The 2014 Great Cocky Count:

a community-based survey for Carnaby's Black-Cockatoos (*Calyptorhynchus latirostris*) and Forest Red-tailed Black-Cockatoos (*Calyptorhynchus banksii naso*)

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SUMMARY

Background

- The Great Cocky Count (GCC) is an annual, citizen science survey for 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 2014 GCC occurred on 6 April 2014. This year's GCC was the 5th consecutive count and 6th overall.
- The 2014 GCC surveyed roost sites for Carnaby's Black-Cockatoos and Forest Red-tailed Black-Cockatoos. Both are endemic to southwestern WA and are listed as threatened under State and Commonwealth legislation.

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 almost 600 registered volunteers surveyed 290 sites across the southwest. Total volunteer participation likely exceeded 700 community members.
- The minimum population count for Carnaby's Black-Cockatoos in the Greater Perth-Peel Region was 7154. The Greater Perth-Peel Region consists of the Perth-Peel Coastal Plain, which encompasses all of the Perth-Peel metropolitan area along the Swan Coastal Plain, and the Northern Darling Scarp and Plateau, which includes the northern Jarrah-Marri Forest.
- Most (59%) 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 (n = 3922) associated with the pine plantation is consistent with previous research and emphasises the importance of pines as a food resource. The Gnangara pine plantation sustains up to 10% of the species population of Carnaby's Black-Cockatoos during the non-breeding season.
- Trend analysis of roost counts for Carnaby's Black-Cockatoos in the Perth-Peel Coastal Plain found declines in both the fraction of occupied roosts and flock size over the last five years (2010-2014). The combined effect of fewer occupied roosts and fewer birds in each roosting flock is an estimated current rate of decline in the total number of Carnaby's Black-Cockatoos on the Perth-Peel Coastal Plain of 15% per year.
- The outcomes of the trend analysis should be treated with caution given the brief time period assessed and the need to assess spatial relationships among roosts. Nonetheless, if this decline continues, it is of serious concern for Carnaby's Black-Cockatoos in the Perth-Peel Coastal Plain.
- On the Perth-Peel Coastal Plain, Carnaby's Black-Cockatoos are restricted to relatively few roost sites, many of which are associated with pines. Protection of these sites and associated feeding habitat is needed to arrest the decline of Carnaby's Black-Cockatoos and ensure species persistence in this region.
- The 2014 GCC was the first focused roost count survey for FRTBC across the southwest of WA and confirmed the presence of FRTBC throughout the inner metropolitan suburbs of Perth.
- The Great Cocky Count is well placed to accurately monitor Carnaby's Black-Cockatoos and FRTBC on the Perth-Peel Coastal Plain and potentially across the range of both species because of continued growth in survey effort and the integration of statistically rigorous trend analyses.

SUMMARY

Regional Results

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

- Volunteers surveyed 186 sites in the Perth-Peel Coastal Plain and counted 6671 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 (*n* = 879 birds roosting at three sites), Curtin University/Collier Park/Technology Park in Como (*n* = 402), Dawesville (*n* = 281), Murdoch University (*n* = 234), Manning Lake in Spearwood (*n* = 168), Underwood Avenue in Floreat (*n* = 159), Hollywood Hospital in Nedlands (*n* = 114), and the City of Stirling Nursery in Karrinyup (*n* = 92).
- The population of Carnaby's Black-Cockatoos inhabiting the Perth-Peel Coastal Plain is significant at a species-scale, with four of the five largest roosts and six of the ten largest roosts for the 2014 Great Cocky Count occurring within the Perth-Peel Coastal Plain.

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

- Volunteers surveyed 44 sites in the Northern Darling Scarp and Plateau and counted 1207 white-tailed black-cockatoos, of which 40% (*n* = 483) were estimated to be Carnaby's Black-Cockatoos. The Northern Darling Scarp and Plateau encompasses the northern Jarrah-Marri Forest between Bindoon and Waroona.
- Significant white-tailed black-cockatoo counts occurred at Bullsbrook (*n* = 328 white-tailed black-cockatoos roosting), Stoneville (*n* = 189 at two sites), Gidgegannup (*n* = 163), and Helena Valley (*n* = 124).

Regional areas: white-tailed black-cockatoos

- Volunteers surveyed 60 sites in regional locations outside of the Greater Perth-Peel Region and recorded 4227 white-tailed black-cockatoos. Counts of white-tailed black-cockatoos in forested areas may include Baudin's Black-Cockatoos and Carnaby's Black-Cockatoos.
- 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 at Myrup (*n* = 791 birds roosting), Chapman Valley (*n* = 451 at two sites), Dandaragan (*n* = 460), the Capes region (*n* = 395 at five sites), Nilgen (*n* = 376), Hill River and Jurien Bay (*n* = 333 at three sites), Goode Beach in Albany (*n* = 182 at two sites), Esperance (*n* = 202), Wagerup (*n* = 186), Hopetoun (*n* = 180 at two sites), Kalgan (*n* = 141), and Gwindinup (*n* = 119).

Forest Red-tailed Black-Cockatoos (FRTBC)

- Volunteers documented roosts for FRTBC throughout the Perth-Peel region, including sites in 15 metropolitan council areas.
- Significant FRTBC roosts occurred at Murdoch University (*n* = 199 birds roosting), Floreat (*n* = 109), Kensington (*n* = 94), Munster (*n* = 92), and Yokine (*n* = 47).

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 all across the southwest of the state on a single evening in early 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 6 April 2014.

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 standardised GCC survey protocol and completed only 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 2014 GCC, additional surveys included any surveys completed before or after Sunday 6 April 2014.

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 GCC, 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 previous 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.* 2009).

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

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

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

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Background

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The 2014 GCC is the fifth consecutive GCC and the sixth overall. BirdLife Australia coordinates the count each year with significant support from the Western Australian Department of Parks and Wildlife (DPaW). Funding for the 2014 GCC came from Perth Region NRM through the Australian Government's Caring For Our Country 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) (a subspecies).[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-Cockatoos are listed as endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, while Baudin's Black-Cockatoos and FRTBC are listed as vulnerable. Listed threatened species constitute a matter of national environmental significance (MNES) under the act and receive special protection.

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 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-Cockatoos 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)

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

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-Cockatoos 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 had been 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 2010 GCC focused on Carnaby's Black-Cockatoos and on the Swan Coastal Plain and the adjacent Darling Plateau, with roost sites identified and surveyed almost exclusively within the Greater Perth-Peel Region. The 2011 GCC broadened to include the whole of southwestern WA, with the aim of gathering information about Carnaby's Black-Cockatoos across the species range. In 2014, the GCC expanded to include the identification and survey of roost sites for FRTBC as a core objective. Future GCCs could extend to identifying and surveying roost sites for Baudin's Black-Cockatoos within the Jarrah (*Eucalyptus marginata*)-Marri (*Corymbia calophylla*) Forest and Karri (*Eucalyptus diversicolor*) Forest.

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). 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. The GCC contributes to the recovery actions identified in these recovery plans. The recovery plans 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

[3] Available from: http://www.planning.wa.gov.au/dop_pub_pdf/black_cockatoos_on_swan_coastal_plain.pdf
[4] Available from: http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0061145
[5] Webpages current as of May 2014.

Carnaby's Black-Cockatoo

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

- **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 2014 GCC were to:

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

(2) identify roost sites and conduct roost counts for Carnaby's Black-Cockatoos 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-Cockatoos across five consecutive GCCs (2010-2014) for roost sites within the Perth-Peel Coastal Plain; and

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

II. METHODS

Survey Timing and Area

Timing

This year's GCC occurred on Sunday 6 April 2014. This date was chosen to maintain consistency with the timing of previous GCCs.

Survey area

The GCC survey area encompasses the geographic range of Carnaby's Black-Cockatoos and FRTBC and extends across most of southwestern WA (Figure 1). The GCC survey area also 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 the area (a) maintains significant populations of Carnaby's Black-Cockatoos and FRTBC and (b) experiences ongoing pressures from urban development, agriculture, forestry, and other land uses. The region encompasses the greater Perth-Peel metropolitan region, including 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 native and non-native species. These threats are discussed further in the recovery plans.

For 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 encompasses much of the Swan Coastal Plain and includes nearly all of the densely-populated portions of the Perth-Peel metropolitan area. Habitats in the Perth-Peel Coastal Plain include coastal heathland, Banksia woodland (principally *Banksia attenuata* and *B. menziesii*), Tuart (*Eucalyptus gomphocephala*) woodland, other eucalypt woodland, pine plantation, and various anthropogenic habitats (e.g. street trees, market gardens, nut orchards). The Northern Darling Scarp and Plateau lies largely within the northern Jarrah-Marri Forest.

Community Engagement and Training

To recruit volunteers for the 2014 GCC, we invited previous GCC volunteers to participate, and distributed information about the 2014 GCC to various community groups, NRM networks, and publications, and to a BirdLife Australia contact list. We also updated the GCC webpage on BirdLife Australia's website.[8] The webpage provided information about the GCC, including forms, protocols, and previous reports.

[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

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

To train volunteers for the GCC, we conducted workshops at locations within the greater Perth-Peel metropolitan area. The workshops were not mandatory, but provided information about the GCC, including guidance and protocols for identifying and counting black-cockatoos.

Volunteers that registered to survey for the 2014 GCC were allocated to a roost site and were provided with information about the site as well as a roost count form (Appendix I) and supporting material (e.g. a "how to" guide for conducting roost counts). The forms and supporting material were also available on the GCC webpage. To supplement the main GCC survey, some volunteers conducted additional surveys on other nights before or after 6 April.

The volunteer engagement and training process followed that used in previous GCCs and is further described in the reports for the 2010-2013 GCCs (Burnham *et al.* 2010; Kabat *et al.* 2012a; Kabat *et al.* 2012b, 2013).

Roost Site Identification

Information about the 2014 GCC also included a request for reports of roost sites for black-cockatoos. Sites reported to BirdLife Australia prior to the 2014 GCC came from community members, DPaW staff members, and other sources. Christine Groom (DPaW) provided sites identified through analysis of movement patterns involving Carnaby's Black-Cockatoos equipped with satellite telemetry tags and through field inspections of locations where birds were potentially roosting (Groom *et al.* 2013). Mark Blythman (DPaW) reported roost sites identified during field surveys for Carnaby's Black-Cockatoos during the month leading up to the 2014 GCC.

Sites in the GCC roost site database are assigned to one of three categories (confirmed roost, unconfirmed roost and potential site) based on the roost count records available for the site (see Key Terms and Abbreviations). We prioritised the allocation of observers to confirmed roosts and then to unconfirmed roosts. Potential sites received the lowest priority for observer allocation. Not all sites in the database were assigned for survey.

