

Carnaby's Cockatoo (*Calyptorhynchus latirostris*)

Recovery Plan



Western Australian Wildlife Management Program No. 52

Department of Parks and Wildlife

October 2013



Department of
Parks and Wildlife



Australian Government

Carnaby's Cockatoo (*Calyptorhynchus latirostris*)

Recovery Plan

October 2013

Department of Parks and Wildlife
Locked Bag 104, Bentley Delivery Centre, Perth, WA 6983

FOREWORD

This is a Recovery Plan prepared within the framework laid down in Department of Parks and Wildlife (DPaW) Policy Statements Numbers 44 and 50 (CALM 1992; CALM 1994), and the Australian Government Department for Sustainability, Environment, Water, Population and Communities (SEWPAC) Recovery Planning Compliance Checklist for Legislative and Process Requirements (DEWHA 2008), with the assistance of funding provided by the Australian Government.

Recovery Plans outline the recovery actions that are required to address those threatening processes most affecting the ongoing survival of threatened taxa or ecological communities, and begin the recovery process. Recovery Plans delineate, justify and schedule management actions necessary to support the recovery of threatened species and ecological communities. This Recovery Plan has been developed with the involvement and cooperation of a range of stakeholders, but individual stakeholders have not necessarily committed to undertaking specific actions. The attainment of objectives and the provision of funds may be subject to budgetary and other constraints affecting the parties involved. Proposed actions may be subject to modification over the life of the plan due to changes in knowledge.

Information in this Recovery Plan was accurate at October 2013.

Recovery Plan Preparation: This Recovery Plan was originally prepared by J. Goldberg, K. Bleby and P. Mawson.

Citation: Department of Parks and Wildlife (2013). Carnaby's cockatoo (*Calyptorhynchus latirostris*) Recovery Plan. Department of Parks and Wildlife, Perth, Western Australia.

Cover photograph: Female Carnaby's cockatoo *Calyptorhynchus latirostris* (Rick Dawson, Department of Parks and Wildlife).

Disclaimer: The State of Western Australia and its employees do not guarantee that this publication is without flaw of any kind or is wholly appropriate for your particular purposes and therefore disclaims all liability for any error, loss or other consequence that may arise from you relying on any information in this publication.

© State of Western Australia Government Department of Parks and Wildlife 2013

This publication is copyright. No part may be reproduced by any process except in accordance with the provisions of the *Copyright Act* 1968.

ABBREVIATIONS

APV	Avian polyomavirus
BFDV	Beak and feather disease virus
CALM	Department of Conservation and Land Management, Western Australia; currently DPaW
CITES	Convention on International Trade in Endangered Species
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEC	Department of Environment and Conservation, Western Australia, formerly CALM, currently DPaW
DAFWA	Department of Agriculture and Food, Western Australia
DEWHA	Department of Environment, Water, Heritage and Arts; currently SEWPAC
DPaW	Department of Parks and Wildlife, Western Australia, formerly DEC
EPA	Environmental Protection Authority, Western Australia
EPBC Act	Environment Protection and Biodiversity Conservation Act (1999)
IOCI	Indian Ocean Climate Initiative Panel
SEWPAC	Department of Sustainability, Environment, Water, Population and Communities, formerly DEWHA
WA	Western Australia
WAPC	Western Australian Planning Commission

ACKNOWLEDGEMENTS

Past and present members of Carnaby's cockatoo Recovery Team have contributed significantly to the development of this Plan. Dr Kristin Warren, Dr Carly Holyoake, Dr Anna Le Souef and Simone Vitali provided information and suggestions on disease and associated impacts. Chris Phillips and Denis Saunders provided comments on drafts. Funding was provided by SEWPAC and the State NRM program.

CONTENTS

FOREWORD	I
ABBREVIATIONS	II
ACKNOWLEDGEMENTS	II
SUMMARY	1
1 INTRODUCTION	5
2 SPECIES INFORMATION	5
2.1 History and Taxonomic Relationships	5
2.2 Description	6
2.3 Distribution, Habitat and Movements	6
2.4 Extent of Occurrence and Area of Occupancy	10
2.5 Biology and Ecology	11
2.6 Conservation Status	12
3 HABITAT CRITICAL TO SURVIVAL	12
4 KNOWN AND POTENTIAL THREATS	14
4.1 Loss of Breeding Habitat	14
4.2 Loss of Non-Breeding Foraging and Night Roosting Habitat	15
4.3 Tree Health	16
4.4 Mining and Extraction Activities	17
4.5 Illegal Shooting	17
4.6 Illegal Taking	18
4.7 Climate Change	18
4.8 Collisions with motor vehicles	19
4.9 Disease	20
5 GUIDE FOR DECISION MAKERS	21
6 MANAGEMENT PRACTICES AND POLICIES	24
7 INTERNATIONAL OBLIGATIONS	25
8 BIODIVERSITY IMPACTS AND BENEFITS	25
9 SOCIAL AND ECONOMIC IMPACTS AND BENEFITS	26
10 AFFECTED INTERESTS	27
11 INDIGENOUS PEOPLE	28
12 PREVIOUS AND EXISTING CONSERVATION MEASURES	29
12.1 Habitat Management	29
12.2 Monitoring	32
12.3 Captive Management Program	34
12.4 Community Actions	34
13 RECOVERY STRATEGY	36
13.1 Recovery Objective	36
13.2 Performance Criteria	37
14 RECOVERY ACTIONS	38
Action 1: Protect and Manage Important Habitat	38
Action 2: Undertake Regular Monitoring	40
Action 3: Conduct Research to Inform Management	41
Action 4: Manage Other Impacts	42
Action 5: Engage with the Broader Community	42
Action 6: Undertake Information and Communication Activities	43
15 IMPLEMENTATION AND EVALUATION	44
15.1 Estimated Costs of Recovery Actions	45
16 REFERENCES	46

SUMMARY

Species: Carnaby's cockatoo *Calyptrorhynchus latirostris* Carnaby 1948

Family: Psittacidae

DPaW Regions: Midwest, South Coast, South West, Swan, Warren and Wheatbelt Regions

Interim Biogeographic Regions: Avon Wheatbelt, Esperance Plains, Geraldton Sandplains, Jarrah Forest, Swan Coastal Plain, Warren, Yalgoo

Current status of taxon: Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*: Endangered (EN)

Western Australian *Wildlife Conservation Act 1950*: Rare or likely to become extinct

Habitat critical for survival:

Habitat critical to survival for Carnaby's cockatoos can be summarized as:

- The eucalypt woodlands that provide nest hollows used for breeding, together with nearby vegetation that provides feeding, roosting and watering habitat that supports successful breeding;
- Woodland sites known to have supported breeding in the past and which could be used in the future, provided adequate nearby food and/or water resources are available or are re-established;
- In the non-breeding season the vegetation that provides food resources as well as the sites for nearby watering and night roosting that enable the cockatoos to effectively utilise the available food resources.

Recovery Objective:

To stop further decline in the distribution and abundance of Carnaby's cockatoo by protecting the birds throughout their life stages and enhancing habitat critical for survival throughout their breeding and non-breeding range, ensuring that the reproductive capacity of the species remains stable or increases.

Performance Criteria:

This Recovery Plan will be deemed completely successful if, within a ten year period, all of the following are achieved:

- The species' area of occupancy does not decline. In the absence of any improved methods this will be measured by the same method used, and compared with the values calculated, in this Recovery Plan: 60,525 km² using a grid size of 15 x 15 km. (The measure of the area of occupancy may be upgraded during the life of the plan provided the benchmark established here is not substantially changed under the replacement system.)
- The number of breeding pairs of Carnaby's cockatoos at pre-determined (and recorded in advance) breeding sites across the breeding range remains stable or increases, averaged over three consecutive years. (Any changes in the breeding sites counted for this measure are to be approved by the DPaW Director, Nature Conservation and to remain statistically comparable with sites used at the commencement of this plan.)
- Estimates of the number of birds and proportion of juveniles across the entirety of known (standardised) night roost sites across the range of the species remains stable or increases, averaged over three consecutive years.
- The extent of nesting habitat (trees with nesting hollows), feeding habitat (as defined by vegetation complexes or suitable revegetation), and night roosting habitat (as identified through community survey) are maintained throughout the species range.

This Recovery Plan will be deemed to not be successful if, within a ten year period, any of the following occur:

- The area of occupancy declines by more than 10% below 60,525 km² using a grid size of 15 x 15 km² (or similar change in amended methodology).
- The number of breeding pairs of Carnaby's cockatoos at monitored breeding sites across the breeding range decreases by more than 10% averaged over three consecutive years.
- The estimated number of adult and proportion of juvenile Carnaby's cockatoos at known night roost sites decreases by more than 10% averaged over three consecutive years.
- The extent of nesting habitat (trees with nesting hollows), feeding habitat (as defined by vegetation complexes), and night roosting habitat (as identified through community survey) decreases by more than 10% throughout the species range.

Recovery Actions:

There are six broad themes to the recovery actions:

1. Protect and Manage Important Habitat

Identify, protect and manage habitat critical for survival (nesting, foraging and roosting) for Carnaby's cockatoos across their breeding and non-breeding range.

2. Undertake Regular Monitoring

Monitor population parameters, habitat, threats and status of the Carnaby's cockatoo.

3. Conduct Research to Inform Management

Undertake research into the biology, ecology, and conservation management of Carnaby's cockatoo.

4. Manage Other Impacts

Monitor the impacts and implement strategies to reduce other factors detrimentally affecting Carnaby's cockatoos, and support rehabilitation programs.

5. Engage with the Broader Community

Engage with and involve people across the community in the conservation of Carnaby's cockatoo.

6. Undertake Information and Communication Activities

Develop and distribute awareness raising and guidance materials for decision makers, establish joint management agreements and provide for improved sharing of information between agencies.

Recovery Team:

Recovery Teams provide advice and assist in coordinating actions described in recovery plans. Recovery teams include representatives from organisations with direct interest in the recovery of the species, including those involved in funding, carrying out or helping to carry out actions that support the recovery of the species. The Carnaby's Cockatoo Recovery Team was first established in 1999 to coordinate the recovery of the species and the development and implementation of the initial recovery plan (Cale 2003). Originally the team comprised of representatives from DPaW, CSIRO, WA Museum, Perth Zoo, BirdLife Australia and a private landowner. Over time other organisations and individuals have been invited to join the team or to share their expertise, experience and knowledge with the recovery team.

Cost:

The estimated cost of implementing this Recovery Plan is \$7,730,000 over ten years. However, this estimated figure does not include costs associated with the ongoing management of habitat by DPaW, other government agencies and private land owners, or all the costs associated with the creation of new habitat, and the re-creation of habitat lost to clearing. No does it include costs associated with mitigating any loss of habitat due to development proposals that may be approved and undertaken at any point in the next 10 years. It should also be noted that volunteers undertake a great deal of work associated with the recovery of this species which is not reflected in the estimated implementation costs.

1 INTRODUCTION

Carnaby's cockatoo (*Calyptorhynchus latirostris*) is one of the five Australian endemic black cockatoo species, and one of two species of white-tailed black cockatoo. Carnaby's cockatoo was once very numerous in Western Australia. Since the late 1940s the species has suffered a 30% contraction in range, a 50% decline in population, and between 1968 and 1990 disappeared from more than a third of its breeding range (Saunders 1990; Johnstone and Storr 1998; Saunders and Ingram 1998; Garnett *et al.* 2011).

The decline of Carnaby's cockatoo has been due primarily to the loss and fragmentation of habitat, as a result of clearing of native vegetation, since the middle of the 20th century (Saunders 1979b, 1980, 1986, 1990; Saunders and Ingram 1987, 1995, 1998; Saunders *et al.* 1985; Mawson and Johnstone 1997). Approximately 56% (over 2 million hectares) of the species' habitat has been cleared since European settlement (DEC unpublished data 2010). As a result of historical and current threats, Carnaby's cockatoo has undergone a major decline in range, particularly in drier areas and the central wheatbelt (Saunders 1990; Johnstone and Storr 1998).

This recovery plan covers the ten year period from 2012 and provides some background information on Carnaby's cockatoo, threatening processes that affect this species, and identifies the recovery objective, success criteria and the actions required over the next ten years to progress towards the longer term recovery of this species.

2 SPECIES INFORMATION

2.1 History and Taxonomic Relationships

Carnaby's cockatoo was first described as a subspecies of Baudin's cockatoo by Ivan Carnaby in 1948 (*Calyptorhynchus baudinii latirostris*; Carnaby 1948). In 1979 it was separated from *C. baudinii* and treated as a subspecies of the yellow-tailed black cockatoo (*C. funereus latirostris*; Saunders 1979a). Since the 1970s it has been conventional to regard *C. latirostris* and *C. baudinii* as two separate species based on morphology, vocalisations, behaviour and ecology (Campbell and Saunders 1976; Johnstone and Storr 1998; Johnstone 2001; Cameron 2007). The current taxonomic arrangement based on the Western Australian Museum State Checklist (Johnstone 2001), is *Calyptorhynchus latirostris* Carnaby, 1948 Carnaby's cockatoo, and *Calyptorhynchus baudinii* Lear, 1832 Baudin's cockatoo.

As a result of the early taxonomic history some historical records can be difficult to assign with certainty to Carnaby's cockatoo.

Recent genetic analysis has found that although the two white-tailed black cockatoos are highly distinct from the yellow-tailed black cockatoos, Carnaby's and Baudin's cockatoos may not be reliably distinguished with the markers used (White *et al.* 2011a; White 2012). Notwithstanding this relative genetic similarity, Carnaby's cockatoo is a recognisable morphologically, behaviourally and ecologically distinct entity and this recovery plan deals with the recovery of that distinct entity.

2.2 Description

Carnaby's cockatoo is a large, mostly black bird with white cheek patches, large white panels on the tail and a strong curved bill. Adults range from 53-58 cm in length and 520-790 g in weight (Saunders 1974; Johnstone and Storr 1998), with a wingspan approximately 100 cm (Higgins 1999). The body feathers are brownish-black or greyish-black in colour and narrowly edged with dull white, giving them a scalloped appearance. In both sexes the iris is dark brown or reddish-brown, and the bill has a flaky texture. Females differ from males in having a light grey bill, blue-grey eye-ring and a large distinctive cheek patch; males have a black bill, a pink eye-ring and a comparatively smaller and duller cheek patch. Immature male birds look similar to adult females, but their bills are smooth and duller in colour and begin to darken in the birds' third year. Both Carnaby's cockatoo and Baudin's cockatoo have distinctive wailing 'Wy-lah' calls, which consist of four segments, but is more drawn out in Carnaby's cockatoo and can be distinguished in the field by experienced observers (Saunders 1979b; Higgins 1999; Johnstone and Storr 1998).

2.3 Distribution, Habitat and Movements

Carnaby's cockatoo is endemic to the south-west of Western Australia, with a widespread distribution (Figure 1). The species is highly mobile and displays a seasonal migratory pattern that is linked to breeding (Saunders 1980, 1990; Berry 2008). Breeding takes place between late July and December and most breeding occurs in the inland parts of its distribution, in areas receiving between 300 and 750 mm of annual average rainfall (Saunders 1974). During the non-breeding season (January to July) the majority of the birds move to the higher rainfall coastal regions of their range including the midwest coast, Swan Coastal Plain and south coast (Saunders 1980, 1990; Berry 2008; Saunders *et al.* 2011b; Johnstone *et al.* 2011) (Figure 2).

