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# Black Cockatoos on the Swan Coastal Plain

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Report for the Department of Planning, Western Australia

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**Front cover:**

Top – Carnaby’s Cockatoo (KL)

Left – Baudin’s Cockatoo (KL)

Right – Forest Red-tailed Black Cockatoo (KL)

Background – Swan Coastal Plain viewed from Bungendore Park, Bedfordale (KS)

**Carnaby's Cockatoo (*Calyptorhynchus latirostris*), Baudin's Cockatoo (*Calyptorhynchus baudinii*) and the Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*) on the Swan Coastal Plain (Lancelin–Dunsborough), Western Australia. Studies on distribution, status, breeding, food, movements and historical changes.**

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**CONTENTS**

1.	BACKGROUND .....	2
2.	PROJECT COMPONENTS.....	2
3.	BLACK COCKATOOS OF SOUTH-WEST WESTERN AUSTRALIA .....	3
4.	SPECIES BACKGROUND INFORMATION.....	5
4.1.	Carnaby's Cockatoo ( <i>Calyptorhynchus latirostris</i> ).....	5
4.1.1.	Distribution .....	5
4.1.2.	Status and Habitat Preferences.....	7
4.1.3.	Breeding.....	7
4.1.4.	Breeding Requirements.....	7
4.1.5.	Social Organisation, Flocking and Movements .....	8
4.1.6.	Historical Changes (distribution, relative abundance and foraging habitat).....	13
4.1.7.	Food .....	14
4.1.8.	Important Habitat Sites on Swan Coastal Plain .....	155
4.2.	Baudin's Cockatoo ( <i>Calyptorhynchus baudinii</i> ) .....	188
4.2.1.	Distribution .....	188
4.2.2.	Status and Habitat Preferences.....	199
4.2.3.	Habitat.....	199
4.2.4.	Breeding.....	199
4.2.5.	Social Organisation, Flocking and Movements .....	20
4.2.6.	Food .....	22
4.2.7.	Conservation .....	233
4.3.	Conclusions.....	233
4.4.	Forest Red-tailed Black Cockatoo ( <i>Calyptorhynchus banksii naso</i> ) .....	244
4.4.1.	Distribution .....	244
4.4.2.	Status and Habitat Preferences.....	255
4.4.3.	Breeding.....	255
4.4.4.	Movements.....	266
4.4.5.	Food .....	277
5.	ISSUES THREATENING COCKATOOS.....	288
6.	RECOMMENDATIONS FOR FURTHER RESEARCH.....	30
7.	ACKNOWLEDGEMENTS .....	31
8.	BIBLIOGRAPHY.....	31
	APPENDIX 1 - Latitude/Longitude of important and known habitat sites for Carnaby's Cockatoo .....	355

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## 1. BACKGROUND

Carnaby's Cockatoo (*Calyptorhynchus latirostris*) is endemic to the south-west of Western Australia. This species faces a declining habitat on the Swan Coastal Plain due to land clearing for urban development. This species is listed as Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and listed as 'rare or likely to become extinct' pursuant to the Western Australian *Wildlife Conservation Act 1950*. It has been ranked as Endangered by the Western Australian Threatened Species Scientific Committee using IUCN (1994) Red List Categories and Criteria, meeting Criterion A1abc.

The Department of Planning (DoP), in partnership with the Department of Environment and Conservation (DEC), received funding from the State NRM Program as part of the 2008/09 and 2009/10 State Budget.

As part of the 2009/10 State NRM funding, the Department of Planning received funds to revert hard copy historical Carnaby's Cockatoo habitat data from the Storr-Johnstone Bird Data Bank into a digital format. The aim of this was to produce maps of habitat (breeding, foraging and roosting) locations on the Perth, Peel and Greater Bunbury region scheme areas. Approximately 9,500 records of Carnaby's Cockatoo observations (feeding, breeding, roosting, flying, calling and other observations) have been collected on the Swan Coastal Plain and mapped to identify the areas of highest potential conflict between land-use planning and conservation of habitat.

This report provides interpretation of this data, as well as advice on the implications of land use development in areas with Carnaby's Cockatoo habitat.

## 2. PROJECT COMPONENTS

Specifically, the report will cover the following information –

1. Based on the Storr-Johnstone Bird Data Bank, review and interpret the existing information on Carnaby's Cockatoos in the region between Lancelin and Busselton and to review literature and data from other sources including recent survey data by R.E. Johnstone and T. Kirkby, Cockatoo Care and specimens held in the Western Australian Museum.
2. Based on the Storr-Johnstone Bird Data Bank, evaluate the current distribution and ecological status of Carnaby's Cockatoo, document areas of critical habitat (especially breeding sites, important foraging habitat and roosts), species range and changes in populations due to impacts of land clearing, nest competition, fire and climate change.
3. Provide a report with the following –
  - a. the current distribution, ecological status and habitat preferences of Carnaby's Cockatoos,
  - b. breeding, feeding and roosting sites of the Carnaby's Cockatoo,
  - c. migration and movements of the Carnaby's Cockatoos on the Swan Coastal Plain,
  - d. historical changes (distribution, relative abundance, foraging habitat),
  - e. issues currently threatening the cockatoos,
  - f. recommendations for further research (identify the gaps in data),
  - g. advice on particular areas under pressure (i.e. Chittering, Bunbury) to assist land use planning decision makers,

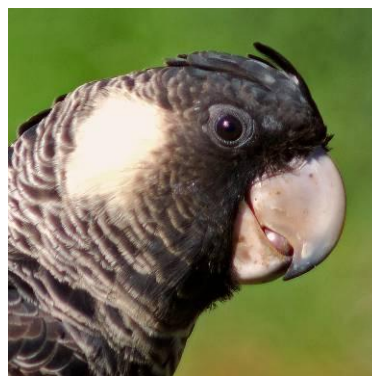
- h. provide a list of areas within and outside Perth, Peel and Greater Bunbury Region scheme areas (such as Bindoon) that have potential for development offset areas with known populations of Carnaby’s Cockatoo,
- i. provide guidance and knowledge about Baudin’s Cockatoo and the Forest Red-tailed Black Cockatoo, which are also protected under State and Commonwealth legislation, as they are closely related to Carnaby’s Cockatoo.

### 3. BLACK COCKATOOS OF SOUTH-WEST WESTERN AUSTRALIA

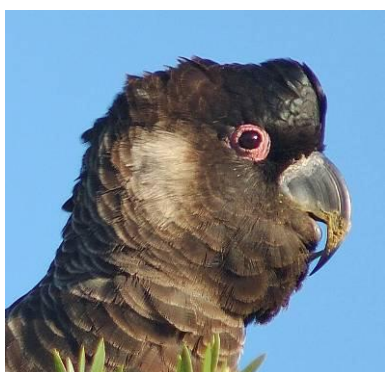
Two species of white-tailed black cockatoo – Baudin’s Cockatoo (*Calyptorhynchus baudinii* Lear, 1832) and Carnaby’s Cockatoo (*Calyptorhynchus latirostris* Carnaby, 1948) and the Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso* Gould, 1837) – are endemic to the south-west of Western Australia (Johnstone and Storr 1998). They form a very distinctive part of the avifauna, with their conspicuous, often large flocks and raucous behaviour. The two white-tailed species can be extremely difficult to separate, even for experienced observers, and were only recognised as separate species in 1979 (Saunders 1979a). Bill size and shape and calls are the most reliable means of identification. Baudin’s Cockatoo has the bill or culmen more laterally compressed than in Carnaby’s with the upper mandible significantly longer and finer (Campbell and Saunders 1976) (i.e. with the tip tapering well beyond the lower mandible when closed).



Male Carnaby’s Cockatoo



Female Carnaby’s Cockatoo



Male Baudin’s Cockatoo



Female Baudin’s Cockatoo

**Figure 1** Bill shape of Carnaby’s Cockatoo (top) and Baudin’s Cockatoo (bottom) (TK)

Baudin’s Cockatoo also has a much shorter “whicha-whicha” contact call compared to the longer “wee-looo wee-looo” of Carnaby’s. Due to the great similarity between the two species many of the historical observational records and indeed even much of the

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recent literature is misleading and requires careful interpretation because of the high degree of error in recording the two species.

All three of these black cockatoos have suffered a substantial decline in numbers and breeding distribution in the past 50 years (Johnstone and Storr 1998). The ability of both Carnaby's and Baudin's cockatoos to exploit resources provided by humans, especially in apple, pear, persimmon and nut orchards and pine plantations, and their habit of forming large feeding flocks, has in the past brought them into conflict with orchardists and foresters (Long 1985). Direct causes of population decline include the large numbers shot by orchardists (mainly with Baudin's Cockatoo), clearing and fragmentation of habitat (especially the loss of breeding hollows), the impact of hollow competitors including the Galah (*Cacatua roseicapilla*), corellas including Butler's Corella (*Cacatua pastinator butleri*), Australian Shelduck (*Tadorna tadornoides*), Australian Wood Duck (*Chenonetta jubata*), the feral European honey bee (*Apis mellifera*) and also vehicle strikes.

Illegal shooting of Baudin's Cockatoos still continues in parts of the south-west (DEC 2008) and with its low reproduction rate (0.6 chick per year or every two years) (Johnstone and Storr 1998) this cockatoo can not replace large numbers shot by orchardists. Around 60% of the original vegetation on the Swan Coastal Plain has been cleared and up to 85% in other parts of the south-west region for agriculture (crops), meat production, dairying, farmlets, orchards, vineyards, pine plantations, mining, timber and wood chipping, cities and towns. At present, extensive tracts of uncleared land only remain in State forest and conservation reserves and what is left of remnant vegetation (in roadside verges etc.) is often disturbed to a varying degree.

The south-west region is now a severely fragmented landscape and the further loss of foraging habitat, the lack of suitable breeding sites, climate change, alterations in the landscape, changing forest structure with almost every part of the Jarrah-Marri forest logged in the past and with most trees too young to form hollows, and competition with exotic species all exacerbate the future conservation of Carnaby's Cockatoo, Baudin's Cockatoo and the Forest Red-tailed Black Cockatoo. Recent studies (Johnstone and Kirkby 2007a) have revealed the devastating impact feral European honeybees are having on cockatoos and other hollow-nesting birds in this region.

While there has been considerable studies carried out on Carnaby's Cockatoo since the 1960s (e.g. Saunders 1974a, 1980 and 1990) very few studies have been conducted on the forest-inhabiting Baudin's Cockatoo and the Forest Red-tailed Black Cockatoo. Baudin's Cockatoo is listed as Threatened (Endangered) under Schedule 1 of the Western Australian *Wildlife Conservation Act 1950*, and as Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Although listed as an endangered species, it is also a declared pest of agriculture as it damages commercial fruits, especially apples and pears (Chapman 2007). The Forest Red-tailed Black Cockatoo is also listed as Schedule 1 (Endangered) under the Western Australian *Wildlife Conservation Act 1950*, and as Vulnerable under the EPBC Act.

Since 2000, the biology of Carnaby's Cockatoo, Baudin's Cockatoo and the Forest Red-tailed Black Cockatoo throughout the south-west of Western Australia has been extensively studied (Johnstone *et al* 2005, Johnstone 2006, Johnstone and Kirkby 2006, Johnstone and Kirkby 2007b, Johnstone and Kirkby 2008a & b, Johnstone and Kirkby 2009a & b, Johnstone *et al* 2010). The key objectives of these studies are to gather information on the current distribution, ecological status, relative abundance, habitat preferences, document areas of critical habitat especially breeding, feeding and

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roosting sites, determine migration and movements and changes in populations due to impacts of land clearing, nest competitors, fire and climate change. A further aim is to assess the impact of introduced and invasive species (especially the feral European honey bee, corellas (including Little Corella, Butler's Corella and Eastern Long-billed Corella) and Galahs on black cockatoo nest hollows and sites and help with the development of effective control measures. The use of artificial nest hollows, and experiments with the design and protocols for the use and installation of artificial nest boxes and PVC tubes have also been undertaken.

These recent studies have encompassed a range of conservation issues including the identification of threats, helped with the establishment of recovery and management plans, the identification of critical habitat and an improved understanding of their breeding biology, movements and changes in distribution and status. Based on this recent work and the Storr-Johnstone Bird Data Bank, all three taxa have changed their distribution patterns in the past 50 years. On the Swan Coastal Plain, Carnaby's Cockatoo has changed its migration and foraging patterns in response to ongoing habitat destruction and the discovery of new food sources. In addition to changes in distribution of all three cockatoos, the roosting sites and localities where birds forage is often subject to change from year to year.

More recently, targeted surveys for breeding, feeding and roosting sites have been undertaken at a number of locations in the mid-west including Eneabba, Badgingarra, Cataby and sections of the Great Northern Highway; on the Swan Coastal Plain at sites including around Lancelin, Gingin, Bindoon, Wanneroo, Armadale, Serpentine, Mandurah, Lake Clifton, sections of the Perth-Bunbury Highway (Forrest Highway) and Capel; and in areas on or near the western edge of the Darling Scarp including east of Bindoon, Mundaring, Bedfordale, Serpentine hills and Whicher Range. The Swan Coastal Plain has been identified as an important region for cockatoos especially Carnaby's Cockatoo, however, there has been little research carried out to determine the potential impacts of current and future urban expansion and habitat loss. Accurate mapping of both the historical and current range of these birds will assist the Department of Planning to make informed decisions and help develop a policy in relation to land usage for the future conservation of black cockatoos within the region.

