The 2015 Great Cocky Count:

A community-based survey for
Carnaby's Black-Cockatoo
(*Calyptorhynchus latirostris*)
and
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(*Calyptorhynchus banksii naso*)

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The 2015 Great Cocky Count: A community-based survey for Carnaby's Black-Cockatoo (*Calyptorhynchus latirostris*) and Forest Red-tailed Black-Cockatoo (*Calyptorhynchus banksii naso*)

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Front cover photo: Carnaby's Black-Cockatoo flock © Keith Lightbody

Back cover photo: Carnaby's Black-Cockatoo flock © Keith Lightbody

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Summary

Background

- The Great Cocky Count (GCC) is an annual citizen science survey for two of the 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 count the numbers of black-cockatoos arriving at the site to roost for the night.
- The 2015 GCC occurred on Sunday 12 April 2015. This year's GCC was the 6th consecutive count and 7th overall.
- The 2015 GCC surveyed roost sites for Carnaby's Black-Cockatoo and Forest Red-tailed Black-Cockatoo (FRTBC). Both are endemic to southwestern WA and are listed as threatened under State and Commonwealth legislation.
- This report builds on the substantial contribution made by previous Great Cocky Count Reports to our knowledge of Black-cockatoos in the greater Perth Region. For ease of comparison with previous years' findings, this report uses similar structure and analysis to previous reports, in particular the 2014 Great Cocky Count Report (Finn *et al.* 2014).

Key Outcomes

- The Great Cocky Count is one of the largest citizen science surveys of its kind in Australia. Community interest was significant – this year over 600 registered volunteers surveyed 293 sites across the southwest of WA. Total volunteer participation likely exceeded 700 community members.
- The minimum population count for Carnaby's Black-Cockatoo in the Greater Perth-Peel Region was 5518. 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 3).
- Almost half of the Carnaby's Black-Cockatoos counted in the Greater Perth-Peel Region were associated with the Gnangara pine plantation north of Perth. The large number of Carnaby's Black-Cockatoos (2423) associated with the pine plantation is consistent with previous surveys. In previous years, the Gnangara pine plantation has supported 27- 59% of the Carnaby's Black-Cockatoos counted in the Perth-Peel Coastal Plain during the non-breeding season (November to June), emphasising the importance of pines as a food resource during this period.
- 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 flock size over the last six years (2010-2015). The combined effect of fewer occupied roosts and fewer birds in each roosting flock is an estimated current rate of decline of 15% per year in the total number of Carnaby's Black-Cockatoos on the Perth-Peel Coastal Plain. This trend estimate should be treated caution, however, given the snapshot sampling method and the need to consider the spatial relationships among roosts. Nonetheless, the apparent ongoing decline represented by the trend is of serious concern for Carnaby's Black-Cockatoo in the Perth-Peel Coastal Plain.

- On the Perth-Peel Coastal Plain, Carnaby's Black-Cockatoos are restricted to few roost sites, many of which are associated with pines. Protection of these sites and associated native feeding habitat is needed to arrest the decline of Carnaby's Black-Cockatoo and ensure its persistence in this region.
- The 2015 GCC confirmed the presence of FRTBC at various locations throughout the inner metropolitan suburbs of Perth.
- The Great Cocky Count is well-placed to continue accurate monitoring of Carnaby's Black-Cockatoo and FRTBC on the Perth-Peel Coastal Plain, and potentially across the range of both species, because of the due to continued growth in survey effort and the integration of statistically rigorous trend analyses.

Regional Results

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

- Volunteers surveyed 185 sites in the Perth-Peel Coastal Plain and counted 5298 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 (multiple sites) and at the Gingin townsite (784 birds), Yeal (750), Hamilton Hill (594 at two sites), Curtin University/Collier Park/Technology Park in Como (460), Dawesville (412 at two sites), Wellard (125), Hollywood Hospital in Nedlands (106), and Underwood Avenue in Floreat (86).
- The population of Carnaby's Black-Cockatoo inhabiting the Perth-Peel Coastal Plain is significant at a species-scale, with three of the five largest roosts and six of the ten largest roosts for the 2015 Great Cocky Count occurring within the Perth-Peel Coastal Plain.

Greater Perth-Peel Region: Carnaby's Black-Cockatoo

- Volunteers surveyed 43 sites in the Northern Darling Scarp and Plateau areas, which encompasses the northern Jarrah-Marri Forest between Bindoon and Waroona, and counted 550 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 40% (220) were estimated to be Carnaby's Black-Cockatoo.
- Significant white-tailed black-cockatoo counts occurred at two sites in the Shire of Swan (217 and 169 birds), and one site in the City of Armadale (60 birds).

Regional areas: white-tailed black-cockatoos

- Volunteers surveyed 65 sites in regional locations outside of the Greater Perth-Peel Region and recorded 3234 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 (156 birds at three sites in the Hill River/Jurien Bay/Dandaragan region, and 995 at Nilgen), in the Shire of Esperance (736 at three sites), the Shire of Harvey (594 at two sites), at Nanson (300), Quindalup (80), in the Shire of Capel (196 at two sites), and in the Shire of Albany (75 at two sites).

Forest Red-tailed Black-Cockatoo (FRTBC)

- Volunteers documented roosts for FRTBC throughout the Perth-Peel region, including sites in 13 metropolitan council areas.
- Significant FRTBC roosts occurred at Kensington (156 birds at two sites), Keysbrook (42), Dawesville (38), Murdoch University (33), and Yokine (28).

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 12 April 2015.

DPaW: Western Australian Department of Parks and Wildlife; formerly known as the Department of Environment and Conservation (DEC).

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, DPaW 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). For the 2015 GCC, additional surveys included any surveys completed before or after Sunday 12 April 2015.

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.

Corrected count: For the 2014 and 2015 GCCs, roost counts of white-tailed black-cockatoos within the Northern Darling Scarp and Plateau were reduced to 0.4 of the recorded count to derive a corrected count of the Carnaby's Black-Cockatoo population in the Greater Perth-Peel Region. This correction is based on field observations by Tony Kirkby (WA Museum) during April 2014 indicating flocks in the Mundaring/Kalamunda/Armadale region consisted of 40% Carnaby's Black-Cockatoos and 60% Baudin's Black-Cockatoos. In 2010-2013 GCCs, roost counts of white-tailed black-cockatoos were reduced by 0.2 based on field observations by Ron Johnstone and Tony Kirkby from the WA Museum.

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.

Great Cocky Count roost site database: A database of known or potential roost sites for black-cockatoos maintained jointly by BirdLife Australia and DPaW.

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*, or *potential site*.

Confirmed roost: Any site where black-cockatoos were recorded roosting as part of a *formal roost survey*.

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 *formal roost survey*.

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

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

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 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 DPaW Swan Region (a DPAW 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 DPaW Swan Coastal District (a DPAW 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 DPaW Perth Hills District (a DPAW 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 black-cockatoos during the non-breeding season (January – June) (Saunders 1974, 1980; Finn *et al.* 2009; Stock *et al.* 2013).

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

Contents

INTRODUCTION

Background

The Great Cocky Count (GCC) 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 12 April 2015.

The 2015 GCC is the sixth consecutive GCC and the seventh overall. BirdLife Australia coordinates the count each year with significant support from the Western Australian Department of Parks and Wildlife (DPaW). Funding for the 2015 GCC came from Perth Region NRM through the Australian Government's National Landcare Program with additional support from the Peel-Harvey Catchment Council (PHCC).

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.

Conservation Status of Carnaby's Black-Cockatoo and FRTBC

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

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

Committee has classified the Forest Red-tailed Black-Cockatoo as vulnerable, and Carnaby's Black-Cockatoo and Baudin's Black-Cockatoo as endangered.[2]

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:

- http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=59523 (Carnaby's Black-Cockatoo)
- http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=67034 (FRTBC)

Information on the ecology of black-cockatoos on the Swan Coastal Plain is available in Johnstone *et al.* (2010)[3] and Stock *et al.* (2013)[4].

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).

Methods for Surveying

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

Evolution of the GCC

While the principal aim of the GCC – to conduct a community-based survey of black-cockatoos in southwestern Australia using roosts counts – has remained, the broader objectives of the GCC have evolved over time. The 2006 and 2010 GCCs focused on Carnaby's Black-Cockatoo and on the Swan Coastal Plain and the adjacent Darling Plateau, with the surveyed roost sites occurring almost exclusively within the Greater Perth-Peel Region. In 2011, the GCC was broadened to include the whole of southwestern WA, with the expanded aim of gathering information about Carnaby's Black-Cockatoo across the species

[2] Baudin's Black-Cockatoo is a declared pest under s 22 of the Western Australia *Biosecurity and Agriculture Management Act 2007*. It appears in the Western Australia Organism List (WAOL): https://www.agric.wa.gov.au/organisms

[3] Available from: http://www.planningnrm.wa.gov.au/dop_pub_pdfmedia/41434/black_cockatoos_on_swan_coastal_plain.pdf

[4] Available from: http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0061145

range. In 2014, the GCC was further extended to include the identification and survey of roost sites for FRTBC, and this was continued in 2015. Future GCCs may be further extended, to identify and survey roost sites for Baudin's Black-Cockatoos within the Jarrah (Eucalyptus marginata)-Marri (Corymbia calophylla) and Karri (Eucalyptus diversicolor) Forests.

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). These reports are available on the Great Cocky Count webpage:

- http://www.birdlife.org.au/projects/carnabys-black-cockatoo-recovery/great-cocky-count

Contribution to Black-Cockatoo Conservation

Recovery plans exist to guide the conservation of Carnaby's Black-Cockatoo and FRTBC and can be accessed at these web pages[5]:

- http://www.environment.gov.au/resource/carnaby%E2%80%99s-cockatoo-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 Cockatoo (*Calyptorhynchus latirostris*) 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 Red-tailed Black-Cockatoo

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 2015 GCC were to:

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

[5] Webpages are current as at July 2015.

(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 Black-Cockatoo within the Perth-Peel Coastal Plain, across the six consecutive GCCs (2010-2015) ; and

(5) identify roost sites and conduct roost counts for the Forest Red-tailed Black-Cockatoo across the species range.

METHODS

Survey Timing and Area

Timing

This year's GCC occurred on Sunday 12 April 2015, 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.[6]

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 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*.[7] Threatening processes for black-cockatoos in the Greater Perth-Peel Region include habitat loss through land-clearing, collisions with cars, 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 2015 GCC, we distributed information about the 2015 GCC and invitations to participate to various community groups, NRM networks and their publications, to the Community Newspaper Group newspapers, and to a BirdLife Australia contact list. All of the 2014 GCC volunteers were also invited to participate. We updated the GCC webpage

[6] A map of the IBRA bioregions is available at: http://www.environment.gov.au/topics/land/national-reserve-system/science-maps-and-data/australias-bioregions-ibra

[7] 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

on BirdLife Australia's website[8], which provides information about the GCC, including forms, protocols, and previous reports. We also promoted the 2015 GCC on BirdLife Australia's social media sites, including Twitter and Facebook.

To train volunteers to do surveys, we conducted several workshops at various locations within the greater Perth-Peel metropolitan area. The workshops provided information about the GCC, including the general ecology of black-cockatoos, information about their occurrence in the local area, and guidelines for identifying and counting black-cockatoos at roost sites.

Volunteers that registered to undertake a survey for the 2015 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). These forms and supporting material were also made available on the GCC webpage.[9]

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).

Roost Site Identification

Information about the 2015 GCC also included a request to report roost sites for black-cockatoos. Sites reported to BirdLife Australia prior to the 2015 GCC, which came from community members, DPaW staff members, and other sources, were collated into a database. Sites in this database were assigned to one of three categories (confirmed roost, unconfirmed roost, or potential site) based on any prior roost count records for the site (see Key Terms and Abbreviations). For the 2015 GCC, we prioritised the allocation of observers to confirmed roosts, and then to unconfirmed roosts; potential sites received the lowest priority. Not all of the sites in the database were assigned for survey.