There are a number of resident populations throughout the species range that do not show breeding migration but remain close to their breeding sites year round (e.g. Jarrah forests from Mundaring to Nannup, Hopetoun, Perth and Peel region (Johnstone and Storr, 1998; Johnstone *et al.* 2011; Raana Scott, BirdLife Australia, *pers. comm.* 2012)). There has been an apparent expansion in the breeding range to include areas 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 and the coastal tuart forests south of Perth (Johnstone and Storr 1998; Johnstone *et al.* 2011).

Carnaby's cockatoo has suffered at least a 50% decline in the total population and has disappeared from more than a third of its breeding range between 1968 and 1990 (Saunders and Ingram 1998). The total population of Carnaby's cockatoo in the 1980s was estimated at between 11,000 and 60,000 birds (Saunders *et al.* 1985), although the population in 2010 was considered to be around 40,000 birds (Peter Mawson, DEC, *pers. comm.* 2010). Though there is some indication that genetic structuring is becoming evident within the population from east to west, likely due to the fragmented nature of the species' distribution, the Carnaby's cockatoo is still considered as one large interconnected population (White 2012).

A preliminary analysis of reporting rates between the first national Bird Atlas (1977 to 1981; Atlas 1; Blakers *et al.* 1984) and second Atlas (1998 – 2002; Atlas 2; Barrett *et al.* 2003) identified a 46% decline in reporting rate (index of abundance) for Carnaby's cockatoos in the northern part of their range (G. Barrett, DEC, *pers. comm.* 2011).

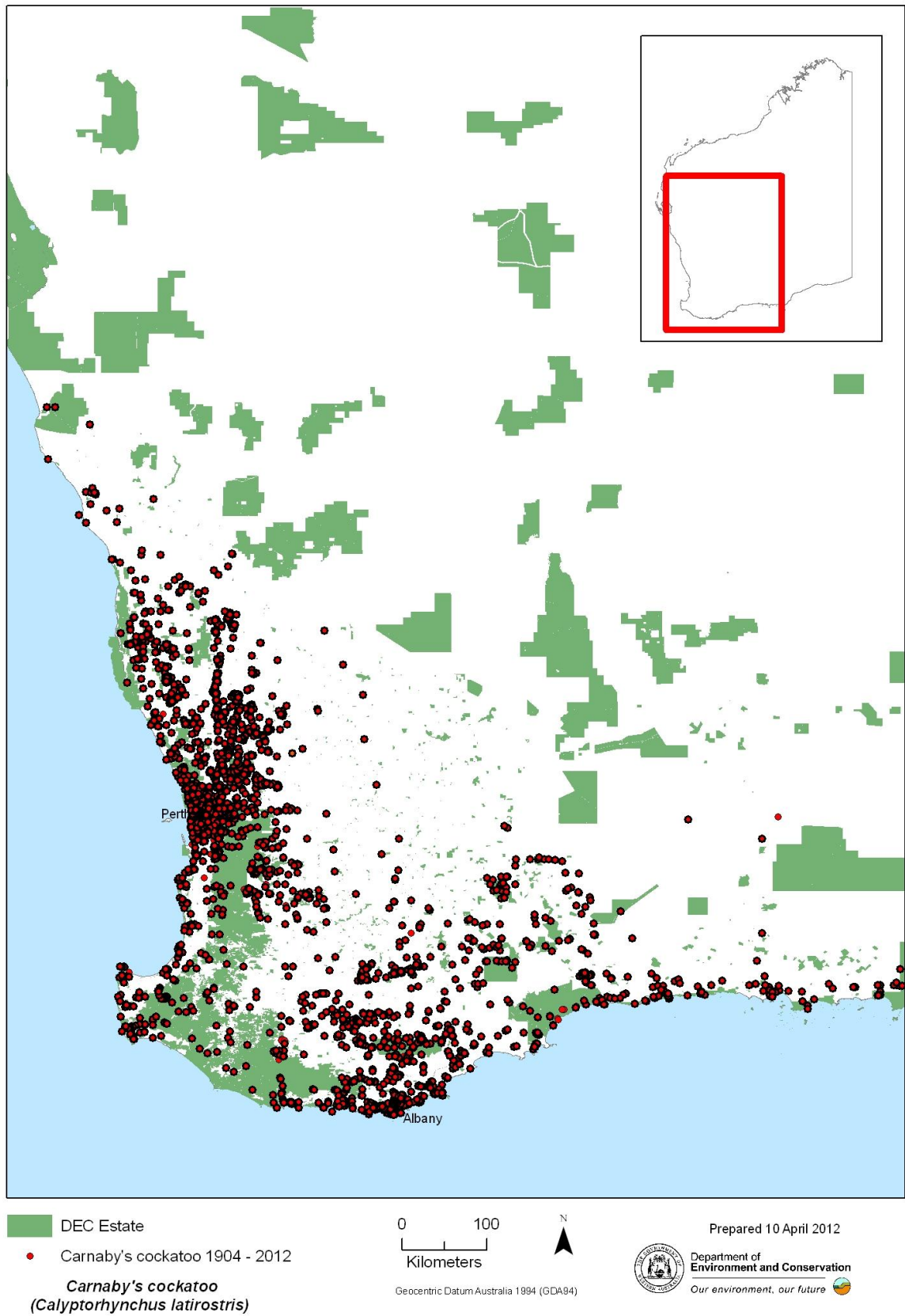
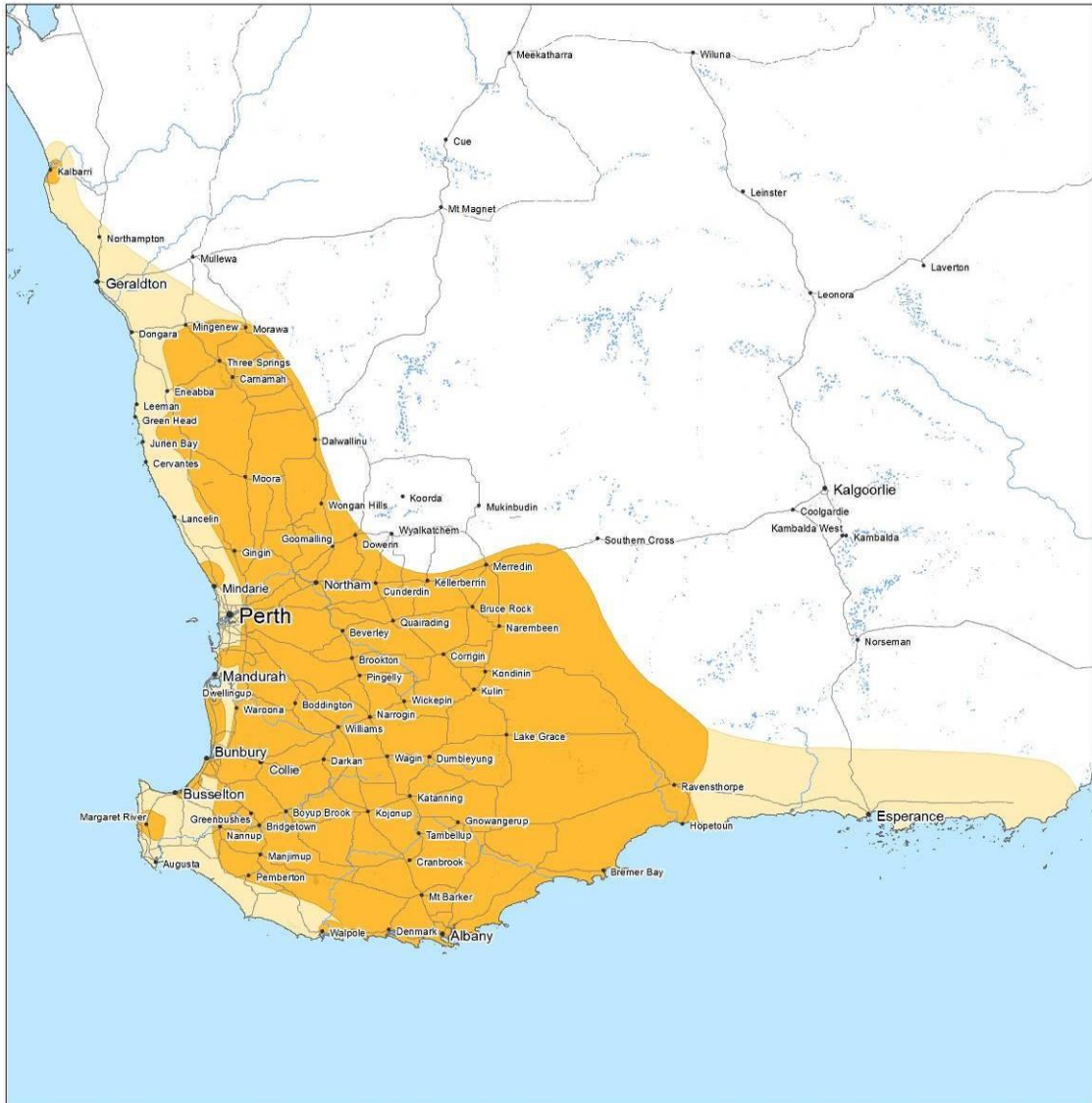


Figure 1: Distribution of Carnaby's cockatoo based on reported sightings between 1904 and 2012.



INDICATIVE MAP ONLY: For the latest departmental information, please refer to the Protected Matters Search Tool at www.environment.gov.au/epbc/index.html



0 50 100 150 200 250 km



Australian Government

Department of Sustainability, Environment,
Water, Population and Communities

Produced by: Environmental Resources Information Network (ERIN)
COPYRIGHT Commonwealth of Australia, 2011

Contextual data sources:
DEWHA (2008), Collaborative Australian Protected Areas Database
Geoscience Australia (2006), Geodata Topo 250K Topographic Data

Legend

- Breeding Range
- Non-breeding Range
- Roads
- Major Rivers
- Lakes
- Cities & Towns

Please Note: The breeding range represents the areas known to be used by birds for breeding as at December 2009. As habitat has been lost in traditional breeding areas, birds have begun breeding at new locations. Distribution created and verified using point locations in SPRAT database (DSEWPac, 2011) and from expert feedback (R. Johnstone, 2011).

CAVEAT: The information presented in this map has been provided by a range of groups and agencies. While every effort has been made to ensure accuracy and completeness, no guarantee is given, nor responsibility taken by the Commonwealth for errors or omissions, and the Commonwealth does not accept responsibility in respect of any information or advice given in relation to, or as a consequence of, anything containing herein. **INDICATIVE MAP ONLY:** This map has been compiled from datasets with a range of geographic scales and quality. Species or ecological community distributions are indicative only and not to be used for local assessment. Local knowledge and information should be sought to confirm the presence of the species, or species habitat, at the location of interest.

Figure 2: Modelled breeding and non-breeding distribution of Carnaby's cockatoo *Calyptorhynchus latirostris* (SEWPAC 2012a).

2.4 Extent of Occurrence and Area of Occupancy

Minimum convex polygons are used to estimate the extent of occurrence (EOO) or area of a species' range, and to assess trends in occupied habitat (Burgman and Fox 2003). The minimum convex polygons are constructed around the most extreme points in space, and so are sensitive to errors in location and the influence of outlying records (Burgman and Fox 2003). The use of EOO for Carnaby's cockatoos is subject to limitations because the effort for obtaining records is not evenly distributed across space, the species is highly mobile, and their range is divided into breeding and non-breeding areas. While Carnaby's cockatoo has become locally extinct in many areas within its historical range, it is still present close to the northern, southern and western limits of this range, therefore analysis does not show any significant change of EOO over time. An EOO of 364,200 km² has been calculated for Carnaby's cockatoo based on records from 1904 to 2010.

Area of occupancy (AOO) is defined as the area actually occupied within the EOO for a given taxon, excluding cases of vagrancy. These calculations are very scale dependant and determining the most appropriate scale depends somewhat on how mobile the species is. Although IUCN recommend a 2 x 2 km grid be used so comparison can be made across taxa, this is not considered appropriate for this highly mobile species. As such, three estimates were derived by summing the number of grid squares in which Carnaby's cockatoos were recorded as present; 10 x 10 km, 15 x 15 km and 20 x 20 km grid squares respectively (Table 1). These three grid square sizes demonstrate the variation that is associated with scale. These calculations include both breeding and non-breeding areas.

Continuing loss of habitat associated with clearing means that the AOO has declined for Carnaby's cockatoo. The AOO was calculated for data both prior to 2003, and between 2003 and 2010 and demonstrate this decline (Table 1.) The most recent estimate of AOO (2010) for Carnaby's cockatoo is between 34,500 km² and 86,800 km² (Table 1).

Table 1: Area of occupancy for Carnaby's cockatoo¹.

Grid Size (km)	Pre-2003 (km ²)	Post-2003 (km ²)	Net loss (%) in area of occupancy
10 x 10	62,600	34,500	55.1
15 x 15	98,100	60,525	61.7
20 x 20	134,800	86,800	64.4

¹ The data used for this analysis includes the Department of Environment and Conservation's Threatened and Priority Species Database, BirdLife Australia Atlas 1 and 2, Land for Wildlife records, WA Museum records, and data from appropriately experienced independent researchers. To focus the analysis onto core habitat areas, the data were filtered to include only records of breeding, feeding or night roosting. In order to estimate the full range of the species in calculating Area of Occupancy, a grid block was considered to be part of the species range if it had one or more records. After filtering, the data were separated into pre and post 2003 records.

2.5 Biology and Ecology

Carnaby's cockatoos nest in the hollows of live or dead eucalypts, primarily the smooth-barked Salmon Gum and Wandoo (Saunders 1979b, 1982), though breeding has been reported in other wheatbelt tree species and some tree species on the Coastal Plain and jarrah forest (Saunders 1979b, 1982; Storr 1991; Johnstone and Storr 1998; Johnstone *et al.* 2011) (see Groom 2010a for tree species used for breeding by Carnaby's cockatoo). Carnaby's cockatoos have been recorded nesting in trees on private property, road and railway reserves, conservation estate and other crown land. There are significant breeding areas located outside the conservation estate, particularly along rail and road reserves and on agricultural land (Saunders 1982; Saunders and Ingram 1998; BirdLife Australia Cockatoo Database 2011). Success in breeding is dependent on the quality and proximity of feeding habitat within 12 km of nesting sites (Saunders 1977, 1986; Saunders and Ingram 1987). Along with the trees that provide nest hollows, the protection, management and increase of this feeding habitat that supports the breeding of Carnaby's cockatoo is a critical requirement for the conservation of the species.

In 1998, Saunders and Ingram considered that there were sufficient hollow-bearing eucalypts for Carnaby's cockatoos in the Wheatbelt, however the senescence and loss of ageing hollows, and competition for hollows is likely to be an issue for the conservation of the species. One of the indirect effects of broad-scale clearing for agriculture in the south-west of Western Australia is that there is a lack of recruitment of nesting trees (Saunders *et al.* 2003). As a consequence there may be a shortage of suitable nesting hollows in some areas in the future, regardless of whether there is sufficient suitable foraging habitat present within close proximity to those breeding sites.