Roost Count Methodology

The 2014 GCC followed the standard survey methodology described in previous GCC reports (Burnham *et al.* 2010; Kabat *et al.* 2012a; Kabat *et al.* 2012b, 2013). Roost count instructions were presented on the roost count survey form and in 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 6 April 2014; (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 black-cockatoos that flew over but did not roost at the site; and (e) count the number of cockatoos in each sub-group that arrived at the site (i.e. whether the birds arrived as triplets, pairs, single individuals, or other multiples).

Species identification protocol

Distinguishing between Carnaby's Black-Cockatoos and Baudin's Black-Cockatoos is difficult, particularly during roost counts where large numbers of birds may arrive at one time. An additional difficulty is that the two

species commonly occur together in flocks. To avoid sampling error associated with incorrect species attributions, volunteers were instructed to record one overall count of the number of white-tailed black-cockatoos roosting at the site. The distributions of Baudin's Black-Cockatoos and Carnaby's Black-Cockatoos overlap in portions of the southwest, particularly in forested areas.

In contrast, even inexperienced observers can easily distinguish between FRTBC and the white-tailed black-cockatoo species because FRTBC calls (vocalisations) 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 northern sites, volunteers likely observed Inland Red-tailed Black-Cockatoos (*Calyptorhynchus banksii samueli*). The Inland Red-tailed Black-Cockatoos are a separate subspecies to the FRTBC; they occur in the northwestern Wheatbelt and Pilbara.

Data Analysis

Organisation of roost count data

We used the roost count data for the individual sites to calculate the total number of Carnaby's Black-Cockatoos (or white-tailed black-cockatoos) and FRTBC counted for five areas:

(1) Perth-Peel Coastal Plain;
(2) Northern Darling Scarp and Plateau;
(3) Greater Perth-Peel Region;
(4) outside the Greater Perth-Peel Region (i.e. regional areas); and
(5) across the species range (i.e. all sites).

The total counts for (a) outside the Greater Perth-Peel Region and (b) across the species range are presented as the total number of white-tailed black-cockatoos and red-tailed black-cockatoos counted. We combined the counts because the distributions of Carnaby's Black-Cockatoos and FRTBC overlap with the distributions of Baudin's Black-Cockatoos and Inland Red-tailed Black-Cockatoos (respectively) in these areas, and it is difficult for observers to distinguish between the two white-tailed black-cockatoo species and between the two red-tailed subspecies. Unlike the Northern Darling Scarp and Plateau, we did not have counts from expert observers from which to infer species proportions for Baudin's Black-Cockatoos and Carnaby's Black-Cockatoos in areas where mixed flocks could occur. The procedure for determining total counts of Carnaby's Black-Cockatoos in the Northern Darling Scarp and Plateau and the Greater Perth-Peel Region is described below.

Roost counts for white-tailed black-cockatoos and red-tailed black-cockatoos 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 surveyed sites that had at least one positive count (i.e. a record of one or more black-cockatoos roosting) for any GCC between 2010 and 2014.

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-Cockatoos 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). For the Northern Darling Scarp and Plateau, we reduced the total white-tailed black-cockatoo count by 0.4 to derive a corrected count of the numbers of Carnaby's Black-Cockatoos based on observations of the proportions of Baudin's Black-Cockatoos and Carnaby's Black-Cockatoos in roosting flocks. 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 Black-Cockatoos and 60% Baudin's Black-Cockatoos. As for 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, which lies largely within the Jarrah-Marri forest. The estimated species proportions for the 2014 GCC differed 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-Cockatoos 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-Cockatoos in the Perth-Peel Coastal Plain, which encompasses nearly all of the greater Perth-Peel metropolitan area. However, the fact that many sites recorded counts of zero birds roosting, and that there were many instances where surveys of known roosts were not conducted, presented certain problems for statistical analysis.

Counts of zero can reflect normal, expected variation in the use of roost sites, inaccuracy in counting, or problems with the study design (e.g. birds did not roost at such sites because they were unsuitable). Zero counts are problematic because they (1) affect estimates of average roost size and therefore any trends (Zuuer *et al.* 2009) and (2) create an excess number of zero counts in the dataset ('zero-inflation' or 'excess zeros'). These issues often arise in citizen science surveys (Kery and Schmid 2004; Schmeller *et al.* 2012) and in count data for rare species (Cunningham and Lindenmayer 2005). Missing counts (i.e. where no survey was done even though birds may have been present) also require some method of interpolating the likely number of birds present, in order to achieve a total count that is comparable between years. Using the 'raw' total counts, which reflect only those sites where surveys were done and does not account for missing sites, will give misleading results.

To deal with these issues, we used an appropriate statistical model that accounted for the large number of zero counts. This model uses a zero-inflated negative binomial distribution to account for the excess zeroes, and 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 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 the 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 the trend in roost sizes.

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) as well as site effects to allow for correlation in the repeated surveys at each site. A negative binomial distribution was appropriate to use because it allows for the potentially excess variation that may arise through various unmodeled sources of variation in the roost counts. We treated the site effects as fixed, rather than random, because the GCC roost count surveys sample a large proportion of the population of Carnaby's Black-Cockatoos 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 in simple linear regression models of counts or log-transformed counts (Cunningham and Lindenmayer 2005). Further details about this approach, including its advantages and limitations, appear in Dobbie and Welsh (2001), Sauer *et al.* (2004), Cunningham

and Lindenmayer (2005), and Humbert *et al.* (2009). The trend analysis of Carnaby's Black-Cockatoos in the Perth-Peel Coastal Plain is the subject of a scientific paper that has been submitted to a scientific journal for peer review.[9]

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 (1) occurred within or immediately adjacent (<1 km from the plantation boundary) to the plantation system or (2) have been documented as roost sites for Carnaby's Black-Cockatoos feeding in the Gnangara pine plantation (Shah 2006; Saunders 1980, Finn *et al.* 2009, Stock *et al.* 2013).

Breeding success

Black-cockatoos are often commonly observed in 'family units'. For Carnaby's Black-Cockatoos, these family units comprise a triplet – the adult mated pair and the fledgling from the current or previous breeding season. As such, the number of triplets in roosting flocks should correlate positively with the level of breeding success for the current or previous breeding season. If pairs of birds are assumed to represent breeding pairs that did not reproduce successfully, the ratio of triplets to pairs should provide a measure of breeding success. This is referred to 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 2014 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 correct counts to account for the presence of Baudin's Black-Cockatoos. We used a chi-square test of independence to test whether the proportions of triplets to pairs differed across years (2010-2014).

Statistical analysis

We used Microsoft Office Excel 2007 for descriptive statistics and IBM SPSS Statistics Version 20 for basic statistical analyses. The trend analyses were performed by Matt Williams (DPaW) using the generalised linear model procedure (GENMOD) of the SAS software (SAS Institute Inc., 2011).

[9] Williams, M. R., C. J. Yates, H. Finn, W. Stock, and G. Barrett. Submitted. Trend analysis of roost counts reveals a significant, ongoing decline of the endangered Carnaby's Black-Cockatoo.

III. RESULTS

A. Community Engagement and Training

Workshops

About 375 people attended 12 Great Cocky Count workshops conducted in March 2014. Workshops were held at locations throughout the Perth-Peel region: Mundijong (*n* = 42 attendees), Spearwood (*n* = 37), Pinjarra (*n* = 30), Leeming (*n* = 41), Wilson (*n* = 41), North Beach (*n* = 35), Lake Clifton (*n* = 25), Kalamunda (*n* = 23), Bullsbrook (*n* = about 20), Peppermint Grove (*n* = 11), Kwinana (*n* = 20), and Murdoch (*n* = about 45).

Supporters for the workshops included Canning River Eco Education Centre, Chittering Landcare Centre, City of Canning, City of Cockburn, City of Kwinana, City of Melville, City of Stirling, City of Subiaco, Coastwest, Friends of Star Swamp Bushland, Friends of Trigg Bushland, Harvey River Restoration Taskforce, Landcare Serpentine-Jarrahdale, Murdoch University, Peel-Harvey Catchment Council, Perth Region NRM, Piney Lakes Environmental Education Centre, Shire of Kalamunda, Shire of Murray, and Western Suburbs Regional Organisation of Councils (WESROC).

Volunteer participation

We assigned 322 survey sites to 592 registered volunteers (Table 1). Roost counts were conducted at 290 (90%) of these sites, a completion rate comparable to rates for the 2012 (84%) and 2013 (92%) GCCs and higher than for the 2011 (67%) GCC.

Some volunteers were assigned to conduct roost counts on one of three alternative survey dates (Saturday 5 April, Monday 7 April, and Sunday 13 April) because of strong volunteer response in certain locations. Of the volunteers that registered in 2014, 66% were new to the GCC and 34% had registered for a previous GCC. Since 2010, more than 1300 people have participated in at least one GCC as a registered volunteer.

Actual volunteer participation for the 2014 GCC likely exceeded 700 community members. Registered volunteers often received support from non-registered volunteers (e.g. family and friends). In addition, the City of Melville and Aquinas College coordinated roost counts at the Piney Lakes Reserve and Salter Point using volunteers from the Piney Lakes Environmental Education Centre and staff and students from the college, respectively. About 40 volunteers participated in the Piney Lakes survey and about 50 volunteers participated in the Salter Point survey.

Many sites were surveyed using teams of volunteers. The largest multi-observer roost count occurred at Murdoch University, where more than 70 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 five Great Cocky Counts (2010-2014). The percentages show the proportion of the total number of sites that were surveyed (a) in the Greater Perth-Peel Region and (b) outside the Greater Perth-Peel Region in each GCC, as well as the proportion of sites that were surveyed in the Perth-Peel Coastal Plain and the Northern Darling Scarp and Plateau.

	2010	**2011**	**2012**	**2013**	**2014**
No. of volunteers assigned	250	263	294	335	592
No. of sites assigned for survey	unknown	248	244	262	322
No. of sites surveyed	187	165	205	241	290
Greater Perth-Peel Region	183 (98%)	150 (91%)	157 (77%)	186 (77%)	230 (79%)
(i) Perth-Peel Coastal Plain	157 (84%)	124 (75%)	127 (62%)	144 (60%)	186 (64%)
(ii) N. Darling Scarp/Plateau	26 (14%)	26 (16%)	30 (15%)	42 (17%)	44 (15%)
Outside Greater Perth-Peel Region	4 (2%)	15 (9%)	48 (23%)	55 (23%)	60 (21%)

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

Sixty-five new sites were added to the GCC roost site database following the 2013 GCC (i.e. between April 2013 and March 2014) (Table 2). Of these, 23 (35%) were confirmed as roosts for Carnaby's Black-Cockatoos based on observations by DPaW staff or community members, including 15 confirmed by volunteers conducting formal surveys as part of the 2014 GCC (either on 6 April or on the supplementary dates of 5, 7, and 13 April).

Fourteen existing sites, which had previously been classified as unconfirmed roosts or potential sites, were confirmed as Carnaby's Black-Cockatoo roosts during the 2014 GCC (Table 2). No roost sites were reclassified as cleared.

