plain may be associated with them including exotic foods such as Cape Lilac in their diet. This is a hypothesis being studied by a PhD student at UWA and has been noted by Johnstone *et al.* 2017:

Over the past 20 years there has been a dynamic change in the foraging ecology of many birds in the northern Darling Range (adjacent to the Perth metropolitan area) driven mainly by their discovery of Cape Lilac as a new food source.

The expansion of FRTBC on the Perth-Peel Coastal Plain may also be a response to changes in water availability with water potentially becoming a scarcer resource on the Darling Scarp by late summer (M. Craig pers. comm). Dr Mike Craig at UWA is currently researching water use by all black-cockatoo species in the northern Jarrah-Marri forest.

It is also possible that a decline in the availability of water in the Darling Scarp, due to the drying of seasonal and permanent streams (petronel et al. 2010), has led to birds moving in to the Perth metropolitan region.

There is evidence in recent years of changes in the black-cockatoo species using some confirmed roost sites - 23 former confirmed white-tailed black-cockatoo roost sites are now used only by FRTBC (Appendix Vd). Thirteen of these are in the Perth-Peel Coastal Plain and this reflects the trend of FRTBC expanding into this area over the last decade. However, some roosts alternate between FRTBC and WTBCs and being joint roosts from year to year. The competitive relationship between cockatoo species for roost sites is another unknown aspect of these species' ecology.

Trend analysis

Trend analysis shows a large increase in FRTBC numbers in the Greater Perth-Peel region. To what extent this is due to a redistribution of birds from forested areas to more urbanised areas or increased breeding rates is unclear. FRTBC are very slow breeding birds, producing only a single egg each year, and breeding data from 2016 show a decline in breeding success (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 due to a redistribution of birds from other areas. The results of the count conducted in October 2018 contrasts markedly with those in April. The low counts in October suggest that most FRTBC return to forested regions in winter, returning to coastal areas in summer. The return to forested areas may be in order to breed where there are more suitable hollows available. The seasonal pattern may also reflect the availability of food resources such as Cape Lilac and native plants (eg Marri, Jarrah).



Conclusion

The Great Cocky Count is a large-scale citizen science survey that engages local communities in the monitoring of nationally threatened black-cockatoos. The last nine GCCs, involving more than 2900 volunteers, have identified several hundred black-cockatoo roosts across the southwest of WA. 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. This information has improved land-use planning and environmental impact assessment, and informed 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 2018 GCC and the trend analyses of the nine annual GCCs between 2010 and 2018 identified several issues that have important implications for black-cockatoo conservation efforts. Firstly, there are indications that the population of Carnaby's Black-Cockatoo that inhabit the Perth-Peel Coastal Plain and are counted through the GCC has declined since 2010, although may have stabilised over the past three years. Secondly, as noted in previous GCC reports, the Gngangara pine plantation sustains a large proportion (up to 73%) of the population of Carnaby's Black-Cockatoo on the Perth-Peel Coastal Plain during the non-breeding season. As such, the decline in numbers of Carnaby's Black-Cockatoo may be partly due to the removal of these pine plantations. Finally, there has been a significant change in the roosting behaviour of Forest Red-tailed Black-Cockatoos from forested areas to the urban portions of the Perth-Peel metropolitan area. These findings provide an important focus for decision-making about the future of the remaining Gngangara pine plantation, 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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APPENDIX I: The 2018 Great Cocky Count survey form

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

Date:	8 April 2018	Start time:		Finish time:	
Site code:		GPS location:	Latitude	Longitude	
Site Address / Location:					

What is the main type of tree that the cockatoos are <u>roosting</u> in: (tick box)	
<input type="checkbox"/> Pine <input type="checkbox"/> Eucalypt <input type="checkbox"/> Marri <input type="checkbox"/> Jarrah <input type="checkbox"/> Tuart Other: _____ <input type="checkbox"/> Not Known	

White-Tailed Black-Cockatoos Count		Sub-totals
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, ...)		
Total Number of White-Tailed Cockatoos at the Roost		
General direction from which cockatoos arrived:	<input type="checkbox"/> North <input type="checkbox"/> South <input type="checkbox"/> East <input type="checkbox"/> West <input type="checkbox"/> Other (e.g. SW): _____	

Red-Tailed Black-Cockatoos Count		Sub-totals
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, ...)		
Total Number of Red-Tailed Cockatoos at the Roost		
General direction from which cockatoos arrived:	<input type="checkbox"/> North <input type="checkbox"/> South <input type="checkbox"/> East <input type="checkbox"/> West <input type="checkbox"/> Other (e.g. SW): _____	



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, eg 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:

Adam Peck, BirdLife Australia
Peregrine House, 167 Perry Lakes Drive
Floreat, WA, 6014



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) **Count all black-cockatoos that roost at the site for at least 30 minutes after sunset** (ie. count until at least **6:30pm**, sometimes cockies arrive late and you may need to stay until 7pm).
 - Only 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.
 - If you see **red-tailed black-cockatoos**, note their numbers on your survey form in the box below the white-tailed box.
 - **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*. If you see **red-tailed black-cockatoos at your site**, note this on your survey form as well.
 - 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.
- 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.
- 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 2018 Great Cocky Count please contact Adam Peck, Great Cocky Count Coordinator, at greatcockycount@birdlife.org.au or (08) 9287 2251/ 0401 840 546.



APPENDIX IIa: Number of sites surveyed across local government areas (2018) and WT 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	22	8	557	Donnybrook-Balingup	11	5	58
Augusta-Margaret River	19	3	86	Esperance	8	3	298
Bindoon	1	0	0	Gingin	1	1	1207
Bridgetown-Greenbushes	9	5	712	Gnowangerup	2	1	90
Bunbury	4	1	79	Harvey	9	5	353
Busselton	14	10	401	Kojonup	1	1	27
Capel	8	4	385	Manjimup	3	2	93
Carnamah	2	2	487	Nannup	1	1	16
Chapman Valley	4	1	130	Narrogin	3	2	62
Cranbrook	3	0	0	Plantagenet	6	4	297
Dandaragan	4	2	144	Ravensthorpe	2	0	0
Dardanup	4	1	101	West Arthur	2	0	0
Denmark	2	1	2	Williams	1	0	0
Greater Perth-Peel region							
Armadale	16	3	51	Mosman Park	1	0	0
Bayswater	3	0	0	Mundaring	28	13	717
Belmont	1	0	0	Murray	3	3	54
Beverley	1	0	0	Nedlands	5	3	234
Boddington	7	3	38	Northam	1	1	8
Cambridge	6	1	259	Rockingham	3	0	0
Canning	5	0	0	Serpentine-Jarrahdale	24	5	519
Chittering	2	0	0	South Perth	4	2	472
Claremont	1	0	0	Stirling	13	1	19
Cockburn	14	3	405	Subiaco	1	0	0
Fremantle	1	0	0	Swan	27	8	522
Gingin	6	3	7389	Toodyay	3	2	131
Gosnells	6	1	120	Victoria Park	7	0	0
Joondalup	6	1	80	Vincent	1	0	0
Kalamunda	19	4	481	Wandering	1	0	0
Kings Park	4	0	0	Wanneroo	23	8	1797
Kwinana	7	3	67	Waroona	4	2	15
Mandurah	7	4	1047	Williams	1	0	0
Melville	8	3	306				