During the non-breeding season (January to July) the majority of the birds migrate to the higher rainfall coastal regions of their range in the midwest coast, Swan Coastal Plain and south coast (Saunders 1980, 1990; Berry 2008; Saunders *et al.* 2011b; Johnstone *et al.* 2011), though some non-breeding birds remain in non-breeding areas all year round. These areas have better natural water sources over the summer period and historically had extensive areas of proteaceous woodlands and shrublands to provide feed for young birds, and good resources for adult birds to stock up for the following breeding season.

Large-scale removal of native vegetation and increased widespread availability of introduced food species has resulted in a significant shift in the dietary composition for Carnaby's

cockatoo. A traditional diet of mostly native seeds and nectar has changed to include increased amounts of seeds from introduced plant species (Groom 2010a) such as commercial broad-acre crops (e.g. canola *Brassica napas* and *B. juncea*) (Jackson 2009) and in the non-breeding part of the species' range, plantation pines (Saunders 1980; Johnstone and Storr 1998; Higgins 1999; Finn *et al.* 2009). In particular, the pine plantations immediately north of Perth have been recognized as an important food resource for Carnaby's cockatoo for over 60 years (Perry 1948; Saunders 1980; Johnstone *et al.* 2011).

2.6 Conservation Status

Carnaby's cockatoo is specially protected under the Western Australian *Wildlife Conservation Act 1950* as fauna that is considered 'likely to become extinct'. 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 Western Australian Minister for Environment has endorsed this ranking. Carnaby's cockatoo meets IUCN Criterion A for Endangered as it has suffered a population decline of at least 50% over the past three generations or 45 years (generation time = the average age of breeding adults in the population which is estimated to be 15 years). This trend is based on direct observation (Criteria A1a), a decline in the AOO (see section 2.4), and quality of habitat (Criteria A1c). There has also been a noted decline in the number of birds in the population (Criteria A1b).

Carnaby's cockatoo is listed as Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Action Plan for Australian Birds 2000 listed Carnaby's cockatoo as Endangered A1abc+2abc (Garnett *et al.* 2011). Criterion 2 included as the decline is considered likely to continue and based on the same factors mentioned above (a, b, and c; Garnett and Crowley 2000).

3 HABITAT CRITICAL TO SURVIVAL

Habitat critical to survival of Carnaby's cockatoo reflects the distinct, but equally important, behavioural components during the breeding and non-breeding seasons. The long-term survival of a robust population of Carnaby's cockatoos depends on the availability of suitable woodland breeding habitat and tree hollows, and foraging habitat capable of providing enough food to sustain the population. More recently, night roost sites have been recognised as important components of the non-breeding habitat. While it is clear that loss of breeding sites should be avoided, at present there is inadequate information to provide for robust quantification across the species range detailing which habitat could be lost without having a

significant adverse impact on the Carnaby's cockatoo population in the long term. In the absence of such information most habitat that provides for feeding, regular roosting and potential for breeding is considered important. Identified breeding and nearby feeding habitat, former breeding habitat that has hollows intact and vegetation that provides habitat for feeding, watering and regular night roosting is considered habitat critical for recovery of the species.

Specific elements of Carnaby's cockatoo habitat, such as nesting sites and night roost sites can be identified and mapped (e.g. Shah 2006, Burnham *et al.* 2010, Glossop *et al.* 2011, Johnstone *et al.* 2011, Kabat *et al.* 2012). However it is difficult to accurately designate and quantify the value of the more 'diffuse' critical habitat such as feeding habitat, mainly because the species is highly mobile and adaptive, and uses resources spread over a relatively large area. The application of a 'buffer' around point records of nesting sites and night roost sites may reflect the potential use of these areas by cockatoos (Glossop *et al.* 2011). In addition, the ecology of the species makes mapping difficult because it involves seasonal migration and movement over long distances (Saunders 1980; Johnstone *et al.* 2011), and the species now depends on altered landscapes. Work proposed under this recovery plan will refine our knowledge and help in the more precise identification and location mapping of habitat critical to the survival of the species.

Habitat critical to survival for Carnaby's cockatoos can be summarized as:

- The eucalypt woodlands that provide nest hollows used for breeding, together with nearby vegetation that provides feeding, roosting and watering habitat that supports successful breeding;
- Woodland sites known to have supported breeding in the past and which could be used in the future, provided adequate nearby food and/or water resources are available or are re-established;
- In the non-breeding season the vegetation that provides food resources as well as the sites for nearby watering and night roosting that enable the cockatoos to effectively utilise the available food resources.

4 KNOWN AND POTENTIAL THREATS

There are multiple reasons for the decline of Carnaby's cockatoo. The decline to date has been brought about primarily by the extensive clearing of nesting and feeding habitat during the 20th century. Continuing threats mostly relate to loss of habitat due to clearing or degradation, competition for nest sites, and loss of individuals due to illegal activities, collisions with motor vehicles and disease. Key aspects of their ecology, such as long generation time (> 15 years), mean that the effect of many of these threats will not be immediately evident. For example threats that reduce breeding success, or result in high mortality of chicks or young birds will not change the number of adult birds for many years.

4.1 Loss of Breeding Habitat

The breeding habitat of Carnaby's cockatoo is made up of the eucalypt woodlands that provide breeding hollows, together with feeding areas and watering sites within foraging distance of breeding sites. The loss of functioning breeding habitat as a whole is due to threats that impact on one or all of these components. Although most habitat loss across the species' entire distribution occurred before the 1980s, habitat loss and degradation continues to occur (Saunders 1990; Shah 2006). Approximately 87% (525,732 ha) of potential Carnaby's cockatoo habitat (i.e. areas of vegetation that contain flora species and vegetation types that could support the species' breeding, feeding and night roosting activities) has been cleared in the wheatbelt since European settlement (DEC unpublished data, 2010).

In the short term (decades), the loss or degradation of feeding habitat adjacent (i.e. <12 km) to breeding sites is considered to pose the greatest risk to Carnaby's cockatoos (Saunders and Ingram 1998). The clearance of heathlands from around woodland breeding sites and the removal of corridors of native vegetation that connect breeding and foraging sites in the wheatbelt region of Western Australia reduces the amount of food available for breeding birds, which will lead to a reduction in productivity and survival of young (Saunders 1977, 1980, 1982, 1986; Saunders *et al.*, 1985; Saunders and Ingram 1987, 1998; Garnett and Crowley 2000). Other factors can contribute to the degradation and loss of habitat, such as altered fire regimes, altered hydrology including drawdown, salinity, grazing, weed invasion, climate change, *Phytophthora* dieback and mining (Hobbs 1987; Johnstone *et al.* 2008; Johnstone *et al.* 2011).

Hollow-bearing trees suitable for nesting are now largely restricted to remnant patches of woodland and individual trees within cleared sites (e.g. paddock trees) (Saunders and Ingram 1998). A lack of natural recruitment appears to be caused by a combination of factors including salinity, reduced annual rainfall over the past 30 years (Pittock 1988; Yates *et al.* 1994; CSIRO 2007), a lack of regeneration events (Yates *et al.* 2000), trampling and soil compaction caused by stock and grazing by stock and rabbits (Wilson 1990; Saunders *et al.* 2003), competition from introduced grasses, and altered hydrological and fire regimes (Hobbs 1987). Studies have reported that it takes 100-200 years for trees to develop suitable hollows (Saunders *et al.* 1982; Rose 1993; Whitford and Williams 2002). Individual trees that contain nest hollows and the nest hollows themselves may be lost as a result of tree-fall, fire, collapse of the nest chamber or damage to the hollows by people (Saunders 1979b). It is sometimes possible to repair damage and so extend the life of individual nest hollows.

Competition for nest hollows with other species will also reduce the number of nest hollows available to Carnaby's cockatoos. Species that compete for nest hollows include the native and introduced corellas (*Cacatua* species), galahs (*Cacatua roseicapilla*), Australian shelducks (*Tadorna tadornoides*), Australian wood ducks (*Chenonetta jubata*) and feral European honey bees (*Apis mellifera*) (Saunders 1979b, 1982; Johnstone and Kirkby 2007; Johnstone *et al.* 2008, Johnstone *et al.* 2011). Additionally, the destruction of nest hollows from nest robbing for the illicit aviculture trade may also reduce the number of nest hollows. Interference with breeding behaviour from other species may lead to breeding failures (e.g. eggs broken by *C. roseicapilla* and *C. pastinator butleri*) (Saunders 1982). The threat posed by western corella and galah is increasing as their populations increase in size and their distribution expands in south-west Western Australia (Johnstone and Storr 1998).

In 2000, approximately 16% of the south-west agricultural areas of Western Australia was estimated to be affected by salinity due to shallow water tables (Short and McConnell 2000). The area affected by salinity is considered likely to increase to 20% by 2020 and to 33% by 2050. However, salinity generally impacts areas low in the landscape (i.e. valley floors) and thus the effect on Carnaby's cockatoo is dependent on the parts of the landscape they are using.

4.2 Loss of Non-Breeding Foraging and Night Roosting Habitat

A further significant threat is the clearing, fragmentation and degradation of foraging and night roosting habitat in the non-breeding parts of Carnaby's cockatoo range in the south-west of Western Australia. In particular, the clearing of feeding habitat on the Swan Coastal Plain

(e.g. *Banksia* woodlands and commercial pine plantations which provide a significant food resource (Perry 1948; Saunders 1974, 1980, 1990; Shah 2006; Valentine and Stock 2008; Finn *et al.* 2009; Johnstone *et al.* 2011)). Native and exotic suburban trees on private and public lands provide a source of habitat for roosting and feeding in the Perth metropolitan area (Johnstone and Kirkby 2008; Johnstone *et al.* 2008; Burnham *et al.* 2010; Kabat *et al.* 2012) and are at risk as urbanisation intensifies and amenity vegetation is lost with urban infill.

Records show that on the Swan Coastal Plain, 617,895 hectares (or 54%) of potential Carnaby's cockatoo habitat (i.e. areas of native vegetation that contain flora species and vegetation types that could support the species' breeding, feeding and roosting activities) has been cleared since European settlement (DEC unpublished data, 2010), and there is ongoing and increasing pressure for continued urban development in the Perth and Peel regions, as well as other cities and towns in other parts of the distribution of Carnaby's cockatoo.

Carnaby's cockatoos are dependent on water being available in the vicinity of roosting sites (Shah 2006; Johnstone and Kirkby 2008; Burnham *et al.* 2010). Important watering points include natural water bodies and artificial water sources such as public fountains, bird baths, artificial dams, stock watering troughs and sprinklers (Johnstone and Kirkby 2008; G. Barrett, DEC, *pers. comm.* 2011). There is evidence that natural water bodies in the south-west are drying up (Wilson and Valentine 2009) and groundwater drawdown may be impacting habitat quality. Excessive groundwater drawdown resulting in the lowering of the watertable has the potential to impact habitat quality through vegetation decline on the Swan Coastal Plain.

4.3 Tree Health

Premature decline syndromes have recently been recorded for many important food and roosting tree species throughout Western Australia. These species include, but are not confined to tuart (*Eucalyptus gomphocephala*), wandoo (*E. wandoo*), jarrah (*E. marginata*), marri (*Corymbia calophylla*), flooded gum (*E. rudis*) and WA peppermint (*Agonis flexuosa*). Soil-borne, foliar and canker pathogens, and insects have been implicated in these declines and are under investigation (Centre of Excellence for Climate Change, Woodland and Forest Health 2012). A widespread decline in the health of canopy species and the ecosystems they support would have consequences for Carnaby's cockatoos in terms of available nesting, food and roosting sites (Saunders *et al.* 1982, 2003).

One particularly aggressive plant pathogen that has been identified in south-west Western Australia is *Phytophthora cinnamomi*. *Phytophthora* disease (or 'dieback') occurs when there

is a combination of susceptible plant species, the presence of the pathogen and vulnerability due to environmental conditions (Environment Australia 2001; O’Gara *et al.* 2005). Susceptible native species include most of the Proteaceae family (e.g. *Banksia* species) and a few taxa of the Myrtaceae family (e.g. jarrah) (Shearer *et al.* 2007), both widely used by Carnaby’s cockatoo. *Phytophthora* dieback can lead to losses of susceptible species, reduction in primary productivity and biomass of these species, altered plant species abundance and richness, changes in community composition and structure, and degradation of habitat for both flora and fauna (Weste 1974; Podger and Brown 1989; Hill *et al.* 1994; Wilson *et al.* 1994; Environment Australia 2001; McDougall *et al.* 2002; Weste *et al.* 2002; Shearer *et al.* 2007; Cahill *et al.* 2008).

4.4 Mining and Extraction Activities

Extraction of sand and gravel, and the mining of mineral sands, iron ore and limestone in the south-west, and of bauxite in the jarrah forests involves the clearing of native vegetation. In some areas such clearing could affect the survival of the species (Johnstone *et al.* 2008), particularly when associated with a change in land use following the mining activity (e.g. to housing development) rather than being regenerated.

Where mining occurs in feeding habitat and is followed by revegetation, this could be considered only a short to medium term loss of habitat. Depending on the species involved and the quality of establishment, revegetation of feeding habitat can begin providing food resources for black cockatoos in eight years (Lee *et al.* 2010). However it is not guaranteed that revegetation will provide the same amount of food value as the original native vegetation, and there are many factors that result in a high risk of failure of revegetation efforts in south-west vegetation types (David Mitchell, DEC, *pers. comm.* 2012).

Clearing for mining that results in the loss of eucalypts with nest hollows will result in a loss of breeding habitat for a significant time and so is likely to impact the species. Eucalypts do not grow large enough to provide nest hollows for Carnaby’s cockatoo for at least 100 to 200 years (Saunders *et al.* 1982; Rose 1993; Whitford and Williams 2002) and despite any revegetation that seeks to replace breeding tree species, any loss of breeding trees or habitat could be considered equivalent to permanent clearing of these breeding trees.

4.5 Illegal Shooting

Carnaby’s cockatoos are illegally shot by landholders where they are considered to be damaging nut and fruit crops and the tops of pine trees (Pittman *et al.* 2007; Saunders *et al.*

2011a). Death by shooting is considered a significant threatening process for the Carnaby's cockatoo species because it reduces the number of birds recruited into local populations and also directly reduce the number of breeding adults. Though direct evidence is lacking, illegal poisoning may also occur.

Injured individuals of the three species of black-cockatoos in south-west Western Australia (Carnaby's cockatoo, Baudin's cockatoo and forest red-tailed black cockatoo (*C. banksii naso*)) are often brought to the Perth Zoo and private wildlife carers. Of the 565 individuals brought into the Perth Zoo from 2000-2009, 49 had been shot (Saunders *et al.* 2011b). This number does not quantify incidences of shooting-related deaths as birds may have been wounded and died without being detected or recorded, or killed and disposed of in the field.