Roost Count Methodology

The 2015 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). Roost count instructions were included on the roost count survey form and in the other written materials provided to each volunteer.

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 12 April 2015; (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

[8] http://www.birdlife.org.au/carnabys/great-cocky-count

[9] http://www.birdlife.org.au/carnabys/great-cocky-count

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 Black-Cockatoo and Carnaby's Black-Cockatoo overlap in portions of the southwest, particularly in forested areas. Distinguishing between Carnaby's Black-Cockatoo 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. At a few of the northern sites, volunteers may have observed the Inland Red-tailed Black-Cockatoos (*Calyptorhynchus banksii samueli*). The Inland Red-tailed Black-Cockatoos, a separate subspecies to the FRTBC, occur in the northwestern Wheatbelt and Pilbara.

Data Analysis

Organisation of roost count data

We used the roost survey results from each site to calculate 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 red-tailed black-cockatoos counted. We combined these counts because the distributions of Carnaby's Black-Cockatoo and FRTBC overlap with the distributions of Baudin's Black-Cockatoos and Inland Red-tailed Black-Cockatoos (respectively) in these areas, and the difficultly in distinguishing between the two white-tailed black-cockatoo species and between the two red-tailed subspecies. 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 Black-Cockatoos 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 2015.

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). In April 2014, Tony Kirkby (WA Museum) conducted field surveys of black-cockatoos at roosts in Kalamunda, Armadale and Mundaring, and estimated that flocks of white-tailed black-cockatoos consisted of 40% Carnaby's and 60% Baudin's Black-Cockatoos. As for the previous GCCs, we assumed that the species proportions observed for sites in these locations would apply generally to all sites in the Northern Darling Scarp and Plateau, and applied this same ratio to the 2015 analysis. We therefore multiplied the total white-tailed black-cockatoo count by 0.4 to derive a 'corrected' count of the numbers of Carnaby's Black-Cockatoo for the Northern Darling Scarp and Plateau area. . The estimated species proportions for the 2014 and 2015 GCCs differed slightly from those for the 2010-2013 GCCs, in which white-tailed flocks in the Northern Darling Scarp and Plateau were estimated (based on field observations) to comprise 20% Carnaby's Black-Cockatoo and 80% Baudin's Black-Cockatoos.

Trend analysis for Perth-Peel Coastal Plain

A key aim for the Great Cocky Count is to assess population trends for Carnaby's Black-Cockatoo in the Perth-Peel Coastal Plain, which encompasses nearly all of the greater Perth-Peel metropolitan area. The fact that many surveys recorded counts of zero birds and the many instances where surveys of known roosts were not conducted, however, presented certain challenges for statistical analysis.

Counts of zero at a surveyed site may reflect normal, expected variation in the use of roost sites (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 problems with the study design (birds do not roost at the site because it is unsuitable). Zero counts, particularly those of the last kind, are problematic because they affect estimates of average roost size and therefore any trends (Zuur *et al.* 2009), and may create 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. 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 a trend estimate and total counts that are comparable between years. Using only the 'raw' total counts, which do not account for any excess zeros or missing surveys, and which reflect only those sites where surveys were done, will 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. This model uses a zero-inflated, negative binomial distribution to account for the excess zeroes, and for the likely over-dispersion in the counts due to the many unexplained sources of variation, such as differences between observers

(Link and Sauer 1997; Dobbie and Welsh 2001; Sauer *et al.* 2004). The model for the occupied roosts assumed a negative binomial distribution for the count data (with the mean being determined by an annual trend in average roost size), and fitted individual site effects to allow for any correlation in the repeated surveys at each site. A negative binomial distribution was appropriate, because it allows for the potentially excess variation that may arise through any unmodeled sources of variation in the roost counts. We treated the site effects as fixed, rather than random, because the GCC surveys sample a large proportion of the population of Carnaby's Black-Cockatoo in the Perth-Peel Coastal Plain and were restricted to a relatively small set of sites. This statistical approach models variation in counts more realistically than simple linear regression models of counts or log-transformed counts (Cunningham and Lindenmayer 2005). 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). Thus, the roost count data were modelled in two stages. First, we used a logistic regression model to estimate the fraction of roost sites occupied each year and any trend in roost occupancy rate. Then we used a log-linear regression model to estimate the average number of birds in each occupied roost each year and any trend in average roost size.

This analysis of the population trend in Carnaby's Black-Cockatoo in the Perth-Peel Coastal Plain is the subject of a separate scientific paper that has recently been published in the international journal of conservation, Oryx.[10]

We also assessed trends separately for roost sites within or associated with the Gnangara pine plantation (see Key Terms and Abbreviations) and 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) the plantation system, or have been documented as roost sites for Carnaby's Black-Cockatoo feeding in the Gnangara pine plantation (Shah 2006; Saunders 1980, Finn *et al.* 2009, Stock *et al.* 2013).

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 formal roost surveys conducted in 2015 and from all sites, on the basis that flocks observed anywhere in the southwest between January and 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

[10] 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.

independence was used to test whether the proportions of triplets to pairs differed across the years 2010–2015.

Statistical analysis

We used Microsoft Office Excel 2007 and SPSS Statistics Version 22 for basic statistical analyses. The trend analyses were performed using the generalised linear model procedure (GENMOD) of the SAS software (SAS Institute Inc., 2011).

RESULTS

A. Community Engagement and Training

Workshops

About 450 people attended the 15 Great Cocky Count workshops conducted in February – April 2015. Workshops were held at locations throughout the Perth-Peel region, including one each at Wanneroo, Mundijong, Wellard, Subiaco, North Beach, Harvey, North Dandalup, Kalamunda, Mt Barker, Winthrop, Canning, Mandurah, and Esperance, and two at Murdoch University.

Supporters for the workshops included the Canning River Eco Education Centre, City of Kwinana, City of Mandurah, City of Melville, City of Stirling, City of Subiaco, City of Wanneroo, Harvey River Restoration Taskforce, Harvey Senior High School, Landcare Serpentine-Jarrahdale, Murdoch University, North Woodvale Primary School, Oyster Harbour Catchment Group Inc. (Claire Bartron), Peel-Harvey Catchment Council, Perth Region NRM, Piney Lakes Environmental Education Centre, Shire of Kalamunda, Shire of Murray, and South West Catchments Council.

Volunteer participation

We assigned 301 survey sites to the 606 registered volunteers (Table 1). Roost counts were conducted at 293 (97%) of these sites, the highest completion rate to date. This compares well with previous completion rates for the 2013 (92%), 2014 (90%), and 2012 (84%) GCCs, and is much higher than for the 2011 GCC (67%).

Of the volunteers that registered in 2015, 447 (74%) were new to the GCC and 159 (26%) had registered previously. Since 2010, more than 1700 people have participated in at least one GCC as a registered volunteer.

Actual volunteer participation for the 2015 GCC likely exceeded 700 community members, as registered volunteers often received support from non-registered volunteers (e.g. family and friends). In addition, Murdoch University, North Woodvale Primary School and Aquinas College coordinated roost counts at the Murdoch University Campus, Warwick Park and Salter Point, respectively, using volunteers, staff and students from those organisations. About 150 volunteers participated in total in these three surveys.

Many sites were surveyed using teams of volunteers. The largest multi-observer roost count was at Murdoch University, where more than 55 volunteers (including Murdoch students and staff and local residents) worked together to conduct a comprehensive survey of the University's 227 ha South Street campus.

Table 1: Volunteer participation and survey effort for six Great Cocky Counts (2010-2015). 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
Registered volunteers	250	263	294	335	592	606
Sites assigned for survey	unknown	248	244	262	322	301
Sites surveyed	187	165	205	241	290	293
In Greater Perth-Peel Region	183 (98%)	150 (91%)	157 (77%)	186 (77%)	230 (79%)	228 (78%)
(i) Perth-Peel Coastal Plain	157 (84%)	124 (75%)	127 (62%)	144 (60%)	186 (64%)	185 (63%)
(ii) N. Darling Scarp/Plateau	26 (14%)	26 (16%)	30 (15%)	42 (17%)	44 (15%)	43 (15%)
– In Regional areas	4 (2%)	15 (9%)	48 (23%)	55 (23%)	60 (21%)	65 (22%)

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

Thirty-three new sites were identified as potential roosts and added to the GCC roost site database prior to the 2015 GCC (i.e. between April 2014 and March 2015; Table 2). Following the GCC, black-cockatoos were recorded roosting at 16 of these (nine with white-tailed and seven with red-tailed cockatoos), and so were reclassified as 'unconfirmed roosts' pending identification of the species of black-cockatoo present. One site was reclassified as a 'confirmed roost' (Carnaby's black-cockatoos roosting). One site (MUNCHIR001) was cleared prior to the 2015 GCC, increasing to 12 the number of roosts sites known to have been cleared since 2006 (Table 2). Black-cockatoos were not recorded roosting at the remaining 16 sites, and so each remains as a 'potential site'.

Table 2: Number of Carnaby's Black-Cockatoo confirmed roosts, unconfirmed roosts, potential sites, and cleared sites in the GCC site database for the six Great Cocky Counts (2010-2015). **Cleared roosts** are confirmed roosts that have been cleared of vegetation since 2010.

	2010	2011	2012	2013	2014	2015
No. of confirmed roosts	Not defined	101	136	174	211	211
No. of unconfirmed roosts	Not defined	40	61	98	96	112
No. of potential sites	Not defined	156	153	169	198	214
No. of cleared roosts	Not defined	3	9	11	11	12
Total no. of sites	**222**	**300**	**359**	**452**	**516**	**549**