Appendix IIb: Number of sites surveyed across local government areas (2018) 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	22	0	0	Donnybrook-Balingup	11	5	192
Augusta-Margaret River	19	2	7	Esperance	8	0	0
Bindoon	1	0	0	Gingin	1	0	0
Bridgetown-Greenbushes	9	3	59	Gnowangerup	2	0	0
Bunbury	4	0	0	Harvey	9	4	48
Busselton	14	2	36	Kojonup	1	0	0
Capel	8	3	42	Manjimup	3	0	0
Carnamah	2	0	0	Nannup	1	0	0
Chapman Valley	4	0	0	Narrogin	3	0	0
Cranbrook	3	0	0	Plantagenet	6	0	0
Dandaragan	4	0	0	Ravensthorpe	2	0	0
Dardanup	4	1	22	West Arthur	2	2	9
Denmark	2	1	8	Williams	1	1	14
Greater Perth-Peel region							
Armadale	16	7	98	Mosman Park	1	0	0
Bayswater	3	3	364	Mundaring	28	8	219
Belmont	1	0	0	Murray	3	2	63
Beverley	1	0	0	Nedlands	5	1	1
Boddington	7	1	2	Northam	1	0	0
Cambridge	6	3	403	Rockingham	3	2	82
Canning	5	3	37	Serpentine-Jarrahdale	24	9	106
Chittering	2	2	97	South Perth	4	1	8
Claremont	1	0	0	Stirling	13	3	369
Cockburn	14	8	705	Subiaco	1	0	0
Fremantle	1	1	29	Swan	27	6	273
Gingin	6	0	0	Toodyay	3	2	34
Gosnells	6	5	730	Victoria Park	7	3	208
Joondalup	6	0	0	Vincent	1	0	0
Kalamunda	19	7	475	Wandering	1	1	16
Kings Park	4	0	0	Wanneroo	23	3	169
Kwinana	7	2	30	Waroon	4	3	81
Mandurah	7	1	14	Williams	1	0	0
Melville	8	3	447				



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

Appendix IIIa: Great Cocky Count (2010-2018) roost counts for Carnaby's Black-Cockatoo at **confirmed roosts** (see page vii) in the Perth-Peel Coastal Plain. 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	Locality	2010	2011	2012	2013	2014	2015	2016	2017	2018	Totals
ARMCHAR001*	Champion Lakes	.	.	.	.	.	.	.	0	3	3
ARMFORR001	Forrestdale	.	.	.	0	0	18	0	0	.	18
ARMHARR001	Harrisdale	.	0	0	.	0	1	3	0	0	4
ARMKELR001	Kelmscott	14	0	0	0	0	.	.	.	0	14
CAMCITR001	City Beach	.	.	.	.	2	0	0	0	.	2
CAMFLOR001	Floreat	237	151	148	157	159	86	239	281	259	1717
CANFERR001	Ferndale	.	.	.	5	0	0	0	0	0	5
CANWILR001*	Willetton	0	0	0	0	68	0	0	0	0	68
CLASWAR001	Swanbourne	.	.	0	0	3	0	0	0	0	3
COCBANR001*	Banjup	.	.	.	.	.	45	.	0	20	65
COCBANR002*	Banjup	.	.	.	.	53	.	0	0	0	53
COCBANR003	Banjup	.	.	.	.	.	.	.	6	16	22
COCCOOR005	Coolbellup	.	.	.	.	.	.	.	38	0	38
COCHAMR001	Hamilton Hill	0	169	215	0	168	68	101	0	0	721
COCHAMR002	Hamilton Hill	.	.	.	.	.	263	194	0	369	826
COCCCCR001	Success	252	cleared	cleared	cleared	cleared	cleared	cleared	cleared	cleared	252
COCCCCR002	Success	15	3	cleared	cleared	cleared	cleared	cleared	cleared	cleared	18
COCSPER001	Spearwood	0	2	.	323	.	0	0	40	0	365
COCSPER002	Spearwood	.	5	0	.	.	0	24	0	.	29
GINGINR001	Gingin	392	378	432	686	879	784	1023	880	1148	6602
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	262
GINYEAR001	Yéal	.	.	387	.	782	.	.	6	0	1175
GINYEAR002	Yéal	49	92	.	.	.	20	.	.	15	176
GINYEAR003	Yéal	.	.	.	.	.	750	4897	3528	6226	15401
GOSCNVR001*	Canning Vale	0	19	.	.	0	0	0	0	.	19
GOSCNVR002*	Canning Vale	.	.	26	52	0	0	151	0	0	229
GOSMARR001*	Martin	.	.	.	.	.	.	.	0	120	120
GOSSOUR002*	Southern River	.	.	.	.	.	.	50	0	0	50
JOODUNR001	Duncraig	.	.	60	0	0	17	43	110	80	310
JOEDGR001	Edgewater	0	0	.	0	0	23	0	0	0	23
JOOPADR001	Padbury	0	.	1	17	7	7	0	0	0	32
JOOWARR001	Warwick	0	60	.	0	0	0	0	0	.	60
KINPERR001	Perth	0	.	0	.	0	0	0	8	0	8
KWICASR001*	Casuarina	2	.	.	0	19	.	.	0	59	80
KWIWANR001	Wandi	63	0	0	1	0	0	0	0	0	64
KWIWANR002	Wandi	.	.	.	0	0	0	0	5	0	5
KWIWANR004	Wandi	.	.	.	.	.	.	.	73	0	73
KWIWELR001*	Wellard	.	.	15	50	0	62	0	0	4	131
KWIWELR002	Wellard	.	.	.	.	.	.	.	.	4	4
MANCOOR002*	Coodanup	.	.	.	21	0	0	2	0	0	23



Site code	Locality	2010	2011	2012	2013	2014	2015	2016	2017	2018	Totals
MANDAWR002*	Dawesville	371	199	11	0	257	135	214	86	71	1344
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	343
MANDAWR007*	Dawesville	.	.	.	.	.	277	167	9	566	1019
MELBATR001	Bateman	8	0	0	0	0	0	0	0	0	8
MELKARR002	Kardinya	0	0	0	.	0	55	0	0	0	55
MELLEER001*	Leeming	0	0	12	0	70	0	0	0	15	97
MELMURR001*	Murdoch	700	60	142	127	234	24	78	0	227	1592
MELWINR001	Winthrop	.	56	81	70	41	0	21	0	0	269
MELWINR003*	Winthrop	117	130	.	.	.	0	7	54	64	372
MELWINR004	Winthrop	0	0	0	0	2	0	0	0	0	2
NEDDALR002*	Dalkeith	0	.	.	.	.	.	0	0	12	12
NEDDALR003	Dalkeith	40	90	0	0	0	0	0	0	0	130
NEDNEDR001	Nedlands	73	103	304	183	114	106	216	242	175	1516
NEDNEDR002	Nedlands	.	.	.	.	0	11	0	0	0	11
NEDNEDR003	Nedlands	.	.	.	.	0	2	33	96	47	178
ROCBALR001	Baldivis	346	.	cleared	cleared	cleared	cleared	cleared	cleared	cleared	346
ROCBALR003*	Baldivis	.	78	0	4	0	0	0	.	0	82
ROCBALR004	Baldivis	.	40	0	0	0	.	0	0	.	40
ROCSECR001	Secret Harbour	0	.	0	0	6	0	0	.	0	6
SERBYFR004*	Byford	.	.	.	.	.	.	111	7	0	118
SERDARR001*	Darling Downs	.	.	.	.	.	.	8	0	0	8
SERKEYR001	Keysbrook	0	.	.	100	3	14	53	0	3	173
SERMUNR002*	Mundijong	.	.	.	.	.	.	10	12	.	22
SEROAKR001	Oakford	0	110	.	0	0	.	.	0	0	110
SEROAKR002*	Oakford	0	0	0	2	.	.	.	0	0	2
SEROAKR003	Oakford	167	0	0	0	0	0	.	.	0	167
SEROAKR004	Oakford	45	3	0	0	50	0	26	2	33	159
SEROAKR005	Oakford	31	0	.	0	0	0	0	0	0	31
SEROAKR007	Oakford	.	.	.	.	.	.	.	2	0	2
SERWELR002	Wellard	.	.	.	.	.	.	.	298	75	373
SERWHIR001	Whitby	.	.	.	.	.	.	34	.	56	90
SOUCOMR001	Como	408	645	558	301	402	460	242	289	470	3775
SOUSALR001*	Salter Point	12	0	0	0	5	0	0	0	2	19
SOUSOUR002	South Perth	0	35	0	0	0	0	0	0	0	35
STIHAMR001	Hamersley	.	.	.	.	0	.	24	0	0	24
STIINNRR001	Innaloo	0	.	0	0	0	0	0	3	0	3
STIKARR001	Karrinyup	.	.	.	121	92	2	45	10	0	270
STINORR001	North Beach	0	230	0	267	0	6	0	23	19	545
SUBSHER001	Shenton Park	0	0	0	9	0	0	0	0	0	9
SWABALR001	Ballajura	0	40	0	92	0	35	0	0	0	167
SWABALR004	Ballajura	0	.	.	.	0	5	105	0	0	110
SWABULR003	Bullsbrook	.	.	.	.	.	.	8	0	0	8
SWABULR004	Bullsbrook	.	.	.	.	.	.	0	5	0	5
SWAELLR001	Ellenbrook	.	.	.	.	14	.	280	0	0	294
SWAHENR002	Henley Brook	.	.	.	.	.	.	.	50	0	50
SWALEXR001	Lexia	0	80	0	0	181	0	0	0	34	295