Table 2: Number of Carnaby's Black-Cockatoo confirmed roosts, unconfirmed roosts, potential sites, and cleared sites in the GCC site database for five Great Cocky Counts (2010-2014). See page iv-v for definitions of the roost classifications. **Cleared roosts** are confirmed roosts that have been cleared of vegetation since 2010.

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

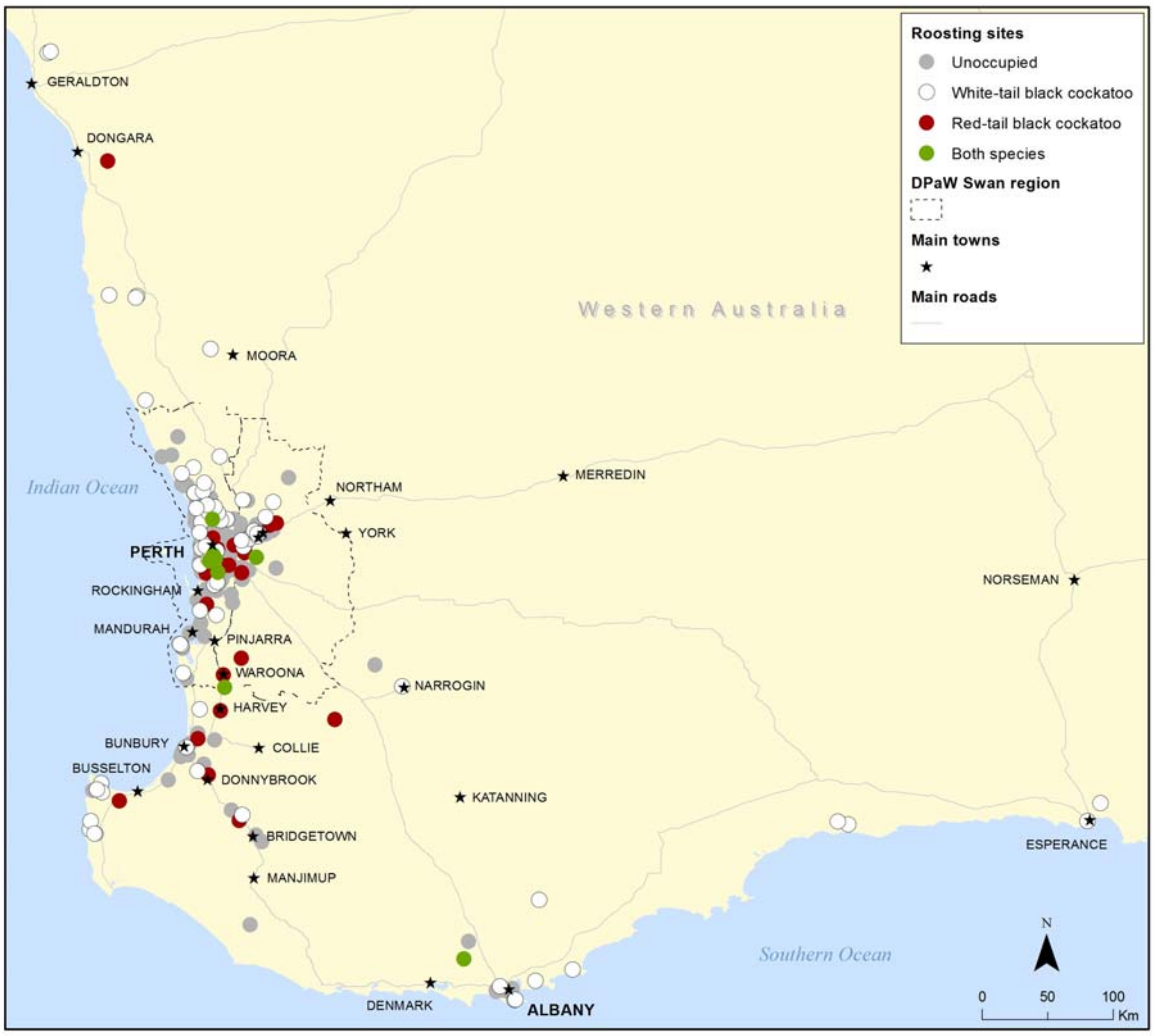

Figure 1: Location of sites (*n* = 290) where roost counts were conducted for the 2014 Great Cocky Count. Roosting sites are classified as *unoccupied* (no black-cockatoos roosting), *white-tail black cockatoo* (white-tailed black-cockatoos roosting), *red-tail black cockatoo* (red-tailed black-cockatoos roosting), or *both species* (both white-tailed black-cockatoos and red-tailed black-cockatoos roosting). The location of the DPaW Swan Region administrative area is also shown; it coincides with the Greater Perth-Peel Region. Figure Credit: Cristina Ramalho (DPaW)

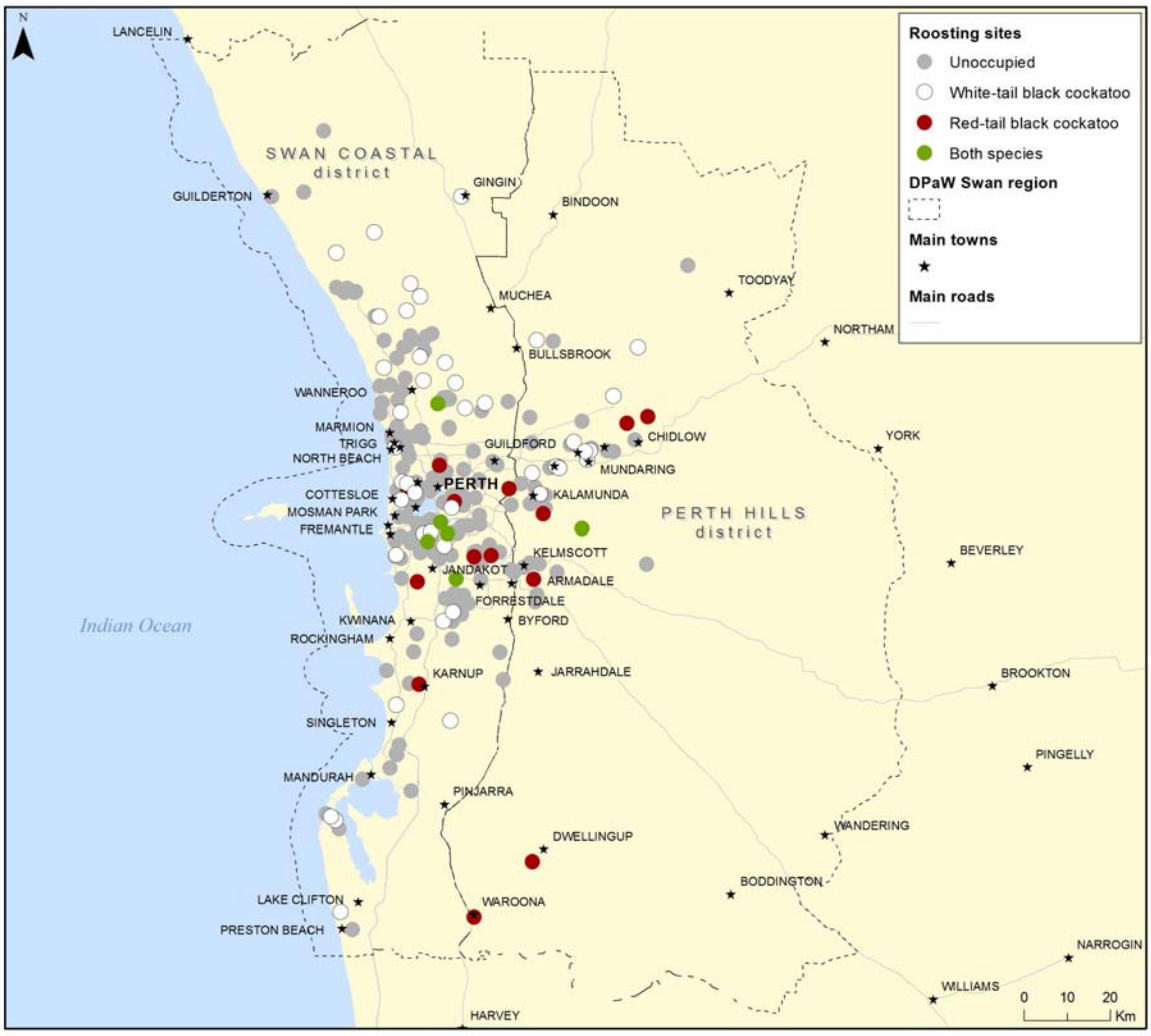

Figure 2: Location of sites (n = 230) in the Greater Perth-Peel Region where roost counts were conducted for the 2014 Great Cocky Count. Roosting sites are classified as *unoccupied* (no black-cockatoos roosting), *white-tail black cockatoo* (white-tailed black cockatoos roosting), *red-tail black cockatoo* (red-tailed black cockatoos roosting), or *both species* (both white-tailed black cockatoos and red-tailed black cockatoos roosting). The location of the DPaW Swan Region, Swan Coastal District, and Perth Hills District is also shown – these areas coincide with the Greater Perth-Peel Region, the Perth-Peel Coastal Plain, and the Northern Darling Scarp and Plateau (respectively). Figure Credit: Cristina Ramalho (DPaW)

C. Carnaby's Black-Cockatoo: Roost Counts

Survey effort

Greater Perth-Peel Region

Volunteers surveyed 230 sites in the Greater Perth-Peel Region. Roost counts occurred in 33 local government areas, with occupied roosts recorded in 20 (61%) of these councils (Appendix II). Survey effort was greatest in the City of Wanneroo, with 32 sites surveyed and 10 occupied roosts recorded.

Outside Greater Perth-Peel Region

Volunteers surveyed 60 sites outside of the Greater Perth-Peel Region (Table 1). Roost counts occurred in 22 local government areas, with occupied roosts (i.e. roosting Carnaby's Black-Cockatoos) recorded in 16 (73%) of these council areas (Appendix II). The greatest survey effort outside of the Greater Perth-Peel Region occurred in the Shire of Albany, with 10 sites surveyed and five occupied roosts recorded.

Across GCCs (2010-2014)

The number of sites surveyed has increased each year since 2011, both in the Greater Perth-Peel Region and outside of the Greater Perth-Peel Region (Table 1). Most surveyed sites have been within the Perth-Peel metropolitan area. In the last three GCCs (2012-4), for example, 60-64% of surveyed sites were located in the Perth-Peel Coastal Plain and just under 80% of surveyed sites were in the Greater Perth-Peel Region.

Total counts

Greater Perth-Peel Region

The 2014 GCC recorded the highest number of Carnaby's Black-Cockatoos counted over the last five GCCs (2010-2014) for the Perth-Peel Coastal Plain (n = 6671 birds), the Northern Darling Scarp and Plateau (n = 483 birds), and the Greater Perth-Peel Region (n = 7154 birds) (Table 3).