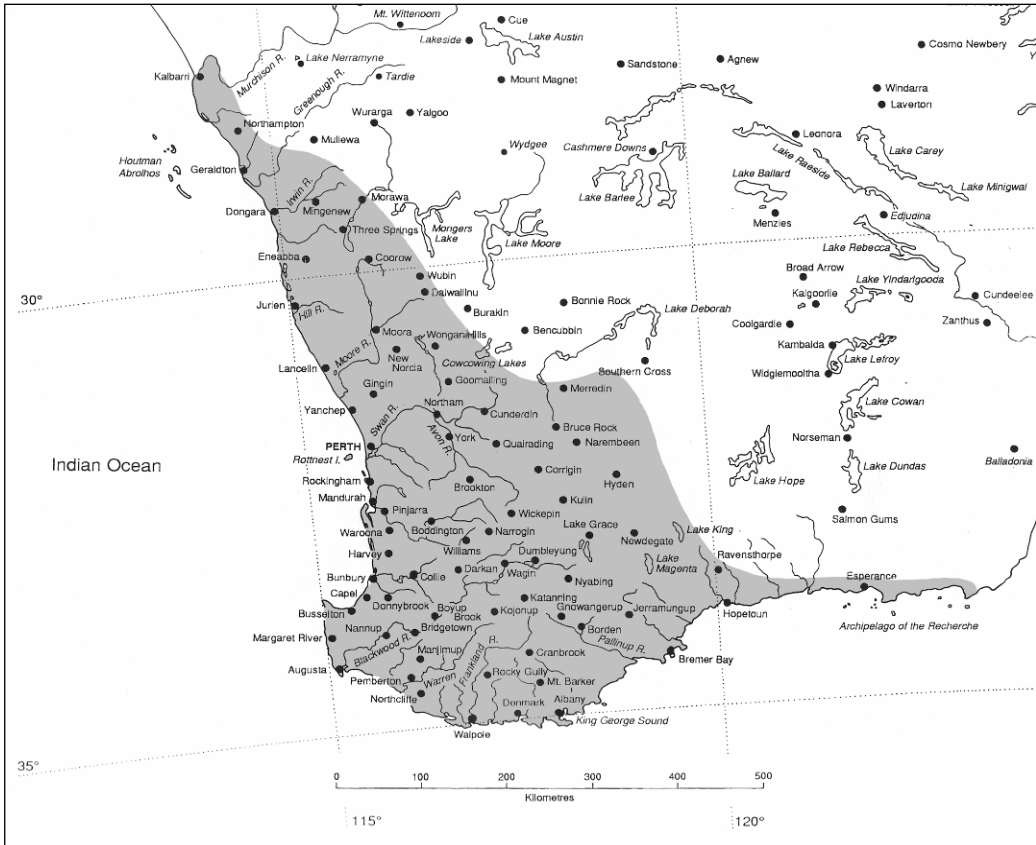
## **4. SPECIES BACKGROUND INFORMATION**

### **4.1. Carnaby's Cockatoo (*Calyptorhynchus latirostris*)**

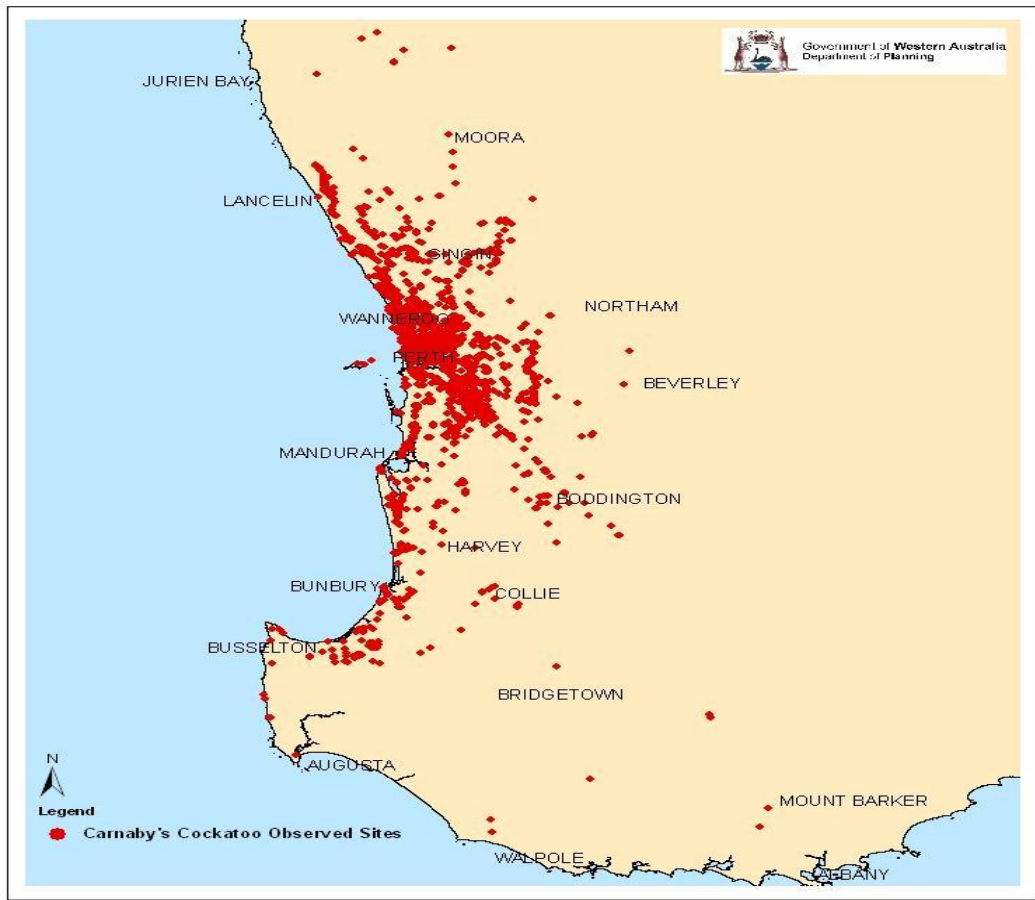
Carnaby's Cockatoo is listed as 'fauna that is rare or likely to become extinct' (generally referred to as threatened fauna) under the Western Australian *Wildlife Conservation Act 1950*, Wildlife Conservation (Specially Protected Fauna) Notice 2010(2). It has been given a ranking of Endangered by the Western Australian Threatened Species Scientific Committee. It is also listed as Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

#### **4.1.1. Distribution**

Carnaby's Cockatoo is endemic to the south-west of Western Australia, north to the lower Murchison River and east to Nabawa, Wilroy, Waddi Forest, Nugadong, Manmanning, Durokoppin, Noogar (Moorine Rock), Lake Cronin, Ravensthorpe Range, head of Oldfield River, 20 km ESE of Coondingup and Cape Arid; also casual on Rottneest Island (Johnstone and Storr 1998).



**Figure 2** Distribution map of Carnaby's Cockatoo.



**Figure 3** 9600 observations from the Storr-Johnstone Bird Data Bank (with emphasis on the Swan Coastal Plain)



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#### 4.1.2. Status and Habitat Preferences

This species is a postnuptial nomad, tending to move west after breeding. For example; most birds breeding in Badgingarra, Dandaragan, Moora and Bindoon regions tend to move west after breeding into higher rainfall areas especially the near-coastal *Banksia* scrubs e.g. at Wanagarren Nature Reserve, Nilgen Nature Reserve, Yanchep area and Wanneroo area then many of these move further south onto the southern Swan Coastal Plain including the southern Perth metropolitan area Baldivis, Lake Clifton and Myalup areas.

It is uncommon to common in the subhumid zone and wetter parts of the semiarid zone, scarce and patchily distributed in the drier parts of its range (north of Arrowsmith Lake and east of Marchagee, New Norcia, Toodyay, Tarin Rock and Lake Magenta) and scarce to moderately common in deep south-west (south of Margaret River, Nannup and Bridgetown and east of Albany).

Carnaby's Cockatoo usually travel in pairs or small flocks, although they are often seen in large flocks (up to 10,000) in non-breeding season (late spring to mid-winter), especially at *Banksia* scrubs and pine plantations on the Swan Coastal Plain. Because of the large-scale post-war clearing of semiarid sandplains, this species has declined in much of the wheatbelt.

#### 4.1.3. Breeding

Breeding occurs mainly from early July to mid-December in the semiarid and subhumid interior from the Three Springs district south to the Stirling Range, west to Cockleshell Gully, Cataby, Regans Ford, Gingin, near mouth of Moore River, Yanchep, Serpentine, Mandurah, Lake Clifton, Bunbury, Nannup and Tone River and east to Manmanning, Kellerberrin, Woolundra, Lake Cronin, Hatters Hill and near Ravensthorpe (Storr-Johnstone Bird Data Bank).

There has been an apparent shift in its breeding range further west and south since the middle of last century with a more rapid increase in the past 10–30 years into the Jarrah-Marri forests of the Darling Scarp and the Tuart forests of the Swan Coastal Plain. There are now numerous breeding records for the northern Darling Scarp, including Bindoon, Bullsbrook, Mundaring, Lower Darkin River, near Canning Dam, near Wungong Dam, Serpentine and near Collie, and on the Swan Coastal Plain at Gingin, Boonanarring, Mooliabeenee, near mouth of Moore River, Yanchep, Baldivis, near Mandurah, Lake Clifton and near Bunbury (Storr-Johnstone Bird Data Bank).

There is also an indication that this species is expanding its breeding range in the far south-east i.e. Lake Cronin, Lake King and Ravensthorpe region.

#### 4.1.4. Breeding Requirements

Carnaby's Cockatoo display strong pair bonds and mate for life. They nest in hollows of smooth-barked eucalypts especially Salmon Gum (*Eucalyptus salmonophloia*) and Wandoo (*Eucalyptus wandoo*) but nests have also been found in other eucalypts including York Gum (*Eucalyptus loxophleba*), Flooded Gum (*Eucalyptus rudis*), Tuart (*Eucalyptus gomphocephala*) and the rough-barked Marri (*Corymbia calophylla*). On the Swan Coastal Plain most nests are in Tuart. Eggs are laid on a mat of wood chips at the bottom of a large hollow (mostly top entry hollows) ranging from a few centimetres to 5 m deep; clutch 1–2 (mostly 2 but only one young reared). Incubation lasts 29 days and only the female incubates and broods. The nestling is

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brooded by the female during which time both rely on the male for food. The female then leaves the nest each day at dawn, sometimes returning mid-morning (with the male) to feed the chick. After about 2–3 weeks she ceases to brood and the chick is fed by one or both parents in the morning and at late evening.



**Figure 4** Female Carnaby's Cockatoo at a nest hollow in the Stirling Range (KL)

Judging from breeding records in the Storr-Johnstone Bird Data Bank, this species is currently expanding its breeding range westward and south into the Jarrah-Marri forests of the Darling Scarp (e.g. Wungong Dam Catchment) and into the Tuart forests of the Swan Coastal Plain including Yanchep, Baldivis, Lake Clifton and near Bunbury. This may be due to climate change.

Breeding success is largely dependent on suitable feeding habitat adjacent to the nest site to provide the necessary food for the survival of the chick. In the Gingin, Bindoon, Yanchep, Lake Clifton, Bunbury, Ludlow and Whicher Range areas where breeding is recorded, there are areas of remnant vegetation, National Parks, Nature Reserves, State Forests, roadside verges and pine plantations that contain breeding and foraging habitat for Carnaby's Cockatoos.

#### 4.1.5. Social Organisation, Flocking and Movements



**Figure 5** Flock of Carnaby's Cockatoos at Bindoon (TK)

Most breeding in the northern wheatbelt is completed by the end of January or early February and family groups begin to move west towards the coast and amalgamate into larger foraging flocks on the northern section of the Swan Coastal Plain (Wanneroo to Lancelin). During February, March, April and occasionally lingering into May-June, large transit flocks forage at major food sources including *Banksia* or Kwongan heaths and *Pinus* plantations on the northern Swan Coastal Plain between Lancelin and Perth. Some examples of these large aggregations are as follows:

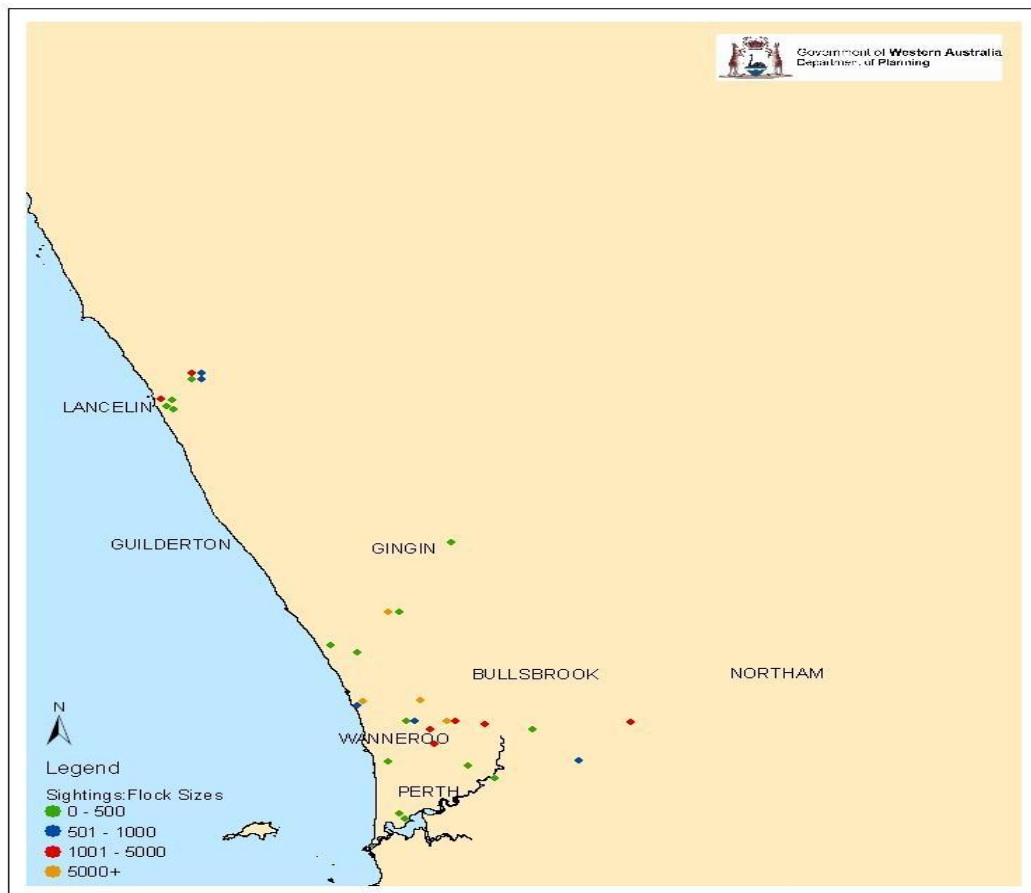
Location	Flock Size	Date Seen
Tamala Park feeding in <i>Dryandra</i> scrub	5,000 – 7,000	29 April 2003
Nilgen feeding in <i>Banksia</i> scrub	2,000	28 May 2003
Mariginup (in pine plantation)	7,000	1 March 2004
Ellenbrook	2,000	26 February 2005
Gnangara	3,000	28 February 2005
Landsdale	3,000	9 March 2005
Wanneroo	500	28 April 2006
Nilgen	1,000 – 2,000	22 May 2008
Eglinton	> 200	24 May 2009
Woodbridge	450 – 500	4 June 2009
Lancelin (Ocean Farms Drive)	500	21 June 2009
Beechboro	200 – 250	25 June 2009
near Wanneroo	600	17 May 2010
Gingin Brook Road	600	17 May 2010