Site code	Locality	2010	2011	2012	2013	2014	2015	2016	2017	2018	Totals
SWALEXR002	Lexia	185	0	.	0	0	0	cleared	cleared	cleared	185
SWAMELR001*	Melaleuca	500	41	0	20	480	0	.	268	0	1309
SWAMILR001	Millendon	.	.	.	.	0	.	250	0	40	290
SWAVINR003*	The Vines	.	.	.	.	.	.	21	0	0	21
SWAWHIR001*	Whiteman	.	69	13	.	.	0	0	7	15	104
VICVICR001	Victoria Park	2	0	0	0	0	0	6	0	0	8
WANCARR001	Carabooda	.	.	2	.	.	0	0	.	0	2
WANCARR004	Carabooda	.	.	.	.	7	.	.	.	.	7
WANCRRR001	Carramar	.	.	.	191	0	0	0	0	0	191
WANGNAR001	Gngangara	0	.	.	.	0	.	454	316	157	927
WANGNAR003	Gngangara	0	14	0	0	0	0	0	0	0	14
WANGNAR004	Gngangara	27	0	0	0	0	0	0	0	0	27
WANGNAR005*	Gngangara	.	.	.	100	0	14	0	260	.	374
WANGNAR006*	Gngangara	.	.	.	.	40	.	3	6	0	49
WANJANR007	Jandabup	.	16	.	0	.	0	cleared	cleared	cleared	16
WANMARR001	Mariginiup	0	20	.	0	.	71	0	770	0	861
WANMARR002*	Mariginiup	0	.	2	3	3	0	0	0	0	8
WANMARR003	Mariginiup	542	152	10	16	147	280	4	1260	625	3036
WANMARR004	Mariginiup	0	0	0	.	.	.	.	8	0	8
WANMARR005	Mariginiup	.	.	.	.	.	.	.	0	350	350
WANNEER001	Neerabup	.	29	.	.	0	.	0	.	.	29
WANNEER002	Neerabup	604	0	0	0	0	0	0	0	0	604
WANNOWR001	Nowergup	.	.	35	10	0	0	0	4	.	49
WANNOWR005*	Nowergup	0	.	.	.	.	.	3	0	0	3
WANPINR001	Pinjar	.	.	853	35	1521	616	1232	900	315	5472
WANPINR002	Pinjar	.	312	276	0	138	101	0	0	0	827
WANPINR003	Pinjar	64	0	0	0	0	0	0	0	.	64
WANPINR005	Pinjar	275	.	.	.	0	0	cleared	cleared	cleared	275
WANPINR006	Pinjar	13	0	0	0	2	0	0	0	.	15
WANPINR011	Pinjar	0	.	.	800	0	179	0	0	0	979
WANTAMR001	Tamala Park	.	.	0	103	20	10	0	0	.	133
WANTWOR001	Two Rocks	0	.	7	573	200	30	0	0	18	828
WANWANR001	Wanneroo	0	11	6	0	0	0	0	0	0	17
WANYANR001	Yanchep	61	.	.	.	450	82	0	.	16	609
WANYANR003	Yanchep	.	16	0	564	0	0	0	0	37	617
WANYANR004	Yanchep	.	0	0	192	0	0	cleared	cleared	cleared	192
WANYANR006	Yanchep	342	305	129	0	0	0	0	136	279	1191
WANYANR007	Yanchep	.	0	0	.	0	.	173	0	.	173
WANYANR008	Yanchep	.	.	.	.	.	.	.	5	0	5
WARLAKR001	Lake Clifton	1	0	0	.	.	0	0	.	.	1
WARPRER001	Preston Beach	.	.	66	330	19	.	158	0	.	573
WARPRER002	Preston Beach	100	.	0	.	0	0	0	.	.	100
WARWARR002*	Waroona	.	.	.	36	0	0	4	0	11	51



Appendix IIIb: Great Cocky Count (2010-2018) roost counts for Carnaby's Black-Cockatoo at **confirmed roosts** (see page iv) (24) that: (a) are within or immediately adjacent (<1 km) to the **Gnangara pine plantation** (see page v) 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	Totals
GINYEAR001	.	.	387	.	782	.	.	6	0	1175
GINYEAR002	49	92	.	.	.	20	.	.	15	176
GINYEAR003	.	.	.	.	.	750	4897	3528	6226	15401
SWALEXR001	0	80	0	0	181	0	0	0	34	295
SWALEXR002	185	0	.	0	0	0	cleared	cleared	cleared	185
SWAMELR001*	500	41	0	20	480	0	.	268	0	1309
WANCARR004	.	.	.	.	7	.	.	.	.	7
WANGNAR001	0	.	.	.	0	.	454	316	157	927
WANGNAR003	0	14	0	0	0	0	0	0	0	14
WANGNAR004	27	0	0	0	0	0	0	0	0	27
WANGNAR005*	.	.	.	100	0	14	0	260	.	374
WANGNAR006*	.	.	.	.	40	.	3	6	0	49
WANJANR007	.	16	.	0	.	0	cleared	cleared	cleared	16
WANMARR001	0	20	.	0	.	71	0	770	0	861
WANMARR002*	0	.	2	3	3	0	0	0	0	8
WANMARR003	542	152	10	16	147	280	4	1260	625	3036
WANMARR005	.	.	.	.	.	.	.	0	350	350
WANNEER001	.	29	.	.	0	.	0	.	.	29
WANNEER002	604	0	0	0	0	0	0	0	0	604
WANPINR001	.	.	853	35	1521	616	1232	900	315	5472
WANPINR002	.	312	276	0	138	101	0	0	0	827
WANPINR003	64	0	0	0	0	0	0	0	.	64
WANPINR005	275	.	.	.	0	0	cleared	cleared	cleared	275
WANPINR006	13	0	0	0	2	0	0	0	.	15
WANPINR011	0	.	.	800	0	179	0	0	0	979
WANTWOR001	0	.	7	573	200	30	0	0	18	828
WANYANR001	61	.	.	.	450	82	0	.	16	609
WANYANR003	.	16	0	564	0	0	0	0	37	617
WANYANR004	.	0	0	192	0	0	cleared	cleared	cleared	192
WANYANR006	342	305	129	0	0	0	0	136	279	1191
WANYANR007	.	0	0	.	0	.	173	0	.	173
Total	2662	1077	1664	2303	3951	2143	6763	7450	8072	36085
% of total Perth-Peel Coastal Plain count	42%	28%	44%	41%	59%	46%	62%	73%	65%	56%
No. of pine-associated sites surveyed	18	18	17	20	26	24	22	23	21	31