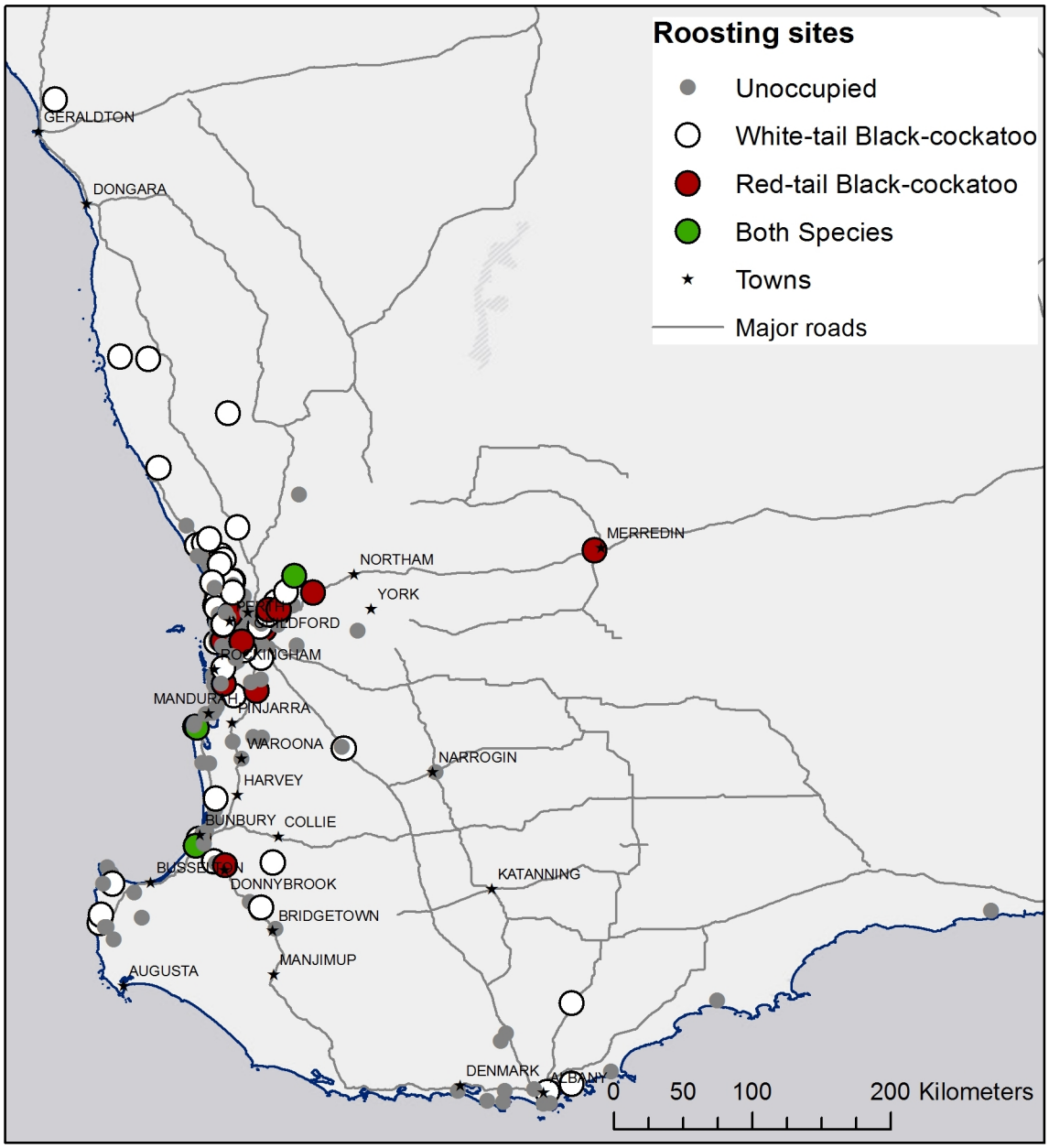

Figure 1: The locations of the 239 sites where surveys were conducted for the 2015 Great Cocky Count. Sites are classified as either unoccupied (no black-cockatoos roosting), White-tailed Black-Cockatoo roost sites, Red-tailed Black-Cockatoo roost sites, or sites where both species roost. Figure Credit: Tegan Douglas.

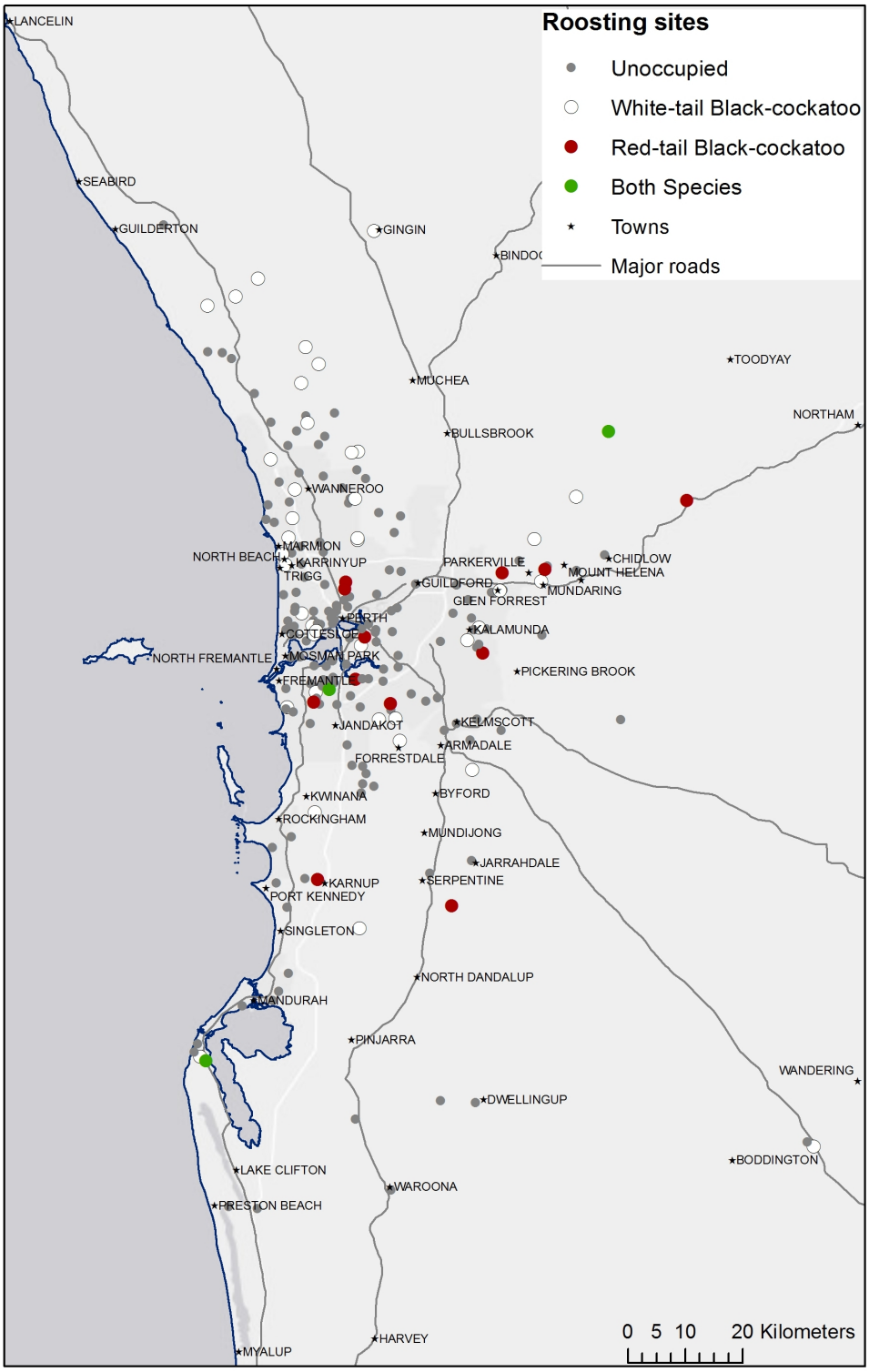

Figure 2: The locations of the 228 sites in the Greater Perth-Peel Region where roost counts were conducted for the 2015 Great Cocky Count. Roosting sites are classified as either unoccupied (no black-cockatoos roosting), White-tailed Black-Cockatoo roost sites, Red-tailed Black-Cockatoo roost sites, or sites where both species roost. 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 228 sites in the Greater Perth-Peel Region. Roost counts occurred in 34 local government areas (LGA), with occupied roosts recorded in 17 (50%) of these (Appendix II). Survey effort was greatest in the Cities of Wanneroo and Stirling, each with 26 sites surveyed. Of these, nine occupied roosts were recorded in the City of Wanneroo and two in the City of Stirling.

Regional areas

Volunteers surveyed 65 sites in Regional areas (Table 1). Roost counts occurred in 19 LGAs, with occupied (Carnaby's Black-Cockatoo) roosts recorded in 13 (68%) of these (Appendix II). The greatest survey effort in Regional areas occurred in the Shire of Albany, with 12 sites surveyed and 2 occupied roosts recorded.

Across GCCs (2010-2015)

The number of sites surveyed has increased each year since 2011, both in the Greater Perth-Peel Region and in Regional areas (Table 1), although most have been in the Perth-Peel metropolitan area. In the last three GCCs (2012–2014), for example, 60-64% of surveyed sites were located in the Perth-Peel Coastal Plain and just under 80% were in the Greater Perth-Peel Region.

Total counts

Greater Perth-Peel Region

The 2015 GCC revealed a decline in the number of Carnaby's Black-Cockatoo counted since the 2014 GCC for the Greater Perth-Peel Region (5518 birds). Likewise, the Perth-Peel Coastal Plain recorded the lowest number of birds (5298) for the last three GCCs (2013-2015), and the Northern Darling Scarp and Plateau recorded a decline from the 2014 GCC (220 birds) (Table 3).

Regional areas

The 2015 GCC also revealed the lowest number of white-tailed black-cockatoos counted over the last four GCCs (2012-2015) for sites outside in Regional areas (3234 birds) and the lowest total number across the species range (9082 birds) in the last three GCCs (2013-2015) (Table 3).

Roost counts – across species range

At occupied roosts, counts for white-tailed black-cockatoos in the 2015 GCC ranged from 1 to 995, with a mean of 135.6 $\pm$ 18.3 (standard error) and a median of 35 (67 roost counts). Roost count sizes did not vary significantly across the three principal survey areas (Perth-Peel Coastal Plain, Northern Darling Scarp and Plateau, and outside the Greater Perth-Peel Region).

Across the species range, the five largest roost counts (995, 784, 750, 616, and 570 birds) accounted for 41% (3715) of the total number of white-tailed black-cockatoos counted

(Appendices III and IV). The ten largest roost counts (995, 784, 750, 616, 570, 560, 460, 360, 331, and 316 birds) accounted for 63% (5742) of the total number of white-tailed black-cockatoos counted. Three of the five largest roost counts and six of the ten largest roost counts 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 784, 750, 616, 560, and 460 birds) accounted for 60% (3170 of 5298) of the Carnaby's Black-Cockatoo counted (Appendix IIIa). Three of these were within the Gnangara pine plantation north of Perth (Appendix IIIb).The roost occupancy rate was 40% for the Perth-Peel Coastal Plain (36 occupied roosts of 89 surveyed sites that had at least one positive count for any GCC between 2010-2015) (Table 4).There was no correlation between the total number of white-tailed black-cockatoos counted and either the overall number of sites surveyed in the Northern Darling Scarp and Plateau ($r = 0.774$, 6 d.f., $p = 0.071$) or of sites that had a positive count in a GCC (2010-2015) ($r = 0.551$, 6 d.f., $p = 0.257$).

Gnangara pine plantation

Volunteers recorded 2423 birds at 10 occupied roosts located within or immediately adjacent to (i.e. < 1 km from the boundary of) the Gnangara pine plantation, and at two roosts in the Yanchep National Park that have, 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).

In the 2015 GCC, birds roosting at sites within or associated with the Gnangara pine plantation accounted for 46% (2423 of 5298) of the Carnaby's Black-Cockatoo counted in the Perth-Peel Coastal Plain. In previous GCCs (2010-2014), birds roosting in the Gnangara pine plantation have accounted for 27% to 59% of the Carnaby's Black-Cockatoo counted in the Perth-Peel Coastal Plain, with total counts ranging from 1063 to 3922 birds.

Other significant roosts

Significant counts were recorded at Gingin (784 birds), Yeal (750 birds), Hamilton Hill (594 at two sites), Curtin University/Collier Park/Technology Park in South Perth (460), Dawesville (412 at two sites), Wellard (125), Hollywood Hospital in Nedlands (106), and Underwood Avenue in Floreat (86).

Roost counts – Northern Darling Scarp and Plateau

Within the Northern Darling Scarp and Plateau, the three largest roost counts accounted for 81% (446 of 550) of the white-tailed black-cockatoos counted. These counts were recorded at two sites in the Shire of Swan (217 and 169 birds), and one in the City of Armadale (60 birds) (Appendix IIIc).

There was no correlation between the total number of white-tailed black-cockatoos counted and either the overall number of sites surveyed in the Northern Darling Scarp and Plateau ($r = 0.208$, 6 d.f., $p = 0.693$) or the number of sites that had a positive count in a GCC (2010-2015) ($r = 0.465$, 6 d.f., $p = 0.355$).

White-tailed black-cockatoos were recorded at only two sites in the Shire of Mundaring (13 sites surveyed and 61 birds), and one in the Shire of Kalamunda (13 sites surveyed and 20

birds) and the City of Armadale (5 sites surveyed and 60 birds) (Appendix IIIc). Roosts were also recorded at sites in Toodyay (12 birds) and Boddington (3 birds). No sites were surveyed along the eastern margin of the Northern Darling Scarp and Plateau.