In November and December 2003, seven Carnaby's Cockatoo chicks from the Western Australian Museum study site at Dandaragan in the central wheatbelt had the ventral surface of the white undertail panels painted with bright red. The paint used was a lanolin-based spray paint and this study was part of a trial in conjunction with Birds Australia and Department of Conservation and Land Management (different colours used at different breeding sites). The aim of the trial was to test tail marking as a tracking method for birds from different populations. A campaign was conducted to encourage members of the public to report sightings of marked birds and searches were conducted by Birds Australia, volunteers and Museum personnel. Three confirmed or highly likely sightings of birds with red-painted tails were made, one at the Gnangara pine plantation (in March 2005) and two in the Perth metropolitan area (Wanneroo and Cottesloe in April 2004). These birds had travelled approximately 160 km SSW from their fledging site. Although only a small number of birds were marked, the study provided valuable information on the migration pathway of birds from the central wheatbelt west and south onto the Swan Coastal Plain.

On the northern Swan Coastal Plain, the reverse movement of transient birds returning back to their wheatbelt breeding quarters is also evident in July, August and September. Some examples of these large aggregations are as follows:

Location	Flock Size	Date Seen
Burns Beach (large loose aggregations in <i>Banksia</i> and <i>Dryandra</i> scrub)	600 – 1,000	September 2005
Yanchep National Park	7,000	3 July 2006
Wanneroo (Military Road, pine plantation)	8,000 – 10,000	24 July 2006
Wanneroo (Military Road, pine plantation)	700 to 6,000–7,000	July–August 2006
Nilgen	200 – 400	July–August 2008
Lancelin (Bashford Nature Reserve)	1,500	16 July 2010

There are, however, some exceptions to this westward and southward yearly movement. For example, a flock of over 300 (including adult and juvenile birds) remain during the autumn-winter period in the Eneabba area. These birds roost in tall river gums in and around the township and forage in both remnant native vegetation and adjacent farmlands. While the region of origin of these birds is unknown, it is noteworthy that they remain here during the autumn-winter period when virtually all other Carnaby's Cockatoos from the broader region (i.e. Three Springs, Moora and Badgingarra) vacate it after breeding.



**Figure 6** Large flock sizes in the northern portion of the Swan Coastal Plain

Counts of birds were made by P. Berry (Berry 2008, Berry and Owen 2010) at a traditional roost site at Hollywood in the Perth Metropolitan area between April 2006 and April 2007. This study showed that numbers varied from zero to over 600 and on average flocks comprised about 60% pairs and 40% pairs with fledged chicks. At this roost the lowest numbers occurred from August to October, after which they increased steadily to a peak in March before steadily declining. The abundance of Carnaby's

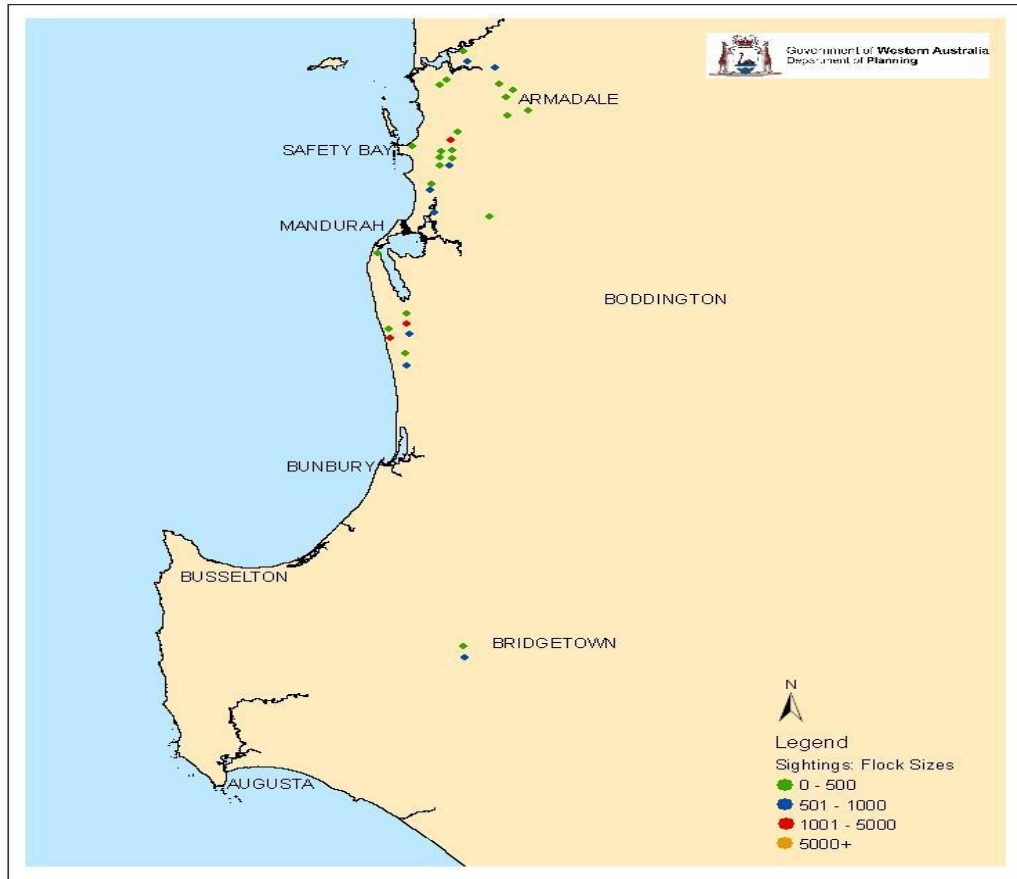
Cockatoo on the Swan Coastal Plain was also studied by Shah (2006). This study included counts by volunteers at 16 roosts between Yanchep and Dawesville. At six roosts, synchronous counts were made over nine consecutive days from 29 April to 7 May 2006. From this, a minimum population estimate of 4,510 birds was determined for the Swan Coastal Plain. Judging from the Storr-Johnstone Bird Bank Data, numbers of birds on the northern Swan Coastal Plain in February, March and July often greatly exceed this estimate. Based on counts in 2005–2006, it is estimated that between 10,000 and 15,000 Carnaby’s Cockatoos were on the Swan Coastal Plain between Lancelin and Dunsborough in the autumn-winter period, and the majority of these were on the northern portion of that region between Lancelin and Perth.

Burnham *et al.* (2010) gives details of 222 roost locations and counts from the Great Cocky Count carried out at 190 roost sites by 350 volunteers on 7 April 2010. Their count of 6,672 for the Swan Coastal Plain is considered an under-estimate for the entire plain as it was carried out a little early (many birds were still migrating onto the plain from breeding sites in April) and it did not include roosts in areas north of Yanchep (large flocks for example were recorded in the Lancelin area in early May 2010) or the far south of the plain from Harvey Estuary south to Dunsborough. The count did support an estimated population of 8,000–10,000 birds for the northern Swan Coastal Plain and highlighted the importance of the Gngangara area compared with the Perth metropolitan area.

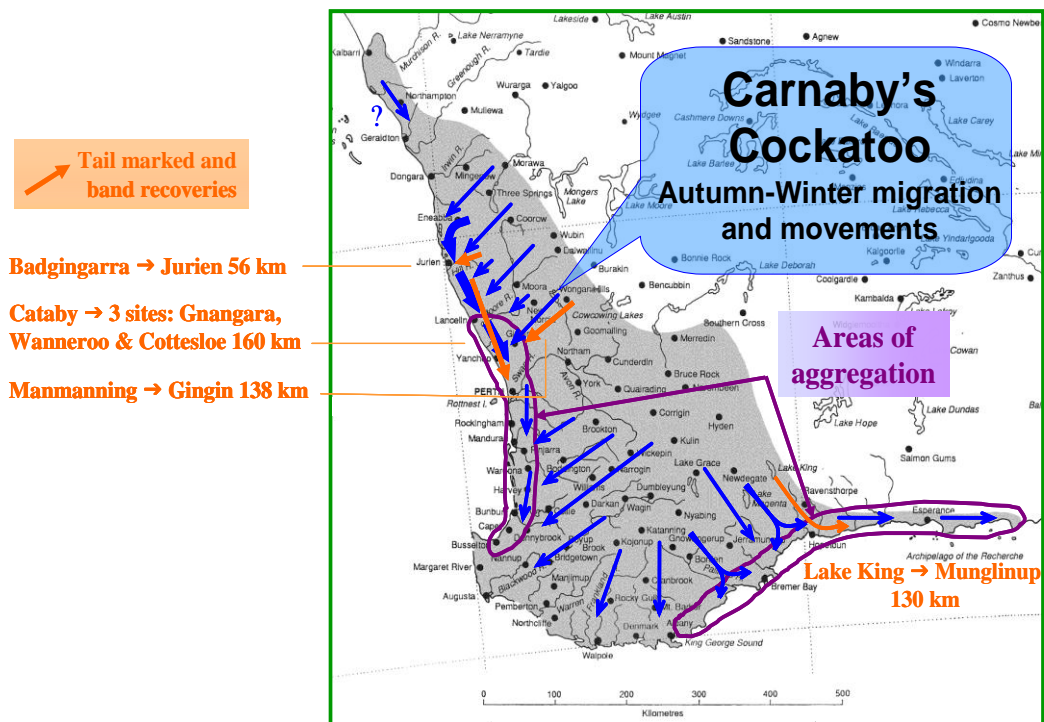
The general movement of birds west and south onto the southern portion of the Swan Coastal Plain (i.e. from Perth south to Bunbury and beyond) occurs around the same time, mainly February, March and April, but apparently (judging from flock sizes) in much smaller numbers. Some examples listed by months for the past 5 years are as follows:

Location	Flock Size	Date Seen
Dawesville	300	15 March 2003
Lake Clifton	1,265	10 March 2004
Baldivis (drinking)	200	21 February 2005
near Rockingham (in Tuarts)	200	4 March 2005
near Baldivis	230	10 March 2005
Myalup	> 600	April 2005
Baldivis (in pines)	600	2 April 2005
Myalup	> 600	April 2005
Baldivis (in pines)	600	2 April 2005
Karnup	800	4 April 2005
Karnup	800	4 April 2005
Karnup	1,200	4 April 2005
Armarillo	150 – 300	Feb/Mar 2006
Baldivis	200	25 March 2006
Karnup (in pines)	574	9 April 2006
Victoria Park (feeding in flowering <i>Callistemon</i> )	200	5 March 2007
Bentley (in pines)	730	27 March 2007
Kenwick	600	12 March 2009
near Wellard	1,200	March 2010

Nearly all the records are from areas with pine plantations or drinking sites. The region of origin of most of these flocks is still largely unknown.



**Figure 7** Large flock sizes on the southern portion of the Swan Coastal Plain



**Figure 8** Migration and movements of Carnaby's Cockatoo.

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It is apparent that flocks move over fairly large parts of the southern Swan Coastal Plain in search of food e.g. a leucistic male (with a whitish head) was photographed at Leeming, Kelmscott and Keysbrook, giving an indication of local movements.

Also noteworthy is that based on Johnstone and Kirkby recent studies there are several small resident populations on the southern Swan Coastal Plain at Lake Clifton (50–100 pairs), also near Bunbury and probably at Baldivis. At each of these sites the birds forage in remnant bushland and in adjacent pine plantations.

On the southern Swan Coastal Plain (e.g. Lake Clifton-Bunbury area) pairs (including resident birds) begin to move back to their breeding sites in September-October (some as late as mid-November) and begin renovating or looking for a suitable nest hollow.

The migration and movements of birds from the south-east portion of their breeding range (mainly the Great Southern region) also appears to follow a fairly regular pattern. During the summer months, flocks tending to move from the inland districts towards the coast and those for example, visiting the south coast then tending to move east or west along it. Some visitors to the southern Swan Coastal Plain (Bunbury-Dunsborough) possibly originate from areas north of the Great Southern region i.e. north of Kojonup but more likely are mainly visitors from parts of the southern forest block for example from the Nannup-Balingup area. Carnaby's Cockatoo is both a common resident and visitor to the Nannup region, for example a flock of 700 was observed feeding in a *Pinus* plantation on 5 February 2003 and a flock of 400 observed flying to a roost on 15 September 2004. It is possible that the small resident population in the Bunbury region is augmented by autumn visitors from regions to the south and south east.