4.6 Illegal Taking

Carnaby's cockatoo is a highly prized cage bird and some eggs and nestlings are taken illegally for avicultural markets (Saunders 1979a; Saunders *et al.* 1985; Mawson and Johnstone 1997; White *et al.* 2011b), where they can be sold for high domestic market prices (~ \$1100 per bird and \$3000-\$5000 per pair (Mawson 1997)). Often trees are cut down or the hollows severely damaged when young and eggs are taken, making these sites unsuitable for future breeding attempts. Between 1991 and 2008 there were 39 prosecutions brought to court against individuals for illegal dealings with Carnaby's cockatoo, resulting in 14 convictions under the *Wildlife Conservation Regulations 1970*. Despite regular publicity following successful prosecutions the observed rate of illegal taking from the wild does not appear to be diminishing.

4.7 Climate Change

Climate change is one of the primary global threats to biodiversity and ecosystem function (Brook *et al.* 2008) and the south-west of Western Australia has been assessed as being particularly vulnerable to the effects of climate change (Pouliquen-Young and Newman 2000; Howden *et al.* 2003). There has been an observed rainfall decrease of 10-20% in the south-west since the 1970s and an approximate increase in temperature of 0.7°C since the 1950s, with warming greater in winter (CSIRO 2002; IOCI 2002). The predicted future trend is continued warming and a decreased winter rainfall, with suggestions of an approximate rise of 1°C and a 70 mm per annum reduction in annual rainfall by 2030 (CSIRO 2002; Timbal 2004). Such a decline in rainfall is likely to have a significant effect on the extent and

survival, or capacity for regeneration of the vegetation within the breeding and non-breeding habitat of Carnaby's cockatoo across its range.

Successful regeneration of the eucalypt species that provide nest hollows requires specific regeneration events, including fire and subsequent rainfall, as well as an adequate rainfall regime after germination. These events may be reduced under future climate change scenarios to the species detriment. The timing and frequency of flowering, and subsequent amount of seed production may also be affected by climate change.

Stochastic events can lead to significant changes to the local population dynamics of birds, including breeding birds, leading to a subsequent reduction in recruitment. Recently Carnaby's cockatoo has shown to be susceptible to catastrophic and unpredictable events. For example in March 2010, a reported 36 Carnaby's cockatoos died and 20 were injured as a result of a severe hail storm within the Perth metropolitan area, and in January 2010 heat stress accounted for the death of over 200 Carnaby's cockatoos at Hopetoun and Munglinup on the south coast of Western Australia (Saunders *et al.* 2011b).

Predictions of climate change in the south-west of Western Australia are that there will be an increased frequency of extreme weather events (Saunders *et al.* 2011b).

4.8 Collisions with motor vehicles

An analysis of data collected for all black cockatoos (Carnaby's cockatoo, Baudin's cockatoo and forest red-tailed black cockatoo) received into care by the DPaW and the Perth Zoo during 2009-2010 indicates that injury or death due to collision with motor vehicles accounts for up to 10% of all cockatoos examined (Saunders *et al.* 2011b). These data are considered to be conservative estimates as a larger proportion of the cockatoos examined had sustained bone fractures, but there were inadequate data accompanying the specimens to assume that those injuries had definitely been sustained from collisions with vehicles. In addition there are likely to be a large proportion of birds killed by motor vehicle collisions that are not reported.

Vehicle strike has been recognised as being an important threatening factor for black cockatoos and is likely to increase in significance as the number of vehicles on roads in Western Australia grows (Le Souëf 2012). In addition, the chance of collisions with vehicles may increase in frequency with some modifications and upgrades to roads (e.g. paving of gravel roads) which allow vehicles to travel at higher speeds and in increased numbers. The proximity of food and pooled water to roadsides combined with increased traffic volumes and

traffic speeds, places the cockatoos at an increased risk of collision with vehicles. While it is not realistic to eliminate all mortality due to these collisions, using sensible road designs, not intentionally planting food resources near busy roads, planting large areas of better quality food supplies away from roads, ensuring that rainfall runoff from roads drains into areas well clear of road verges, and increased signage may reduce collisions with vehicles. It is recognised that redesigning already established road networks, particularly in rural areas, may not be practical. In such cases hotspots should be identified for targeted works, and signage erected as a minimum.

There have been significant advances in the capacity to treat, rehabilitate and release injured birds back into the wild. Previously only 30% of injured birds recovered by DPaW were able to be released back into the wild. With the collaborative development of new handling protocols along with better informed treatment regimes and assistance of volunteers, the proportion of cockatoos that have been released back to the wild has steadily risen to the current level of 54% (DPaW / Perth Zoo unpublished data).

Though data are lacking, collision with other structures (e.g. powerlines) may also be impacting Carnaby's cockatoo.

4.9 Disease

Many aspects of the disease status of wild Carnaby's cockatoo populations remain unknown, however, recent research has highlighted the potential importance of the role of disease in the conservation of Carnaby's cockatoos (Saunders *et al.* 2011b; Le Souëf 2012).

Infectious diseases such as beak and feather disease virus (BFDV), avian polyomavirus (APV) and chlamydophilosis may pose a threat to Carnaby's cockatoo (DEWHA 2005), as they are significant in other captive and free-living psittacine species (Bernier *et al.* 1981; Gilardi *et al.* 1995; Ortiz-Catedral *et al.* 2009). Murdoch University, in collaboration with DPaW and Perth Zoo, has commenced research on the health of free-living black cockatoo, primarily Carnaby's cockatoo nestlings in the south-west of Western Australia. This study is investigating the prevalence of BFDV, APV and *Chlamydomphila psittaci* infection in black cockatoo nestlings. During the 2010 nesting season, BFDV was detected in 8.5% of nestlings and in nest material from one nest (9%). Five nestlings also tested positive to APV and three chicks were concurrently infected with both viruses. No nestlings tested positive for *C. psittaci* infection or exposure. The detection of BFDV and APV in the nestlings is of

potential concern, however the clinical significance of these viral infections remains unknown and long-term research is required.

To date, infection with or exposure to *C. psittaci* has not been detected in any wild black cockatoos admitted to the Perth Zoo Veterinary Department for treatment or rehabilitation. However, an outbreak of chlamydophilosis occurred in black cockatoos at a rehabilitation centre in 2010. The origin of infection in these birds remains unknown (Le Souëf, Perth Zoo, *pers. comm.* 2011). This outbreak highlighted the importance of appropriate disease risk management practices to minimise the transmission of disease from wild psittacines to black cockatoos undergoing rehabilitation and prevent released birds introducing novel diseases into wild populations.

In September 2009 at least 12 Carnaby's cockatoo hens were found dead in nest hollows at Coorow. The bodies were severely autolysed when found, therefore testing was limited but it seems probable that the deaths were due to disease infection or toxicity (Saunders *et al.* 2011b).

Wildlife diseases may be an undetermined risk, and until reliable baseline data are collected it will not be possible to adequately interpret the results of the recent events that have been observed. Long-term monitoring of wild black cockatoo nestlings and opportunistic sample collection from injured wild adult birds is essential for providing insight into the epidemiology and significance of disease as a threatening agent for Carnaby's cockatoo.

5 GUIDE FOR DECISION MAKERS

Loss of habitat caused by development and on-ground works (e.g. residential and industrial development, firebreaks, road works, mining, drainage works) may significantly affect Carnaby's cockatoo and so such developments may require environmental impact assessment under the Western Australian *Environmental Protection Act 1986* and/or the Commonwealth EPBC Act. In addition taking of individual Carnaby's cockatoo requires licensing under the Western Australian *Wildlife Conservation Act 1950*.

The Environmental Protection Authority (EPA) has published information about approaches and expectations for environmental impact assessment in Guidance Statement No. 33 Environmental Guidance for Planning and Development (EPA 2008), which provides the EPA's advice on a range of environmental factors in order to assist participants in land use planning and development to protect, conserve and enhance biodiversity and environmental values.

Habitat of Carnaby's cockatoo is considered under Guidance Statement No. 33 as areas of high conservation significance that the EPA expects must be fully protected in Western Australia. Further, Guidance Statement No. 33 states that the EPA is unlikely to recommend the approval of projects that have significant adverse impact on the species.

The Commonwealth Department of Sustainability, Environment, Water, Population and Communities (SEWPAC) has published guidance on how the EPBC Act will be applied, notably the *Significant Impact Guidelines 1.1 - Matters of National Environmental Significance* (DEWHA 2009), and the *EPBC Act 1999 Referral Guidelines for three threatened black cockatoo species* (SEWPAC 2012a) which provides guidance on whether a proposed action requires a referral under the EPBC Act.

Both the State and Commonwealth governments may produce further guidance in relation to the conservation of Carnaby's cockatoo during the life of this recovery plan

The success of this Recovery Plan can only be achieved by avoiding those activities that will adversely affect Carnaby's cockatoo and then minimizing or mitigating those that cannot be avoided.

Activities that may have an impact on Carnaby's cockatoo, or its habitat include:

- Any activity or action that leads to the permanent loss of eucalypt woodlands within the species range that currently or potentially provide nest hollows for breeding, along with nearby areas that provide important feeding and watering habitat that supports breeding of Carnaby's cockatoo.
- Any activity or action that leads to the permanent loss of native vegetation that forms habitat of Carnaby's cockatoo during the non-breeding season, that provides for feeding, night roosting and watering.
- Any activity or action that leads to temporary loss of native vegetation related to breeding, feeding, watering or night roosting habitat for Carnaby's cockatoo.
- Any action, including changes in land use and hydrology within catchments, that leads to the cumulative loss or degradation of areas currently or potentially used as breeding feeding, watering or night roosting habitat.
- The removal, without adequate replacement, of extensive areas of commercial pine plantations on the Swan Coastal Plain, and elsewhere, on which major flocks now depend for food.

- Clearing of areas of habitat (feeding, roosting and breeding) that have been established through revegetation or restoration, and are successful in providing resources for Carnaby's cockatoo (e.g. offsets for this species).

Some actions do not directly affect Carnaby's cockatoo but can create a foreseeable likelihood of future impacts on the species through conflicts with human endeavour. For example establishment of commercial plantations of species (including nut and fruit tree crops) known to be very attractive to black cockatoos within the range of a black cockatoo species will, without effective impact avoidance measures, lead to crop damage from cockatoos and likely conflicts. This likelihood needs to be included when planning for such activities and decision makers should only support such endeavours where effective mitigation/avoidance is incorporated in the plan (e.g. avoiding cockatoo areas, appropriate plantation design and cockatoo exclusion netting). Another example is road design and maintenance that inadvertently attracts cockatoos to roadsides to drink from puddles or feed on spilt grain, or roadside plantings of food plants, leading to likelihood of death or injury when feeding birds are hit by motor vehicles. This conflict is foreseeable and can be avoided with careful attention to road design, construction and maintenance, and by avoiding planting foraging species as roadside rehabilitation on roadways.

Mapping of habitat used for breeding, feeding, watering and night roosts can provide a tool to assist in conservation planning and recovery activities for the species, and also for strategic land use planning. It can provide an initial step in assisting statutory planners or consultants in deciding whether the conservation of Carnaby's cockatoo needs to be considered in a given planning area. Such spatial tools can identify areas that require investigation as Carnaby's cockatoo habitat, and additional detailed site mapping and field examination is recommended for identifying actual Carnaby's cockatoo resources or use by Carnaby's cockatoo before any environmental assessment or planning decisions are made.

When making planning and environmental approval decisions and decisions on management of areas, decision makers should ensure consistency with this Recovery Plan as well as guidance provided by the EPA and SEWPAC, and seek to fully protect Carnaby's cockatoo habitat. If additional clearing of large areas of habitat critical to survival continues and if there is not significant success in replacing important habitat approved for development it is likely there will be further reductions in the population of Carnaby's cockatoo resulting in a failure to achieve the success criteria of this Recovery Plan.

6 MANAGEMENT PRACTICES AND POLICIES

Due to the broad geographic area and variety of habitats used by Carnaby's cockatoo, a range of policies, strategies and plans have a role in the protection of the species and areas of habitat that support Carnaby's cockatoo. They include, but are not limited to:

- DPaW Policy Statement No. 29 Translocation of Threatened Flora and Fauna (CALM 1995);
- DPaW Policy Statement No. 33 Conservation of endangered and specially protected fauna in the wild (CALM 1991);
- Minimising Disease Risk in Wildlife Management (Chapman *et al.* 2011);
- Threat Abatement Plan for dieback caused by the root-rot fungus *Phytophthora cinnamomi*. (Environment Australia 2001);
- Guidelines for Protection of the Values of Informal Reserves and Fauna Habitat Zones, DPaW, Sustainable Forest Management Series, SFM Guideline No. 4 (DEC 2009);
- Guidelines for the Selection of Fauna Habitat Zones, DPaW, Sustainable Forest Management Series, SFM Guideline No. 6. (DEC 2010);
- Western Australian Forest Management Plan 2004-2013 and 2014-2023 for south west forests;
- The Action Plan for Australian Birds 2010 (Garnett *et al.* 2011);
- DPaW Regional Biodiversity Plans for the Midwest, South Coast, South West, Swan, Wheatbelt, and Warren Regions;
- Recovery Plans for species with some overlapping habitat requirements (e.g. Forest Black Cockatoo (Baudin's Cockatoo *Calyptorhynchus baudinii* and Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso*) Recovery Plan 2007-2016 (Chapman 2008);
- EPBC Act Referral guidelines for three threatened black cockatoo species: Carnaby's cockatoo (endangered) *Calyptorhynchus latirostris*, Baudin's cockatoo (vulnerable) *Calyptorhynchus baudinii* and Forest red-tailed black cockatoo (vulnerable) *Calyptorhynchus banksii naso* (SEWPAC 2012a);
- EPBC Act Environmental Offset Policy (SEWPAC 2012b);
- EPA Position Statements (e.g. Environmental Protection of Native Vegetation in WA Position Statement No. 2; Environmental Offsets Position Statement No. 9);

- WA Environmental Offsets Policy (Government of Western Australia, September 2012);
- Regional Fire Management Plans and Guidelines within the species range;
- Area management plans for DPaW managed conservation reserves and parks, as well as area management plans for local government and other lands managed for conservation within the species range;
- Landscape scale conservation management plans, strategies and projects (e.g. A biodiversity and cultural conservation strategy for the Great Western Woodlands (DEC 2011d), NRM groups and Catchment Councils);
- Private land conservation actions under conservation covenants or other voluntary habitat conservation management under programs including Conservation Covenants , Land for Wildlife, etc.;
- Non government organisation programs that encourage landholders to rehabilitate and/or retain remnant habitat (e.g. BirdLife Australia’s Carnaby’s Black-Cockatoo Recovery Project, WWF’s ‘Healthy Bushland’; Gondwana Link)
- Private, non government organisations such as the Australian Wildlife Conservancy and Bush Heritage Australia which purchase property with suitable habitat and aim to manage these properties for conservation purposes

7 INTERNATIONAL OBLIGATIONS

All parrots and their allies in the Order Psittaciformes, including Carnaby’s cockatoo, are listed on Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Australia is a member country to CITES and thus has an obligation to ensure that international trade in specimens of this species does not threaten their survival (CITES 1973). The recovery plan is consistent with these international obligations. This recovery plan is also consistent with the aims and recommendations of the Convention on Biological Diversity, ratified by Australia in June 1993, and will assist in implementing Australia’s responsibilities under that Convention.