Outside Greater Perth-Peel Region

The 2014 GCC also recorded the highest number of white-tailed black-cockatoos counted over the last five GCCs (2010-2014) for sites outside of the Greater Perth-Peel Region (n = 4277 birds) and across the species range (n = 12105 birds) (Table 3).

Roost counts - across species range

At occupied roosts, counts for white-tailed black-cockatoos in the 2014 GCC ranged from one to 1521, with a mean of 151.3 $\pm$ 26.3 (standard error) and a median of 65 (n = 80 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 (n = 480, 782, 791, 879, 1521 birds) accounted for 37% (n = 4453) of the total number of white-tailed black-cockatoos counted (Appendices III and IV). The ten largest roost counts (n = 328, 376, 402, 450, 460, 480, 782, 791, 879, 1521 birds) accounted for 53% (n = 6469) of the total number of white-tailed black-cockatoos counted. Four 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 roost counts (*n* = 450, 480, 782, 879, and 1521 birds) accounted for 62% (*n* = 4112 of 6671) of the Carnaby's Black-Cockatoos counted in the district (Appendix IIIa). Four of these counts occurred at sites within the Gnangara pine plantation north of Perth (Appendix IIIb).

Roost occupancy rates were 48% (*n* = 38 occupied roosts out of 79 sites surveyed that had at least one positive count for any GCC between 2010-2014) for the Perth-Peel Coastal Plain (Table 4).

Across the five GCCs, the correlation of the number of sites surveyed in the Perth-Peel Coastal Plain (Table 1) and the number of Carnaby's Black-Cockatoos counted in the district (Table 3) was significant ($r^2 = 0.825$, 3 d.f., $p = 0.033$). However, the correlation between the number of sites surveyed that had a positive count in a GCC (2010-2014) and the number of Carnaby's Black-Cockatoos counted in the district was weak ($r^2 = 0.42$) and was not significant ($p = 0.247$).

Gnangara pine plantation

Volunteers recorded 3922 birds at 11 occupied roosts located within or immediately adjacent (i.e. less than 1 km from the plantation boundary) to the Gnangara pine plantation, or at two roosts in the Yanchep National Park historically used by Carnaby's Black-Cockatoos feeding in the Gnangara pine plantation (Saunders 1980, Finn *et al.* 2009, Stock *et al.* 2013) (Appendix IIIb).

In the 2014 GCC, birds roosting at sites within or associated with the Gnangara pine plantation accounted for 59% (*n* = 3922 of 6671) of the Carnaby's Black-Cockatoos counted in the Perth-Peel Coastal Plain. In previous GCCs (2010-2013), birds roosting in the Gnangara pine plantation have accounted for 27% to 43% of the Carnaby's Black-Cockatoos counted in the Perth-Peel Coastal Plain, with total counts ranging from 1063 to 2662 birds.

Other significant roosts

Significant counts were recorded at Gingin (*n* = 879 birds), Curtin University/Collier Park/Technology Park in South Perth (*n* = 402), Dawesville (*n* = 281 at two sites), Murdoch University (*n* = 234), Manning Lake in Spearwood (*n* = 168), Underwood Avenue in Floreat (*n* = 159), Hollywood Hospital in Nedlands (*n* = 114), and the City of Stirling Nursery in Karrinyup (*n* = 92) (Appendix IIIa).

Roost counts - Northern Darling Scarp and Plateau

Within the Northern Darling Scarp and Plateau, the five largest roost counts (*n* = 124, 141, 163, 182, 328 birds) accounted for 78% (*n* = 938 of 1207) of the white-tailed black-cockatoos counted in the district (Appendix IIIc).

There was no correlation between the total number of white-tailed black-cockatoos counted in the district and either the overall number of sites surveyed in the Northern Darling Scarp and Plateau ($r^2 = 0.004$, 3 d.f., $p = 0.924$) or of sites that had a positive count in a GCC (2010-2014) ($r^2 = 0.008$, 3 d.f., $p = 0.883$).

White-tailed black-cockatoos were not recorded at sites in the City of Armadale (*n* = 12 sites surveyed) and were present at only one site in the Shire of Kalamunda (*n* = 13 sites surveyed) (Appendix IIIc).

White-tailed black-cockatoos were recorded at sites in the Shire of Mundaring (*n* = 16 sites surveyed and *n* = 7 occupied roosts). Roosts were also recorded at sites in Toodyay (*n* = 56 birds), Gidgegannup (*n* = 163 birds) and

Bullsbrook (*n* = 328 birds). No sites were surveyed along the eastern margin of the Northern Darling Scarp and Plateau.

Roost counts – outside Greater Perth-Peel Region

Outside the Greater Perth-Peel Region, the five largest roost counts (*n* = 250, 262, 376, 460, 791 birds) accounted for 50% (*n* = 2139 of 4227) of the white-tailed black-cockatoos counted in this area (Appendix IV). These sites were located in Hill River, Nanson, Nilgen, Dandaragan and Myrup, respectively.

Areas with significant counts included Chapman Valley (*n* = 451 birds at two sites), the northern Swan Coastal Plain (*n* = 460 at Dandaragan; *n* = 333 at three sites in the Hill River/Jurien Bay region; and *n* = 376 at Nilgen), Wagerup (*n* = 186), Gwindinup (*n* = 119), the Capes region (*n* = 395 at five sites), Goode Beach in Albany (*n* = 182 at two sites), a pine plantation in Kalgan (*n* = 141 birds), Hopetoun (*n* = 180 birds at two sites), Esperance (*n* = 202), and a pine plantation in Myrup (*n* = 791) (Appendix IV).

Breeding success

The proportion of white-tailed black-cockatoos flying into roosts (*n* = 43 sites with group counts reported) as pairs or as triplets was similar to the proportions observed in previous GCCs (2010-2013) (Table 5). The proportions of birds arriving as pairs or triplets did not differ significantly across years (chi-square = 3.05, 4 d.f., *p* = 0.550).

Table 3: Roost count summary for Carnaby's Black-Cockatoos across five Great Cocky Counts (2010-2014). The counts for the **Perth-Peel Coastal Plain** are assumed to include only Carnaby's Black-Cockatoos. The counts for the **Northern Darling Scarp and Plateau** are corrected to account for the presence of both white-tailed black-cockatoo species (Baudin's Black-Cockatoo and Carnaby's Black-Cockatoo). The counts for the **Greater Perth-Peel Region** represent the combined counts for Carnaby's Black-Cockatoos from the two districts. The counts for (a) **outside the Greater Perth-Peel Region** and (b) **across species range** represent the totals counts for white-tailed black-cockatoos and are not corrected for the presence of both white-tailed 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-Cockatoos

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

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

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

Table 4: Number of surveyed sites, number of occupied roosts, number of new roosts discovered, and roost occupancy rates for Carnaby's Black-Cockatoos in the Perth-Peel Coastal Plain and white-tailed black-cockatoos in the Northern Darling Scarp and Plateau for five Great Cocky Counts.

Sites with a positive count in a GCC had a record of ≥1 white-tailed black-cockatoo roosting in at least one GCC (2010-2014). **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 (2010-2014) 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 they were surveyed or in a subsequent GCC. **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 in that district 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 (2010-2014).

	2010	2011	2012	2013	2014	Total
No. of sites surveyed that had a positive count in a GCC						
Perth-Peel Coastal Plain	58	57	59	70	79	89
Northern Darling Scarp and Plateau	18	18	21	28	28	38
% of all sites that had a positive count in a GCC						
Perth-Peel Coastal Plain (*n* = 89 sites)	65%	64%	66%	79%	89%	-
Northern Darling Scarp and Plateau (*n* = 38 sites)	47%	47%	55%	74%	74%	-
No. of new roosts discovered						
Perth-Peel Coastal Plain	58 (65%)	11 (12%)	10 (11%)	5 (6%)	5 (6%)	-
Northern Darling Scarp and Plateau	18 (47%)	7 (18%)	5 (13%)	4 (11%)	4 (11%)	-
No. of occupied roosts (% of all sites surveyed)						
Perth-Peel Coastal Plain	35 (22%)	37 (30%)	26 (20%)	34 (24%)	38 (20%)	-
Northern Darling Scarp and Plateau	15 (58%)	13 (50%)	15 (50%)	14 (33%)	12 (27%)	-
Roost occupancy rate						
Perth-Peel Coastal Plain	60%	65%	44%	49%	48%	-
Northern Darling Scarp and Plateau	83%	72%	71%	50%	43%	-

Table 5: The number of white-tailed black-cockatoos arriving at roosts in groups of two (i.e. a pair) or three (i.e. a triplet) for five years (2010-2014). The percentages that were pairs or triplets are shown 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-Cockatoos.

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%)

D. Carnaby's Black-Cockatoo: Trend Analysis for the Perth-Peel Coastal Plain (2010-2014)

General survey trends

The number of sites surveyed in the Perth-Peel Coastal Plain varied from 124 to 186 across the five GCCs (2010-2014) (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 rates for new roosts declined, with most (65%) roosts discovered in 2010 and few (only ten) new roosts discovered in 2013 and 2014.

Positive counts (i.e. $\geq$ 1 Carnaby's Black-Cockatoo roosting) were recorded at 89 sites (Table 4). From 2010-2012, volunteers surveyed 64-66% of these sites in each GCC. In 2013 and 2014, volunteers observed 79% and 89% of these sites, respectively. Three sites (ROCBALR001, COCSCCR001, and COCSCCR002) were cleared prior to the 2011 GCC (the Baldivis site) and the 2012 GCC (the two Success sites) (Appendix IIIa). If these site removals are considered, then volunteers surveyed 65% (2011), 69% (2012), 81% (2013), and 92% (2014) of the sites with positive counts.

Largest roosts

The ten largest roosts (combined across years) accounted for over half (54.4%, n = 14320 of 26339) of the Carnaby's Black-Cockatoos counted in the 2010-2014 GCCs within the Perth-Peel Coastal Plain (Appendix IIIa). Five of these sites are within the Gnangara pine plantation (WANPINR001, GINYEAR001, SWAMELR001, WANMARR003, WANPINR001). The other five sites were located at Gingin (GINGINR001), Curtin University/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 23.6% (n = 6218 of 26339) of the Carnaby's Black-Cockatoos counted in the five GCCs. Six of these roosts were within or associated with the Gnangara pine plantation (WANTWOR001, WANYANR006, WANPINR002, WANNEER002, WANYANR003, WANYANR001). The other five sites were located at Hollywood Hospital in Nedlands (NEDNEDR001), Manning Lake in Spearwood (COCHAMR001), Star Swamp in North Beach (STINORR001), and Lake Preston (WARPRER001).

Overall, the 40 largest roosts accounted for 93.8% (n = 24713 of 26339) of the Carnaby's Black-Cockatoos counted in the Perth-Peel Coastal Plain across the five GCCs.