Roost counts – Regional areas

In Regional areas, the five largest roost counts (995, 570, 360, 316, 300 birds) accounted for 79% (2541 of 3234) of the white-tailed black-cockatoos counted (Appendix IV). These sites were located at Nilgen, Myalup, Esperance (two sites), and Nanson.

Areas with significant counts were recorded in the northern Swan Coastal Plain (156 at three sites in the Hill River/Jurien Bay/Dandaragan region; and 995 at Nilgen), the Shire of Esperance (736 at three sites), the Shire of Harvey (594 at two sites), at Nanson (300) and Quindalup (80), in the Shire of Capel (196 at two sites), and in the Shire of Albany (75 at two sites). White-tailed black-cockatoos were also recorded near Bridgetown (44 at one site), in the Stirling Range National Park (25 at one site), and at Gracetown (16 at two sites), Bunbury (7), and Mumballup (7). (Appendix IV).

Breeding success

The proportion of white-tailed black-cockatoos flying into roosts as pairs or as triplets (of the 43 sites with group counts reported) was similar to the proportions recorded in previous GCCs (2010-2013) (Table 5) and did not differ significantly across years (chi-square = 9.076, 5 d.f., p = 0.106).

Table 3: Roost count summary for Carnaby's Black-Cockatoo across six Great Cocky Counts (2010-2015). The counts for the **Perth-Peel Coastal Plain** are assumed to include only Carnaby's Black-Cockatoo, whereas the counts for the **Northern Darling Scarp and Plateau** are corrected to account for the mixed flocks of Baudin's and Carnaby's Black-Cockatoos. The counts for the **Greater Perth-Peel Region** are the combined counts for Carnaby's Black-Cockatoo from the two areas. The counts for Regional areas and **across the species range** are the totals for white-tailed black-cockatoos and not corrected for the presence of both white-tailed cockatoo species. The number of roosts is the number of **occupied roosts** (i.e. roosts where at least one white-tailed black-cockatoo roosted).

WT = white-tailed black-cockatoo (Baudin's Black-Cockatoo and Carnaby's Black-Cockatoo)

* assumes 20% of the total number of white-tailed black-cockatoos counted are Carnaby's Black-Cockatoo

assumes 40% of the total number of white-tailed black-cockatoos counted are Carnaby's Black-Cockatoo

** represents a total count for white-tailed black-cockatoos

	2010	2011	2012	2013	2014	2015
Greater Perth-Peel Region						
No. of Carnaby's Black-Cockatoo counted in **Perth-Peel Coastal Plain**	6330 (35 roosts)	3912 (37 roosts)	3871 (26 roosts)	5555 (34 roosts)	6671 (38 roosts)	5298 (37 roosts)
No. of Carnaby's Black-Cockatoo counted in **Northern Darling Scarp and Plateau** (corrected)	386* (total WT count = 1929; 15 roosts)	79* (total WT count = 393; 13 roosts)	165* (total WT count = 826; 15 roosts)	163* (total WT count = 816; 14 roosts)	483# (total WT count = 1207; 12 roosts)	220# (total WT count = 550; 9 roosts)
No. of Carnaby's Black-Cockatoo counted in **Greater Perth-Peel Region**	6716 (50 roosts)	3991 (50 roosts)	4036 (41 roosts)	5718 (48 roosts)	7154 (50 roosts)	5518 (46 roosts)
Regional areas						
No. of white-tailed black-cockatoos counted **in Regional areas****	246 (2 roosts)	610 (9 roosts)	3329 (23 roosts)	3980 (27 roosts)	4227 (30 roosts)	3234 (21 roosts)
Across Species Range						
No. of white-tailed black-cockatoos counted **across species range****	8505 (52 roosts)	4915 (59 roosts)	8026 (64 roosts)	10351 (75 roosts)	12105 (80 roosts)	9082 (67 roosts)

Table 4: 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, for each of the six Great Cocky Counts 2010 – 2014.

Sites with a positive count in a GCC had ≥1 white-tailed black-cockatoo roosting in at least one GCC (2010-2015). **Percentage (%) of all sites with a positive count in a GCC** is the percentage of the total number of sites with a positive count in a GCC (2010-2015) that were surveyed during the GCC that year. **New roosts discovered** are sites that were surveyed and had white-tailed black-cockatoos present, either in the first year or in a subsequent GCC survey. **Occupied roosts** are sites at which at least one white-tailed black-cockatoo was recorded roosting. **Percentage (%) of all sites surveyed** is the percentage of 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 (2010-2015).

	2010	2011	2012	2013	2014	2015	Total
No. of sites surveyed, of those that have had a positive count in a GCC							
Perth-Peel Coastal Plain	58	57	59	70	79	89	99
Northern Darling Scarp and Plateau	18	18	21	28	28	38	39
% of sites surveyed, of those that have had a positive count in a GCC							
Perth-Peel Coastal Plain (99 sites)	59%	58%	60%	71%	80%	90%	-
Northern Darling Scarp and Plateau (39 sites)	46%	46%	54%	72%	72%	97%	-
No. of new roost sites discovered							
Perth-Peel Coastal Plain	60 (61%)	12 (12%)	10 (10%)	6 (6%)	6 (6%)	5 (5%)	-
Northern Darling Scarp and Plateau	18 (46%)	7 (18%)	5 (13%)	4 (10%)	4 (10%)	1 (3%)	-
No. of occupied roosts (% of all sites surveyed)							
Perth-Peel Coastal Plain	35 (22%)	37 (30%)	26 (20%)	34 (24%)	38 (20%)	36 (19%)	-
Northern Darling Scarp and Plateau	15 (58%)	13 (50%)	15 (50%)	14 (33%)	12 (27%)	9 (21%)	-
Roost occupancy rate							
Perth-Peel Coastal Plain	60%	65%	44%	49%	48%	40%	-
Northern Darling Scarp and Plateau	83%	72%	71%	50%	43%	24%	-

Table 5: The number of white-tailed black-cockatoos arriving at roosts in pairs or triplets, for the six GCCs 2010– 2015, with percentages in parentheses. Totals are drawn from all formal roost surveys conducted in each year at sites across the southwest of Western Australia. The totals are not corrected for proportions of Baudin's Black-Cockatoos and Carnaby's Black-Cockatoo.

Year	Pairs	Triplets
2010	329 (64%)	186 (36%)
2011	175 (60%)	118 (40%)
2012	319 (61%)	203 (39%)
2013	249 (61%)	157 (39%)
2014	246 (59%)	174 (41%)
2015	213 (57%)	158 (43%)

D. Carnaby's Black-Cockatoo: Trend Analysis for the Perth-Peel Coastal Plain (2010-2015)

General survey trends

The number of sites surveyed in the Perth-Peel Coastal Plain varied from 124 to 186 across the six GCCs (2010-2015) (Table 1). The number of occupied roosts varied between 26 and 38, with occupied roosts representing 20-30% of the total number of sites surveyed each year (Table 4). The discovery rate for new roosts has declined, with most (59%) roosts discovered in 2010 and relatively few new roosts discovered from 2013 to 2015 (17 in total).

Positive counts (i.e. $\geq$ 1 Carnaby's Black-Cockatoo roosting in at least one GCC) have been recorded from 99 sites (Table 4). Between 2010 and 2012, volunteers surveyed 58 – 60% of these sites, in 2013 and 2014, 71% and 80%, and in 2015, 90% of these sites.

Four occupied roosts (ROCBALR001, COCSCCR001, COCSCCR002, and MUNCHIR001) were cleared prior to the 2011 GCC, two (at Success) were cleared prior to the 2012 GCC, and one (Mundaring) was cleared before the 2015 GCC (Appendix IIIa).

Largest roosts

Within the Perth-Peel Coastal Plain, the ten largest roosts (based on combined counts across years) accounted for over half (59.1%, or 17914 of 30311) of the Carnaby's Black-Cockatoos counted in the 2010-2015 GCCs (Appendix IIIa). Five of these are within the Gnangara pine plantation (WANPINR001, GINYEAR001, SWAMELR001, WANMARR003, and WANPINR001) and the other five are at Gingin (GINGINR001), Curtin University/Collier Park/Technology Park in South Perth (SOUCOMR001), Murdoch University (MELMURR001), Underwood Avenue in Floreat (CAMFLOR001), and Dawesville (MANDAWR001).

The next ten largest roosts accounted for a further 22.4% (6795 of 30311) of the Carnaby's Black-Cockatoo counted in the six GCCs. Six of these are within or associated with the

Gnangara pine plantation (WANTWOR001, WANYANR006, WANPINR002, WANNEER002, WANYANR003, and WANYANR001) and the other four are at Manning Lake in Spearwood (COCHAMR001), Hollywood Hospital in Nedlands (NEDNEDR001), Star Swamp in North Beach (STINORR001), and Winthrop Park in Melville (MELWINR003).

Overall, the 40 largest roosts accounted for 95% (28787 of 30311) of the Carnaby's Black-Cockatoo counted in the Perth-Peel Coastal Plain across the six GCCs.

Occupancy rate

The fraction of occupied roosts within the Perth-Peel Coastal Plain is estimated to be declining at a rate of approximately 9% per year (Figure 3). This decline is statistically significant (p=.009), and equates to the loss of about 8 roosts per year of the average 89 surveyed roosts. The trends for both pine-associated and non-pine-associated roosts 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 at approximately 12% per year. This decline is statistically significant (p=.009), and equates to the loss of about 5 birds per year from the overall median of around 40 birds at each roost. The trends for pine-associated and non-pine-associated roosts are not significantly different; both are declining.

Total population size

Combining the estimated declines in average roost size (12%) and roost occupancy rate (9%), the current (2015) rate of decline in the total number of birds is thus 20% per year (100% – (100 – 12)% x (100 – 9)%).

As indicated above, a relatively small number of roost sites account for the bulk of birds recorded within the Perth-Peel Coastal Plain region. Analysis of the trends in subsets of the largest 10, 20 and 30 roosts, which show less variation in occupancy rates, resulted in estimated rates of decline of 7%, 8% and 13%, respectively. Thus, the low occupancy rate of small roosts may be inflating the estimated rate of decline, and the true rate may be less than that resulting from analysis of the entire dataset. While closer examination of the roost count data should provide a more accurate estimate of the trend (Williams et al. 2015), the current rate of decline can be confidently estimated to be around 10% – 20% per year, i.e. an average of 15% per year, consistent with previous years (e.g. Finn *et al*. 2014).