8 BIODIVERSITY IMPACTS AND BENEFITS

The implementation of this plan will provide biodiversity benefits to other threatened and important taxa of both flora and fauna and threatened ecological communities that occur within the area of occupancy of Carnaby’s cockatoo. Details of threatened and priority fauna

and flora, and threatened and priority ecological communities inhabiting habitat critical used by Carnaby's cockatoo are available from DPaW.

Since Carnaby's cockatoo is found to occupy and utilize a wide range of habitats (i.e. forests, proteaceous vegetation, heathland vegetation) it can be considered an umbrella species and the protection of habitat critical to Carnaby's cockatoo will result in the protection of a variety of threatened and important flora and ecological communities. For example, declared rare flora records cross referenced with Carnaby's cockatoo habitat resulted in 138 declared rare flora records in breeding habitat, 816 records in feeding habitat, and 233 records roosting habitat.

Similarly there will be considerable benefits to other threatened and important fauna species including the direct protection and retention of habitat and specifically the retention and promotion of tree hollows for tree hollow dependant species. Cross referencing Carnaby's cockatoo habitat with threatened fauna records indicate that this benefit will extend to amphibians, arachnids, birds, crustaceans, fish, insects, mammals, molluscs and reptiles.

There are no expected negative impacts to biodiversity as a result of implementing this recovery plan.

9 SOCIAL AND ECONOMIC IMPACTS AND BENEFITS

Carnaby's cockatoos use both private and public lands to meet their requirements for breeding, feeding, watering and night roosting. While some private lands that contain Carnaby's cockatoo habitat are managed in a manner to protect and conserve Carnaby's cockatoo, some owners of private property that support Carnaby's cockatoo habitat have expectations of land development for other purposes. In some cases this expectation is supported by existing government planning and environmental approval decisions, such as zoning under Region Schemes and similar mechanisms under State planning legislation. The protection of all the habitat necessary to conserve the species may result in some land owners not receiving approval to develop part of their land resulting in some real or perceived economic impact. There are large areas of feeding habitat used by Carnaby's cockatoo in the metropolitan Perth and Peel regions that is not currently protected in conservation reserves.

Where the species is known to occur on or use habitat that occurs on private property, recovery actions will require continued liaison between stakeholders with regards to managing and protecting these areas. Where development is proposed on private property

containing Carnaby's cockatoo habitat the aim is to, where possible, protect the habitat through the statutory planning and environmental approval assessment processes.

Carnaby's cockatoos have a demonstrated ability to discover and use introduced plant species as new food sources, and are known to use pine plantations, and also to feed on nut crops and spilt canola. It is conceivable that in the future, birds could include more commercial agricultural crops in their diet beyond what has already been reported (Valentine and Stock 2008; Jackson 2009), which may result in damage to agricultural crops from cockatoo feeding and subsequent conflict with land owners.

Pine plantations have been demonstrated to be an important food source for Carnaby's cockatoo (Saunders 1980; Johnstone and Storr 1998; Higgins 1999; Finn *et al.* 2009). Historically plantations have been managed on a rotation basis resulting in a consistent food supply over the landscape and over years. The removal process for pines in the Gnangara, Pinjar and Yanchep plantations is underway (staged removal between 2004 and 2031) with no stated plan to re-establish the pine plantations. Not providing an alternative food resource following removal of pines is likely to have a significant impact on the food resources available to Carnaby's cockatoo in the Perth region. Efforts to avoid (by retaining pine trees that might otherwise be harvested) or mitigate (replanting of cockatoo feed species) this impact may incur significant economic costs.

10 AFFECTED INTERESTS

Stakeholders potentially affected by the implementation of this plan can be divided into broad groups:

- managers of lands that are important to Carnaby's cockatoos;
- groups and organisations that provide funding or carry out recovery actions for Carnaby's cockatoo and assist in implementation and research; and
- decision makers and those that provide infrastructure or undertake broadscale development. Examples of such stakeholders are presented in Table 2.

Table 2: Stakeholders potentially affected by the implementation of this plan.

Stakeholder Group	Examples
Decision makers	<ul style="list-style-type: none"> • Commonwealth Department of Sustainability, Environment, Water, Population and Communities (SEWPAC) • Conservation Commission of Western Australia • Department of Parks and Wildlife (DPaW) • Department of Agriculture and Food WA (DAFWA) • Forest Products Commission of Western Australia • Environmental Protection Authority (EPA) • Local Government Authorities • Western Australian Planning Commission (WAPC) • Agencies with delegated decision making authority
Land managers	<ul style="list-style-type: none"> • Department of Parks and Wildlife (DPaW) • Other State government agencies • Local Government Authorities • Commonwealth Department of Defence, and other Commonwealth agencies • Private landholders including industry and NGOs managing land for conservation
Implementation and research	<ul style="list-style-type: none"> • BirdLife Australia • Perth Zoo • Regional Natural Resource Management (NRM) groups • Western Australian Museum • Western Australian universities • Wildlife carers and rehabilitation providers • Volunteer and community groups, and individuals
Development and infrastructure providers	<ul style="list-style-type: none"> • Local governments • Land developers • Main Roads WA • Mineral exploration and mining companies • Water Corporation • Western Power and other utility providers • Westrail

11 INDIGENOUS PEOPLE

The DPaW has consulted with indigenous communities in the Carnaby's cockatoo range identified in this plan. Implementation of recovery actions under this plan will include consideration of the role and interests of indigenous communities in the region. Input and involvement will be welcomed from any indigenous groups that have an active interest in areas that are habitat for Carnaby's cockatoos. A search of the Department of Indigenous Affairs' Aboriginal Heritage Sites Register has identified 168 sites in the areas that Carnaby's cockatoo populations use. However, not all significant sites are listed on the Register.

12 PREVIOUS AND EXISTING CONSERVATION MEASURES

The existing Western Australian Carnaby's Cockatoo Recovery Plan (2000 - 2009) identified five primary recovery actions; management of breeding habitat, management of feeding habitat, monitoring of populations, community involvement and captive-breeding programs. Elements of each action have been realised, however not all actions in the Recovery Plan were fully implemented.

Since the 1990 listing of the species under the *Wildlife Conservation Act 1950* as (otherwise specially protected fauna), and its threat upgrading to specially protected fauna considered likely to become extinct (threatened) in 1996, the WA DPaW has included works for the protection of the species in its annual operations. These works have included specific actions for survey and monitoring, the protection of birds and nests from illegal taking, and conservation management of breeding and feeding habitat.

12.1 Habitat Management

Habitat management is undertaken and/or coordinated by a number of organisations and institutions. DPaW manages large natural areas that provide nesting, feeding and roosting habitat for Carnaby's cockatoo as part of the reserve system. While this reserve management is intended to benefit all the biodiversity values of these areas and is not specifically targeted at Carnaby's cockatoo, the retention and management of Carnaby's cockatoo is one of the considerations of this management. BirdLife Australia's Carnaby's Black Cockatoo Recovery Project is a long running on-ground project that engages landholders to actively manage habitat for conservation (Scott and Gole 2011).

As part of a project funded through the State Natural Resource Management (NRM) program, run by the DPaW and operated on-ground by BirdLife Australia, critical nesting and foraging habitat in the wheatbelt region was identified during 2009-2010. High quality areas of remnant vegetation at those sites that would benefit from improved protection were identified and negotiations were then held with the private land owners to obtain their agreement to fence (or re-fence in some cases) those remnants. Fencing began in 2011 and once completed land owners are engaged to develop individual management guidelines for each property to help ensure the maintenance, and where necessary improvement, of the quality of the habitat. Within BirdLife Australia's programs, voluntary management agreements with private landholders are protecting and/or better managing habitat critical to survival through fencing and revegetation with appropriate plant species. Willing landowners are being directed to

relevant agencies to establish conservation covenants or voluntary management agreements over habitat critical to survival. Additionally, the Western Australian Museum has been actively identifying habitat critical to survival across the entire range of Carnaby's cockatoo.

In a project managed by BirdLife Australia, 13 Important Bird Areas (IBAs) have been designated specifically for Carnaby's cockatoo (Table 3) (Dunstan *et al.* 2009). IBAs are sites of global bird conservation importance and are considered a priority for bird conservation. The criteria used for the designation of IBAs for Carnaby's cockatoos are sites supporting at least 20 breeding pairs, or 1% of the population regularly utilising an area in the non-breeding part of the range. In addition to the IBAs listed in Table 3, a number of other IBAs were designated primarily for other species but also list Carnaby's cockatoos as breeding. These IBAs may also meet designation criteria in the future.

Table 3: Important Bird Areas (IBAs) designated specifically for Carnaby's cockatoo.

IBA Name	Summary
Bindoon-Julimar	Supports at least 110 pairs in nesting and associated feeding habitat; this is the largest population of breeding birds in south-west Australia.
Calingiri	Supports up to 20 breeding pairs which nest in woodland remnants and isolated paddock trees and feed in native shrublands.
Cataby	Supports up to 24 breeding pairs which nest in woodland remnants and isolated paddock trees and feed in native shrublands.
Coomallo	Supports up to 40 breeding pairs which nest in woodland remnants and isolated paddock trees and feed in native shrublands.
East Borden	Supports at least 20 breeding pairs which nest in woodland remnants and feed in native shrublands.
Gillingarra	Supports up to 20 breeding pairs which nest in Marri trees and feed in native shrublands.
Jalbarragup	Supports at least 20 breeding pairs and at least three breeding pairs of the endangered Baudin's cockatoo and associated habitat within a 10 km radius of the locality of Jalbarragup.
Koobabbie	Supports up to 32 breeding pairs which nest in Salmon Gum on the property.
Kwobrup-Badgebup	Supports up to 20 breeding pairs
Moora	Supports up to 60 breeding pairs
Northern Swan Coastal Plain	Supports 4,600-15,000 birds in the non-breeding season and a small number of pairs of breeding birds; this is the largest population of non-breeding birds in south-west Australia.
Stirling Range	Supports populations of Carnaby's cockatoo
Walebing	Supports up to 40 breeding pairs which nest in woodland remnants and isolated paddock trees and feed in native shrublands.

(refer to <http://www.birdsaustralia.com.au/our-projects/important-bird-areas.html> for more information on IBAs)

BirdLife Australia and the DPaW have collaboratively developed the methodology to map roosting cockatoos on the Swan Coastal Plain, and DPaW and WA Department of Planning have collaborated to develop maps for the Swan Coastal Plain and adjacent Jarrah Forest depicting indicative breeding, roosting and feeding habitat (based on datasets from the Great Cocky Count 2010 and 2011 surveys, and WA Museum data) (Glossop *et al.* 2011).

The *Plants for Carnaby's Search Tool* (Groom 2010a) is an on-line resource available on the DPaW webpage which provides information on plants used by Carnaby's cockatoos for food, night roosting or nesting, and captures information from both the published and unpublished literature.

Research to provide a greater understanding of available food resources and their use by Carnaby's cockatoos is underway on the Swan Coastal Plain (Johnston 2011) and will help provide land managers and decision makers with a tool to determine what natural resources must be conserved, and where in the landscape those resources need to be maintained.

Over the last 16 years damaged and degraded natural nest hollows used by Carnaby's cockatoo have been repaired as part of a long-term program coordinated by BirdLife Australia. Furthermore, the installation of PVC artificial nest hollows has been trialled as part of a WA Museum program. Artificial hollows have been erected on a variety of tenures including private property, state forest, road verges and shire reserves (Groom 2010b). Of the three black cockatoo species occurring in the south-west of Western Australia, Carnaby's cockatoo has been found to be the most willing species to use artificial hollows. The underlying philosophy for using artificial hollows, the key elements of design and construction and the need for regular maintenance and monitoring have been described in a series of three information sheets produced by DPaW and the WA Museum (DEC 2011a, 2011b and 2011c). The methodology for repairing existing, but substandard, natural hollows is described in an information brochure being developed jointly by BirdLife Australia and DPaW.

The Australian and WA Governments have been discussing cooperative approaches to the assessment of urban land development proposals. SEWPaC has required offsets as conditions of approvals for actions that impact on matters of national environmental significance. The offset packages have included funding for purchase of uncleared areas which contain like-for-like habitat, retaining vegetation on-site, planting new street trees and rehabilitation of nearby degraded sites with seed and/or topsoil from the cleared site to enhance or create new habitat,

and the establishment of artificial nest hollows. As of October 2011 the acquisition of a total of 5,500 ha of Carnaby's cockatoo habitat had been finalized and purchased as part of the offset process, and 8,500 ha are in negotiation.

At the time of preparing this Recovery Plan the WA State Government and the Australian Government were cooperating in a strategic assessment of the Perth and Peel regions of Western Australia in accordance with section 146 of the EPBC Act. This strategic Assessment is considering the conservation of Carnaby's cockatoo and other matters of National Environmental Significance under the EPBC Act.

12.2 Monitoring

Accurately monitoring a highly mobile but fragmented species which displays seasonal migratory patterns linked to breeding is difficult. A number of approaches have been attempted and many have adapted over time. This section is limited to presenting only current monitoring initiatives.

The Great Cocky Count is an annual survey initiated and coordinated by BirdLife Australia and undertaken by hundreds of volunteers. It was first organised in 2006 as a community-based survey aimed at describing the pattern of Carnaby's cockatoo abundance and providing a minimum population estimate of cockatoos on the Swan Coastal Plain (Shah 2006). An important insight from this 2006 survey was the value of counting birds at night roosts, as a means of monitoring population size, and a methodology was established based on Berry (2008). Since 2010 the Great Cocky Count has been undertaken annually by BirdLife Australia with funding from DPaW and the Australian Government (Burnham *et al.* 2010; Kabat *et al.* 2012) and in 2011-2012 it was expanded beyond the Swan Coastal Plain to include regional areas.

BirdLife Australia has established a long-term monitoring program where nesting sites on private properties have been identified and many are surveyed annually. This monitoring began in the northern agricultural region in 2001 and in the south coast and south eastern wheatbelt in 2006.

The DPaW has been monitoring key nesting sites in the northern wheatbelt since 2003 and more recently in the southern wheatbelt since 2009. During this annual monitoring program the nesting productivity of key sites is measured along with measurements of relative health status of nestling Carnaby's cockatoos. Data from this program have been combined with those of Saunders (1986, 1990; Saunders and Ingram 1998) and new analyses carried out.

This research has shown a clear, significant and negative relationship between the extent of clearing of native vegetation within 6 km of key nesting sites and the nesting success and proportion of chicks whose body weight is more than one standard deviation below an established benchmark for Carnaby's cockatoo chicks. The relationship holds at a distance of up to 12 km from the nest sites, but is not significant ($p > 0.05$). It also appears that key sites at the north-eastern margin of the breeding range of Carnaby's cockatoo that appear to be productive in terms of the number of nests and nestlings produced, are below average in terms of the chicks body weight in relation to age. This suggests that in the event of any further loss of foraging habitat or continued decline in rainfall associated with climate change, the breeding range of Carnaby's cockatoo will contract westwards in that part of its breeding range. At present there is no matching evidence to suggest a similar trend in the southern part of the species' breeding range.

A monitoring method has been developed that allows marked (i.e. leg banded) Carnaby's cockatoos to be identified without the need to capture and physically restrain the birds to confirm their identity (see Saunders *et al.* 2011b). Though leg banding has been widely used in bird monitoring worldwide, this technique uses photography to identify individuals and is proving reliable and easy to apply.