Occupancy rate

The fraction of occupied roosts within the Perth-Peel Coastal Plain declined at a rate of approximately 4.2% per year (year trend parameter = 0.18, Wald Chi-square = 4.76, p = 0.03, equivalent to an annual decline in occupancy rate of 4.2-4.5%) (Figure 3). This decline is statistically significant and equates to the loss of about 2.7 roosts per year of the average 65 surveyed roosts. The trends for pine-associated roosts and non-pine-associated roosts are not significantly different; however, both are declining.

Roosting flock size

The average number of birds in each roosting flock within the Perth-Peel Coastal Plain declined at approximately 6.8% per year (year trend parameter = -0.07, Wald Chi-square = 1.48, p = 0.22) (Figure 4). This decline is not statistically significant, but equates to the loss of about 2.9 birds per year from the overall median of around 43

birds at each roost. The trends for pine-associated roosts and non-pine-associated roosts are not significantly different; both are declining.

Between 2010 and 2014 the estimated total decline in the abundance of Carnaby's Black-Cockatoo, incorporating the declines in both roost site occupancy and average roost size, was 45%, or an estimated past rate of change of 13.8% per year. The current (2014) rate of decline is 14.9%.

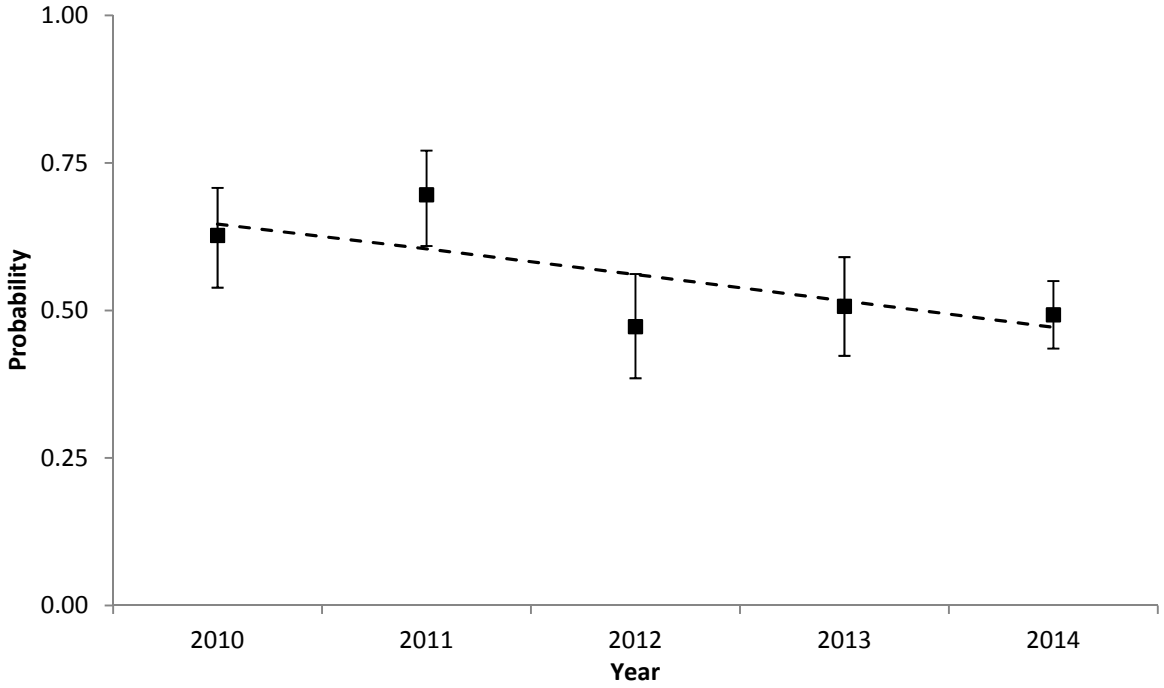

Figure 3: Estimated roost occupancy rate for Carnaby's Black-Cockatoos in the Perth-Peel Coastal Plain for five Great Cocky Counts (2010 – 2014), estimated using a log-linear zero-inflated regression model (filled symbols with standard error and estimated trend).

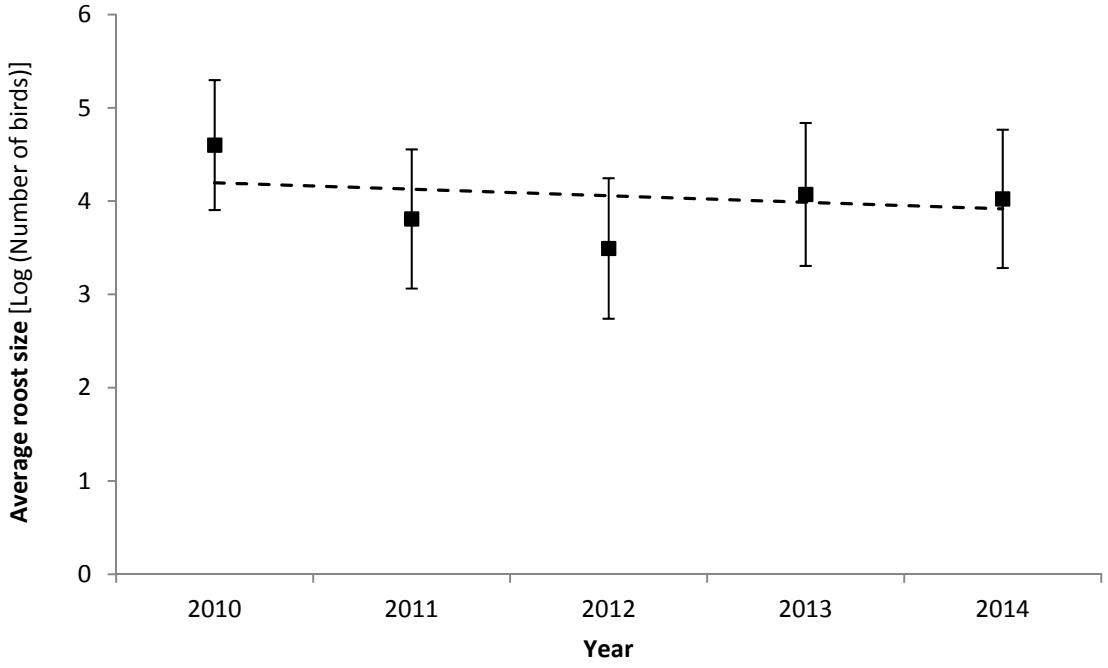

Figure 4: Average roost size (log scale) for Carnaby's Black-Cockatoos in the Perth-Peel Coastal Plain for five Great Cocky Counts (2010 – 2014), estimated using a log-linear zero-inflated regression model (annual estimates with standard errors and estimated trend).

E. Forest Red-tailed Black-Cockatoo

Roost Site Identification

Perth-Peel Coastal Plain

FRTBC were recorded at roosts in 12 local government areas across the Perth-Peel Coastal Plain: Canning, Cambridge, Cockburn, Gosnells, Kalamunda, Melville, Rockingham, South Perth, Stirling, Victoria Park, and Wanneroo. The 2013 GCC and additional surveys also confirmed two roost sites in the City of Mandurah. There are unconfirmed roosts in five other local government areas in the Perth-Peel Coastal Plain: Bayswater, Fremantle, Joondalup, Kwinana, and Vincent.

Northern Darling Scarp and Plateau

Volunteers recorded FRTBC at roost sites in five local government areas within the Northern Darling Scarp and Plateau: Kalamunda, Armadale, Mundaring, Waroona, and Murray. Previous GCCs (including additional surveys) also identified confirmed roosts in the City of Swan, Shire of Serpentine-Jarrahdale, and Shire of Toodyay. There is also an unconfirmed roost in the Shire of Chittering.

Outside Greater Perth-Peel Region

FRTBC were recorded at roost sites in eight local government areas outside of the Greater Perth-Peel Region: 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. Birds at the other locations are likely to be Forest Red-tailed Black-Cockatoos.

Roost Counts

FRTBC were recorded roosting at 29 sites across the GCC survey area, with most (69%) sites occurring within the Greater Perth-Peel Region (Table 6; Appendix V). Thirteen (45%) of the roosts were new sites that had not been surveyed prior to the 2014 GCC; five had been reported by community members specifically as FRTBC roosts.

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 total number of FRTBC counted in the Greater Perth-Peel Region and 60% of total number of FRTBC counted across the species range.

FRTBC were recorded at 10% of all sites surveyed across the GCC survey area (n = 29 of 290 sites) and 15% of sites outside of the Greater Perth-Peel Region (n = 9 of 60 sites). Within the Greater Perth-Peel Region, volunteers recorded FRTBC at 7% of sites in the Perth-Peel Coastal Plain (n = 13 of 186 sites) and 16% of sites in the Northern Darling Scarp and Plateau (n = 7 of 44 sites).

Volunteers recorded eight roosts where both FRTBC and white-tailed black-cockatoos roosted (Appendix V). Seven other FRTBC roosts, while not used as roosts by white-tailed black-cockatoos in 2014, had positive counts of white-tailed black-cockatoos in previous GCCs (2010-2013).

Roost counts for FRTBC ranged from two to 199, with a mean of 31.0 $\pm$ 8.1 (standard error) and a median of 17 (n = 29 roosts).

Table 6: Summary of roost counts for red-tailed black-cockatoos in the 2014 Great Cocky Count. Counts within the Greater Perth-Peel Region are assumed to be Forest Red-tailed Black-Cockatoos. 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**	616 (*n* = 13 roosts)
No. of FRTBC counted in **Northern Darling Scarp and Plateau**	148 (*n* = 7 roosts)
No. of FRTBC counted in **Greater Perth-Peel Region**	764 (*n* = 20 roosts)
No. of red-tailed black-cockatoos counted **outside of Greater Perth-Peel Region**	134 (*n* = 9 roosts)
No. of red-tailed black-cockatoos counted **across the species range**	898 (*n* = 29 roosts)

IV. DISCUSSION

Community Engagement and Training

Participation in the 2014 count

The 2014 Great Cocky Count included almost 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 larger citizen science surveys of its kind in Australia. Volunteers surveyed 290 sites at locations 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+ participant) groups at Murdoch University, Piney Lakes, and Salter Point (Aquinas College).

Workshops

About 375 people attended training workshops in 2014. While not all workshop attendees ultimately participated in the 2014 GCC, it is likely that most participants in the 2014 GCC had either participated in a previous GCC or had attended a training workshop. Informal feedback from GCC participants and NRM staff indicated strong support for holding workshops in regional areas.

Volunteer retention

More than 1300 volunteers have participated in at least one GCC since 2010. Volunteer fidelity is reasonably strong, with 34-47% of the volunteers for the 2012-2014 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 exceeds 50%. Most survey sites were unoccupied at the time of the GCC and many volunteers expressed disappointment at not being able to survey black-cockatoos at their site.