Appendix IIIc: Great Cocky Count (2010-2018) roost counts for White-tailed Black-Cockatoos at confirmed roosts (see page vii) in the Northern Darling Scarp and Plateau. Sites with an asterisk are or 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	Totals
ARMBEDR001*	Bedfordale	57	0	.	0	0	0	0	6	0	63
ARMBEDR002*	Bedfordale	70	22	.	3	0	.	0	0	0	95
ARMBEDR003*	Bedfordale	385	.	.	0	0	60	6	3	12	466
ARMBEDR005*	Bedfordale	.	.	.	.	.	.	.	0	36	36
ARMKELR002	Kelmscott	0	10	.	0	0	0	0	0	0	10
ARMROLR001*	Roleystone	108	13	140	40	0	0	157	70	0	528
ARMROLR003*	Roleystone	.	0	0	50	0	0	0	0	0	50
ARMROLR004*	Roleystone	.	.	.	.	0	.	28	0	0	28
BEVFLYR002*	Flynn	.	.	.	.	.	.	.	19	0	19
BODBODR001	Boddington	.	.	.	.	.	.	9	0	25	34
BODBODR002	Boddington	.	.	.	.	.	.	.	0	2	2
BODCROR002	Crossman	10	0	.	.	.	3	.	0	.	13
BODMARR001*	Marradong	.	.	.	.	.	.	16	0	0	16
BODMARR002	Marradong	.	.	.	.	.	.	141	0	11	152
KALCARR002	Carmel	.	.	.	.	.	.	.	90	.	90
KALKALR001	Kalamunda	30	.	25	0	0	0	0	0	.	55
KALKALR002	Kalamunda	.	25	23	85	28	10	58	107	48	384
KALKALR004	Kalamunda	.	.	.	.	.	.	65	215	0	280
KALLESR001	Lesmurdie	.	0	0	0	0	8	0	0	.	8
KALMAIR003	Maida Vale	.	.	.	.	.	.	0	5	.	5
KALPICR001	Pickering Brook	.	.	.	.	.	.	.	5	0	5
KALPICR002*	Pickering Brook	.	.	.	.	2	.	0	0	.	2
KALPIER001*	Piesse Brook	.	82	46	0	0	0	163	.	210	501
KALPIER002*	Piesse Brook	.	.	.	.	.	.	.	6	60	66
KALPIER003	Piesse Brook	.	.	.	.	.	.	97	132	163	392
KALWALR001*	Walliston	0	5	0	0	0	0	.	0	0	5
MUNCHIR001	Chidlow	16	0	.	0	0	cleared	cleared	cleared	cleared	16
MUNDARR001	Darlington	443	7	147	0	0	0	.	0	0	597
MUNGLER001	Glen Forrest	.	.	32	51	45	25	65	5	51	274
MUNGLER002	Glen Forrest	.	.	13	0	0	0	0	0	0	13
MUNGLER003	Glen Forrest	.	.	.	.	45	.	0	335	17	397
MUNHEL001*	Helena Valley	.	3	16	42	124	0	44	0	3	232
MUNHOVR001*	Hovea	.	.	40	0	.	0	0	0	0	40
MUNHOVR002	Hovea	243	22	10	0	0	0	18	0	.	293
MUNMTHR001*	Mt Helena	.	.	.	8	0	0	0	0	2	10
MUNMTHR002	Mt Helena	.	.	.	.	0	.	147	0	0	147
MUNMTHR003*	Mt Helena	.	.	.	.	.	.	24	0	0	24
MUNMUNR001*	Mundaring	78	.	.	85	45	36	0	0	82	326
MUNMUNR003*	Mundaring	.	.	.	.	.	.	0	0	4	4
MUNPARR002	Parkerville	.	.	.	.	182	.	66	157	58	463
MUNPARR003*	Parkerville	.	.	.	.	.	.	320	70	80	470
MUNPARR004*	Parkerville	.	.	.	.	.	.	209	213	309	731
MUNPARR005*	Parkerville	.	.	.	.	.	.	.	152	50	202
MUNSTOR001*	Stoneville	.	.	.	.	141	0	7	0	0	148
MUNSTOR002	Stoneville	.	86	0	.	0	0	0	0	7	93
MUNSTOR003*	Stoneville	.	.	.	.	48	.	30	0	0	78



Site code	Locality	2010	2011	2012	2013	2014	2015	2016	2017	2018	Totals
MUNSTOR004*	Stoneville	.	.	.	.	.	.	90	0	0	90
MUNSTOR005*	Stoneville	.	.	.	.	.	.	19	21	12	52
MUNSTOR006	Wooroloo	.	.	.	.	.	.	.	.	42	42
MURDWER001	Dwellingup	.	40	.	.	.	0	.	8	.	48
MURDWER002*	Dwellingup	.	.	.	.	0	.	.	45	6	51
MURDWER003	Dwellingup	.	.	.	.	.	.	.	.	15	15
MURNORR001*	North Dandalup	.	.	.	.	.	.	20	14	33	67
MURTEER001	Teesdale	21	0	0	0	.	0	.	.	.	21
NORBAKR001	Bakers Hill	217	.	.	.	.	.	94	52	.	363
NORWOOR002	Woottating	.	.	.	.	.	.	.	.	8	8
NORWUNR001*	Wundowie	125	.	8	0	.	0	0	0	.	133
SERJARR001	Jarrahdale	0	60	0	.	.	0	.	0	0	60
SERKEYR002*	Keysbrook	25	.	0	30	.	0	.	0	.	55
SERKEYR003	Keysbrook	.	.	.	.	.	.	.	255	352	607
SWABULR002*	Bullsbrook	.	18	117	120	328	.	178	0	260	1021
SWAGIDR002	Gidgegannup	101	.	23	40	.	217	129	93	0	603
SWAGIDR003	Gidgegannup	.	.	3	.	.	.	0	0	0	3
SWAGIDR005	Gidgegannup	.	.	.	197	163	169	152	0	113	794
SWAGIDR007*	Gidgegannup	.	.	.	.	.	.	0	0	51	51
SWAGIDR008*	Gidgegannup	.	.	.	.	.	.	0	3	2	5
SWAGIDR009*	Gidgegannup	.	.	.	.	.	.	0	0	7	7
TOOMORR001*	Morangup	.	.	183	29	56	12	140	44	99	563
TOOMORR003*	Morangup	.	.	.	.	.	.	.	55	32	87
WARWAGR001*	Wagerup	.	.	.	236	186	.	.	.	.	422
WARWARR003*	Waroona	.	.	.	.	.	.	.	.	4	4
WNDNORR001	North Bannister	.	.	.	.	.	.	4	.	.	4



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

Appendix IV: Great Cocky Count (2010-2018) roost counts for White-tailed Black-Cockatoo at **confirmed roosts** (see page vii) in regional areas. 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	Locality	2010	2011	2012	2013	2014	2015	2016	2017	2018	Totals
ALBCHER001	Cheynes	.	.	70	.	.	.	.	.	.	70
ALBCHER002	Cheynes	.	.	0	.	60	0	0	.	0	60
ALBCHER004	Cheynes	.	.	.	.	.	.	.	.	8	8
ALBCHER005	Cheynes	.	.	.	.	.	.	.	.	14	14
ALBCHER006	Cheynes	.	.	.	.	.	.	.	.	13	13
ALBGOOR001	Goode Beach	.	.	.	84	62	.	0	3	0	149
ALBGOOR002	Goode Beach	.	111	.	0	120	0	0	0	0	231
ALBGRER002	Green Valley	.	.	.	.	.	.	.	15	0	15
ALBKALR001	Kalgan	.	.	213	472	141	73	0	0	.	899
ALBKALR004	Kalgan	.	.	.	.	.	.	.	760	219	979
ALBKORR002	Kronkup	.	.	.	.	.	.	.	7	0	7
ALBLOWR003	Lowlands	.	.	.	.	.	.	.	6	0	6
ALBMANR002	Manypeaks	.	.	.	.	.	.	.	.	250	250
ALBMCKR001*	McKail	.	.	33	.	18	0	107	110	49	317
ALBMETR001	Mettler	.	.	40	145	.	.	.	.	.	185
ALBMTCR001	Mt Clarence	.	4	.	.	0	0	0	.	.	4
ALBROBR001	Robinson	.	.	0	43	0	.	0	31	0	74
ALBSEPR001	Seppings	.	0	0	0	0	2	.	3	0	5
ALBTORR002	Torbay	.	.	.	.	.	.	.	.	2	2
ALBTORR005	Torbay	.	.	.	.	.	.	.	.	2	2
AUGCHAR002*	Chapman Hill	.	.	.	.	.	.	.	23	0	23
AUGFORR002*	Forest Grove	.	.	.	.	.	.	6	0	0	6
AUGGRAR001	Gracetown	.	.	.	.	1	12	2	12	0	27
AUGGRAR002	Gracetown	.	.	.	7	85	4	26	3	54	179
AUGHAMR001	Hamelin Bay	.	.	.	.	.	.	0	2	.	2
AUGMARR001	Margaret River	.	.	11	1	47	0	57	0	0	116
AUGMARR004	Margaret River	.	.	.	.	.	.	6	0	.	6
AUGMARR006	Margaret River	.	.	.	.	.	.	.	2	0	2
AUGMARR007	Margaret River	.	.	.	.	.	.	.	5	0	5
AUGMARR008	Margaret River	.	.	.	.	.	.	.	16	0	16
AUGMARR012	Margaret River	.	.	.	.	.	.	.	20	0	20
AUGMARR013	Margaret River	.	.	.	.	.	.	.	13	0	13
AUGMARR014	Margaret River	.	.	.	.	.	.	.	60	0	60
AUGROSR001	Rosa Glen	.	.	.	.	.	.	.	46	29	75
AUGWITR002	Witchcliffe	.	.	.	.	.	.	.	7	3	10
BRIBOYR001	Boyup Brook	.	.	.	.	.	.	.	.	28	28
BRIBRIR003	Bridgetown	.	.	.	.	.	.	.	5	0	5
BRIBRIR004	Bridgetown	.	.	.	.	.	.	.	.	23	23
BRIGLER001	Glenlynn	.	.	70	250	0	.	.	.	614	934
BRIGRER003*	Greenbushes	.	.	.	.	.	.	5	0	2	7
BRINORR001	North Greenbushes	.	.	.	.	74	44	2	.	0	120
BRINORR002*	North Greenbushes	.	.	.	.	.	.	39	27	45	111