A collaborative health monitoring project between Murdoch University (School of Veterinary Biology), Perth Zoo, BirdLife Australia and DPaW that commenced in November 2010 is now examining nestlings at a range of sites across the known breeding range of Carnaby's cockatoo to determine baseline blood profiles for healthy chicks in nest hollows which can be compared with sick or injured wild birds received at the Perth Zoo. The project will also determine the presence and prevalence of diseases such Beak and Feather Disease Virus, Avian polyomavirus and *Chlamydophila psittaci* (Warren *et al.* 2011). A part of this project is also designed to collect skin tissue samples from known age birds to allow an 'age curve' to be developed for black cockatoos (*Calyptorhynchus* spp.). This can then be compared with samples from wild birds that are received at the Perth Zoo and other rehabilitation facilities. Knowing the age demographics of the birds that are being killed or injured will provide important information on whether recruitment (post-fledging) is limited or whether a disproportionate amount of the adult breeding birds are being lost from the wild population. Additional samples are taken to build DNA sequences and genotype databases for other uses (see below).

12.3 Captive Management Program

A captive rearing program was undertaken between 1996 and 1999 to decrease the domestic retail price for Carnaby's cockatoos in an attempt to reduce the motivation for illegally taking eggs or chicks from the wild. Between 1996 and 1998, 148 eggs and chicks were collected from the wild, of which 124 chicks (84%) survived to January 1999 (CALM 1999). The majority of these birds were subsequently sold, through a public tender process, into private aviculture. This resulted in the average domestic price for Carnaby's cockatoo's falling from \$3000 per bird to around \$1100, which remains the average price since that time. In addition, the increase in the number of provenanced birds derived from the captive rearing program provided new blood-stock for captive breeding efforts within private aviculture. One aspect of aviculture involving Carnaby's cockatoos that has not been resolved is the very low rate of captive breeding. Most other species of black cockatoos (*Calyptrorhynchus* spp.) breed well in captivity, but Carnaby's cockatoo is proving the exception. Until this problem is solved there will still be a demand that will encourage illegal taking from the wild stocks. Regardless of any progress on captive breeding, there will also still be an illegal trade of eggs for the international market. The continued future involvement of SEWPAC and Australian Customs to help address the illegal international trade will be important.

Injured or 'derelict' cockatoos that cannot be released back to the wild are held in captivity under a DPaW managed program. While the number of Carnaby's cockatoos that are retained in captivity as a result of injuries sustained in the wild continues to increase, the rate at which new birds are added to the captive flock is declining as rehabilitation techniques developed by the Perth Zoo and private rehabilitation groups improves (see Saunders *et al.* 2011b).

The capacity to successfully identify when illegal taking of eggs and chicks from the wild has taken place has improved dramatically in the past five years, due to the knowledge gained during a PhD project undertaken at Murdoch University (White 2011). Twenty-two micro-satellite markers have been developed for use in black cockatoo systematics (White *et al.* 2011) and the entire genome for Carnaby's cockatoo has been sequenced (White 2012). Successful prosecutions for illegal taking of black cockatoos, including Carnaby's cockatoos, have been achieved based on these DNA technologies (White *et al.* 2011b).

12.4 Community Actions

Carnaby's cockatoo has a large degree of community interest due to its significant presence in the skies and trees of south-western Australia. Community-based programs include those that

raise awareness and the profile of the species as being threatened with extinction, and those that deliver direct species conservation outcomes.

Community awareness programs include:

- Cockatoo Care program co-ordinated by the Western Australian Museum
- Information sheets at the Western Australian Museum and on their website
- BirdLife Australia Carnaby's Black-Cockatoo Recovery Project
- Public awareness programs at Perth Zoo and black cockatoos used for public presentations at schools, fetes and conferences to increase community education and awareness
- The Black Cockatoo Preservation Society Education Program
- Websites with dedicated pages dealing with the conservation of black cockatoos (e.g. WA Museum website; DPaW website; Perth Zoo website; BirdLife Australia website)
- Various, and numerous local and regional community groups promoting awareness.

Programs that deliver direct conservation outcomes include BirdLife Australia's Carnaby's Black-Cockatoo Recovery Project which support and financially assist private landholders to undertake recovery actions (fence, revegetate and repair hollows), provide weed and competitor control as appropriate, and collect distribution data and monitor nesting (e.g. Great Cocky Count) (Scott and Gole 2011).

A collaborative program between the Perth Zoo and the Murdoch University School of Veterinary Biology has further enhanced the capacity to manage wild black cockatoos taken into care. A post-graduate placement as a clinical veterinarian at Perth Zoo provides an opportunity to investigate aspects of the veterinary treatment and rehabilitation of endangered Western Australian black cockatoos and the health status of free-living black cockatoo nestlings. Information arising from these studies will be important for the future care of cockatoos received at Perth Zoo and private veterinary practices, and for the subsequent care and rehabilitation of injured birds in the purpose-built cockatoo rehabilitation facilities.

There are a number of community run wildlife rehabilitation facilities that now have the appropriate facilities and techniques to cater for sick, injured or orphaned black cockatoos. These include Kaarakin Black Cockatoo Rehabilitation Centre and Native Animal Rescue.

In December 2008, 75 scientists, conservation workers and community members attended a symposium and workshop in Perth on Carnaby's cockatoo, jointly organised by BirdLife

Australia, DPaW and WWF-Australia, to help promote collaboration and information sharing (Burbidge 2009). The workshop aimed to identify key conservation issues for the future, and developed a strategic framework to help guide management and conservation of Carnaby's cockatoo and these have informed the development of this Recovery Plan. In 2010 the Urban Bushland Council WA organised a symposium titled Endangered Black Cockatoos in Western Australia with 12 presenters covering the biology, natural history, threats and conservation efforts, and published the proceedings (Kendrick 2011).

13 RECOVERY STRATEGY

Full recovery of a long-lived species such as Carnaby's cockatoo will take many decades, requiring reversal of the threats and factors that have led to the decline in the species before significant increases in numbers of breeding birds and finally in the overall species population can occur. This recovery plan covers a ten year period and identifies the recovery objective, success criteria and the actions required over those ten years to progress towards the longer term recovery of the species. This phase will focus primarily on reducing the rate of decline in the species population, and in increasing the proportion of the population that is successfully breeding.

13.1 Recovery Objective

To stop further decline in the distribution and abundance of Carnaby's cockatoo by protecting the birds throughout their life stages and enhancing habitat critical for survival throughout their breeding and non-breeding range, ensuring that the reproductive capacity of the species remains stable or increases.

13.2 Performance Criteria

This Recovery Plan will be deemed completely successful if, within a ten year period, all of the following are achieved:

- The species' area of occupancy does not decline. In the absence of any improved methods this will be measured by the same method used, and compared with the values calculated, in this Recovery Plan: 60,525 km² using a grid size of 15 x 15 km. (The measure of the area of occupancy may be upgraded during the life of the plan provided the benchmark established here is not substantially changed under the replacement system.)
- The number of breeding pairs of Carnaby's cockatoos at pre-determined (and recorded in advance) breeding sites across the breeding range remains stable or increases, averaged over three consecutive years. (Any changes in the breeding sites counted for this measure are to be approved by the DPaW Director, Nature Conservation and to remain statistically comparable with sites used at the commencement of this plan.)
- Estimates of the number of birds and proportion of juveniles across the entirety of known (standardised) night roost sites across the range of the species remains stable or increases, averaged over three consecutive years.
- The extent of nesting habitat (trees with nesting hollows), feeding habitat (as defined by vegetation complexes or suitable revegetation), and night roosting habitat (as identified through community survey) are maintained throughout the species range.

This Recovery Plan will be deemed to not be successful if, within a ten year period, any of the following are occur:

- The area of occupancy declines by more than 10% below 60,525 km² using a grid size of 15 x 15 km² (or similar change in amended methodology).
- The number of breeding pairs of Carnaby's cockatoos at monitored breeding sites across the breeding range decreases by more than 10% averaged over three consecutive years.
- The estimated number of adult and proportion of juvenile Carnaby's cockatoos at known night roost sites decreases by more than 10% averaged over three consecutive years.
- The extent of nesting habitat (trees with nesting hollows), feeding habitat (as defined by vegetation complexes), and night roosting habitat (as identified through community survey) decreases by more than 10% throughout the species range.

14 RECOVERY ACTIONS

The recovery actions below are presented in themes. They are set out in general order of priority however this should not prevent the implementation of lower priority actions where opportunities arise.

Recovery actions are summarised in Table 4 with timing and indicative costs.

Action 1: Protect and Manage Important Habitat

Complete restoration of the original extent of Carnaby's cockatoo habitat is not possible. It is therefore important to identify those parts of the species' habitat most critical to survival and to protect and manage as much of this important habitat as possible to minimise the impacts of habitat loss. While planting of species that support Carnaby's cockatoo is effective over the long-term and encouraged, protection and regeneration of existing habitat is significantly more efficient and effective. Therefore efforts in this Recovery Plan are primarily directed towards protection and enhancement of existing habitat.

The reproductive output of Carnaby's cockatoo is primarily limited by factors associated with habitat and food requirements during the breeding season. However, sufficient habitat and food resources during the non-breeding season are also critical for both survival of young and in conditioning breeding birds. Therefore Recovery Actions have been directed towards the protection of both breeding and non-breeding habitat.

Management of breeding habitat and associated feeding habitat

Tasks include:

- Locate and map breeding sites, including currently recognised Important Bird Areas (see Table 3), across the breeding range and identify those that are most important for the conservation of the species based on factors such as site size, site productivity and the number of breeding pairs that use the site.
- Ensure protection of areas of existing and potential breeding habitat, including consideration during statutory planning and environmental approvals processes.
- Implement management to protect and improve the condition of breeding habitat and associated feeding habitat, including activities that:
 - Prevent clearing and loss of breeding and associated feeding habitat;
 - Control grazing (e.g. fencing to exclude stock and control rabbits);
 - Manage fire regimes, salinity, weeds and dieback;

- Promote regeneration and revegetate areas within and adjacent to breeding habitat and associated feeding habitat;
- Prevent further degradation of habitat;
- Maintain natural and artificial water sources used by cockatoos.
- Replace any loss of feeding habitat, and increase the area of feeding habitat near known breeding sites (within 12 km) by regeneration and revegetation with cockatoo feed species.
- Increase hollow availability by reducing the impact of nest competitors (e.g. feral European honeybees, galahs and corellas) and repairing damaged and suboptimal hollows.
- Supplement hollow availability at breeding sites by installing and maintaining artificial nest hollows.
- Improve the protection of breeding habitat and associated feeding habitat through purchase and transfer of vesting, conservation covenants, or other appropriate means.

Protection and management of non-breeding habitat

Tasks include:

- Locate and map feeding habitat sites (with associated night roosts and watering sites) throughout the non-breeding range and identify the most important areas that if lost would have the greatest impacts on the species. Prioritise the following protection and management actions on these sites to maximise the conservation benefits of management.
- Improve the security of tenure and management of important areas of feeding habitat through purchase and transfer of vesting, conservation covenants, or other appropriate means.
- Ensure protection of important areas of feeding and night roost habitat, including consideration during statutory planning and environmental approvals processes.
- Implement management to protect and improve the condition of feeding habitat and night roosts throughout the non-breeding range, including activities that:
 - Prevent clearing and permanent habitat loss;
 - Control grazing (e.g. fencing to exclude stock and control rabbits);
 - Manage fire regimes, salinity, weeds and dieback;
 - Promote regeneration and revegetate within and adjacent to night roosts and associated feeding habitat;
 - Maintain natural and artificial water sources used by cockatoos.

- Maintain or increase the area of non-breeding feeding habitat and night roosts by planting areas of native vegetation (to increase area, provide a buffer or a linkage, particularly within 6 km of existing roost sites) and investigate the value of providing artificial water sources at potential roost locations.
- Develop and implement approaches to avoid, mitigate or offset impacts of harvesting pine trees without replacement, especially in the Yanchep, Pinjar and Gnangara plantations.

Action 2: Undertake Regular Monitoring

Regular monitoring of Carnaby's cockatoo populations and habitat will provide information on the size of the breeding population, breeding success, and use of habitat by the species, and changes in those parameters over time. The following activities will be used to establish a monitoring framework and monitoring protocol to inform the measurement of success of recovery actions. This monitoring framework will be informed by new knowledge and may change with improved understanding.

Monitoring breeding

Tasks include:

- Develop and implement standard protocols for monitoring breeding success and the quality of nestlings in comparison to historic benchmarks across the current breeding range.
- Monitor use and success of artificial nest hollows across the distribution of Carnaby's cockatoo.
- Monitor vegetation condition of breeding habitat and feeding habitat, including nesting hollows, and stand structure of woodlands across their range.
- Monitor effectiveness of nest competitor (e.g. galah, corella and feral honey bee) control actions at breeding sites (i.e. removal of competitors and subsequent use by Carnaby's cockatoo).

Monitoring non-breeding factors

Tasks include:

- Monitor night roost sites (such as through the Great Cocky Count) to determine the number and distribution of roosts, number of birds in night roosts, and use of night roosts within and between years.

- Monitor extent and condition of feeding habitat across the non-breeding range, including monitoring the impact of threatening processes on habitat.
Monitor the use of newly established and revegetated non-breeding habitat by Carnaby's cockatoo.

Action 3: Conduct Research to Inform Management

Further research and knowledge into the biology and ecology of Carnaby's cockatoo is required in order to inform the best management. Research and surveys are important to enable accurate monitoring of the population, its conservation status and the effectiveness of recovery actions.

Tasks include:

- Establish and maintain a register of research priorities for Carnaby's cockatoo.
- Identify, centralise and consolidate existing (and future) data including addressing issues relating to access and custodianship.
- Establish a robust population model using all available information for use in decision making.
- Conduct studies into the age structure demographics of Carnaby's cockatoos in breeding and non-breeding habitat.
- Study the impact of pine plantation removal on Carnaby's cockatoos and their feeding / night roosting requirements.
- Assess the size and health of breeding populations across the breeding range.
- Confirm habitat preferences of Carnaby's cockatoo across its range, including the importance of the southern Swan Coastal Plain and south coast.
- Research Carnaby's cockatoo movements, feeding and roosting behaviour to better understand how they use resources.
- Conduct climate change modelling to better inform future management actions around priority sites.
- Describe any genetic structuring in the population.
- Conduct longitudinal studies of the epidemiology and clinical significance of BFDV and APV infections in wild populations

Action 4: Manage Other Impacts

The impacts of other factors detrimentally affecting Carnaby's cockatoos such as motor vehicle collisions and illegal activities needs to be monitored and programs developed to manage these for species conservation, and to rehabilitate injured birds.

Tasks include:

- Monitor patterns, trends and impacts of factors such as motor vehicle collisions and illegal activities (e.g. habitat destruction, poaching and shooting).
- Develop and implement strategies to reduce the incidence of motor vehicle collisions (e.g. identification of hotspots, signage, road design, planting of food resources and drainage).
- Implement and publicise enforcement programs to counter illegal taking of Carnaby's cockatoo (poaching and shooting).
- Support black cockatoo rehabilitation programs which ensure that injured and debilitated wild black cockatoos receive specialised veterinary treatment and assessment, and monitor the success rate of rehabilitating injured birds back to the wild.