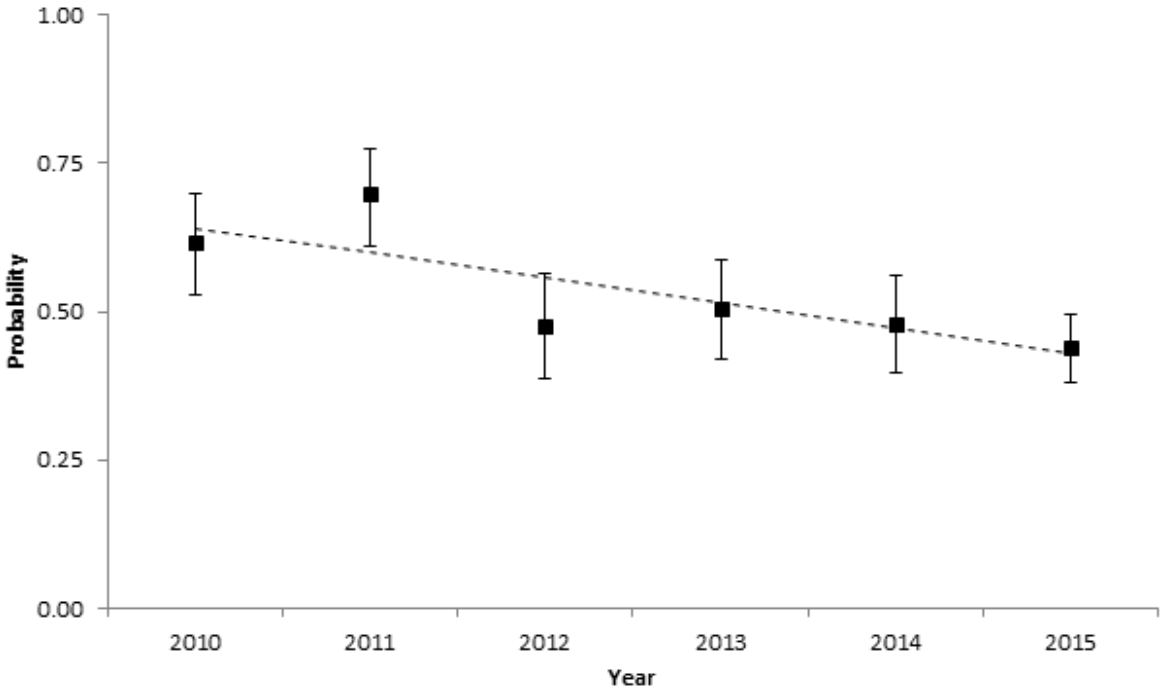

Figure 3: Roost occupancy rate (filled symbols with standard error) for Carnaby's Black-Cockatoo in the Perth-Peel Coastal Plain for six Great Cocky Counts (2010 – 2015) and trend (dashed line), estimated using a log-linear zero-inflated regression model .

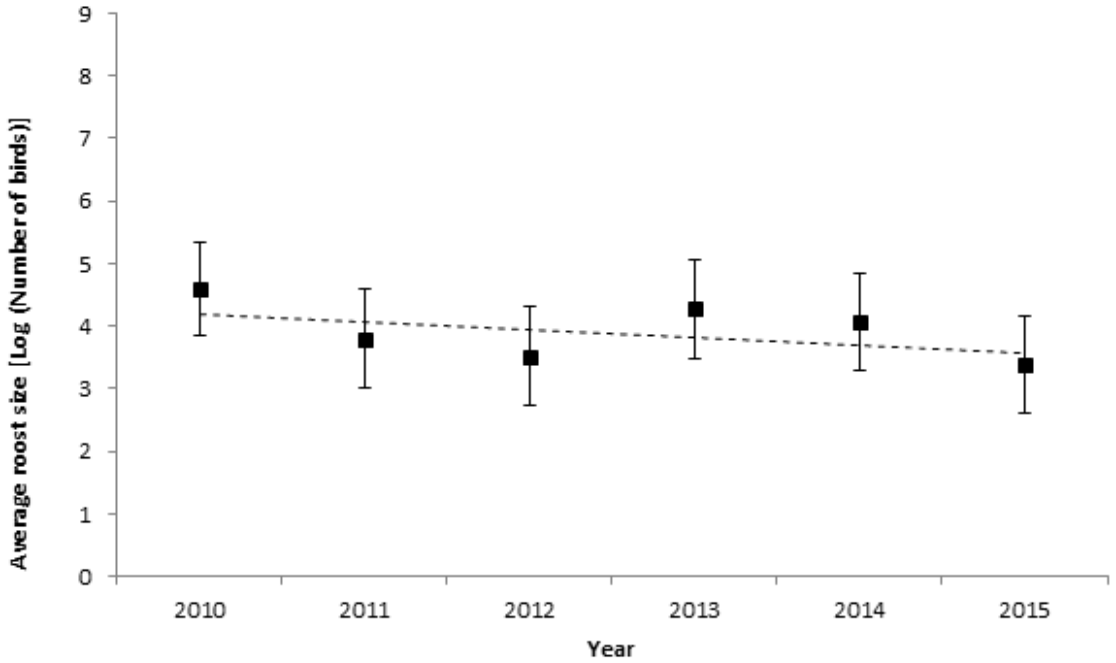

Figure 4: Average roost size (filled symbols with standard errors, log scale) for Carnaby's Black-Cockatoo in the Perth-Peel Coastal Plain for six Great Cocky Counts (2010 – 2015) and trend (dashed line), estimated using a log-linear zero-inflated regression model.

E. Forest Red-tailed Black-Cockatoo

Roost Site Identification

Perth-Peel Coastal Plain

FRTBC were recorded at roosts in eight LGAs across the Perth-Peel Coastal Plain: Canning, Stirling, Mandurah, Melville, Rockingham, Cockburn, Gosnells, and Victoria Park. The 2014 GCC also confirmed roost sites in the Cities of Cambridge and South Perth, and the Shire of Wanneroo. There are also several unconfirmed roosts in five other LGAs: Bayswater, Fremantle, Joondalup, Kwinana, and Vincent.

Northern Darling Scarp and Plateau

Volunteers recorded FRTBC at roost sites in five LGAs within the Northern Darling Scarp and Plateau: Kalamunda, Mundaring, Northam, Serpentine-Jarrahdale, and Toodyay. Previous GCCs and additional surveys also identified confirmed roosts in the Cities of Armadale and Swan, and the Shires of Waroona, Murray, Serpentine-Jarrahdale, and Toodyay. There is also an unconfirmed roost in the Shire of Chittering.

Regional areas

FRTBC were recorded at roost sites in five Regional LGAs: Albany, Capel, Donnybrook-Balingup, Merredin, and Trayning. Previous GCCs and additional surveys also identified confirmed roosts in the Shires of Bridgetown, Busselton, Donnybrook, Harvey, Irwin, Plantagenet, Waroona, and Williams. The red-tailed black-cockatoos recorded at the Irwin site are likely to be Inland Red-tailed Black-Cockatoos, whereas those at the other locations are likely to be Forest Red-tailed Black-Cockatoo.

Roost Counts

FRTBC were recorded roosting at 24 sites across the GCC survey area, with most (75%) sites occurring in Regional areas (Table 6; Appendix V). Seven of these (35%) were new sites that had not been surveyed prior to the 2015 GCC.

Roost counts at sites in the Greater Perth-Peel Region accounted for 85% of the total number of FRTBC counted. The five largest counts of FRTBC (47, 92, 94, 109, 199 birds) were all in the Perth-Peel Coastal Plain and accounted for 71% of the total number of FRTBC counted in the Greater Perth-Peel Region and 60% of the total number of FRTBC counted across the species range.

FRTBC were recorded at 8% of all sites surveyed across the GCC survey area (24 of 293 sites) and 11% of sites outside of the Greater Perth-Peel Region (7 of 65 sites). Within the Greater Perth-Peel Region, volunteers recorded FRTBC at 4% of sites in the Perth-Peel Coastal Plain (10 of 228 sites) and 16% of sites in the Northern Darling Scarp and Plateau (7 of 43 sites).

Volunteers recorded four roosts where both FRTBC and white-tailed black-cockatoos roosted (Appendix V). Ten other FRTBC roosts, while not used as roosts by white-tailed black-

cockatoos in 2015, had positive counts of white-tailed black-cockatoos in previous GCCs (2010-2014).

Roost counts for FRTBC ranged from 1 to 697, with a mean of 70.3 $\pm$ 20.3 (standard error) and a median of 15.5 (24 roosts).

Table 6: Summary of roost counts for red-tailed black-cockatoos in the 2015 Great Cocky Count. Counts within the Greater Perth-Peel Region are assumed to be Forest Red-tailed Black-Cockatoo. Counts outside of the Greater Perth-Peel Region are not corrected to account for the possible presence of Inland Red-tailed Black-Cockatoos at some sites.

No. of FRTBC counted in **Perth-Peel Coastal Plain**	314 (10 roosts)
No. of FRTBC counted in **Northern Darling Scarp and Plateau**	112 (7 roosts)
No. of FRTBC counted in **Greater Perth-Peel Region**	426 (17 roosts)
No. of red-tailed black-cockatoos counted **outside of Greater Perth-Peel Region**	1262 (7 roosts)
No. of red-tailed black-cockatoos counted **across the species range**	1688 (24 roosts)

DISCUSSION

Community Engagement and Training

Participation in the 2015 count

The 2015 Great Cocky Count included over 600 registered volunteers and is likely to have exceeded 700 participants overall, making this year's survey the largest to date and one of the largest citizen science surveys in Australia. Volunteers surveyed 293 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, Warwick Park, and Salter Point (Aquinas College).

Workshops

About 450 people attended training workshops in 2015. While not all workshop attendees ultimately participated in the 2015 GCC, it is likely that most participants in the 2015 GCC had either participated in a previous GCC or had attended a training workshop. Informal feedback from 2014 and 2015 GCC participants and NRM staff indicated strong support for holding workshops in regional areas.

Volunteer retention

More than 1700 volunteers have participated in at least one GCC since 2010. Volunteer retention from year to year has been reasonably strong, with 26-47% of the volunteers for the 2012-2015 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 has exceeded 50%. This may be because most 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.

Ongoing monitoring

Many volunteers undertake ongoing, systematic monitoring of several sites in the Greater Perth-Peel Region, including the Hollywood Hospital roost in Nedlands, the Underwood Avenue roost in Floreat, roosts in the towns of Gingin and Bullsbrook, and roosts in Yanchep National Park and surrounds. Regular roost monitoring also occurs in Nilgen and at a few other locations.

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) any injuries or property damage sustained while surveying, (4) anxiety about the quality of the observations collected and (5) 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 2015 included the delivery of more than twelve training workshops across the Perth-Peel region and the further development of a set of observer instructions for each roost site based on previous observer comments. Strategies for improving future GCCs include:

- enhancing volunteer retention through social media engagement and other interactive approaches,
- supporting volunteers who regularly monitor local roosts,
- improving volunteer understanding of roost sites and the importance of documenting the absence of black-cockatoos from roosts,
- 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 Carnaby's Black-Cockatoo 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 contrast, 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 has declined steadily since 2010. Many of the confirmed roosts identified since 2012 have been identified through a research program, combining the satellite telemetry tracking of Carnaby's Black-Cockatoo released from rehabilitation centres with field surveys to inspect potential roost sites and conduct roost counts when birds are present (Christine Groom, DPaW, unpublished data; Groom *et al.* 2013). Field surveys by Mark Blythman (DPaW) have also identified previously unknown sites within the Perth-Peel Coastal Plain and Northern Darling Scarp and Plateau over the last three years.

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 large but unknown fraction of the Carnaby's Black-Cockatoos present

The number of roost sites discovered has declined steadily, suggesting that the GCC surveys a substantial fraction of the occupied roosting sites for Carnaby's Black-Cockatoo in the Perth-Peel Coastal Plain and, thus, of the birds present in the district at the time of the survey. In addition, the significant 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 Gnangara 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 an approach for estimating the proportion of undetected birds become available, it should 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.

However, as the GCC appears to survey a large fraction of the population of the Carnaby's Black-Cockatoo present in the Perth-Peel Coastal Plain, the GCC is closer to a census (i.e. a survey in which all individuals present are counted) than to a smaller, representative sample. As such, estimated trends based on the GCC data should be closer to the true rate of change for the population than to estimates of the rate of change based on smaller, representative

samples. Estimates of statistical significance, which apply to smaller, representative samples, are therefore very conservative in the circumstances.

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

Based on the 2015 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.

Significant 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 significant at a species-scale.

The current recovery plan suggests that the total population size of Carnaby's Black-Cockatoo is around 40,000 individuals (DPaW 2013, p. 7), meaning that approximately 15% of the species' population occurs within the Perth-Peel Coastal Plain at the time of the count.

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

A species population of 40,000 birds means that around 6% of the species occurred within the remaining portions of the Gnangara pine plantation in early April 2015.