Site code	Locality	2010	2011	2012	2013	2014	2015	2016	2017	2018	Totals
BUNCOLR001	College Grove	.	.	0	20	0	7	0	22	0	49
BUNCOLR002	College Grove	.	.	.	.	0	.	0	3	0	3
BUNGLER001	Glen Iris	.	.	25	0	.	0	0	62	0	87
BUNGLER002	Glen Iris	.	.	.	8	4	0	.	41	79	132
BUSCARR001	Carbunup	.	.	.	.	.	.	.	121	108	229
BUSDUNR001	Dunsborough	.	.	.	32	99	0	0	0	5	136
BUSDUNR002	Dunsborough	.	.	.	.	.	.	82	8	10	100
BUSJINR001	Jindong	.	.	.	.	.	.	.	.	30	30
BUSJINR002*	Jindong	.	.	.	.	0	.	0	1	.	1
BUSMEER002	Meelup	.	.	.	.	.	.	.	14	.	14
BUSMETR002*	Metricup	.	.	.	.	.	.	.	22	3	25
BUSQUIR001	Quindalup	.	.	.	71	107	31	64	30	137	440
BUSWILR002	Wilyabrup	.	.	.	.	.	.	.	.	45	45
BUSYALR001	Yallingup	.	.	.	0	57	.	.	.	0	57
BUSYALR004	Yallingup	.	.	.	.	.	.	8	0	30	38
BUSYALR005	Yallingup	.	.	.	.	.	.	.	.	30	30
BUSYALR006	Yallingup	.	.	.	.	.	.	.	.	3	3
CAPCAPR001	Capel	.	.	.	.	0	.	.	7	0	7
CAPCAPR002*	Capel	.	.	.	.	.	.	.	.	64	64
CAPGELR001	Gelorup	.	.	38	6	0	0	4	0	0	48
CAPGELR002*	Gelorup	.	.	.	.	0	21	2	12	5	40
CAPGWIR001	Gwindinup	194	.	14	0	119	175	216	48	193	959
CAPGWIR002	Gwindinup	.	.	.	.	.	.	.	.	123	123
CAPNORR001	North Boyanup	.	.	.	4	0	0	26	0	0	30
CARENNR001	Eneabba	.	.	.	.	.	.	40	.	.	40
CARENNR002	Eneabba	.	.	.	.	.	.	.	.	83	83
CARWARR001	Warradarge	.	.	.	.	.	.	.	.	404	404
CHAHOWR001	Howatharra	.	.	.	.	.	.	.	.	130	130
CHANANR001	Nanson	.	.	.	302	262	300	270	0	0	1134
CHANANR002	Nanson	.	.	.	0	189	.	0	0	0	189
DANDANR001	Dandaragan	.	.	313	228	460	2	0	144	0	1147
DANHILR001	Hill River	.	.	160	0	250	0	0	0	0	410
DANHILR002	Hill River	.	.	136	.	.	11	.	.	.	147
DANHILR003	Hill River	.	.	.	.	131	.	.	0	.	131
DANHILR004	Hill River	.	.	.	.	.	.	.	.	16	16
DANJURR001	Jurien Bay	.	.	51	225	52	143	436	230	128	1265
DANREGR001	Regans Ford	0	22	0	.	.	.	.	.	.	22
DARBURR001*	Burekup	.	.	.	.	.	.	.	.	101	101
DAREATR001	Eaton	.	4	19	14	0	0	.	20	0	57
DENSCOR001	Scotsdale	.	.	.	.	.	.	70	.	.	70
DENSCOR003	Scotsdale	.	.	.	.	.	.	.	.	2	2
DONBALR002*	Balingup	.	.	.	.	.	.	.	.	3	3
DONCOLR001	Collie	.	.	.	.	.	.	.	.	15	15
DONCOLR002*	Collie	.	.	.	.	.	.	.	.	6	6
DONDONR001*	Donnybrook	.	.	.	11	0	0	.	0	0	11
DONMUMR001	Mumballup	.	29	.	0	.	7	.	.	.	36
DONMUMR003	Mumballup	.	.	.	.	.	.	0	20	33	53
DONMUNR001*	Mungallup	.	.	.	.	.	.	4	0	0	4



Site code	Locality	2010	2011	2012	2013	2014	2015	2016	2017	2018	Totals
DONNOGR001*	Noggerup	.	.	.	.	.	.	0	14	0	14
DONYABR001*	Yabberup	.	.	.	.	.	.	.	9	1	10
ESPESPR001	Esperance	.	196	226	230	202	.	665	125	36	1680
ESPESPR002	Esperance	.	.	.	.	.	360	.	0	0	360
ESPESPR003	Esperance	.	.	.	.	.	60	.	111	163	334
ESPESPR004	Esperance	.	.	.	.	.	316	.	205	99	620
ESPMYRR001	Myrup	.	.	555	589	791	0	32	0	0	1967
ESPMYRR002	Myrup	.	.	1018	0	.	.	.	500	0	1518
ESPMYRR003	Myrup	.	.	.	.	.	.	.	559	0	559
GINNILR001	Nilgen	.	.	.	583	376	995	500	855	1207	4516
GNOSTIR001	Stirling Range National	.	.	52	.	38	.	.	187	90	367
GOOGOR001	Goomalling	.	9	.	.	.	.	0	.	.	9
HARCOOR001	Cookernup	.	.	.	.	.	.	.	.	68	68
HARHARR001*	Harvey	.	.	.	.	0	.	10	.	14	24
HARLESR001*	Leschenault	.	.	.	.	.	.	14	11	21	46
HARMYAR001	Myalup	.	0	0	0	35	0	349	0	0	384
HARMYAR002	Myalup	52	155	cleared	cleared	cleared	cleared	cleared	cleared	cleared	207
HARMYAR003	Myalup	.	.	.	.	.	570	33	123	167	893
HARSUNR001	Harvey	.	.	.	.	.	24	.	.	83	107
IRWMILR001	Milo	.	.	1	.	0	.	.	.	.	1
JERBOXR001	Boxwood Hill	.	.	11	0	.	0	.	.	.	11
KOJKOJR001	Kojonup	.	.	.	.	.	.	.	48	27	75
MNJCROR001	Crowea	.	.	.	5	0	.	.	0	.	5
MNJMNJR001*	Manjimup	.	.	.	.	.	.	17	0	0	17
MNJMNJR002	Manjimup	.	.	.	.	.	.	.	.	27	27
MNJMNJR003	Manjimup	.	.	.	.	.	.	.	.	66	66
NANNANR001	Nannup	.	.	.	.	.	.	.	16	16	32
NARNARR002	Narrogin	.	.	16	19	36	.	21	77	17	186
NARNARR004	Narrogin	.	.	0	9	.	0	.	.	0	9
NARNARR005	Narrogin	.	80	0	0	.	.	0	.	45	125
PLAMOUR001	Mount Barker	.	.	3	0	0	0	.	.	.	3
PLANARR001*	Narrikup	.	.	.	.	.	.	191	0	7	198
PLANARR002*	Narrikup	.	.	.	.	45	.	0	.	.	45
PLAPORR003*	Porongurup	.	.	.	.	.	.	.	9	137	146
PLAPORR006	Porongurup	.	.	.	.	.	.	.	200	0	200
PLAPORR007	Porongurup	.	.	.	.	.	.	.	.	67	67
PLASTIR001	Stirling Range National	.	.	254	316	.	25	.	76	86	757
RAVHOPR001	Hopetoun	.	.	.	.	30	.	0	0	0	30
RAVHOPR002	Hopetoun	.	.	.	.	150	.	0	.	0	150
THRARRR002	Arrino	.	.	.	70	.	.	.	.	.	70
WARYARR001	Yarloop	.	.	.	.	.	.	36	.	.	36