#### **4.1.6. Historical Changes (distribution, relative abundance and foraging habitat)**

Due to the large-scale post-war clearing of the semi-arid sandplains for agriculture Carnaby's Cockatoo have declined in much of the wheatbelt. This decrease in the food supply has been partly offset by its discovery in the early 1930s of a new food resource, namely the seeds of *Pinus* spp. the large plantations of which are located within the subhumid and humid zones especially on the Swan Coastal Plain and adjacent Darling Range. At the same time, the number of Salmon Gums and Wandoo (its principal nest trees in the wheatbelt) has steadily diminished. Consequently the centre of gravity of this cockatoo's distribution has shifted considerably westwards and southwards since the 1950s. Judging from the historical data base, a fairly good picture of the overall distribution of Carnaby's Cockatoo on the Swan Coastal Plain since colonial times can be seen. Gould (1865) notes under *Calyptorhynchus baudinii* (= Carnaby's and Baudin's). "I have never seen specimens from any other part of Australia than the colony of Swan River, over the whole of which it seems to be equally distributed". In the early 1900s large flocks were recorded on parts of the coastal plain e.g. A.W. Milligan (1903) lists a flock of 2,000 at Yanchep in late December 1902.

Alexander (1921) listed the species as a common resident in the Swan River District. "Small flocks travel about from place to place, and there appears to be a regular passage of individuals southward after the breeding season, but the movements of this species are not properly understood".

Perry (1948) noted that all of the pine plantations around Perth planted in 1926 were used extensively by Carnaby's Cockatoos by the mid 1930s. In the early 1940s he recorded flocks estimated at 5,000–6,000 birds at four metropolitan plantations

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namely the Collier plantation, South Perth, Somerville plantation, Applecross; the Scaddan plantation near Mt Lawley and the Gnangara plantation near Wanneroo.

Serventy (1948) noted that “the species does not nest in the district, being mainly a passage nomad. Frequently parties may be seen flying northwards over the area in the autumn, from March to June, and southwards in the spring, from August to November. It may be observed even over the city of Perth at times. In the Tuart belt, north of Perth, flocks may be seen during most of the year. Large numbers are attracted to the Forests Department pine plantations, where they eat the seed”.

Saunders *et al.* (1985) estimated a total population of 60,000 birds across the range of the species.

Storr and Johnstone (1988) list the status of Carnaby’s Cockatoo on the Swan Coastal Plain as follows: visitor (all months) and resident. Common; usually in pairs or flocks (up to 2,000). Mainly pine plantations, eucalypt woodlands and forests, and proteaceous scrubs and shrublands; attracted to seeding *Pinus* spp. and flowering *Dryandra sessilis*. Breeding in small numbers, mainly in far north-east (Regans Ford south to Gingin) but also sparingly as far south as Bunbury. Most birds presumably come from further north or east, e.g. birds banded at Manmanning and recovered at Beermullah, Yanchep and Gnangara (Saunders 1980).

Stranger (2003) lists Carnaby’s Cockatoo for the Mandurah District as “a visitor to the coastal plain from the north, nomadic. Formerly in very large flocks of 1,000–2,000. It is now comparatively rare and possibly threatened. Small numbers may range into the Jarrah forest”.

Johnstone *et al.* (2008b) give an estimate of 10,000–15,000 birds on the Swan Coastal Plain with the majority of birds between Perth and Lancelin on the northern part of the plain.

Judging from the above accounts it is clear that while the overall distribution of this cockatoo on the Swan Coastal Plain has not changed since the early 1900s, its relative abundance has declined greatly. Furthermore as its foraging habitat has been reduced it appears that the remnant *Banksia* woodlands and the remaining pines are not large enough to provide adequate food resources for the existing population. In the past 10 years there appears to be a marked increase in birds foraging in suburban gardens often on single trees and in some small remnant patches of *Banksia* woodland on the plain have been heavily stripped of cones and flowers and there is little or no recruitment of trees.

#### **4.1.7. Food**

In the food descriptions the genus *Dryandra* has been retained contra Mast and Thiele (2007) who combined *Dryandra sessilis* as *Banksia sessilis*, *Dryandra praemorsa* as *Banksia undata* and *Dryandra lindleyana* as *Banksia dallanneyi*.

Carnaby’s Cockatoo has been observed feeding on a wide range of foods including the seeds of *Banksia attenuata*, *B. baxteri*, *B. coccinea*, *B. menziesii*, *B. grandis*, *B. prionotes*, *B. speciosa*, *B. ilicifolia*, *B. longifolia*, *B. ericifolia*, *B. quercifolia*, *B. hookeriana*, *Dryandra fraseri*, *D. praemorsa*, *D. carlinoides*, *D. squarrosa*, *D. sessilis*, *Corymbia calophylla*, *C. citriodora*, *Eucalyptus patens*, *E. todtiana*, *E. marginata*, *E. caesia*, *E. salmonophloia*, *Hakea erinacea*, *H. laurina*, *H. incrassata*, *H. lasiantha*, *H. lissocarpha*, *H. stenocarpa*, *H. trifurcata*, *Hakea undulata*, *H. prostrata*, *H. lasianthoides*, *Grevillea* spp., *Pinus* spp. (including *P. radiata*, *P. caribaea* and *P. canariensis*), *Callitris*, *Jacaranda*, *Helianthus*,



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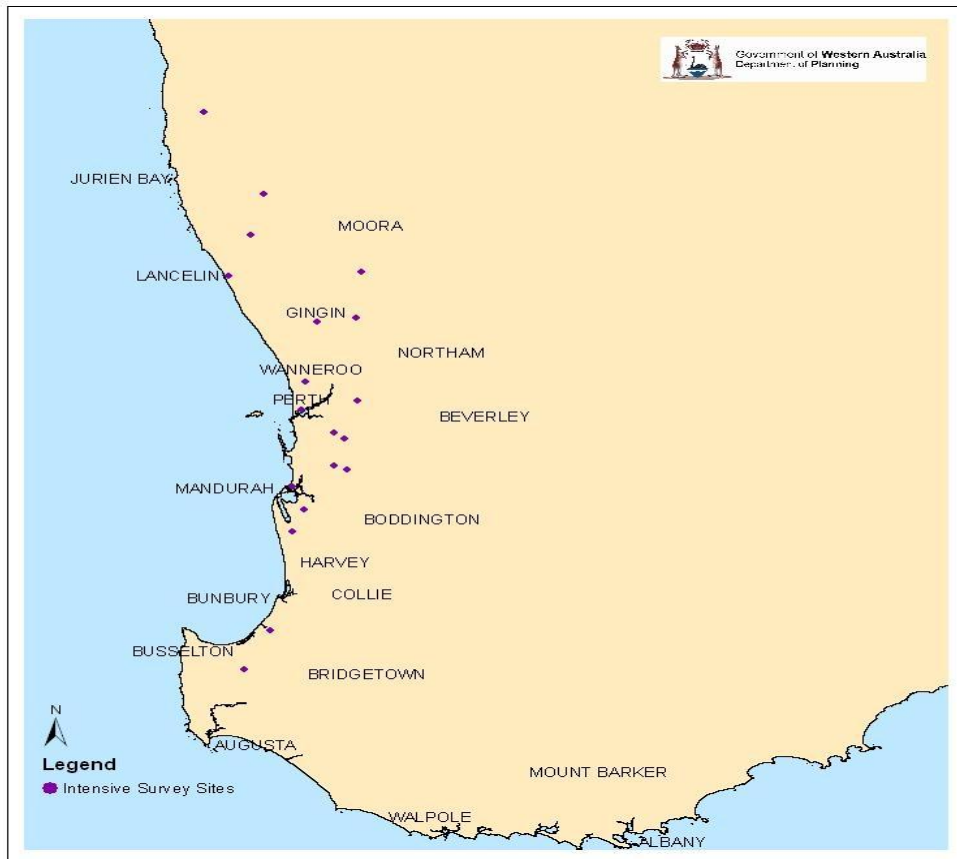
*Macadamia*, *Prunus*, *Carya*, *Liquidambar styraciflua*, *Mesomelaena* spp., *Citrullus lanatus* and *Erodium* spp.; flower buds, flowers and nectar of *Banksia attenuata*, *B. ericifolia*, *B. grandis*, *B. ilicifolia*, *B. menziesii*, *Callistemon* spp., *Corymbia calophylla*, *Dryandra lindleyana*, *D. squarrosa*, *D. sessilis*, *Eucalyptus erythrocorys*, *E. gomphocephala*, *E. patens*, *E. robusta*, *Grevillea robusta*, *Stenocarpus sinuatus*, *Protea* spp., insect larvae and insects (including weevils) from under bark, from wood of live and dead trees and shrubs, from galls and from flowers and flower stems, of *Acacia* spp. (including *A. saligna* and *A. pentedenia*) *Banksia* spp., *Eucalyptus* spp., *Jacksonia*, *Agonis* and *Xanthorrhoea*; also the flesh and juice of apples and persimmons.



**Figure 9** Female Carnaby's Cockatoo feeding on a *Banksia menziesii* cone (KL)

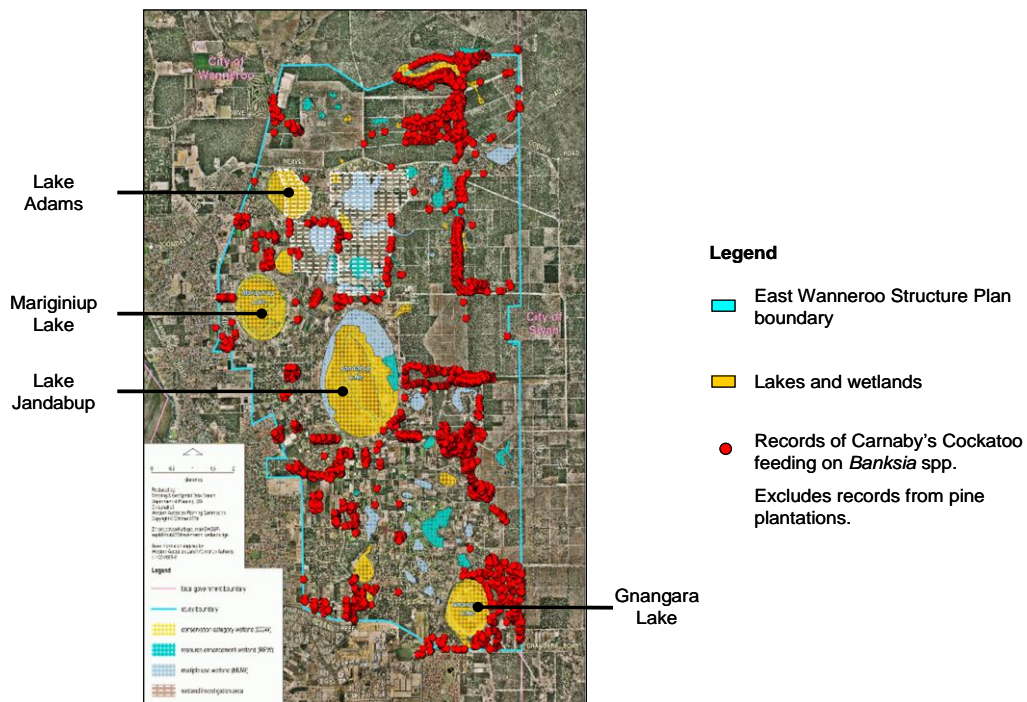
#### **4.1.8. Important Habitat Sites on Swan Coastal Plain**

Apart from recent roost surveys and counts (see Burnham *et al.* 2010) very little of the Swan Coastal Plain and adjacent Darling Scarp has been surveyed for feeding, breeding and roosting sites. The only studies carried out so far with detailed information on foraging and breeding are in the Gnangara Sustainability study area, the East Wanneroo area, near Bindoon, the corridor of the Forrest Highway, Wungong Dam Catchment, the Serpentine area and parts of the Whicher Range and in the Bunbury-Busselton road verges. In most cases these too have also only been short term studies of only a few months making it difficult to determine the importance of certain habitats and sites.

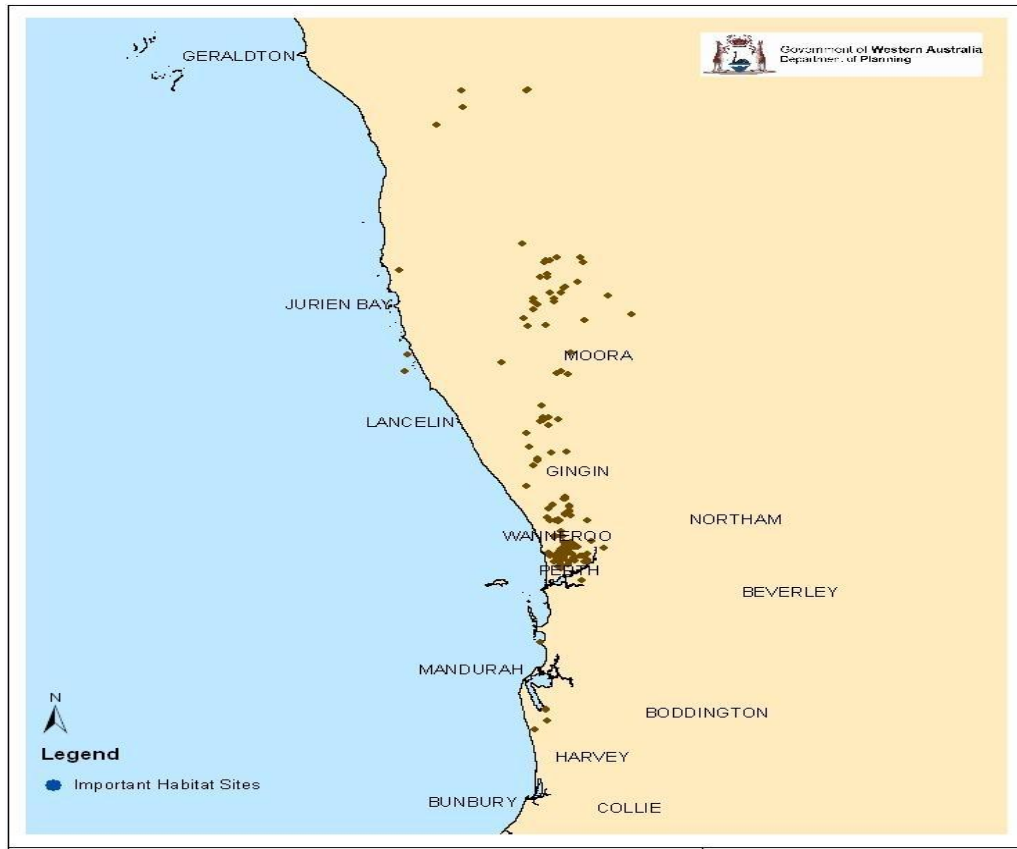


**Figure 10** Location of intensive survey sites

Recent surveys in the East Wanneroo area have highlighted the importance of both Pine plantations and Banksia woodlands in the April–July period. The map below is an example demonstrating such a recent intensive survey.