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

Significant roosts 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; Hamilton Hill in Cockburn; Hollywood Hospital and associated roosts in Nedlands; Star Swamp in North Beach; and the City of Stirling Nursery in Karrinyup.

(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 frequently between roosts, rather than consistently occupying a single main roost.

Numbers are not increasing in the Perth-Peel Coastal Plain

Comparisons with previous GCCs indicate that the population of Carnaby's Black-Cockatoo inhabiting the Perth-Peel Coastal Plain is not increasing. In the 2006 GCC, 26 volunteers surveyed 13 partially aggregated roost sites in the district and counted 4510 Carnaby's Black-Cockatoo (Shah 2006). By contrast, over 300 volunteers surveyed 185 sites during the 2015 GCC and counted 5298 birds. Furthermore, a higher number was recorded in the 2010 count than the 2015 count (6330 vs. 5298 birds) despite substantial increases in the number of sites (157 vs. 185) and known roosts (58 vs. 89) surveyed.

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

There are strong indications that Carnaby's Black-Cockatoo in the Perth-Peel Coastal Plain is experiencing an ongoing decline. Trend analysis of roost counts over the last six GCCs found a current rate of decline of an estimated 15% per year. When the analysis was restricted to the larger, more stable roosts, the decline was still estimated at around 10%. From these results, we conclude that the population of Carnaby's Black-Cockatoo on the Perth-Peel Coastal Plain continues to decline at a rate of around 10 – 20% per annum (average 15%), consistent with trends estimated up to 2014 (Finn et al. 2015; Williams et al. 2015). Such a rapid decline may manifest in the loss of flocks associated with particular roosts and, should this trend continues, it is of serious concern for the future viability of Carnaby's Black-Cockatoo in the Perth-Peel Coastal Plain.

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 Perth-Peel Coastal Plain region, 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 all of these factors, until a better understanding of the demographics of Carnaby's Black-Cockatoo emerges.

Feeding and roosting habitats on the Perth-Peel Coastal Plain are both subject to ongoing losses due to land development, possible impacts from climate change, and other processes (DPaW 2013). Clearing of the remaining portions of the Gnangara pine plantation is currently scheduled to proceed until all remaining pine is harvested by or before 2030. In addition, many thousands of hectares of Banksia woodland, a key feeding habitat for Carnaby's Black-Cockatoo (Johnston 2013) will be cleared for urban development in the Perth-Peel region over the next 20 years (WAPC and DoP 2010). Urban infill (i.e. increased housing density in existing urban areas) will also remove food plants in suburban landscapes, such as backyards and road verges (Groom *et al.* 2014). Many of the urban and suburban roosts are associated with remnant stands of pine trees, remnants of former plantations established prior to 1950 (Saunders 1974; Finn *et al.* 2009). The long-term future of these stands is unclear, given local development pressures, their lack of formal protection and the natural senescence of the trees.

The significance of the Gnangara pine plantation for Carnaby's Black-Cockatoo

Almost 2500 Carnaby's Black-Cockatoos were recorded in roosts within or associated with the Gnangara pine plantation in the 2015 GCC. This abundance is consistent with 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 Gnangara pine plantation, including flocks of 7000 in Mariginiup in March 2004, 2000 in Ellenbrook in February 2005, 3000 in Gnangara in February 2005, 3000 in Landsdale in March 2005, 5000-7000 in Tamala Park in April 2003, 7000 in Yanchep National Park in July 2006, and 8000-10 000 in the pine plantation along Military Road north of Wanneroo in July 2006. Shah (2006) reported that 2789 birds roosted at sites within or associated with the Gnangara pine plantation in April

2006, as part of the 2006 GCC.[11] Based on observations conducted between January and May 2009, Finn *et al.* (2009) reported that large (~3000 birds) concentrations of Carnaby's Black-Cockatoo use the Gnangara pine plantation during the non-breeding season. Given these records, and their consistency with the count recorded for the Gnangara plantation system in the 2015 GCC, it is likely that at least 2000 – 4000 Carnaby's Black-Cockatoos feed within the Gnangara pine plantation each year.

Previous GCCs are likely to have underestimated the number of birds present in the Gnangara pine plantation as it is problematic to survey, for several reasons. Firstly, the plantation covers an area of 23 000 ha and extends for over 50 km from north to south. Secondly, the density of the pine stands makes it difficult to obtain clear sightlines for counting birds as they fly into roosts. Thirdly, Carnaby's Black-Cockatoos feed throughout the plantation system (Stock *et al.* 2013) and may roost within the plantation system or at its peripheries (Finn *et al.* 2009). Fourthly, much of the plantation is remote from human settlement, creating issues of access and volunteer safety. Finally, Carnaby's Black-Cockatoos may shift between roosting locations, both from day to day and from year to year, making it difficult to determine how to select survey sites and allocate observers. 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, near the Pinjar power station. In contrast, during the 2014 GCC no birds were recorded at WANPINR011, but 1521 roosted at WANPINR001.

Harvesting without replacement of the remaining pines in the Gnangara plantation will remove a food source that currently supports a significant portion (at least 6% and possibly as much as 10%) of the Carnaby's Black-Cockatoo population between January-April each year. The impact of this loss should not be underestimated, particularly given that extensive areas of Banksia woodland are also scheduled for removal, and the species is already listed as endangered. The loss of the pine food resource is readily described as an impact that is "important, notable or of consequence, having regard to its context or intensity"[12] and easily meets several of the significant impact criteria proposed for species listed as endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* in the most recent guidelines (DSEWPAC 2012, Department of the Environment 2013). The State Government is currently undertaking a strategic assessment of the impacts of proposed development in the Perth Peel Coastal Plain area[13], with the intention of mitigating or offsetting the impacts of habitat removal on Black Cockatoos. A draft report assessing the likely impacts and the proposed offset measures is expected to be available for public comment early in 2016.

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

[12] This is the interpretation of 'significant impact' stated by Branson J in *Booth v Bosworth* [2001] FCA 1453 and which appears in the significant impact guidelines for the *Environment Protection and Biodiversity Conservation Act 1999* prepared by the Commonwealth Department of the Environment (Department of the Environment 2013).

https://www.dpc.wa.gov.au/Consultation/StrategicAssessment/Pages/Default.aspx

[13] 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

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

Based on the 2014 GCC and previous 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).

(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 likely reflects differences in the timing of the northward migration of Baudin's Black-Cockatoos during their non-breeding season.

Baudin's Black-Cockatoos breed in the Karri Forest and southern Jarrah-Marri Forest 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 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. In previous GCCs (2010-2013), we have applied a species mix of 80% Baudin's Black-Cockatoo and 20% Carnaby's Black-Cockatoo to obtain an estimate of numbers of Carnaby's Black-Cockatoo from the overall counts of white-tailed black-cockatoos, based on the estimates of expert observers at the time of each GCC. This year, roost counts by expert observers indicated a mix of 60% Baudin's Black-Cockatoo and 40% Carnaby's Black-Cockatoo. The higher overall count of Carnaby's Black-Cockatoo in the Northern Darling Scarp and Plateau this year (483 birds) reflects this change in species proportion (cf. an overall count of 386 Carnaby's Black-Cockatoo out of 1929 white-tailed black-cockatoos in the 2010 GCC).

Further work is required to clarify the variation in the proportions of Baudin's and Carnaby's Black-Cockatoos at roosts in the Northern Darling Scarp and Plateau. One potential approach is to ask volunteers to record black-cockatoo contact calls during roost counts (Tony Kirkby, WA Museum, personal communication). Experts could then analyse the recordings and estimate species proportions based on the frequency of contact calls for each species.

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 two years at more than 40 regional sites and have been conducted for at least three consecutive years at more than 15 sites.

Some initial inferences can therefore be made about the distribution of Carnaby's Black-Cockatoo during the middle of the non-breeding season. Firstly, along the west coast, significant populations 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 lower 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 (probably 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 significant 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 several very large roosts (>200 birds) accounted for the majority of Carnaby's Black-Cockatoos recorded in regional areas in the 2015 GCC. 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 would provide valuable information about population trends in regional areas.

Forest Red-tailed Black-Cockatoo

Identification of roost sites for FRTBC

The 2015 GCC built on the previous year's GCC as the only broad-scale survey for the Forest Red-tailed Black-Cockatoo, with volunteers documenting 24 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. With a few exceptions, the sites allocated for survey in the 2014 GCC were known

or potential Carnaby's Black-Cockatoo roost sites. Subsequent GCCs will benefit from the addition of FRTBC-specific roost sites to the GCC database.

Although the task of identifying roosts for FRTBC remains in its early stages, it is clear that some roosts are used by both FRTBC and white-tailed black-cockatoos (e.g. Murdoch University) and that significant FRTBC roosts sometimes occur very close to significant Carnaby's Black-Cockatoo roosts. Examples of the latter situation include the FRTBC roost in Kensington (VICKENR001) and the Carnaby's Black-Cockatoo roost site in Dawesville (MANDAWR002).

Distribution of FRTBC in the Perth metropolitan area

Two clear outcomes emerged from the 2015 GCC: (a) FRTBC roosted at sites throughout the Perth metropolitan area, including roosts in the northern, western, and southern suburbs and (b) reasonably large FRTBC roosts (up to 121 birds) occurred at several suburban sites. Observations from the 2013 to 2015 GCCs confirmed roosts in 13 LGAs in the Perth-Peel Coastal Plain, with unconfirmed roosts reported in another five. Volunteers recorded sizable counts at Murdoch University, Floreat, Kensington, and Munster. These counts are much larger than flock sizes reported for FRTBC in forested regions (Abbott 1998, Lee *et al.* 2013).

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 2015 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 associated 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).

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 six GCCs, involving more than 1700 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 on 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 roosts and feeding habitat. These are tangible successes reflecting the contributions of hundreds 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 2015 GCC and the trend analyses of the six GCCs 2010 – 2015 identified several issues that have important implications for black-cockatoo conservation efforts. Firstly, there are strong indications that the population of Carnaby's Black-Cockatoo inhabiting the Perth-Peel Coastal Plain continues to decline. Secondly, the Gnangara pine plantation sustains a large proportion, up to 46%, of the species population of Carnaby's Black-Cockatoo on the Perth-Peel Coastal Plain during the non-breeding season. Finally, Forest Red-tailed Black-Cockatoos now occur through the urban portions of the Perth-Peel metropolitan area, with significant roosts in several urban locations. These findings provide an important focus for decision-making about the future of the Gnangara pine plantation, the conservation of urban and peri-urban Banksia woodland, and the protection of roosts and food resources throughout the region.

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APPENDIX I: Completed example of the 2015 Great Cocky Count survey form

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

Date:	12 April 2015	**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)*

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

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

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

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 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.

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

via email:

greatcockycount@birdlife.org.au

via post:

Matt Byrne, BirdLife Australia

Peregrine House, 167 Perry Lakes Drive

Floreat, WA, 6014

How to Do a Roost Count

1) **Arrive at your allocated roost site at least 45 minutes before sunset** so you are in position and ready to record birds as they arrive. **Start counting from 5:30pm**.

2) **Count all white-tailed black-cockatoos that roost at the site for <u>at least</u> 30 minutes after sunset** (ie. count until at least **6:30pm**).

   - 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).
   - 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 how many you count on your survey form, but do not include them in your count for white-tailed black-cockatoos.
   - **Count <u>ALL</u> 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.

3) **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.

4) Send completed forms to BirdLife WA:

via email: greatcockycount@birdlife.org.au
via post: Matt Byrne, Great Cocky Count Coordinator
BirdLife Australia
Peregrine House, 167 Perry Lakes Drive,
Floreat, WA 6014

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 when 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, beware of traffic.

For inquiries about the 2015 Great Cocky Count please contact Matt Byrne, Great Cocky Count Coordinator, at greatcockycount@birdlife.org.au or (08) 9287 2251.