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

Appendix Va: Great Cocky Count (2014-2018) roost counts for FRTBC at **confirmed roosts** (see page vii) in the Perth-Peel Coastal Plain. 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	Locality	2014	2015	2016	2017	2018	Totals
ARMARMR002	Armadale	.	.	17	.	15	32
ARMARMR004	Armadale	.	.	.	.	6	6
ARMCHAR001*	Champion Lakes	.	.	.	11	16	27
BAYEMBR002	Embleton	.	.	.	.	34	34
BAYMORR001	Morley	0	0	36	130	300	466
BAYMORR002	Morley	.	.	.	8	30	38
CAMFLOR002	Floreat	109	.	49	261	360	779
CAMFLOR003	Floreat	.	.	.	.	40	40
CAMKARR001	Karrakata	.	.	.	.	3	3
CANRIVR001	Riverton	.	.	6	11	7	24
CANROSR001	Rossmoyne	.	.	.	.	14	14
CANWILR001*	Willetton	4	7	7	5	16	39
CHIMUCR001	Muchea	.	.	.	43	26	69
COCBANR001*	Banjup	.	0	.	6	17	23
COCBANR002*	Banjup	3	.	32	24	109	168
COCCOCR001	Cockburn Central	.	.	.	.	15	15
COCCOOR001	Coolbellup	.	13	0	0	8	21
COCCOOR003	Coolbellup	.	.	57	6	71	134
COCMUNR001	Munster	92	.	73	0	365	530
COCMUNR003	Munster	.	.	38	0	108	146
COCSPER003	Spearwood	.	.	.	35	12	47
FREWHIR001	White Gum Valley	0	.	0	38	29	67
GOSCNVR001*	Canning Vale	2	0	0	0	.	2
GOSCNVR002*	Canning Vale	0	4	0	0	0	4
GOSGOSR004	Gosnells	19	.	31	32	79	161
GOSKENR001	Kenwick	.	.	.	51	334	385
GOSKENR002	Kenwick	.	.	.	.	72	72
GOSMARR001*	Martin	.	.	.	75	37	112
GOSSOUR002*	Southern River	.	.	0	36	208	244
KWICASR001*	Casuarina	0	.	.	75	16	91
KWIWELR001*	Wellard	0	0	9	0	0	9
KWIWELR003	Wellard	.	.	.	.	14	14
MANCOOR002*	Coodanup	0	0	30	0	0	30
MANDAWR002*	Dawesville	0	38	0	0	0	38
MANDAWR007*	Dawesville	.	0	2	0	0	2
MANPARR001	Parklands	0	.	16	0	14	30
MELLEER001*	Leeming	0	0	11	25	5	41
MELMURR001*	Murdoch	199	33	125	209	441	1007
MELWINR003*	Winthrop	.	.	.	.	1	1
NEDDALR002*	Dalkeith	.	.	.	.	1	1
ROCBALR003*	Baldivis	17	25	24	.	45	111
ROCKARR002	Karnup	.	.	.	5	37	42



Site code	Locality	2014	2015	2016	2017	2018	Totals
SERBYFR002	Byford	.	.	0	2	0	2
SERBYFR003	Byford	.	.	6	.	0	6
SERBYFR004*	Byford	.	.	88	32	9	129
SERDARR001*	Darling Downs	.	.	26	0	24	50
SERKEYR004	Keysbrook	.	.	.	14	26	40
SERKEYR005	Keysbrook	.	.	.	.	8	8
SERKEYR006	Keysbrook	.	.	.	6	3	9
SERMUNR002*	Mundijong	.	.	0	4	.	4
SEROAKR002*	Oakford	.	.	.	4	15	19
SERSERR003	Serpentine	0	0	3	0	9	12
SERSERR005	Serpentine	.	.	12	0	4	16
SOUSALR001*	Salter Point	2	0	0	0	8	10
STIBALR001	Ballajura	.	.	.	.	10	10
STIMENR002	Menora	0	.	0	5	0	5
STIYOKR002	Yokine	0	1	0	.	83	84
STIYOKR003	Yokine	47	28	0	239	276	590
SWABALR003	Ballajura	.	.	0	120	151	271
SWABULR005	Bullsbrook	.	.	.	.	41	41
SWAMELR001*	Melaleuca	0	0	.	129	0	129
SWAVINR002	The Vines	.	.	.	.	6	6
SWAVINR003*	The Vines	.	.	31	5	0	36
SWAWESR001	West Swan	.	.	.	.	36	36
SWAWHIR001*	Whiteman	.	0	0	4	0	4
VICKENR001	Kensington	94	121	0	116	108	439
VICKENR002	Kensington	.	35	42	0	.	77
VICLATR001	Lathlain	0	0	0	0	15	15
VICWATR002	Waterford	.	.	0	45	85	130
WANGNAR005*	Gnangara	0	0	0	7	.	7
WANGNAR006*	Gnangara	3	.	0	4	0	7
WANJANR008	Jandabup	.	.	.	102	156	258
WANMARR002*	Maraginiup	.	.	.	.	11	11
WANNOWR005*	Nowergup	.	.	0	0	2	2
WARLAKR002	Lake Clifton	.	.	.	4	.	4
WARLAKR003	Lake Clifton	.	.	.	6	26	32
WARWARR002*	Warooka	10	0	0	0	20	30



Appendix Vb: Great Cocky Count (2014-2018) roost counts for FRTBC at **confirmed roosts** (see page vii) in the Northern Darling Scarp and Plateau. 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	Locality	2014	2015	2016	2017	2018	Totals
ARMASHR001	Ashendon	.	.	.	3	.	3
ARMBEDR001*	Bedfordale	21	0	0	0	0	21
ARMBEDR002*	Bedfordale	0	.	0	22	0	22
ARMBEDR003*	Bedfordale	0	0	0	0	3	3
ARMBEDR004	Bedfordale	.	.	18	6	0	24
ARMBEDR005*	Bedfordale	.	.	.	0	4	4
ARMBEDR006	Bedfordale	.	.	.	14	14	28
ARMROLR001*	Roleystone	0	0	0	9	0	9
ARMROLR003*	Roleystone	0	0	0	4	0	4
ARMROLR004*	Roleystone	0	.	35	0	0	35
ARMROLR005	Roleystone	.	.	0	36	40	76
BEVFLYR002*	Flynn	.	.	.	83	0	83
BODMARR001*	Marradong	.	.	16	0	0	16
BODMARR004	Marradong	.	.	.	18	0	18
BODMARR005	Marradong	.	.	.	.	2	2
CHICHIR001	Chittering	.	.	.	52	71	123
KALCARR001	Carmel	.	.	0	12	0	12
KALFORR002	Forrestfield	.	.	.	.	42	42
KALFORR003	Forrestfield	.	.	.	.	31	31
KALHIGR001	High Wycombe	.	.	.	7	78	85
KALHIGR003	High Wycombe	.	.	0	7	0	7
KALMAIR002	Maida Vale	25	.	56	98	137	316
KALMAIR005	Maida Vale	.	.	3	0	0	3
KALMAIR006	Maida Vale	.	.	.	3	.	3
KALPICR002*	Pickering Brook	42	.	0	7	.	49
KALPIER001*	Piesse Brook	0	0	25	.	29	54
KALPIER002*	Piesse Brook	.	.	.	2	8	10
KALWALR001*	Walliston	43	1	.	0	0	44
KALWATR002	Wattle Grove	.	.	150	31	150	331
MUNCHIR002	Chidlow	12	.	49	65	0	126
MUNCHIR003	Chidlow	.	.	4	4	0	8
MUNGLER004	Glen Forrest	.	.	33	4	41	78
MUNHEL001*	Helena Valley	0	0	4	31	0	35
MUNHEL002	Helena Valley	.	.	.	.	79	79
MUNHOVR001*	Hovea	.	14	52	21	78	165
MUNHOVR004	Hovea	.	.	.	3	.	3
MUNMTHR001*	Mt Helena	0	0	0	0	2	2
MUNMTHR003*	Mt Helena	.	.	41	0	2	43
MUNMUNR001*	Mundaring	0	0	0	0	8	8
MUNMUNR002	Mundaring	.	20	16	32	7	75