**Figure 11** Showing importance of Banksia woodlands in East Wanneroo region as foraging habitat for Carnaby's Cockatoo in July 2010



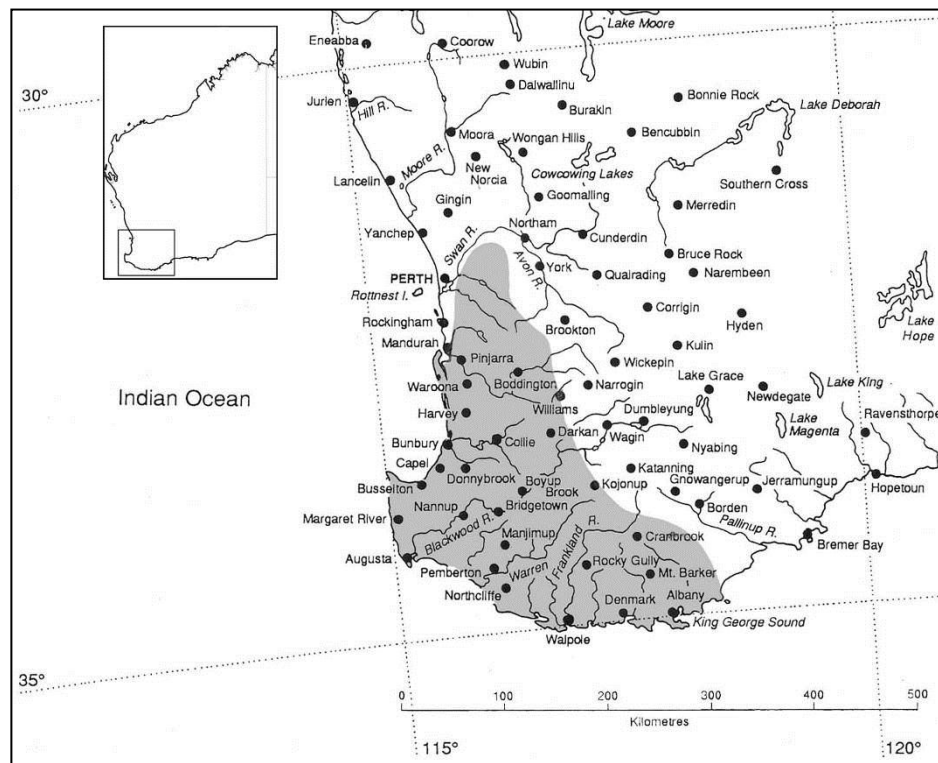
**Figure 12** Important habitat sites (based on latitude/longitude)

Refer to Appendix 1 for the latitude and longitudes of the known important habitat sites on Swan Coastal Plain and adjacent Darling Scarp.

## 4.2. Baudin's Cockatoo (*Calyptorhynchus baudinii*)

Baudin's Cockatoo is listed as 'fauna that is rare or likely to become extinct' under the Western Australian *Wildlife Conservation Act 1950*, Wildlife Conservation (Specially Protected Fauna) Notice 2010(2). It has been given a ranking of Endangered by the Western Australian Threatened Species Scientific Committee. It is also listed as Endangered under the *Environment Protection and Biodiversity Conservation Act 1999*.

Baudin's Cockatoo (*Calyptorhynchus baudinii*) is a large, iconic, forest cockatoo, endemic to the south-west corner of Western Australia and currently listed as endangered. It has suffered a substantial decline in numbers in the past 50 years. Direct causes of population decline include large numbers shot by orchardists, fragmentation of habitat and the impact of hollow competitors. In this paper we provide details of distribution, status, habitat preferences, breeding, social organisation, migration and movements, roost sites and diet.



**Figure 13** Distribution map of Baudin's Cockatoo *Calyptorhynchus baudinii*

### 4.2.1. Distribution

Figure 8 shows the distribution of Baudin's Cockatoo based on observations and reliable historic records. This cockatoo is confined to the south-western humid and subhumid zones (areas with average rainfall of 600 mm or more). It ranges north to Gidgegannup and Hoddy Well and east to Clackline, Wundowie, the lower Darkin River, Boyagin Rock, Wandering, Williams, Kojonup and the King River also west to the eastern strip of the Swan Coastal Plain including West Midland, Armadale, Byford, Mundijong, Serpentine, North Dandalup and further west to the coast at Lake Clifton, Australind, Bunbury, Busselton, Dunsborough, Leeuwin-Naturaliste National

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Park and Augusta, also the Stirling and Porongurup Ranges and east along the south coast to Waychinicup National Park.

#### **4.2.2. Status and Habitat Preferences**

Depending on their region of origin, Baudin's Cockatoo is a resident, a postnuptial nomad and migrant, with the bulk of the population largely vacating the coldest parts of their range (i.e. the Karri forest block) in the autumn and migrating northwards or with a strong tendency to wander from the interior towards the coast, but also in a few places resident in small numbers (e.g. Manjimup and the Leeuwin-Naturaliste ridge). Migrations and movements including visits between March and September from the deep south-west to the central and northern Darling Range (e.g. Collie, Samson Brook, Crossman, Bannister, North Dandalup hills area, Serpentine-Jarrahdale area, Wungong Valley, Araluen, Mundaring, Chidlow) and adjacent far east of the Swan Coastal Plain (e.g. Maida Vale, Kelmscott, Armadale, Byford, Mundijong, Serpentine, North Dandalup and further west to Lake Clifton, Bunbury, Capel, Busselton and Dunsborough). Baudin's Cockatoo is gregarious and is usually seen in family groups and small flocks.

Its relative abundance ranges from scarce to moderately common (most numerous in the deep south-west during the spring breeding season September–December and in the northern Darling Range during autumn April–August). Usually observed in small flocks (up to 30) occasionally in larger flocks (up to 50) or aggregations (up to 1,200) at drinking sites or roosts.

Based on recent surveys and roost counts, it is estimated the total population to be 15,000 birds.

#### **4.2.3. Habitat**

Baudin's Cockatoo is mainly found in eucalypt forests, especially Jarrah (*Eucalyptus marginata*)-Marri (*Corymbia calophylla*) forest, Karri (*Eucalyptus diversicolor*) forest, and less frequently in woodlands of Wandoo (*Eucalyptus wandoo*), Blackbutt (*Eucalyptus patens*), Flooded Gum (*Eucalyptus rudis*), Yate (*Eucalyptus cornuta*), partly cleared farmlands and urban areas including roadside trees and house gardens. This cockatoo forages at all levels of the forest from the canopy to the ground, often feeding in the understorey on proteaceous trees and shrubs, especially *Banksia*, and in orchards both in trees and on dropped or fallen fruit on the ground.

#### **4.2.4. Breeding**

There is very little breeding information and the breeding biology of this species is poorly known. Recorded breeding in deep south-west, north to the Whicher Range and Lowden and also isolated records at Wungong Catchment, Serpentine (hills area) and east to Kojonup and near Albany. They nest in large, mostly vertical, hollows of Karri (*Eucalyptus diversicolor*), Marri (*Corymbia calophylla*), Wandoo (*Eucalyptus wandoo*) and Bullich (*Eucalyptus megacarpa*). Baudin's Cockatoos display strong pair bonds are monogamous, and probably mate for life and the pair remain together all year round except when the female is incubating and brooding. Both adults play a part in selecting the nest hollow, but only the female is responsible for renovation and preparing the hollow for breeding. Preparation of the hollow consists of chewing around the entrance of the hollow and down one part of the interior wall. Males have been recorded making the breeding call and displaying to females in most months, but this behaviour is more frequent in August, September and October. Pairs have also

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been recorded prospecting for hollows in most months and also outside the breeding range. Egg laying is recorded in August, September, October, November and December. The clutch size is 1–2, incubation lasts for 29 days and only the female incubates and broods.



**Figure 14** Female Baudin's Cockatoo at a nest hollow in Wungong Dam catchment (TK)

#### **4.2.5. Social Organisation, Flocking and Movements**

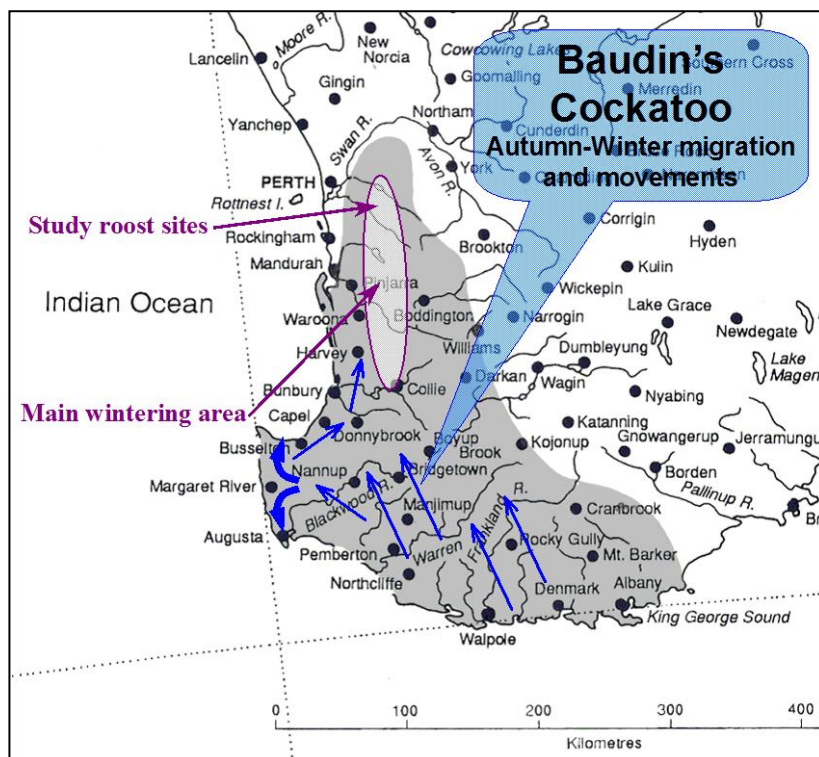
Following breeding the birds leave the nesting areas and family groups then amalgamate to form larger foraging flocks. The flocks begin to arrive at non-breeding traditional roosts in the central and northern parts of the Darling Scarp (from about Collie north to Mundaring) in early February and March. The largest groups (600+) being recorded between April and September with some foraging out onto the southern Swan Coastal Plain to areas such as Kelmscott, Mundijong, Serpentine, Pinjarra, Harvey, Myalup, Bunbury, Capel, Tutunup, Busselton, Dunsborough and Meelup. Judging from recent surveys (Johnstone. and Kirkby 2008a) for the groups of birds that have spent the non-breeding season in the Perth hills districts, there appears to be a definite shift westward onto the southern Swan Coastal Plain, just prior to the flocks moving south to breed.



**Figure 15** Flock of Baudin's Cockatoo at Araluen (TK)

This shift begins in mid-August and flocks of up to 200 birds have been recorded in August-September, at Armadale, Byford, Mundijong, Keysbrook, Serpentine, North Dandalup, Waroona and Yarloop during this period. At this time some of the groups also formed roost sites at the western edge of the scarp (Kelmscott 2006-2007) or out onto the coastal plain (Mundijong 2006-2007).

By mid-October most birds are either back in their breeding areas, or heading there, and in breeding condition. For example, on 17 October 2006 a flock of over 200 was observed near Frankland feeding on Storksbill (*Erodium* spp.) and Marri seed. On 22 October several breeding pairs were observed near Walpole, with males feeding females and one female entering and remaining in a nest hollow. On the same day, 10-12 pairs with displaying males were recorded near Lake Muir. On 23 October 2006 a flock of over 300 (mostly in pairs and family groups) with many males giving the breeding call and displaying to females was observed near Bridgetown. Most of this latter flock left what appeared to be a resting site in tall Lemon-scented Gums at about 09:30, and although some pairs remained in the vicinity a large loose aggregation (most of the flock) appeared to be still moving southwards. Also on 9 October 2006, a flock of 250 was observed feeding on Storksbill on the Vasse Highway near Nannup and on 20 October 2006 a flock of 200 was observed 3 km south of Nannup feeding on Storksbill.



**Figure 16** Map of south-western Australia showing migration and movements of Baudin's Cockatoo, main wintering range and Araluen and Wungong study roost sites

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Also noteworthy is that two flocks were recorded near Williams, a flock of 16 flying south with males making the breeding call on 20 October 2004, and a flock of 21 was flying east on 17 October 2006. These records are of interest as Baudin's Cockatoo is generally not recorded in the Williams area and these birds were most likely migrating back to their breeding sites.