APPENDIX II: Number of sites surveyed across local government areas (2015)

Appendix II: Number of roost sites surveyed and number of occupied roosts for white-tailed black-cockatoos in local government areas in the 2015 Great Cocky Count. The number of **occupied roosts** (see page vi) is shown in parentheses.

Local Government Area	**No. of Sites Surveyed** (Occupied Roosts)	**Local Government Area**	**No. of Sites Surveyed** (Occupied Roosts)
Outside Greater Perth-Peel Region			
Shire of Esperance	5 (3)	Shire of Donnybrook	4 (1)
Shire of Denmark	1 (0)	City of Bunbury	3 (1)
Shire of Plantagenet	3 (1)	Shire of Harvey	5 (2)
Shire of Jerramungup	1 (0)	Shire of Trayning	1 (1)
Shire of Albany	12 (2)	Shire of Narrogin	1 (0)
Shire of Merredin	1 (0)	Shire of Gingin	1 (1)
Shire of Augusta-Margaret River	6 (2)	Shire of Dandaragan	4 (3)
Shire of Busselton	6 (1)	Shire of Chapman Valley	1 (1)
Shire of Dardanup	1 (0)	Shire of Bridgetown	3 (1)
Shire of Capel	5 (2)		
Greater Perth-Peel Region			
City of Armadale	8 (2)	Town of Mosman Park	1 (0)
City of Bayswater	2 (0)	Shire of Mundaring	13 (2)
City of Belmont	3 (0)	Shire of Murray	3 (0)
Shire of Beverley	1 (0)	City of Nedlands	6 (3)
Town of Cambridge	5 (1)	City of Perth	5 (0)
City of Canning	6 (0)	City of Rockingham	6 (0)
Town of Claremont	2 (0)	Shire of Serpentine Jarrahdale	7 (1)
City of Cockburn	12 (3)	City of South Perth	3 (1)
City of Fremantle	1 (0)	City of Stirling	26 (2)
Shire of Gingin	4 (3)	City of Subiaco	4 (0)
City of Gosnells	6 (0)	City of Swan	10 (4)
City of Joondalup	10 (3)	Shire of Toodyay	1 (1)
Shire of Kalamunda	12 (2)	Town of Victoria Park	7 (0)
Shire of Northam	1 (0)	City of Vincent	3 (0)
City of Kwinana	5 (1)	City of Wanneroo	26 (9)
City of Mandurah	10 (4)	Shire of Waroona	3 (0)
City of Melville	14 (2)	Shire of York	1 (0)

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

Appendix IIIa: Great Cocky Count (2010-2015) roost counts for Carnaby's Black-Cockatoo at **confirmed roosts** (see page iv) in the Perth-Peel Coastal Plain. A period in a cell means that the site was not surveyed that year.

Site Code	Locality	2015	2014	2013	2012	2011	2010
ARMARMR001	Armadale	0	0	0	.	.	.
ARMFORR001	Forestdale	18	0	0	.	.	.
ARMHARR001	Harrisdale	1	0	.	0	0	.
ARMKELR001	Kelmscott	.	0	0	0	0	14
CAMCITR001	City Beach	0	2	.	.	.	.
CAMFLOR001	Floreat	86	159	157	148	151	237
CAMFLOR002	Floreat	.	0	.	.	.	.
CANFERR001	Ferndale	0	0	5	.	.	.
CANWILR001	Willeton	0	68	0	0	0	0
CLASWAR001	Swanbourne	0	3	0	0	.	.
COCBANR002	Banjup	.	53	.	.	.	.
COCBIBR003	Bibra Lake	0	0	0	.	0	0
COCFORR001	Forrestdale	.	0	.	.	.	.
COCFORR002	Forrestdale	.	0	.	.	.	.
COCHAMR001	Hamilton Hill	331	168	0	215	169	0
COCMUNR001	Munster	.	0	0	.	.	.
COCSPER001	Spearwood	.	0	323	.	2	0
COCSPER002	Spearwood	.	0	.	0	40	.
COCSCCR001	Success	cleared	cleared	cleared	cleared	0	252
COCSCCR002	Success	cleared	cleared	cleared	cleared	3	15
GINGINR001	Gingin	784	879	686	432	378	392
GINGUIR001	Guilderton	.	0	.	.	.	.
GINWOOR001	Woodridge	0	0	30	0	119	113
GINYEAR001	Yeal	750	782	.	387	.	.
GINYEAR002	Yeal	20	.	.	.	92	49
GOSCNVR001	Canning Vale	0	0	.	.	19	0

Site Code	Locality	2015	2014	2013	2012	2011	2010
GOSCNVR002	Canning Vale	0	0	52	26	.	.
JOODUNR001	Duncraig	17	0	0	60	.	.
JOOPADR001	Padbury	7	7	17	1	.	0
JOOWARR001	Warwick	0	0	0	.	60	0
KINKINR001	Kings Park	0	.	0	0	.	0
KWICASR001	Casuarina	.	19	0	.	.	2
KWIWANR001	Wandi	0	0	1	0	0	63
KWIWANR002	Wandi	0	0	0	.	.	.
KWIWANR003	Wandi	0	0	.	.	.	.
KWIWELR001	Wellard	125	0	50	15	.	.
MANCOOR002	Coodanup	0	0	21	.	.	.
MANDAWR002	Dawesville	135	257	0	11	199	371
MANDAWR004	Dawesville	22	24	0	.	.	159
MANDAWR005	Dawesville	0	0	0	.	30	.
MELBATR001	Bateman	0	0	0	0	0	8
MELLEER001	Leeming	0	70	0	12	0	0
MELMURR001	Murdoch	24	234	127	142	60	700
MELWINR001	Winthrop	0	41	70	81	56	.
MELWINR003	Winthrop	0	9	0	80	130	117
MELWINR004	Winthrop	0	2	0	0	0	0
NEDDALR003	Dalkeith	0	0	0	0	90	40
NEDDALR004	Dalkeith	.	0	.	.	.	.
NEDNEDR001	Nedlands	106	114	183	304	103	73
NEDNEDR002	Nedlands	11	0	.	.	.	.
ROCBALR001	Baldivis	cleared	cleared	cleared	cleared	cleared	346
ROCBALR003	Baldivis	0	0	4	0	78	.
ROCBALR004	Baldivis	.	0	0	0	5	.
ROCSECR001	Secret Harbour	0	6	0	0	.	0
SERKEYR001	Keysbrook	14	3	100	.	.	0
SEROAKR001	Oakford	.	0	0	.	110	0
SEROAKR002	Oakford	.	.	2	0	0	0

Site Code	Locality	2015	2014	2013	2012	2011	2010
SEROAKR003	Oakford	0	0	0	0	0	167
SEROAKR004	Oakford	0	50	0	0	3	45
SEROAKR005	Oakford	0	0	0	.	0	31
SOUCOMR001	Como	460	402	301	558	645	408
SOUSALR001	Salter Point	0	5	0	0	0	12
SOUSOUR002	South Perth	0	0	0	0	35	0
STIKARR001	Karrinyup	2	92	121	.	.	.
STIMENR001	Menora	0	0	0	.	.	.
STIMENR002	Menora	.	0	.	.	.	.
STINORR001	North Beach	6	0	267	0	230	0
STIYOKR001	Yokine	.	.	0	0	0	.
STIYOKR003	Yokine	0	0	.	0	0	0
SUBSHER001	Shenton Park	0	0	9	0	0	0
SWABALR001	Ballajura	35	0	92	0	40	0
SWABALR004	Ballajura	5	0	.	.	.	0
SWAELLR001	Ellenbrook	.	14	.	.	.	.
SWALEXR001	Lexia	0	181	0	0	80	0
SWALEXR002	Lexia	0	0	0	.	0	185
SWAMELR001	Melaleuca	0	480	20	0	41	500
SWAVINR002	The Vines	.	0	.	.	.	.
SWAWHIR001	Whiteman Park	0	.	.	13	69	.
VICKENR001	Kensington	0	0	0	0	.	0
VICVICR001	Victoria Park	0	0	0	0	0	2
WANCARR001	Carabooda	0	.	.	2	.	.
WANCARR004	Carabooda	.	7	.	.	.	.
WANCRRR001	Carramar	0	0	191	.	.	.
WANGNAR003	Gnangara	0	0	0	0	14	0
WANGNAR004	Gnangara	0	0	0	0	0	27
WANGNAR005	Gnangara	14	0	100	.	.	.
WANGNAR006	Gnangara	.	40	.	.	.	.

Site Code	Locality	2015	2014	2013	2012	2011	2010
WANJANR002	Jandabup	0	.	.	.	.	.
WANJANR005	Jandabup	.	.	.	0	.	0
WANJANR007	Jandabup	0	.	0	.	16	.
WANMARR001	Mariginiup	71	.	0	.	20	0
WANMARR002	Mariginiup	0	3	3	2	.	0
WANMARR003	Mariginiup	560	147	16	10	152	542
WANNEER001	Neerabup	.	0	.	.	29	.
WANNEER002	Neerabup	0	0	0	0	0	604
WANNOWR001	Nowergup	0	0	10	35	.	.
WANPINR001	Pinjar	616	1521	35	853	.	.
WANPINR002	Pinjar	101	138	0	276	312	.
WANPINR003	Pinjar	0	0	0	0	0	64
WANPINR005	Pinjar	0	0	.	.	.	275
WANPINR006	Pinjar	0	2	0	0	0	13
WANPINR007	Pinjar	.	.	0	0	0	0
WANPINR011	Pinjar	179	0	800	.	.	0
WANTAMR001	Tamala Park	10	20	103	0	.	.
WANTWOR001	Two Rocks	30	200	573	7	.	0
WANWANR001	Wanneroo	0	0	0	6	11	0
WANYANR001	Yanchep	82	450	.	.	.	61
WANYANR003	Yanchep	0	0	564	0	16	.
WANYANR004	Yanchep	0	0	192	0	0	.
WANYANR006	Yanchep	0	0	0	129	305	342
WARLAKR001	Lake Clifton	0	.	.	0	0	1
WARPRER001	Preston Beach	.	19	330	66	.	.
WARPRER002	Preston Beach	0	0	.	0	.	100

Appendix IIIb: Great Cocky Count (2010-2015) roost counts for Carnaby's Black-Cockatoo at **confirmed roosts** (see page v) (24) that: (a) are within or immediately adjacent (<1 km) to the **Gnangara pine plantation** (see page vi) or (b) have historically been used as a roost by cockatoos feeding within the plantation system. Use of the two 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).

Pine-associated sites: All roost sites in the GCC roost site database (including confirmed roosts, unconfirmed roosts, and potential sites) that are within or immediately adjacent (<1 km) to the Gnangara pine plantation. A period in a cell means that the site was not surveyed that year.