Site code	Locality	2014	2015	2016	2017	2018	Totals
MUNMUNR003*	Mundaring	.	.	59	0	0	59
MUNPARR003*	Parkerville	.	.	12	8	0	20
MUNPARR004*	Parkerville	.	.	0	4	0	4
MUNPARR005*	Parkerville	.	.	.	4	2	6
MUNSTOR001*	Stoneville	0	24	0	0	0	24
MUNSTOR003*	Stoneville	0	.	9	0	0	9
MUNSTOR004*	Stoneville	.	.	3	0	0	3
MUNSTOR005*	Stoneville	.	.	15	0	0	15
MUNWOOR001	Wooroloo	17	.	.	.	0	17
MURDWER002*	Dwellingup	3	.	.	0	60	63
MURNORR001*	North Dandalup	.	.	26	0	3	29
NORWUNR001*	Wundowie	.	6	0	8	.	14
SERJARR002	Jarrahdale	.	.	.	7	0	7
SERJARR003	Jarrahdale	.	.	30	59	0	89
SERKARR001	Karrakup	.	.	.	.	8	8
SERKEYR002*	Keysbrook	.	37	.	0	.	37
SWABULR002*	Bullsbrook	0	.	0	26	0	26
SWAGIDR001	Gidgegannup	.	.	3	0	0	3
SWAGIDR007*	Gidgegannup	.	.	86	44	12	142
SWAGIDR008*	Gidgegannup	.	.	25	21	27	73
SWAGIDR009*	Gidgegannup	.	.	15	0	0	15
TOOMORR001*	Morangup	0	5	0	0	0	5
TOOMORR002	Morangup	.	.	.	36	11	47
TOOMORR003*	Morangup	.	.	.	23	23	46
WARWAGR001*	Wagerup	38	.	.	.	.	38
WARWARR003*	Waroona	.	.	.	.	35	35
WILQUIR001	Quindanning	10	.	0	15	0	25
WNDSPRR001	Springs	.	.	74	7	16	97



Appendix Vc: Great Cocky Count (2014-2018) roost counts for FRTBC at confirmed roosts (see page iv) in regional areas. 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	Locality	2014	2015	2016	2017	2018	Totals
ALBKALR003	Kalgan	.	.	27	12	.	39
ALBMCKR001*	McKail	0	0	0	10	0	10
ALBMETR002	Mettler	.	.	.	7	.	7
ALBTORR003	Torbay	.	2	.	0	0	2
ALBTORR004	Coffey	.	5	.	.	.	5
AUGCHAR001	Chapman Hill	.	.	.	21	0	21
AUGCHAR002*	Chapman Hill	.	.	.	35	0	35
AUGCOWR004	Cowaramup	.	.	.	.	4	4
AUGFORR002*	Forest Grove	.	.	9	0	0	9
AUGMARR015	Margaret River	.	.	.	.	3	3
BINBINR002	Bindoon	.	.	.	15	0	15
BRIGRER002	Greenbushes	20	0	6	27	31	84
BRIGRER003*	Greenbushes	.	.	7	5	26	38
BRIGRER004	Greenbushes	.	.	7	0	2	9
BRINORR002*	North	.	.	1	0	0	1
BUSJINR002*	Jindong	2	.	0	0	.	2
BUSMETR002*	Metricup	.	.	.	.	27	27
BUSQUIR003	Quindalup	.	.	5	.	.	5
BUSQUIR004	Quindalup	.	.	.	.	9	9
CAPBOYR001	Gwindinup	.	15	10	0	17	42
CAPCAPR002*	Capel	.	.	.	.	8	8
CAPFERR001	Ferguson	.	.	.	2	.	2
CAPGELR002*	Gelorup	0	11	4	15	17	47
DARBURR001*	Burekup	.	.	.	2	0	2
DAREATR002	Eaton	.	.	.	0	22	22
DENHAYR001	Hay	.	.	.	.	8	8
DONBALR002*	Balingup	.	.	.	13	71	84
DONCOLR002*	Collie	.	.	.	.	27	27
DONDONR001*	Donnybrook	14	6	.	0	0	20
DONLOWR001	Lowden	.	.	3	7	0	10
DONMUMR002	Mumballup	.	.	7	.	.	7
DONMUNR001*	Mungilup	.	.	84	0	0	84
DONNOGR001*	Noggerup	.	.	49	0	21	70
DONRIVR001	Donnelly River	.	.	.	.	70	70
DONYABR001*	Yabberup	.	.	.	.	3	3
HARBRUR002	Brunswick	.	.	9	29	.	38
HARHARR001*	Harvey	6	.	11	.	0	17
HARLESR001*	Leschenault	.	.	23	7	5	35
HARLESR002	Leschenault	.	.	.	.	16	16
HARROER002	Roelands	3	.	29	0	24	56
HARROER003	Roelands	.	.	0	2	3	5
MNJMNJR001*	Manjimup	.	.	16	0	0	16
PLANARR001*	Narrikup	.	.	0	8	0	8
PLANARR002*	Narrikup	39	.	29	.	.	68
PLAPORR003*	Porongurup	.	.	.	2	0	2
WESDARR002	Darkan	.	.	.	.	5	5
WESMOOR001	Moodiarrup	.	.	.	.	4	4
WILQUIR002	Quindanning	.	.	38	0	14	52



Appendix Vd: Former white-tailed black-cockatoo roosts which are now solely FRTBC roosts. Definition of a roost where FRTBC have replaced white-tailed black-cockatoos: a roost which had >1 white-tailed Black-Cockatoo roosting in previous years, with solely FRTBC roosting in that year. White-tailed Black-Cockatoos not counted in subsequent years either.

Site	Region	Year replaced
KALWALR001	Northern Darling Scarp and Plateau	2014
GOSCNVR001	Perth Peel Coastal Plain	2014
ROCBALR003	Perth Peel Coastal Plain	2014
DONDONR001	Regional	2014
CANWILR001	Perth Peel Coastal Plain	2015
SERKEYR002	Perth Peel Coastal Plain	2015
MUNHOVR001	Northern Darling Scarp and Plateau	2015
NORWUNR001	Northern Darling Scarp and Plateau	2015
COCBANR002	Perth Peel Coastal Plain	2016
PLANARR002	Regional	2016
ARMBEDR002	Northern Darling Scarp and Plateau	2017
ARMROLR003	Northern Darling Scarp and Plateau	2017
KALPICR002	Northern Darling Scarp and Plateau	2017
SWABULR002	Northern Darling Scarp and Plateau	2017
GOSSOUR002	Perth Peel Coastal Plain	2017
SEROAKR002	Perth Peel Coastal Plain	2017
SWAVINR003	Perth Peel Coastal Plain	2017
MUNMTHR003	Northern Darling Scarp and Plateau	2018
SERBYFR004	Northern Darling Scarp and Plateau	2018
SERDARR001	Northern Darling Scarp and Plateau	2018
WANMARR002	Northern Darling Scarp and Plateau	2018
WANNOWR005	Northern Darling Scarp and Plateau	2018
DONNOGR001	Regional	2018



Appendix Ve: Comparison of average FRTBC GCC counts (April) 2014-2018 and October 14, 2018 FRTBC counts at 15 sites in the Greater Perth-Peel region. Sites with an asterisk are or have been recorded as having both White-tailed and FRTBC roosting.