#### 4.2.6. Food

Baudin's Cockatoo has been observed feeding on a wide range of foods including the seeds of *Corymbia calophylla*, *Eucalyptus marginata*, *Allocasuarina fraseriana*, *Banksia grandis*, *B. quercifolia*, *B. littoralis*, *B. ilicifolia*, *Hakea erinacea*, *H. prostrata*, *H. stenocarpa*, *H. trifurcata*, *H. lasianthoides*, *H. ruscifolia*, *H. lissocarpha*, *H. varia*, *H. cristata*, *H. marginata*, *Dryandra sessilis*, *D. squarrosa*, *D. praemorsa*, *Grevillea wilsonii*, *Xanthorrhoea preissii*, *Kingia australis*, *Reedia spathacea*, *Pinus radiata*, *Erodium* spp. (including *E. botrys*), *Jacaranda* spp., *Macadamia* spp., Pecan (*Carya illinoensis*), Apples *Malus* spp., Pears *Pyrus* spp., Persimmons *Diospyros* spp. and *Quercus* spp.; nectar, buds and flowers of *Corymbia calophylla*, *C. citriodora*, *Eucalyptus marginata*, *E. wandoo*, *Eucalyptus* spp., *Banksia grandis*, *Dryandra sessilis*, *D. lindleyana*, *D. squarrosa*, *Darwinia citriodora* and *Callistemon* spp.; insect larvae and insects (including beetle, wasp and moth larvae) from under bark and in wood of live and dead trees, from galls and from flower spikes of *Xanthorrhoea*; the pith of *Anigozanthos flavidus*; also the juice of ripe persimmons and the growing tips of *Pinus* spp. Overall Marri (*Corymbia calophylla*) is the primary food source with the birds using its seeds, flowers, nectar and buds. Also it appears that in years when the Marri fails to flower or flowers poorly are the years when damage by this cockatoo to cultivated fruits is most severe.



**Figure 17** Baudin's Cockatoo male (left) and female (right) feeding (TK)



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#### **4.2.7. Conservation**

The long-term survival of Baudin's Cockatoo is of increasing concern. Previously a very robust population, it appears to have declined greatly in the past 50 years (Johnstone and Storr 1998). Its low rate of reproduction (0.6 chick per year or every two years) (Johnstone and Storr 1998) precluding it from replacing the large numbers shot by orchardists and those lost through other causes e.g. habitat destruction and vehicle strikes. Over a quarter of its original habitat has been cleared. There is no doubt that the future conservation of this forest cockatoo provides us with an immediate challenge in reducing its major threats, namely illegal shooting by orchardists, deaths caused by road strikes, loss of feeding and breeding habitat and the impact of nest competitors including the feral European honey bee. The current view that, as a result of these threats, this species is declining and threatened with extinction (DEC 2008) gives some urgency to the development of recovery and management plans. It is also crucial that research into its breeding biology, including migration and movements, threatening processes, food requirements and the size and health of breeding populations are undertaken.

#### **4.3. Conclusions**

Despite Baudin's Cockatoo being a large iconic forest cockatoo we still know very little about its breeding biology, its breeding range, timing of nesting events, nest tree and nest hollow characteristics, clutch size, incubation period, fledging period and nesting success. Furthermore, there is an urgent need to clarify the habitat requirements and movements of both Baudin's and Carnaby's Cockatoos in many parts of the south west. The movements of both of these cockatoos are no doubt dictated by food availability as controlled by climatic effects on habitat, and if this is the case, how do these birds co-ordinate their migrations accordingly? Judging from the historical data, there have been enormous changes in the distribution and status of both of these cockatoos in the past 50 years. As the climate warms in the south-west, species that currently undergo extensive movements may either shorten their migration distance or even stop migrating and remain year round in certain rainfall zones. With a decrease in rainfall (which has occurred over the past 30 years), Baudin's Cockatoo could be expected to contract towards high rainfall zones in the south-west. On the other hand, we would expect the more-arid adapted Carnaby's Cockatoo to be contracting or extending its breeding range westwards and southwards and, judging from the historical and recent data, this shift appears to be happening.

Further GIS study of roost sites would no doubt yield valuable results. Baudin's Cockatoos appear to have set foraging patterns that change based on the availability and seasonality of resources and can range daily over about 6 km. Mapping the available resources within a 10 km radius and how far some of these flocks range to find food could have useful applications especially in areas with a mosaic of forest, agriculture (fruit growing) and urban landscapes. Further studies are now also required to determine the breeding distribution and to map and monitor important breeding, feeding and roosting sites throughout the south-west.

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

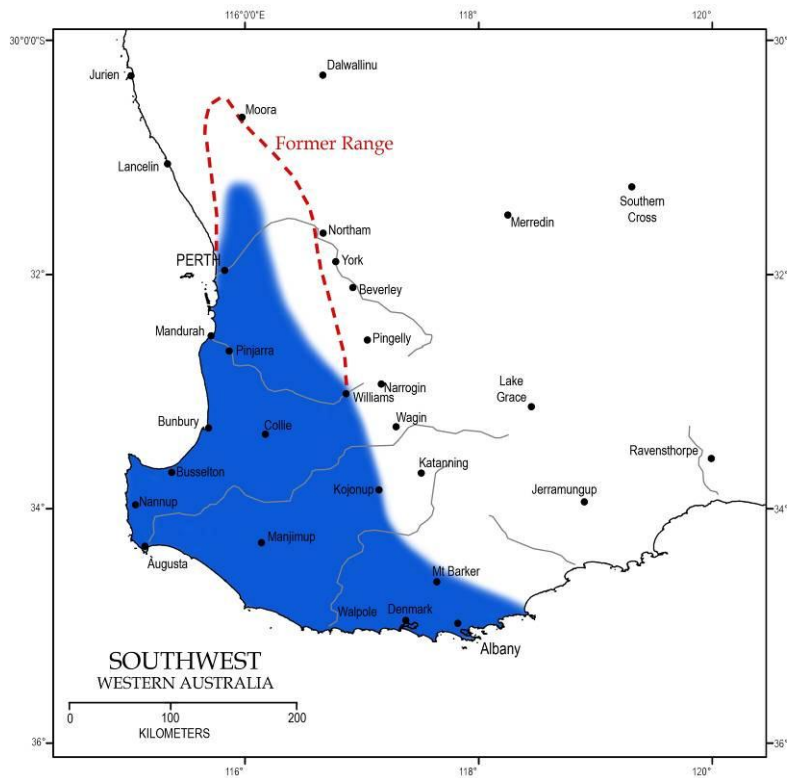
The Forest Red-tailed Black Cockatoo is listed as 'fauna that is rare or likely to become extinct' under the Western Australian *Wildlife Conservation Act 1950*, Wildlife Conservation (Specially Protected Fauna) Notice 2010(2). It has been given a ranking of Endangered by the Western Australian Threatened Species Scientific Committee. It is also listed as Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999*.



**Figure 18** Forest Red-tailed Black Cockatoo pair *Calyptorhynchus banksii naso* (TK)

##### 4.4.1. Distribution

The Forest Red-tailed Cockatoo is endemic to the south-west of Western Australia. This subspecies occurs in the humid and subhumid south-west mainly the hilly interior, north to Gingin (formerly to Dandaragan), Gidgegannup, and east to Mt Helena (formerly Toodyay), Chidlow, Wooroloo, Wundowie, The Lakes, Christmas Tree Well, near Brookton, Bannister (formerly to Wandering), Mt Saddleback, Kojonup, Rocky Gully, the upper King River and Porongurup Range. 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 Lake 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 (see Figure 18).



**Figure 19** Map of South-western Australia showing distribution of Forest Red-tailed Black Cockatoo

#### 4.4.2. Status and Habitat Preferences

It was formerly common, but is now rare to uncommon and patchily distributed over a range which has become markedly reduced. Usually in pairs or small flocks, seldom large flocks (up to 200). Estimate of total population 10,000–15,000 birds but breeding population is small possibly only 10–20 %.

#### 4.4.3. Breeding

Breeding has been recorded from February to December (with a peak between October and December, also a peak in some years in April–May).

The Forest Red-tailed Black Cockatoo nests in large hollows of Marri (*Corymbia calophylla*), Jarrah (*Eucalyptus marginata*), Wandoo (*Eucalyptus wandoo*), Bullich (*Eucalyptus megacarpa*), Tuart (*Eucalyptus gomphocephala*) and Karri (*Eucalyptus diversicolor*). Clutch one (rarely 2) and only the female incubates and broods. Incubation period 29–31 days and nestling period 75–85 days (Johnstone and Storr 1998). Most pairs appear to breed every second year.

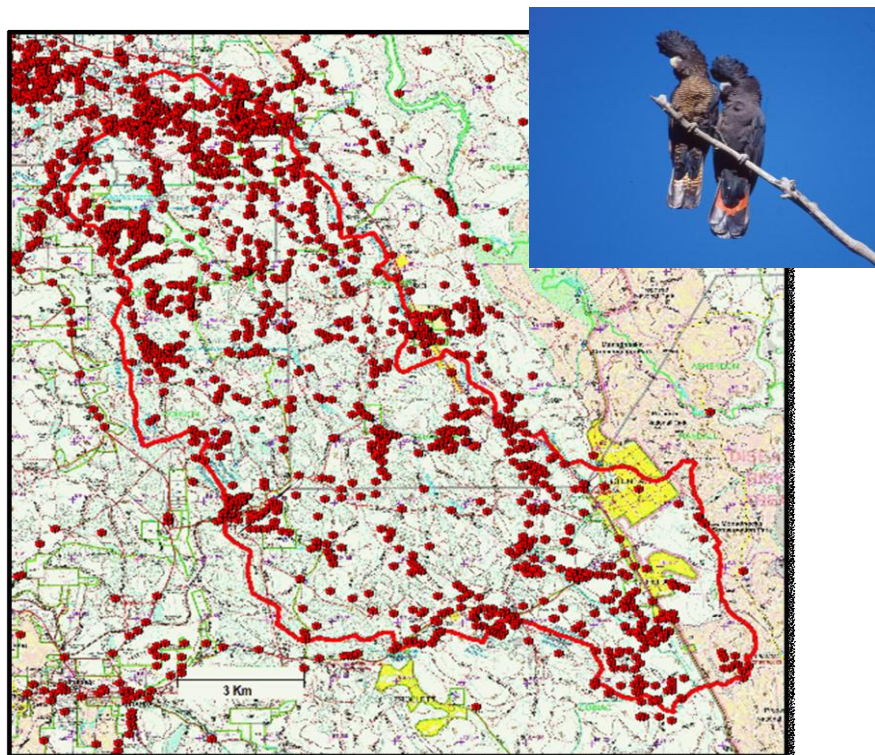
On the Swan Coastal Plain breeding has been recorded in November–December.

Birds begin to breed at 4+ years of age. This species favours large top entry hollows with entrances ranging from 12–14 cm in diameter and hollow depth 1–5 metres.

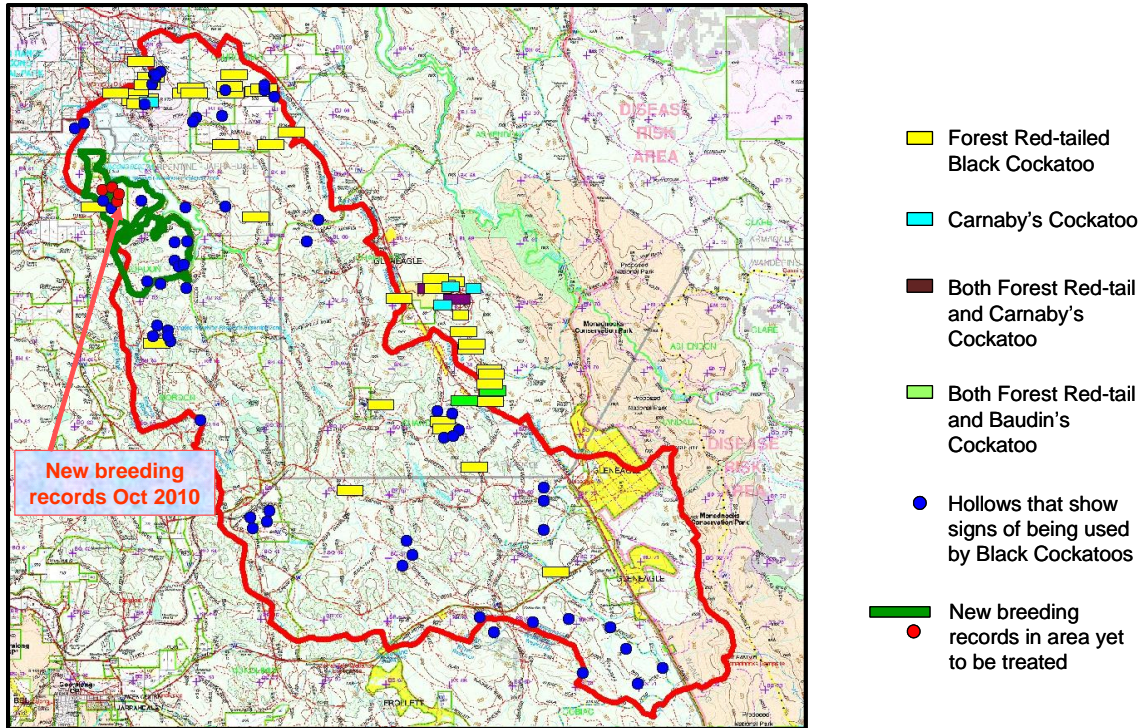


**Figure 20** Pair male (left) female (right) of Forest Red-tailed Black Cockatoos at nest hollow (TK)

#### 4.4.4. Movements



**Figure 21** Map showing the distribution of the Forest Red-tailed Black Cockatoo in the Wungong Dam Catchment (Johnstone and Kirkby 2009).