Site Code	Plantation	2015	2014	2013	2012	2011	2010
GINYEAR001	Yanchep	750	782	.	387	.	.
GINYEAR002	Yanchep	20	.	.	.	92	49
SWAELLR001	Gnangara	.	14	.	.	.	.
SWALEXR001	Gnangara	0	181	0	0	80	0
SWALEXR002	Gnangara	0	0	0	.	0	185
SWAMELR001	Gnangara	0	480	20	0	41	500
WANCARR004	Pinjar	.	7	.	.	.	.
WANGNAR004	Gnangara	0	0	0	0	0	27
WANGNAR005	Gnangara	14	0	100	.	.	.
WANJANR007	Gnangara	cleared	cleared	0	.	16	.
WANMARR001	Gnangara	71	.	0	.	20	0
WANMARR003	Gnangara	560	147	16	10	152	542
WANNEER001	Pinjar	.	0	.	.	29	.
WANNEER002	Pinjar	0	0	0	0	0	604
WANPINR001	Pinjar	616	1521	35	853	.	.
WANPINR002	Pinjar	101	138	0	276	312	.
WANPINR003	Gnangara	0	0	0	0	0	64
WANPINR005	Gnangara	0	0	.	.	.	275
WANPINR006	Gnangara	0	2	0	0	0	13
WANPINR011	Pinjar	179	0	800	.	.	0
WANTWOR001	Yanchep	30	200	573	7	.	0
WANYANR001	Pinjar	82	450	.	.	.	61
WANYANR003	YNP	0	0	564	0	16	.
WANYANR006	YNP	0	0	0	129	305	342
TOTAL		2423	3922	2108	1662	1063	2662
% of total Perth-Peel Coastal Plain count		42%	59%	38%	43%	27%	42%
No. of pine-associated sites surveyed		20	26	18	17	20	25

Appendix IIIc: Great Cocky Count (2010-2015) roost counts for white-tailed black-cockatoos at **confirmed roost**s (see page iv) (45) in the Northern Darling Scarp and Plateau. The counts are for white-tailed black-cockatoos generally and are not corrected for the relative proportions of Baudin's Black-Cockatoos and Carnaby's Black-Cockatoo. A period in a cell means that the site was not surveyed that year.

Site Code	Locality	2015	2014	2013	2012	2011	2010
ARMBEDR001	Bedfordale	0	0	0	.	0	57
ARMBEDR002	Bedfordale	.	0	3	.	22	70
ARMBEDR003	Bedfordale	60	0	0	.	.	385
ARMKELR002	Kelmscott	0	0	0	.	10	0
ARMROLR001	Roleystone	0	0	40	140	13	108
ARMROLR003	Roleystone	0	0	50	0	0	.
BODCROR002	Crossman	3	.	.	.	0	10
KALKALR001	Kalamunda	0	0	0	25	.	30
KALKALR002	Kalamunda	20	28	85	23	25	.
KALLESR001	Lesmurdie	8	0	0	0	0	.
KALPICR002	Pickering Brook	.	2	.	.	.	.
KALPIER001	Piesse Brook	0	0	0	46	82	.
KALWALR001	Walliston	0	0	0	0	5	0
KALWATR001	Wattle Grove	.	.	0	0	.	.
MUNCHIR001	Chidlow	0	0	0	.	0	16
MUNDARR001	Darlington	0	0	0	147	7	443
MUNGLER001	Glen Forrest	25	45	51	32	.	.
MUNGLER002	Glen Forrest	0	0	0	13	.	.
MUNGLER003	Glen Forrest	.	45	.	.	.	.
MUNHELR001	Helena Valley	0	124	42	16	3	.
MUNHOVR001	Hovea	0	.	0	40	.	.
MUNHOVR002	Hovea	0	0	0	10	22	243
MUNMTHR001	Mount Helena	0	0	8	.	.	.
MUNMUNR001	Mount Helena	36	45	85	.	.	78
MUNPARR001	Parkerville	.	182	0	.	.	.
MUNSTOR001	Stoneville	0	141	.	.	.	.
MUNSTOR002	Stoneville	0	0	.	0	86	.
MUNSTOR003	Stoneville	.	48	.	.	.	.
MUNWOOR001	Woorooloo	.	0	0	.	.	0

Site Code	Locality	2015	2014	2013	2012	2011	2010
MURDWER001	Dwellingup	0	.	.	.	40	.
MURTEER001	Teesdale	0	.	0	0	0	21
NORBAKR001	Bakers Hill	.	.	.	.	.	217
NORWOOR001	Woottating	.	.	0	.	.	0
NORWUNR001	Wundowie	0	.	0	8	.	125
SERJARR001	Jarrahdale	0	.	.	0	60	0
SERKEYR002	Keysbrook	0	.	30	0	.	25
SWABULR002	Bullsbrook	.	328	120	117	18	.
SWAGIDR002	Gidgegannup	217	.	40	23	.	101
SWAGIDR003	Gidgegannup	.	.	.	3	.	.
SWAGIDR005	Gidgegannup	169	163	197	.	.	.
SWAMILR001	Millendon	.	0	.	.	.	.
SWASTRR001	Stratton	.	0	0	.	.	.
TOOMORR001	Toodyay	12	56	29	183	.	.
WARWARR002	Waroona	0	0	36	.	.	.
YORTALR001	York	0	.	0	0	.	.

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

Appendix IV: Great Cocky Count (2010-2015) roost counts for white-tailed black-cockatoos at major roosts in regional areas. A period in a cell means that the site was not surveyed that year.

Site Code	Locality	2015	2014	2013	2012	2011	2010
Mid-West (Chapman Valley and Three Springs)							
CHANANR001	Nanson	300	262	302	.	.	.
CHANANR001	Nanson	2	189	0	.	.	.
THRARRR002	Arrino	.	.	70	.	.	.
Northern Swan Coastal Plain (Dandaragan and Gingin)							
DANDANR001	Dandaragan	0	460	228	313	.	.
DANHILR001	Hill River	.	250	0	160	.	.
DANHILR002	Hill River	11	.	.	136	.	.
DANHILR003	Hill River	.	131	.	.	.	.
DANJURR001	Jurien Bay	143	52	225	51	.	.
DANREGR001	Regans Ford	.	.	.	0	22	.
GINNILR001	Nilgen	995	376	583	.	.	.
Southern Swan Coastal Plain (south of Lake Preston and Waroona)							
BUNCOLR001	College Grove	7	0	20	0	.	.
BUNGLER001	Glen Iris	0	0	0	25	.	.
BUNGLER002	Glen Iris	0	4	8	.	.	.
CAPGELR001	Gelorup	0	0	6	38	.	.
CAPGELR002	Gelorup	21	.	.	.	.	.
CAPGWIR001	Gwindinup	175	119	0	14	.	194
CAPNORR001	North Boyanup	0	0	4	.	.	.
DAREATR001	Eaton	0	0	14	19	4	.
HARMYAR002	Myalup	.	35	0	0	0	.
HARMYAR002	Myalup	cleared	cleared	cleared	0	155	52
HARMYAR003	Myalup	570	.	.	.	.	.
WARWAGR001	Wagerup	.	186	236	.	.	.
Capes Region (Busselton and Augusta-Margaret-River)							
AUGGRAR001	Gracetown	2	1	.	.	.	.
AUGGRAR002	Gracetown	4	85	7	.	.	.

Site Code	Locality	2015	2014	2013	2012	2011	2010
AUGMARR001	Margaret River	0	47	1	11	.	.
BUSDUNR001	Dunsborough	0	99	32	.	.	.
BUSQUIR001	Quindalup	83	107	71	.	.	.
BUSYALR001	Yallingup	.	57	0	.	.	.
South Coast (Albany)							
ALBCHER001	Cheynes	.	.	70	.	.	.
ALBCHER002	Cheynes	0	60	.	0	.	.
ALBGOOR001	Goode Beach	.	62	84	.	.	.
ALBGOOR002	Goode Beach	0	120	0	.	111	.
ALBKALR001	Kalgan	73	141	472	213	.	.
ALBMCKR001	McKail	0	18	.	33	.	.
ALBMETR001	Mettler	.	.	145	40	.	.
ALBMTCR001	Mt Clarence	0	0	.	.	4	.
ALBROBR001	Robinson	.	0	43	0	.	.
ALBSEPR001	Seppings	2	.	.	.	.	.
South Coast (Esperance and Ravensthorpe)							
ESPESPR001	Esperance	.	202	230	226	196	.
ESPESPR002	Esperance	360	.	.	.	.	.
ESPESPR003	Esperance	60	.	.	.	.	.
ESPESPR004	Esperance	316	.	.	.	.	.
ESPMYRR001	Myrup	0	791	589	555	.	.
ESPMYRR002	Myrup	.	.	0	1018	.	.
RAVHOPR001	Hopetoun	.	30	.	.	.	.
RAVHOPR001	Hopetoun	.	150	.	.	.	.
Great Southern (Plantagenet and Gnowangerup)							
GNOSTIR001	Stirling Range National Park	.	38	.	52	.	.
PLAMOUR001	Mount Barker	.	0	0	3	.	.
PLANARR002	Narrikup	.	45	.	.	.	.
PLASTIR001	Stirling Range National Park	25	.	316	254	.	.
Central Wheatbelt (Narrogin and Northam)							
NARNARR002	Narrogin	0	36	19	16	.	.

Site Code	Locality	2015	2014	2013	2012	2011	2010
NARNARR004	Narrogin	.	.	9	0	.	.
NARNARR005	Narrogin	0	.	0	0	80	.
NORBAKR001	Bakers Hill	.	.	.	.	.	217
NORWUNR001	Wundowie	.	.	0	8	.	125
Southern Jarrah-Marri Forest (Bridgetown and Donnybrook)							
BRIGLER001	Glenlynn	.	0	250	70	.	.
BRINORR001	North Greenbrushes	44	74	.	.	.	.
DONDONR001	Donnybrook	0	0	11	.	.	.
DONMUMR001	Mumballup	7	.	0	.	29	.

APPENDIX V: Roost counts for Forest Red-tailed Black-Cockatoo (2015)

Appendix V: Roost counts for red-tailed black-cockatoos for the 2015 Great Cocky Count. Roost counts are likely to be of Forest Red-tailed Black-Cockatoo except as indicated. The three survey areas are: (a) Northern Darling Scarp and Plateau; (b) Perth-Peel Coastal Plain; and (c) regional (i.e. sites outside of the Greater Perth-Peel Region).

[1] white-tailed black-cockatoos also recorded roosting in 2015 GCC

[2] white-tailed black-cockatoos recorded roosting in a previous GCC (2010-2014)

[3] new roost (i.e. not surveyed before 2015 GCC)

Site Code	Locality	Survey Area	2015 Count
ALBTORR003 [3]	Torbay	Regional	2
ALBTORR004 [3]	Torbay	Regional	5
CANWILR001 [2]	Willeton	Perth-Peel Coastal Plain	16
CAPBOYR001 [3]	Gwindinup	Regional	15
CAPGELR002 [1 3]	Gelorup	Regional	11
COCCOOR001	Coolbellup	Perth-Peel Coastal Plain	13
DONDONR001 [2]	Donnybrook	Regional	6
GOSCNVR002	Canning Vale	Perth-Peel Coastal Plain	4
KALWALR001 [2]	Walliston	Northern Darling Scarp and Plateau	1
MANDAWR002 [1]	Dawesville	Perth-Peel Coastal Plain	38
MELMURR001 [1 2]	Murdoch	Perth-Peel Coastal Plain	33
MERMERR001	Merredin	Regional	526
MUNHOVR001	Hovea	Northern Darling Scarp and Plateau	14
MUNMUNR002 [3]	Mundaring	Northern Darling Scarp and Plateau	20
MUNSTOR001	Stoneville	Northern Darling Scarp and Plateau	24
NORWUNR001	Wundowie	Northern Darling Scarp and Plateau	6
ROCBALR003 [2]	Baldivis	Perth-Peel Coastal Plain	25
SERKEYR002	Keysbrook	Northern Darling Scarp and Plateau	42
STIYOKR002	Yokine	Perth-Peel Coastal Plain	1
STIYOKR003 [2]	Yokine	Perth-Peel Coastal Plain	28
TOOMORR001 [1]	Morangup	Northern Darling Scarp and Plateau	5
TRATRAR001 [3]	Trayning	Regional	697
VICKENR001 [2]	Kensington	Perth-Peel Coastal Plain	121
VICKENR002 [3]	Kensington	Perth-Peel Coastal Plain	35

The Great Cocky Count is an annual citizen-science initiative to determine the population size of black-cockatoos in Western Australia's southwest, particularly Carnaby's Black-Cockatoo in the Greater Perth-Peel Region.

The Great Cocky Count is a joint initiative between BirdLife Western Australia and the Western Australian Department of Parks and Wildlife.

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