Ongoing monitoring

Groups of 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 town of Gingin, a roost in Bullsbrook, and roosts in the Yanchep National Park and surrounds. Regular roost monitoring also occurs in Nilgen and at a few other locations.

Evaluation of community engagement and training

Though there is room for improvement, the Great Cocky Count remains an effective approach 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 collect; (3) confidence that observations are collected according to a valid scientific protocol; (4) 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) 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 2014 included the delivery of more than ten training workshops across the Perth-Peel region and the 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 and other interactive approaches;
- developing and supporting volunteers to 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; and
- facilitating interaction with GCC staff and with the community of GCC volunteers.

Carnaby's Black-Cockatoo: Roost site identification

Community reporting of roost sites remains a useful means of identifying new roosts for Carnaby's Black-Cockatoos in rural and peri-urban areas in the Greater Perth-Peel Region and in regional areas across the species range. New, significant roosts for this species continue to be identified in these areas.

In contrast, it is likely that nearly all of the intensively utilised roosts in the urban portions of the Perth metropolitan area have 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 food resources changes.

The rate of discovery for new roosts in the Perth-Peel Coastal Plain has declined steadily since 2010. Many of the confirmed roosts identified in the district since 2012 have been identified through a research program combining the satellite telemetry tracking of Carnaby's Black-Cockatoos released from rehabilitation centres with field surveys to inspect potential roost sites and conduct roost counts when birds are present (Christine Groom, DPaW, unpublished data; Groom *et al.* 2013). Field surveys by Mark Blythman (DPaW) have also identified 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 district. New 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 Carnaby's Black-Cockatoos (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 new roost sites discovered has declined steadily, suggesting that the GCC surveys a substantial fraction of the occupied roosting sites for Carnaby's Black-Cockatoos 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 within or 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 counted in each GCC, there is currently no reliable approach for estimating the proportion of Carnaby's Black-Cockatoos that go undetected in each GCC. Without this information, the GCC count data can only provide a minimum population count. 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-Cockatoos. 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 and the 'zero-inflated' nature of the dataset.

However, given that the GCC appears to survey a large fraction of the population of the Carnaby's Black-Cockatoos 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-Cockatoos on the Perth-Peel Coastal Plain

Based on the 2014 GCC and previous GCCs, several inferences can be made about the abundance and distribution of Carnaby's Black-Cockatoos in the Perth-Peel Coastal Plain, which encompasses all of the Perth-Peel metropolitan area on the Swan Coastal Plain.

(1) Carnaby's Black-Cockatoos occur 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 17% of the species population occurred 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 almost 10% of the species occurred within the remaining portions of the Gnangara pine plantation in early April 2014.

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

Significant roosts where Carnaby's Black-Cockatoos roost consistently in large (90+) numbers include the Gingin townsite; Curtin University/Collier Park/Technology Park in South Perth; bushland in Dawesville; Murdoch University and associated roosts in nearby reserves; Manning Lake and associated roosts in Spearwood; Underwood Avenue in Floreat; Hollywood Hospital and associated roosts in Nedlands; and 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 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-Cockatoos inhabiting the Perth-Peel Coastal Plain is not increasing. In the 2006 GCC, for example, 26 volunteers surveyed 13 sites in the district and counted 4510 Carnaby's Black-Cockatoos (Shah 2006). By contrast, over 300 volunteers surveyed 186 sites during the 2014 GCC. The 2010 count (6330 birds) was also similar to the 2014 count (6330 birds vs. 6671 birds) despite substantial increases in the number of sites (157 vs. 186) and known roosts (58 vs. 79) surveyed.

Populations of Carnaby's Black-Cockatoos are declining in the Perth-Peel Coastal Plain

There are strong indications that Carnaby's Black-Cockatoos in the Perth-Peel Coastal Plain are experiencing an ongoing decline. Trend analysis of roost counts over the last five GCCs found that the combined rate of decline of roost occupancy and roost size between 2010 and 2014 was 13.8% with a current (2014) rate of decline of 15% per year. Such a rapid decline may manifest in the loss of flocks associated with particular roosts and, if this trend continues, it is of serious concern for Carnaby's Black-Cockatoos in the Perth-Peel Coastal Plain.

It is not clear to what extent the decline reflects (e.g.) mortality of adult birds, reduced survivorship of juvenile birds, reduced breeding effort or success, migration of birds from the Perth-Peel Coastal Plain, or the displacement of birds from existing to new roost sites. Further research is needed to elucidate the contribution of these factors to the decline. Nonetheless, it would be prudent to take a precautionary approach until a better understanding of the demographics of Carnaby's Black-Cockatoos in the area emerges.

Feeding and roosting habitats on the Perth-Peel Coastal Plain are subject to development pressure, 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. Further native vegetation – particularly Banksia woodland, a key feeding habitat for Carnaby's Black-Cockatoos (Johnston 2013) – will be cleared to support urban development in the Perth-Peel region (WAPC and DoP 2010). Urban infill will also remove food plants in suburban landscapes (e.g. backyards, road verges) (Groom *et al.*, in press). Many of the urban and suburban roosts are associated with remnant stands of mature or senescent pine left over from 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 and the natural senescence of the trees.

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

Almost 4000 Carnaby's Black-Cockatoos were recorded in roosts within or associated with the Gnangara pine plantation in the 2014 GCC. This abundance is consistent with previous reports for Carnaby's Black-Cockatoos in the plantation system (Perry 1948; Saunders 1974, 1980; Shah 2006; Finn *et al.* 2009; Johnstone *et al.* 2010; Stock *et al.* 2013). The observers who recorded the larger counts within the plantation system in the 2014 GCC were highly experienced observers.

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, and 3000 in Landsdale in March 2005, as well as flocks of 5-7000 in Tamala Park in April 2003, 7000 in Yanchep National Park in July 2006 and 8-10 000 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.[10] Finn *et al.* (2009) reported, based on observations conducted between January and May 2009, that large (~3000 birds) concentrations of Carnaby's Black-Cockatoos use the Gnangara pine plantation during the non-breeding season. Given these reports and their consistency with the count recorded for the Gnangara plantation system in the 2014 GCC, it is likely that 3000 to 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. The pine plantation 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 shift between roosting locations, both from day to day and from year to year, making it difficult to determine how to allocate observers. For example, 800 birds were recorded at a pine roost (WANPINR011) along the western edge of Lake Pinjar in the 2013 GCC and only 35 birds roosting at another pine roost (WANPINR001) at the northern edge of the lake, near the Pinjar power station. In the 2014 GCC, no birds were recorded at WANPINR011 but 1521 roosted at WANPINR001.

Harvesting without replacement of the remaining pine in the Gnangara pine plantation will remove a food source that currently supports up to 10% of the species population between January-April each year. The impact of this loss should not be underestimated, particularly when the species in question is listed as endangered under the federal environmental law. The loss of the food source is readily described as an impact that is "important, notable or of consequence, having regard to its context or intensity"[11] 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).

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-Cockatoos 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-Cockatoos occur in low densities along 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-Cockatoos occur consistently throughout the western margin of the Jarrah-Marri Forest, though typically in low densities.

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

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

There are few GCC records for roosts along the southern and eastern portions of the Northern Darling Scarp and Plateau. Carnaby's Black-Cockatoos appear 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-Cockatoos 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 proportion of 80% Baudin's Black-Cockatoo-20% Carnaby's Black-Cockatoo to obtain a count of Carnaby's Black-Cockatoos from an overall account of white-tailed black-cockatoos based on the roost counts of expert observers at the time of each GCC. This year, roost counts by expert observers indicated a species proportion of 60% Baudin's Black-Cockatoo-40% Carnaby's Black-Cockatoo. The higher overall count of Carnaby's Black-Cockatoo in the Northern Darling Scarp and Plateau this year (n = 483 birds) reflects the change in species proportion (cf. an overall count of 386 Carnaby's Black-Cockatoos out of 1929 white-tailed black-cockatoos in the 2010 GCC).

Further work is required to clarify the species proportions of Baudin's Black-Cockatoos 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 regional 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-Cockatoos in 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-Cockatoos 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-Cockatoos 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 (>200 birds) roosts accounted for the majority of Carnaby's Black-Cockatoos recorded in regional areas in the 2014 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-Cockatoos

Identification of new roost sites for FRTBC

The 2014 GCC was the first broad-scale roost count survey for Forest Red-tailed Black-Cockatoos, with volunteers documenting 29 FRTBC roosts. The survey was conducted in tandem with the survey for Carnaby's Black-Cockatoos and relied on the existing GCC roost site database, which was developed specifically for Carnaby's Black-Cockatoos. 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 in Como (SOUCOMR001) as well as two roosts in the Underwood Avenue area in Floreat (CAMFLOR001 and CAMFLOR002).

Distribution of FRTC in the Perth metropolitan area

Two clear outcomes emerged from the 2014 GCC: (a) FRTBC roosted at sites throughout the Perth metropolitan area, including roosts in the northern, western, and southern suburbs and (b) very large (90 – 200 birds) FRTBC roosts occurred at several suburban sites. Observations from the 2013 and 2014 GCCs confirmed roosts in 13 local government areas in the Perth-Peel Coastal Plain, with unconfirmed roosts reported in another five local government areas. 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 support 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 2014 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 by GCC volunteers also indicate that FRTBC 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 five GCCs have identified several hundred black cockatoo roosts across the southwest and involved more than 1000 volunteers in surveys. In the Greater Perth-Peel Region, the GCC provides valuable information on the location and use of black-cockatoo roosts and on potential population trends. This information has improved land-use planning and environmental impact assessment and informed conservation efforts for black-cockatoo at all levels of government. More broadly, the GCC has raised community and industry awareness about the threatened status of black-cockatoos and the need to protect roosts and feeding habitat in local areas. These are tangible successes reflecting the contributions of hundreds of community members. Ongoing investment in volunteer training and engagement is needed, 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 West Australia community.

The 2014 GCC and the trend analyses of the five GCCs have identified several findings that have important implications for black-cockatoo conservation efforts. Firstly, there are strong indications that the population of Carnaby's Black-Cockatoos inhabiting the Perth-Peel Coastal Plain is declining. Secondly, the Gnangara pine plantation sustains up to 10% of the species population of Carnaby's Black-Cockatoos during the non-breeding season. Finally, FRTBC 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 Banksia woodland, and the protection of roosts and food plants throughout the region.

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How to Do a Roost Count

1) **Arrive at your allocated roost site at least 30 minutes before sunset** so you are in position & ready to record birds as they arrive (in Perth, arrive before 5.30pm on Sunday 6 April 2014).
2) **Count all white-tailed black-cockatoos that roost at the site for at least 30 minutes before and at least 30 minutes after sunset** (in Perth, count from at least 5.30pm to 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.
   - If 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) **Send completed forms** to greatcockycount@birdlife.org.au or the mailing address below.

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.