Site	Locality	Average GCC count, April 2014-18	October 2018 count
BAYMORR001	Morley	93	0
CAMFLOR002	Floreat	195	0
COCBANR002*	Banjup	42	0
COCMUNR001	Munster	133	0
COCMUNR003	Munster	49	0
GOSKENR001	Kenwick	193	0
GOSSOUR002*	Southern River	81	0
KALMAIR002	Maida Vale	79	0
KALWATR002	Wattle Grove	110	0
MELMURR001*	Murdoch	201	4
MUNHOVR001*	Hovea	41	29
STIYOKR003	Yokine	118	0
SWABALR003	Ballajura	90	0
VICKENR001	Kensington	88	0
WANJANR008	Jandabup	129	10
Average all sites		109	4

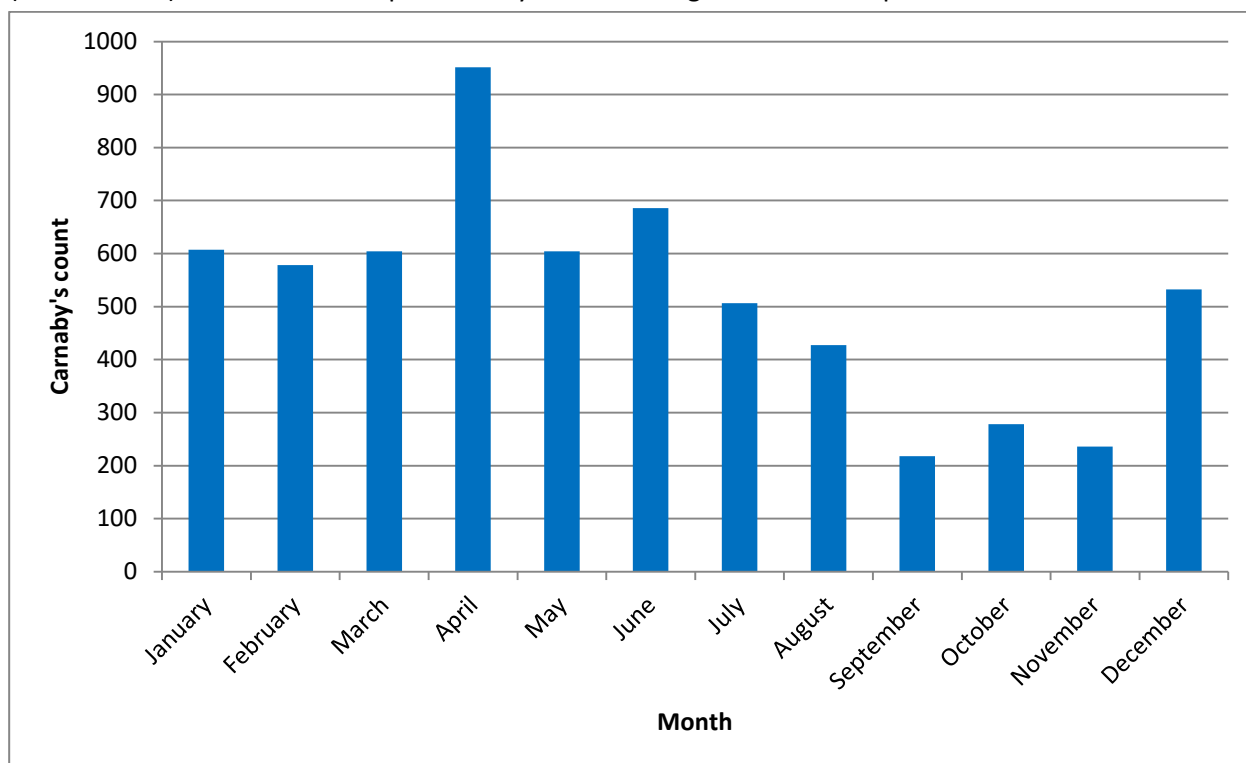


Appendix VI: Summary of 2018 GCC Survey Monkey results (291 respondents)

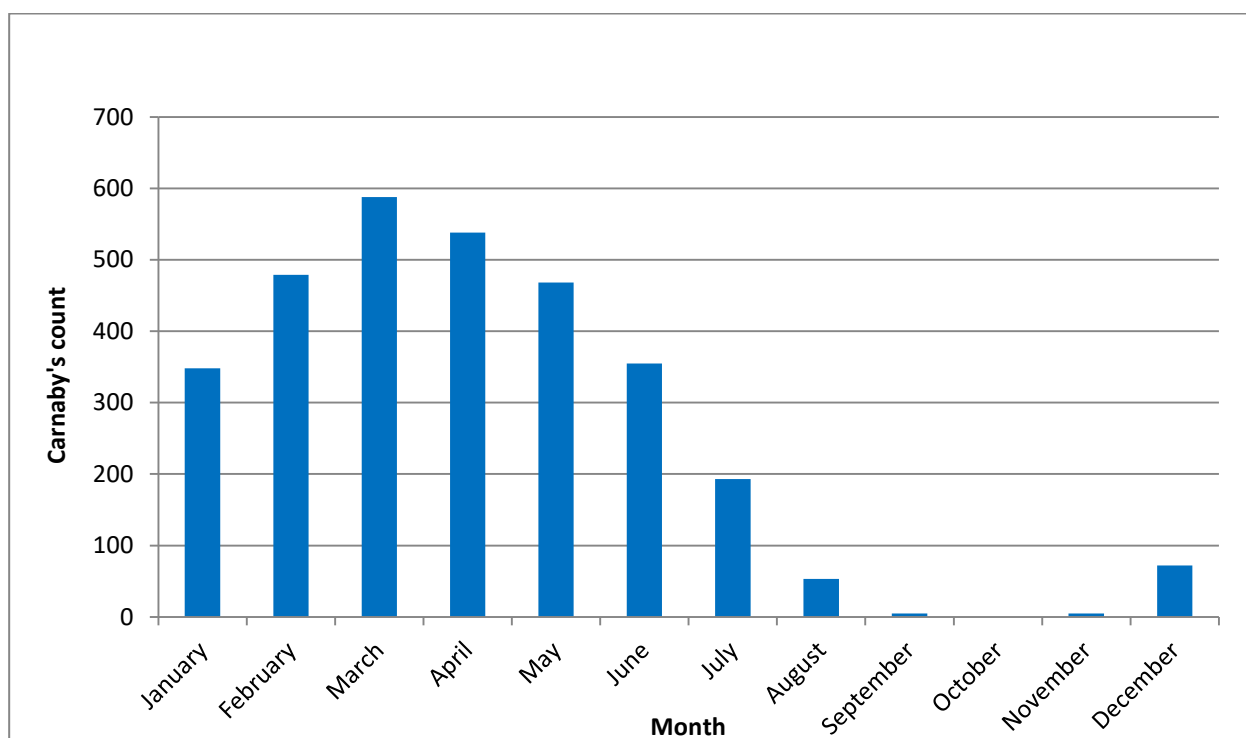
Was 2018 the first time you participated in the GCC?	Yes 41%	No 59%					
Did you attend a GCC workshop prior to the count?	Yes 23%	No 77%					
How would you rate your 2018 GCC experience?	Excellent 60%	Good 32%	Satisfactory 4%	Disappointing 2%	I did not participate in the end 2%		
Do you feel we communicated the information about your roost site and counting instructions clearly?	Yes 96%	No 4%					
Were you allocated a site with other volunteers?	Yes 56%	No 44%					
Did you bring along a friend or relative to help out?	Yes 47%	No 53%					
Are you a BirdLife member?	Yes 26%	No 74%					
Do you intend to participate in the GCC again?	Yes 99%	No 1%					
Age bracket	Under 20 0.5%	20-30 4.5%	30-40 11%	40-50 20%	50-60 24%	60-70 25%	Over 70 15%



Appendix VIIa: Average monthly counts of Carnaby's Black-Cockatoos at the Gingin roost (GIGGINR001) 2016-2017. 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: SAS code to analyse the Great Cocky Count results for Carnaby’s Black-Cockatoo 2010 – 2018.

```
/* Program to analyse the roost survey data from the annual Great Cocky Counts, 2010-2018 */
/* Matt Williams, Dept of Biodiversity, Conservation & Attractions */
/* August 2018 */
```

```
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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