**Figure 22** Map showing breeding distribution of all three black cockatoo species in the Wungong Dam Catchment 1992–2010 (Johnstone, Kirkby and Sarti 2010)

#### 4.4.5. Food

The Forest Red-tailed Black Cockatoo feeds mainly on the seeds of Marri *Corymbia calophylla* and Jarrah *Eucalyptus marginata*; other foods include Sheoak *Allocasuarina fraseriana*, Snottygobble *Persoonia longifolia*, Blackbutt *Eucalyptus patens* and introduced species including White Cedar (Cape Lilac) *Melia azedarach* and Lemon-scented Gum *Corymbia citriodora* (Johnstone and Kirkby1999).

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## 5. ISSUES THREATENING COCKATOOS

The major threatening process for Carnaby's Cockatoo, Baudin's Cockatoo and the Forest Red-tailed Black Cockatoo are as follows:

- **Habitat Loss and Destruction.** Around 60% of the original vegetation across the south west (and up to 90% in parts of the wheatbelt and Swan Coastal Plain) has been cleared for agriculture (crops), meat production, dairying, farmlets, orchards, vineyards, pine plantations, mining, wood chipping, cities and towns. At present extensive tracts of uncleared land only remain in State forest and conservation reserves and what is left of remnant vegetation (in roadside verges etc.) is often disturbed to a varying degree. This region is now a severely fragmented landscape and the loss of remnant vegetation, the lack of regeneration, the changing fire regimes, the altered hydrology, the urban and rural sprawl, Dieback *Phytophthora cinnamomi*, lack of suitable breeding sites, competition with exotic species and climate change all exacerbate the future conservation of black cockatoos in this region.
- **Loss of Gnangara Pine Plantation.** The Gnangara, Pinjar and Yanchep pine plantations are to be progressively removed over the next 20 years. This is likely to have a significant impact on the number and movements of birds on the northern Swan Coastal Plain. Overall pine plantations appear to provide a very high percentage of food for large migratory flocks on the northern Swan Coastal Plain in the January to June period. The loss here will be compounded by the loss of remnant Banksia woodland. Recent studies in the East Wanneroo area confirm the importance of both pine plantations and remnant blocks of Banksia woodlands for Carnaby's Cockatoos in the January-July period. Figure 7 shows feeding evidence in Banksia woodlands in east Wanneroo in the March-June period in 2010. The further reduction of pines and Banksia woodlands in this area will no doubt lead to a reduction in numbers of birds wintering in this region.
- **Illegal Shooting of Baudin's Cockatoos by Orchardists.** Illegal shooting of Baudin's Cockatoos still continues in parts of the south-west. With its low reproduction rate (0.6 chick per year or every two years) this cockatoo cannot replace large numbers shot by orchardists (Pittman, Scott, Stojanovic & McLellan 2007).
- **Nest Hollow Competition.** Apart from the dwindling supply of hollows in the urban, agricultural and forest landscapes, cockatoos (and other hollow users) must also compete with the introduced European honeybee and also invading superabundant species including Galahs and corellas (including introduced eastern corellas). Recent studies (Johnstone & Kirkby 2007a) have revealed the devastating impact feral European honeybees are having on cockatoos and other hollow-nesting fauna. In a number of cockatoo study sites in the south-west, up to 50% of nest hollows have been lost to feral European honeybees in the past ten years. Also noteworthy was a female Baudin's Cockatoo that appeared to have been killed by bees while incubating in a nest hollow at Nannup in 2004.
- **Loss of Veteran and Stag Trees with Nest Hollows.** It is now very evident that in many areas of the south-west there is a paucity of suitable nest hollows for cockatoos and the importance of veteran (ageing) and stag (dead) trees. It takes a minimum of 233 years for a tree to develop hollows suitable for cockatoos.
- **Climate Change.** Rainfall has declined significantly over the entire south-west in the past 30 years, and changes in the distribution of species may already be occurring. Over the past 50 years the distribution of Carnaby's Cockatoo has

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shifted considerably westwards and southwards (Johnstone and Storr 1998). As the climate warms and rainfall declines in the south-west species that currently undergo extensive movements may either shorten their migration distance or even stop migrating and remain year-round in certain rainfall zones. There appears to be a steady shift in distribution southwards and westwards of Carnaby's Cockatoo and increasing temperatures may allow a greater penetration into the western section of the forest block. If rainfall does decrease, Baudin's Cockatoo and the Forest Red-tailed Black Cockatoo could be expected to contract towards the high rainfall zones in the south-west. Other aspects of climate change could be the loss of large veteran trees (and their hollows) in parts of this region. Although we usually consider range expansion in terms of breeding populations, the establishment of a new wintering range or migration route is no doubt also important to both Carnaby's and Baudin's cockatoos, especially with destruction of feeding habitat at various stages along their migratory flyways. There has been a dramatic change in the foraging ecology of Forest Red-tailed Black Cockatoos in the Perth region in the past 12 years with birds foraging west onto the Swan Coastal Plain and east into the wheatbelt.

- **Fire.** Recent studies in the Perth hills indicate that intensive wildfire has a major impact on the survival of cockatoo populations especially local resident populations.
- **Water abstraction.** In some areas this could impact on remnant bushland especially *Banksia* woodland and Tuart forests. Water abstraction also removes the natural bodies of standing water that the birds need for drinking.
- **Mining.** Mining of bauxite, gravel, mineral sands and limestone in the south-west involves the broad-scale clearing of native vegetation. The clearing of some areas could have a significant impact on the survival of some local populations.
- **Forest Management.** State forests that contain habitat critical to the survival of cockatoos should have management guidelines to help protect feeding, breeding and roosting sites. Mapping important breeding sites and protecting nest trees from fire should be part of these guidelines.
- **Poaching.** The taking of eggs and chicks for the aviary trade could still persist to the present day. Often the hollows are severely damaged or trees cut down when young and eggs are taken, making them unsuitable for future breeding (Mawson & Johnstone 1997).
- **Vehicle strikes.** Large numbers of all three species are killed each year by vehicle strikes, e.g. 10 Forest Red-tailed Black Cockatoos were killed by trucks while drinking at a single location on Albany Highway near Bedfordale in August–September 2009; five Baudin's Cockatoos were killed by a vehicle while drinking on the road 10 km east of Manjimup on 22 April 2010 and large numbers of Carnaby's Cockatoos are reported killed by vehicles each year on Wanneroo Road between Wanneroo and Lancelin.

## 6. RECOMMENDATIONS FOR FURTHER RESEARCH

- Targeted surveys for black cockatoos in the region especially in areas where breeding is recorded e.g. around Guilderton, Yanchep, Gingin, Boonanarring, Bindoon, Bedfordale, Serpentine, Baldivis, Lake Clifton, Bunbury, Ludlow, Tutunup, Whicher Range, Carburnup and between Cape Naturaliste and Augusta. Surveys should be temporally spaced to account for seasonal variation. Further work here would help confirm the significance of breeding, feeding and roosting sites within the region.



**Figure 23** Map of where further survey effort should be

- Further survey work in the south-west region to determine the significance of cockatoo migration and movements.
- Study of food resource use by cockatoos. Mapping important feeding sites as done in the East Wanneroo region is crucial for urban planning.
- Seasonal analysis of numbers could be done through the Cockatoo Care Program and could involve DEC and landcare groups.
- Monitor nest hollows that have already been located and determine which species is using the nest hollows and the timing of nesting events.
- Document nest trees with information on hollow size, height and aspect of hollow, circumference of nest tree at breast height, distance apart of nests and details of local vegetation. This will provide a profile of a preferred nest site. Nest tree characteristics may also help provide a protocol of identifying primary habitat trees that may be potential future nest trees.



- Document clutch size, incubation period, fledging period, breeding behaviour and movements.
- Assess over the next few breeding seasons the size and health of some of the breeding populations.
- Assess the impact of hollow competitors.
- Study how the birds use the landscape - do they prefer fragmented landscape and/or the edge trees of pine plantations.

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## APPENDIX 1 - Latitude/Longitude of important and known habitat sites for Carnaby's Cockatoo

Important and known habitat sites on Swan Coastal Plain and adjacent Darling Scarp are listed below. Recommendations for further targeted surveys are given above in chapter 6.

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Wanagarren Nature Reserve	30° 46' 47" S, 115° 15' 11" E
Bashford Nature Reserve, Lancelin	30° 53' 16" S, 115° 23' 06" E
Nilgen Nature Reserve	30° 59' 08" S, 115° 22' 31" E
Moore River National Park	31° 03' 00" S, 115° 40' 00" E
Regans Ford	30° 59' 09" S, 115° 41' 51" E
Regans Ford	30° 59' 12" S, 115° 42' 03" E
Gingin region	31° 04' 09" S, 115° 44' 46" E
Gingin region	31° 16' 26" S, 115° 50' 45" E
Gingin region	31° 15' 40" S, 115° 49' 42" E
Gingin region	31° 23' 11" S, 115° 53' 48" E
Boonanarring Nature Reserve	31° 15' 18" S, 115° 52' 50" E
Bindoon region	31° 23' 00" S, 116° 05' 00" E
Lower Moore River	31° 20' 00" S, 115° 33' 00" E
Mooliabeenee	31° 17' 00" S, 116° 04' 00" E
Caraban	31° 20' 00" S, 115° 33' 00" E
Yanchep National Park	31° 33' 00" S, 115° 41' 00" E
Pinjar plantations	31° 33' 13" S, 115° 46' 21" E
Gnangara area	31° 47' 00" S, 115° 52' 00" E
Muchea area	31° 35' 00" S, 115° 58' 00" E
Avon Valley National Park	31° 37' 00" S, 116° 12' 00" E
Alkimos region	31° 36' 00" S, 115° 40' 00" E
Neerabup National Park	31° 39' 00" S, 115° 43' 00" E
Tamala Park	31° 42' 00" S, 115° 43' 00" E
Melaleuca Park	31° 41' 00" S, 115° 44' 00" E
Whiteman Park	31° 49' 00" S, 115° 56' 00" E
Walyunga National Park	31° 44' 00" S, 116° 05' 00" E
East Wanneroo area	31° 45' 00" S, 115° 48' 00" E

Block bounded by Sydney Road in north, Joyce Road in south, Steel Road in east and Pine Crest Way in west.

Block at north end of Wandoo Road (just north of Sandpiper Crescent).

Block in northern zone of project area, east of Wandoo Road and just north of Neaves Road.

Block running east-west between Bulok Road (in west) and Wandoo Road (in east) between pine plantations.

Block extending from Silver Road (at junction of Meadowlands Drive and Silver Road) south to Amarante Road.

Coogee Park.

Block bounded by Mulga Road in north and east, Wirrega Road in south and Hawkins Road in west.

Caporn Park

Edgar Griffiths Park (north end)

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Damian Park	
Chicquita Park	
Franklin Park	
Benmuni Park	
Block at south junction of Coogee Road and Mornington Drive	
Lake Jandabup Reserve	31° 45' 00" S, 115° 51' 00" E
Little Mariginiup Lake	31° 42' 00" S, 115° 49' 00" E
Mariginiup Lake	31° 43' 00" S, 115° 49' 00" E
Gnangara Lake Reserve	31° 47' 07" S, 115° 52' 34" E
Burns Beach area	31° 43' 00" S, 115° 43' 00" E
Karrinyup Golf Course	31° 52' 00" S, 115° 47' 00" E
Carine Lakes area	31° 51' 00" S, 115° 47' 00" E
Star Swamp	31° 51' 00" S, 115° 45' 00" E
Greenmount National Park	31° 54' 00" S, 116° 03' 00" E
Hartfield Park, Forrestfield	32° 00' 02" S, 116° 00' 08" E
Kelvin Rd, Orange Grove	32° 01' 22" S, 116° 00' 55" E
Passmore Rd, Gosnells	32° 07' 06" S, 115° 57' 58" E
Matson Rd, Gosnells	32° 06' 55" S, 115° 57' 14" E
Ranford Rd, Gosnells	32° 07' 40" S, 115° 57' 47" E
Wellard St, Yangebup	32° 07' 06" S, 115° 47' 57" E
Beeliar Campus, Beeliar	32° 07' 54" S, 115° 49' 13" E
Liddelow Rd, Banjup	32° 09' 55" S, 115° 53' 21" E
Liddelow Rd, Banjup	32° 09' 55" S, 115° 53' 23" E
Liddelow Rd, Banjup	32° 09' 53" S, 115° 53' 24" E
Liddelow Rd, Banjup	32° 09' 55" S, 115° 53' 24" E
Liddelow Rd, Banjup	32° 09' 56" S, 115° 53' 23" E
Liddelow Rd, Banjup	32° 09' 57" S, 115° 53' 22" E
Liddelow Rd, Banjup	32° 09' 56" S, 115° 53' 22" E
Harry Waring Research Station, Wattleup	32° 09' 47" S, 115° 50' 02" E
Thomsons Lake Nature Reserve, Wattleup	32° 09' 32" S, 115° 50' 01" E
Bush Forever Site 492, Banjup	32° 09' 46" S, 115° 51' 47" E
Bush Forever Site 492, Banjup	32° 09' 48" S, 115° 51' 49" E
Bush Forever Site 492, Banjup	32° 09' 44" S, 115° 51' 52" E
Bush Forever Site 492, Banjup	32° 09' 52" S, 115° 57' 57" E
Beliar Regional Park, Cockburn	32° 09' 41" S, 115° 46' 46" E
Beliar Regional Park, Cockburn	32° 09' 43" S, 115° 46' 47" E
Beliar Regional Park, Cockburn	32° 09' 16" S, 115° 46' 47" E
Cockburn Rd, Cockburn	32° 10' 09" S, 115° 46' 20" E
Banjup	32° 10' 05" S, 115° 52' 16" E
Bartfield St, Hammond Park	32° 10' 41" S, 115° 51' 11" E
Rowley Rd, Hammond Park	32° 10' 50" S, 115° 51' 01" E
Rowley Rd, Mandogalup	32° 10' 45" S, 115° 50' 48" E
Rowley Rd, Mandogalup	32° 10' 44" S, 115° 50' 48" E
Rowley Rd, Mandogalup	32° 10' 42" S, 115° 50' 47" E
Frankland Ave, Mandogalup	32° 10' 42" S, 115° 50' 47" E
Frankland Ave, Mandogalup	32° 10' 22" S, 115° 50' 51" E