Name of lead observer(s):	**Telephone:**	**Email:**
Ima Redtail	9287 2251	greatcockycount@birdlife.org.au
Name of additional observer(s):	**Telephone:**	**Email:**
Ima Carnaby	0400 177 615	greatcockycount@birdlife.org.au

Site code: eg SOUCOMR001	**Address/Location** (describe site location):
SOUCOMR001	Curtin University/Collier Park Golf Course/Technology Park, corner of Hayman Road and Kent Street, Bentley

GPS location in either UTM (Universal Transverse Metric) or Latitude/Longitude:

UTM Easting 7 digits - e.g. 0384667	**UTM Northing** 7 digits - e.g. 0384667	**Latitude** e.g. 32° 26′ 52″ Deg / Min / Sec	**Longitude** e.g. 115° 46′ 10″ Deg / Min / Sec	**Accuracy** (meters)
		31 / 59 / 38	115 / 53 / 4	5 meters

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

X Pine □ Eucalypt □ Marri □ Jarrah □ Tuart Other: _____ □ Not Known

Date:	Time start:	Time finish:	Site code:
6 April 2014	5.15 pm	6.40 pm	SOUCOMR001

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
4, 3, 20, 15, 10, 2, 3, 2, 1, 4, 3, 14, 2, 1, 1, 2, 2, 5, 8, 34, 2, 2, 3	143
Total Number of White-Tailed Cockatoos at the Roost	**143**
Total Number of Red-Tailed Cockatoos at the Roost	0

Direction from which cockatoos arrived

☐North ☐South ☐East ☐West ☐Other (e.g. SW): **NE**

Comments

Most cockatoos moved to the north side of Hayman Road after dark. We did not see any red-tailed black cockatoos. Cockatoos may have been drinking from a backyard a little to the NE.

Please send completed forms to:

Hugh Finn, Great Cocky Count Coordinator, BirdLife Australia
Peregrine House, 167 Perry Lakes Drive, Floreat, WA 6014
E greatcockycount@birdlife.org.au
T 9287 2251 or 0400 177 615

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.

APPENDIX II: Number of sites surveyed across local government areas (2014)

Appendix II: Number of roost sites surveyed and number of occupied roosts for white-tailed black-cockatoos in local government areas in the 2014 Great Cocky Count. The number of **occupied roosts** (see page v) is shown in parentheses.

Shire of Gingin: One surveyed site and one occupied roost were located outside of the Greater Perth-Peel Region (#).

Shire of Waroona: One surveyed site and one occupied roost were located outside of the Greater Perth-Peel Region (*).

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	2 (2)	Shire of Donnybrook	2 (0)
Shire of Ravensthorpe	2 (2)	City of Bunbury	3 (1)
Shire of Plantagenet	2 (1)	Shire of Harvey	5 (1)
Shire of Gnowangerup	1 (1)	Shire of Waroona	1* (1*)
Shire of Albany	10 (5)	Shire of Williams	1 (0)
Shire of Manjimup	1 (0)	Shire of Narrogin	1 (1)
Shire of Augusta-Margaret River	4 (3)	Shire of Cuballing	1 (0)
Shire of Busselton	5 (3)	Shire of Gingin	1# (1)#
Shire of Dardanup	1 (0)	Shire of Dandaragan	4 (4)
Shire of Capel	6 (1)	Shire of Irwin	1 (0)
Shire of Bridgetown	4 (1)	Shire of Chapman Valley	2 (2)
Greater Perth-Peel Region			
City of Armadale	12 (0)	Town of Mosman Park	1 (0)
City of Bayswater	2 (0)	Shire of Mundaring	16 (7)
City of Belmont	2 (0)	Shire of Murray	1 (0)
Shire of Beverley	1 (0)	City of Nedlands	6 (1)
Town of Cambridge	4 (2)	City of Perth	1 (0)
City of Canning	6 (1)	City of Rockingham	5 (1)
Town of Claremont	2 (1)	Shire of Serpentine Jarrahdale	9 (2)
City of Cockburn	10 (2)	City of South Perth	3 (2)
City of Fremantle	2 (0)	City of Stirling	14 (1)
Shire of Gingin	5# (2#)	City of Subiaco	4 (0)
City of Gosnells	7 (0)	City of Swan	15 (6)
City of Joondalup	10 (1)	Shire of Toodyay	2 (1)
Shire of Kalamunda	12 (1)	Town of Victoria Park	5 (0)
King's Park	4 (0)	City of Vincent	2 (0)
City of Kwinana	5 (1)	City of Wanneroo	32 (10)
City of Mandurah	10 (3)	Shire of Waroona	3*(1*)
City of Melville	15 (5)		

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

Appendix IIIa: Great Cocky Count (2010-2014) roost counts for Carnaby's Black-Cockatoos 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	2014	2013	2012	2011	2010
ARMARMR001	Armadale	0	0	.	.	.
ARMFORR001	Forestdale	0	0	.	.	.
ARMHARR001	Harrisdale	0	.	0	0	.
ARMKELR001	Kelmscott	0	0	0	0	14
CAMCITR001	City Beach	2	.	.	.	.
CAMFLOR001	Floreat	159	157	148	151	237
CAMFLOR002	Floreat	0	.	.	.	.
CANFERR001	Ferndale	0	5	.	.	.
CANWILR001	Willeton	68	0	0	0	0
CLASWAR001	Swanbourne	3	0	0	.	.
COCBANR002	Banjup	53	.	.	.	.
COCBIBR003	Bibra Lake	0	0	.	0	0
COCFORR001	Forrestdale	0	.	.	.	.
COCFORR002	Forrestdale	0	.	.	.	.
COCHAMR001	Hamilton Hill	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	0	252
COCSCCR002	Success	cleared	cleared	cleared	3	15
GINGINR001	Gingin	879	686	432	378	392
GINGUIR001	Guilderton	0	.	.	.	.
GINWOOR001	Woodridge	0	30	0	119	113
GINYEAR001	Yeal	782	.	387	.	.
GINYEAR002	Yeal	.	.	.	92	49
GOSCNVR001	Canning Vale	0	.	.	19	0
GOSCNVR002	Canning Vale	0	52	26	.	.
JOODUNR001	Duncraig	0	0	60	.	.
JOOPADR001	Padbury	7	17	1	.	0
JOOWARR001	Warwick	0	0	.	60	0
KINKINR001	Kings Park	.	0	0	.	0
KWICASR001	Casuarina	19	0	.	.	2
KWIWANR001	Wandi	0	1	0	0	63

Site Code	Locality	2014	2013	2012	2011	2010
KWIWANR002	Wandi	0	0	.	.	.
KWIWANR003	Wandi	0	.	.	.	.
KWIWELR001	Wellard	0	50	15	.	.
MANCOOR002	Coodanup	0	21	.	.	.
MANDAWR002	Dawesville	257	0	11	199	371
MANDAWR004	Dawesville	24	0	.	.	159
MANDAWR005	Dawesville	0	0	.	30	.
MELBATR001	Bateman	0	0	0	0	8
MELLEER001	Leeming	70	0	12	0	0
MELMURR001	Murdoch	234	127	142	60	700
MELWINR001	Winthrop	41	70	81	56	.
MELWINR003	Winthrop	9	0	80	130	117
MELWINR004	Winthrop	2	0	0	0	0
NEDDALR003	Dalkeith	0	0	0	90	40
NEDDALR004	Dalkeith	0	.	.	.	.
NEDNEDR001	Nedlands	114	183	304	103	73
NEDNEDR002	Nedlands	0	.	.	.	.
ROCBALR001	Baldivis	cleared	cleared	cleared	cleared	346
ROCBALR003	Baldivis	0	4	0	78	.
ROCBALR004	Baldivis	0	0	0	5	.
ROCSECR001	Secret Harbour	6	0	0	.	0
SERKEYR001	Keysbrook	3	100	.	.	0
SEROAKR001	Oakford	0	0	.	110	0
SEROAKR002	Oakford	.	2	0	0	0
SEROAKR003	Oakford	0	0	0	0	167
SEROAKR004	Oakford	50	0	0	3	45
SEROAKR005	Oakford	0	0	.	0	31
SOUCOMR001	Como	402	301	558	645	408
SOUSALR001	Salter Point	5	0	0	0	12
SOUSOUR002	South Perth	0	0	0	35	0
STIKARR001	Karrinyup	92	121	.	.	.
STIMENR001	Menora	0	0	.	.	.
STIMENR002	Menora	0	.	.	.	.
STINORR001	North Beach	0	267	0	230	0
STIYOKR001	Yokine	.	0	0	0	.
STIYOKR003	Yokine	0	.	0	0	0
SUBSHER001	Shenton Park	0	9	0	0	0
SWABALR001	Ballajura	0	92	0	40	0

Site Code	Locality	2014	2013	2012	2011	2010
SWABALR004	Ballajura	0	.	.	.	0
SWAELLR001	Ellenbrook	14	.	.	.	.
SWALEXR001	Lexia	181	0	0	80	0
SWALEXR002	Lexia	0	0	.	0	185
SWAMELR001	Melaleuca	480	20	0	41	500
SWAVINR002	The Vines	0	.	.	.	.
SWAWHIR001	Whiteman Park	.	.	13	69	.
VICKENR001	Kensington	0	0	0	.	0
VICVICR001	Victoria Park	0	0	0	0	2
WANCARR001	Carabooda	.	.	2	.	.
WANCARR004	Carabooda	7	.	.	.	.
WANCRRR001	Carramar	0	191	.	.	.
WANGNAR003	Gnangara	0	0	0	14	0
WANGNAR004	Gnangara	0	0	0	0	27
WANGNAR005	Gnangara	0	100	.	.	.
WANGNAR006	Gnangara	40	.	.	.	.
WANJANR002	Jandabup	.	.	.	.	.
WANJANR005	Jandabup	.	.	0	.	0
WANJANR007	Jandabup	.	0	.	16	.
WANMARR001	Mariginiup	.	0	.	20	0
WANMARR002	Mariginiup	3	3	2	.	0
WANMARR003	Mariginiup	147	16	10	152	542
WANNEER001	Neerabup	0	.	.	29	.
WANNEER002	Neerabup	0	0	0	0	604
WANNOWR001	Nowergup	0	10	35	.	.
WANPINR001	Pinjar	1521	35	853	.	.
WANPINR002	Pinjar	138	0	276	312	.
WANPINR003	Pinjar	0	0	0	0	64
WANPINR005	Pinjar	0	.	.	.	275
WANPINR006	Pinjar	2	0	0	0	13
WANPINR007	Pinjar	.	0	0	0	0
WANPINR011	Pinjar	0	800	.	.	0
WANTAMR001	Tamala Park	20	103	0	.	.
WANTWOR001	Two Rocks	200	573	7	.	0
WANWANR001	Wanneroo	0	0	6	11	0
WANYANR001	Yanchep	450	.	.	.	61
WANYANR003	Yanchep	0	564	0	16	.
WANYANR004	Yanchep	0	192	0	0	.