Action 5: Engage with the Broader Community

Since Carnaby's cockatoo occurs over a range of land tenures, including private property, coordinated public information and participation programs are an essential strategy for its recovery. Facilitation of public awareness and community involvement in conservation projects, and good communication between the Recovery Team, community groups and individual landholders is vital.

Carnaby's cockatoos are a highly visible and charismatic species and have engendered strong community interest. This interest has been fostered through community and education programs developed and disseminated by both government and non-government organization. These networks are well placed to expand upon existing programs and further increase the stewardship of Carnaby's cockatoo by the community.

Tasks include:

- Promote awareness of the conservation needs of Carnaby's cockatoo and support for its recovery within the broader community (public, industry, business and government).
- Develop information and guidelines for management of Carnaby's cockatoo habitat in formats that can be used by individuals, groups and organisations/agencies.

- Encourage and support landholder and community volunteer participation in conservation actions for Carnaby's cockatoo by way of extension, stewardship and incentive programs which result in the retention and management of Carnaby's cockatoo habitat on private land.
- Provide opportunities for community participation in activities that improve or protect habitat and decrease threats to the species such as coordinated programs for monitoring and management of areas.
- Seek resources through budget allocations, grants, donations and sponsorships to fund programs to assist landholders, agencies and community groups to recover Carnaby's cockatoo and its habitat (e.g. restoration and revegetation).

Action 6: Undertake Information and Communication Activities

One of the best means of improving the conservation status of Carnaby's cockatoos will be to achieve a higher level of acceptance and understanding by decision makers of the importance of, and the roles they can play in, the conservation of this species. One means to help achieve this is through programs raising the awareness of decision makers of the species conservation needs and urgency. A second means is through expanding the establishment of joint management agreements for habitat protection. The sharing of information between agencies and groups and individuals involved actively in land conservation will also assist in achieving this.

Tasks include:

- Develop and distribute awareness raising and guidance materials for decision makers and proponents aimed at:
 - increasing awareness of the habitat and conservation requirements of Carnaby's cockatoo and importance of local areas;
 - improving land use planning so as to minimise the potential for conflict with Carnaby's cockatoo (e.g. locating orchards, commercial plantations and roadside plantings).
- Establish joint management agreements or memoranda of understanding with agencies that manage lands (e.g. Water Corporation, local government authorities, etc.) that are utilised by Carnaby's cockatoos.

- Provide for improved sharing of information between State and Commonwealth agencies concerning environmental impact assessment and enforcement activities under State and Commonwealth legislation.

15 IMPLEMENTATION AND EVALUATION

Recovery Teams provide advice and assist in coordinating actions prescribed in recovery plans. Recovery teams include representatives from organisations with direct interest in the recovery of the species, including those involved in funding, carrying out or helping to carry out actions that support the recovery of the species. The Carnaby's Cockatoo Recovery Team was first established in 1999 to coordinate the recovery of the species and the development and implementation of the initial recovery plan (Cale 2003). Originally the team comprised of representatives from DPaW, CSIRO, WA Museum, Perth Zoo, BirdLife Australia and a private landowner. Over time other organisations and individual have been invited to join the team or to share their expertise, experience and knowledge with the recovery team.

The DPaW, in consultation with the Carnaby's Cockatoo Recovery Team, will evaluate the performance of this Recovery Plan, and in particular the performance against the recovery objective and the criteria for success and failure, so as to review and change the recovery actions in response to new information. One of the Recovery Actions is to set up a monitoring framework and protocols, and this will inform the measurement of success and failure criteria. The plan will otherwise be reviewed within five years of its adoption, again ten years after adoption if not replaced prior to that time. The recovery actions carried out, and any changes to management and recovery actions, will be documented accordingly and the plan amended if necessary.

The estimated cost of implementing this Recovery Plan is \$7,730,000 over ten years (Table 4). However, this estimated figure does not include costs associated with the ongoing management of habitat by DPaW, other government agencies and private land owners, or all the costs associated with the creation of new habitat, and the re-creation habitat lost to clearing. Nor does it include costs associated with mitigating any loss of habitat due to development proposals that may be approved and undertaken at any point in the next 10 years. It should also be noted that volunteers undertake a great deal of work associated with the recovery of this species which is not reflected in the estimated implementation costs.

15.1 Estimated Costs of Recovery Actions

Table 4: Summary of recovery actions over ten years and indicative costs.

Recovery Action Theme	Year 1 Cost (\$1,000s)	Year 2 Cost (\$1,000s)	Year 3 Cost (\$1,000s)	Year 4 Cost (\$1,000s)	Year 5 Cost (\$1,000s)	Year 6 Cost (\$1,000s)	Year 7 Cost (\$1,000s)	Year 8 Cost (\$1,000s)	Year 9 Cost (\$1,000s)	Year 10 Cost (\$1,000s)	Total Cost (\$1,000s)
1: Protect and Manage Important Habitat Identify, protect and manage habitat critical to survival (nesting, foraging and roosting) for Carnaby's cockatoo across their breeding and non-breeding range	345,000	345,000	315,000	315,000	215,000	165,000	165,000	165,000	165,000	165,000	2,360,000
2: Undertake Regular Monitoring Monitor population parameters, habitat, threats and status of Carnaby's cockatoo	220,000	220,000	130,000	130,000	150,000	130,000	120,000	120,000	140,000	160,000	1,520,000
3: Conduct Research to Inform Management Undertake research into the biology, ecology and conservation management of Carnaby's cockatoo	300,000	270,000	300,000	240,000	145,000	40,000	40,000	40,000	45,000	40,000	1,460,000
4: Manage Other Impacts Monitor the impacts and implement strategies to reduce anthropogenic factors affecting Carnaby's cockatoos, and support rehabilitation programs	110,000	110,000	110,000	110,000	110,000	110,000	110,000	110,000	110,000	110,000	1,100,000
5: Engage with the Broader Community Engage with and involve people across the community in the conservation of Carnaby's cockatoo	105,000	105,000	85,000	65,000	65,000	65,000	65,000	85,000	85,000	65,000	790,000
6: Undertake Information and Communication Activities Develop and distribute educational and guidance materials for decision makers, establish joint management agreements and provide for information sharing	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	500,000
TOTAL	1,130,000	1,100,000	990,000	910,000	735,000	560,000	550,000	570,000	595,000	590,000	7,730,000

16 REFERENCES

- Barrett, G., Silcocks, A., Barry, S., Cunningham, R. and Poulter, R. (2003). *The New Atlas of Australian Birds*. Birds Australia (Royal Australasian Ornithologists Union), Melbourne.
- Berry, P.F. (2008). Counts of Carnaby's cockatoo (*Calyptorhynchus latirostris*) and records of flock composition at an overnight roosting site in metropolitan Perth. *Western Australian Naturalist*. **26**: 1-11.
- Bernier, G., Morin, M. and Marsolais, G. (1981). A generalised inclusion body disease in the budgerigar (*Melopsittacus undulates*) caused by a papovavirus-like agent. *Avian Diseases*. **25**:1083-1092.
- Blakers, M., Davies, S.J.J.F. and Reilly, P.N. (1984). *The Atlas of Australian Birds*. Royal Australian Ornithologists Union (Birds Australia), Melbourne.
- Burbidge, A.H. (ed.) (2009) *Proceedings of the Carnaby's Cockatoo Symposium*. Produced by WWF-Australia in partnership with Birds Australia Western Australia Inc. and the Western Australia Department of Environment and Conservation, WA.
- Burnham, Q., Barrett, G., Blythman, M. and Scott, R. (2010). *Carnaby's Cockatoo (Calyptorhynchus latirostris) identification of nocturnal roost sites and the 2010 Great Cocky Count*. Birds Australia Western Australia and the Western Australia Department of Environment and Conservation, WA.
- Brook, B.W., Sodhi, N.S. and Bradshaw, C.J.A. (2008). Synergies among extinction drivers under global change. *Trends in Ecology & Evolution*. **23**: 453-60.
- Burgman, M.A and Fox, J.C. (2003). Bias in species range estimates from minimum convex polygons: implications for conservation and options for improving planning. *Animal Conservation*. **6**: 19-28.
- Cahill, D.M., Rookes, J.E., Wilson, B.A., Gibson, L. and McDougall, K.L. (2008). *Phytophthora cinnamomi* and Australia's biodiversity: impacts, predictions and progress towards control. *Australian Journal of Botany*. **56**: 279-310.
- Cale, B. (2003). *Carnaby's cockatoo (Calyptorhynchus latirostris) Recovery Plan 2000-2009*. Western Australian Wildlife Management Program No. 36. Threatened Species and Communities Unit, Department of Conservation and Land Management, Perth, WA.
- CALM (1991). *Policy Statement No. 33: Conservation of endangered and specially protected fauna in the wild*. WA Department of Conservation and Land Management, Perth, WA.
- CALM (1992). *Policy Statement No. 44: Wildlife management programs*. WA Department of Conservation and Land Management, Perth, WA.
- CALM (1994). *Policy Statement No. 50: Setting priorities for the conservation of Western Australia's threatened flora and fauna*. WA Department of Conservation and Land Management, Perth, WA.
- CALM (1995). *Policy Statement No. 29: Translocation of threatened flora and fauna*. WA Department of Conservation and Land Management, Perth, WA.
- CALM (1999). Captive breeding program for Carnaby's cockatoo (*Calyptorhynchus latirostris*) 1996-1998. Unpublished report.
- Cameron, M. (2007). *Cockatoos*. CSIRO Publishing, Victoria, Australia.

- Carnaby, I.C. (1948). Variation in the White-tailed Black Cockatoo. *Western Australian Naturalist*. **1**: 136-138.
- Centre of Excellence for Climate Change Woodland and Forest Health (2012). Available at: <http://www.foresthealth.com.au/> (Accessed Jan. 2012).
- Campbell, N. A. and Saunders, D. A. (1976). Morphological variation in the White-tailed Black Cockatoo, *Calyptorhynchus baudinii*, in Western Australia. *Australian Journal of Zoology*. **24**: 589-95.
- Chapman, T. (2008) *Baudin's Cockatoo Calyptorhynchus baudinii and Forest Red-tailed Black Cockatoo Calyptorhynchus banksii naso Recovery Plan*. WA Department of Environment and Conservation, Perth, WA.
- Chapman, T., Sims, C. and Mawson, P. (2011). Minimising Disease Risk in Wildlife Management: standard operating procedures for fauna translocation, monitoring and euthanasia in the field (3rd edition). Department of Environment and Conservation. Perth, WA.
- CITES (1973). *Convention on International Trade in Endangered Species of Wild Fauna and Flora*. CITES, Washington D.C.
- CSIRO (2002). *Future Climate Change in Australia*. Available at: www.cmar.csiro.au (Accessed July 2006).
- CSIRO (2007). *Climate Change in Australia*. Technical Report 2007. CSIRO and Bureau of Meteorology.
- DEC (2009). *Guidelines for Protection of the Values of Informal Reserves and Fauna Habitat Zones*. Department of Environment and Conservation, Sustainable Forest Management Series, SFM Guideline No. 4, WA.
- DEC (2010). *Guidelines for the Selection of Fauna Habitat Zones*. Department of Environment and Conservation, Sustainable Forest Management Series, SFM Guideline No. 6, WA.
- DEC (2011a). *When to use artificial hollows for Carnaby's black cockatoo*. Department of Environment and Conservation <http://www.dec.wa.gov.au/content/view/full/6333/2006/> (Accessed Feb. 2012).
- DEC (2011b). *How to design and place artificial hollows for Carnaby's black cockatoo*. Department of Environment and Conservation. Available at: <http://www.dec.wa.gov.au/content/view/full/6333/2006/> (Accessed Feb. 2012).
- DEC (2011c). *How to monitor and maintain artificial hollows for Carnaby's black cockatoo*. Department of Environment and Conservation. Available at: <http://www.dec.wa.gov.au/content/view/full/5983/2006/> (Accessed Feb. 2012).
- DEC (2011d). *A biodiversity and cultural conservation strategy for the Great Western Woodlands*. Available at: <http://www.dec.wa.gov.au/content/view/full/6115/2391/> (Accessed Feb. 2012).
- DEWHA (2005). *Threat Abatement Plan for Psittacine Beak and Feather Disease Affecting Endangered Psittacine Species*. Department of the Environment and Heritage Commonwealth of Australia. Available at: www.deh.gov.au/biodiversity/threatened/publications/tap/beak-feather/ (Accessed Feb. 2010).
- DEWHA (2008). *Recovery Planning Compliance Checklist for Legislative and Process Requirements*. Available at: <http://www.environment.gov.au/biodiversity/threatened/publications/recovery/guidelines/pubs/recovery-checklist.pdf> (Accessed February 2012).

- DEWHA (2009). *Significant Impact Guidelines 1.1 - Matters of National Environmental Significance*. Available at: <http://www.environment.gov.au/epbc/publications/nes-guidelines.html> (Accessed Feb 2012).
- Environment Australia. (2001). *Threat abatement plan for dieback caused by the root-rot fungus (Phytophthora cinnamomi)*. Environment Australia, Canberra.
- EPA (2008). *Guidance Statement No. 33 Environmental Guidance for Planning and Development*. Available at: http://www.epa.wa.gov.au/epadoclib/2717_GS33.pdf (Accessed Feb. 2012).
- Finn, H., Stock, W. and Valentine, L. (2009). *Pines and the ecology of Carnaby's cockatoos (Calyptorhynchus latirostris) in the Gnangara Sustainability Strategy study area*. A report prepared for the Forest Products Commission and the Gnangara Sustainability Strategy, Perth.
- Garnett, S.T. and Crowley, G.M. (2000). *The Action Plan for Australian Birds: 2000*. Environment Australia and Birds Australia.
- Garnett, S., Szabo, J. and Dutson, G. (2011). *The Action Plan for Australian Birds 2010*. CSIRO Publishing, Melbourne, Victoria.
- Gilardi, K.V., Lowenstine, L.J., Gilardi, J.D. and Munn, C.A. (1995). A survey for selected viral, chlamydial, and parasitic diseases in wild dusky-headed parakeets (*Aratinga weddellii*) and tui parakeets (*Brotogeris sanctithomae*) in Peru. *Journal of Wildlife Diseases*. **31**:523-528.
- Glossop, B., Clarke, K., Mitchell, D. and Barrett, G. (2011). *Habitat mapping for Carnaby's cockatoo on the Swan Coastal Plain and Jarrah Forest*. Internal Report, WA Department of Environment and Conservation, Perth, WA.
- Groom, C.J. (2010a). *Plants for Carnaby's Search Tool*. Department of Environment and Conservation. Available at: <http://www.dec.wa.gov.au/content/view/5983/2006/> (Accessed Feb. 2012).
- Groom, C.J. (2010b). *An investigation of the placement, use, monitoring and maintenance requirements of artificial hollows for Carnaby's black cockatoo*. Department of Environment and Conservation. Available at: <http://www.dec.wa.gov.au/content/view/6333/2006/> (Accessed Feb. 2012).
- Hobbs, R.J. (1987). Disturbance regimes in remnants of natural vegetation. In: *Nature Conservation: The role of remnants of native vegetation*. (Eds. D.A. Saunders, G.W. Arnold, A.A. Burbidge and A.J. Hopkins) Pp. 233-40. Surrey Beatty and Sons, Chipping Norton, NSW.
- Higgins, P.J. (1999). (Ed.) *Handbook of Australian, New Zealand and Antarctic Birds, Volume 4. Parrots to Dollarbird*. Oxford University Press: Melbourne.
- Hill, T.C.J., Tippett, J.T. and Shearer, B.L. (1994). Invasion of Bassendean Dune Banksia woodland by *Phytophthora cinnamomi*. *Australian Journal of Botany*, **42**: 725-738.
- Howden, M., Hughes, L., Dunlop, M., Zethoven, I., Hilbert, D. and Chilcott, C. (2003). *Climate Change Impacts on Biodiversity in Australia*. Outcomes of a workshop sponsored by the Biological Diversity Advisory Committee, 1-2October 2002. Commonwealth of Australia, Canberra.
- IOCI. (2002). *Climate variability and change in the South West of Western Australia*. Indian Ocean Climate Initiative Panel (IOCI), Department of Environment, Perth, Western Australia.
- Jackson, C. (2009). *Assessing and quantifying canola crop damage by Carnaby's cockatoo Calyptorhynchus latirostris in the south-west of Western Australia*. M. Appl. Sc. Thesis, University of Sydney, NSW.