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Frankland Ave, Mandogalup	32° 10' 39" S, 115° 50' 54" E
Frankland Ave, Mandogalup	32° 10' 32" S, 115° 50' 48" E
Miles Rd, Wandí	32° 11' 45" S, 115° 52' 36" E
De Haer Rd, Wandí	32° 11' 43" S, 115° 51' 59" E
Anketell Rd, Wandí	32° 12' 30" S, 115° 53' 39" E
Anketell Rd, Wandí	32° 12' 30" S, 115° 53' 39" E
Anketell Rd, Wandí	32° 12' 30" S, 115° 54' 12" E
Anketell Rd, Wandí	32° 12' 28" S, 115° 54' 53" E
Tuart Rd, Wandí	32° 12' 37" S, 115° 53' 18" E
Tuart Rd, Wandí	32° 12' 41" S, 115° 53' 18" E
Tuart Rd, Wandí	32° 12' 39" S, 115° 52' 35" E
De Haer Rd, Wandí	32° 12' 17" S, 115° 52' 09" E
De Haer Rd, Wandí	32° 12' 17" S, 115° 52' 11" E
Thomas Rd, Wandí	32° 13' 11" S, 115° 53' 11" E
Thomas Rd, Wandí	32° 13' 10" S, 115° 53' 44" E
Thomas Rd, Wandí	32° 13' 07" S, 115° 53' 39" E
Thomas Rd, Wandí	32° 13' 17" S, 115° 53' 31" E
Thomas Rd, Bertram	32° 13' 52" S, 115° 51' 08" E
Marri Park Rd, Marri Park	32° 14' 09" S, 115° 52' 55" E
Drain Reserve 1205, Bertram	32° 14' 03" S, 115° 50' 48" E
Drain Reserve 1205, Bertram	32° 14' 03" S, 115° 50' 49" E
Drain Reserve 1205, Bertram	32° 14' 02" S, 115° 50' 49" E
Thomas Rd, Bertram	32° 14' 01" S, 115° 50' 53" E
Baldivis Rd, Baldivis	32° 21' 52" S, 115° 49' 42" E
Sixty Eight Rd, Baldivis	32° 21' 53" S, 115° 48' 36" E
Karnup Nature Reserve, Baldivis	32° 21' 41" S, 115° 49' 24" E
Karnup Nature Reserve, Baldivis	32° 22' 25" S, 115° 49' 27" E
Karnup Nature Reserve, Baldivis	32° 22' 24" S, 115° 49' 26" E
Karnup Nature Reserve, Baldivis	32° 22' 34" S, 115° 49' 26" E
Karnup Nature Reserve, Baldivis	32° 22' 22" S, 115° 49' 28" E
Baldivis Rd, Baldivis	32° 22' 04" S, 115° 49' 35" E
Mandurah Rd, Baldivis	32° 22' 09" S, 115° 46' 51" E
Baldivis Rd, Baldivis	32° 23' 06" S, 115° 46' 05" E
Henderson Rd, Serpentine	32° 24' 22" S, 115° 51' 44" E
Yangedi South Rd, Serpentine	32° 27' 12" S, 115° 52' 53" E
Old Coast Rd, Mandurah	32° 34' 38" S, 116° 39' 51" E
Karnup Rd, Serpentine	32° 21' 48" S, 115° 58' 13" E
River Rd, Karnup	32° 23' 56" S, 115° 53' 03" E
Henderson Rd, Serpentine	32° 24' 22" S, 115° 51' 29" E
Henderson Rd, Serpentine	32° 24' 22" S, 115° 51' 50" E
Henderson Rd, Serpentine	32° 24' 22" S, 115° 51' 51" E
Henderson Rd, Serpentine	32° 24' 20" S, 115° 51' 31" E
Punrak Rd, Serpentine	32° 25' 20" S, 115° 52' 53" E
Punrak Rd, Serpentine	32° 25' 39" S, 115° 52' 33" E
Yangedi South Rd, Serpentine	32° 27' 09" S, 115° 52' 33" E
Yangedi South Rd, Serpentine	32° 27' 14" S, 115° 52' 33" E

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Yangedi South Rd, Serpentine	32° 27' 28" S, 115° 52' 33" E
Corio Rd, Serpentine	32° 30' 36" S, 115° 51' 36" E
Broome St, Forrestdale	32° 09' 09" S, 115° 56' 51" E
Armadale Golf Course, Forrestdale	32° 09' 27" S, 115° 57' 30" E
Armadale Rd, Forrestdale	32° 08' 19" S, 115° 53' 59" E
Armadale Rd, Forrestdale	32° 08' 18" S, 115° 53' 57" E
Armadale Rd, Forrestdale	32° 08' 17" S, 115° 53' 57" E
Armadale Rd, Forrestdale	32° 08' 17" S, 115° 53' 59" E
Armadale Rd, Forrestdale	32° 08' 19" S, 115° 54' 00" E
Bibra Lake Dve, Bibra Lake	32° 05' 21" S, 115° 49' 12" E
Bibra Lake Dve, Bibra Lake	32° 05' 19" S, 115° 49' 12" E
Bibra Lake Dve, Bibra Lake	32° 05' 15" S, 115° 49' 13" E
Bibra Lake Dve, Bibra Lake	32° 05' 17" S, 115° 49' 14" E
Hope Rd, North Lake	32° 05' 06" S, 115° 49' 50" E
Hope Rd, North Lake	32° 05' 08" S, 115° 49' 51" E
Hope Rd, North Lake	32° 05' 08" S, 115° 49' 52" E
Hope Rd, North Lake	32° 05' 07" S, 115° 49' 52" E
Farrington St, Murdoch	32° 04' 33" S, 115° 49' 49" E
Bibra Dve, Bibra Lake	32° 06' 02" S, 115° 49' 46" E
Little Rush Lake, Yangebup	32° 06' 46" S, 115° 06' 46" E
Little Rush Lake, Yangebup	32° 06' 47" S, 115° 49' 32" E
Little Rush Lake, Yangebup	32° 06' 47" S, 115° 49' 34" E
Little Rush Lake, Yangebup	32° 06' 47" S, 115° 49' 36" E
Yangebup Lake, Yangebup	32° 06' 48" S, 115° 49' 30" E
Yangebup Lake, Yangebup	32° 06' 49" S, 115° 49' 35" E
Cogolup Lake, Yangebup	32° 07' 42" S, 115° 49' 39" E
Cogolup Lake, Yangebup	32° 07' 41" S, 115° 49' 57" E
Cogolup Lake, Yangebup	32° 07' 40" S, 115° 49' 38" E
Hammond Rd, Yangebup	32° 07' 44" S, 115° 50' 31" E
Hird St, Yangebup	32° 08' 08" S, 115° 50' 42" E
Bartram St, Yangebup	32° 08' 44" S, 115° 50' 56" E
Water Corporation, Yangebup	32° 08' 35" S, 115° 48' 40" E
Lorimer Rd, Yangebup	32° 08' 49" S, 115° 49' 00" E
Water Corporation, Yangebup	32° 08' 49" S, 115° 48' 48" E
Water Corporation, Yangebup	32° 08' 55" S, 115° 48' 49" E
Skaife Park, Wattleup	32° 09' 04" S, 115° 48' 38" E
Holdsworth Reserve, Wattleup	32° 10' 05" S, 115° 49' 12" E
Bush Forever Site 393, Mandogalup	32° 10' 58" S, 115° 49' 27" E
Mandogalup Rd, Mandogalup	32° 10' 58" S, 115° 49' 27" E
Wattleup Rd, Mandogalup	32° 10' 38" S, 115° 49' 52" E
Mandogalup Rd, Wattleup	32° 11' 31" S, 115° 49' 58" E
Cardup Nature Reserve, Cardup	32° 14' 36" S, 115° 59' 18" E
Bush Rd, North Dandalup	32° 29' 55" S, 115° 51' 22" E
Bush Rd, North Dandalup	32° 29' 54" S, 115° 51' 21" E
Bush Rd, North Dandalup	32° 29' 55" S, 115° 51' 11" E
Bush Rd, North Dandalup	32° 29' 56" S, 115° 51' 10" E

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Bush Rd, North Dandalup	32° 29' 55" S, 115° 51' 03" E
Bush Rd, North Dandalup	32° 29' 55" S, 115° 50' 57" E
Bush Rd, North Dandalup	32° 29' 56" S, 115° 51' 13" E
Bush Rd, North Dandalup	32° 29' 56" S, 115° 51' 16" E
Bush Rd, North Dandalup	32° 29' 57" S, 115° 51' 17" E
Bush Rd, North Dandalup	32° 29' 57" S, 115° 51' 19" E
Bush Rd, North Dandalup	32° 29' 58" S, 115° 51' 21" E
Bush Rd, North Dandalup	32° 29' 58" S, 115° 51' 22" E
Coolup South Rd, Coolup	32° 47' 07" S, 115° 52' 01" E
Wellesley	33° 13' 04" S, 115° 44' 49" E
Wellesley	33° 13' 15" S, 115° 44' 41" E
Wellesley	33° 13' 15" S, 115° 44' 45" E
Old Coast Rd, Myalup	33° 37' 34" S, 115° 43' 13" E
Wellesley Rd, Binningup	33° 08' 54" S, 115° 44' 50" E
Stakehill area	32° 27' 58" S, 115° 47' 43" E
Lake McLarty area	32° 42' 00" S, 115° 42' 00" E
Lake Clifton area	32° 49' 00" S, 115° 41' 00" E
Yalgorup National Park	32° 54' 00" S, 115° 40' 00" E
Perth Airport	31° 56' 00" S, 115° 58' 00" E
Kewdale area	31° 58' 00" S, 115° 57' 00" E
Queens Park (remnant Banksia woodlands)	32° 00' 00" S, 115° 56' 00" E
Perry Lakes	31° 56' 46" S, 115° 46' 54" E
Bold Park	31° 56' 44" S, 115° 46' 52" E
Bold Park	31° 56' 53" S, 115° 46' 43" E
Bold Park	31° 56' 51" S, 115° 46' 49" E
Bold Park	31° 56' 48" S, 115° 46' 37" E
Bold Park	31° 56' 37" S, 115° 46' 42" E
Bold Park	31° 56' 34" S, 115° 46' 39" E
Bold Park	31° 56' 35" S, 115° 46' 44" E
Bold Park	31° 56' 39" S, 115° 46' 45" E
Reabold Hill, Bold Park	31° 56' 25" S, 115° 46' 34" E
Kings Park	31° 58' 00" S, 115° 50' 00" E
Shenton Park	31° 57' 00" S, 115° 48' 00" E
Jandakot Airport area	32° 06' 00" S, 115° 52' 00" E
Jandakot Rd, Forrestdale	32° 06' 52" S, 115° 52' 27" E
Jandakot Rd, Forrestdale	32° 07' 26" S, 115° 54' 02" E
Warton Rd, Forrestdale	32° 07' 56" S, 115° 53' 53" E
Forrestdale Lake area	32° 09' 00" S, 115° 56' 00" E
Modong Nature Reserve, Oakford	32° 13' 08" S, 115° 54' 12" E
Modong Nature Reserve, Oakford	32° 13' 09" S, 115° 54' 11" E
Modong Nature Reserve, Oakford	32° 13' 11" S, 115° 54' 11" E
Modong Nature Reserve, Oakford	32° 13' 11" S, 115° 54' 13" E
Modong Nature Reserve, Oakford	32° 13' 13" S, 115° 54' 13" E
Mortimer Rd, Baldvis	32° 15' 21" S, 115° 15' 51" E
Leda Nature Reserve, Kwinana	32° 16' 10" S, 115° 48' 12" E
Leda Nature Reserve, Kwinana	32° 16' 12" S, 115° 48' 13" E

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Millar Rd, Baldivis	32° 16' 21" S, 115° 50' 20" E
Baldivis	32° 16' 22" S, 115° 50' 17" E
Millar Rd, Baldivis	32° 16' 29" S, 115° 50' 08" E
Pagononi Reserve	32° 26' 32" S, 115° 46' 40" E
Baldivis area	32° 18' 00" S, 115° 50' 00" E
Wungong Dam Catchment	32° 12' 00" S, 116° 03' 00" E
Kooljerrenup Nature Reserve, Pinjarra	32° 44' 03" S, 115° 43' 32" E
Kooljerrenup Nature Reserve, Pinjarra	32° 44' 31" S, 115° 43' 32" E
Mounsey Rd, Coolup	32° 46' 41" S, 115° 47' 23" E
proposed National Park, Harvey	32° 58' 13" S, 115° 44' 31" E
proposed National Park, Harvey	32° 58' 47" S, 115° 45' 04" E
proposed National Park, Harvey	32° 58' 48" S, 115° 45' 19" E
Nicholson Rd, Yarloop	32° 59' 01" S, 115° 49' 50" E
Centre Rd, Harvey	32° 59' 19" S, 115° 45' 14" E
Centre Rd, Harvey	32° 59' 29" S, 115° 45' 09" E
Centre Rd, Harvey	32° 59' 31" S, 115° 45' 11" E
Riverdale Nature Reserve, Harvey	32° 59' 34" S, 115° 47' 04" E
Myalup area	33° 06' 00" S, 115° 41' 00" E
Tuart Forest National Park	33° 38' 00" S, 115° 26' 00" E
Ludlow area	33° 36' 00" S, 115° 29' 00" E
Whicher National Park	33° 46' 00" S, 115° 27' 00" E
Quindalup area	33° 37' 00" S, 115° 07' 00" E