Site Code	Locality	2014	2013	2012	2011	2010
WANYANR006	Yanchep	0	0	129	305	342
WARLAKR001	Lake Clifton	.	.	0	0	1
WARPRER001	Preston Beach	19	330	66	.	.
WARPRER002	Preston Beach	0	.	0	.	100

Appendix IIIb: Great Cocky Count (2010-2014) roost counts for Carnaby's Black-Cockatoos at **confirmed roosts** (see page iv) (n = 24) that: (a) are within or immediately adjacent (<1 km) to the **Gnangara pine plantation** (see page v) or (b) have historically been used as a roost by cockatoos feeding within the plantation system. Use of the 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	2010	2011	2012	2013	2014
GINYEAR001	Yanchep	.	.	387	.	782
GINYEAR002	Yanchep	49	92	.	.	.
SWAELLR001	Gnangara	.	.	.	.	14
SWALEXR001	Gnangara	0	80	0	0	181
SWALEXR002	Gnangara	185	0	.	0	0
SWAMELR001	Gnangara	500	41	0	20	480
WANCARR004	Pinjar	.	.	.	.	7
WANGNAR004	Gnangara	27	0	0	0	0
WANGNAR005	Gnangara	.	.	.	100	0
WANJANR007	Gnangara	.	16	.	0	cleared
WANMARR001	Gnangara	0	20	.	0	.
WANMARR003	Gnangara	542	152	10	16	147
WANNEER001	Pinjar	.	29	.	.	0
WANNEER002	Pinjar	604	0	0	0	0
WANPINR001	Pinjar	.	.	853	35	1521
WANPINR002	Pinjar	.	312	276	0	138
WANPINR003	Gnangara	64	0	0	0	0
WANPINR005	Gnangara	275	.	.	.	0
WANPINR006	Gnangara	13	0	0	0	2
WANPINR011	Pinjar	0	.	.	800	0
WANTWOR001	Yanchep	0	.	7	573	200
WANYANR001	Pinjar	61	.	.	.	450
WANYANR003	YNP	.	16	0	564	0
WANYANR006	YNP	342	305	129	0	0
TOTAL		2662	1063	1662	2108	3922
% of total Perth-Peel Coastal Plain count		42%	27%	43%	38%	59%
No. of pine-associated sites surveyed		25	20	17	18	26

Appendix IIIc: Great Cocky Count (2010-2014) roost counts for white-tailed black-cockatoos at **confirmed roost**s (see page iv) (n = 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-Cockatoos.

A period in a cell means that the site was not surveyed that year.

Site Code	Locality	2014	2013	2012	2011	2010
ARMBEDR001	Bedfordale	0	0	.	0	57
ARMBEDR002	Bedfordale	0	3	.	22	70
ARMBEDR003	Bedfordale	0	0	.	.	385
ARMKELR002	Kelmscott	0	0	.	10	0
ARMROLR001	Roleystone	0	40	140	13	108
ARMROLR003	Roleystone	0	50	0	0	.
BODCROR002	Crossman	.	.	.	0	10
KALKALR001	Kalamunda	0	0	25	.	30
KALKALR002	Kalamunda	28	85	23	25	.
KALLESR001	Lesmurdie	0	0	0	0	.
KALPICR002	Pickering Brook	2	.	.	.	.
KALPIER001	Piesse Brook	0	0	46	82	.
KALWALR001	Walliston	0	0	0	5	0
KALWATR001	Wattle Grove	.	0	0	.	.
MUNCHIR001	Chidlow	0	0	.	0	16
MUNDARR001	Darlington	0	0	147	7	443
MUNGLER001	Glen Forrest	45	51	32	.	.
MUNGLER002	Glen Forrest	0	0	13	.	.
MUNGLER003	Glen Forrest	45	.	.	.	.
MUNHELR001	Helena Valley	124	42	16	3	.
MUNHOVR001	Hovea	.	0	40	.	.
MUNHOVR002	Hovea	0	0	10	22	243
MUNMTHR001	Mount Helena	0	8	.	.	.
MUNMUNR001	Mount Helena	45	85	.	.	78
MUNPARR001	Parkerville	182	0	.	.	.
MUNSTOR001	Stoneville	141	.	.	.	.
MUNSTOR002	Stoneville	0	.	0	86	.
MUNSTOR003	Stoneville	48	.	.	.	.
MUNWOOR001	Woorooloo	0	0	.	.	0
MURDWER001	Dwellingup	.	.	.	40	.
MURTEER001	Teesdale	.	0	0	0	21
NORBAKR001	Bakers Hill	.	.	.	.	217
NORWOOR001	Woottating	.	0	.	.	0

NORWUNR001	Wundowie	.	0	8	.	125
SERJARR001	Jarrahdale	.	.	0	60	0
SERKEYR002	Keysbrook	.	30	0	.	25
SWABULR002	Bullsbrook	328	120	117	18	.
SWAGIDR002	Gidgegannup	.	40	23	.	101
SWAGIDR003	Gidgegannup	.	.	3	.	.
SWAGIDR005	Gidgegannup	163	197	.	.	.
SWAMILR001	Millendon	0	.	.	.	.
SWASTRR001	Stratton	0	0	.	.	.
TOOMORR001	Toodyay	56	29	183	.	.
WARWARR002	Waroona	0	36	.	.	.
YORTALR001	York	.	0	0	.	.

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

Appendix IV: Great Cocky Count (2010-2014) 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	2014	2013	2012	2011	2010
Mid-West (Chapman Valley and Three Springs)						
CHANANR001	Nanson	262	302	.	.	.
CHANANR001	Nanson	189	0	.	.	.
THRARRR002	Arrino	.	70	.	.	.
Northern Swan Coastal Plain (Dandaragan and Gingin)						
DANDANR001	Dandaragan	460	228	313	.	.
DANHILR001	Hill River	250	0	160	.	.
DANHILR002	Hill River	.	.	136	.	.
DANHILR003	Hill River	131	.	.	.	.
DANJURR001	Jurien Bay	52	225	51	.	.
DANREGR001	Regans Ford	.	.	0	22	.
GINNILR001	Nilgen	376	583	.	.	.
Southern Swan Coastal Plain (south of Lake Preston and Waroona)						
BUNCOLR001	College Grove	0	20	0	.	.
BUNGLER001	Glen Iris	0	0	25	.	.
BUNGLER002	Glen Iris	4	8	.	.	.
CAPGELR001	Gelorup	0	6	38	.	.
CAPGWIR001	Gwindinup	119	0	14	.	194
CAPNORR001	North Boyanup	0	4	.	.	.
DAREATR001	Eaton	0	14	19	4	.
HARMYAR002	Myalup	35	0	0	0	.
HARMYAR002	Myalup	cleared	cleared	0	155	52
WARWAGR001	Wagerup	186	236	.	.	.
Capes Region (Busselton and Augusta-Margaret-River)						
AUGGRAR001	Gracetown	1	.	.	.	.
AUGGRAR002	Gracetown	85	7	.	.	.
AUGMARR001	Margaret River	47	1	11	.	.
BUSDUNR001	Dunsborough	99	32	.	.	.
BUSQUIR001	Quindalup	107	71	.	.	.
BUSYALR001	Yallingup	57	0	.	.	.

Site Code	Locality	2014	2013	2012	2011	2010
South Coast (Albany)						
ALBCHER001	Cheynes	.	70	.	.	.
ALBCHER002	Cheynes	60	.	0	.	.
ALBGOOR001	Goode Beach	62	84	.	.	.
ALBGOOR002	Goode Beach	120	0	.	111	.
ALBKALR001	Kalgan	141	472	213	.	.
ALBMCKR001	McKail	18	.	33	.	.
ALBMETR001	Mettler	.	145	40	.	.
ALBMTCR001	Mt Clarence	0	.	.	4	.
ALBROBR001	Robinson	0	43	0	.	.
South Coast (Esperance and Ravensthorpe)						
ESPESPR001	Esperance	202	230	226	196	.
ESPMYRR001	Myrup	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	.	316	254	.	.
Central Wheatbelt (Narrogin and Northam)						
NARNARR002	Narrogin	36	19	16	.	.
NARNARR004	Narrogin	.	9	0	.	.
NARNARR005	Narrogin	.	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	74	.	.	.	.
DONDONR001	Donnybrook	0	11	.	.	.
DONMUMR001	Mumballup	.	0	.	29	.

APPENDIX V: Roost counts for Forest Red-tailed Black-Cockatoos (2014)

Appendix V: Roost counts for red-tailed black-cockatoos for the 2014 Great Cocky Count. Roost counts are likely to be of Forest Red-tailed Black-Cockatoos 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 2014 GCC

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

[3] new roost (i.e. not surveyed before 2014 GCC)

probable Inland Red-tailed Black-Cockatoo (*Calyptorhynchus banksii samueli*)

Site Code	Locality	Survey Area	2014 Count
GOSCNVR001[2]	Canning Vale	Perth-Peel Coastal Plain	2
BUSJINR002[3]	Jindong	Regional	2
IRWMILR002#	Milo	Regional	2
SOUSALR001[1]	Salter Point	Perth-Peel Coastal Plain	2
HARROER002[3]	Roelands	Regional	3
MURDWER002[3]	Dwellingup	Regional	3
WANGNAR006[1,3]	Gnangara	Perth-Peel Coastal Plain	3
COCBANR002[1,3]	Banjup	Perth-Peel Coastal Plain	3
CANWILR001[1]	Willetton	Perth-Peel Coastal Plain	4
HARHARR001	Harvey	Regional	6
WILQUIR001[3]	Quindanning	Regional	10
WARWARR002[2]	Waroona	Northern Darling Scarp and Plateau	10
MUNCHIR002[3]	Chidlow	Northern Darling Scarp and Plateau	12
DONDONR001[2]	Donnybrook	Regional	14
ROCBALR003[2]	Baldivis	Perth-Peel Coastal Plain	17
MUNWOOR001	Wooroloo	Northern Darling Scarp and Plateau	17
GOSGOSR004[3]	Gosnells	Perth-Peel Coastal Plain	19
BRIGRER002[3]	Greenbrushes	Regional	20
ARMBEDR001[2]	Bedfordale	Northern Darling Scarp and Plateau	21
KALMAIR002[3]	Maida Vale	Perth-Peel Coastal Plain	25
WARWAGR001[1]	Wagerup	Regional	38
PLANARR002[1,3]	Narrikup	Regional	39
KALPICR002[1,3]	Pickering Brook	Northern Darling Scarp and Plateau	42
KALWALR001[2]	Walliston	Northern Darling Scarp and Plateau	43
STIYOKR003	Yokine	Perth-Peel Coastal Plain	47
COCMUNR001	Munster	Perth-Peel Coastal Plain	92
VICKENR001	Kensington	Perth-Peel Coastal Plain	94
CAMFLOR002[3]	Floreat	Perth-Peel Coastal Plain	109
MELMURR001[1,2]	Murdoch University	Perth-Peel Coastal Plain	199