- Johnston, T.R. (2011). Five-star dining for Carnaby's. *Landscape*. **27**(2): 52-57.
- Johnstone, R.E. (2001). Checklist of the birds of Western Australia. *Records of the Western Australian Museum*. Suppl. No. **63**: 75-90.
- Johnstone, R.E. and Kirkby, T. (2008). Distribution, status, social organisation, movements and conservation of Baudin's Cockatoo (*Calyptorhynchus baudinii*) in South-west Western Australia. *Records of the Western Australian Museum*. **25**: 107-118.
- Johnstone, R.E. and Kirkby, T. (2007). Feral European honey bees: a major threat to cockatoos and other tree hollow users. *West. Aust. Nat.* **25**(4): 252-254.
- Johnstone, R.E. and Storr, G.M. (1998). *Handbook of Western Australian Birds, Volume I, Non-passerines (Emu to Dollarbird)*. Western Australian Museum, Perth.
- Johnstone, R.E., Johnstone, C. and Kirkby, T. (2008). *Carnaby's cockatoo (Calyptorhynchus latirostris) on the Northern Swan Coastal Plain (Lancelin-Perth) Western Australia*. Report to Department of the Environment, Water, Heritage and the Arts.
- Johnstone, R.E., Johnstone, C. and Kirkby, T. (2011). *Black Cockatoos on the Swan Coastal Plain*. Report for the Department of Planning, Western Australia.
- Kabat, A.P., Scott, R. Barrett, G. and Kabat, T. (2012). 2011 *Great Cocky Count: Population estimates and identification of night roost sites for the Carnaby's Cockatoo (Calyptorhynchus latirostris)*. BirdLife Australia and Department of Environment and Conservation, Perth, WA.
- Kendrick, A.W. (Ed.) (2011). *Endangered Black Cockatoos in Western Australia: proceedings of a symposium about their biology, status, threats and efforts to restore their habitat and populations, 26 November 2010*. Urban Bushland Council WA,
- Lee, J., Finn, H. And Calver, M. (2010) Mine-site revegetation monitoring detects feeding by threatened black-cockatoos within 8 years. *Ecological Management and Restoration*. **11**: 141-143.
- Le Souef, A.L. (2012). *Black Cockatoo (Calyptorhynchus spp.) Conservation in Western Australia: Developing and improving tools for the clinical evaluation and management of rehabilitated birds*, PhD Thesis (currently under examination), Murdoch University.
- Mawson, P. (1997). A captive breeding program for Carnaby's cockatoo *Calyptorhynchus latirostris*. *Eclectus* **3**; 21-23.
- Mawson, P. and Johnstone, R. (1997). Conservation status of parrots and cockatoos in Western Australia. *Eclectus*. **3**: 21-23.
- McDougall, K.L., Hobbs, R.J. and Hardy, G.E.S. (2002). Floristic and structural differences between *Phytophthora* infested and adjoining uninfested vegetation in the northern jarrah (*Eucalyptus marginata*) forest of Western Australia. *Australian Journal of Botany*. **50**: 277-288.
- O'Gara, E., Howard, K., Wilson, B.A. and Hardy, G.E.S.J. (2005). Management of *Phytophthora cinnamomi* for Biodiversity Conservation in Australia: Part 2 - National Best Practice Guidelines. In: *A report funded by the Commonwealth Government Department of the Environment and Heritage*. Centre for *Phytophthora* Science and Management, Murdoch University, WA.
- Ortiz-Catedral L, McInnes K, Hauber M, Brunton D. (2009). First report of beak and feather disease virus (BFDV) in wild Red-fronted Parakeets (*Cyanoramphus novaezelandiae*). *Emu*. **109**: 244-247.
- Perry, D.H. (1948). Black Cockatoos and pine plantations. *Western Australian Naturalist*, **1**: 133-135.

- Pouliquen-Young, O. and Newman, P. (2000). *The Implications of Climate Change for Land-based Nature Conservation Strategies*. Final Report 96/1306. Australian Greenhouse Office, Environment Australia, Canberra and Institute for Sustainability and Technology Policy, Murdoch University, Perth, WA.
- Pittman, H., Scott, R., Stojanovic, D and McLellan, L. (2007). Caring for Carnaby's. *Wingspan*, **17**: No. 4.
- Pittock, A.B. (1988). Actual and anticipated changes in Australia's climate. In: *Greenhouse: Planning for climate change*. (Ed. G.I. Pearman) Pp. 335-51. CSIRO, Australia.
- Podger, F.D. and Brown, M.J. (1989). Vegetation damage caused by *Phytophthora cinnamomi* on disturbed sites in temperate rainforest in Western Tasmania. *Australian Journal of Botany*. **37**: 443-480.
- Rose, P.W. (1993). *Production of habitat hollows by wheatbelt eucalypts: final report, Save the bush research grant 1991/92, project R053*. Report prepared by Rose and Bending Forest and Environmental Consultants for the Department of Conservation and Land Management, WA.
- Saunders, D.A. (1974). Subspeciation in the White-tailed Black Cockatoo, *Calyptorhynchus baudinii*, in Western Australia. *Australian Wildlife Research*. **1**: 55-69.
- Saunders, D.A. (1977). The effect of agricultural clearing on the breeding success of the White-tailed Black Cockatoo. *Emu*. **77**: 180-184.
- Saunders, D.A. (1979a). Distribution and taxonomy of the White-tailed and Yellow-tailed black-cockatoos *Calyptorhynchus* spp. *Emu*. **79**: 215-227.
- Saunders, D.A. (1979b). The availability of tree hollows for use as nest sites by White-tailed Black Cockatoos. *Australian Wildlife Research*. **6**: 205-216.
- Saunders, D.A. (1980). Food and movements of the short-billed form of the White-tailed Black Cockatoo. *Australian Wildlife Research*. **7**: 257-269.
- Saunders, D.A. (1982). The breeding behaviour and biology of the short-billed form of the White-tailed Black Cockatoo *Calyptorhynchus funereus*. *Ibis*. **124**: 422-455.
- Saunders, D.A. (1986). Breeding season, nestling success and nestling growth in Carnaby's cockatoo, *Calyptorhynchus funereus latirostris*, over 16 years at Coomallo Creek, and a method for assessing the viability of populations in other areas. *Australian Wildlife Research*. **13**: 261-273.
- Saunders, D.A. (1990). Problems of survival in an extensively cultivated landscape: the case of Carnaby's cockatoo *Calyptorhynchus funereus latirostris*. *Biological Conservation*. **54**: 277-290.
- Saunders, D.A., Dawson, R. and Mawson, P. (2011a). Photographic identification of banded Carnaby's Black Cockatoos. *Corella*. **35**: 52-54.
- Saunders, D.A. and Ingram, J.A. (1987). Factors affecting survival of breeding populations of Carnaby's cockatoo *Calyptorhynchus funereus latirostris* in remnants of native vegetation. In: *Nature Conservation: The Role of Remnants of Native Vegetation*. (Eds. D.A. Saunders, G.W. Arnold, A.A. Burbidge and A.J.M. Hopkins) Pp. 249-258. Surrey Beatty and Sons, Chipping Norton.
- Saunders, D. and Ingram, J. (1995). *Birds of Southwestern Australia: An Atlas of Changes in the Distribution and Abundance of Wheatbelt Avifauna*. Surrey Beatty and Sons, Chipping Norton.
- Saunders, D.A. and Ingram, J.A. (1998). Twenty-eight years of monitoring a breeding population of Carnaby's cockatoo. *Pacific Conservation Biology*. **4**: 261-270.

- Saunders, D.A., Mawson, P. and Dawson, R. (2011b). The impact of two extreme weather events and other causes of death on Carnaby's Black Cockatoo: a promise of things to come for a threatened species? *Pacific Conservation Biology*. **17**: 141-148.
- Saunders, D.A., Rowley, I. and Smith, G.T. (1985). The effects of clearing for agriculture on the distribution of cockatoos in the southwest of Western Australia. In: *Birds of Eucalypt Forests and Woodlands: Ecology, Conservation, Management*. (Eds. A. Keast, H.F. Recher, H. Ford and D. Saunders) Pp. 309-321. Surrey Beatty & Sons, Chipping Norton.
- Saunders, D. A., Smith, G. T., Ingram, J. A. and Forrester, R. I. (2003). Changes in a remnant of salmon gum *Eucalyptus salmonophloia* and York gum *E. loxophleba* woodland, 1978 to 1997. Implications for woodland conservation in the wheat-sheep regions of Australia. *Biological Conservation* **110**: 245-256.
- Saunders, D. A., Smith, G. T. and Rowley, I. (1982). The availability and dimensions of tree hollows that provide nest sites for cockatoos (Psittaciformes) in Western Australia. *Australian Wildlife Research* **9**: 541-56.
- Scott, R. and Gole, C. (2011). The Birds Australia Carnaby's black cockatoo recovery project 2000-2010: a then year community-based approach to conservation. In: *Endangered Black Cockatoos in Western Australia: proceedings of a symposium about their biology, status, threats and efforts to restore their habitat and populations, 26 November 2010*. (Ed. A.W. Kendrick) Pp. 39-40. Urban Bushland Council WA,
- SEWPAC (2012a). *Environment Protection and Biodiversity Conservation Act 1999 draft referral guidelines for three threatened black cockatoo species: Carnaby's cockatoo (endangered) Calyptorhynchus latirostri, Baudin's cockatoo (vulnerable) Calyptorhynchus baudinii, Forest red-tailed black cockatoo (vulnerable) Calyptorhynchus banksii naso*. DSEWPAC, Canberra.
- SEWPAC (2012b). EPBC Act Environmental Offset Policy; consultation draft. Available at: <http://www.environment.gov.au/epbc/publications/consultation-draft-environmental-offsets-policy.html> (Accessed February 2012).
- Shah, B. (2006). *Conservation of Carnaby's cockatoo on the Swan Coastal Plain, Western Australia*. Project Report, Birds Australia Western Australia, Perth.
- Shearer, B.L., Crane, C.E., Barrett, S. and Cochrane, A. (2007). Assessment of threatened flora susceptibility to *Phytophthora cinnamomi* by analysis of disease progress curves in shadehouse and natural environments. *Australasian Plant Pathology*. **36**: 609-620.
- Short, R. and McConnell, C. (2000). *Extent and Impacts of Dryland Salinity. Project 1A-DAW29*. Agriculture Western Australia, National Land and Water Resources Audit.
- Storr, G. (1991). Birds of the South-West Division of Western Australia. *Records of the Western Australian Museum Supplement* No. 35.
- Timbal, B. (2004). Southwest Australia past and future rainfall trends. *Climate Research*. **26**: 233-249.
- Valentine, L.E. and Stock, W. (2008). *Food Resources of Carnaby's cockatoo (Calyptorhynchus latirostris) in the Gnamptara Sustainability Strategy Study Area*. A report prepared for the Forest Products Commission and the Gnamptara Sustainability Strategy, Perth.
- Warren, K., Le Souef, A., Vitali, S., Calver, M., Mawson, P., Dawson, R., Morris, K., Raidal, S., Klandorf, H. and Holyoake, C. (2011). *Health status and population demographics of free-living endangered*

black cockatoos (Calyptorhynchus spp.) in Western Australia. Abstract. Wildlife Disease Association Conference, Meningie, South Australia. 25th-30th September 2011.

- Weste, G. (1974). *Phytophthora cinnamomi* - the cause of severe disease in certain native communities in Victoria. *Australian Journal of Botany*. **29**: 261-276.
- Weste, G., Brown K., Kennedy J. and Walshe T. (2002). *Phytophthora cinnamomi* infestation - a 24-year study of vegetation change in forests and woodlands of the Grampians, Western Victoria. *Australian Journal of Botany*. **50**: 247-274.
- Wilson, A.D. (1990). The effect of grazing on Australian ecosystems. *Proceedings of the Ecological Society of Australia*, **16**: 235-244.
- Wilson, B., and Valentine, L. (2009). *Biodiversity values and threatening processes of the Gnamagara groundwater system*. Chapter One: Introduction and Approach. Gnamagara Sustainability Strategy, Department of Environment and Conservation, Western Australia.
- Wilson, B.A., Newell, G., Laidlaw, W.S. and Friend, G.R. (1994). Impact of plant diseases on faunal communities. *Journal of the Royal Society of Western Australia*. **77**: 139-143.
- White, N. E. (2012). Molecular approaches used to infer evolutionary history, taxonomy, population structure and illegal trade of white-tailed black-cockatoos (*Calyptorhynchus* spp.). PhD thesis, Murdoch University, Western Australia.
- White, N. E., Phillips, M. J., Gilbert, T., Alfaro-Nunez, A., Willerslev, E., Mawson, P. R., Spencer, P. B. S. and Bunce, M. (2011a). The evolutionary history of cockatoos (Aves: Psittaciformes: Cacatuidae). *Molecular Phylogenetics and Evolution*. **59**: 615-622.
- White, N. E., Dawson, R., Coglan, M.L., Tridicio, S.R., Mawson, P.R., Hile, J. and Bunce, M. (2011b) Application of STR markers in wildlife forensic casework involving Australian black-cockatoos (*Calyptorhynchus* spp.). *Forensic Science International: Genetics*. **6**: 665-670.
- Whiteford, K.R. and Williams, M.R. (2002). Hollows in jarrah (*Eucalyptus marginata*) and marri (*Corymbia calophylla*) trees: II. Selecting trees to retain for hollow dependent fauna. *Forest Ecology and Management*. **160**: 215-278.
- Yates, C.J., Hobbs, R.J. and Atkins, L. (2000). Establishment of perennial shrub and tree species in degraded *Eucalyptus salmonophloia* (salmon gum) remnant woodlands: effects of restoration treatments. *Restoration Ecology*. **8**: 135-143.
- Yates, C.J., Hobbs, R.J. and Bell, R.W. (1994). Landscape-scale disturbances and regeneration in semi-arid woodlands of south-western Australia. *Pacific Conservation Biology*. **1**: 214-221.